# Single and Multi-Photon Events with Missing Energy in $e^+e^-$ Collisions at $\sqrt{s} = 189$ GeV with the L3 detector


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# Introduction

**General framework :**

**Search for Supersymmetry with $R_p$ conserved**
**Lightest Supersymmetric Particle is stable**

**Search for new particles A and B**

$$A \longrightarrow B\gamma$$

**where B is invisible**

$$\tilde{\chi}^0_2 \longrightarrow \tilde{\chi}^0_1\gamma \qquad \text{or} \qquad \tilde{\chi}^0_1 \longrightarrow \tilde{G}\gamma$$

**At LEP**

$$e^+e^- \longrightarrow AB \Longrightarrow \text{Single Photon}$$

$$e^+e^- \longrightarrow AA \Longrightarrow \text{2 Acoplanar Photons} + \not{E}$$

**Data collected in 98 with the L3 detector**

- $\sqrt{s} = 189$ GeV
- $\mathcal{L} = 176\ \mathrm{pb}^{-1}$

**All results are preliminary**

# Analysis

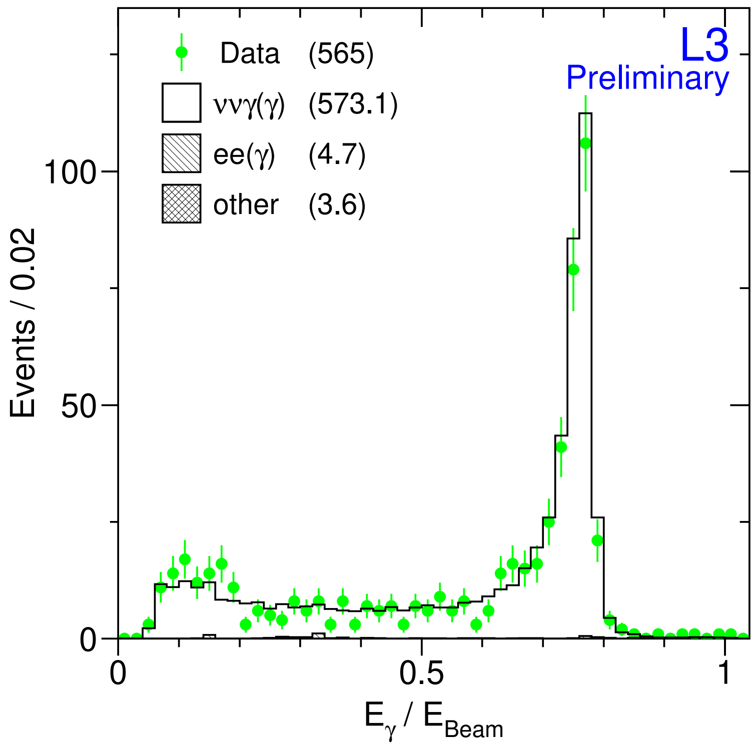
## Single Photon :

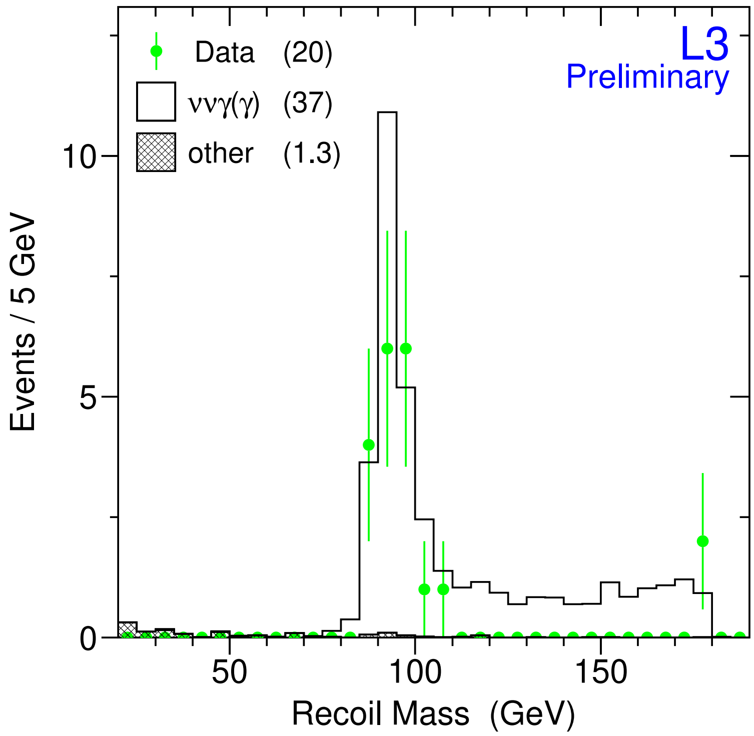
- $E_\gamma \geq 5$ GeV
- $\theta_\gamma \geq 15^\circ$ from beam pipe
- Only one significant energy deposit
- Energy deposit compatible with a photon

## 2 Acoplanar Photons :

- $E_{\gamma 1} \geq 5$ GeV, $E_{\gamma 2} \geq 1$ GeV
- Acoplanarity $> 5.2^\circ$ and Acollinearity $> 8.1^\circ$
- Recoil Mass greater than 20 GeV/$c^2$
- $P_{t\gamma\gamma} \geq 3$ GeV
- $\theta_{miss} > 12^\circ$ from beam pipe

# Energy and Mass Distributions



# Checks

A $3\sigma$ deficit of data compared to MC prediction for 2 photons

Many checks were done to understand the discrepancy :

- ♣ A second independant analysis
- ♣ Trigger and performance of the electromagnetic calorimeter checked using events with similar topology (bhabha and $e^+e^- \to \gamma\gamma(\gamma)$)
- ♣ Detector noise studied with randomly triggered events
- ♣ Comparison of generators

No explanation found

It could be a statistical fluctuation

# Results

- **No excess of events found in single and 2 photons signals**

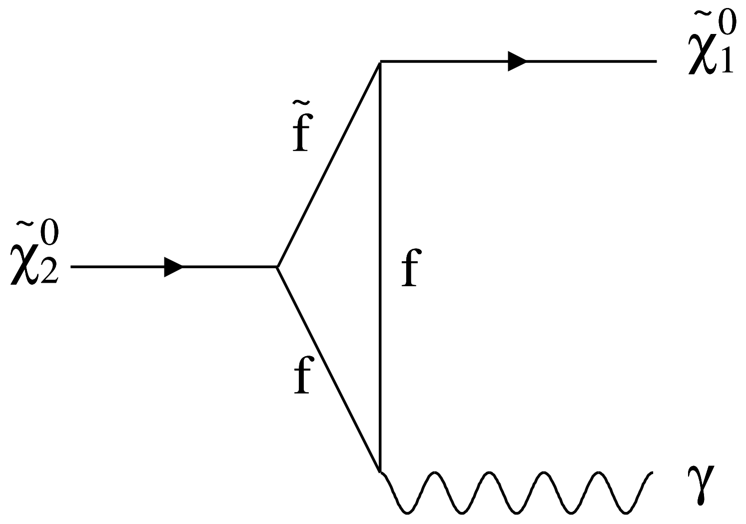
- **derivation of exclusion plots in various SUSY models**

- **Many of those models were used to explain the CDF event:**

$$\mathbf{p\bar{p} \rightarrow e^+e^-\gamma\gamma}\ \not{E}_T$$

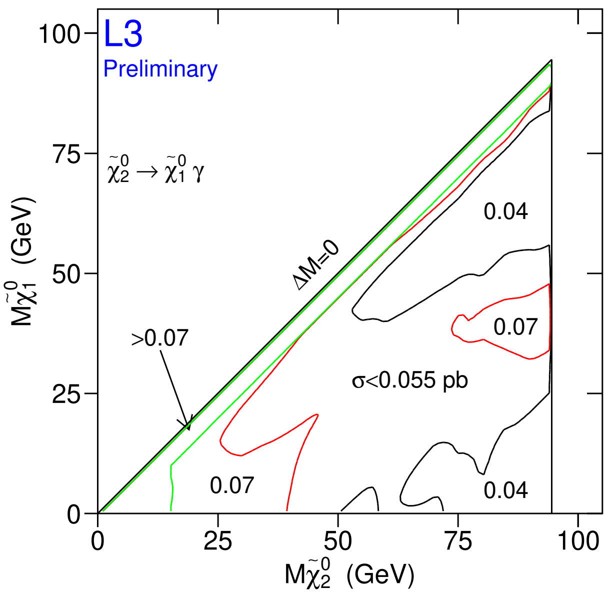
# Supergravity-MSSM

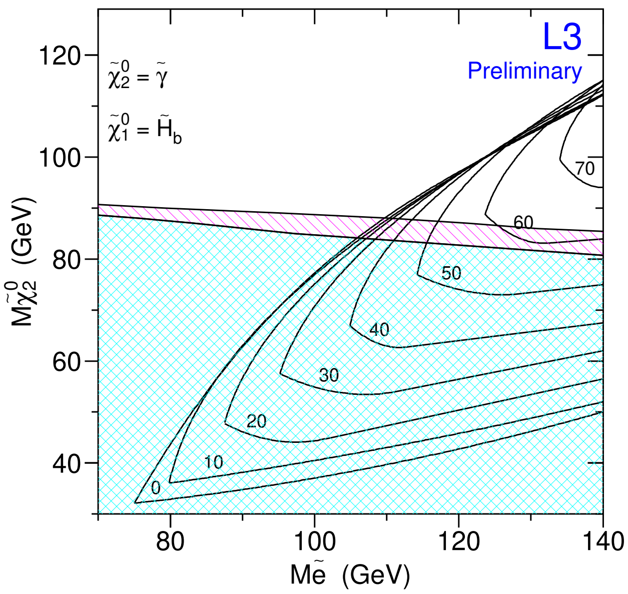
## Radiative Decay of the $\tilde{\chi}_2^0$




## High Branching Ratio if $\tilde{\chi}_1^0$ and $\tilde{\chi}_2^0$ are of opposite nature : higgsino x gaugino

Cross-section of $e^+e^- \rightarrow \tilde{\chi}_2^0\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0\gamma\gamma$ ( BR=1 )



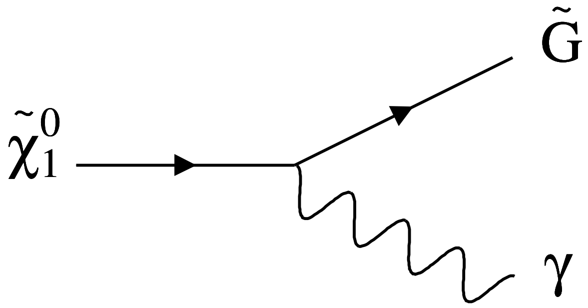




$p\bar{p} \rightarrow \tilde{e}^+\tilde{e}^-X$

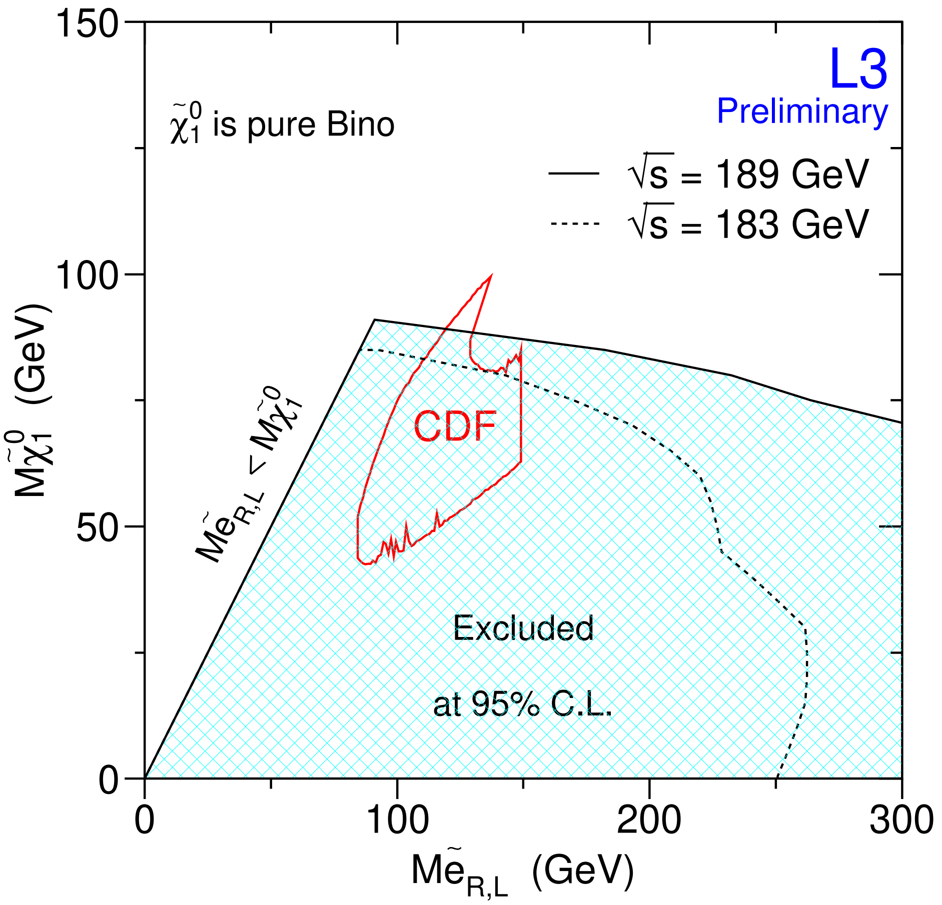
$\tilde{e}^+\tilde{e}^- \rightarrow e^+e^-\tilde{\chi}_2^0\tilde{\chi}_2^0 \rightarrow e^+e^-\tilde{\chi}_1^0\tilde{\chi}_1^0\gamma\gamma$

# GMSB

- **New U(1) gauge interaction to propagate SUSY breaking**
- **LSP is a light gravitino $\tilde{G}$ (1 eV $< M_{\tilde{G}} <$ 1 keV)**



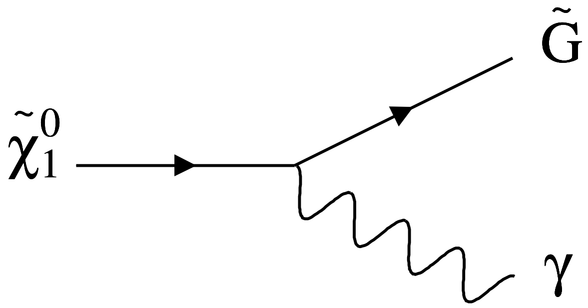

$$e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0 \to \tilde{G}\tilde{G}\gamma\gamma$$




$$p\bar{p} \to \tilde{e}^+\tilde{e}^-X$$
$$\tilde{e}^+\tilde{e}^- \to e^+e^-\tilde{\chi}_1^0\tilde{\chi}_1^0 \to e^+e^-\tilde{G}\tilde{G}\gamma\gamma$$

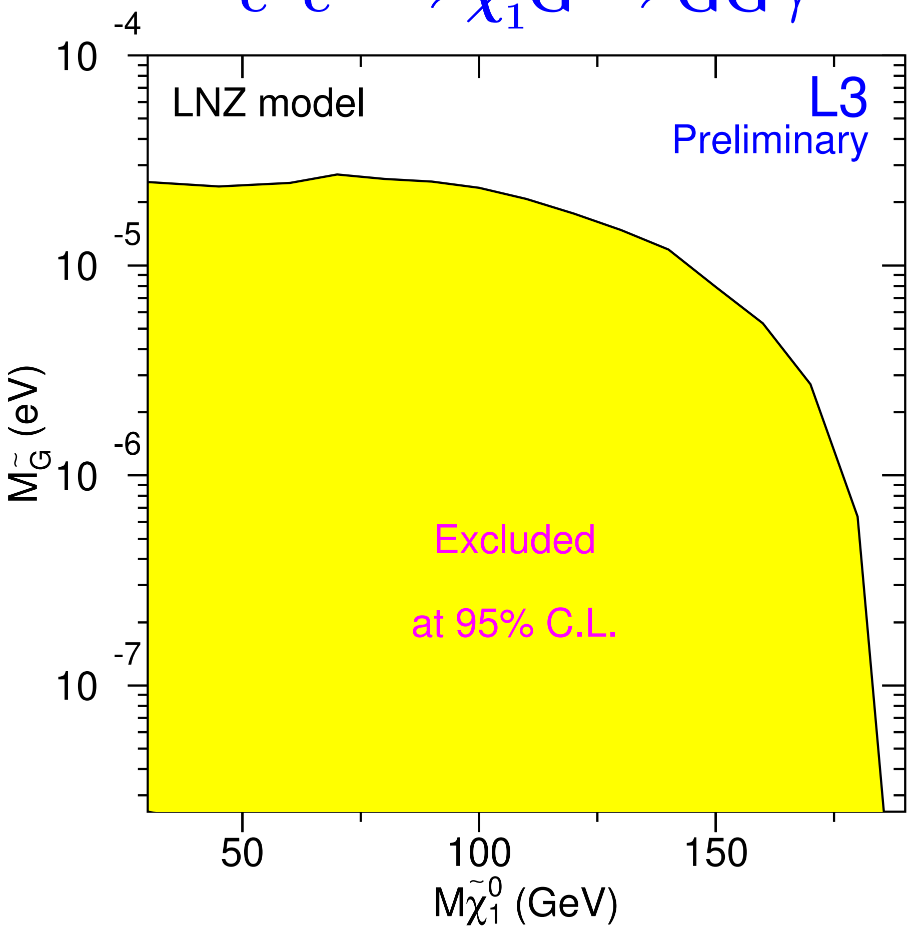
# No-scale Supergravity : LNZ

- Phenomenologically similar to GMSB




- LSP is a very light gravitino and NLSP is a bino-like $\tilde{\chi}_1^0$
- The mass spectrum is determined by the gravitino mass and one other parameter

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



# Conclusions

- a 3 $\sigma$ deficit for 2 acoplanar photons

- No evidence of New Physics was found in photonic signals at $\sqrt{s}$= 189 GeV

- New preliminary excluded regions were derived in $M_{\tilde{\chi}_2^0}$-$M_{\tilde{e}}$ plane (MSSM), $M_{\tilde{\chi}_1^0}$-$M_{\tilde{e}}$ plane (GMSB) and $M_{\tilde{\chi}_1^0}$-$M_{\tilde{G}}$ plane (LNZ)

- The GMSB explanation of the CDF Event is almost ruled out in the $\tilde{e}$ pair production scenario