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FINAL RESULTS FROM DELPHI ON THE SEARCHES FOR SM AND MSSM NEUTRAL HIGGS BOSONS

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ABSTRACT

These final results from DELPHI searches for the Standard Model SM Higgs boson, together with benchmark scans of the Minimal Supersymmetric Standard Model MSSM neutral Higgs bosons, used data taken at centre-of-mass energies between 200 and 209 GeV with a total integrated luminosity of 224 $pb^{-}1$.The data from 192 to 202 GeV are reanalyzed with improved b-tagging for MSSM final states decaying to four b-quarks. The 95% confidence level lower mass bound on the Standard Model Higgs boson is 114.1 GeV. Mass limits are also given on the lightest scalar and pseudo-scalar Higgs bosons of the MSSM.

1 Introduction

The dominant production mechanism at LEP for a scalar Higgs boson, such as the SM predicts, is the s-channel process $e^+e^- \rightarrow Z^* \rightarrow HZ$. In the MSSM, the production of the lightest scalar Higgs boson, h, proceeds through the same processes as in the SM.

The data from the search for the SM Higgs boson also provide information on the h boson. However, in the MSSM the production cross-section is smaller than the SM one and can even vanish in certain regions of the MSSM parameter space. There is also a CP-odd pseudo-scalar, A, which would be produced mostly in the

$e^+e^- \rightarrow \mathrm{Z}^* \rightarrow \mathrm{hA}$ process at LEP2. This channel is therefore also considered. For MSSM parameter values for which single h production is suppressed, the associated hA production is enhanced (if kinematically permitted).

In the HZ channel, all known decays of the Z boson (hadrons, charged leptons and neutrinos) have been taken into account, while the analyses have been optimized for decays of the Higgs particle into $\mathrm{b\bar{b}}$, making use of the expected high branching fraction of this mode, and for Higgs boson decays into a pair of τ particles, which is the second main decay channel in the SM and in most of the MSSM parameter space. The hA production has been searched for in the two main decay channels, namely the $b\bar{b}\ b\bar{b}$ and $\mathrm{b\bar{b}}\tau^+\tau^-$ final states.

The present results are published in [1].The SM Higgs limit is improved when combining the four LEP experiments to $m_H > 114.4 GeV/c^2$ [2]. A LEP combination in the MSSM is expected for the coming months.

2 Statistical procedure

The statistical procedure to combine the different search channels is a confidence level calculation in two hypothesis: a background only and a background plus signal hypothesis. Confidence levels are calculated using a modified frequentist technique based on the extended maximum likelihood ratio [3] which has also been adopted by the LEP Higgs working group.

The basis of the calculation is the likelihood ratio test-statistic defined using the signal and background densities for each event. These densities are constructed using two-dimensional discriminant information. The first variable is the reconstructed Higgs boson mass (or the sum of the reconstructed h and A masses in the hA channels), the second one is channel-dependent.

3 SM Higgs

Curves of the confidence level CL_b and CL_s as a function of the test mass m_H are shown in Fig. 1. In the presence of a sizable Higgs signal, the value of the observed CL_b would approach one, since it measures the fraction of experiments with only background processes which are more background-like than the observation. Here the compatibility between the observation and the expectation from background processes is well within one standard deviation over the range of masses tested. The observed 95% CL lower limit on the mass is 114.1 GeV/c^2 while the expected median limit is 113.3 GeV/c^2.

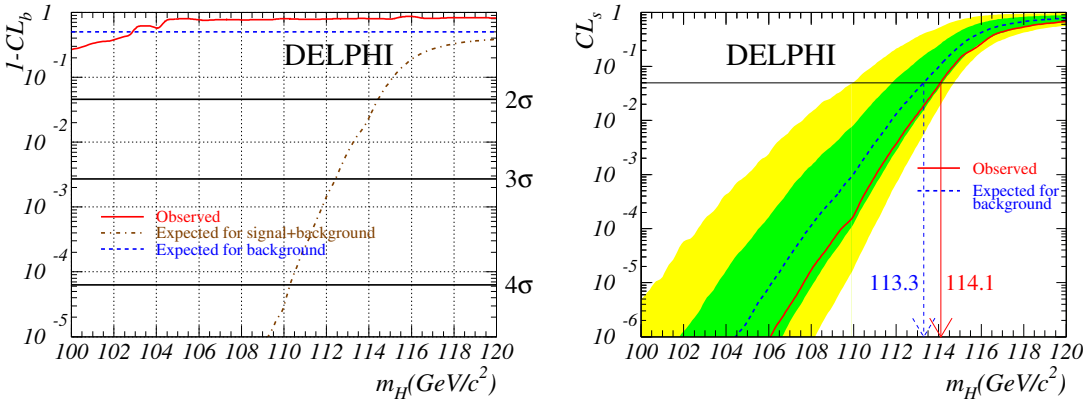

Figure 1: *Final DELPHI* SM *Higgs* CL_b *and* CL_s *curves.*

4 MSSM neutral Higgs

In the benchmark scenarios proposed, a scan was performed over the MSSM parameters $tan\beta$ and m_A. The results come in terms of exclusion ranges as shown in Table 1. An updated version of the MSSM DELPHI results can be found in [4].

Table 1: *Final DELPHI* MSSM *Neutral Higgs exclusion ranges.*

m_h^{max} scenario:	
$m_h > 89.7 GeV/c^2$ and $m_A > 90.5 GeV/c^2$ $tan\beta < 0.54$ or $tan\beta > 2.36$	for any $tan\beta \geq 0.4$ for any m_A
no mixing scenario scenario:	
$m_h > 92.0 GeV/c^2$ and $m_A > 93.0 GeV/c^2$ $tan\beta < 0.8$ or $tan\beta > 9.36$	for any $tan\beta \geq 0.8$ for any m_A

References

1. J.Abdallah *et al*, CERN-EP/2003-008 (Submitted to Eur. Phys. J. C).

2. ALEPH, DELPHI L3 and OPAL Collaborations. The LEP Working Group for Higgs Boson Searches. CERN-EP/2003-011 (Submitted to Physics Letters B).

3. A.L. Read, *Modified Frequentist Analysis of Search Results (The* CL_s *Method)*, in CERN Report 2000-005, p. 81 (2000), edited by F.James, L.Lyons and Y.Perrin.

4. V. Ruhlmann-Kleider, DELPHI 2003-045 CONF-665.