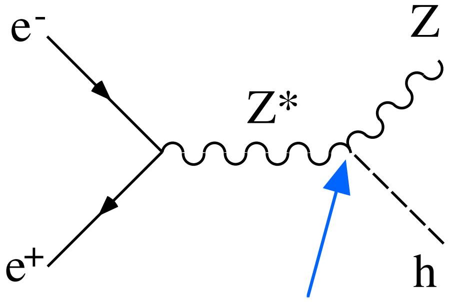
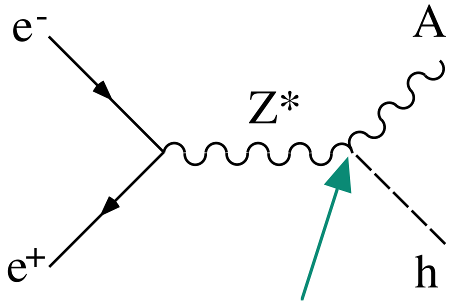
MSSM Higgs bosons

$e^+e^- \rightarrow hZ$



$\sin^2(\beta-\alpha)$

$e^+e^- \rightarrow hA$



$\cos^2(\beta-\alpha)$

Complementary

Dominates for
Large tan β

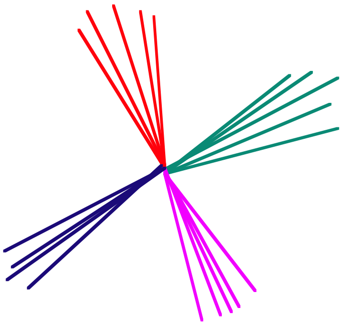
Dominates for
Small tan β

Topologies

- *Same as for the SM H^0*
- *Invisible decays*

  $(h \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0, Z \rightarrow l^+ l^-, q\bar{q})$
- *$m_A < m_A/2 \rightarrow h \rightarrow AA$*

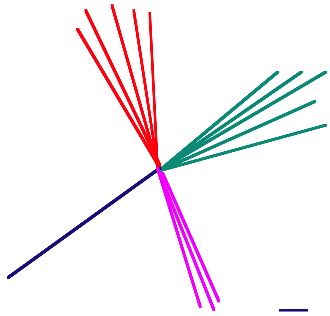
Topologies



$hA \rightarrow b\bar{b}b\bar{b}$

(four jets, all with b-flavour)

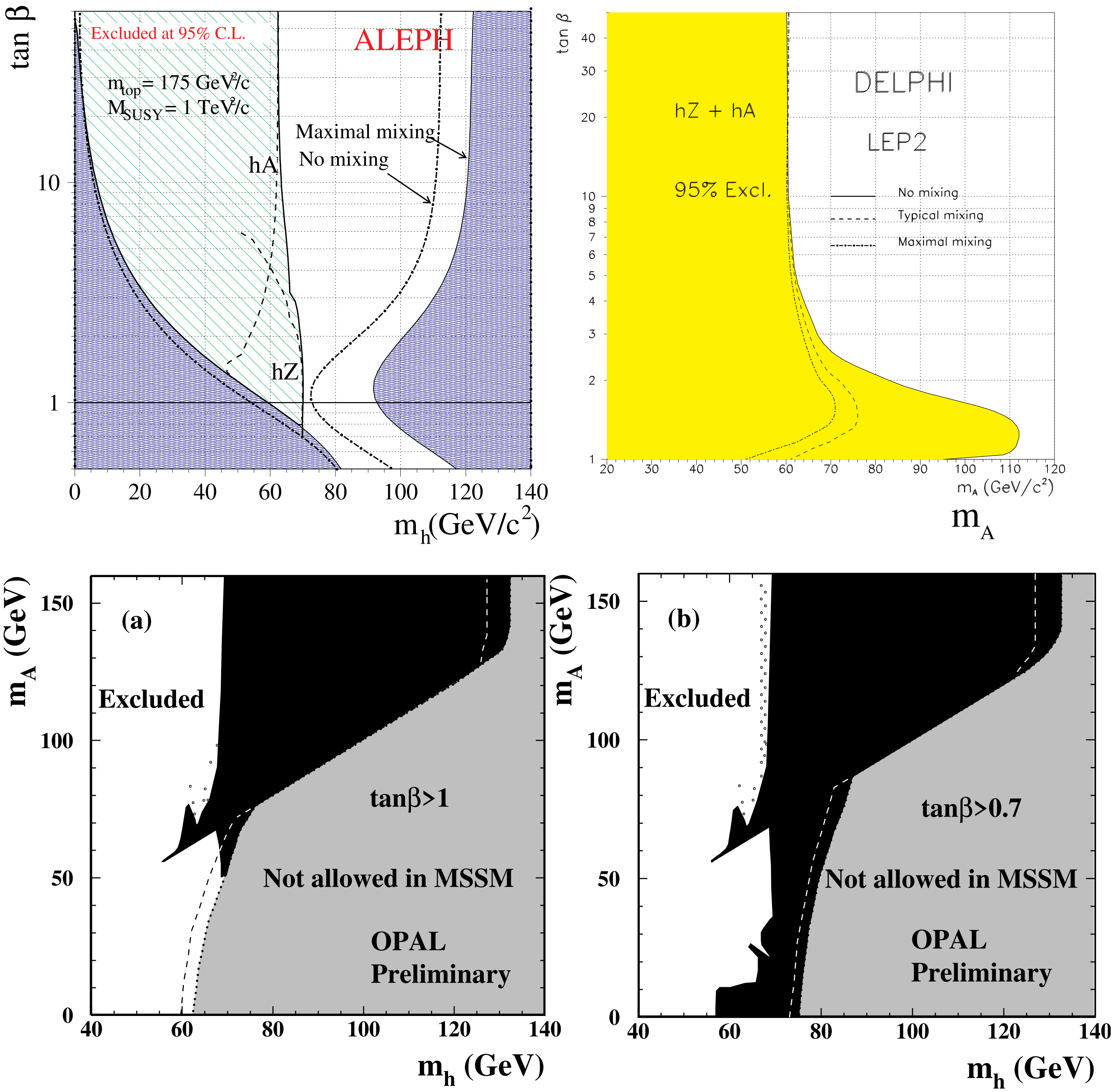
if $m_h > 2m_A$ $hA \rightarrow b\bar{b}b\bar{b}b\bar{b}$



$hA \rightarrow \tau^+\tau^- b\bar{b}$

(two b-jets and two taus)

m_h, m_A limits



hZ/hA results

	m_h(GeV)	m_A(GeV)
ALEPH	64.5*	64.5*
DELPHI	59.5	51.0
OPAL	56.0	50.6

* Includes $\sqrt{s}$=183 GeV data

m_h, m_A limits

Scan of several MSSM parameters:

$0 < m_0 < 1000$ GeV

$0 < M_2 < 2000$ GeV

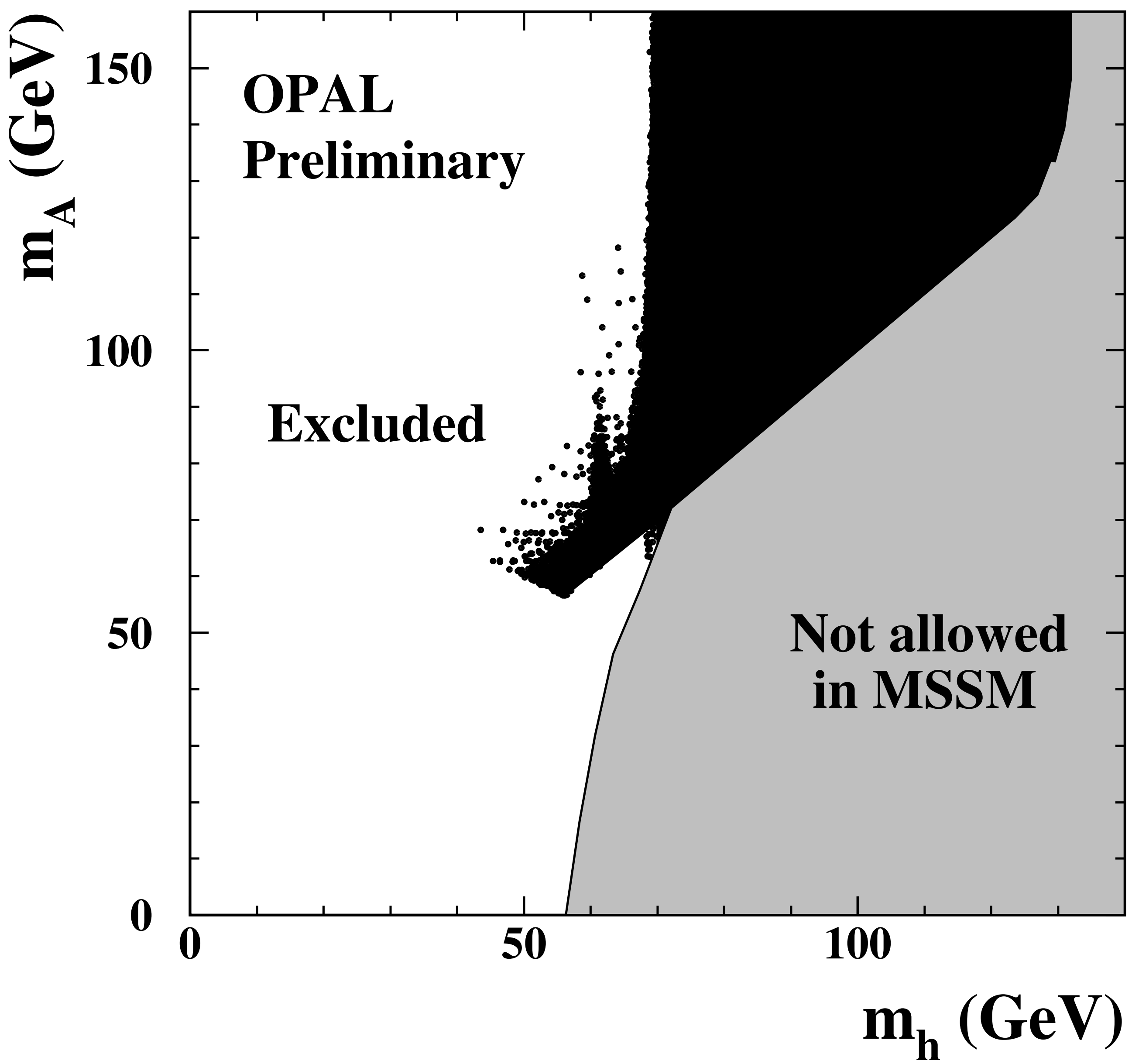
$-2.5\ m_0 < A < 2.5\ m_0$

$-1000 < \mu < 1000$ GeV

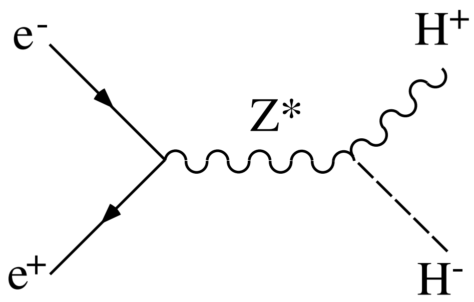
$5 < m_A < 160$ GeV

$0.7 < \tan\beta < 50$

$m_t = 165, 175, 185$ GeV

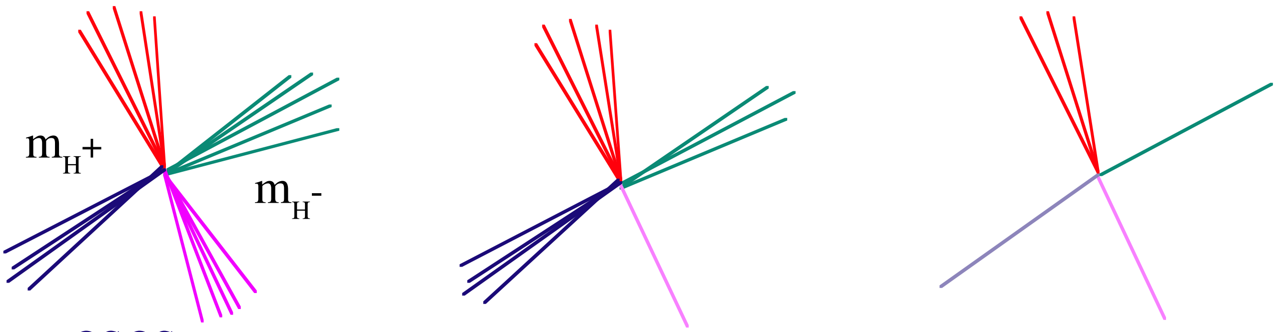


Charged Higgs bosons

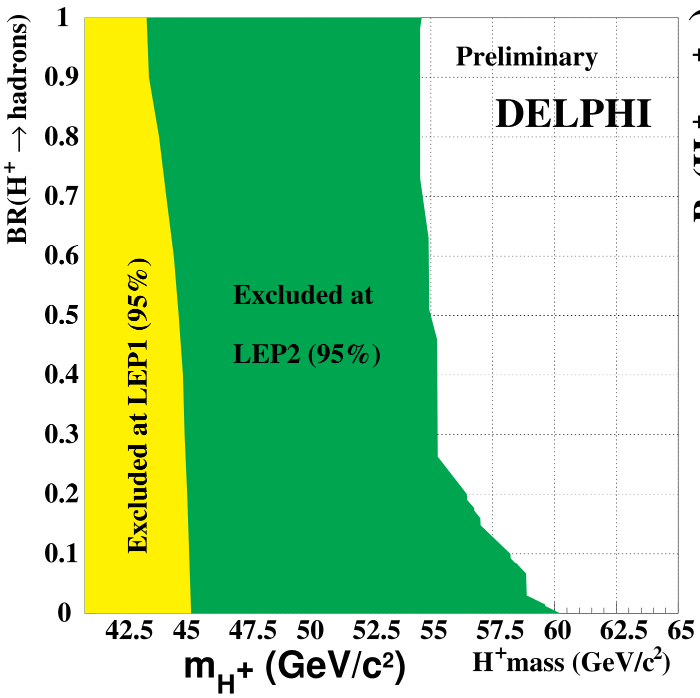


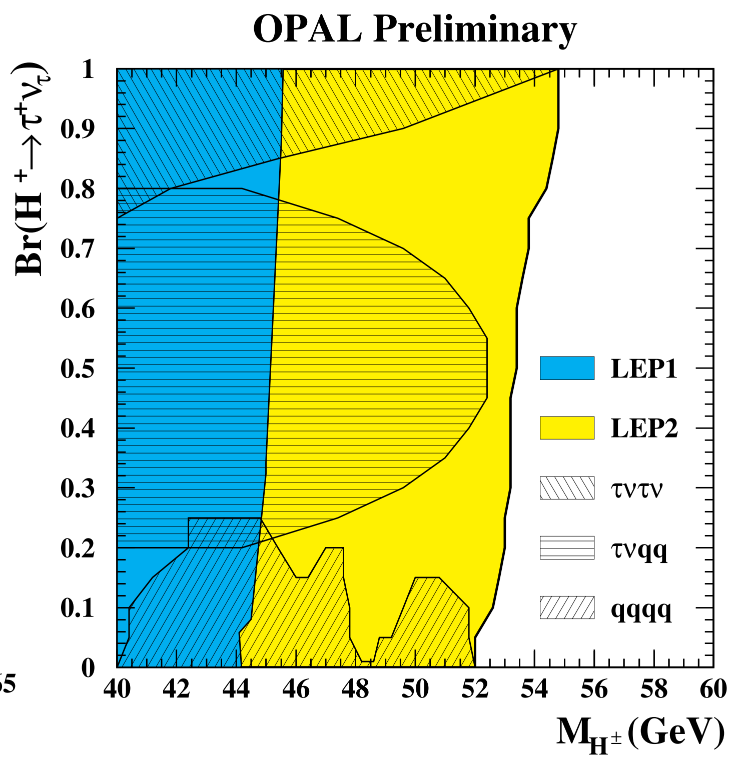
$H^{\pm} \rightarrow cs, \tau\nu$

Topologies



cscs csτν τντν





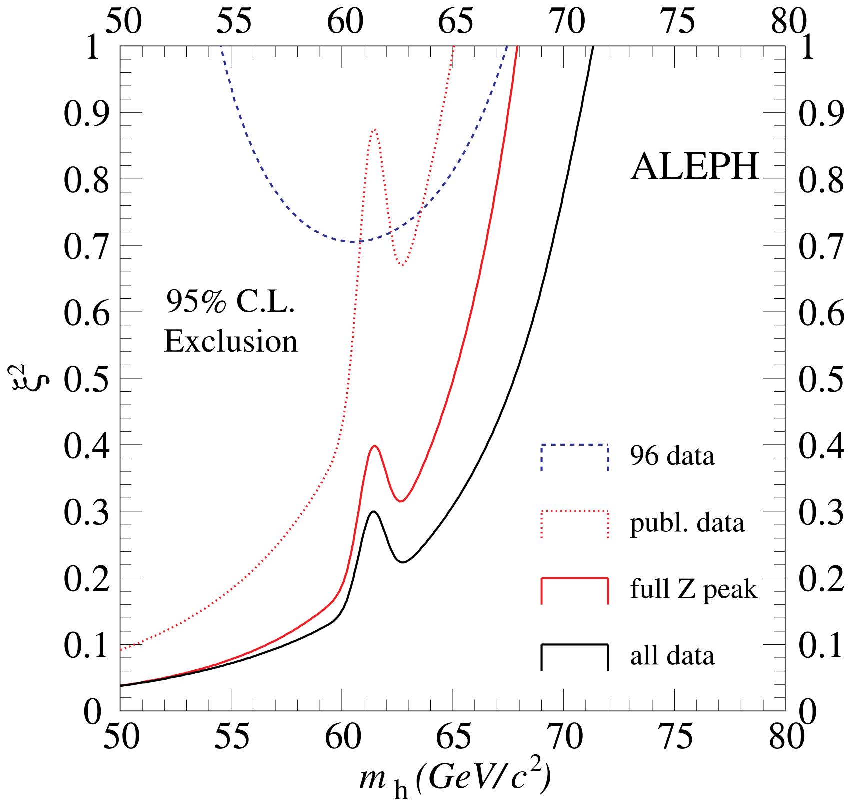
$m_{H^\pm} > 52.0$ GeV (ALEPH)

$m_{H^\pm} > 54.5$ GeV (DELPHI)

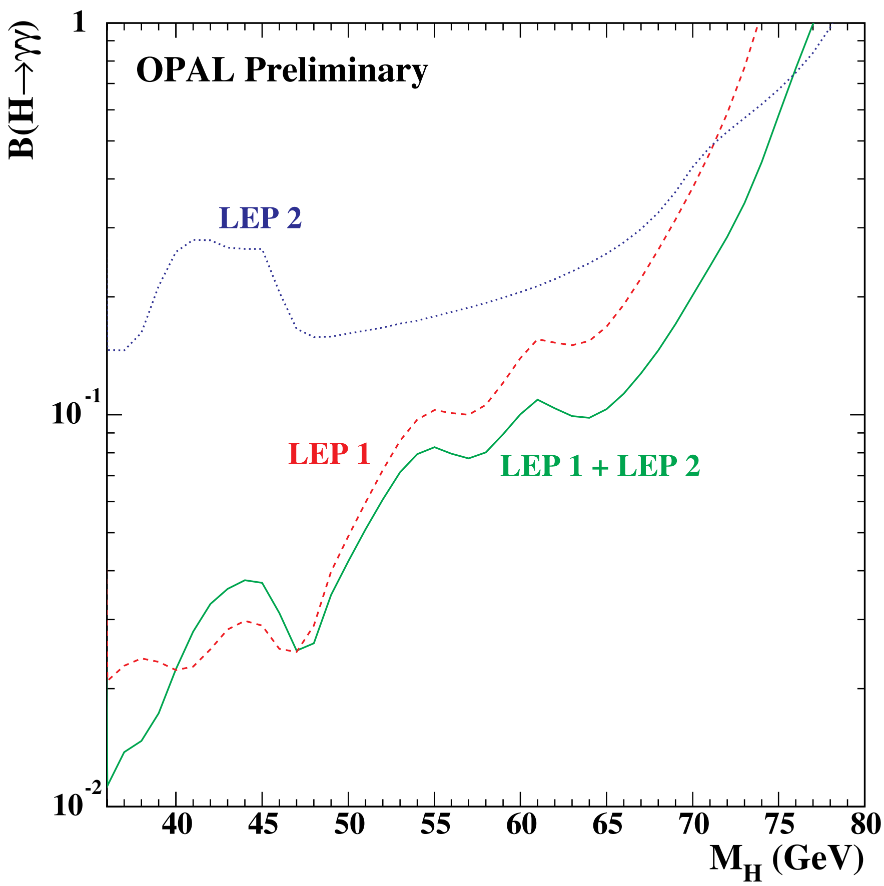
$m_{H^\pm} > 52.0$ GeV (OPAL)

More Higgs searches

Invisible Higgs decays ($h \rightarrow \tilde{\chi}^0 \tilde{\chi}^0$)



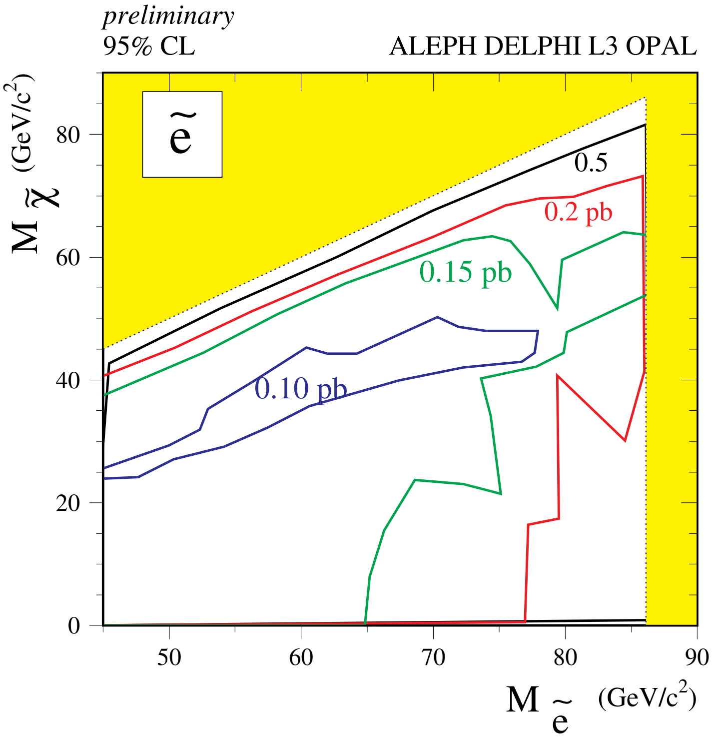
$H \rightarrow \gamma\gamma$

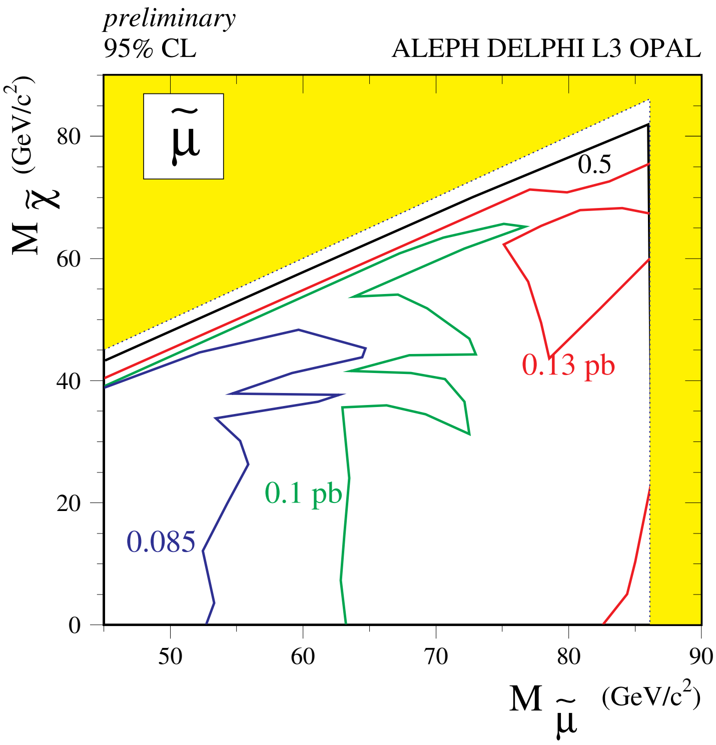


Sleptons

LEP combined results

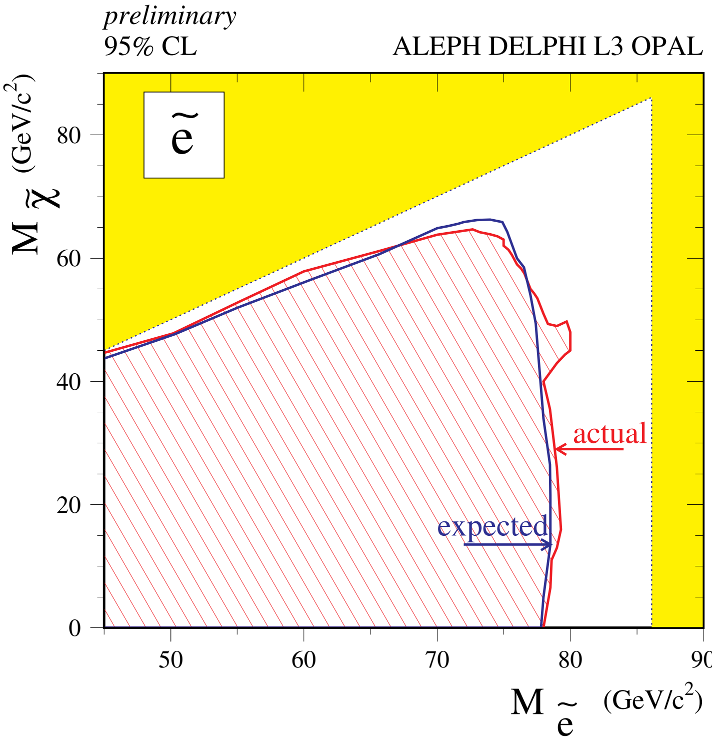
Cross-section limits

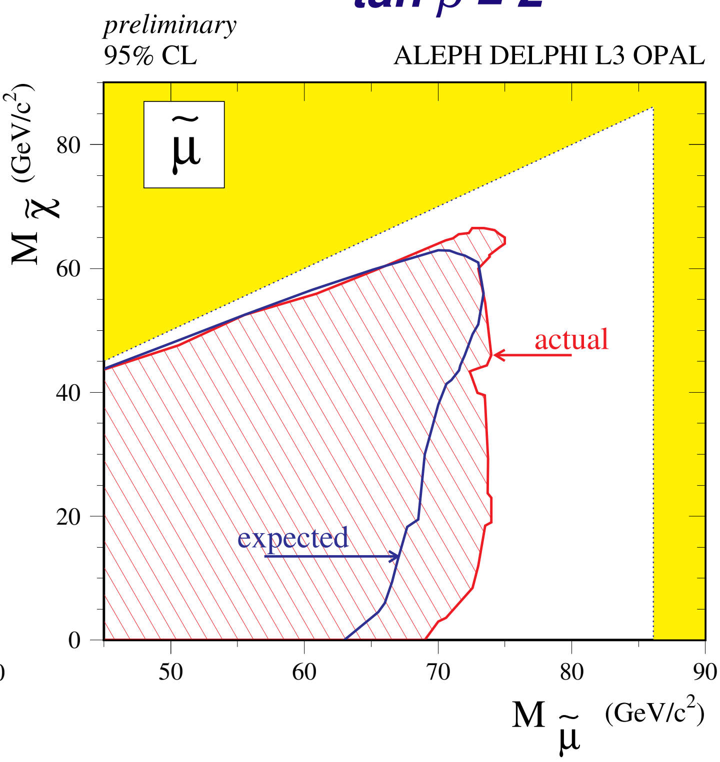




MSSM limits

μ = -200 GeV
tan β = 2

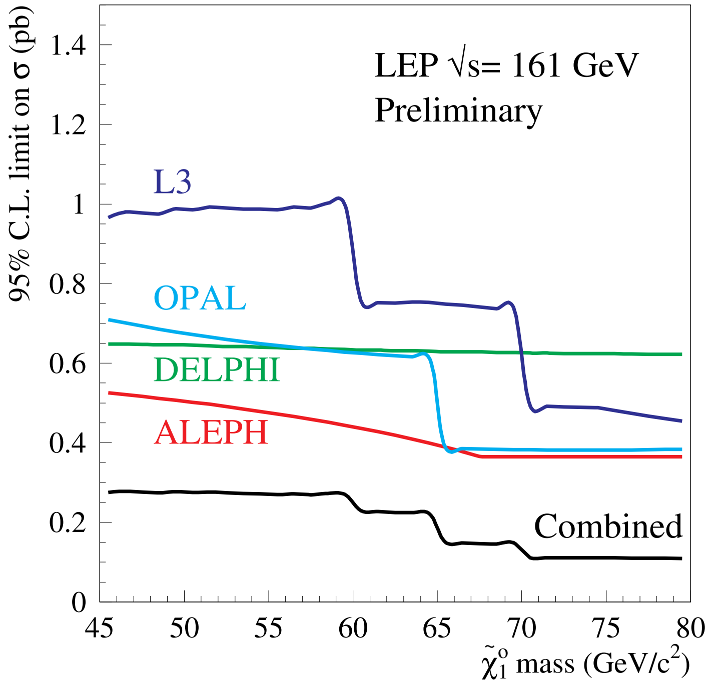


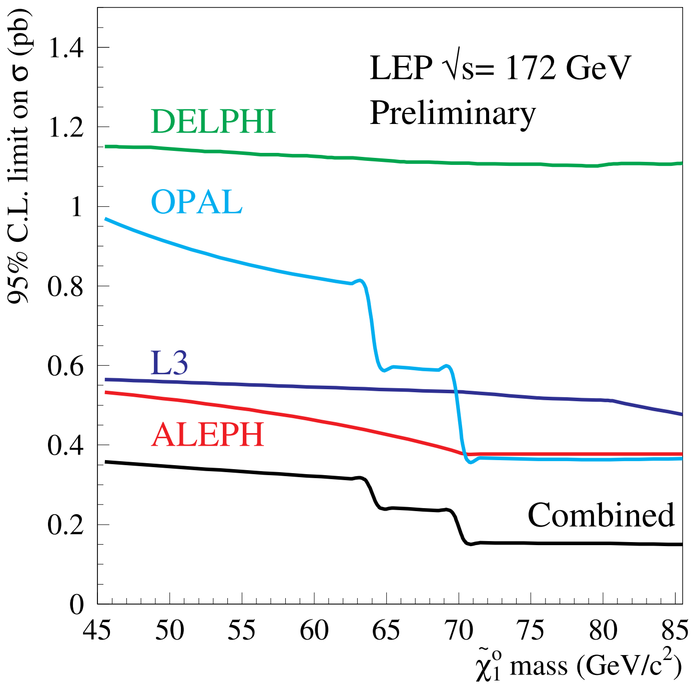


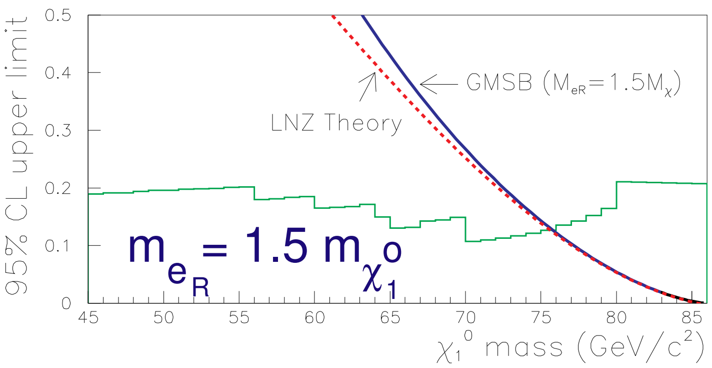
Acoplanar photon events

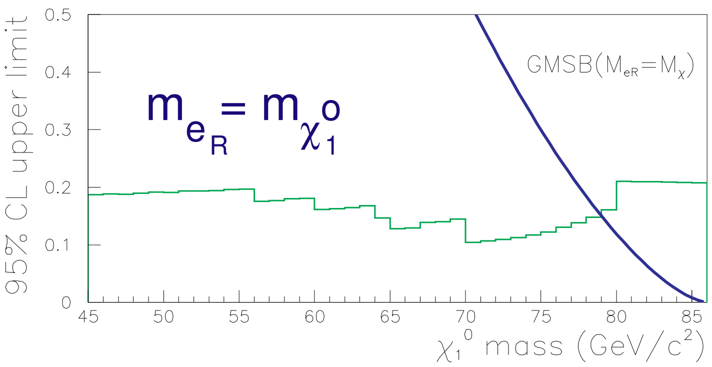
LEP Combined

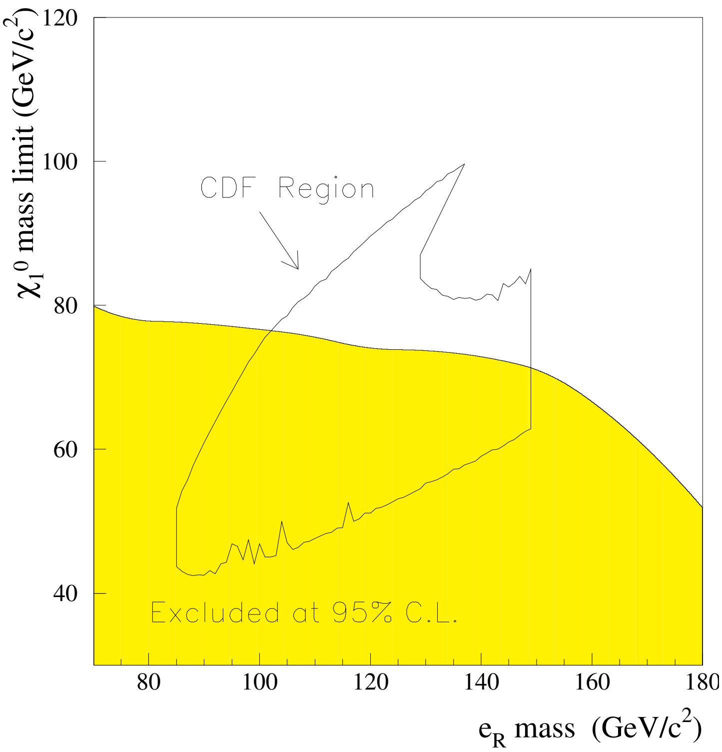
cross-section limits











Long-lived heavy charged particles

Most SUSY searches assume the LSP is neutral and weakly interacting and that all SUSY particles ultimately decay with a very short lifetime into the LSP plus standard particles.

HOWEVER the possibility of SUSY long-lived charged particles is favoured by some models.

For instance, in gauge-mediated SUSY models, if the slepton is the next-to-lightest supersymmetric particle (NLSP), it can decay into a standard lepton and a gravitino which is assumed to be the LSP:

$$\tilde{l}^{\pm} \rightarrow l^{\pm} \tilde{G}$$

with a lifetime dependent on the SUSY-breaking energy scale $\sqrt{F}$ ***:***

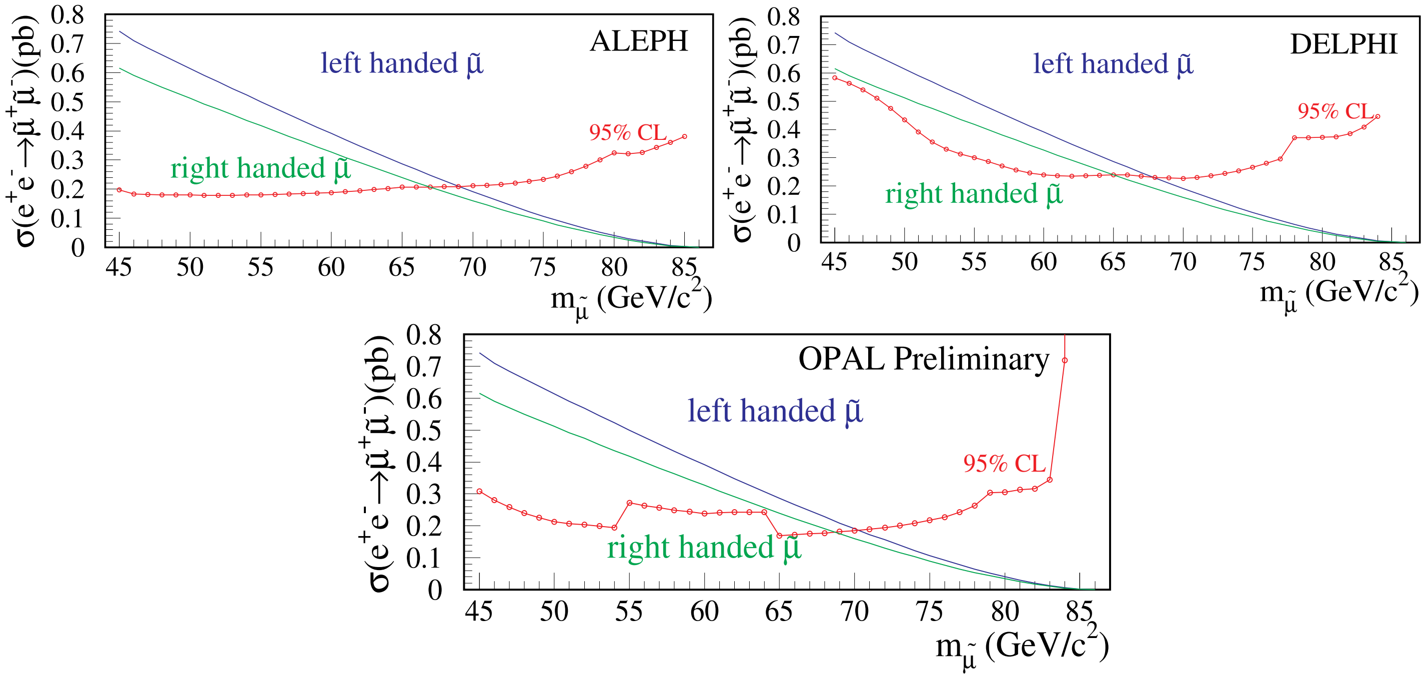
$$c\tau = (130\ \mu m)\ (100\ GeV/m_{\tilde{l}})^5\ (\sqrt{F}/100\ TeV)^4$$

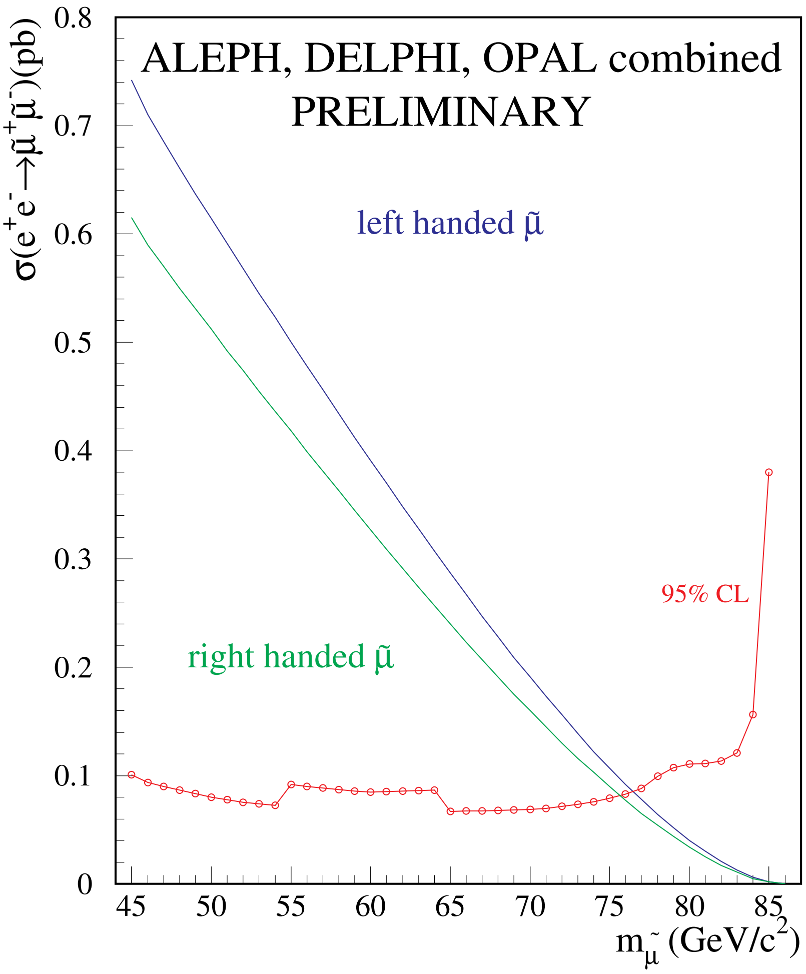
If $\sqrt{F}$ ***>> a few thousand TeV, a 70 GeV slepton has a decay length greater than 10 meters, which corresponds to the typical size of a LEP experiment detector.***

Long-lived charged SUSY particles also exist in the context of SUSY models if there is a high mass degeneracy with the LSP and also in RPV SUSY models if the couplings are small.

The selection is based on the specific ionization loss measurements (dE/dx) . DELPHI also uses the particle ID provided by the RICH detectors.

Long-lived heavy charged particles





95% CL upper limit on the production cross-section of 0.1-0.4 pb for masses between 45 and 86 GeV

Assuming MSSM:

$m_{\tilde{\mu}_R^{\pm}, \tilde{\tau}_R^{\pm}} > 75.6$ GeV

$m_{\tilde{\mu}_L^{\pm}, \tilde{\tau}_L^{\pm}} > 76.5$ GeV

Conclusions

- **Many searches for physics beyond the SM have been performed with the data available from LEP 2**
- **So far, no excess of events in any of the presented topologies has been observed $\rightarrow$ limits on charginos, neutralinos, Higgs bosons and several other SUSY particles have been derived. These limits greatly improve the limits obtained with LEP data at the Z^0 peak. Some limits already derived with the 1997 data.**
- **With more LEP data let's hope to finally discover something!**