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ECFA-summary

Higgs, gamma-gamma, and e-gamma physics

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Abstract. Recent results obtained within ECFA/DESY and ECFA Study by the Higgs and $\gamma\gamma/e\gamma$ physics working groups are presented.

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1 Introduction

The recents results obtained within ECFA/DESY and ECFA Study for a Linear Collider (LC) for Higgs search in e^+e^- mode and in $\gamma\gamma/e\gamma$ option (Photon Linear Collider - PLC) are presented. For the $e\gamma$ option results for testing anomalous gauge couplings are also shown. The extensive summary of the studies of Higgs physics in e^+e^- collisions and on physics at PLC can be found in [1] and [2], respectively.

2 Higgs studies for an e^+e^- linear collider

The Linear Collider is considered as a tool for precision Higgs measurements, as it was shown in TESLA TDR [3]. The further study was concentrated on more realistic simulations of essential processes, and studying of new theoretical ideas and LHC-LC synergy.

Higgs quantum numbers. New ideas how to test the spin and CP-parity of Higgs bosons were presented recently. One bases on Higgs boson decay into ZZ [4] (results for PLC based on this idea are shown below). The other method uses the decay $H \to \tau\bar{\tau}$, with further decay of tau's into ρ, where the correlation of the decay products of τ's allows to establish the CP-parity of a Higgs boson. The study of the process $e^+e^- \to HZ \to \tau\bar{\tau}X$ for CM energy equal to 350 GeV and luminosity 1 ab^{-1} [5] shows that one can discriminate the scalar SM-Higgs with mass 120 GeV from the pseudoscalar one (with the same production rate as for H) at the 8 σ level, see Fig. 1 (Left).

Top Yukawa coupling. New analyses [6] of the measurement of the Yukawa coupling of the SM Higgs particle h to top quarks is extended to higher masses, up to 200 GeV, with inclusion of the $h \to WW$, and with full 6-fermion background (BG). The results for expected relative precision for g_{tth} are presented in Fig. 1 (Right), for the energy of collision of 800 GeV, luminosity of 1 ab^{-1} and various final states (for two different background normalizations). Combining channels the precision can reach 6 to 14 %.

Supersymmetric Higgs bosons. The study of heavy Higgs bosons H and A has been performed for a particular MSSM scenario [7], in which the lighest Higgs boson h couples to gauge bosons with a full strength ($\sin(\beta-\alpha)=1$). Then H, with couplings to gauge bosons proportional to $\cos(\beta-\alpha)$, is produced in e^+e^- collision predominanty in pair with A, with cross section $\propto \sin^2(\beta-\alpha)$. The decays of H and A are mainly to fermions b and τ's, and both H and A are nearly degenerate in masses. The reconstructed difference and sum of masses, for the $b\bar{b}$ final state, with $Br(H,A \to b\bar{b})$ =0.9, presented in Fig. 2 for 500 Gev e^+e^- collider energy with luminosity of 500 fb^{-1} correspond to a precision 0.2 to 2.8 GeV.

3 Higgs resonance at photon linear collider

A resonant production of Higgs boson(s), a unique feature of PLC, was studied in detail for the Standard Model (SM), MSSM and Two Higgs Doublet Model (2HDM).

***$b\bar{b}$* final state.** The realistic simulations of the production of the SM Higgs boson with mass between 120 to 160 GeV decaying into $b\bar{b}$ were performed [8,9], including effect of overlaying events (OE) [8]. The accuracy of extraction of the $\Gamma_{\gamma\gamma}Br(H \to b\bar{b})$ is between 2 to 7 % (with OE) (Fig. 3). The realistic analysis [11] of production of heavy Higgs bosons H and A in MSSM, with parameters [10] corresponding to a case where only one SM-like Higgs particle h can be seen at LHC ("LHC wedge"), shows the large potential of PLC in search of H/A (Fig. 4 (Left and Middle)).

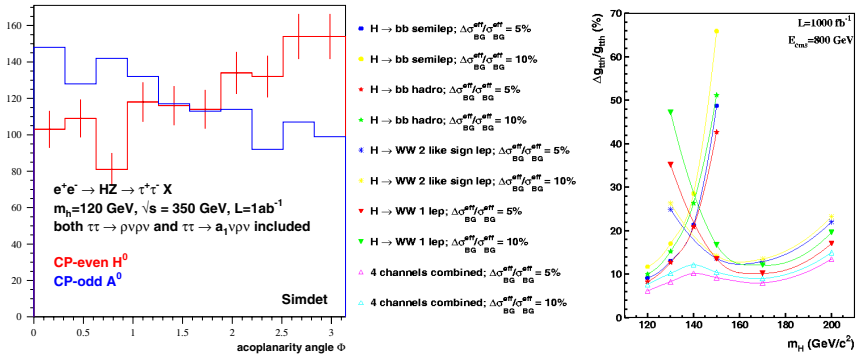

Fig. 1. *Left:* Distinguishing scalar from pseudoscalar using tau's; *Right:* Relative precision for g_{ttH} from various channels

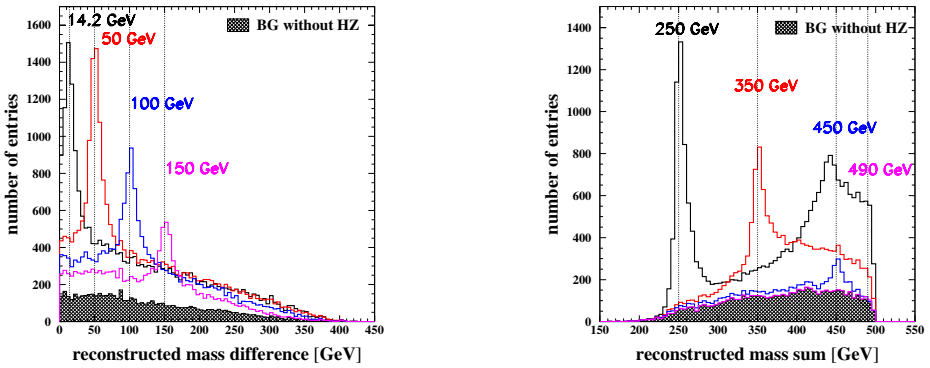

Fig. 2. Results for the reconstructed difference and sum of mass of Higgs bosons in MSSM, for the $b\bar{b}$ final state

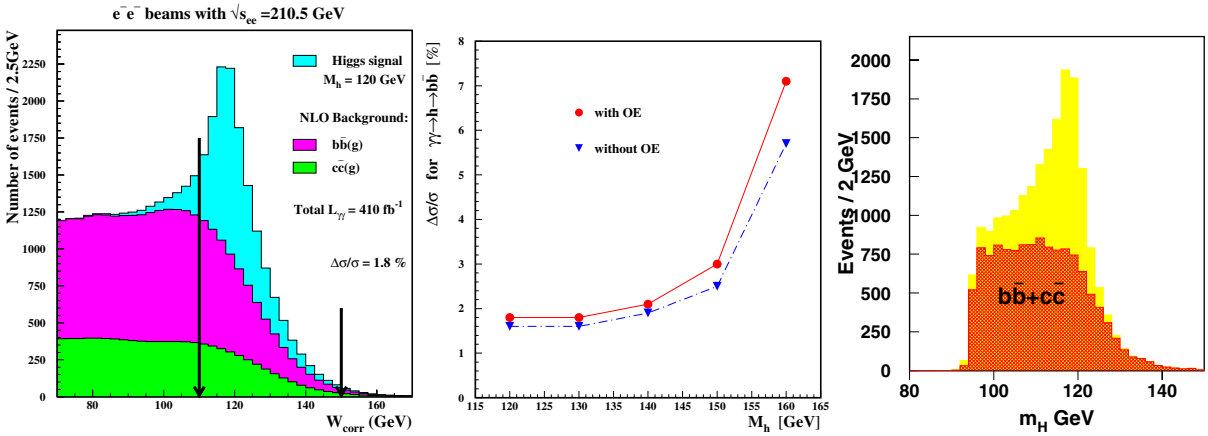

Fig. 3. Results for production of the SM Higgs with mass 120 GeV in $\gamma\gamma \to h \to b\bar{b}$ (*Left:* from [8], *Right:* from [9]); *Middle:* A precision of measurement of the cross section as a function of mass with and without OE included in analysis [8]

WW and ZZ final states. A detailed study of the Higgs boson ϕ, with or without defined CP-parity, in processes $\gamma\gamma \to \phi \to WW/ZZ$ is presented in [12]. It was found that interference with background allows to measure besides the decay width $\Gamma_{\gamma\gamma}$ also the phase of the amplitude $\phi_{\gamma\gamma}$. This enlarges a discrimination power for various SM-like extensions (Fig. 4 (Right)), it is also useful to combine WW and ZZ channels. Parameters of CP-violation effects can be measured precisely: mixing angle ϕ_{HA} in 2HDM and couplings $\lambda_{A,H}$ for a generic case, shown in Fig. 5.

4 Anomalous gauge coupling in $e\gamma$ collision

A study of measuring trilinear gauge couplings, κ_γ λ_γ, from the hadronic decay of W at an $e\gamma$ - collider at energy 450 GeV was performed in [13]. Expected errors are $\sim 10^{-3}$ for κ_γ and 10^{-4} for λ_γ if fit includes the azimuthal angle ϕ of final fermion (Fig. 6 (Left)). The contour plot for the deviation from SM for both couplings is given in Fig. 6 (Right). It was found, that the uncertainty due to the variable photon beam polarizations is large for κ_γ, while negligible for λ_γ.

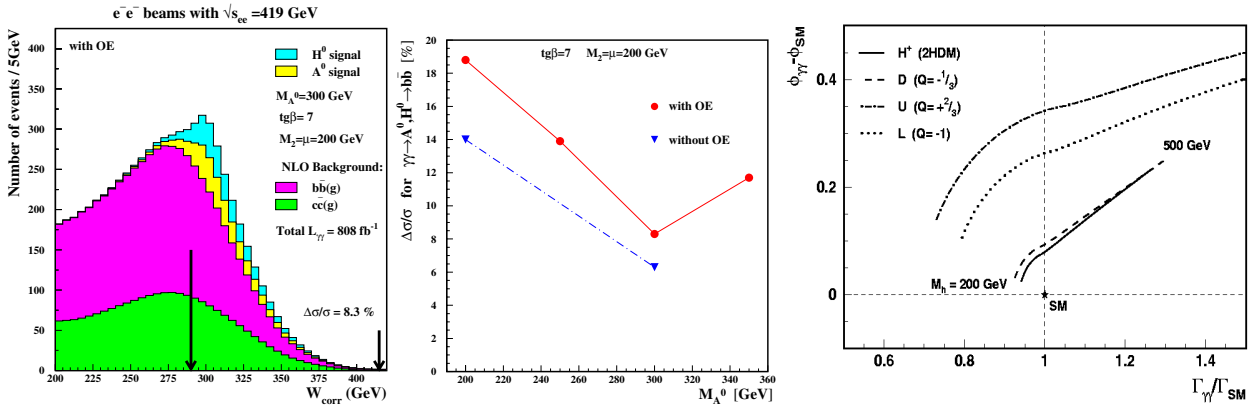

Fig. 4. Results for $\gamma\gamma \to H, A \to b\bar{b}$ in MSSM for "LHC wedge" (*Left and Middle*); *Right:* $\phi_{\gamma\gamma}$ and $\Gamma_{\gamma\gamma}$ in SM-like models

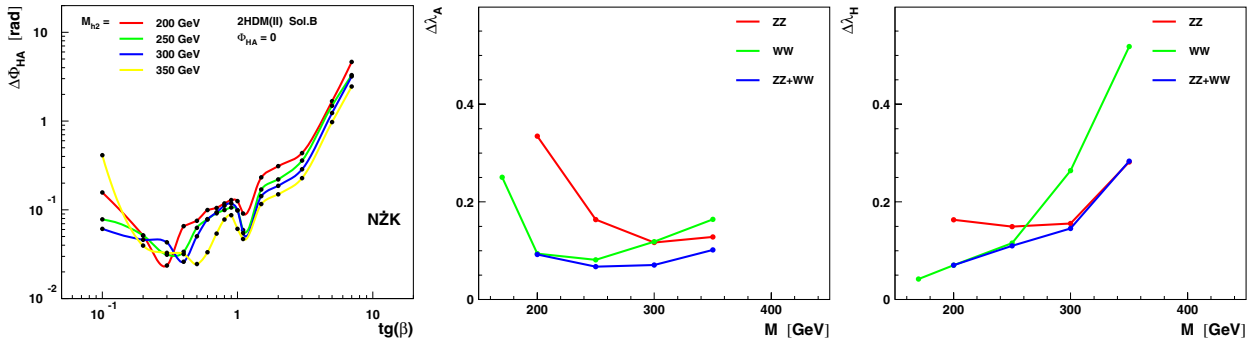

Fig. 5. *Left:* The precision of the determination of mixing angle between H and A in 2HDM with small CP-violation; *Middle and Right:* the precision of extraction of CP-even (λ_H) and CP-odd (λ_A) couplings to gauge bosons for a generic CP-violation

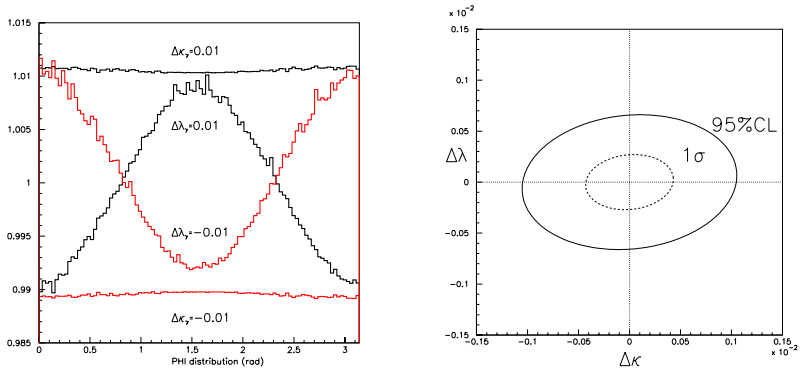

Fig. 6. Results for $\Delta\lambda_\gamma$ and $\Delta\kappa_\gamma$. *Left:* Deviation in ϕ distribution; *Right:* 95% CL (—) and 1σ (- - -) contour plots

5 Outlook

A new ECFA Study continues precision theoretical and experimental studies of the potential of the LC for Higgs search and effects of new physics for e^+e^- and $\gamma\gamma$ and $e\gamma$ options.

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