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NEUTRAL HIGGS BOSON SEARCH IN A TWO DOUBLET MODEL

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ABSTRACT

The search of Higgs Bosons in a two doublet model, using the data collected by the DELPHI collaboration, is updated in order to take into account the radiative corrections. In the framework of minimal SUSY theory the following limit are derived: $m_h \geq 42$ GeV and $m_A \geq 36$ GeV. These limits are computed assuming a top mass $m_t = 135$ GeV and a squark mass of 1 TeV.

1. Introduction

Recent introduction of loop corrections[1] in the MSSM[2] has changed the predictions about the masses and decay modes of the lightest Higgs boson h. Now it is understood that it has a high probability to decay into two light A's. As a consequence previous searches are partially invalidated and a new analysis has been performed to cover all the possibilities allowed by the two doublet model.

In general the used method depends mainly on the mass of the A boson and, in the present analysis, three mass regions are considered. For some channels it is possible to reinterpret results obtained in previous analyses or limits derived by

measured width of the Z^0.

Two complementary mechanisms are responsible for the production of the A and h boson: in the pair production reaction both A and h are created and the cross section is proportional to $\cos^2(\alpha - \beta)$. In the bremsstrahlung reaction the h is produced together with a virtual Z^0 and the cross section is proportional to $\sin^2(\alpha - \beta)$.

The data presented corresponds to the total sample of 1990 and 1991, on average it amounts to about 350000 hadronic Z^0, with different selections in different channels.

2. Decay of h in two A's

Direct searches for hA are only relevant when h is heavy since the width limit is sufficient to exclude this channel for $m_h \leq 30$ GeV when $m_A \leq 10$ GeV.

The three mass regions of the A boson studied are: below the μ threshold, up to the heavy quark threshold and above this region. In the first domain the Higgs can be invisible, or decay into 2γ or into e^+e^- and be visible as a V_0 inside the TPC. If the Higgs boson is not seen in the detector the signature are two acoplanar leptons or jets. For the 2γ channel events with only two acoplanar photons or with jets and isolated photons have been looked for, and no events have been found. When the A boson decays into e^+e^- it can be seen in the TPC as a V_0 or as monotrack due to the Lorentz boost which is due to the mass differences between the two bosons ($E_A \sim m_h/2$). Previous analyses used for SM light Higgs cannot be used because in this case the A lifetime can be longer. A new direct search was prepared to look for 5 different topologies: 2 V_0, 2 monotracks, 1 V_0 and 1 monotrack, 1 V_0, 1 monotrack. The last two cases are important to keep a good efficiency when one of the two A escape the detection. After first kinematical cuts some events are observed which can be explained by well known backgrounds, while with final cuts no events remain. The efficiency and the excluded mass region for these channels are shown in table 1.

In the intermediate region the A boson mainly decays into muons, pions and kaons with a two-prong topology. For the muon case there are no problems because the signature is very clear, for the other cases, since the relative branching ratios are not well known, a search has been done for low multiplicity monojets (below 15 GeV) or two jet events (above 15 GeV). The channel hA gives very easy to observe three jet events ("Mercedes" configuration).

The last studied region is for A masses above 10 GeV; this region is well covered by previous searches, it remains to exclude only the hA into $6b$ channel. This can be done studying multijet events with at least one high p_t lepton in the final state. No events were observed.

3. Suppressed decay of h in two A's

For values of $\tan\beta \gg 1$ the b decay mode is strongly enhanced and the h

Table 1: Limits on BR(hZ^0) and BR(hA) when h goes into 2A

m_A	Channel	$\epsilon(hA)\%$	BR(hA)	$\epsilon(hZ^*)\%$	BR(hZ^*)	$m_h > GeV$
$\leq \mu\mu$	2γ	50	10^{-4}	30	$2.5\ 10^{-5}$	54
	inv.	0	$7\ 10^{-3}$	35	$2\ 10^{-5}$	49.5
	ee	50	$3\ 10^{-5}$	30	$6\ 10^{-5}$	47
$\leq \tau\tau$	$\mu\mu$	50	$1.5\ 10^{-5}$	35	$2\ 10^{-5}$	55
	Had	50	$4\ 10^{-4}$	10	$6\ 10^{-5}$	46.5
$\geq \tau\tau$	$\tau\tau$	11	$2\ 10^{-4}$	14	$5\ 10^{-5}$	46.5
$\leq b\bar{b}$	qq	35	$4\ 10^{-4}$	10	$6\ 10^{-5}$	46.5
$\geq b\bar{b}$	qq	40	$2\ 10^{-3}$	10	$6\ 10^{-5}$	46
$\geq b\bar{b}$	bb	7	$1.5\ 10^{-3}$	10	$6\ 10^{-5}$	46

will decay mainly into $b\bar{b}$ and not into $2A$. All the regions of interest are covered by the analysis described in the previous section. The efficiencies and the limit on branching ratio are shown in table 2.

4. Two doublet and MSSM Limit

In the two doublet model it is possible to translate the limit on branching ratios given in table 1,2 in limits on the value of $\sin^2(\alpha-\beta)+\cos^2(\alpha-\beta)$. A point in the plane (m_h, m_A) is excluded if such limit goes below 1. The exclusion contour is given in Fig 1a.

In the framework of MSSM the allowed domain for m_h and m_A is restricted, for a given top mass and a given squark mass, as shown in Fig 1b. Assuming $m_t = 135$ GeV and $m_{sq} = 1$ TeV one obtains the contour shown in the same figure. Irrespective of $\tan\beta$ the h boson with mass below 42 GeV and the A boson with mass below 36 GeV are excluded (95% confidence level). The limit on m_h is quite insensitive to m_t, while the limit on m_A depends strongly on the top mass and may even vanish for $m_t > 170$ GeV.

Conclusions

The analysis presented fully takes into account the possibility that the scalar Higgs boson decays into two pseudoscalar as predicted by recent calculations. In particular the case of h decays into very light A is covered both for hZ^* and hA channels. In the two doublet model the mass limit is 40 Gev for $\tan\beta$ greater than

Table 2: Limits on BR(hA) when h into 2A is suppressed

m_A	Channels	$\epsilon(hA)\%$	BR(hA)	$m_h > GeV$
$\leq \mu\mu$	2γ	30	10^{-4}	46.5
	inv.	45	$1.5\ 10^{-5}$	47
	ee	15	$7.0\ 10^{-5}$	46.5
$\leq \tau\tau$	$\mu\mu$	30	$2.5\ 10^{-5}$	47
	Had	35	10^{-4}	46.5
$\geq \tau\tau$	$\tau\tau$	7	$6.0\ 10^{-4}$	46
$\geq bb$	$\tau\tau$	1	10^{-3}	46

one. In the MSSM scheme the mass limit is 42 GeV.

References

1. J.Ellis, G.Ridolfi and F.Zwirner,*Phys. Lett.***B257**(1991) 83.
2. See J.F.Gunion,H.E.Haber,G.Kane and S.Dawson,*The Higgs Boson Hunter Guide*(Addison-Wesley,Reading,MA,1990) and reference therein.

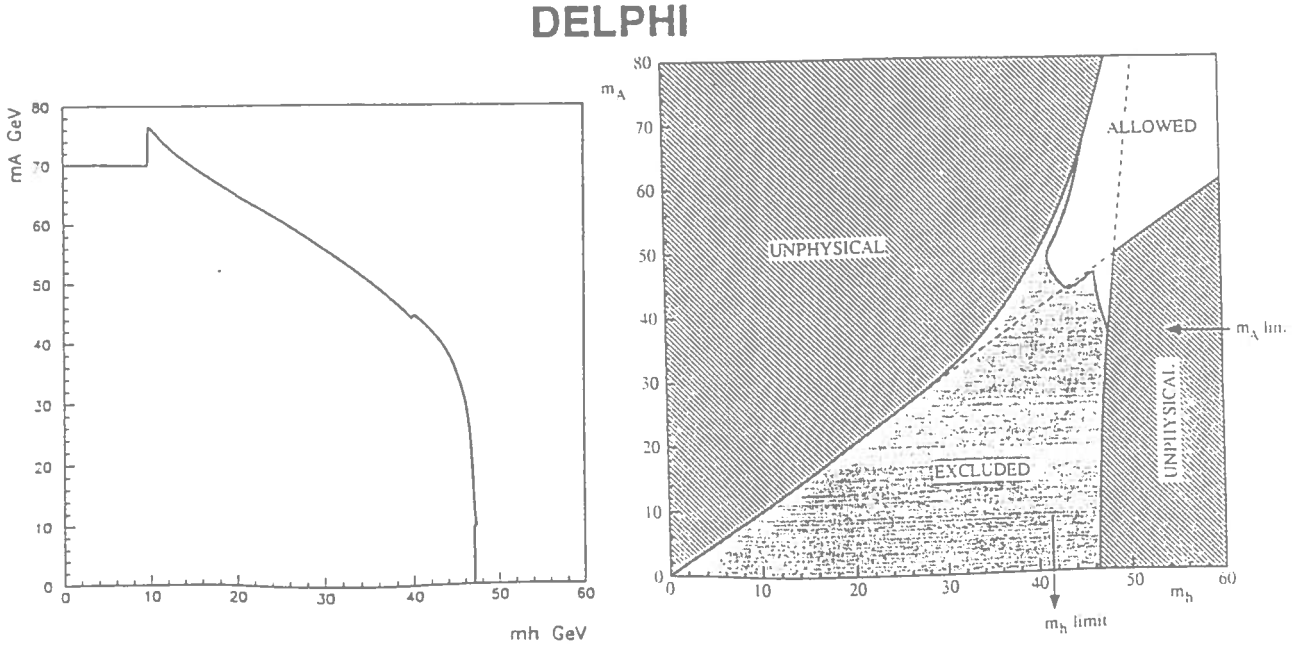

Figure 1: a) Two doublet limit; b) MSSM limit