LHC WEDGE AT THE PLC: OBSERVABILITY OF $\gamma\gamma \to A, H \to b\bar{b}$ *

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(Received April 7, 2006)

Analysis of the heavy neutral MSSM Higgs bosons production at the Photon Collider is presented for $M_A = 200$, 250, 300 and 350 GeV in the parameter range corresponding to the so called "LHC wedge" and beyond. The expected precision of the cross section measurement for the process $\gamma\gamma \to A, H \to b\bar{b}$ is evaluated for different MSSM scenarios. The analysis takes into account all relevant theoretical and experimental issues which could affect the measurement. For $\tan\beta = 7$ the statistical precision of the cross-section determination is estimated to be 8–34%, after one year of Photon Collider running, for four considered MSSM parameters sets. As heavy neutral Higgs bosons in these scenarios may not be discovered at LHC or at the first stage of the e^+e^- collider, an opportunity of being a discovery machine is also studied for the Photon Collider.

PACS numbers: 14.80.Cp, 13.87.Ce

A photon-collider option of the future e^+e^- linear collider offers unique possibility to produce neutral Higgs bosons as s-channel resonances. In case of MSSM production of h, A and H can be considered. For h the statistical precision of the cross section measurement of about 2% is expected, similar to the SM case [1]. Here we estimate the precision of the corresponding measurement for the heavy MSSM Higgs bosons, focusing our analysis on the so-called "LHC wedge", *i.e.* the region of intermediate values of $\tan\beta$, $\tan\beta \approx 4$–10, and masses $M_{A,H}$ above 200 GeV, where heavy bosons A and H may not be discovered at the LHC and at the first stage of the e^+e^- linear collider.

* Presented by P. Nieżurawski at the PLC2005 Workshop, 5–8 September 2005, Kazimierz, Poland.

We consider MSSM scenarios described by parameter sets similar to those used in [2], *i.e.* $\tan\beta = 7$, $\mu = \pm 200\,\mathrm{GeV}$ and $M_2 = 200\,\mathrm{GeV}$; these two parameter sets we denote as I and III. The intermediate scenario II with $\mu = -150\,\mathrm{GeV}$ was also proposed. The scenario IV used in [3] is also included, for comparison with predictions presented by LHC experiments. Total widths and branching ratios of the Higgs bosons and the H mass were calculated with the program Hdecay [4], taking into account decays to and loops of supersymmetric particles. These parameters were used during generation of events with the Pythia program [5].

This analysis is based on the realistic simulations of the $\gamma\gamma$-luminosity spectra for the PLC at TESLA [6, 7]. One-year run of PLC is assumed with the center-of-mass energy of colliding electron beams optimized for the production of a Higgs bosons with the given mass. The distribution of the primary vertex and the beams crossing angle are taken into account.

As the main background to the Higgs-bosons production the heavy-quark pair production was considered; the event samples were generated using the program based on the NLO QCD results [8]. Other background processes, which were neglected in the earlier analyses, were also studied: $\gamma\gamma \to W^+W^-$, $\gamma\gamma \to \tau^+\tau^-$, and light-quark pair production $\gamma\gamma \to q\bar{q}$.

Due to the large cross section and huge $\gamma\gamma$-luminosity at low invariant mass of colliding photons, $W_{\gamma\gamma}$, about two $\gamma\gamma \to$ *hadrons* events (so-called overlaying events) are expected per bunch crossing. To evaluate their impact on the reconstruction of other events produced in the same bunch crossing, we generated $\gamma\gamma \to$ *hadrons* events with Pythia, and overlaid them on signal and background events according to the Poisson distribution.

The detector performance was simulated by the program Simdet [9]. Jets were reconstructed using the Durham algorithm. The low-angle tracks and clusters were not taken into account to minimize the influence of $\gamma\gamma \to$ *hadrons* overlaying events. Two or three jet events were accepted. To reduce heavy-quark production background the lower cut on the polar angle for each jet and the upper cut on the total longitudinal momentum of the event were imposed. Additional cuts to suppress $\gamma\gamma \to W^+W^-$ background were also applied. Realistic b-tagging algorithm was used. The criteria of event selection were optimized separately for each considered Higgs-boson mass. More detailed description of event generation, simulation and selection cuts can be found in [1, 10].

The result of the analysis for $M_A = 300\,\mathrm{GeV}$ is shown in Fig. 1. The distribution of the corrected invariant mass, W_{corr} (see [11]), after imposing all selection cuts is presented for signal and all background contributions. From the number of signal and background events in the optimized W_{corr} window the expected statistical precision of the cross-section measurement is 11%.

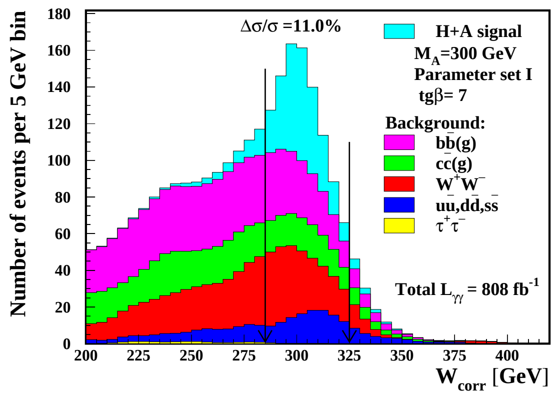

Fig. 1. Distributions of the corrected invariant mass, $W_{\rm corr}$, for the signal and all considered background contributions, with overlaying events included. The best precision of 11% for $\gamma\gamma \to A, H \to b\bar{b}$ cross section measurement is achieved in the $W_{\rm corr}$ window between 285 and 325 GeV.

We estimated statistical precision for $\gamma\gamma \to A, H \to b\bar{b}$ cross section measurement for all considered parameter sets. The results obtained for $\tan\beta = 7$ are compared in Fig. 2. The most precise measurement is expected for parameter sets II and III — precision is about 10% and hardly depends on M_A. The worst measurement is expected for scenario IV, *i.e.* the one considered by the CMS collaboration [3]. For all considered values of M_A the dependence of the measurement precision on $\tan\beta$ was studied; the results for $M_A = 200$ and 350 GeV are shown in Fig. 3. The precision

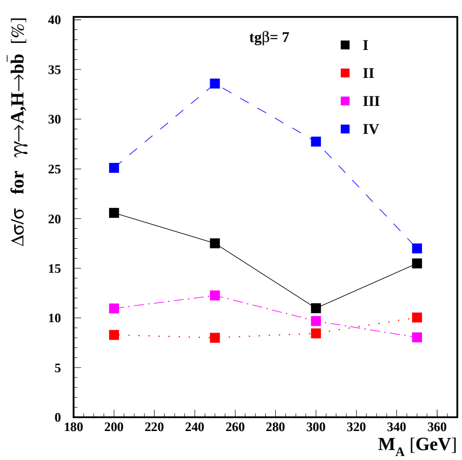

Fig. 2. The precision of $\sigma(\gamma\gamma \to A, H \to b\bar{b})$ measurement is shown for MSSM parameter sets I–IV, for $M_A = 200$–350 GeV and $\tan\beta = 7$. The lines are drawn to guide the eye.

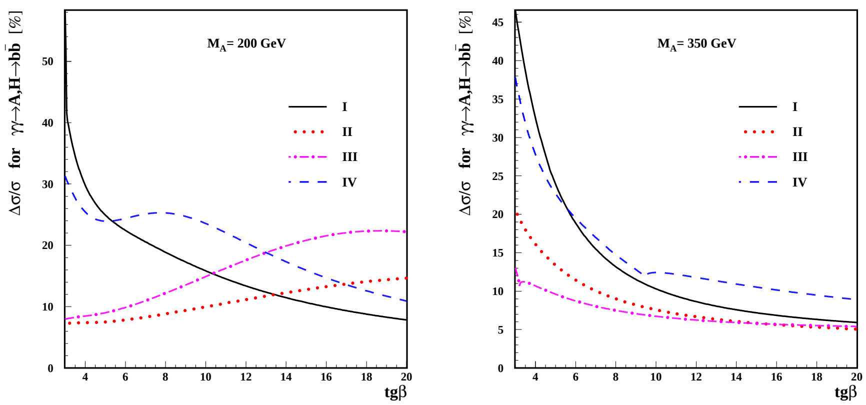

Fig. 3. The precision of $\sigma(\gamma\gamma \to A, H \to b\bar{b})$ measurement is shown for $M_A = 200$, 350 GeV, for MSSM parameter sets *I-IV* with $\tan\beta = 3$–20.

weakly depends on $\tan\beta$ if parameter sets II or III are considered. We also observe that for greater M_A values better precision of the cross section determination can be achieved. In case of parameter sets I or IV the precise measurement will not be possible for low $\tan\beta$ values, $\tan\beta \lesssim 5$.

After discovery or a "hint" of the resonant-like excess of events at LHC or ILC, the PLC can be used to confirm the observation. Thus, we studied the significance of signal measurement for $\tan\beta = 3$–20. The results are shown in Fig. 4. For all parameter sets the expected statistics of signal events for $M_A = 200$–350 GeV will be sufficient to cover most of the consid-

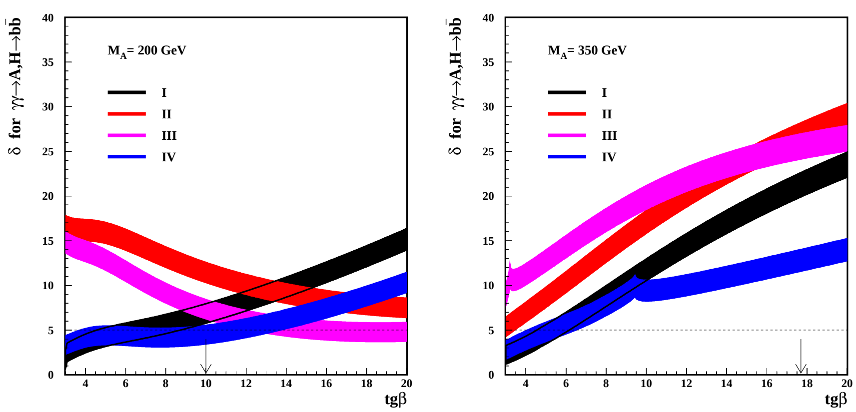

Fig. 4. The statistical significance of $\sigma(\gamma\gamma \to A, H \to b\bar{b})$ measurement is shown for $M_A = 200$, 350 GeV, for MSSM parameter sets *I–IV* with $\tan\beta = 3$–20. The band widths indicate the level of possible statistical fluctuations of the actual measurement. The estimated lower limit of the discovery region of LHC experiment (as presented by CMS collaboration [3]) is indicated by arrows.

ered MSSM parameters space. We can conclude that for $M_A \gtrsim 300\,\mathrm{GeV}$ the PLC should be able to discover Higgs bosons for much lower values of $\tan\beta$ than experiments at the LHC.

We would like to thank our colleagues from the ECFA/DESY working groups for valuable discussions. This work was partially supported by the Polish State Committee for Scientific Research (KBN), grant no. 1 P03B 040 26 and project no. 115/E-343/SPB/DESY/P-03/DWM517/2003 -2005. P.N. acknowledges partial support by the Polish State Committee for Scientific Research (KBN), grant no. 2 P03B 128 25.

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