ECFA-Summary

Higgs, gamma-gamma and e-gamma physics

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Received: date / Revised version: date

Abstract. Recent results obtained within ECFA/DESY and ECFA Study by the Higgs and γγ/eγ physics working groups are presented.

PACS. 14.80.Bn – 14.80.Cp

1 Introduction

The recent results obtained within ECFA/DESY and ECFA Study for a Linear Collider (LC) for Higgs search in e⁺e⁻ mode and in γγ/eγ option (Photon Linear Collider - PLC) are presented. 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 $H \to \tau\tau$, with further decay of tau’s into $\rho$, where the correlation of the decay products of $\tau$'s allows to establish the CP-parity of a Higgs boson. The study of the process $e^+e^- \to HZ \to \tau\tau X$ 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 $\sigma$ level, see Fig. 1 (Left).

Top Yukawa coupling New analysis [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 lightest 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 predominantly in pair with $A$, with cross section $\propto \sin^2(\beta - \alpha)$. The decays of $H$ and $A$ are mainly to fermions $b$ and $\tau$'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 energy of $e^+e^-$ collider of 500 GeV 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 bosons(s), a unique feature of PLC, was studied in detail for Standard Model (SM), MSSM and Two Higgs Doublet Model (2HDM).

$b\bar{b}$ final state The realistic simulations of the production of SM Higgs boson with mass between 120 to 160 GeV decaying into $b\bar{b}$ were performed [8], including effect of overlaying events (OE) [9]. 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 [10] of production of heavy Higgs bosons $H$ and $A$ in MSSM, with parameters [11] corresponding to a case where only one SM-like Higgs particle $h$ can be seen at LHC (“LHC wedge”), shows large potential of PLC in search of $H/A$ (Fig. 4 (Left and Middle)).
sides the decay width that interference with background allows to measure be-

Results for production of the SM Higgs with mass 120 GeV in Fig. 3.

A precision of measurement of the cross section as a function of mass with and without OE included in analysis [8].

φ

φ

A detailed study of Higgs boson \( \phi \) 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 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 \( \phi_{HA} \) in 2HDM and couplings \( \lambda_{A,H} \) for a generic case, shown in Fig. 5.

**WW and ZZ final states** A detailed study of Higgs boson \( \phi \), 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 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 \( \phi_{HA} \) 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, \( \kappa, \lambda_{\gamma} \), from the hadronic decay of W at an \( e\gamma \) - collider at energy 450 GeV was performed in [13]. An expected error are \( \sim 10^{-3} \) for \( \kappa \), and \( 10^{-4} \) for \( \lambda_{\gamma} \) if fit includes the azimuthal angle \( \phi \) 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 \( \kappa_{\gamma} \), while negligible for \( \lambda_{\gamma} \).
5 Outlook

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

Acknowledgment: I am grateful to K. Desch, P. Nie\-\[urawski, F. A. \[zarnecki, K. Moenig and J. Sekaric for valuable contributions to this summary.

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