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Probing the dilaton in central exclusive processes at the LHC

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The existence of a dilaton as a pseudo-Nambu-Goldstone boson in spontaneous breaking of scale symmetry is predicted in beyond standard model theories in which electroweak symmetry is broken via strongly coupled conformal dynamics. Such a particle is expected to have a mass below the conformal symmetry breaking scale f and couplings to standard model particles similar to those of the SM Higgs boson. In this paper we estimate, for the first time, the dilaton production in exclusive processes considering Pomeron-Pomeron ($\mathbb{PP}$) and photon-photon ($\gamma\gamma$) interactions, which are characterized by two rapidity gaps and intact hadrons in the final state. Our results indicate that if the dilaton is massive ($M_\chi \geq 2M_W$), the study of dilaton production by $\mathbb{PP}$ interactions in pp collisions can be useful to determine its mass and the conformal energy scale.

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The prediction of the existence of new scalar particles is a characteristic of several candidate theories beyond the standard model (SM) (See e.g. Ref. [1]). One of these particles is the dilaton, denoted as χ, which is predicted to appear as a pseudo-Nambu-Goldstone boson in spontaneous breaking of scale symmetry [2]. In the particular scenario in which electroweak symmetry is broken via strongly coupled conformal dynamics, a neutral dilaton is expected with a mass below the conformal symmetry breaking scale f and couplings to standard model particles similar to those of the SM Higgs boson. The searching of the dilaton in *inclusive* proton-proton collisions at LHC energies motivated a lot of work, with special emphasis in the discrimination of the dilaton from the SM Higgs signals [3–9]. In particular, in Refs. [3,4] the authors have derived regions of the mass M_χ and the conformal breaking scale of the dilaton allowed by constraints from Higgs searches at LEP and LHC. They find that for low values of f, the dilaton is already excluded by the LHC in a large portion of parameter space ($M_\chi - f$) and that for large f and large M_χ the dilaton is not excluded but could be discovered at LHC with more luminosity. In this paper we extend these previous studies for *exclusive* processes, in which the hadrons colliding remain intact after the interaction, losing only a small fraction of their initial energy and escaping the central detectors [10]. The signal would be a clear one with a dilaton tagged in the central region of the detector accompanied by regions of low hadronic activity, the so-called "rapidity gaps." In contrast to the inclusive production, which is characterized by large QCD activity and backgrounds which complicate the identification of a new physics signal, the exclusive production will be characterized by a clean topology associated to hadron-hadron interactions mediated by colorless exchanges. Our analysis is motivated by the studies performed in Refs. [11–14], which demonstrated that central exclusive processes are very sensitive to Beyond Standard Model contributions.

In this paper we will calculate the dilaton production considering Pomeron-Pomeron ($\mathbb{PP}$) or photon-photon ($\gamma\gamma$) interactions in pp and $PbPb$ collisions at LHC energies. These processes are represented in Figs. 1(a) and (b), respectively, and can be written in the form

$$h_1 + h_2 \to h_1 \otimes \chi \otimes h_2, \tag{1}$$

where h_i is a proton or a nucleus and χ is the dilaton. The basic characteristic of these processes is the presence of two rapidity gaps ($\otimes$) in the final state, separating the dilaton from the intact outgoing hadrons. Experimentally, these processes have a very clear signal in the absence of pile-up, with the presence of the final state χ and no other hadronic activity seen in the central detector. Moreover, the measurement of the outgoing hadrons with installation of forward hadron spectrometers can be useful to separate the exclusive events [10]. Such possibility is currently under discussion in the ATLAS and CMS Collaborations at LHC. For comparison with our predictions for the dilaton production, we update previous estimates of the SM Higgs in exclusive processes and analyze the possibility of distinguish between these states in these processes.

In what follows we present a brief review of the theoretical description of Pomeron-Pomeron ($\mathbb{PP}$) or photon-photon ($\gamma\gamma$) interactions in pp and $PbPb$ collisions at LHC energies. For the central exclusive production of a dilaton by pomeron-pomeron interactions we consider the model proposed by Khoze, Martin and Ryskin [15–17] some years ago, denoted Durham model hereafter, which

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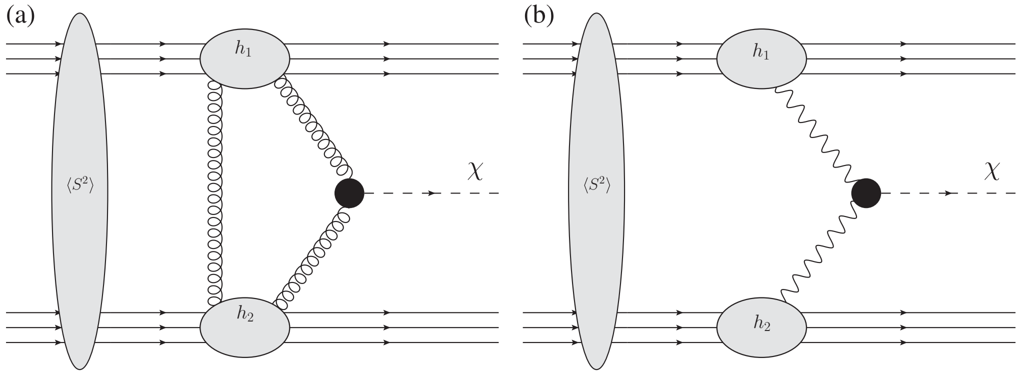

FIG. 1. Dilaton production in (a) Pomeron-Pomeron and (b) photon-photon interactions. $\langle \mathcal{S}^2 \rangle$ is the gap survival probability, which gives the probability that secondaries, which are produced by soft rescatterings, do not populate the rapidity gaps.

has been used to estimate a large number of different final states and have predictions in reasonable agreement with the observed rates for exclusive processes measured by the CDF collaboration [18–20] and in the Run I of the LHC (For a recent review see Ref. [21]). In this model, the total cross section for central exclusive production of a dilaton by $\mathbb{PP}$ interactions can be expressed in a factorized form as follows

$$\sigma = \int dy \langle \mathcal{S}^2 \rangle \mathcal{L}_{\mathrm{excl}} \frac{2\pi^2}{M_\chi^3} \Gamma(\chi \to gg), \tag{2}$$

where $\langle \mathcal{S}^2 \rangle$ is the gap survival probability (see below), Γ stand for the partial decay width of the dilaton χ in a pair of gluons and $\mathcal{L}_{\mathrm{excl}}$ is the effective luminosity, given by

$$\mathcal{L}_{\mathrm{excl}} = \left[\mathcal{C} \int \frac{dQ_t^2}{Q_t^4} f_g(x_1, x_1', Q_t^2, \mu^2) f_g(x_2, x_2', Q_t^2, \mu^2) \right]^2, \tag{3}$$

where $\mathcal{C} = \pi/[(N_c^2 - 1)b]$, with b the t-slope ($b = 4$ GeV^{-2} in what follows), Q_t^2 is the virtuality of the soft gluon needed for color screening, x_1 and x_2 being the longitudinal momentum of the gluons which participate of the hard subprocess and x_1' and x_2' the longitudinal momenta of the spectator gluon. Moreover, the quantities f_g are the skewed unintegrated gluon densities. Since

$$\left(x' \approx \frac{Q_t}{\sqrt{s}} \right) \ll \left(x \approx \frac{M_\chi}{\sqrt{s}} \right) \ll 1 \tag{4}$$

it is possible to express $f_g(x, x', Q_t^2, \mu^2)$, to single log accuracy, in terms of the conventional integrated gluon density $g(x)$, together with a known Sudakov suppression T which ensures that the active gluons do not radiate in the evolution from Q_t up to the hard scale $\mu \approx M_\chi/2$. Following [16] we will assume that

$$f_g(x, x', Q_t^2, \mu^2) = S_g \frac{\partial}{\partial \ln Q_t^2} \left[\sqrt{T(Q_t, \mu)} x g(x, Q_t^2) \right], \tag{5}$$

where S_g accounts for the single log Q^2 skewed effect, being $S_g \sim 1.2(1.4)$ for LHC (Tevatron) (For a more detailed discussion about S_g see Ref. [22]). The Sudakov factor $T(Q_t, \mu)$ is given by

$$T(Q_t, \mu) = \exp \left\{ - \int_{Q_t^2}^{\mu^2} \frac{dk_t^2}{k_t^2} \frac{\alpha_s(k_t^2)}{2\pi} \times \int_0^{1-\Delta} dz \left[z P_{gg}(z) + \sum_q P_{qg}(z) \right] \right\}, \tag{6}$$

with k_t being an intermediate scale between Q_t and μ, $\Delta = k_t/(\mu + k_t)$, and $P_{gg}(z)$ and $P_{qg}(z)$ are the leading order Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) splitting functions [23]. In this paper we will calculate f_g in the proton case considering that the integrated gluon distribution $xg(x, Q_T^2)$ is described by the MSTW parametrization [24]. In the nuclear case we will include the shadowing effects in f_g^A considering that the nuclear gluon distribution is given by the EPS09 parametrization [25], where

$$x g_A(x, Q_T^2) = A R_g^A(x, Q_T^2) x g_p(x, Q_T^2), \tag{7}$$

with R_g^A describing the nuclear effects in xg_A and A the number of mass of the nucleus. Moreover, the partial decay width of the dilaton into two gluons is given by [4]

$$\Gamma_{\chi \to gg}(M_\chi) = \mathcal{C}_g \frac{v^2}{f^2} \frac{G_F \alpha_s^2 M_\chi^3}{36\sqrt{2}\pi^3} \left| \frac{3}{4} \sum\nolimits_f F_{1/2}(\tau_f) \right|^2, \tag{8}$$

where $v = 246$ GeV is the scale of electroweak symmetry breaking, f is the energy scale of conformal scale (see discussion below), G_F is the Fermi constant and α_s is the strong running coupling. The scaling variables are $\tau_f = 4m_f^2/M_\chi^2$, $\tau_W = 4m_W^2/M_\chi^2$ and the sums runs over all fermions. The loop functions are given by the following expressions [26],

$$F_1(\tau) = 2 + 3\tau + 3\tau(2-\tau)f(\tau) \quad (9)$$

$$F_{1/2}(\tau) = -2\tau[1 + (1-\tau)f(\tau)] \quad (10)$$

where

$$f(\tau) = \begin{cases} [\sin^{-1}(1/\sqrt{\tau})]^2, & \tau \geq 1 \\ -\frac{1}{4}\left[\ln\left(\frac{1+\sqrt{1-\tau}}{1-\sqrt{1-\tau}}\right) - i\pi\right]^2, & \tau < 1 \end{cases} \quad (11)$$

with $\tau = 4m_i^2/M_\chi^2$. Moreover, the coefficient $\mathcal{C}_g$ in Eq. (8) is given by

$$\mathcal{C}_g = \frac{|-b_G + 1/2\sum_{i=q}F_{1/2}(\tau_i)|^2}{|1/2\sum_{i=f}F_{1/2}(\tau^2)|^2}, \quad (12)$$

where $b_G = 11 - \frac{2}{3}n_f$, with $n_f = 6$, and the sum runs over quarks only.

On the other hand, the cross section for the exclusive dilaton production in the two-photon fusion process, Fig. 1(b), is given by [27]

$$\sigma = \langle\mathcal{S}^2\rangle \int_0^\infty \frac{d\omega_1}{\omega_1}\int_0^\infty \frac{d\omega_2}{\omega_2} F(\omega_1,\omega_2)\hat{\sigma}_{\gamma\gamma\to\chi}(\omega_1,\omega_2) \quad (13)$$

where $\hat{\sigma}_{\gamma\gamma\to\chi}$ is the cross section for the subprocess $\gamma\gamma \to \chi$, ω_1 and ω_2 the energy of the photons which participate of the hard process and F is the folded spectra of the incoming particles (which corresponds to an "effective luminosity" of photons) which we assume to be given by [28]

$$F(\omega_1,\omega_2) = 2\pi\int_{R_A}^\infty db_1 b_1 \int_{R_B}^\infty db_2 b_2 \times \int_0^{2\pi} d\phi N_1(\omega_1,b_1)N_2(\omega_2,b_2) \times \Theta(b - R_A - R_B) \quad (14)$$

where b_i is the impact parameter of the hadrons in relation to the photon interaction point, ϕ is the angle between $\mathbf{b}_1$ and $\mathbf{b}_2$, R_i are the projectile radii and $b^2 = b_1^2 + b_2^2 - 2b_1b_2\cos\theta$. The theta function in Eq. (14) ensures that the hadrons do not overlap [28]. The Weizsäcker-Williams photon spectrum for a given impact parameter is given in terms of the nuclear charge form factor $F(k_\perp^2)$, where $k_\perp$ is the four-momentum of the quasi-real photon, as follows [29]

$$N(\omega,b) = \frac{\alpha Z^2}{\pi^2\omega}\left|\int_0^{+\infty} dk_\perp k_\perp^2 \frac{F((\frac{\omega}{\gamma})^2 + \vec{b}^2)}{(\frac{\omega}{\gamma})^2 + \vec{b}^2}\cdot J_1(bk_\perp)\right|^2, \quad (15)$$

where J_1 is the Bessel function of the first kind. For a pointlike nucleus one obtains that [29]

$$N(\omega,b) = \frac{\alpha_{\rm em}Z^2}{\pi^2}\left(\frac{\xi}{b}\right)^2\left\{K_1^2(\xi) + \frac{1}{\gamma^2}K_0^2(\xi)\right\}, \quad (16)$$

with $K_{0,1}$ being the modified Bessel function of second kind, $\xi = \omega b/\gamma v$, v the velocity of the hadron, γ the Lorentz factor and $\alpha_{\rm em}$ the electromagnetic coupling constant. This expression has been derived considering a semiclassical description of the electromagnetic interactions in peripheral collisions, which works very well for heavy ions (See e.g. [27]). For protons, it is more appropriate to obtain the equivalent photon spectrum from its elastic form factors in the dipole approximation (See e.g. [30]). An alternative is to use Eq. (16) assuming $R_p = 0.7$ fm for the proton radius, which implies a good agreement with the parametrization of the luminosity obtained in [31] for proton-proton collisions. We will assume this procedure in what follows. The $\gamma\gamma \to \chi$ cross section can be expressed as follows

$$\hat{\sigma}_{\gamma\gamma\to\chi}(\omega_1,\omega_2) = \int ds\delta(4\omega_1\omega_2 - s)\frac{8\pi^2}{M_\chi}\Gamma_{\chi\to\gamma\gamma}(M_\chi)\delta(s - M_\chi^2), \quad (17)$$

where partial decay width of the dilaton into two photons, $\Gamma_{\chi\to\gamma\gamma}$, was calculated in [4] and is given by:

$$\Gamma_{\chi\to\gamma\gamma}(M_\chi) = \mathcal{C}_\gamma \frac{v^2}{f^2}\frac{G_F\alpha_{\rm em}M_\chi^3}{128\sqrt{2}\pi^3}\left|F_1(\tau_W) + \sum\nolimits_f N_c Q_f^2 F_{1/2}(\tau_f)\right|^2 \quad (18)$$

where $\alpha_{\rm em}$ is the electromagnetic coupling constant, N_c is the number of colors, Q_f is the fermion charge. Moreover, the coefficient $\mathcal{C}_\gamma$ is given by [4]

$$R_\gamma = \frac{|-b_{\rm EM} + \sum_{i=f,b}N_{c,i}Q_i^2F_i(\tau_i)|^2}{|\sum_{i=f,b}N_{c,i}Q_i^2F_i(\tau_i)|^2} \quad (19)$$

where $b_{\rm EM} = -11/3$, the sum runs over fermions (f) and bosons (b), $N_{c,i}$ is the color multiplicity number ($N_{c,i} = 1$ for bosons and leptons and $N_{c,i} = 3$ for quarks) and Q is the electric charge in units of e.

In what follows we will present our predictions for the dilaton production in pp ($\sqrt{s} = 14$ TeV) and $PbPb$ ($\sqrt{s} = 5.5$ TeV) collisions at LHC energies. We assume $m_W = 80.4$ GeV, $m_t = 173$ GeV, $m_b = 4.2$ GeV, $m_c = 1.4$ GeV and $m_\tau = 1.77$ GeV. Moreover, in order to obtain realistic predictions for the exclusive production of the dilaton, it is crucial to use an adequate value for the gap survival probability, $\langle\mathcal{S}^2\rangle$. This factor is the probability that secondaries, which are produced by soft rescatterings do not populate the rapidity gaps, and depends on the particles involved in the process and in the center-of-mass energy. For the case of the central exclusive production described by the Durham model we will assume that $\langle \mathcal{S}^2 \rangle = 3\%$ for proton-proton collisions at LHC energies [16]. However, the value of the corresponding value of the survival probability for nuclear collisions still is an open question. Here we assume the conservative estimate proposed in Ref. [12] which assume that : $\langle \mathcal{S}^2 \rangle_{A_1 A_2} = \langle \mathcal{S}^2 \rangle_{pp}/(A_1 \cdot A_2)$. In contrast, for two-photon interactions, it is expected that the contribution of secondary interactions for the cross section will be negligible [10]. For simplicity, we will assume that $\langle \mathcal{S}^2 \rangle_{A_1 A_2} = \langle \mathcal{S}^2 \rangle_{pp} = 1$ for the dilaton production by two photons. However, this subject deserves a more detailed analysis. For our calculations of the SM Higgs production in exclusive processes, we will assume the same parameters described before and will take $\mathcal{C}_{\gamma/g} \frac{v^2}{f^2} = 1$ in Eqs. (8) and (18). Moreover, we assume $M_H = 125$ GeV.

In Figs. 2(a) and (b) we present our results for the dependence of the total cross sections on the mass of the dilaton considering $\mathbb{P}\mathbb{P}$ and $\gamma\gamma$ interactions in pp and $PbPb$ collisions, respectively. For comparison, we also present the corresponding predictions for the SM Higgs production. Following previous studies [4,5], which have derived allowed regions for the dilaton mass M_χ and conformal energy scale f by considering the LHC data relevant to the double gauge boson decays of the dilaton, we restrict our analysis for the following ranges: (a) $f = 1.0$ TeV and $M_\chi \leq 126$ GeV; (b) $f = 4.0$ TeV and $M_\chi \leq 175$ GeV and (c) $f = 5.0$ TeV, with all values of M_χ being allowed [4,5]. As the partial decay widths of the dilaton into gluons and photons, Eqs. (8) and (18), are proportional to $1/f^2$, we obtain that the cross sections are strongly dependent on the choice of f, decreasing at larger values of the conformal energy scale. For the case of $\mathbb{P}\mathbb{P}$ interactions, Fig. 2(a), we obtain that the predictions for the dilaton production in $PbPb$ collisions is three orders of magnitude larger than for pp collisions. In comparison with the SM Higgs predictions, we obtain that for $M_\chi = 125$ GeV the dilaton cross section is larger than the exclusive SM Higgs cross section for $f = 1.0$ TeV and a factor ≥ 2 smaller for $f \geq 4.0$ TeV. In contrast, for $\gamma\gamma$ interactions, Fig. 2(b), we obtain that at small M_χ the predictions for the dilaton production in $PbPb$ collisions is six orders of magnitude larger than for pp collisions, which is directly associated to the Z^2 dependence of the nuclear photon flux. Moreover, we obtain that this difference decreases at larger values of M_χ, which is associated to the fact that the maximum value of the photon energy in the photon flux is given by $\gamma/b_{\max}$ [29], where γ is the Lorentz factor and $b_{\max}$ is proportional to the hadron radius. Consequently, the proton photon flux contains a larger number of energetic photons, which increases the cross section for the production of a massive final state in pp collisions in comparison to the nuclear case. However, we predict very small values for the dilaton production induced by two-photon fusion in pp cross section. Finally, in comparison to the SM Higgs cross section for $\gamma\gamma$ interactions, we obtain for $M_\chi = 125$ GeV and $f = 1.0$ TeV that the dilaton cross section is a factor five smaller than the SM Higgs one.

In Figs. 3(a) and (b) we present our results for the rapidity distribution for the dilaton production in $\mathbb{P}\mathbb{P}$ interactions considering pp and $PbPb$ collisions at LHC energies, respectively. In these figures we assume $M_\chi = M_H = 125$ GeV. In agreement with the results presented in Fig. 2(a), we obtain that the predictions are strongly dependent on f and the dilaton production in nuclear collisions is four orders of magnitude larger than in pp collisions. For $f = 1$ TeV, we predict larger values of the rapidity distribution for the dilaton production than the SM Higgs one.

In Table I we present our results for the production rates for dilaton production at LHC energies considering the $\mathbb{P}\mathbb{P}$ and $\gamma\gamma$ interactions assuming that $M_\chi = M_H = 125$ GeV.

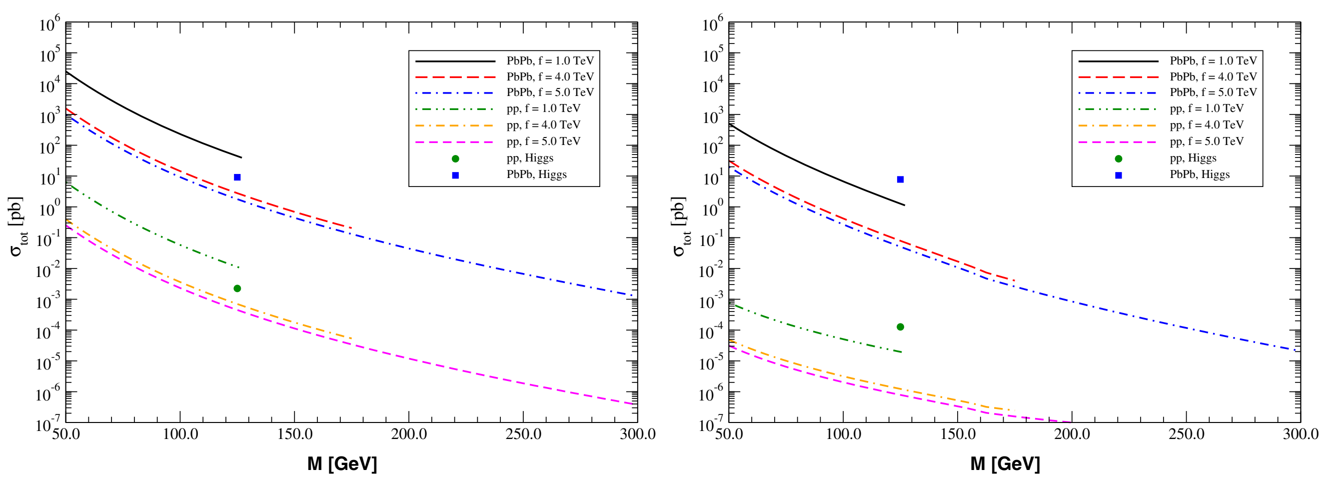

FIG. 2 (color online). Total cross section for the dilaton production in (a) Pomeron-Pomeron and (b) photon-photon interactions in pp and $PbPb$ collisions as a function of the dilaton mass. The corresponding predictions for the SM Higgs production are also presented for comparison.

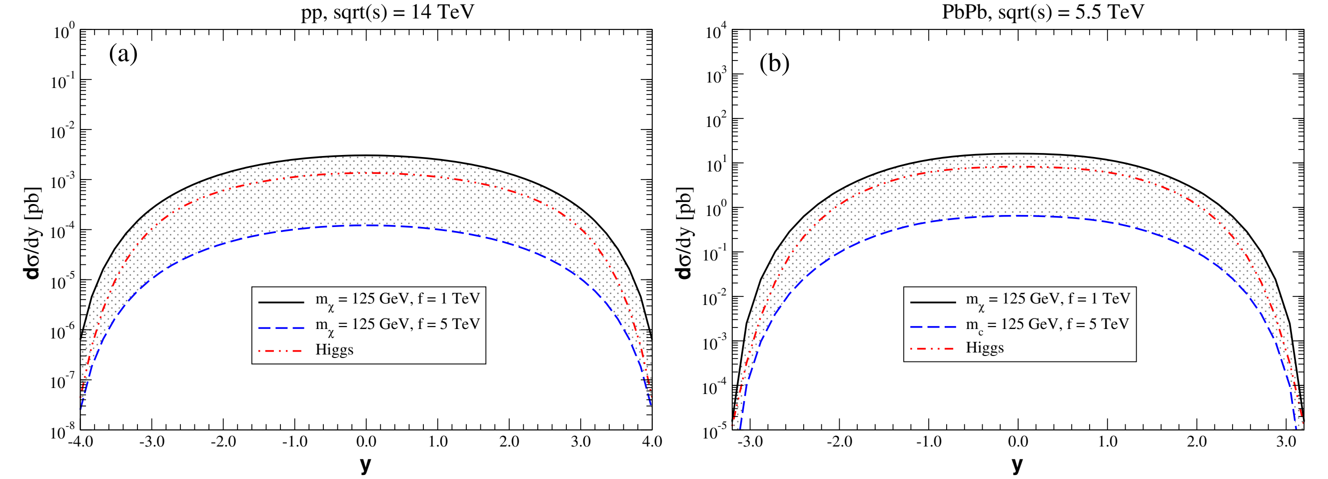

FIG. 3 (color online). Rapidity distribution for the dilaton production in $\mathbb{PP}$ interactions considering (a) pp and (b) $PbPb$ collisions at LHC energies. The corresponding predictions for the SM Higgs production are also presented for comparison.

At LHC we assume the design luminosities $\mathcal{L} = 10^7/0.5\ \mathrm{mb}^{-1}\,\mathrm{s}^{-1}$ for $pp/PbPb$ collisions at $\sqrt{s} = 14/5.5$ TeV and a run time of $10^7(10^6)$ s for collisions with protons (ions). The predictions for the SM Higgs production also are presented for comparison. Due to the small luminosity for heavy ion collisions, we obtain very small values for the event rates of Higgs and dilaton production in $\mathbb{PP}$ and $\gamma\gamma$ interactions. In contrast, we obtain that the event rates are a factor $\geq 10^3$ larger for pp collisions. For $\gamma\gamma$ interactions in pp collisions we obtain that the predictions for the dilaton production ($f = 1.0$ TeV) are one order of magnitude smaller than the SM Higgs one, as expected from the Fig. 2. Moreover, the predictions for the dilaton and SM Higgs production in $\mathbb{PP}$ interactions are a factor ≥ 10 larger than those for $\gamma\gamma$ interactions. In particular, we obtain that the dilaton production for $f = 1.0$ TeV is a factor five larger than the SM Higgs one due to the magnitude of the factor $C_g v^2/f^2$ in Eq. (8), which is larger than one for this value of the conformal energy scale. At larger values of f, the Higgs production dominates due to the $1/f^2$ dependence of the dilaton cross section.

Let us discuss now the potential backgrounds for the dilaton production in exclusive processes. The partial widths for the dilaton to decay into any SM final state were estimated in Refs. [4,5]. Depending on the dilaton mass, different channels seem more favorable, and each of the decay channels has its own difficulties for the experimental identification. At $M_\chi < 2M_W$ the dilaton decay is characterized by a large gg branching fraction, in contrast to the Higgs decay which is dominated by the decay in $b\bar{b}$ pair for $M_H \leq 140$ GeV. This distinct behavior is due to the enhancement of the χgg coupling via the QCD beta function coefficient in Eq. (12). In contrast, for $M_\chi > 2M_W$ the dilaton decays predominantly to WW, ZZ and $t\bar{t}$. Consequently, the main backgrounds are the gg and WW production in exclusive processes. The cross sections for these processes were estimated e.g. in Refs. [32,33]. As demonstrated in Ref. [32], the gg contribution dominates the central exclusive production of dijets. Comparing our results with those obtained in Ref. [32], we obtain that our predictions for the production of a dilaton with mass $M_\chi < 140$ GeV which decays into a gg final state is two orders of magnitude smaller than the exclusive gg dijet production. Consequently, the identification of a light dilaton in exclusive processes considering this final state will not be possible. On the other hand, for the production of a massive dilaton which decays into a WW pair, we need to compare our predictions with those presented in Ref. [33], which have demonstrated that the central exclusive W^+W^- production is dominated by the two-photon fusion. We obtain that also in this case the signal of the dilaton production will be smaller than the background, in particular for large M_χ masses, since the cross section for the $pp \to ppW^+W^-$ (via $\gamma\gamma$) process is weakly dependent on the invariant mass M_{WW} (See Fig. 14 in Ref. [33]). However, if the $\gamma\gamma$ and $\mathbb{PP}$ processes are separated by

TABLE I. Number of events by year for the production of a dilaton in pp and $PbPb$ collisions considering $\mathbb{PP}$ and $\gamma\gamma$ interactions. Values obtained for $M_\chi = 125$ GeV and $f = 1.0(5.0)$ TeV. The corresponding predictions for the SM Higgs production are also presented for comparison.

$\mathbb{PP}$ interactions	pp collisions	$PbPb$ collisions
Dilaton	1100 (40)	21.1×10^{-3} (7.35×10^{-4})
Higgs	200	5×10^{-3}

$\gamma\gamma$ interactions	pp collisions	$PbPb$ collisions
Dilaton	1.9 (7.3×10^{-2})	0.6×10^{-3} (2.5×10^{-5})
Higgs	19	4.9×10^{-3}

measuring the four-momentum transfers squared in the proton lines, as planned for future studies at ATLAS and CMS, we have that the signal will be similar to the background associated to the $pp \to ppW^+W^-$ (via gg) process. An alternative to search a massive dilaton in exclusive processes, is to consider its decay into a ZZ pair and/or a Higgs pair. As demonstrated in Ref. [5], these two decay channels are similar to the WW one for $M_\chi >$ 200 GeV. The exclusive ZZ production has been estimated in Ref. [14] as a probe of large extra dimension scenario. Comparing our results with the SM predictions presented in [14], we obtain that the signal will be larger than the background for large invariant masses of this final state. The magnitude of the double Higgs production in exclusive processes still is an open question, but it is expected to be very small. Consequently, the search of the dilaton considering its decay into a Higgs pair can also be a promising way.

Finally, lets summarize our main results and conclusions. In this paper we estimated, for the first time, the dilaton production in exclusive processes considering $\mathbb{PP}$ and $\gamma\gamma$ interactions, which are characterized by two rapidity gaps and intact hadrons in the final state. Our goal was to verify if exclusive processes can be considered a viable alternative to the proposed searches of the dilaton in inclusive processes. In contrast to inclusive processes, where the incident hadrons dissociate and the final state is populated by a large number of particles, which makes the separation of the dilaton a hard task, in exclusive processes the incident hadron remains intact and the dilaton will be centrally produced, separated from the very forward hadrons by large rapidity gaps. Consequently, in exclusive processes the dilaton is expected to be produced in a clean environment. Moreover, if the momenta of the outgoing hadrons are measured by forward detectors, the mass of the dilaton is expected to be reconstructed with very precise resolution. All these aspects have motivated the analysis performed in this paper. We have considered one of the possible scenarios which predicts the dilaton and could be analyzed at LHC, in which the scale invariance of the strong dynamics is manifested at very high energy but is spontaneously broken at a scale f, not too above the electroweak scale. Consequently, the identification of the dilaton provide a hint to the conformal nature of the strong sector. Taking into account the constraints in f and M_χ from the Higgs searches at LEP and LHC, we have estimated the dilaton cross sections and event rates for the dilaton production induced by $\mathbb{PP}$ and $\gamma\gamma$ interactions in pp and $PbPb$ collisions. For a dilaton with mass identical to the SM Higgs, we predict larger cross sections in comparison to the SM Higgs production in Pomeron-Pomeron interactions for $f = 1.0$ TeV, which is the minimal value of f allowed for $M_\chi = 125$ GeV. At larger values of f, the dilaton cross section becomes smaller than the Higgs one due to its $1/f^2$ dependence. In contrast, for photon-photon interactions, the dilaton cross section is smaller to the SM Higgs one for all allowed values of f. Taking into account the main decay channels of the dilaton, we have compared our predictions with potential backgrounds. Our results demonstrated that for a light dilaton the signal-to-background ratio will be very small, which implies that the probe of a light dilaton in exclusive processes at LHC will be not possible. In contrast, our results indicated that for a massive dilaton, which can be produced if $f > 4.0$ TeV, the signal-to-background ratio will be favorable if the dilaton decay channels into ZZ and/or HH are considered. Our main conclusion is that the study of exclusive processes can be useful to search a massive dilaton, as well as to constrain the mass and the conformal energy scale.

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