0.1 Production of heavy Higgs bosons in weak boson fusion

The possibility to enhance cross sections by using beam polarization can be very important for detecting processes with a very low rate. In Ref. [1] the production of the heavy neutral $\mathcal{CP}$-even Higgs boson H of the MSSM was studied. Since for large values of the $\mathcal{CP}$-odd Higgs boson mass M_A the heavy Higgs bosons A and H are approximately mass degenerate, $M_A \approx M_H$, the pair production channel $e^+e^- \to HA$ is limited by kinematics to the region $M_H < \sqrt{s}/2$. The kinematic limit of the LC can in principle be extended by single Higgs production in the process $e^+e^- \to \nu\bar{\nu}H$. However, due to the decoupling properties of the heavy Higgs bosons for $M_A \gg M_Z$ the VVH coupling ($V = W^\pm, Z$) is very small, so that the process $e^+e^- \to \nu\bar{\nu}H$ has only a very low rate.

In Ref. [1] it was shown that higher-order contributions to this Higgs-boson production process can remedy this situation, making the process potentially accessible at the LC. This requires a high integrated luminosity and polarized beams. The cross section becomes enhanced for left-handedly polarized electrons and right-handedly polarized positrons. While an 80% polarization of the electron beam alone results in a cross section that is enhanced by a factor 1.8, the polarization of both beams, i.e. 80% polarization for electrons and 60% polarization for positrons, would yield roughly an enhancement by a factor of 2.9. With an anticipated integrated luminosity of the LC running at its highest energy of $\mathcal{O}(2\mathrm{ab}^{-1})$ the enhancement in the cross section due to the beam polarization can extend the kinematic reach of the LC by roughly 100 GeV compared to the case of unpolarized beams.

0.2 Precision tests of the electroweak theory

The precise measurement of the effective leptonic weak mixing angle at the Z-boson resonance, $\sin^2\theta_{\mathrm{eff}}$, at GigaZ will allow a very sensitive test of the electroweak theory [2]. With both beams polarized, i.e. 80% polarization for electrons and 60% polarization for positrons, an accuracy of $\Delta\sin^2\theta_{\mathrm{eff}} = \pm 1.3 \times 10^{-5}$ can be achieved [3]. If only electron polarization were available, this would result in an accuracy of only about $\Delta\sin^2\theta_{\mathrm{eff}} = \pm 9.5 \times 10^{-5}$ [4].

The impact of the more precise measurement for testing the electroweak theory is indicated in Fig. 0.1, where the experimental accuracy (using the current experimental central value of $\sin^2\theta_{\mathrm{eff}}$ [6]) is compared with the predictions in the SM and the MSSM. The theoretical predictions are shown as a function of M_h, which corresponds to the Higgs-boson mass in the SM and the mass of the lightest $\mathcal{CP}$-even Higgs boson in the MSSM. In the region where both models overlap, $M_h \lesssim 135$ GeV [7], the SM prediction corresponds to the MSSM result in the limit where all SUSY partners are

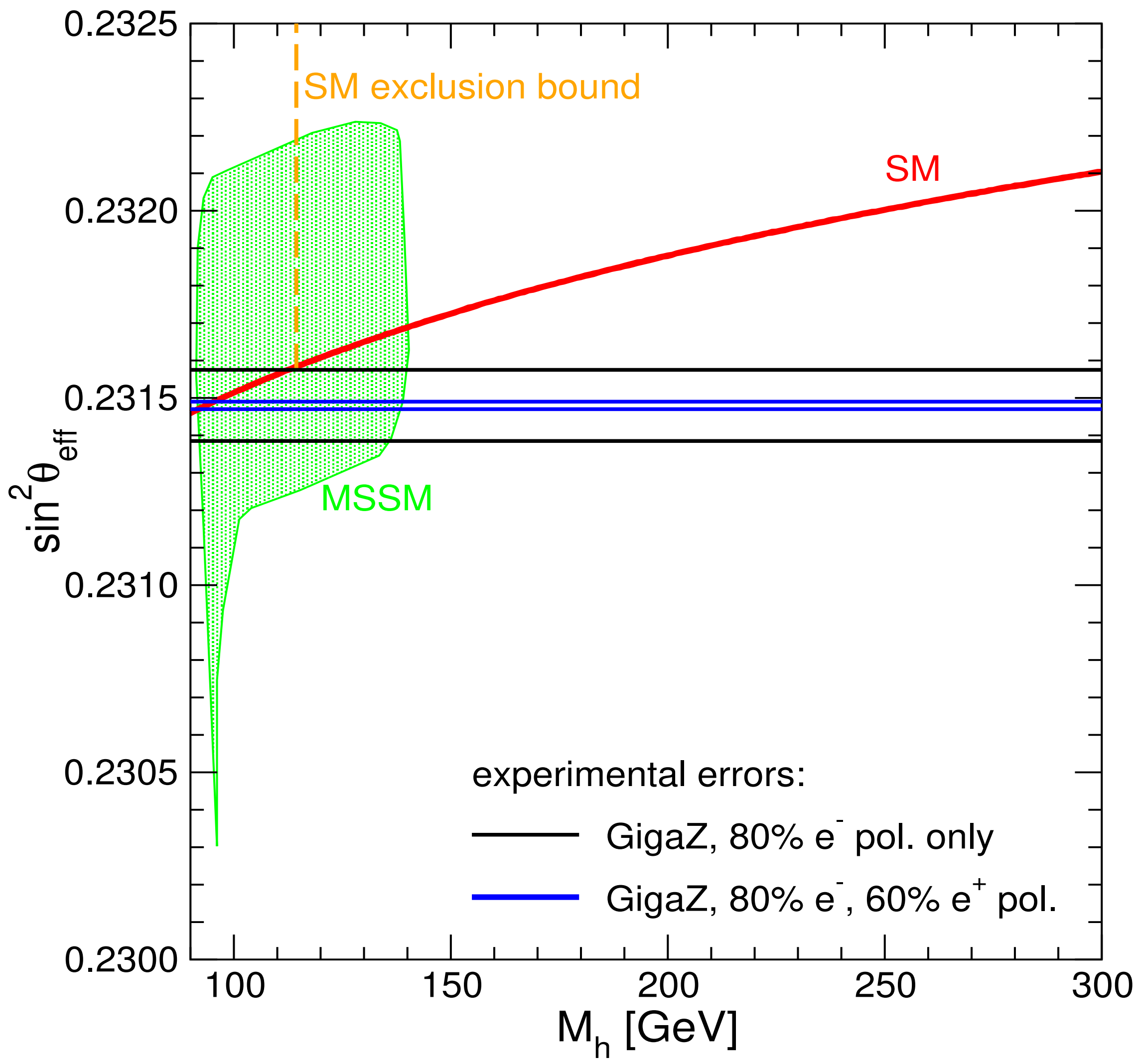

Figure 0.1: The predictions for $\sin^2\theta_{\mathrm{eff}}$ in the SM and the MSSM as a function of M_h, which corresponds to the Higgs-boson mass in the SM and the mass of the lightest $\mathcal{CP}$-even Higgs boson in the MSSM. The exclusion bound on the SM Higgs mass of $M_h > 114.4$ GeV [5] is indicated in the plot. The SM prediction is given for $m_t = 175 \pm 0.1$ GeV, while in the MSSM the SUSY parameters have been scanned. The theory predictions are compared with the experimental accuracies obtainable at GigaZ with an 80% polarized electron beam only and with the case of simultaneous polarization of both beams.

heavy. The area corresponding to the MSSM prediction was obtained by varying all relevant SUSY parameters independently, taking into account the constraints from the direct search for SUSY particles and the LEP Higgs search. The MSSM predictions are based on the results described in Ref. [8], and the Higgs mass predictions have been obtained with *FeynHiggs2.0* [9].

Within the SM, the precision in $\sin^2\theta_{\rm eff}$ achievable with both beams polarized constrains the Higgs-boson mass to an interval of few GeV (neglecting the uncertainties from unknown higher-order corrections), while the precision corresponding to electron polarization leaves an uncertainty of about ± 25 GeV in M_h. Within the MSSM the parameter space in the M_h–$\sin^2\theta_{\rm eff}$ plane is reduced by about a factor 7 with the $\sin^2\theta_{\rm eff}$ measurement based on simultaneous polarization of both beams as compared to the case with electron polarization only. This puts sensitive constraints on the possible values of the underlying SUSY parameters. Combined with direct information on the SUSY spectrum the precise measurement of $\sin^2\theta_{\rm eff}$ will allow a very stringent consistency test of the MSSM.

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The code is obtainable at `www.feynhiggs.de`.