

Search for gauge mediated supersymmetry breaking

ALEPH



DELPHI

LEP

L3



OPAL

$$E_{cm} = 189 - 209 \text{ GeV}$$

(Collected during the years 1998, 1999 & 2000)

$$\int \mathcal{L} dt \sim 4 \times 600 \text{ pb}^{-1}$$

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DPF2002 - Williamsburg



**Hidden
sector**

SUSY breaking

**Messenger
sector**

M, \sqrt{F}

**Observable
sector**

$\Lambda, \text{SP, SM}$

Minimal GMSB

- \sqrt{F} , SUSY breaking in the messenger sector
- M , Messenger mass scale
- N , Messenger index
- $\tan(\beta)$, Ratio of the VEV from the two Higgs doublets
- $\text{sign}(\mu)$, Sign of the Higgs sector mixing parameter
- $m_{\tilde{G}}$, Gravitino mass

$\Lambda = F/M$, effective SUSY breaking scale
(determine the super-partner mass spectrum)

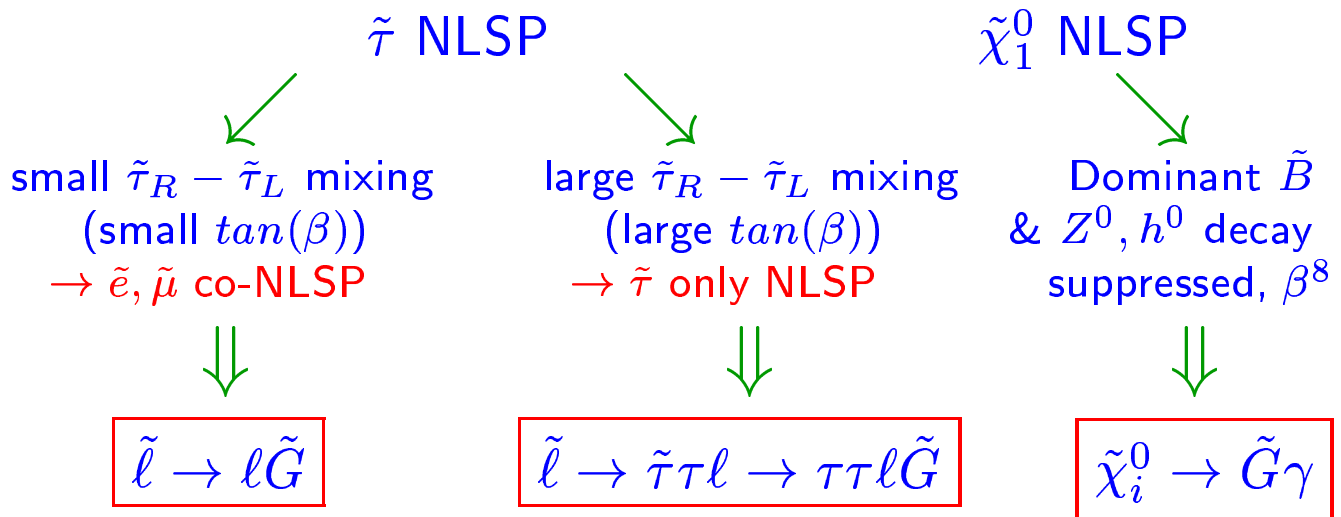
R-parity conservation \Rightarrow **Stable LSP**

The Gravitino (\tilde{G}) is the LSP for any relevant \sqrt{F} ,
(Implied by FCNC).

$$SP \rightarrow NLSP \rightarrow LSP \quad (\tilde{G})$$

Where the NLSP, for different sets of the parameters, is either the $\tilde{\chi}_1^0$ or the $\tilde{\tau}$

Decay of the NLSP



Average decay distance for the NLSP

$$L = f(m_{\tilde{G}}^2, m_{NLSP}^{-5})$$



- $L \ll detector$, Instant decay of the NLSP ($\rightarrow \Lambda$)
- $L \sim detector$, Tracks with large impact parameters (IP) or kinks ($\rightarrow \Lambda$ & $m_{\tilde{G}}$)
- $L \gg detector$, Heavy stable NLSP ($\rightarrow \Lambda$)



$$e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}\gamma\tilde{G}$$

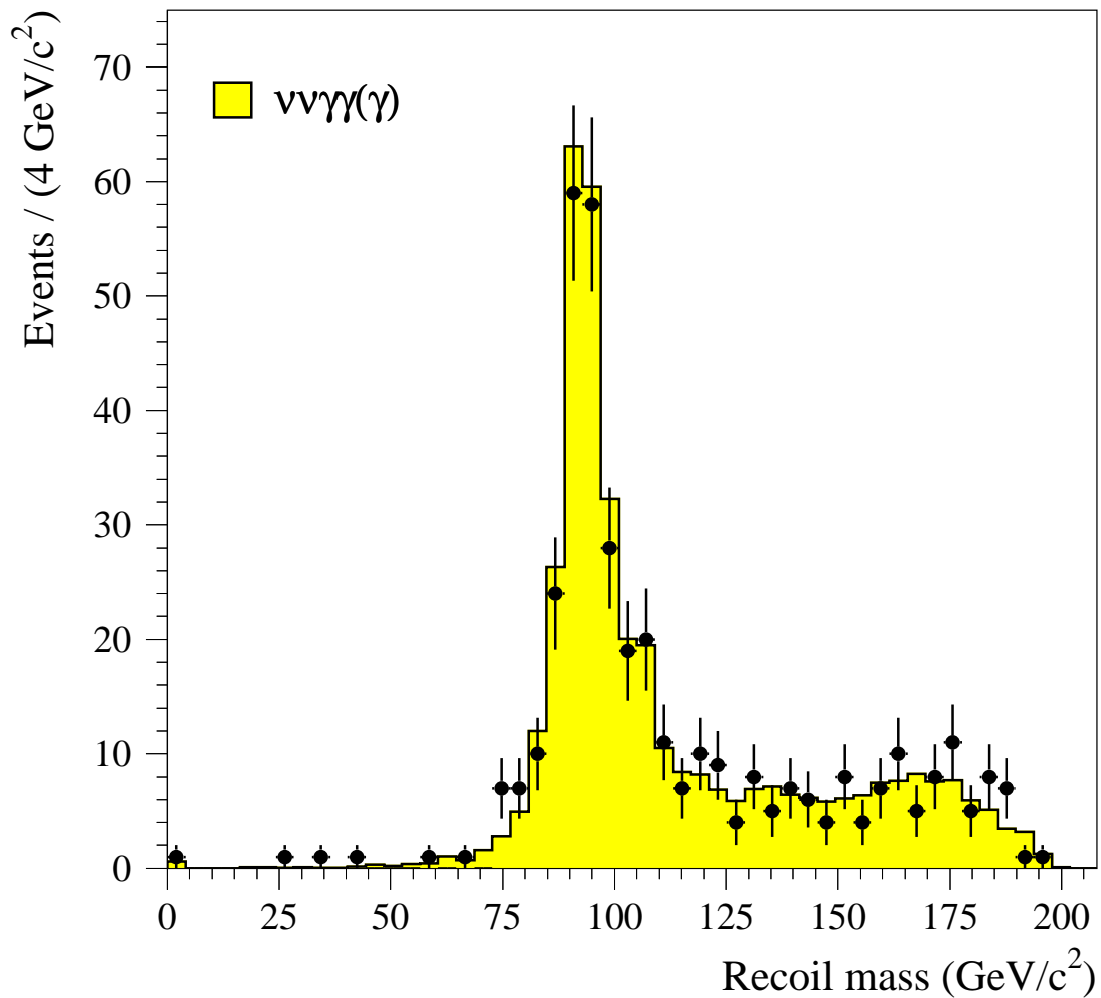
$L \ll \text{detector}$
2 acoplanar $\gamma + \cancel{E}$

Recoil mass distribution

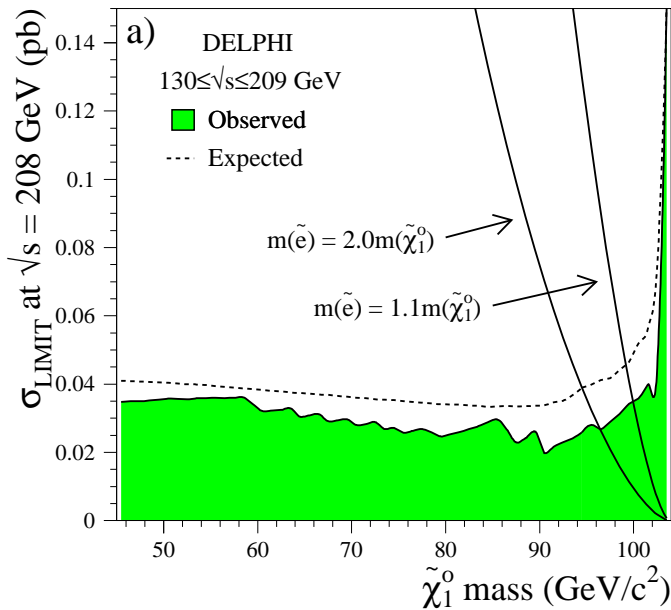
 $130 \leq \sqrt{s} \leq 208$ GeV

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preliminary



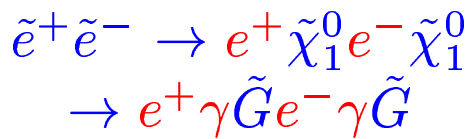
Cross section limit



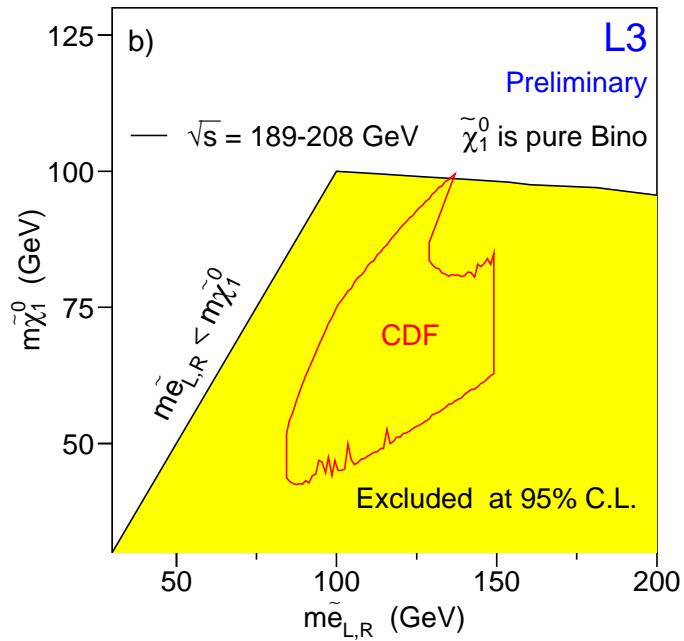
$$\sigma(\tilde{\chi}_1^0 \tilde{\chi}_1^0) < 0.036 \text{ pb}$$

$$m_{\tilde{\chi}_1^0} < 100 \text{ GeV}/c^2$$

CDF event:



$m_{\tilde{e}} - m_{\tilde{\chi}_1^0}$ Exclusion



$$e^+e^- \rightarrow \tilde{\chi}_1^0 \tilde{G} \rightarrow \gamma \tilde{G} \tilde{G}$$

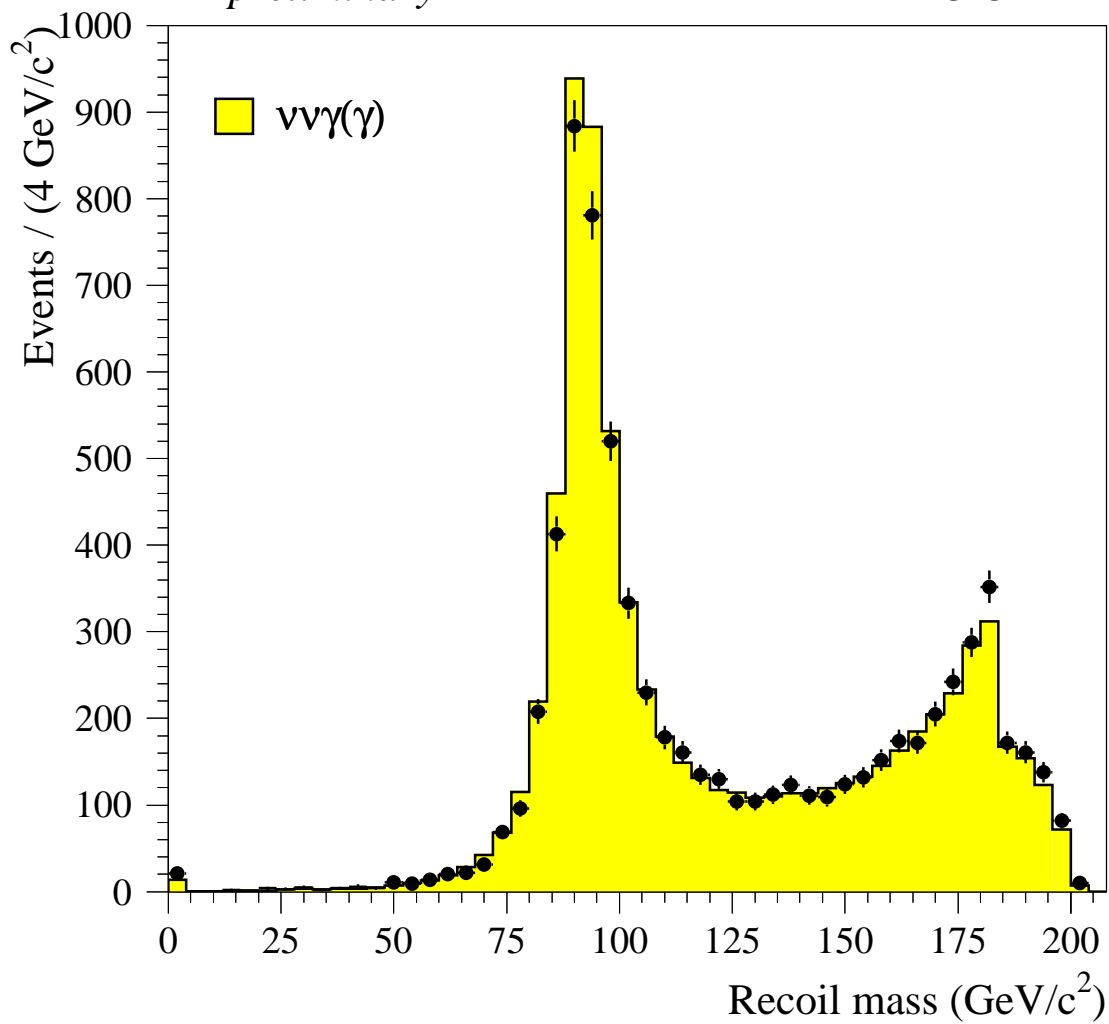
$L \ll \text{detector}$
Single $\gamma + \cancel{E}$

Recoil mass distribution

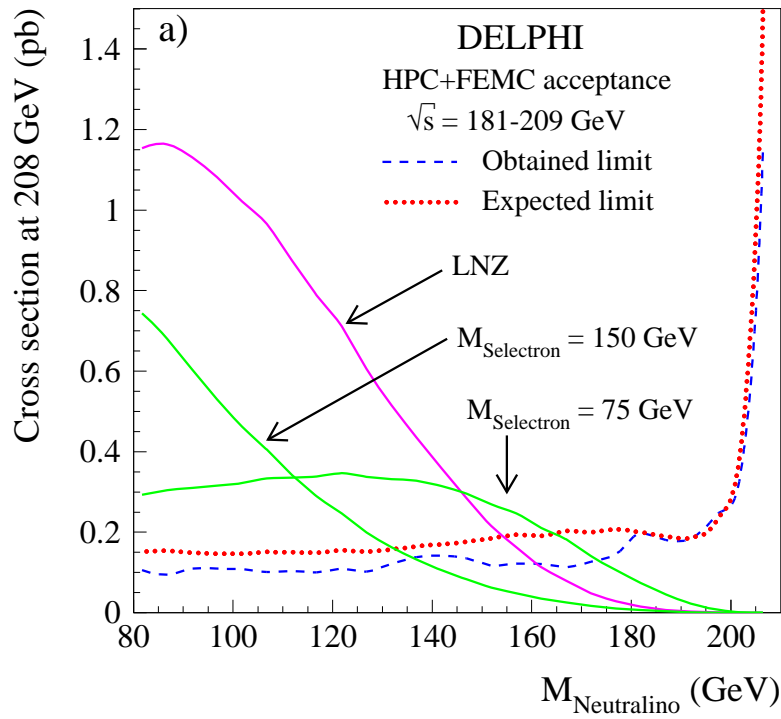
 $130 \leq \sqrt{s} \leq 208$ GeV

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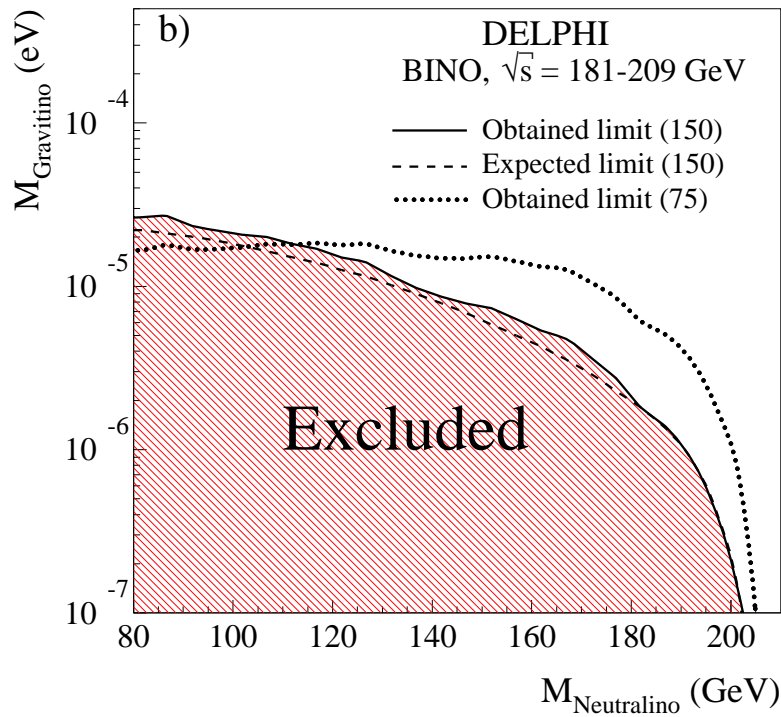
preliminary



Cross section limit



$m_{\tilde{\chi}_1^0} - m_{\tilde{G}}$ Exclusion



$$e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}\gamma\tilde{G}$$

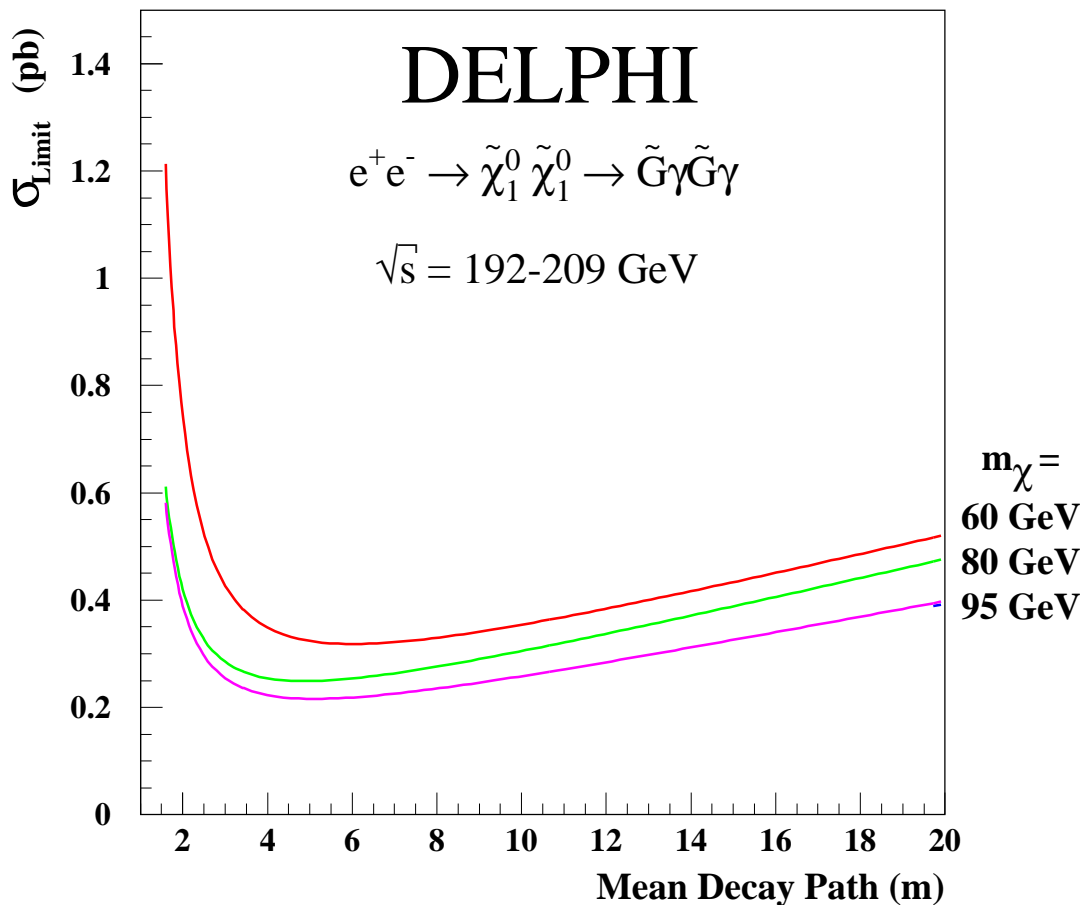
$L \sim \text{detector}$
1 Non-pointing γ

DELPHI, $E_{cm} = 192 - 209$ GeV

Observed # events: 16

Expected # events: 15

Cross section limit



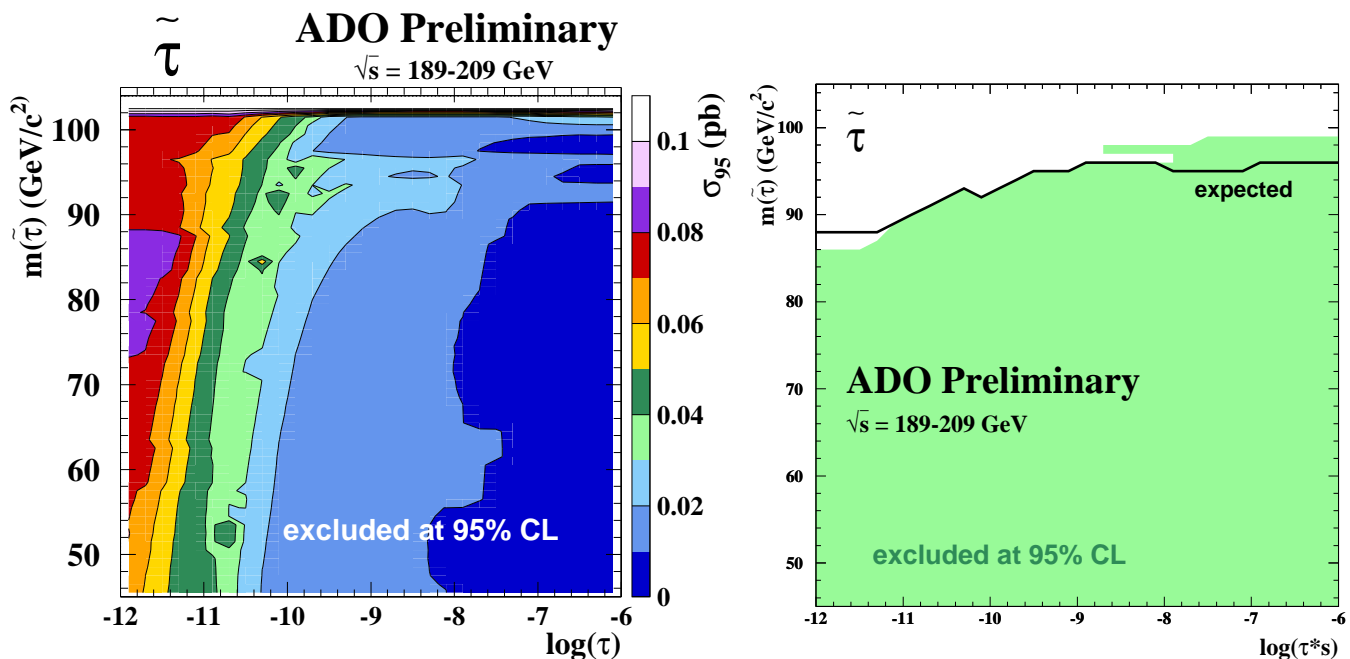
$$e^+e^- \rightarrow \tilde{\tau}^+\tilde{\tau}^- \rightarrow \tau^+\tilde{G}\tau^-\tilde{G}$$

Any $\tilde{\tau}_R - \tilde{\tau}_L$ mixing ($\tan(\beta)$)

$$2\ell + \cancel{E}$$

2 tracks with large IP or kinks
2 tracks with anomalous dE/dx

Cross section and Exclusion plots (co-NLSP) in the $\log(\tau) - m_{\tilde{\tau}}$ plane



$$m_{\tilde{\tau}} > 86.1 \text{ GeV}/c^2 \text{ } (\tilde{\ell} \text{ co-NLSP})$$

$$m_{\tilde{\tau}} > 85.6 \text{ GeV}/c^2 \text{ } (\tilde{\tau} \text{ NLSP})$$

$$e^+e^- \rightarrow \tilde{l}^+\tilde{l}^- \rightarrow l^+\tilde{G}l^-\tilde{G}$$

$$\tilde{l} = \tilde{\mu}, \tilde{e}$$

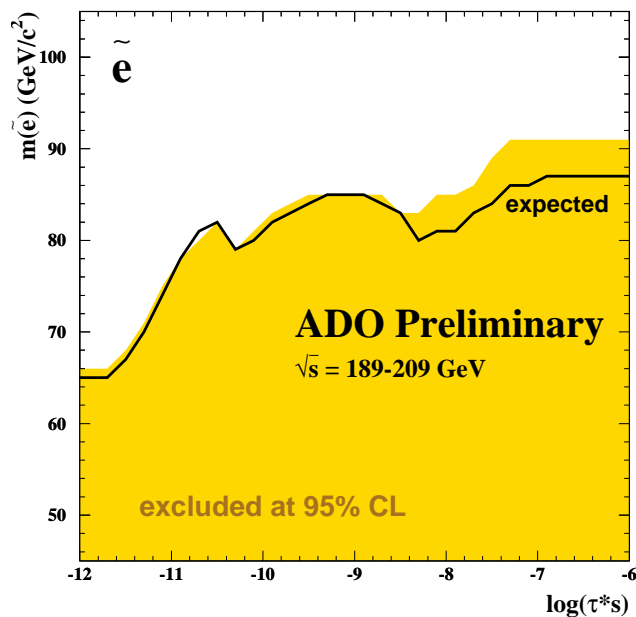
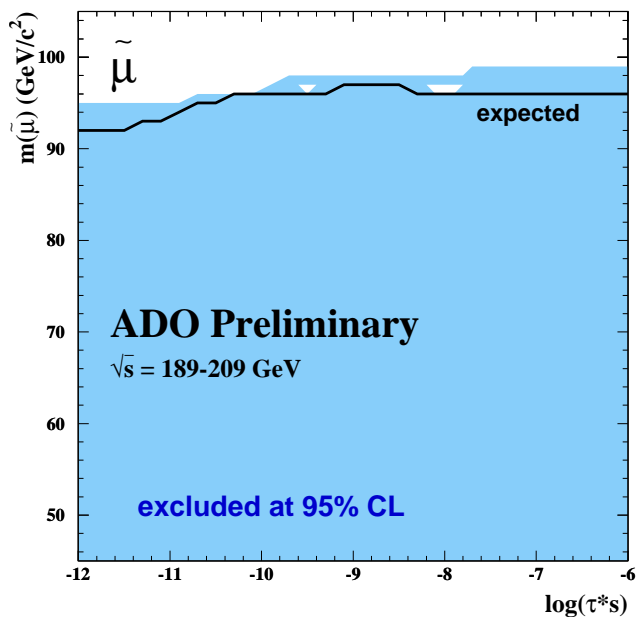
Small $\tilde{\tau}_R - \tilde{\tau}_L$ mixing ($\tan(\beta)$)

$$2l + \cancel{E}$$

2 tracks with large IP or kinks

2 tracks with anomalous dE/dx

Exclusion plots in the $m_{\tilde{l}} - \log(\tau)$ plane



$$m_{\tilde{\mu}} > 95.2 \text{ GeV}/c^2$$

$$m_{\tilde{e}} > 66.0 \text{ GeV}/c^2$$

$$e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0 \rightarrow \tilde{\ell}^\pm\tilde{\ell}^\mp\tilde{\ell}^\pm\tilde{\ell}^\mp \rightarrow \ell^\pm\ell^\mp\tilde{G}\ell^\pm\ell^\mp\tilde{G}$$

$$\tilde{\ell} = \tilde{\tau}, \tilde{\mu}, \tilde{e}$$

$$L \leq 3m$$

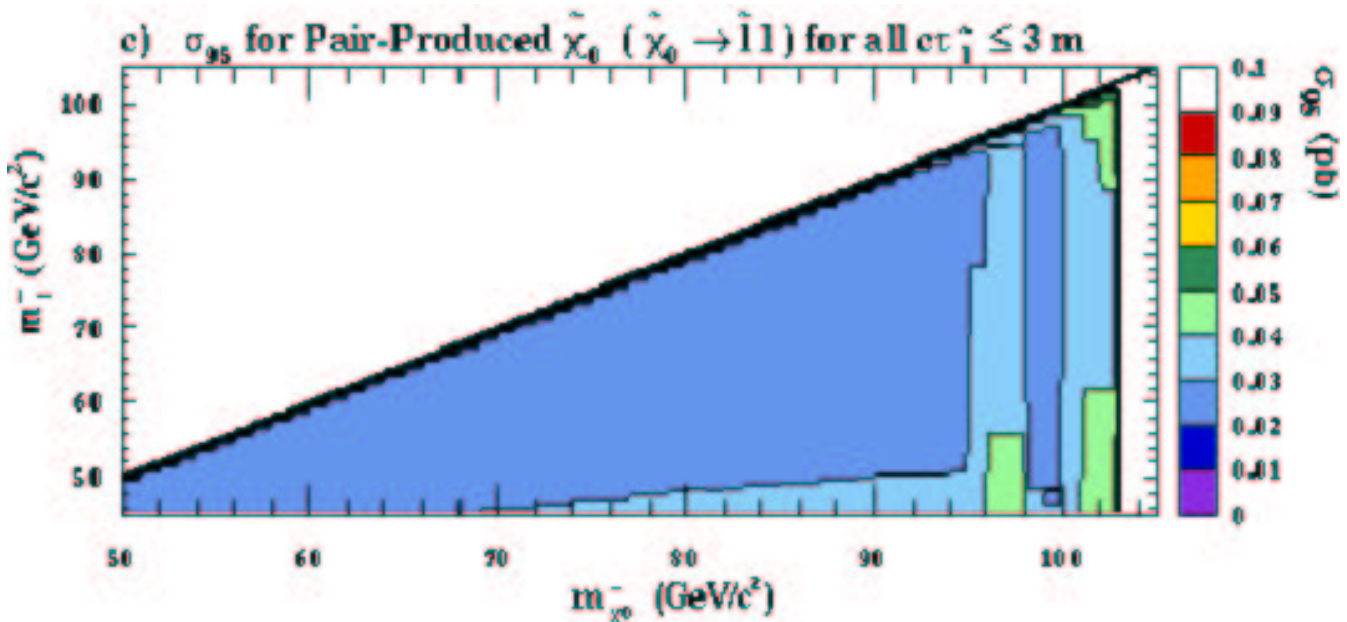
Small $\tilde{\tau}_R - \tilde{\tau}_L$ mixing ($\tan(\beta)$)

$$4\ell + \cancel{E}$$

2 tracks + 2 tracks with large IP or kinks

OPAL, $E_{cm} = 189 - 209$ GeV

**Cross section limit
in the $m_{\tilde{\chi}_1^0} - m_{\tilde{\ell}}$ plane**



$$\sigma(\tilde{\chi}_1^0\tilde{\chi}_1^0) < 0.06 \text{ pb}$$

No excess observed



Cross section and exclusion limits have been set

$\tilde{\chi}_1^0$ **NLSP:**

$$\sigma(\tilde{\chi}_1^0 \tilde{\chi}_1^0) < 0.036 \text{ pb}$$

$$L \ll \text{Detector} \ \& \ m_{\tilde{\chi}_1^0} < 100 \text{ GeV}/c^2$$

Interpretation of the CDF event excluded

$\tilde{\tau}$ **NLSP:**

$$m_{\tilde{\tau}} > 85.6 \text{ GeV}/c^2$$

$\tilde{\ell}$ **co-NLSP:**

$$m_{\tilde{\tau}} > 86.1 \text{ GeV}/c^2$$

$$m_{\tilde{\mu}} > 95.2 \text{ GeV}/c^2$$

$$m_{\tilde{e}} > 66.0 \text{ GeV}/c^2$$

Further LEP GMSB results,

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<http://lepsusy.web.cern.ch/lepsusy/Welcome.html>

