Flavour Independent Search for the Higgs Boson in the hZ-Channel

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In theories which reach beyond the Standard Model, the minimal Higgs mechanism leading to a single physical boson is no longer valid. There is a large class of theories involving two complex doublet fields, the 'Two Higgs Doublet Models' (2HDM). One application is the Minimal Supersymmetric Extension of the Standard Model. 2HDM models predict five Higgs bosons, two neutral scalars (the light h_0 and the heavy H_0), a neutral pseudoscalar A_0, and two charged scalar bosons, the $H^{\pm}$ (cf. iteGU90).

Two popular models arise from special fermion couplings of the Higgs fields: Either one doublet does not couple to fermions at all and the second doublet yields couplings equivalent to those in the Standard Model (Type I). Or each of the doublets couples to either down- or up-type quarks exclusively (Type II).

Two parameters characterize the models: the ratio of the two vacuum expectation values and the mixing of the two Higgs fields to the h_0 and the H_0. These parameters influence the magnitude of the branching fractions.

The search is being performed using the approximately 220 pb^{-1} of data recorded in the year 2000 with the OPAL detector at energies between 202 and 209 GeV. We are looking for the production of the lightest Higgs boson through the Higgs-strahlung process, where an off-shell Z boson radiates a Higgs boson, and becomes on shell (Fig. 1). In most of the cases, the Z and the Higgs decay hadronically, leading to a final state with four jets. This is the decay channel under study.

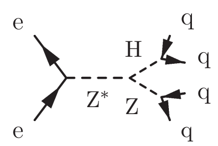

Fig. 1: The Higgsstrahlungs process

A crucial ingredient in searches for the Standard Model Higgs boson is the tagging of bottom quarks. This technique cannot be applied here due to the strong dependence of the decay branching fractions on the model parameters chosen. Therefore this analysis relies exclusively on kinematic variables, mainly on the event topologies. The Higgs boson, being a scalar, should decay isotropically in its rest frame, unlike the background processes consisting mainly of vector bosons (WW and ZZ production). To make the best use of the kinematic variables, hypothetical 'test' masses are assumed, mainly between 100 and 115 GeV.[1]

This leads to a kinematic fit for Zh events, that does not only use the four momentum conservation as constraints but also the assumed mass of the Higgs and a so called 'soft mass constraint', that accounts for the width of the Z boson.

After a cut based preselection [2], a likelihood technique [3] is applied, based on variables such as the energy distribution of the jets, the number of charged tracks, fit probabilities for Zh and WW events and event topologies for QCD and Zh events. The resulting likelihoods for signal, background and data are shown in Fig. 2. With a likelihood cut at 0.6 one obtains efficiencies between 25 and 35 % depending on the mass of the Higgs.

Two more variables are presently under study: The thrust, being a measure for the anisotropy in the jet distribution of each event yields a good discrimination power between Higgs events and the four fermion background, as can be seen in Monte Carlo simulations. The actual gain for the analysis is expected to be smaller, though, because it is highly correlated with the other event shape variables in use.

The second variable is the product of charge and momentum of the two assumed Higgs jets. Even though this variable does not give such a clear distinction as the thrust, it should provide useful additional information, because it introduces a new physical property which is uncorrelated with the other variables.

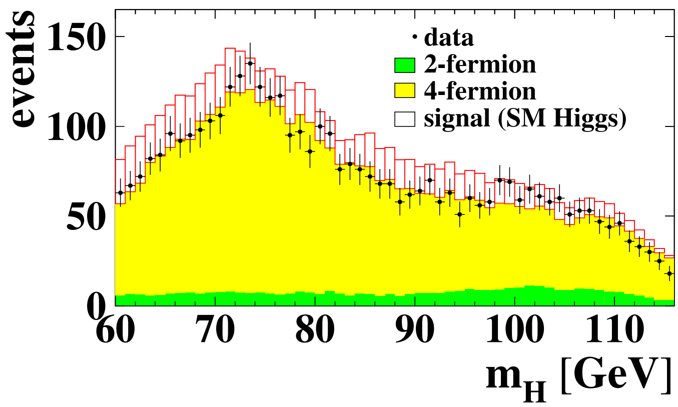

Fig. 2: The number of candidates with a likelihood above 0.6 for Higgs masses between 60 and 115 GeV.

After a decision on the use of additional likelihood variables this analysis will be combined with flavour independent searches in other decay topologies to increase the sensitivity to the full parameter space of the 2HDM models.

References

[1] J. F. Gunion, H. E. Haber, G. L. Kane, S. Dawson, *The Higgs Hunter's Guide* , Perseus Publishing, Cambridge, MA 2000

[2] The OPAL Collaboration, G. Abbiendi et al., *Search for Neutral Higgs Bosons in e^+e^- Collisions at $\sqrt{s} \sim 189GeV$*, Eur. Phys. J. **C12** (1998) 567

[3] The OPAL Collaboration, G. Abbiendi et al., *Two Higgs Doublet Model and Model Independent Interpretation of Neutral Higgs Boson Searches*, CERN-EP 2000-092, CERN, 2000. Submitted to Eur. Phys. J. **C**