MSSM Higgs Searches at LEP II

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- Introduction
- The new Benchmark Scans
- The Data Set
- Results

XXXV Recontres de Moriond;

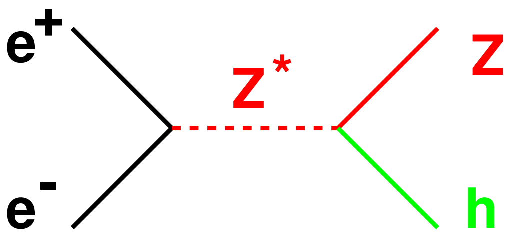
Electroweak Interactions and Unified Theories;

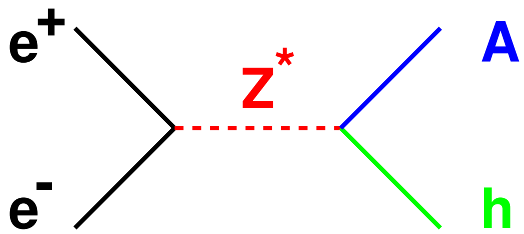
11-18 March 2000 Les Arcs, France

The Higgs Sector in the MSSM

5 physical Higgs Bosons

2 CP-even neutral Higgses	h^0, H^0	$m_h < m_H$
1 CP-odd neutral Higgs	A^0	
2 charged Higgses	$H^\pm$	
Free parameters:	$\tan\beta = v_2/v_1$	(VEV ratio)
	α	(mixing angle of h, H)
tree level:	$m_h < m_Z < m_H$	
rad.corrected:	$m_h <$ 135 GeV	





"Higgsstrahlung"

$\sigma = \sin^2(\beta - \alpha)\,\sigma_{HZ}^{SM}$

- largest at small $\tan\beta \approx 1.4$
- SM topologies
- recycle SM searches

"Associated Production"

$\sigma = \cos^2(\beta - \alpha)\bar{\lambda}\sigma_{\nu\bar{\nu}}^{SM}$

- largest at $\tan\beta > 15$
- typically $m_A \approx m_h$
- new topologies
- dedicated searches:

$hA \to b\bar{b}b\bar{b}, hA \to \tau^+\tau^- b\bar{b}$

SUSY Searches at LEP

Spin	0	1/2		1
	$\tilde{\ell}^{+}$, $\tilde{\nu}$ - *sleptons*	ℓ, ν		
	$\tilde{q}$ - *squarks*	q		
		$\tilde{g}$ - *gluinos*		g
	H^0, h^0, A^0	$\tilde{\gamma}$, $\tilde{H}$, $\tilde{Z}$, $\tilde{h}$	Mix, $\tilde{\chi}^0_i$ *Neutralinos*	γ, Z
	$H^{\pm}$	$\tilde{H}^{\pm}$, $\tilde{W}$	Mix, $\tilde{\chi}^{\pm}_j$ *Charginos*	$W^{\pm}$

Two: $m(\tilde{\chi}^{\pm}_1) < m(\tilde{\chi}^{\pm}_2)$

Four: $m(\tilde{\chi}^0_1) < m(\tilde{\chi}^0_2) < m(\tilde{\chi}^0_3) < m(\tilde{\chi}^0_4)$

Assume R-Parity conserved $\Rightarrow$ SUSY particles produced in pairs

$$R = (-1)^{3B + L + 2S}$$

$\Rightarrow$ decays to lightest SUSY particle (LSP), escapes detector

Masses, Cross Sections, Br's of $\tilde{\chi}^{\pm}_j$ and $\tilde{\chi}^0_i$ from:

- M_2, SU(2) gaugino mass @ electroweak scales
- $\tan\beta$, ratio of vacuum exp. values of Higgs doublets, $\langle v_2\rangle/\langle v_1\rangle$
- μ, superpotential Higgsino mass (enters gaugino-Higssino sector)
- m_0, common mass of squarks and sleptons at GUT scales

(GUT: $M_1 = \frac{5}{3} M_2 \tan^2\theta_W$)

The new Benchmark Scans

in constrained MSSM (hep-ph /9912223)

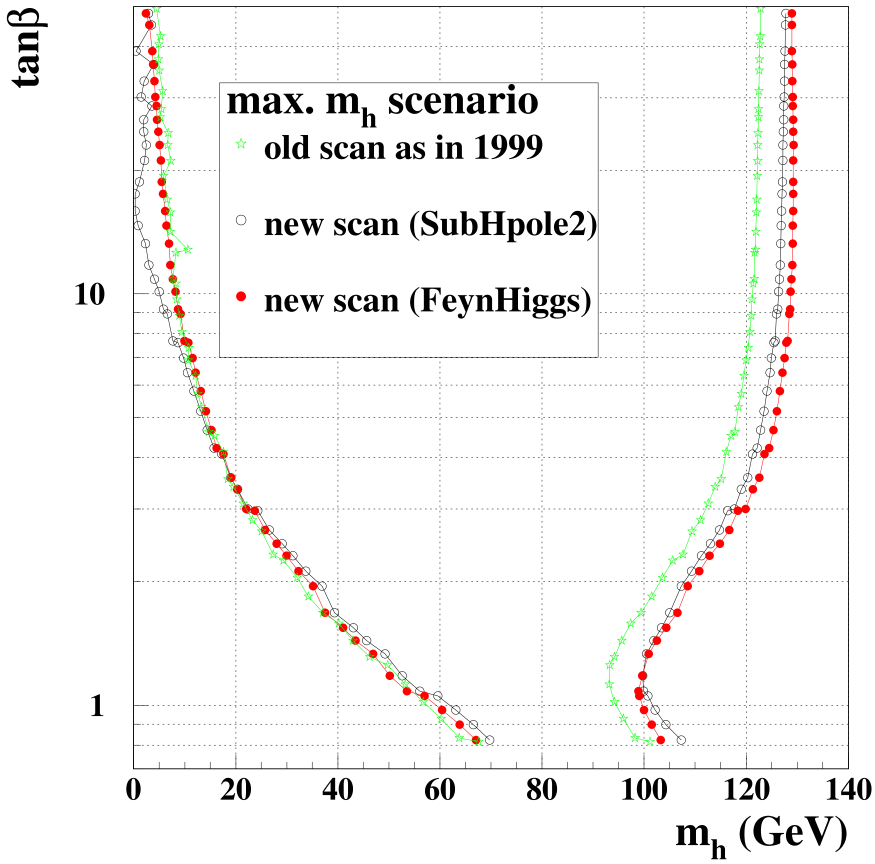
no mixing /max. m_h scenario :

M_{SUSY}	= 1 TeV	sfermion masses at EW scale
μ	= -200 GeV	Higgs mixing parameter
M_2	= 200 GeV	gaugino mass at EW scale
$m_{\tilde{g}}$	= 0.8 M_{SUSY}	gluino mass
M_A	$\leq$ 1000 GeV	A mass
X_t	= 0 / $2 \cdot M_{SUSY}$	stop mixing parameter
A_b	= A_t	trilinear Higgs-stop coupling
$\tan\beta$	= 0.4 - 50	ratio of vacuum expect. value

large μ scenario:

$\longrightarrow$ pathological points with Br$(h \longrightarrow b\bar{b}) \ll 1$

... not shown here ...



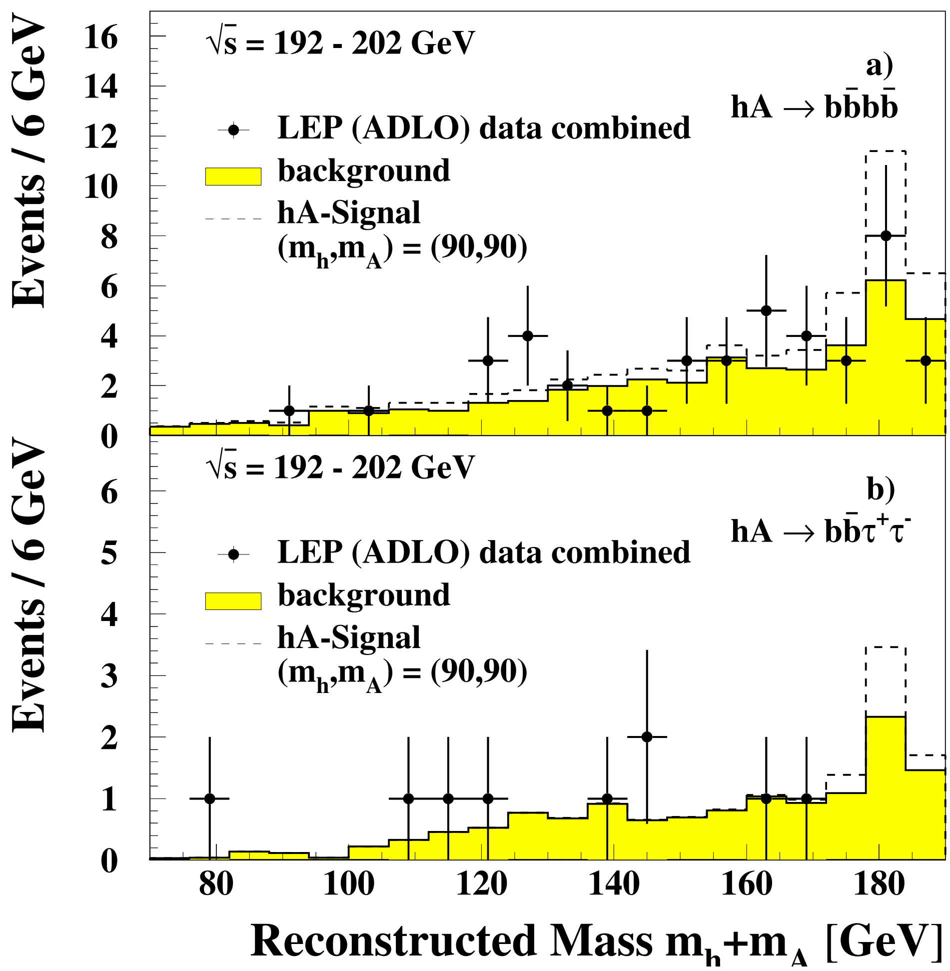
use FeynHiggs to increase m_h by $\sim$ 10 GeV wrt to 1999 scan

$\Rightarrow$ conservative $\tan\beta$ exclusion

The Data Set

	ALEPH	DELPHI	L3	OPAL
$\mathcal{L}(pb^{-1})$	237.0	222-228	232.4	213-217
hZ obs./exp.	74 / 97.8	282 / 307.5	58 / 49.8	53 / 51.5
hA obs./exp.	31 / 49.1	53 / 58.2	10 / 15	22 / 18.2

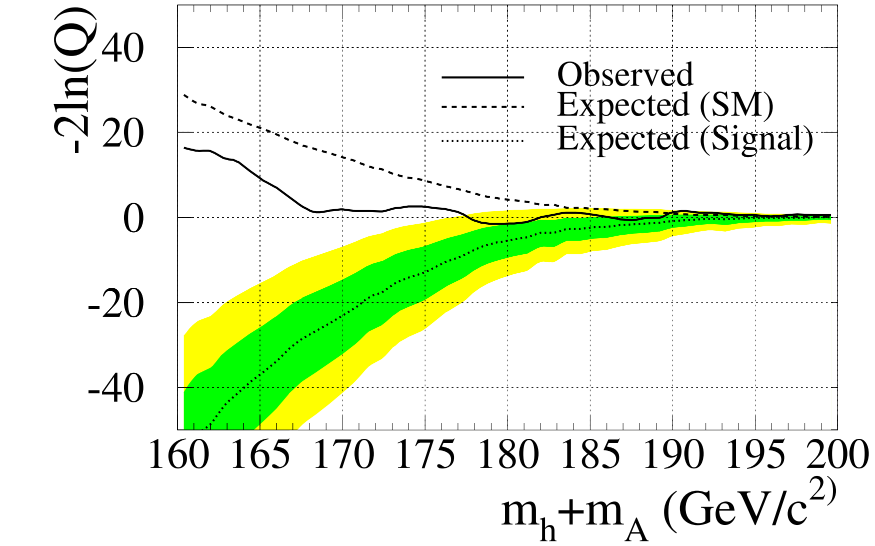
All Data and Plots are PRELIMINARY !



Br ≈ 86 %
ϵ ≈ 50 %

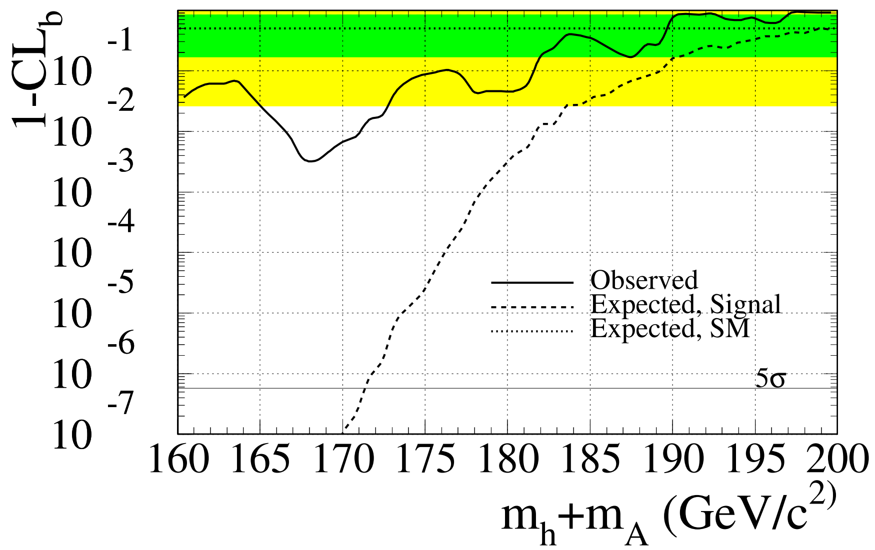
Br ≈ 13 %
ϵ ≈ 45 %

The Limits for $m_h \approx m_A$



negative log-likelihood ratio

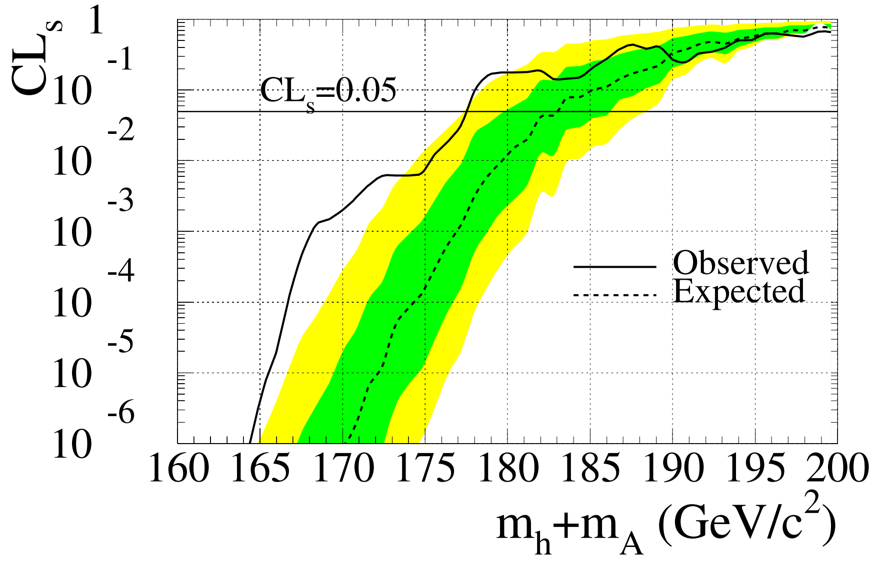
$$\frac{\mathcal{L}(s(m_h)+b)}{\mathcal{L}(b)}$$



confidence level for background consistency

5σ discovery would be

$$1 - CL_b < 5.7 \times 10^{-7}$$

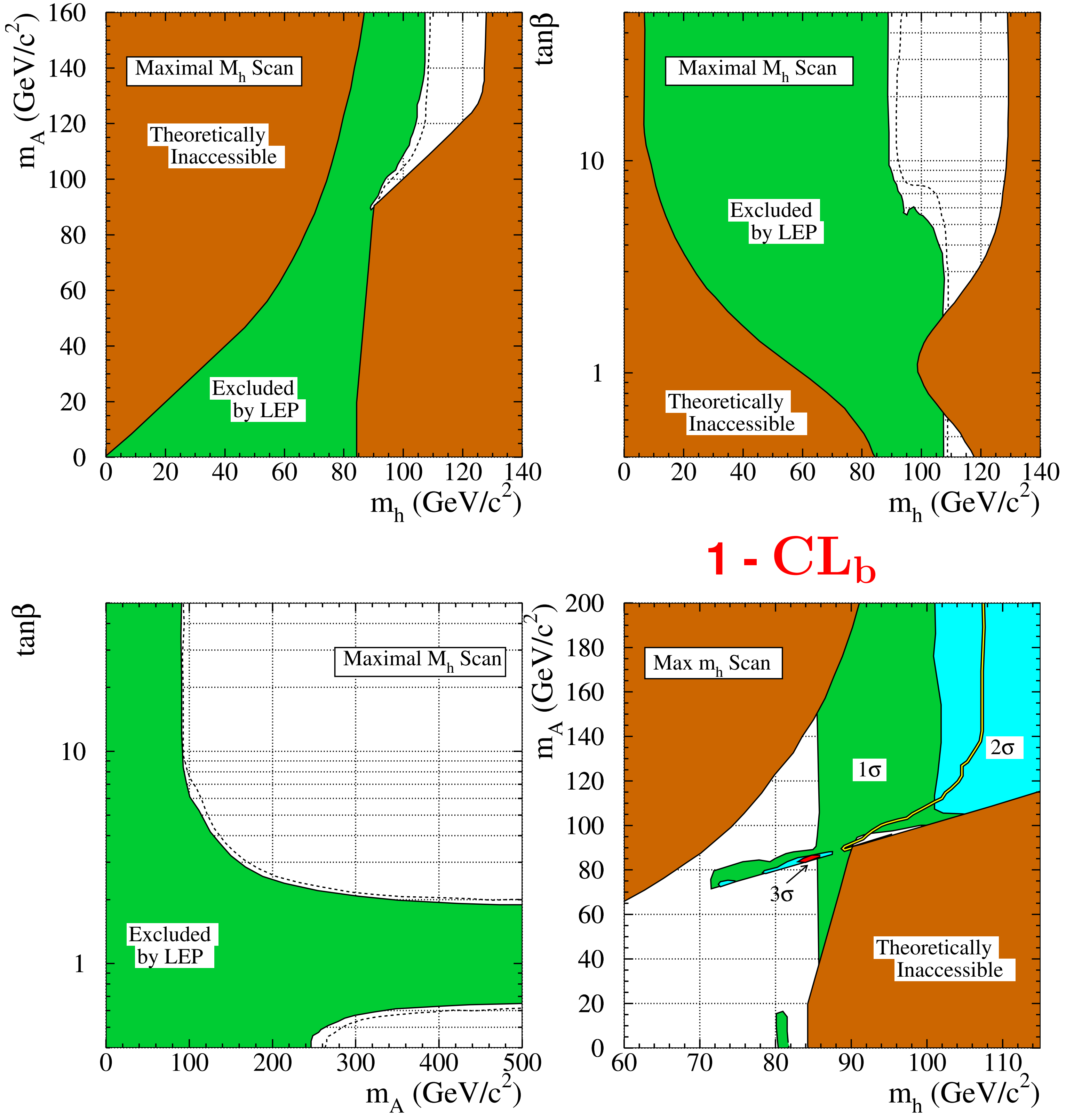


confidence level for signal + background

assumed signal is

$(m_A, m_h) = (90, 90)$ **GeV**

The maximal m_h Scenario

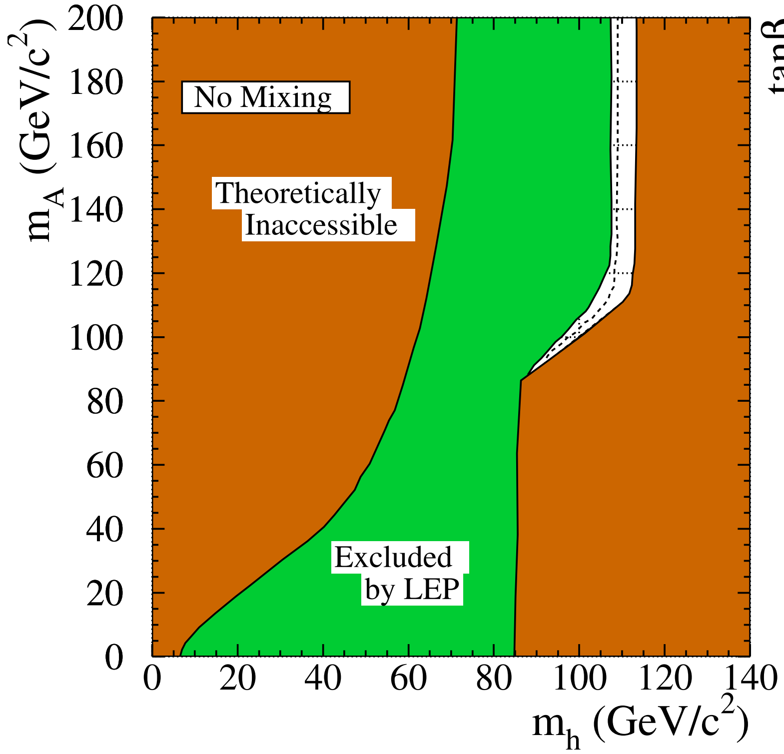


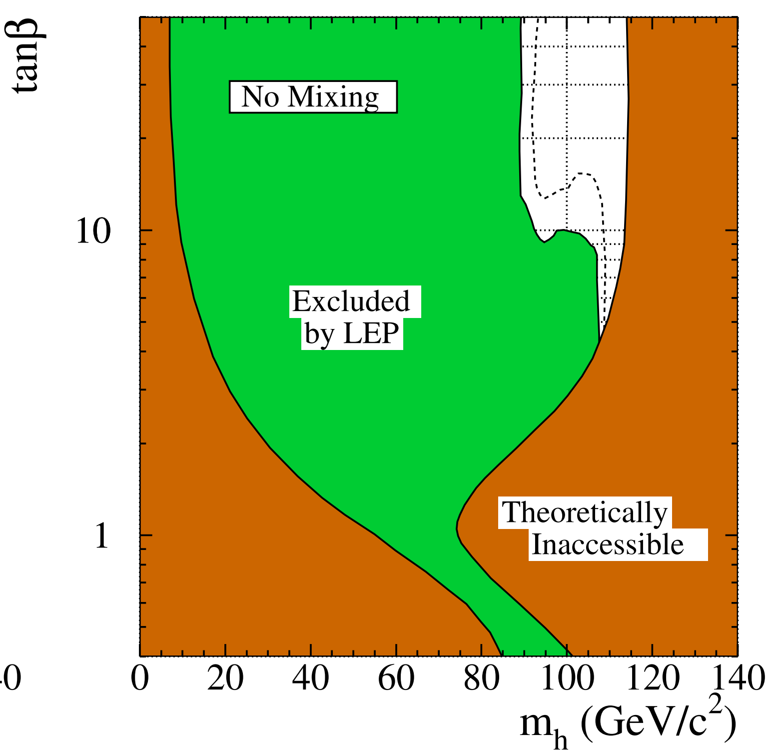
obs. (exp.): $m_h >$ 88.3 (90.5) GeV (exclusion limit

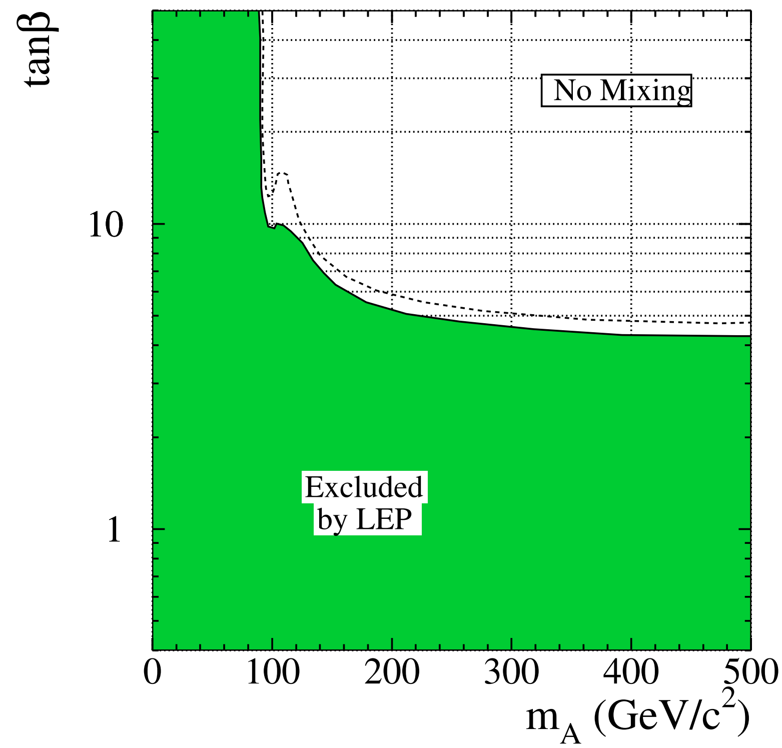
$m_A >$ 88.7 (91.1) GeV at 95% CL)

$\tan\beta =$ 0.7-1.8 (0.6-1.9)

The minimal Mixing Scenario







obs. (exp.): $m_h >$ **88.3 (90.8) GeV** **(exclusion limit**

$m_A >$ **88.4 (88.7) GeV** **at 95% CL)**

$\tan\beta =$ **0.4-4.1 (0.4-4.6)**

Summary

The four LEP experiments presented searches for MSSM Higgs from 1999 data up to $\sqrt{s}$ = 202 GeV

New (more conservative) benchmark scans have been defined and implemented into HZHA3.0

No signal has been observed $\longrightarrow$ limits at 95% CL:

	m_h (GeV)	m_A (GeV)	$\tan\beta$
no mixing	88.3 (90.8)	88.4 (91.1)	0.4-4.1 (0.4-4.6)
max. m_h	88.3 (90.5)	88.7 (91.1)	0.7-1.8 (0.6-1.9)

Looking forward to year 2000 data ...