Searches for MSSM Higgs Bosons with the DELPHI Detector up to $\sqrt{s} = 209$ GeV

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Outline

- Higgs processes in the MSSM
- The hA channels
- The invisible Higgs channels
- Summary

The MSSM

- The MSSM is one of the most favored extensions of the Standard Model.
- The MSSM has two 2 fundamental Higgs fields with 5 physical Higgs states.

h	CP-even	light (< 130 GeV)
H	CP-even	too heavy for LEP
A	CP-odd	possibly light
$H^\pm$	charged	heavier than $W^\pm$

The Higgs sector in the MSSM depends mainly on A mass m_A , the ratio of the vacuum expectation values $\tan \beta$, the mixing angle in the CP even sector α and the mixing in the stop sector X_t

Neutral Higgs Boson processes in the MSSM

BR at LEP2

$$h \rightarrow b\bar{b} \quad 85\%$$

$$h \rightarrow \tau^+\tau^- \quad 8\%$$

hA pair production and the **Higgs decay into sparticles**, especially $\tilde{\chi}_1^0$, are possible in the MSSM

The hA process

Channels:

$$hA \rightarrow b\bar{b}b\bar{b} \text{ or } b\bar{b}\tau\bar{\tau}$$

Signature:

for $b\bar{b}b\bar{b}$ 4 btagged Jets

for $b\bar{b}\tau\bar{\tau}$ 2 btagged Jets, 2 τ

Challenges:

b-tagging, τ identification

Main backgrounds:

ZZ pairs (irreducible) and
QCD

Results

A limit of $m_h = 85.0 \text{ GeV}/c^2$ (85.3 GeV/c² expected) and $m_A = 86.2 \text{ GeV}/c^2$ (87.1 GeV/c² expected) is derived for 1999 data.

Exclusion in the $\tan \beta$ m_h plane

We consider two MSSM scenarios, one with no mixing in stop sector, and one with maximal mixing (m_h max scenario) in the stop sector.

2000 update

A limit of $m_h = 85.1$ GeV/c^2 (87.0 GeV/c^2 expected) and $m_A = 86.7$ GeV/c^2 (88.5 GeV/c^2 expected) is derived for 2000 data up to July.

The invisible Higgs channel: Introduction

In the MSSM the **L**ightest **S**upersymmetric **P**article (LSP) is the lightest Neutralino $\tilde{\chi}_1^0$. The couplings of the Higgs-Bosons to the LSP depends on the mixing.

MSSM-Parameter

- $\tan \beta$ small (≈ 3)
- μ positive 100 - 250 GeV/c²
- M_2 100 - 400 GeV/c²

Invisible Higgs decays

Channels:

$$h \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0, Z \rightarrow q\bar{q}, l\bar{l}$$

Signature:

2 Jets/Leptons + missing energy

Challenges:

Energy reconstruction
and τ identification

Main backgrounds:

$q\bar{q}\nu\bar{\nu}$ and $W e\nu$ for the hadronic channel and WW pairs for the leptonic channels.

The final selected candidates

Limits on σ_{inv} and BR_{inv}

For a Higgs decaying to 100% into $\tilde{\chi}_1^0$, the observed limit is $m_h = 102.5 \text{ GeV}/c^2$ ($103.4 \text{ GeV}/c^2$ expected). A more general limit, independent of the branching ratio into $\tilde{\chi}_1^0$ is $m_h = 96.5 \text{ GeV}/c^2$.

2000 update

For a Higgs decaying to 100% into $\tilde{\chi}_1^0$ the observed limit is
 $m_h = 104.3 \text{ GeV}/c^2$ (107.0 GeV/ c^2 expected) including the
 preliminary 2000 data (73 pb⁻¹).

Conclusion

- Searches for MSSM Higgs Bosons have been performed.
- No evidence for a signal has been found.
- For m_h and m_A the is limit around $85 \text{ GeV}/c^2$.
- For the first time a $\tan \beta$ region ($0.8 < \tan \beta < 2$) is excluded in all scenarios.
- For the invisible Higgs channels the exclusion limit is $104 \text{ GeV}/c^2$.