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Decay-mode independent searches for new light scalars at future Higgs factories

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* *DESY*

The existence of Higgs-like scalars produced in association with a Z boson is predicted by many BSM models. A study searching for these new scalars taking the ILD detector concept and ILC parameters at 250 GeV has been performed. In order to make the searches as model-independent as possible, the analysis uses the recoil of this new particle against the Z, being independent of its decay modes.

This work was carried out in the framework of the ILD concept group

1 Introduction

Prospects for discovering Higgs-like scalars produced in association with a Z boson at future Higgs factories have been studied. The most model indepent way for those searches is to use the recoil of the new scalar against the Z. Such searches have been performed, as an example, based on the detailed, Geant4-based, simulation of the ILD detector concept [1] at the ILC with a center-of-mass energy of 250 GeV. The studies are performed for any mass of the new scalar and using the decay of the Z boson to two muons.

2 Event Generation and Detector Simulation

Background samples were generated with Whizard 2.8.5[2] being simulated and reconstructed using the ILD_l5_o2_v02 model and ILCSoft v02-02-01. Signal samples were generated with the same Whizard version using the SGV fast detector simulation [3], adapted to the ILD, for detector simulation and high-level reconstruction. The decay branching ratios of the extra scalar are fixed as same as the 125 GeV Higgs boson.

3 Event selection and background rejection

The signal searched for is $e^+e^- \to S+Z$ production, with the Z boson decaying to a pair of muons. A first cut was performed rejecting events with a high energetic ISR photon. The cut was based on the energy and the angle of the previously identified isolated photons found in the event. Secondly, events with two isolated muon candidates were requested, satisfying that the di-muon does not differ from the Z mass in more than 40 GeV and the recoil mass is inside the kinematic range. After these two preselection cuts, selection and pairing of isolated leptons were performed in the surviving events, applying the FSR correction for further calculation of the di-muon mass and momentum. A loose cut on those variables was performed. For the remaining events two BDTGs based on TMVA[4] were trained separately against 2 fermion and 4 fermion backgrounds. In both cases the same seven input variables were used for the training: recoil mass, muon pair invariant mass, the polar angle of each muon, the polar angle of the muon pair, the opening angle of the muon pair, and the $\pi - (\phi_{\mu^+} - \phi_{\mu^-})$, where $\phi_{\mu^\pm}$ is the azimuthal angles of the muons with respect to the beam line. Events were selected based on cuts, dependent of the new scalar mass, on the output of these two BDTGs. An additional cut on the recoil mass, also dependent on the scalar mass, was performed as last selection criteria.

4 Results

Preliminary exclusion limits for the 250 GeV ILC are shown in figureFigure 1. The limits are given as a function of the scale factor between the scalar production cross section and the SM Higgs boson production cross section at given mass [MORE COMMENTS WILL BE ADDED AFTER NEW RESULTS].

5 Conclusions

The potential of the future Higgs factories to search for new scalars has been investigated taking as example scenario the ILD detector concept at the ILC with $\sqrt{S}$ = 250 GeV. The detailed, Geant4-based, simulation of the ILD detector concept was used for this study. The method is optimized to be independent of the scalar decay modes, being based on the the recoil of the new scalar against the Z. 2σ expected exclusion limits on the scale factor between the scalar cross section and the cross section of the SM Higgs particle with the same mass are shown for scalar mass from 10 to 160 GeV. The results are one or two orders of magnitudes more sensitive than LEP, and covering substantial new phase spaces.

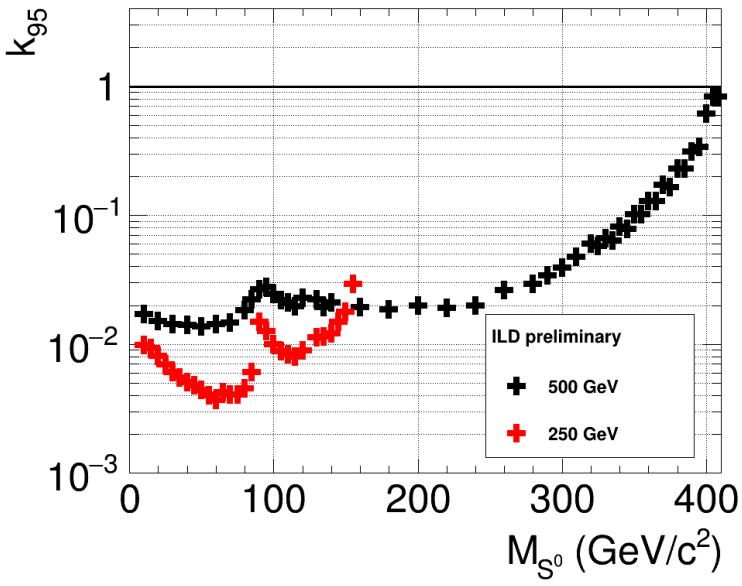

Figure 1: Preliminary Final Exclusion Limits for 250/500 GeV ILC [TO BE UPDATED, ONLY WITH 250 GeV results].

6 References

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