Search for R–parity violation with the L3 detector at LEP II

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L3 Collaboration

- R–parity violating $\tilde{\nu}$ exchange in $\mathrm{e^+e^-} \rightarrow \mathrm{e^+e^-}, \mu^+\mu^-$
- R–parity violating $\tilde{\mathrm{q}}$ exchange in $\mathrm{e^+e^-} \rightarrow \mathrm{q\bar{q}}$
- R–parity violating neutralino and chargino decays

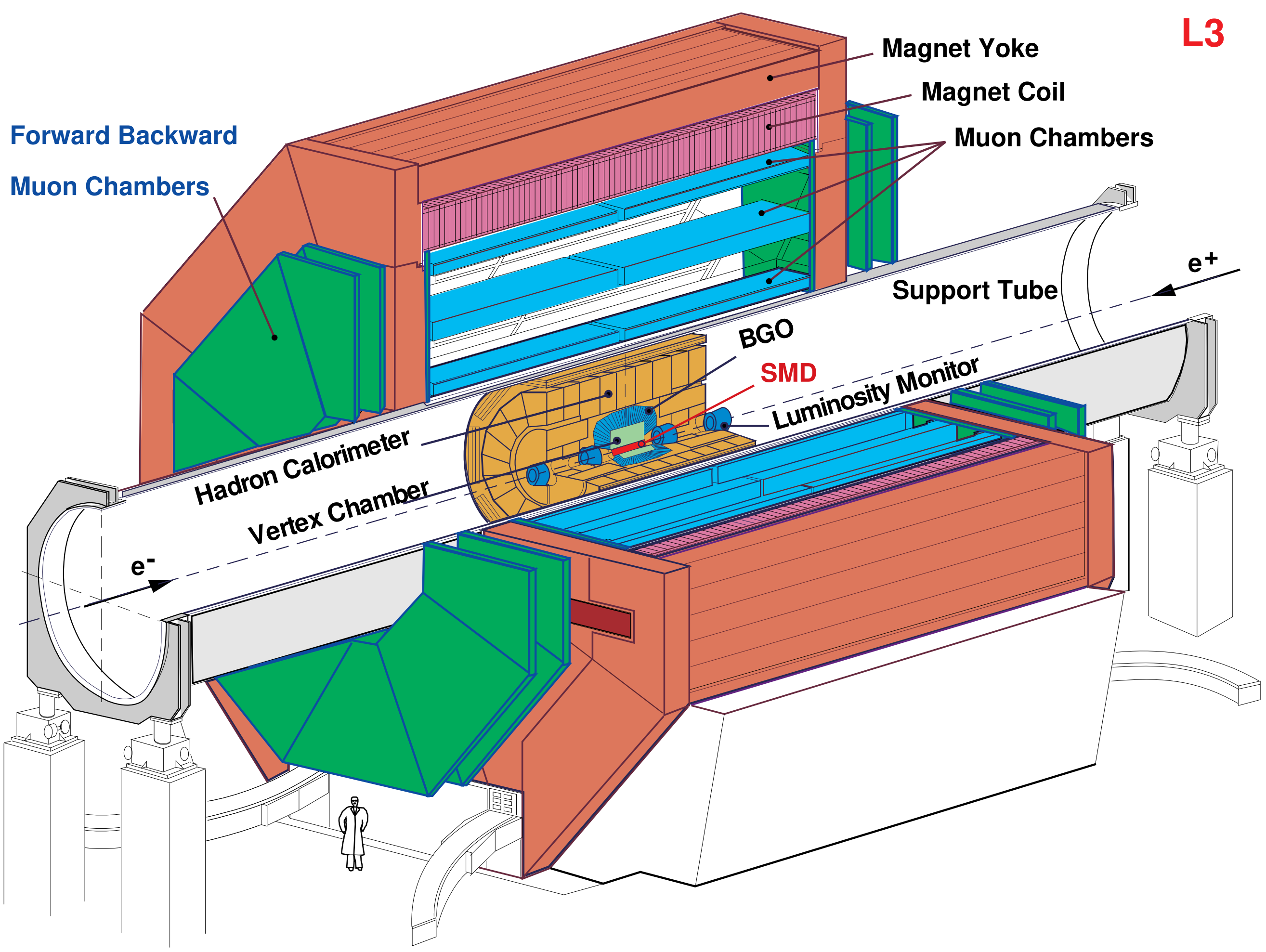
Introduction

- R–parity:

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

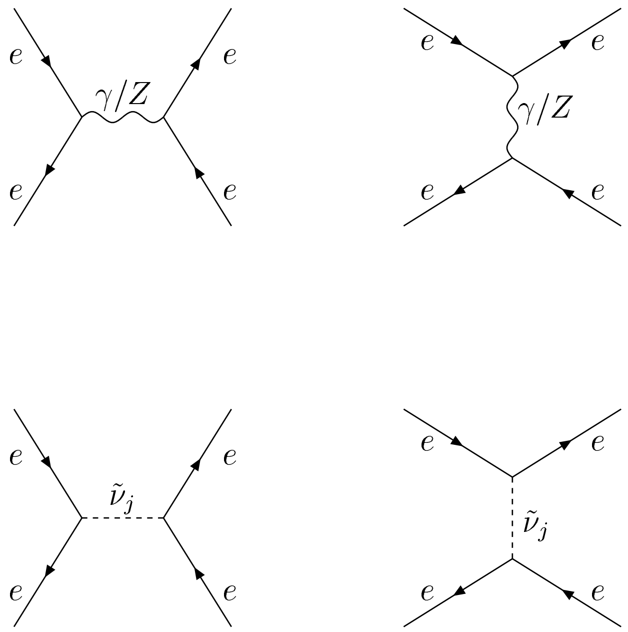
- R–parity conserved:
  SUSY particles produced in pairs,
  LSP ($\tilde{\chi}_0^1$) stable
- $\not{R}_p$:
  single production of SUSY particles allowed
  LSP decays
- Exclusion limits from R_p conservation are not valid under $\not{R}_p$

The L3 Detector



$\not{R}_p$ sneutrino exchange

- $e^+e^- \to e^+e^-, \;\; e^+e^- \to \mu^+\mu^-$
- Additional contributions to σ and A_{fb} from $\lambda_{ijk} L_i L_j \overline{E_k}$



$\not{R}_p$ sneutrino exchange

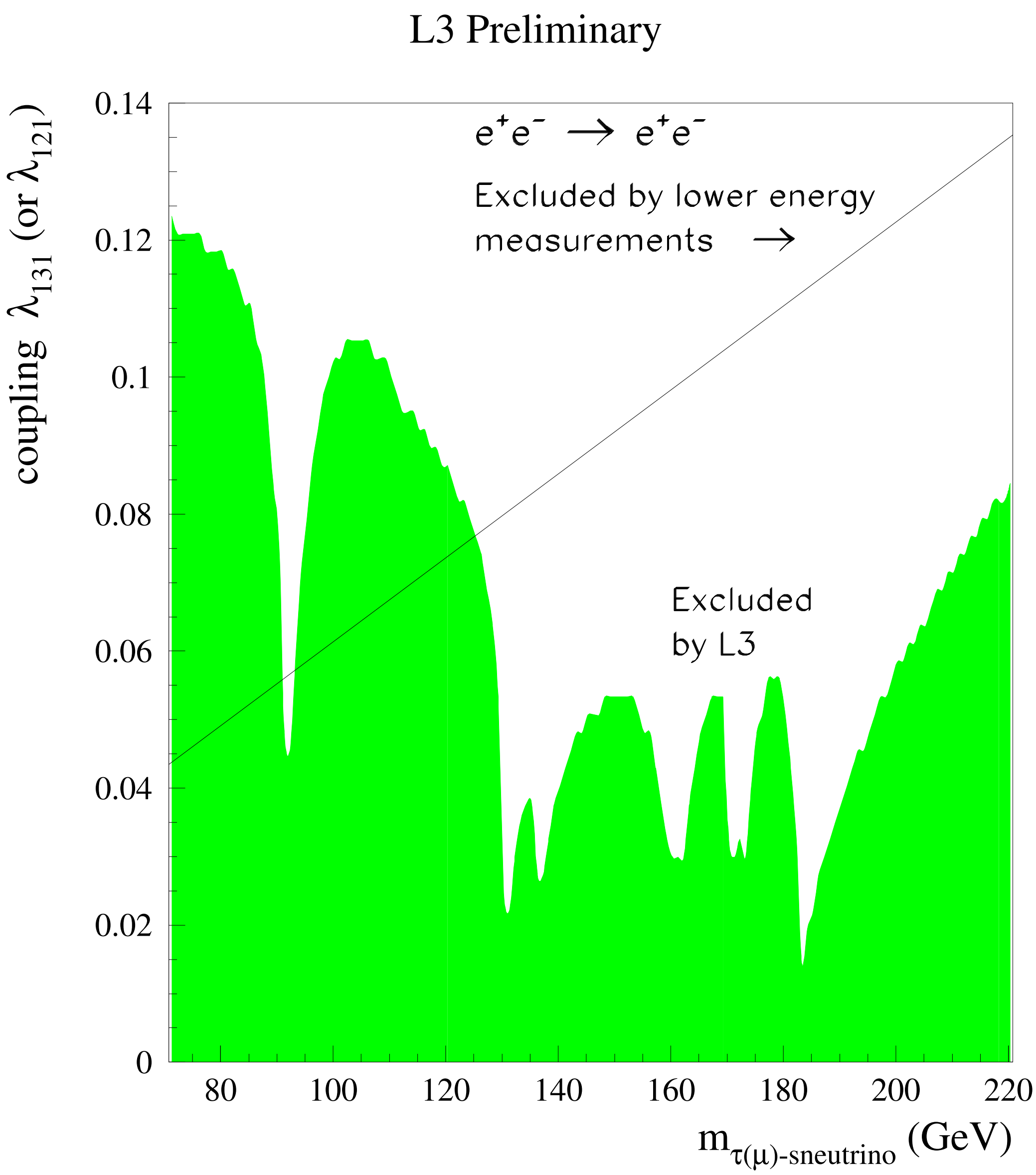
- L3 1995–97 data, $\sqrt{s} = 130.3 - -182.7$ GeV
- Reject ISR: $\sqrt{\mathrm{s}'} > 0.85\sqrt{\mathrm{s}}$
- Deviations from SM due to sneutrino exchange: J.Kalinowski, R. Rüeckl, H. Spiesberger and P. Zerwas, DESY 97-044
- $\mathrm{m}_{\tilde{\nu}}$: 60–260 GeV

  λ: 0.01–0.20

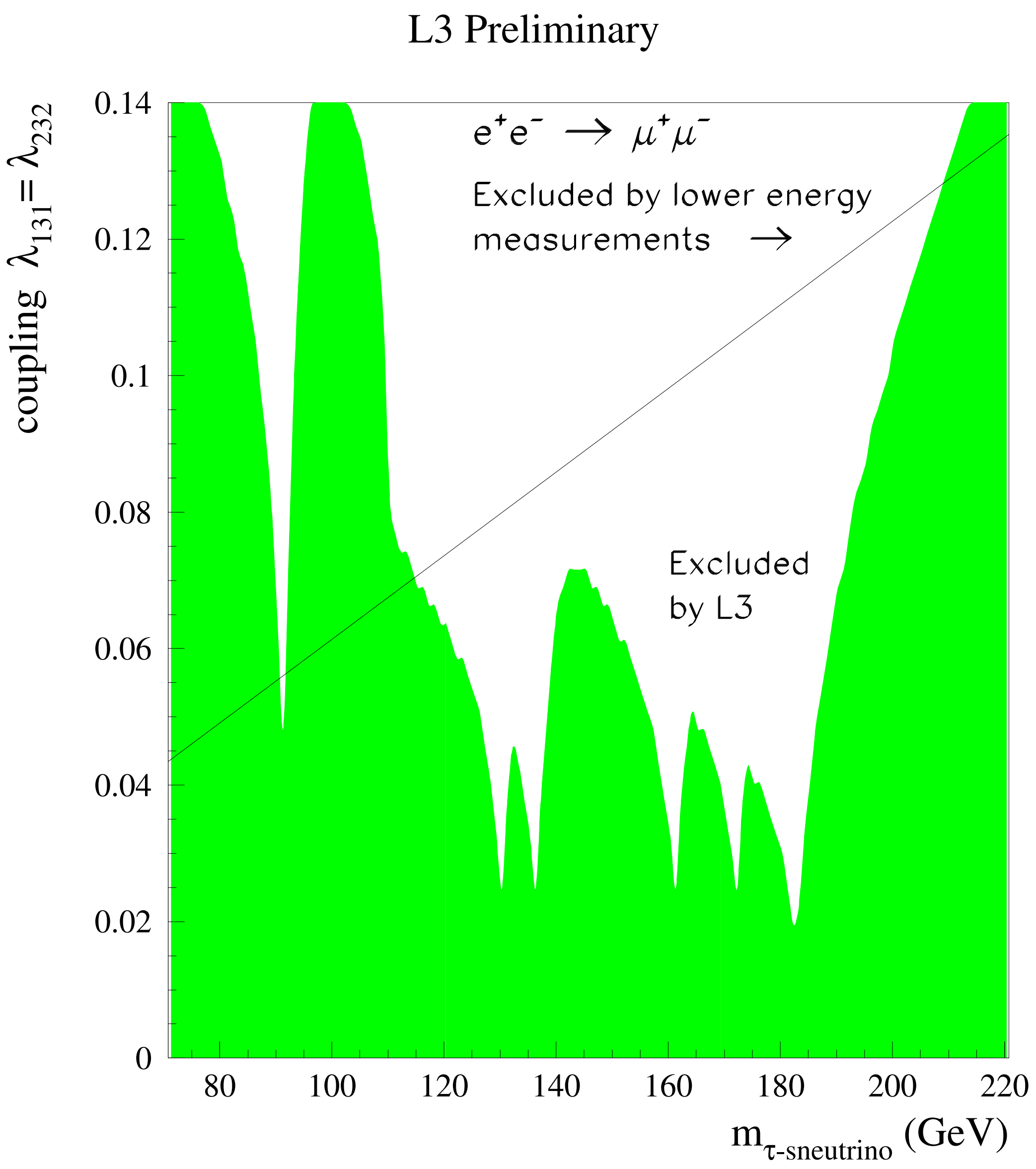
$$-\ln \mathrm{L} = \sum \left(\frac{(\sigma - \sigma^{\mathrm{meas}})^2}{2 \cdot \delta_\sigma^2} + \frac{(\mathrm{A_{fb}} - \mathrm{A_{fb}^{meas}})^2}{2 \cdot \delta_{\mathrm{A_{fb}}}^2} \right) \qquad (2)$$

$$\begin{aligned} \delta_\sigma &= \mathrm{error}(\sigma(\mathrm{SM}; \lambda, \mathrm{m}_{\tilde{\nu}}) - \sigma^{\mathrm{meas}}) \ , \\ \delta_{A_{\mathrm{fb}}} &= \mathrm{error}(\mathrm{A_{fb}}(\mathrm{SM}; \lambda, \mathrm{m}_{\tilde{\nu}}) - \mathrm{A_{fb}^{meas}}) \ , \end{aligned}$$

$\not{R}_p$ sneutrino exchange

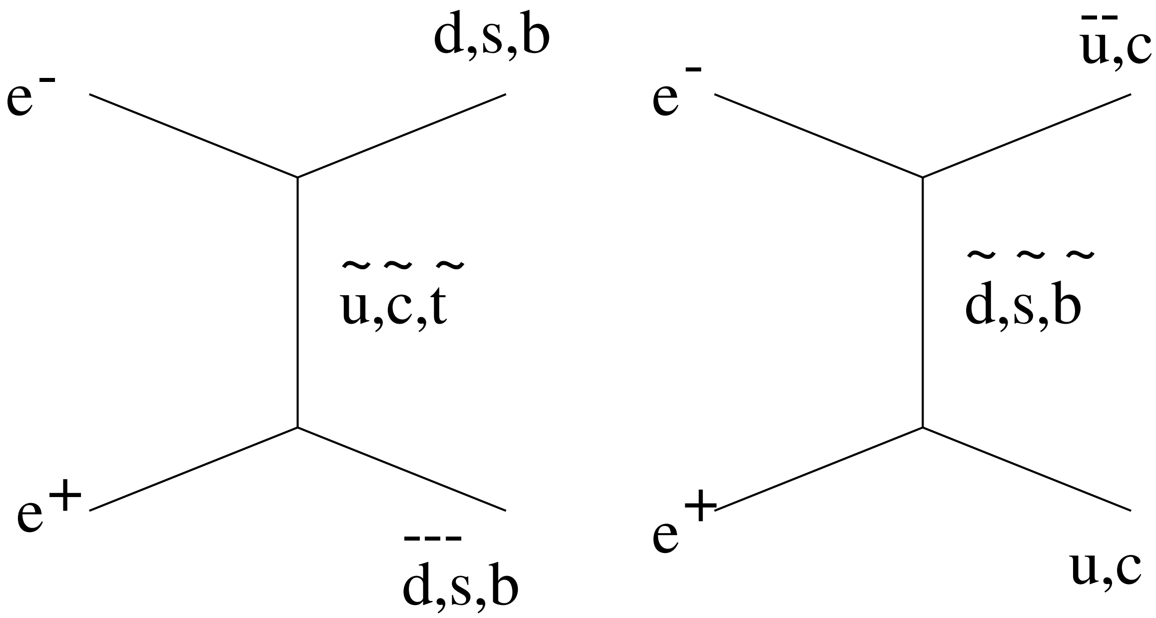


$R\!\!\!/_p$ sneutrino exchange



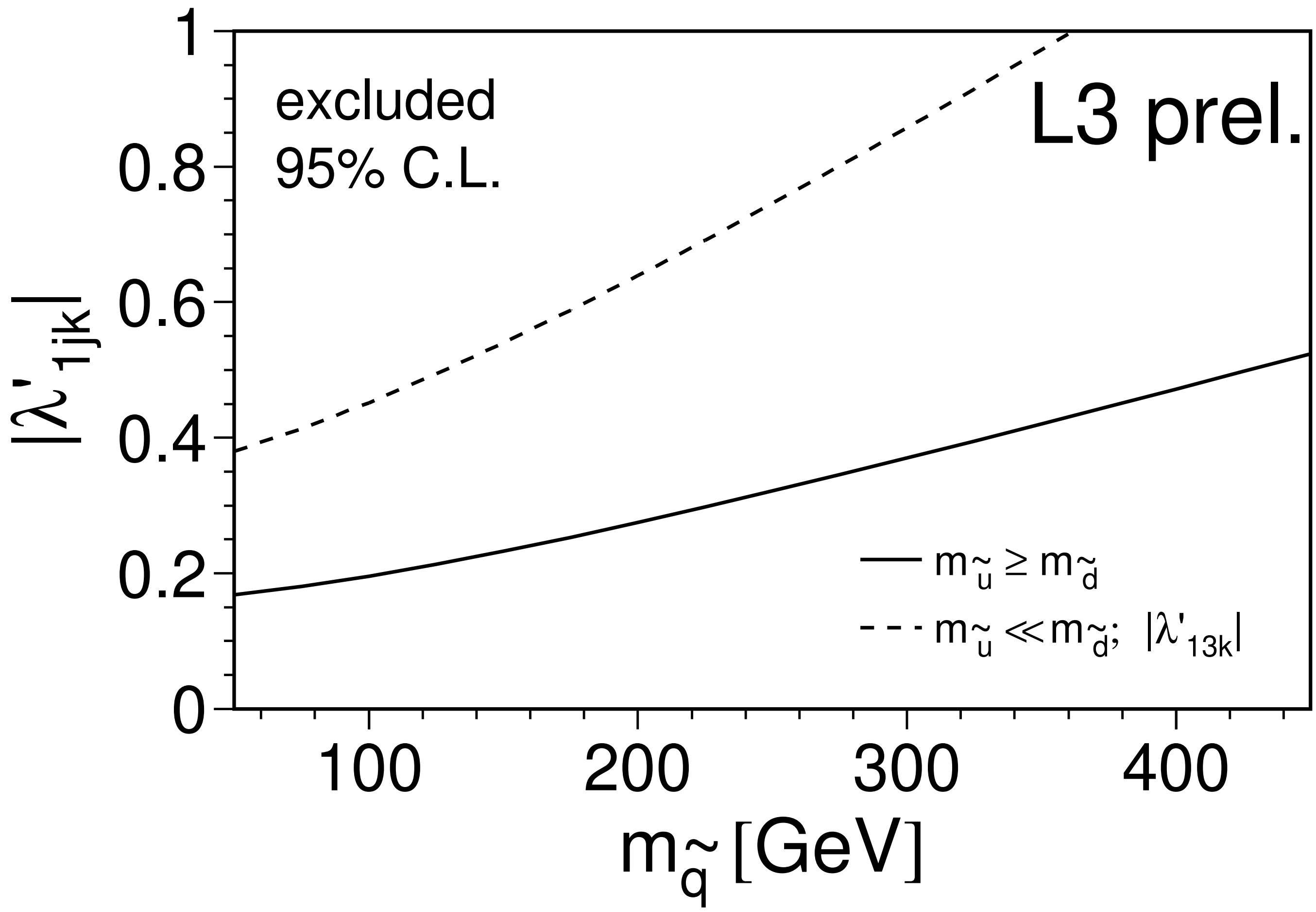
$\not{R}_p$ scalar quarks exchange

- Additional contributions to σ and A_{fb} in $e^+e^- \rightarrow q\bar{q}$ from $\lambda'_{ijk}L_iQ_j\overline{D_k}$



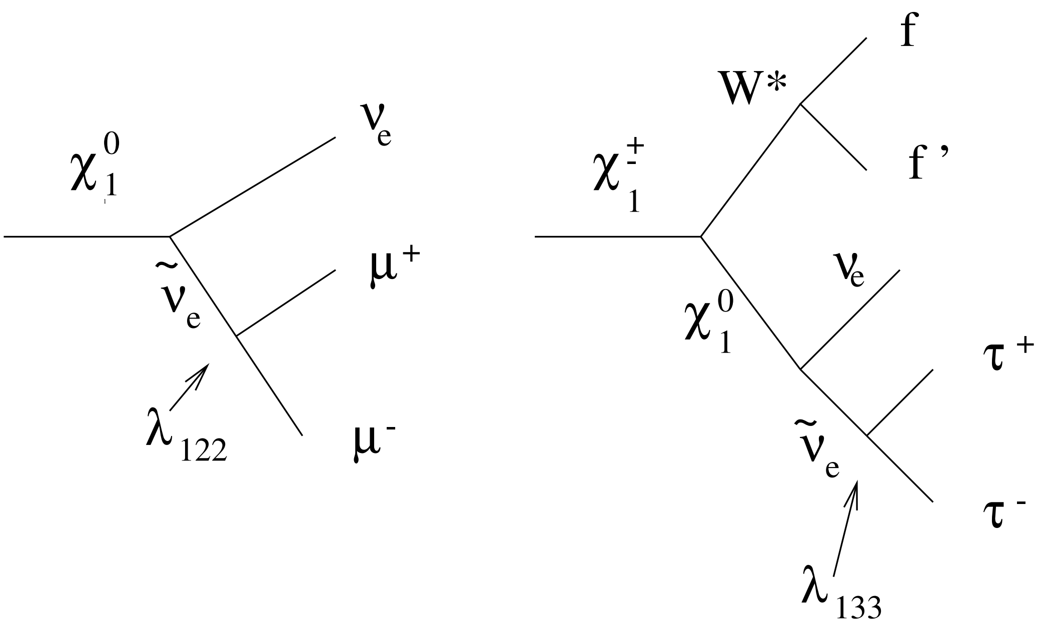
- t-channel: λ'_{1jk} j,k = 1,2,3
  Interference with A_{LR}
- u-channel: λ'_{1jk} j = 1,2, k = 1,2,3
  Interference with A_{LL}
- L3 1995-97 data
- ISR

$R\!\!\!/_p$ scalar quarks exchange



$\not{R}_p$ $\tilde{\chi}^1_0$ and $\tilde{\chi}^\pm_1$ decays

- R_p violation via $\lambda_{ijk} L_i L_j \overline{E_k}$
- L3 161 – 183 data, $\mathcal{L} = 76\ \mathrm{pb}^{-1}$
- $e^+e^- \to \tilde{\chi}^1_0 \tilde{\chi}^1_0 \to ll\ \nu\ \ ll\ \nu$
  $e^+e^- \to \tilde{\chi}^2_0 \tilde{\chi}^1_0 \to \tilde{\chi}^1_0\ Z^* \tilde{\chi}^1_0$
  $e^+e^- \to \tilde{\chi}^+_1 \tilde{\chi}^-_1 \to \tilde{\chi}^1_0 W^* \tilde{\chi}^1_0 W^*$
- λ_{122} and λ_{133}: highest and lowest selection efficiency



$\not{R}_p$ $\tilde{\chi}_0^1$ and $\tilde{\chi}_1^{\pm}$ decays

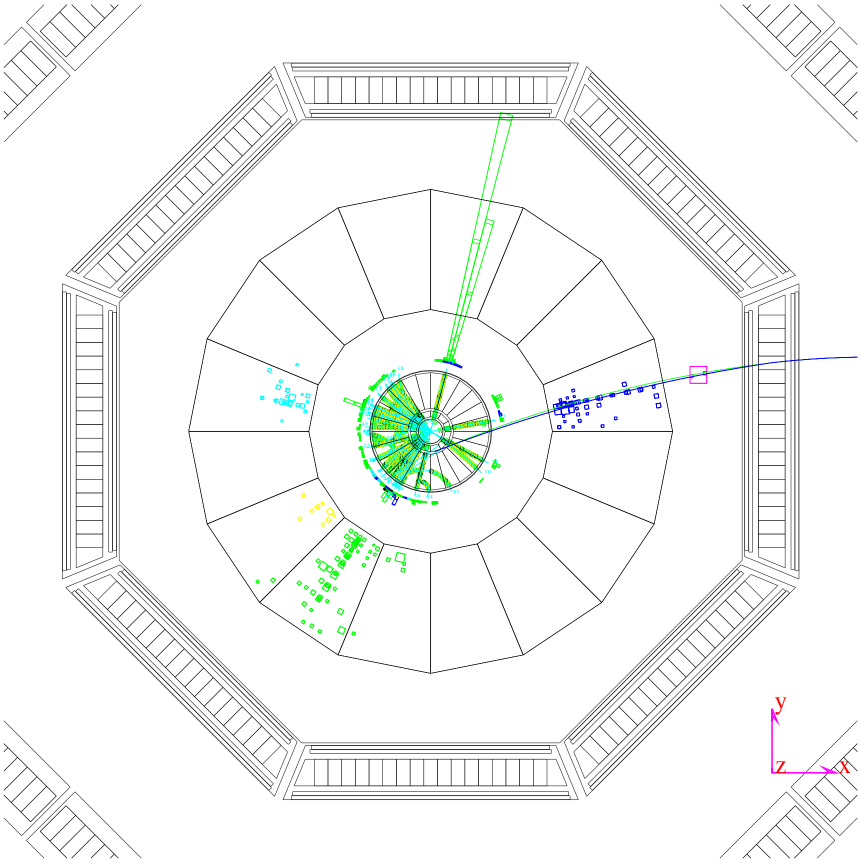
- Identification of leptons from $\tilde{\chi}_0^1$ decays
- Different final states depending on $\tilde{\chi}_1^{\pm}$ decay modes and $\Delta M = M_{\tilde{\chi}_1^{\pm}} - M_{\tilde{\chi}_0^1}$
- Sensitivity $1/\sigma_{95}$ optimization according to:

$$\sigma_{95} = \frac{1}{\varepsilon} \sum_{n=0}^{\infty} c_n P_b(n). \tag{3}$$

- No evidence of signal:
  λ_{122}: $N_{exp} = 3.1$, $N_{found} = 2$
  λ_{133}: $N_{exp} = 3.5$, $N_{found} = 2$

$\not{R}_p$ $\tilde{\chi}^1_0$ and $\tilde{\chi}^{\pm}_1$ decays

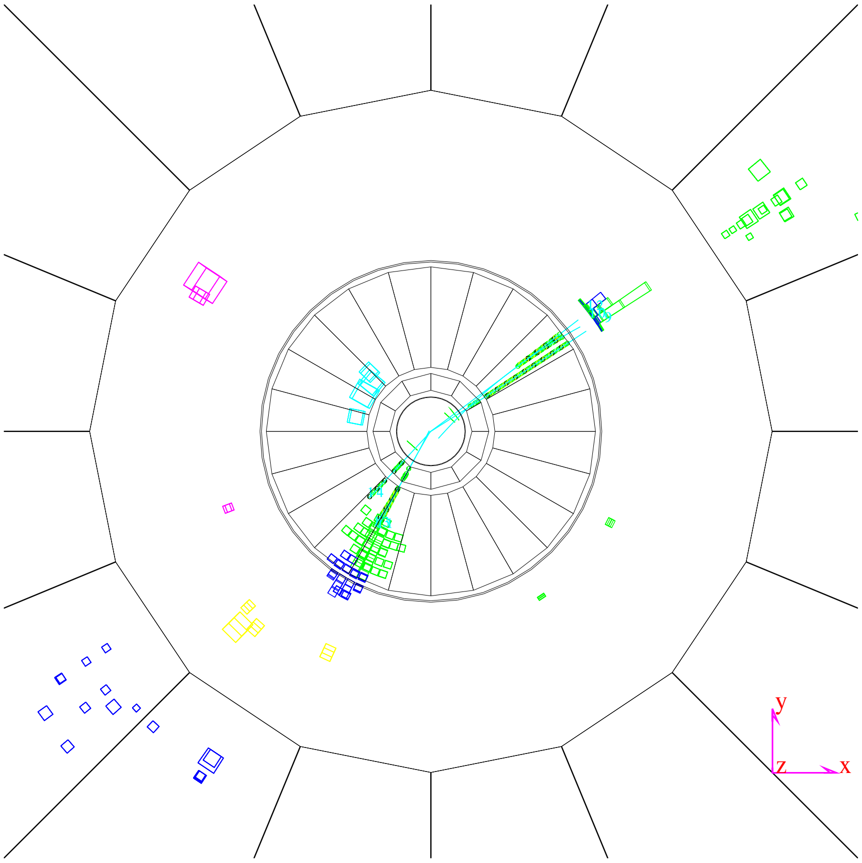
Run # **678307** **Event #** **2060** Total Energy : 142.25 GeV



Transverse Imbalance :	.1320	**Longitudinal Imbalance :**	-.1345		
Thrust :	.8032	**Major :**	.4026	**Minor :**	.1674
Event DAQ Time :	*970913 92707*				

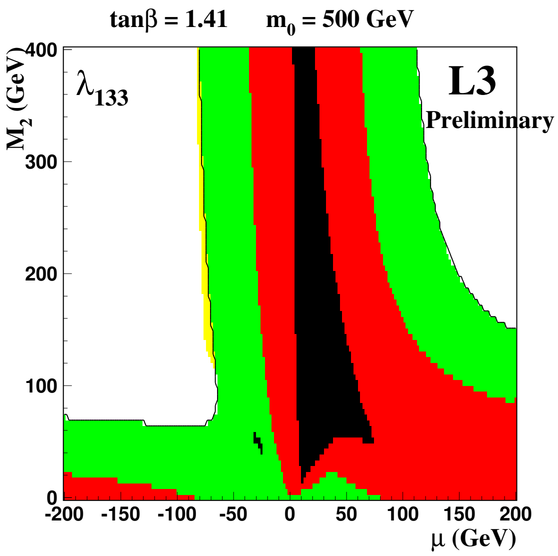
$\not{R}_p$ $\tilde{\chi}_0^1$ and $\tilde{\chi}_1^{\pm}$ decays

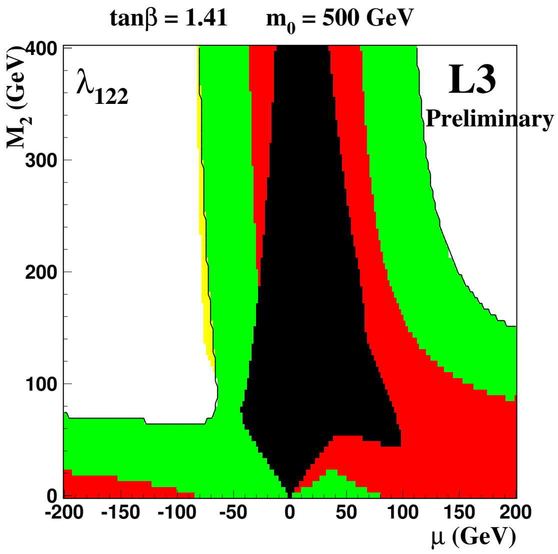
Run # **682202** **Event #** **4900** Total Energy : 33.06 GeV



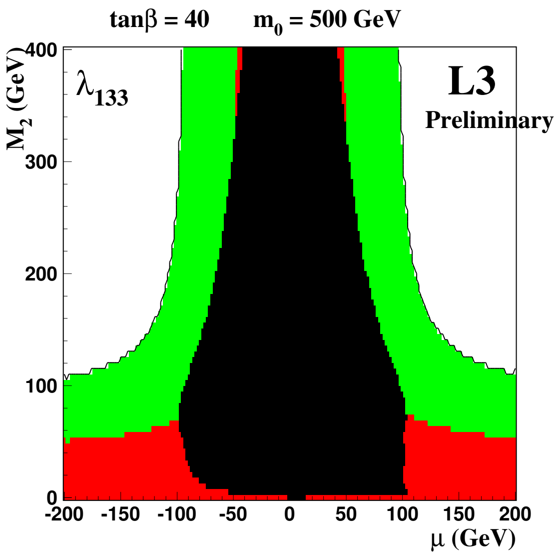
Transverse Imbalance : .0565		**Longitudinal Imbalance :** .6182	
Thrust : .9297	**Major :** .2164	**Minor :** .0402	
Event DAQ Time :	*970928 145410*		

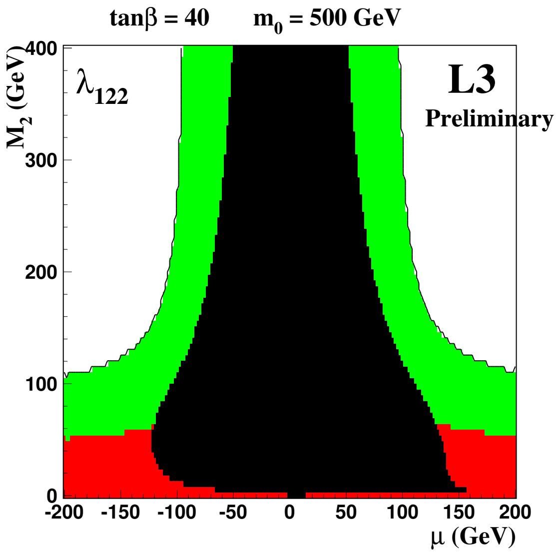
$R\!\!\!/_p$ $\tilde{\chi}_0^1$ and $\tilde{\chi}_1^{\pm}$ decays



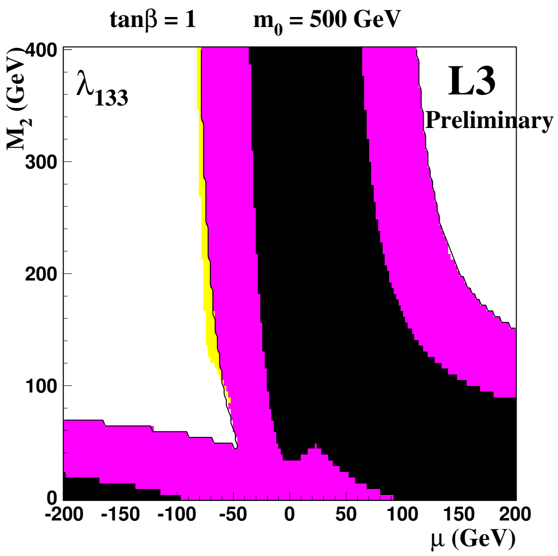


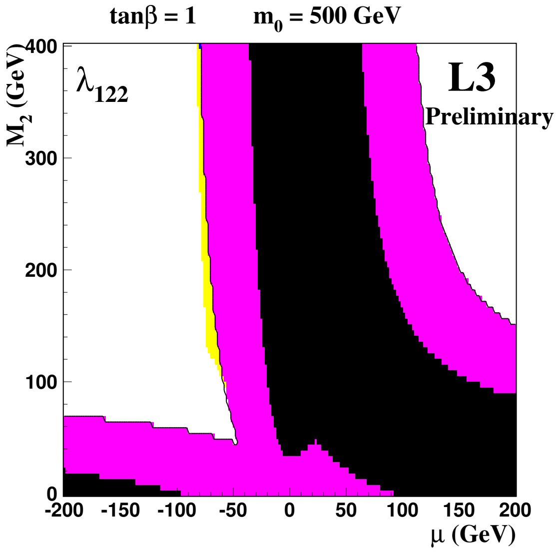
$R\!\!\!/_p$ $\tilde{\chi}_0^1$ and $\tilde{\chi}_1^{\pm}$ decays





$\not{R}_p$ $\tilde{\chi}^1_0$ and $\tilde{\chi}^\pm_1$ decays





Conclusions

- R-parity violating effects due to $\tilde{nu}$ and $\tilde{\mathrm{q}}$ exchange have been searched for in the processes $\mathrm{e^+e^-} \to \mathrm{e^+e^-}, \mu^+\mu^-, \mathrm{q\bar{q}}$

- no deviations from SM have been observed in σ and A_{fb} measurements

- Limits at 95% C.L. have been set on the Yukawa couplings λ_{121}, λ_{131}, λ_{232} and λ'_{1jk}

Conclusions

- R-parity violating effects in $\tilde{\chi}_0^1$ and $\tilde{\chi}_1^{\pm}$ decays have been searched for, using the high energies L3 data ($\mathcal{L} = 76\ \mathrm{pb}^{-1}$)

- Two possible Yukawa couplings, λ_{122} and λ_{133} have been considered

- No evidence of signal has been found and 95% C.L. limits have been set in the SUSY parameter space

- $\tilde{\chi}_1^{\pm}$ production is excluded up to the kinematic limit ($\mathrm{m}_0 = 500$ GeV)

- For $\mathrm{m}_0 = 500$ GeV a lower limit on the $\tilde{\chi}_0^1$ mass has been set at 27.7 GeV