(hep-ph/yymmddd)

YUMS 00-09, KIAS-P00060, SNUTP 00-024

Enhancement of the Higgs pair production at LHC; the MSSM and extra-dimension effects

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Abstract

The neutral Higgs pair production at LHC is studied in the MSSM, the large extra dimension model and the Randall-Sundrum model, where the total cross section can be enhanced by more than one order of magnitude, compared to that in the SM. We have obtained the p_T, invariant mass and rapidity distributions. Both of the extra-dimensional cases show distinctive features: The distribution shapes are almost independent of the string scale $M_{\rm S}$; the p_T and invariant mass distributions peak around $M_{\rm S} \sim$ TeV, while the SM and MSSM contributions drop rapidly at this high scale; the rapidity distributions show significantly narrow peaks. It is concluded that various distributions of the Higgs pair production at LHC with restrictive kinematic cuts would provide one of the most robust signals of the extra dimensional effects.

PACS numbers: 04.50.+h,12.60.-i,13.85.-t,13.90.+i

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I. INTRODUCTION

The Standard Model (SM) has been very successful in explaining accelerator experiments, including the recent CERN e^+e^- collider LEP experiments at $\sqrt{s} = 202$ GeV [1]. Nevertheless one of the most important ingredients of the SM, the Higgs mechanism, has not been experimentally probed yet. Since the Higgs mechanism is responsible for spontaneous electroweak symmetry breaking accompanying the mass generation of the W and Z gauge bosons as well as fermions, it is natural that primary efforts of the future collider experiments are to be directed toward the search for Higgs bosons [2].

In particular, the pair production of Higgs bosons holds a distinctive position in understanding the Higgs mechanism. First, it may provide the experimental reconstruction of the Higgs potential, as the triple self-coupling of Higgs particles is involved. The establishment of the Higgs' role in the electroweak symmetry breaking is crucially dependent on this measurement. Second, the signal-to-background ratio is significantly improved compared to that of a single Higgs boson production. The invariant mass scale of the *single* Higgs production is fixed by the Higgs mass, of order ~ 100 GeV. Thus its detection through heavy quark decay modes suffers from large QCD backgrounds. Besides, one viable decay mode $h \to \gamma\gamma$ has a very small branching ratio of order 10^{-3} [4]. For the *pair* production of the Higgs particles, the four b-jets in the final states are energetic, reducing the main background $hb\bar{b}$ with soft b-jets [5]. Third, this is a rare process in the sense that the effects of physics beyond the SM can remarkably enhance the cross section with respect to that in the SM: the Minimal Supersymmetric Standard Model (MSSM) [3] provides some parameter space for the large enhancement of the total cross section, which should accommodate the large Yukawa coupling of the b quarks, the resonant decay of $H \to hh$ [6], and/or dominantly large contribution of the squark loops [5]; extra dimensional models provide tree level diagrams mediated by the Kaluza-Klein (KK) gravitons, leading to much larger total cross sections. In fact, these two theoretical approaches have drawn extensive attention as candidates for the solution of the gauge hierarchy problem, the existence and stability of the enormous hierarchy between the electroweak and Planck scales. Therefore, it is worth studying the production of a neutral Higgs pair with the effects of the MSSM and extra dimensional models, and finding the characteristic distribution of each model. We shall restrict ourselves to the procedure at the CERN LHC, which is scheduled to start operating in 2005. It takes a practical advantage over the future e^+e^- linear colliders despite the assurance of the latter of the detectibility of the lightest CP-even MSSM Higgs boson with $\sqrt{s} \gtrsim 250\,\text{GeV}$ and $\int \mathcal{L} dt \gtrsim 10\ \text{fb}^{-1}$ [7].

The remainder of the paper is organized as follows. The next Section details the neutral Higgs pair production at the CERN LHC in the SM, the MSSM, the large extra dimensional (ADD) model [8], and the Randall-Sundrum (RS) model [9]. In Section III, we discuss various distributions useful to discriminate between the models. The last Section contains a brief summary and conclusions.

II. THEORETICAL DISCUSSIONS AND FORMULAE

The production of a Higgs boson pair at a hadron collider proceeds through several modes: WW fusion, bremsstrahlung of Higgs bosons off heavy quarks, and gluon-gluon fusion. At the LHC, the gg fusion is expected to play a main role, since the gluon luminosity increases with beam energy. In this paper, therefore, we focus on the process $gg \to hh$, where the h is the lightest Higgs boson in each theory. For the numerical analysis, we use the leading order MRST parton distribution functions (PDF) for the gluon in the proton [10]. The QCD factorization and renormalization scales Q are set to be the hh invariant mass, *i.e.*, $\sqrt{\hat{s}}$. The Q^2-dependence is expected to be small on the distribution shapes which are of our main interest. The center-of-momentum (c.m.) energy at pp collisions is $\sqrt{s} = 14$ TeV. And we have employed the kinematic cuts of $p_T \geq 25$ GeV and $|\eta| \leq 2.5$ throughout the paper.

A. In the SM

In the SM, there are two types of Feynman diagrams as depicted in Fig. 1. One is the triangle diagram where a virtual Higgs particle, produced from gg fusion through heavy quark triangles, decays into a pair of Higgs particles. The other is the box diagram where the Higgs pair is produced through heavy quark boxes. It is to be noted that the triangle diagram incorporates the triple self-coupling of Higgs particles. For analytic expressions of all the one-loop amplitudes of the process $gg \to hh$, we refer the reader to Ref. [5,6]. Figure 2 shows, with respect to the Higgs mass m_h, the total cross section of the SM Higgs pair production at the LHC. At $m_h \simeq 100$ GeV, the $\sigma_{\rm tot}$ is of order 60 fb, which decreases rapidly with increasing m_h.

B. In the MSSM

The existence of a fundamental scalar particle in the SM causes the well-known gauge hierarchy problem; it is unnatural that the Higgs mass at the electroweak scale is protected from the presence of the enormous Planck scale. Traditional approaches are to introduce some symmetries, motivated by the chiral symmetry for light fermion masses and the gauge symmetries for gauge boson masses. Supersymmetry is one of the most popular candidates for this new symmetry.

The MSSM Higgs pair production has distinctive contributions coming from the new Higgs and squark sectors which provide the possibilities to greatly enhance the total cross section of the process. Firstly, two doublets and thus two different vacuum expectation values of the Higgs fields allow the Yukawa coupling of the b quark to be compatible with that of the top quark, which corresponds to the large $\tan\beta$ case. Much smaller mass of the b quark makes its loop contribution even larger than the top quark contribution [6]. Secondly, two Higgs doublets imply the presence of a heavy CP-even neutral Higgs boson H, which can resonantly decay into two light Higgs bosons if kinematically allowed. This resonant contribution $gg \to H \to hh$ is shown to enhance the total cross section with respect to the SM case by about an order of magnitude. Thirdly, the MSSM permits a parameter space where the $\tilde{b}$ or $\tilde{t}$ loop contributions can exceed the SM quark loop contributions by more than two orders of magnitude [5]. For the maximization of squark loop contributions which occurs through the $\tilde{b}$ loops, this parameter space should permit large value of $\tan\beta$, considerably light $\tilde{b}_1$ mass, and large mass of A and/or $|\mu|$. Since the third enhancement possibility has rather restrictive parameter space (for example, the squark loop contributions are practically negligible unless $m_{\tilde{b}_1} \lesssim 120$ GeV), we consider only the quark loop contributions, as in Ref. [6]. The corresponding Feynman diagrams are the same as in the SM case, except for the different coupling strengths and the presence of the neutral heavy Higgs boson H (see Fig. 1).

The MSSM total cross section as a function of the Higgs mass shows behavior similar to that of the SM, except for the overall enhancement, which can be seen in Ref. [6]. As anticipated, the total cross sections in the large and small $\tan\beta$ cases are much increased compared to the SM case. In particular, the large $\tan\beta$ value with $m_h \simeq 100$ GeV leads to an order of magnitude enhancement of the cross section.

C. In the ADD model

Recently, Arkani-Hamed, Dimopoulos, and Dvali (ADD) have approached the gauge hierarchy problem without resort to any new symmetry [8]. Instead, one prerequisite of the hierarchy problem itself is removed; the Planck mass is not fundamental; the nature allows only one fundamental mass scale $M_{\rm S}$ which is at the electroweak scale. By introducing the $N \geq 2$ extra compact space, the observed huge Planck mass is attributed to the large volume of the extra space, since $M_{\rm Pl}^2 \simeq M_{\rm S}^{N+2} R^N$, where the R is the size of the extra dimension. The prohibition of the SM particles' escaping into the extra space can be achieved by describing the matter fields as open strings of which the end-points are fixed to our four-dimensional world.

Of great interest and significance is that this idea is testable at colliders. The KKreduction from the whole $(4+N)$-dimensions to our four-dimensional world yields towers of massive KK-states in the four-dimensional effective theory. Even though each graviton in the KK-tower couples to the ordinary matter fields with the couplings extremely suppressed by the Planck scale, tiny mass-splitting $\Delta m_{\rm KK} \sim 1/R$ (which is about 10^{-3} eV for the $N=2$ case) induces summation over all KK-states, which compensates for the Planck scale suppression. In addition to single graviton emission processes as missing energy events [11], the indirect effects of the massive graviton exchange on various collider experiments [12], and the possible Lorentz and CPT invariance violations through the change of the metric on the brane [13] have been extensively studied.

For the Higgs pair production through the gluon-gluon fusion, there exists a tree level Feynman diagram mediated by spin-2 KK-gravitons (see Fig. 3). Based on the effective four-dimensional Lagrangian [14,15], the obtained scattering amplitude squared for $gg \to hh$ is

$$\overline{|\mathcal{M}|^2} = 4 \left| \frac{m_h^4 - \hat{t}\,\hat{u}}{M_{\rm S}^4} \right|^2 . \tag{1}$$

Note that in the parton c.m. frame, this can be written as

$$\overline{|\mathcal{M}|^2}_{gg-{\rm c.m.}} = 4 \left| \frac{p_T^2\, \hat{s}}{M_{\rm S}^4} \right|^2 , \tag{2}$$

where p_T is the transverse momentum of an outgoing Higgs particle.

There might be a concern with our ignorance of the parton mode $q\bar{q} \to hh$ mediated by the KK-gravitons. The concern is grounded in the fact that the characteristic parton energy scale of the process in extra dimensional models, $\sqrt{\hat{s}}$, is $M_{\rm S}$ of TeV order, unlike a few hundred GeV scale in the SM and MSSM. Therefore, the dominant momentum fraction x may not be so small as in the SM and MSSM cases, and the parton distribution functions of, in particular, the valence quarks become substantial. In the following, we have included the parton mode $q\bar{q} \to hh$, which has the scattering amplitude squared

$$\overline{|\mathcal{M}|^2} = \frac{1}{9 M_{\rm S}^8} (t-u)^2 (t\,u - m_h^4) \,. \tag{3}$$

According to the following numerical analysis, however, the contribution of $q\bar{q} \to hh$ mode turns our to be at most a few percent to the total cross sections. The amplitude squared itself is smaller than that of $gg \to hh$ mode (by a factor of about 1/36) while the PDF of a valence quark and a sea quark is of the same order as that of two gluons.

The apparent violation of unitarity in Eq. (2) can be understood since the amplitude is obtained from the four-dimensional effective Lagrangian which is valid roughly below the cut-off scale $M_{\rm S}$. The issue of perturbativity, not that of unitarity, is more relevant for the calculations based on an effective low-energy theory [15]. We assume that a perturbative calculation is reliable when the expansion parameter of graviton loop corrections is less than about 1/3. Since the expansion parameter becomes one at $E_{\rm max}(> 7.2\, M_{\rm S})$ [15], the region of $E < 2.5 M_{\rm S}$ is to be trusted for a perturbative expansion.

The scale of $M_{\rm S}$ is one of the primary subjects of the theory. For the gauge hierarchy problem, $M_{\rm S}$ is no more than about 10 TeV. At the CERN LHC, however, $M_{\rm S}$ below 10 TeV questions the applicability of the effective theory approach, since the parton c.m. energy $\sqrt{\hat{s}}$ can, in principle, reach 14 TeV even if the parton luminosity at this high energy scale is highly suppressed. In Fig. 4, we show the total cross section of the Higgs pair production as a function of $M_{\rm S}$, obtained by two methods: the 'with cut' line denotes the cross section only over $\sqrt{\hat{s}} < 2.5 M_{\rm S}$ (*i.e.*, the amplitude is set to be zero when $\sqrt{\hat{s}} > 2.5 M_{\rm S}$); the 'no cut' line denotes $\sigma_{\rm tot}$ over all $\sqrt{\hat{s}}$. The Higgs mass is set to be 100 GeV. It can be seen that $\sigma_{\rm tot}$'s of the two methods start deviating from each other when $M_{\rm S} \lesssim 5$ TeV; the perturbative calculation based on the effective theory can be applicable and trustworthy only at $M_{\rm S} \gtrsim 5$ TeV. And as expected from the presence of a tree level diagram, the total cross section is highly enhanced, which is about $\sim$pb for $M_{\rm S} = 6$ TeV. Moreover, even the $M_{\rm S} \simeq 10$ TeV case yields non-negligible cross section compared to the SM case.

In Fig. 2, we present the total cross section as a function of m_h with $M_{\rm S} = 6$ TeV. It is of interest that $\sigma_{\rm tot}$ is not sensitive to m_h, contrary to the SM and MSSM cases. It is attributed to the scattering amplitude in Eq. (1); the characteristic energy scale of order $M_{\rm S}$ is much larger than the Higgs mass. The ADD model would give significant production of Higgs pairs at LHC when the Higgs mass is large enough.

D. In the RS model

More recently, Randall and Sundrum (RS) have proposed another scenario where, without the *large* volume of the extra dimensions, the hierarchy problem is solved by a geometrical exponential factor, called a warp factor [9]. The spacetime in this model has a single S^1/Z_2 orbifold extra dimension with the metric

$$ds^2 = e^{-2kr_c|\phi|}\eta_{\mu\nu}dx^\mu dx^\nu + r_c^2 d\phi^2, \tag{4}$$

where ϕ is confined to $0 \leq |\phi| \leq \pi$; r_c is the compactification radius which is to be stabilized by an appropriate mechanism [16]. Two orbifold fixed points accommodate two three-branes, the hidden brane at $\phi = 0$ and our visible brane at $|\phi| = \pi$. The allocation of our brane at $|\phi| = \pi$ renders a fundamental scale m_0 to appear as the four-dimensional physical mass $m = e^{-kr_c\pi}m_0$, which solves the hierarchy problem. And the effective Planck mass is

$$M_{\rm Pl}^2 = (M^3/k)(1 - e^{-2kr_c\pi}),$$

where M is the five-dimensional Planck scale. Note that all $M_{\rm Pl}$, k, and M are of the Planck scale.

The compactification of the fifth dimension leads to the following interaction Lagrangian [17] in the four-dimensional effective theory,

$$\mathcal{L} = -\frac{1}{M_{\rm Pl}}T^{\mu\nu}(x)h^{(0)}_{\mu\nu}(x) - \frac{1}{\Lambda_\pi}T^{\mu\nu}(x)\sum_{n=1}^{\infty}h^{(n)}_{\mu\nu}(x)\,, \tag{5}$$

where $\Lambda_\pi \equiv e^{-kr_c\pi}M_{\rm Pl}$. Unlike almost continuous KK-graviton spectrum in the ADD model, we have one zero mode of the KK-gravitons with the coupling suppressed by the Planck scale, and the massive KK-graviton modes with the electroweak scale coupling Λ_π. The masses of the KK-gravitons are also at electroweak scale, given by [18],

$$m_n = kx_n e^{-kr_c\pi} = \frac{k}{M_{\rm Pl}}\Lambda_\pi x_n\,, \tag{6}$$

where the x_n's are the n-th roots of the Bessel function of order one.

The scattering amplitude squared for $gg \to hh$, considering only the KK-mediated diagrams in the narrow width approximation, becomes

$$|\mathcal{M}|^2 = \sum_{n=1}^{\infty} \left| \frac{m_h^4 - \hat{t}\hat{u}}{4\Lambda_\pi^2(\hat{s} - m_n^2 + i m_n \Gamma_n)} \right|^2 = \sum \left| \frac{p_T^2 \hat{s}}{4\Lambda_\pi^2(\hat{s} - m_n^2 + i m_n \Gamma_n)} \right|^2 , \tag{7}$$

where the second equality holds only in the parton c.m. frame, and Γ_n is the decay width of the n-th KK-graviton, $\Gamma_n = \rho m_n x_n^2 (k/M_{\rm Pl})^2$. Here ρ, fixed to be one, is a model-dependent parameter which varies according to the decay pattern of KK-gravitons [17].

The observables based on the effective theory are determined by two parameters, $(\Lambda_\pi, k/M_{\rm Pl})$. The value of Λ_π is expected to be below 10 TeV, in order to explain the hierarchy problem. The value of $k/M_{\rm Pl}$ may be theoretically constrained to be less than about 0.1 [19]; the magnitude of the five-dimensional curvature, $R_5 = -20\,k^2$, is required to be smaller than M^2 ($\simeq M_{\rm Pl}^2$) so that the classical RS solution derived from the leading order term in the curvature is reliable. Recently, there have been various phenomenological studies of the RS model, focused on the KK-gravitons [17] as well as on the bulk gauge fields [19]. In particular, the current LEP II experiments (with $\sqrt{s} = 195$ GeV and $\int \mathcal{L} dt = 2.5$ fb^{-1}) and the Tevatron run I (with $\sqrt{s} = 2$ TeV and 110 pb^{-1}) provide a lower bound of Λ_π to be about 1.5 TeV in the case of $k/M_{\rm Pl} = 0.1$.

In Fig. 2, we plot with respect to the Higgs mass the total cross sections in the RS model. We set $\Lambda_\pi = 3$ TeV and $k/M_{\rm Pl} = 0.1$. Though smaller than $\sigma_{\rm tot}$ of the ADD case, $\sigma_{\rm tot}$ is larger than that of the SM, – for example, by an order of magnitude when $m_h = 100$ GeV. Moreover, $\sigma_{\rm tot}$ is almost independent of the Higgs mass, as in the ADD cases.

Figure 5 presents the total cross sections of the pair production of Higgs bosons in the RS model as a function of Λ_π, considering three values of the ratio $k/M_{\rm Pl} = 0.01$, 0.1 and 0.3. The Higgs mass is again 100 GeV. As Λ_π increases, $\sigma_{\rm tot}$ drops rapidly. And it can be seen that the smaller value of the ratio $k/M_{\rm Pl}$ produces higher cross sections, contrary to the RS contributions to $e^+e^- \to \mu^+\mu^-$ which increase with $k/M_{\rm Pl}$ [17]. This is due to the fact that the amplitude is, with a given Λ_π, inversely proportional to $(k/M_{\rm Pl})^4$ at each resonance which yields dominant contribution.

III. NUMERICAL DISCUSSIONS AND DISTRIBUTIONS

In the previous Section, we have shown the possibilities that the Higgs pair production can be greatly enhanced at the CERN LHC. In such a circumstance, it is worthwhile to search for appropriate distributions which are able to distinguish the contributions of one model from others. Moreover, in the extra dimensional models, the shapes of each distribution show little dependence on the low energy quantum gravity scale, since the string scale, $M_{\rm S}$ or Λ_π, is factored out in the scattering amplitude (see Eqs. (2) and (7)). In the numerical analysis of the distributions, we have employed the following parameters: The Higgs mass is set to be 100 GeV; in the MSSM, $\tan\beta = 30$, $\mu = -640$ GeV, $M_{\tilde{t}} = M_{\tilde{b}} = 1000$ GeV, and $A_t = A_b = -410$GeV; in the ADD model we set $M_{\rm S} = 6$ TeV; in the RS model, $\Lambda_\pi = 3$ TeV and $k/M_{\rm Pl} = 0.1$.

In Fig. 6, we present the p_T distributions for each model. The SM and MSSM contributions peak around 150 GeV and 25 GeV, respectively, and drop rapidly with increasing p_T, as we have employed the kinematic cuts of $p_T \geq 25$ GeV and $|\eta| \leq 2.5$. This is the usual unitary behavior at hadron colliders. The ADD case shows a broad peak around 6 TeV. This is anticipated since the scattering amplitude is increasing as p_T^4 and the gluon PDF is highly suppressed at high p_T. The RS contributions have successive resonances – the first peak and almost continuous spectrum which consists of broads peaks overlapped. It is known that the measurement of ultra-high p_T has no restriction, contrary to that of low p_T. Therefore, very hight p_T-cut, say 1 TeV, would eliminate all the SM and MSSM contributions, providing one of the most straightforward methods to signal the existence of low scale quantum gravity effects.

Figure 7 illustrates the invariant mass distributions of the Higgs pair. The SM case, where the top quark loop contributions are dominant, peaks around the threshold $\sqrt{\hat{s}} \simeq 2m_t$. The MSSM case with large $\tan\beta$ has dominant contributions from b quarks, showing peaks just above the kinematic threshold, $\sqrt{\hat{s}} \simeq 2m_h$. The high peak in the RS model implies the first KK-state of gravitons with $m_1 \simeq 750$ GeV. The ADD model receives dominant contributions around $M_{hh} \sim 10$ TeV.

Finally, we illustrate the rapidity distributions in Fig. 8. It can be seen that the extra dimensional models produce a Higgs pair somewhat more centrally in rapidity than the SM and MSSM. More restrictive cut on η, such as $\eta \leq 1.0$, would eliminate a substantial portion of the SM and MSSM contributions.

IV. CONCLUSIONS

The pair production of neutral Higgs bosons from the gluon-gluon fusion at LHC has been studied in the Standard Model (SM), the Minimal Supersymmetric Standard Model (MSSM), the large extra dimensional (ADD) model and the Randall-Sundrum (RS) model. We have shown that both the supersymmetric and extra-dimensional models can enhance the total cross section of the Higgs pair production by more than one order of magnitude. In the MSSM case, the large $\tan\beta$ value enables the b-quark contribution to dominate over the top quark contribution, and the resonant decay of a heavy Higgs particle into two light Higgs particle. The extra dimensional models allow a tree level Feynman diagram mediated by the Kaluza-Klein gravitons, which significantly increases the total cross sections. In addition, we have shown that the total cross sections in the ADD and RS models are almost independent of the Higgs mass, whereas those in the SM and MSSM decrease rapidly with increasing Higgs mass.

Under the circumstance that Higgs pairs are produced at a much higher rate than the SM, we have demonstrated the p_T, invariant mass and rapidity distributions for each case. The distribution shapes are shown to be different for each model, providing valuable criteria to distinguish between the models. In the extra-dimensional cases, moreover, the distribution shapes are almost independent of the string scale because the latter is factored out in the scattering amplitude of the process. Each model exhibits distinctive behavior in the distributions. In the p_T distribution, the ADD case shows a broad peak around $M_{\rm S}$, which is generated from the increasing amplitude as p_T^4, and from the decreasing gluon distribution function at high p_T. The RS contributions also have considerable distribution at high p_T. Since the SM and MSSM contributions drop rapidly with increasing p_T, hight p_T-cut around 1 TeV would eliminate almost all the SM and MSSM contributions. The invariant mass distributions are similar to the p_T distributions: the SM and MSSM have peaks around a few hundred GeV while the extra-dimensional models have dominant contributions at $M_{hh} \sim 10$ TeV. Finally, the rapidity distributions in the ADD and RS models show significantly narrower peaks around $\eta = 0$.

It is to be concluded that the Higgs pair production at LHC can be highly enhanced due to the MSSM or extra-dimension effects. Various distributions with restrictive kinematic cuts may provide one of the most straightforward methods to signal the existence of low scale quantum gravity effects.

ACKNOWLEDGMENTS

We thank G. Cvetic and P. Zerwas for careful reading of the manuscript and valuable comments. The work of C.S.K. was supported in part by Grant No. 2000-1-11100-003-1 and SRC Program of the KOSEF, and in part by the KRF Grants (Project No. 1997-011-D00015 and Project No. 2000-015-DP0077). The research of J.S. was supported by the BK21 Program.

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FIGURES

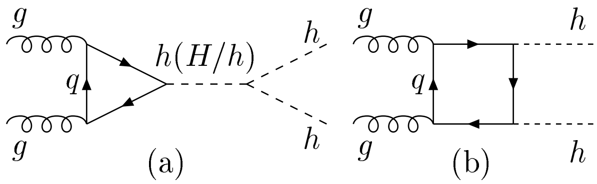

FIG. 1. The Feynman diagrams of the $gg \to hh$ process in the SM (MSSM).

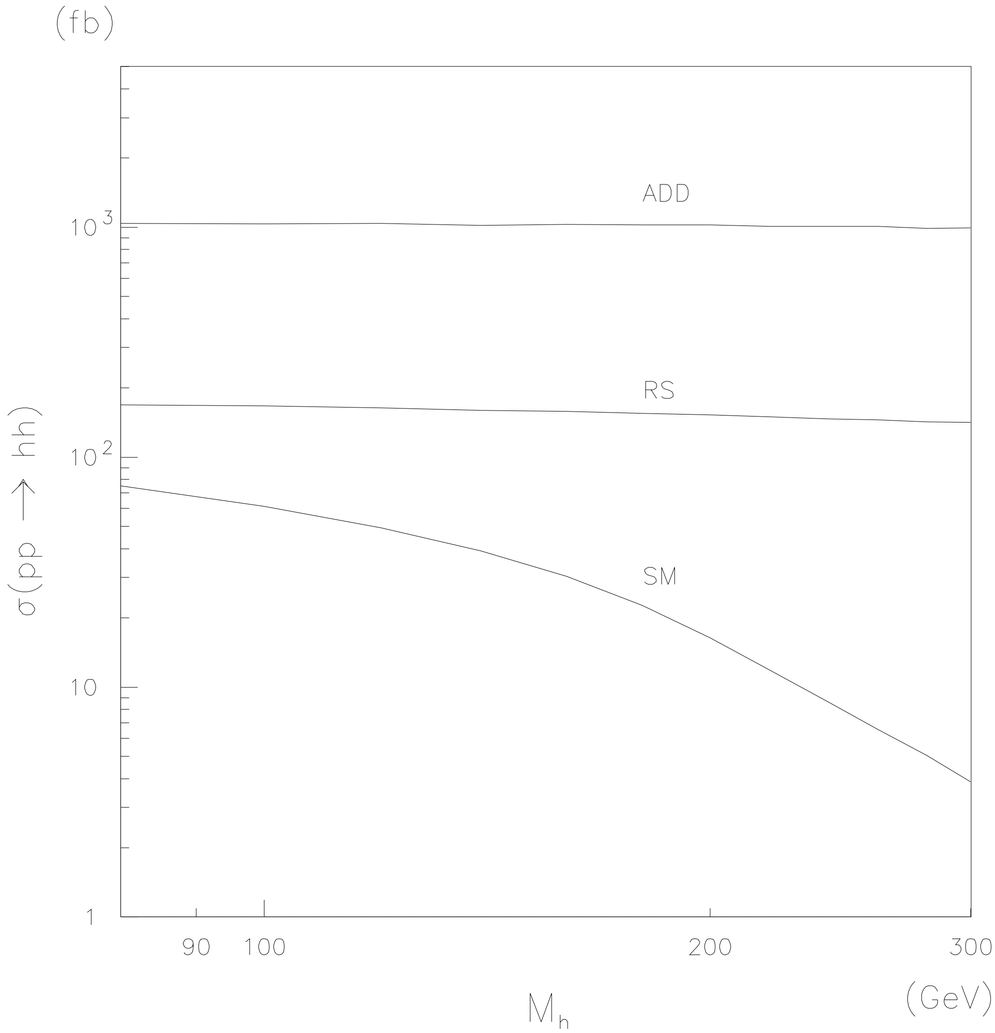

FIG. 2. As a function of the Higgs mass, the total cross section of the Higgs pair production at LHC with $\sqrt{s} = 14$ TeV in the SM, ADD and RS models.

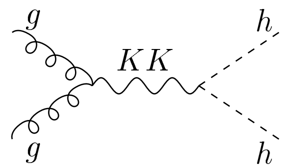

FIG. 3. The Feynman diagrams of the $gg \to hh$ in the ADD and RS models.

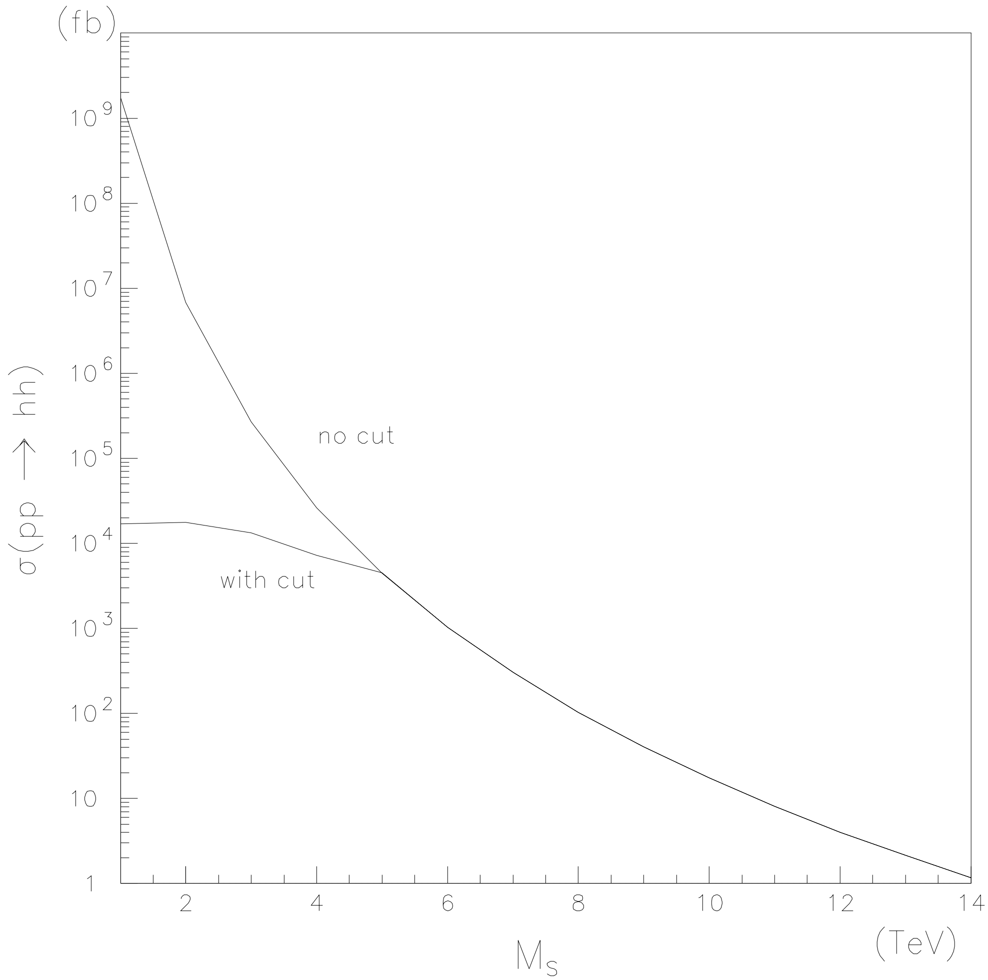

FIG. 4. The total cross section of $gg \to \mathrm{KK}-\text{gravitons} \to hh$ in the ADD model. One ('with cut' case) is obtained only for $\sqrt{\hat{s}} < 2.5\ M_\mathrm{S}$; the other is for all $\sqrt{\hat{s}}$. The M_S is 6 TeV, and Higgs mass m_h is set to be 100 GeV.

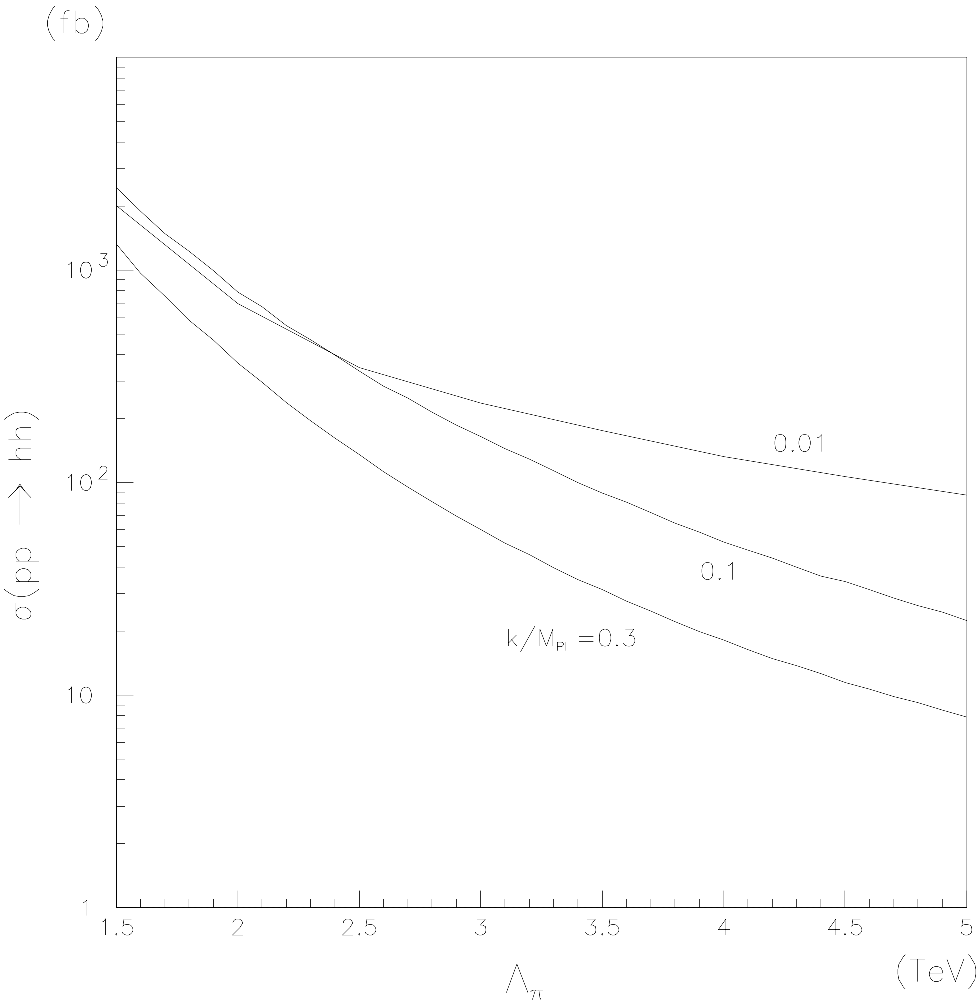

FIG. 5. The total cross sections of the Higgs pair production in the RS model as a function of Λ_π, considering three values of the ratio $k/M_{\rm Pl} = 0.01$, 0.1 and 0.3. The m_h is set to be 100 GeV.

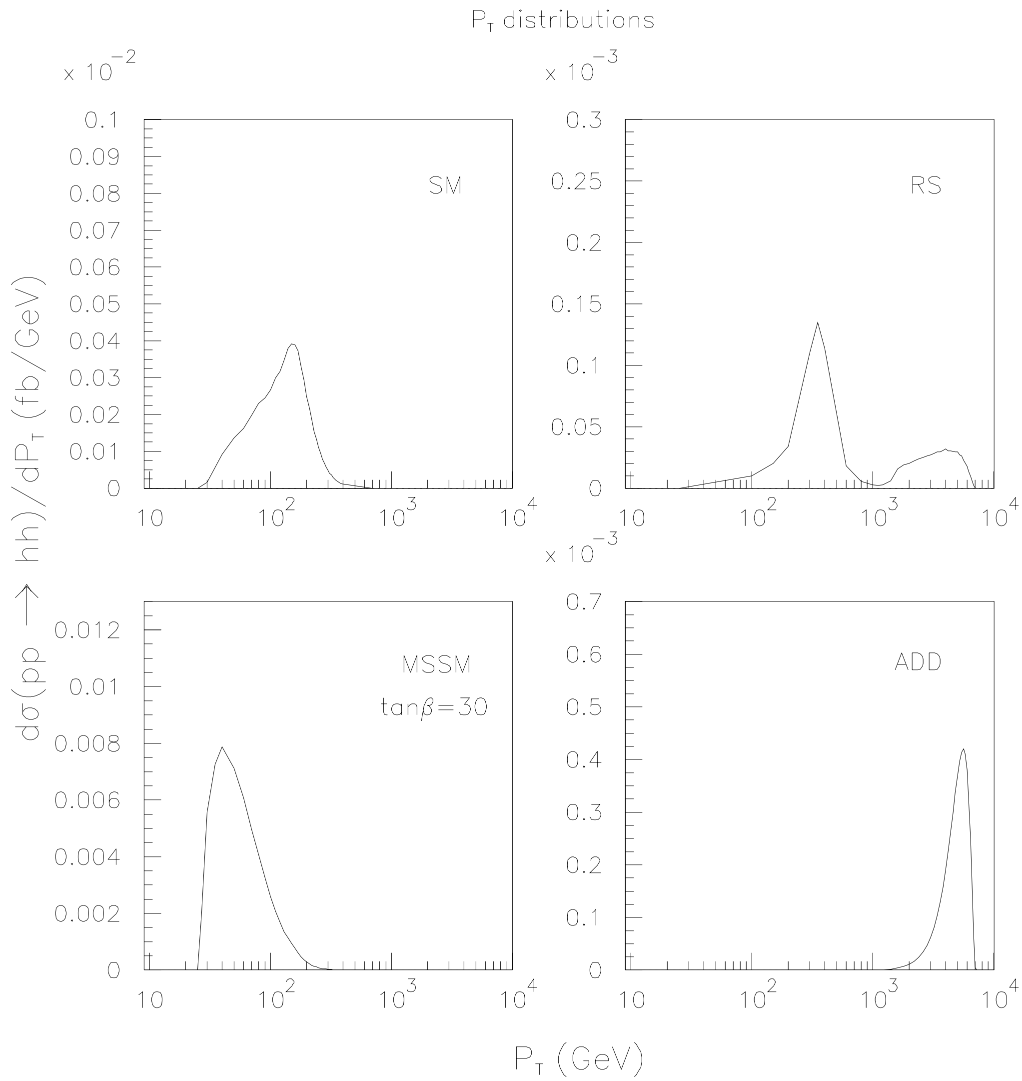

FIG. 6. The p_T distributions of the Higgs pair production in the SM, MSSM, RS and ADD models. The m_h is set to be 100 GeV.

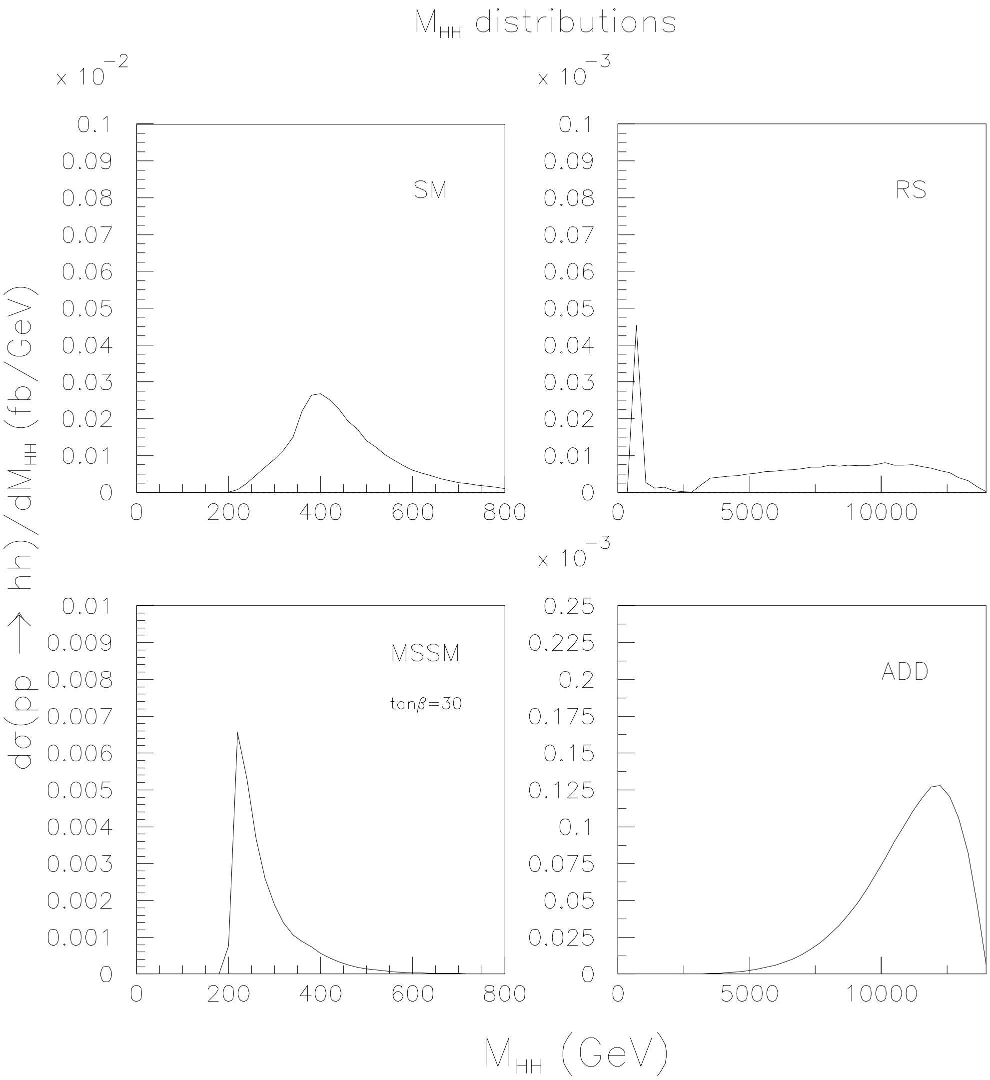

FIG. 7. The M_{hh} distributions of the Higgs pair production in the SM, MSSM, RS and ADD models. The m_h is set to be 100 GeV.

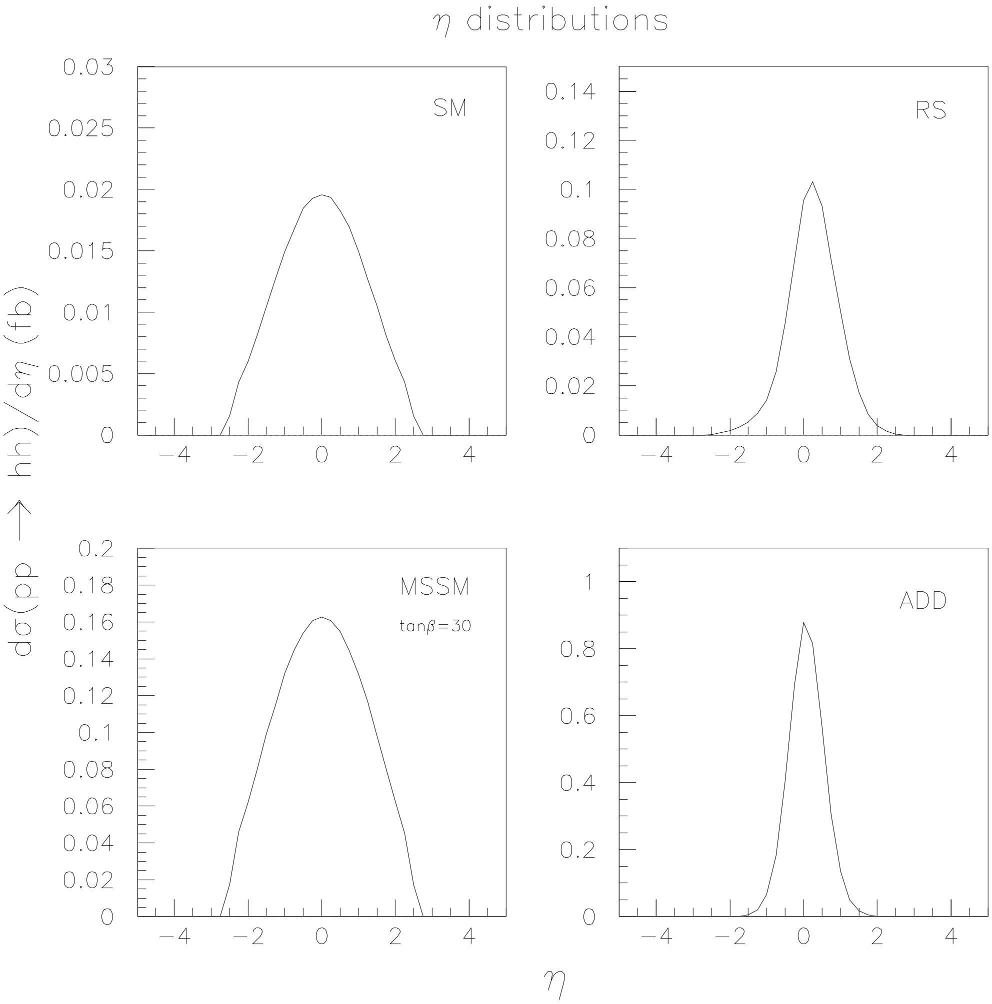

FIG. 8. The η distributions of the Higgs pair production in the SM, MSSM, RS and ADD models. The m_h is set to be 100 GeV.