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HIGGS BOSON PRODUCTION IN $\gamma\gamma$ COLLISIONS VIA RESOLVED PHOTON CONTRIBUTIONS*

STEPHEN GODFREY and SHOU-HUA ZHU†

Ottawa-Carleton Institute for Physics, Department of Physics, Carleton University, Ottawa, Canada K1S 5B6

M.A. DONCHESKI

Department of Physics, Pennsylvania State University Mont Alto, PA 17237 USA Group, Laboratory, Address

We studied single Higgs boson production in $\gamma\gamma$ collisions proceeding via the hadronic content of the photon. For SM Higgs masses of current theoretical interest, the resolved photon contributions are non-negligible in precision cross section measurements. We found that production of the heavier Higgs bosons H^0 and A^0 of the MSSM can probe regions of the SUSY parameter space that will complement other measurements. Finally, we showed that associated $tH^\pm$ production in $\gamma\gamma$ collisions can be used to make an accurate determination of $\tan\beta$ for low and high $\tan\beta$ by precision measurements of the $\gamma\gamma \to H^\pm t + X$ cross section.

Keywords: Higgs bosons, Resolved photons, SUSY.

1. Introduction

The photon-photon "Compton-collider", which utilizes laser light backscattered off of highly energetic and possibly polarized electron beams, has been advocated as a valuable part of the LC physics program [1]. We explored various aspects of Higgs boson production via the hadronic content of the photon[2,3] which we briefly describe. Details and complete references are given in Ref. 2 and 3.

In the resolved photon approach the quark and gluon content of the photon are treated as partons described by partonic distributions, $f_{q/\gamma}(x, Q^2)$, in direct analogy to partons inside hadrons [4]. The parton subprocess cross sections are convoluted with the parton distributions to obtain the final cross sections. These have to be further convoluted with the photon energy distributions obtained from either the backscattered laser or the Weizsäcker Williams distributions to obtain cross sections that can be compared to experiment.

*Supported in part by the Natural Sciences and Engineering Research Council of Canada
†Address after December 1 2004: Institute of Theoretical Physics, School of Physics, Peking University, Beijing 100871, P.R. China

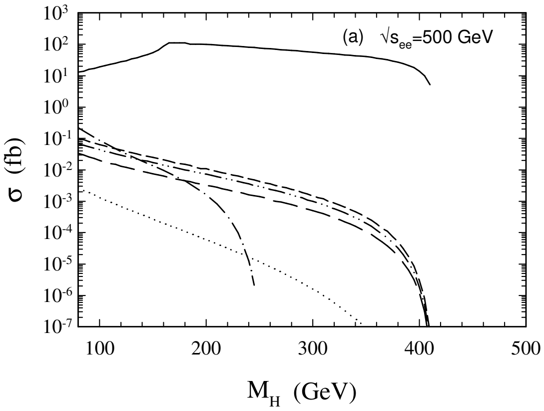

Fig. 1. Production cross sections for SM Higgs boson including the backscattered laser spectrum. The solid line is for $\gamma\gamma \to h$, the short dashed line for $\hat{\sigma}(b\bar{b} \to h) + \hat{\sigma}(c\bar{c} \to h)$, the dot-dot-dashed line for $\hat{\sigma}(c\bar{c} \to h)$, the long-dashed line for $\hat{\sigma}(b\bar{b} \to h)$, the dotted line for $\hat{\sigma}(gg \to h)$ and the dot-dashed line for $\hat{\sigma}(WW \to H)$.

2. Single Neutral Higgs Production

One of the strongest motivations for the Compton collider is to measure Higgs boson properties. Measurement of the $\gamma\gamma \to H$ cross section is especially interesting as it proceeds via loop contributions and is therefore sensitive to new particles that cannot be produced directly. It is important that all SM contributions to this cross section be carefully considered. The resolved photon contributions to Higgs production are shown in Fig. 1 for the backscattered laser case with $\sqrt{s_{ee}} =$ 500 GeV. We also show the $\sigma(\gamma\gamma \to H)$ production which proceeds via loops and the contribution from gluon fusion, $\hat{\sigma}(gg \to H)$, which arises from the gluon content of the photon. A final process is $\gamma\gamma \to HW^+W^-$ whose cross section is comparable to the resolved photon processes. Although the loop process dominates over the resolved photon processes for the full range of Higgs masses, the latter processes contribute at the percent level for $M_H \sim 150$ GeV and $\sqrt{s_{ee}} = 500$ GeV increasing to several percent for $\sqrt{s_{ee}} = 1.5$ TeV. Thus, Higgs production via the hadronic content of the photon may not be negligible for precision measurement of $\sigma(\gamma\gamma \to H)$ suggesting that these contributions deserve further study.

In the MSSM there exist a total of three neutral Higgs bosons which can be produced in $\gamma\gamma$ collisions; $\gamma\gamma \to h^0,\ H^0,\ A^0$. However, the resolved photon process has different dependence on $\tan\beta$ than that of the loop processes. If H and A were produced in sufficient quantity the cross section could be used to constrain $\tan\beta$. This can be seen most clearly in Fig. 2 which shows the regions of the $\tan\beta - M_A$ plot which can be explored via A production for $\sqrt{s}_{ee} = 500$ GeV. The regions covered would complement measurements made in other processes.

3. Measurement of $\tan\beta$ in associated $tH^\pm$ Production in $\gamma\gamma$ Collisions

The ratio of neutral Higgs field vacuum expectation values, $\tan\beta$, is a key parameter needed to be determined in type-II Two-Higgs Doublet Models and the MSSM. $\tan\beta$

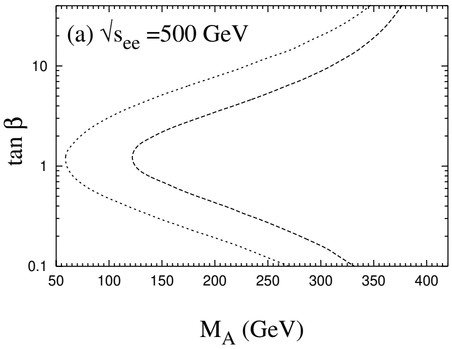

Fig. 2. Regions of sensitivity in $\tan\beta - M_A$ parameter space to A production via resolved photons with backscattered laser photons for $\sqrt{s_{ee}} = 500$ GeV. The region to the left is accessable and the region to the right is unaccessable. The dotted line gives $\sigma = 0.1$ fb contour so that at least 100 events would be produced in the region to the left for 1 ab^{-1} integrated luminosity. Similary the dashed line gives the $\sigma = 0.02$ fb contour designating the the boundary for producing at least 20 events.

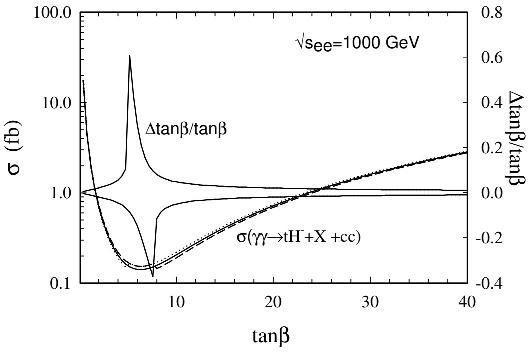

Fig. 3. $\sigma(\gamma\gamma \to tH^- + X)$ *vs.* $\tan\beta$ for the backscattered laser case and the sensitivities to $\tan\beta$ based only on statistical errors (solid lines) for $\sqrt{s_{ee}} = 1$ TeV and $M_H = 200$ GeV. For the cross sections, the solid line represents the expected cross section at the nominal value of $\tan\beta$, while the dashed (dotted) line represents the expected cross section at $\tan\beta - \Delta\tan\beta$ ($\tan\beta + \Delta\tan\beta$).

can be measured in associated $tH^\pm$ production in $\gamma\gamma$ collisions. The subprocess $b\gamma \to H^- t$ utilizes the b-quark content of the photon. $\tan\beta$ enters through the $tbH^\pm$ vertex. In Fig. 3 we show the cross section as a function of $\tan\beta$ with the measurement precision superimposed. We found that $\gamma\gamma \to tH^\pm + X$ can be used to make a good determination of $\tan\beta$ for most of the parameter space with the exception of the region around $\tan\beta \simeq 7$ where the cross section is at a point of inflection. This measurement provides an additional constraint on $\tan\beta$ which complements other processes. Subsequently Choi *et al* [5] studied the related process of $\tau\tau \to H$ where the τ's come from the fermionic content of the photon.

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