Trilinear Self-Couplings of MSSM Higgs Bosons

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Abstract.
We present an analysis of multiple production of the CP-even (h^0, H^0) and CP-odd (A^0) Higgs bosons as well as of the trilinear self-couplings in the context of the Minimal Supersymmetric Standard Model (MSSM) at the Future International Linear e^+e^- Collider (ILC). The analysis is based in the reactions $e^+e^- \to bbh_ih_i$ with $h_i = h, H, A$. We evaluate the total cross section of bbh_ih_i and calculate the total number of events considering the complete set of Feynman diagrams at tree-level. The numerical computation is done for the energy which is expected to be available at the ILC with a center-of-mass energy varies in the range $500 \leq \sqrt{s} \leq 1600$ *GeV* and a luminosity 1000 fb^{-1}.

Keywords: Gauge and Higgs boson production in e+e- interactions, Total cross sections.
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INTRODUCTION

The Higgs boson plays an important role in the Standard Model (SM) ; it is responsible for generating the masses of all the elementary particles (leptons, quarks, and gauge bosons). However, the Higgs-boson sector is the least tested in the SM, in particular the Higgs boson self-interaction. If Higgs bosons are responsible for breaking the symmetry from $SU(2)_L \times U(1)_Y$ to $U(1)_{EM}$, it is natural to expected that other Higgs bosons are also involved in breaking other symmetries. One of the more attractive extensions of the SM is Supersymmetry (SUSY), mainly because of its capacity to solve the naturalness and hierarchy problems while maintaining the Higgs bosons elementary.

The search for Higgs bosons is one of the principal missions of present and future high-energy colliders. The observation of this particle is of major importance for the present understanding of fundamental particle interactions. Indeed, in order to accommodate the well established electromagnetic and weak interaction phenomena, the existence of at least one isodoblete scalar field to generate fermion and weak gauge bosons masses is required. The theoretical framework of this work is the Minimal Supersymmetric extension of the Standard Model (MSSM).

In this work we present an analysis of multiple production of the CP-even (h^0, H^0) and CP-odd (A^0) Higgs bosons as well as of the trilinear self-couplings of the MSSM at the International Linear e^+e^- Collider (ILC) [1].

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TABLE 1. Total production of Higgs bosons pairs in the MSSM for $\tan\beta = 35$, $\mathscr{L} = 1000\ fb^{-1}$ and $\kappa = 1.5$.

Total Production of Higgs Boson Pairs	$e^+e^- \to \bar{b}bhh(HH,AA)$		$\kappa = 1.5$
$M_A(GeV)$	$\sqrt{s} =$ 500 GeV	$\sqrt{s} =$ 1000 GeV	$\sqrt{s} =$ 1600 GeV
200	42 (-,-)	22 (7,7)	12 (7,7)
250	42 (-,-)	22 (7,7)	12 (7,7)
300	42 (-,-)	22 (7,7)	12 (7,7)
350	42 (-,-)	22 (7,7)	12 (7,7)
400	42 (-,-)	22 (7,7)	12 (7,7)

THE TRILINEAR SELF-COUPLINGS OF MSSM NEUTRAL HIGGS BOSONS AT THE ILC

To illustrate our results of the sensitivity to the hhh, Hhh, HHh, HHH, hAA, HAA trilinear modifies Higgs bosons self-coupling, we show the κ dependence of the total cross-section for $e^+e^- \to \bar{b}bhh(HH,AA)$ in Fig. 1. We consider one representative value of the Higgs boson mass, $M_A = 400\ GeV$, and $\tan\beta = 35$ with a center-of-mass energy of $\sqrt{s} = 500, 1000, 1600$ GeV and varying the trilinear couplings $\kappa hhh, \kappa Hhh, \kappa HHh, \kappa HHH, \kappa hAA, \kappa HAA$ within the range $\kappa = -1$ and $+2$. In all the case the cross-section is sensitive to the value of the trilinear coupling, and in the case of the process $e^+e^- \to bbhh$ and for large values of M_A (the decoupling limit) the corresponding MSSM trilinear coupling approaches the SM trilinear coupling [2]. As an indicator of the order of magnitude we present in Table 1 the Higgs bosons number of events (of course we have to multiplicate for the corresponding Branching Ratios to obtain the observable number of events) for several Higgs boson mass M_A, center-of-mass energy and κ values and for a luminosity of $1000\,fb^{-1}$.

CONCLUSIONS

The extended Higgs spectrum in supersymmetric theories gives rise to a plethora of trilinear couplings. The hhh coupling is generally quite different from the standard model. It can be measured in Higgs double production at future international linear e^+e^- collider (ILC). Even though the e^+e^- cross sections are below the hadronic cross sections, the strongly reduced number of background events renders the search for the Higgs-pair signal events, through $bbbb$ final states for instance, easier in the e^+e^- environment than in jetty LHC final states. For sufficiently high luminosities even the first phase of these colliders with an energy of 500 GeV will allow the experimental analysis of self-couplings for Higgs bosons in the intermediate mass range.

In summary, we have analyzed the trilinear Higgs bosons self-coupling at future e^+e^- colliders energies, with the reactions $e^+e^- \to \bar{b}bhh(HH,AA)$. This process is significant after consider the h decay, and have to be statistically sufficient for an accurate determination of κ.

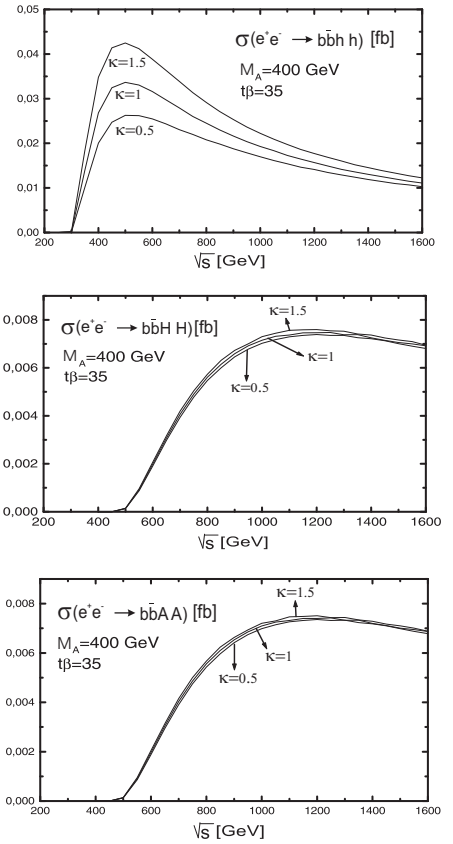

FIGURE 1. The dependence of the cross-section with the center-of-mass energy $\sqrt{s}$ for $M_A = 400\ GeV$ and $\tan\beta = 35$. The variation of the cross-section for modified trilinear couplings $\kappa\lambda_{hhh}$, $\kappa\lambda_{Hhh}$ $\kappa\lambda_{hAA}$, $\kappa\lambda_{HAA}$, $\kappa\lambda_{hHH}$ and $\kappa\lambda_{HHH}$ is indicated by $\kappa = 0.5, 1.5$.

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