

ECFA/DESY

Oxford

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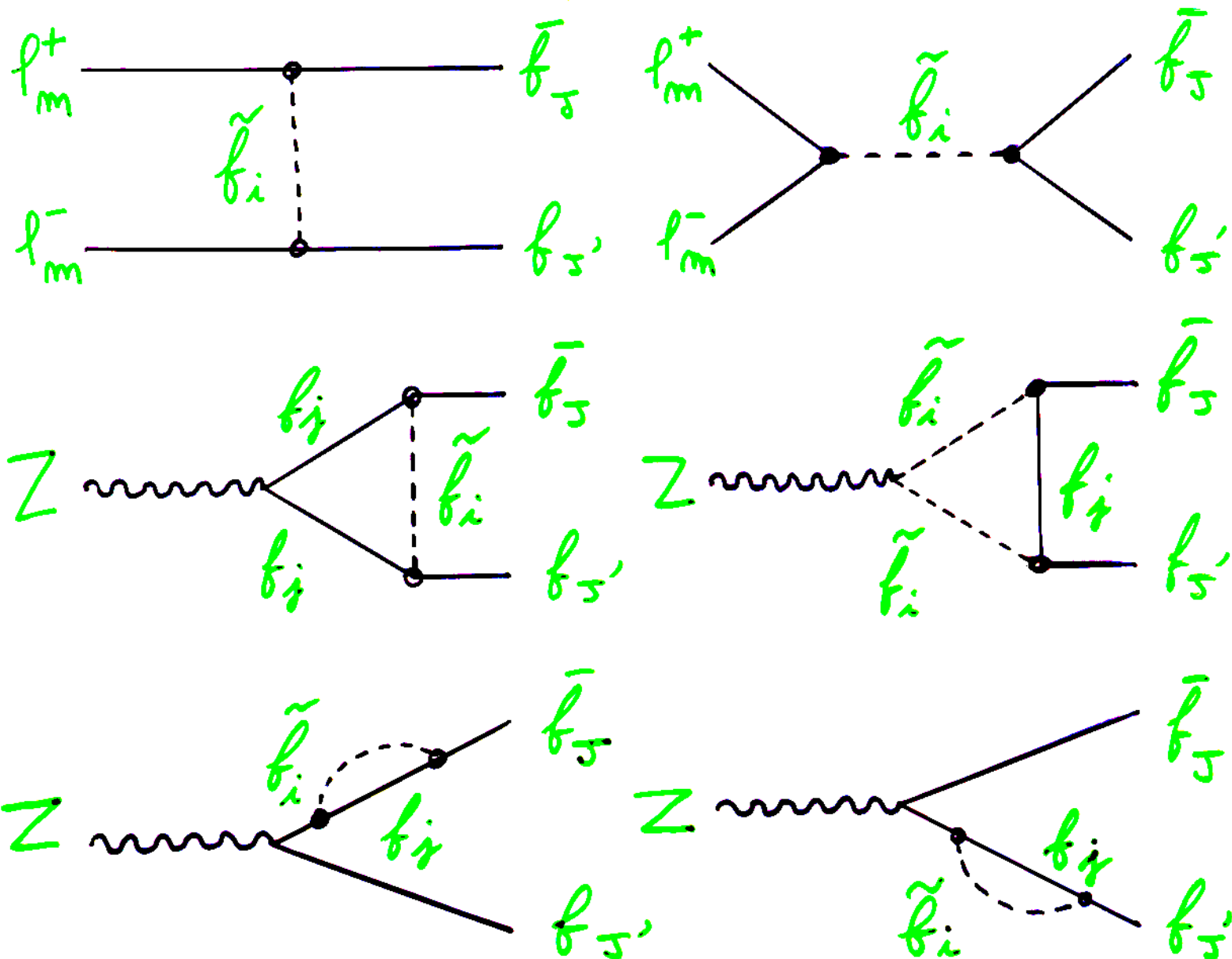
Phenomenological Studies
on
R parity Violation

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{ hep-ph/9806494
hep-ph/9807509
hep-ph/9808428

Broken R parity contributions to Flavor Changing Neutral Currents and CP violation in $l^+ l^- \rightarrow \bar{f}_j f_j$



tree: (imm, iJJ') ; (imJ, imJ') , $(iJm, iJ'm)$ (t, u)

loop: (ijJ, ijJ') ; $(iJj, iJ'j)$; $(i \leftrightarrow j)$

\mathcal{R}_p coupling constants: $\lambda_{abc} \lambda_{abc}^*$ or $\lambda'_{abc} \lambda'_{abc}^*$

fermionic final state: $f_a = l_a, u_a, d_a$

CP Asymmetries

$$\mathcal{A} = \frac{|M|^2 - |\bar{M}|^2}{|M|^2 + |\bar{M}|^2}$$

$$\left. \begin{aligned} M &= a_0 + \sum_{ij} a_{ij} F_{ij} \\ \bar{M} &= a_0^* + \sum_{ij} a_{ij}^* F_{ij} \end{aligned} \right\} \begin{array}{l} M \xrightarrow{CP} \bar{M} \\ \bar{f}_J f_{J'} \longrightarrow f_J \bar{f}_{J'} \end{array}$$

$$a_0 = a_0 \left(\frac{\lambda_{imJ} \lambda_{imJ}^*}{\Gamma - m_i^2} \right)$$

$$a_{ij} = a_{ij} \left(\lambda_{ijJ} \lambda_{ijJ}^* \right)$$

$$F_{ij} = F_{ij} (s + i\epsilon, \tilde{m}_i, m_j)$$

$$\mathcal{A} = \frac{2}{|a_0|^2} \left[\sum_{ij} \text{Im}(a_0 a_{ij}^*) \text{Im}(F_{ij}) - \sum_{ij < i'j'} \text{Im}(a_{ij} a_{i'j'}^*) \text{Im}(F_{ij} F_{i'j'}^*) \right]$$

Results

FCNC rates

$$\sigma_{JJ'} \approx \left(\frac{\lambda}{0,1}\right)^4 \left(\frac{100 \text{ GeV}}{\tilde{m}}\right)^{2-3} (1-10) \text{ fbarns}$$

Z^0 boson peak:

$$B_{JJ'} \approx \left(\frac{\lambda}{0,1}\right)^4 \left(\frac{100 \text{ GeV}}{\tilde{m}}\right)^{2-3} 10^{-9} \sim B_{JJ'}^{\text{th.}} (\text{S.M.})$$

CP Asymmetries

$$\mathcal{A}_{JJ'} \approx (10^{-2} - 10^{-3}) \sin \psi, \quad \psi \equiv \text{CP phase}$$

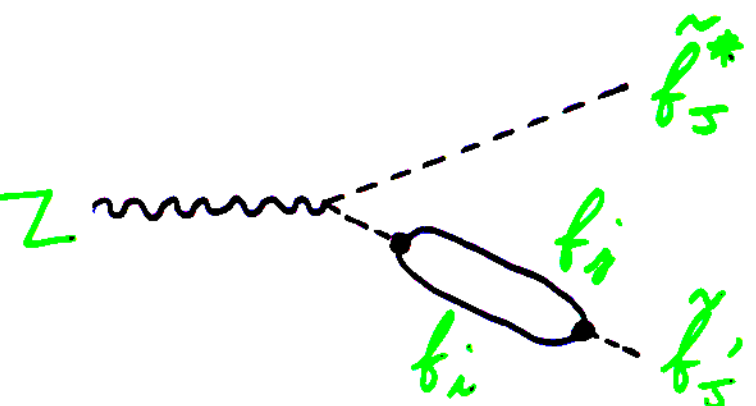
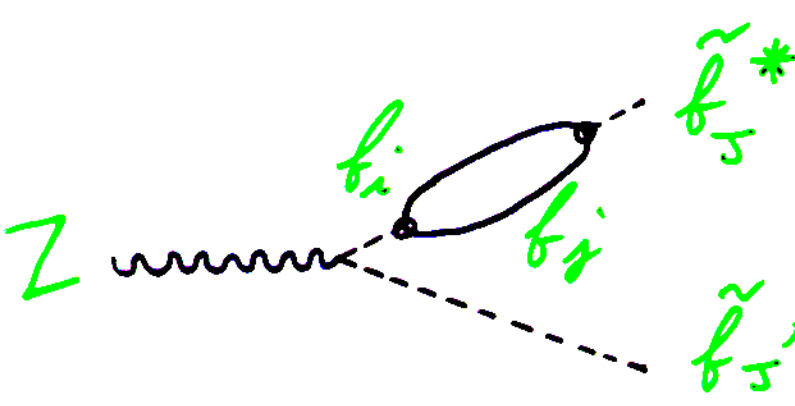
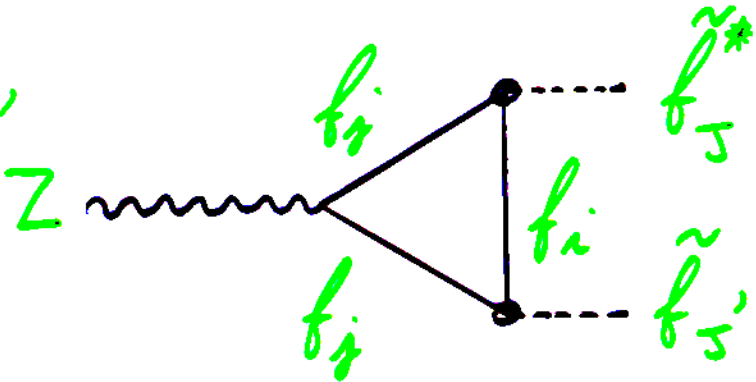
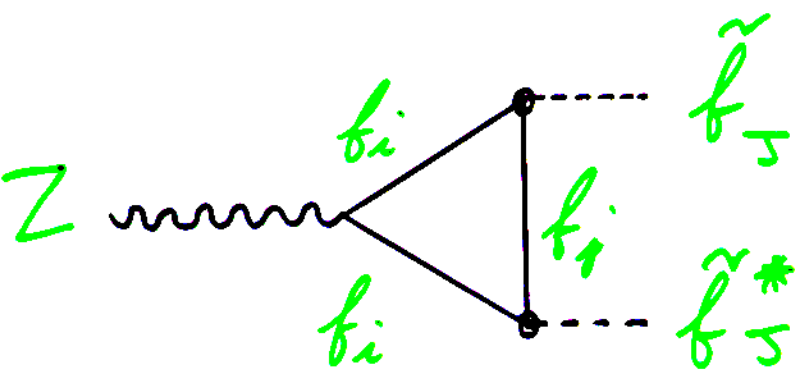
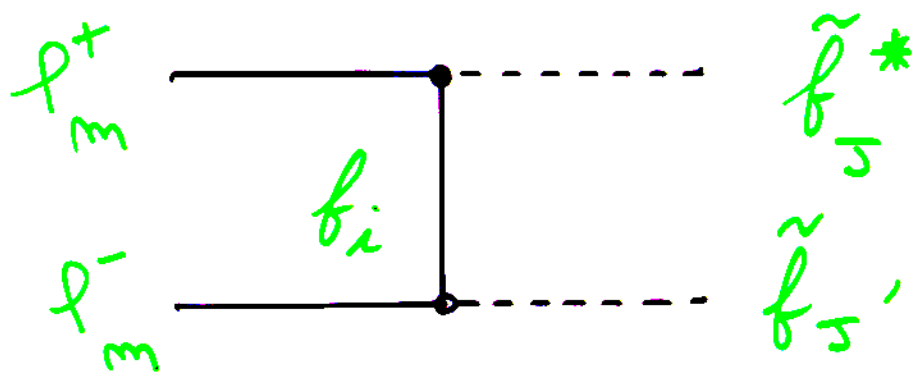
Z^0 boson peak:

$$\mathcal{A}_{JJ'} \approx (10^{-1} - 10^{-3}) \sin \psi \gtrsim \mathcal{A}_{JJ'}^{\text{th.}} (\text{S.M.})$$

$$B_{JJ'}^{\text{exp.}} < 1,7 | 9,8 | 17 \cdot 10^{-6} \quad JJ' = 12 | 23 | 13$$

$$\Rightarrow \left\{ \begin{array}{l} \lambda_{ijJ} \lambda_{ijJ'}^* < 0,46 | 1,1 | 1,4 \\ \lambda'_{Jjk} \lambda'^*_{Jjk} < 0,38 | 0,91 | 1,2 \cdot 10^{-1} \end{array} \right.$$

Broken R parity contributions to Flavor Changing Neutral Currents and CP Violation in $p^+p^- \rightarrow \tilde{f}_j^* \tilde{f}_j$



tree: (imJ, imJ') ; $(iJm, iJ'm)$

loop: (ijJ, ijJ') ; $(iJj, iJ'j)$

R_p coupling constants: $\lambda_{abc} \lambda_{abc}^*$ or $\lambda'_{abc} \lambda'_{abc}^*$

sfermionic final state: $\tilde{f}_a = \tilde{\nu}_a, \tilde{l}_a, \tilde{u}_a, \tilde{d}_a$

Results

FCNC rates

$$\sigma_{\tau\tau'} \approx \left(\frac{\lambda}{0,1}\right)^4 (2-20) \text{ fbarns}, \tilde{m} < 400 \text{ GeV}$$

Sleptons oscillations model:

$$\sigma_{\tau\tau'} \approx (10^{-2} - 10^2) \text{ fbarns}, 190 < \sqrt{s} < 500 \text{ GeV}$$

CP Asymmetries

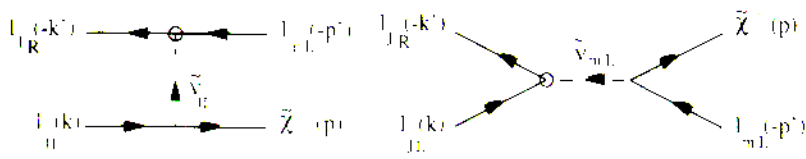
$$\mathcal{A}_{\tau\tau'} \approx (10^{-2} - 10^{-3}) \sin \psi, \psi \equiv \text{CP phase}$$

Sleptons oscillations model:

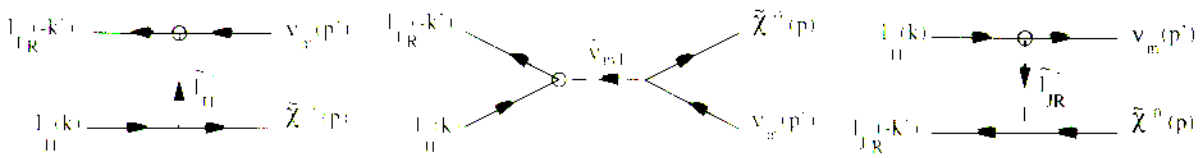
$$\mathcal{A}_{\tau\tau'} \approx 10^{-3} \sin \varphi, \varphi \equiv \text{CP phase}$$

Single production of supersymmetric particles: $p+p \rightarrow$ two bodies

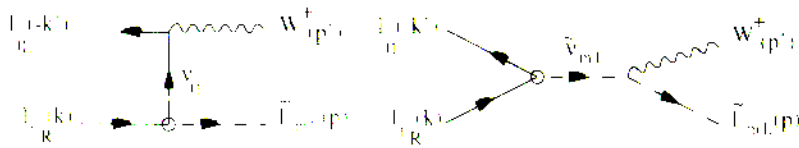
R_p coupling constant: λ_{mJJ}



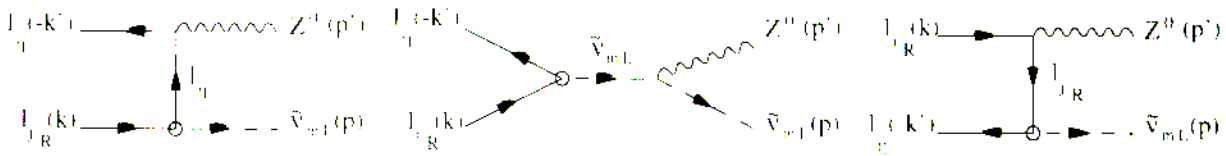
(a)



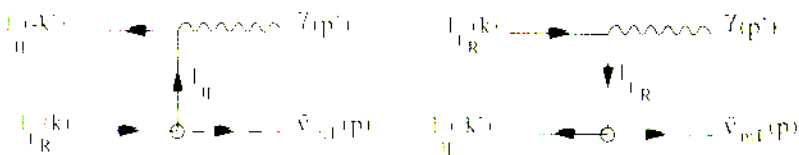
(b)



(c)



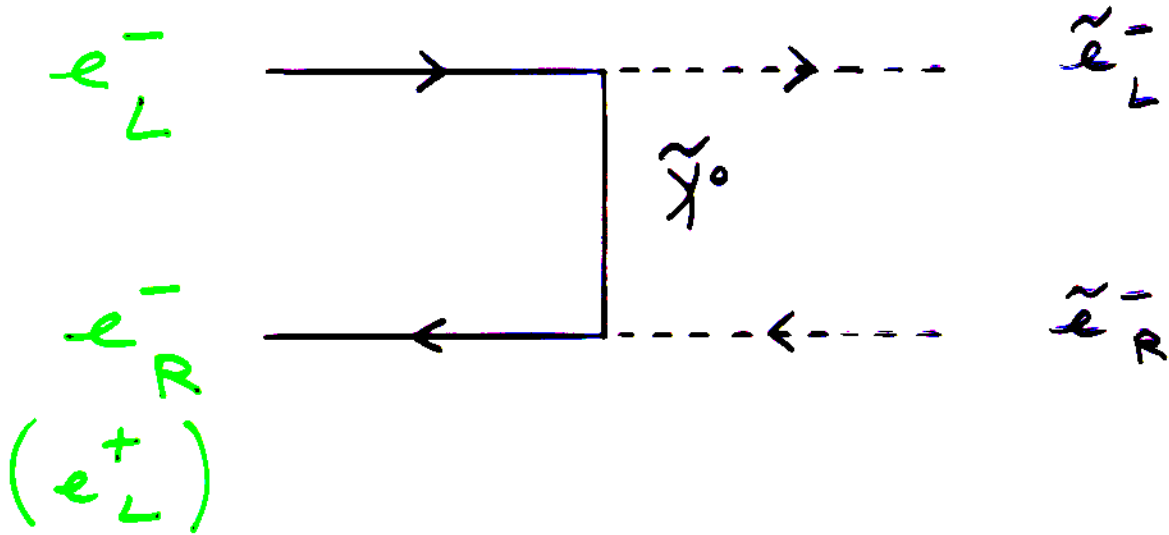
(d)



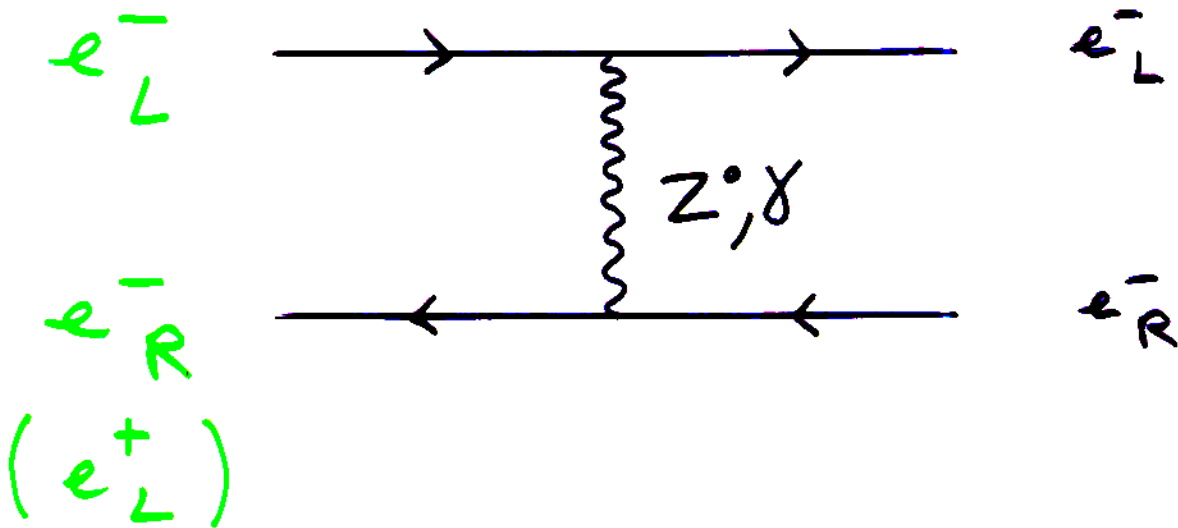
(e)

\Rightarrow Electron and positron of same
helicity

M.S.S.M.:



S.M.:



Neglecting the Higgs and Higgsinos
couplings.

Cross Sections

LEP II	$\sqrt{s} =$ 200 GeV	$\int \mathcal{L} dt =$ 200 pb ⁻¹	$\sigma \approx$ 100 fb
Linear Collider	500 GeV	500 fb ⁻¹	10 fb

$$\hookrightarrow \text{for } \lambda_{m\tilde{J}\tilde{J}} = 0,05 \left(\frac{\tilde{m}}{100 \text{ GeV}} \right)$$

Decay channels of the produced supersymmetric particles
(λ_{ijk})

\Rightarrow Signals with small Standard Model background:

$$4l + \cancel{E}, 2l + Z^0 + \cancel{E}, 3l + Z^0 + W + \cancel{E}, \dots$$

Monte Carlo simulation

Event Generator

↳ SUSYGEN

Signal: $e^+e^- \rightarrow \tilde{\chi}_1^\pm \mu^\mp$

$$\lambda_{121} = 0,05$$

Final state: 4 leptons + ~~E~~

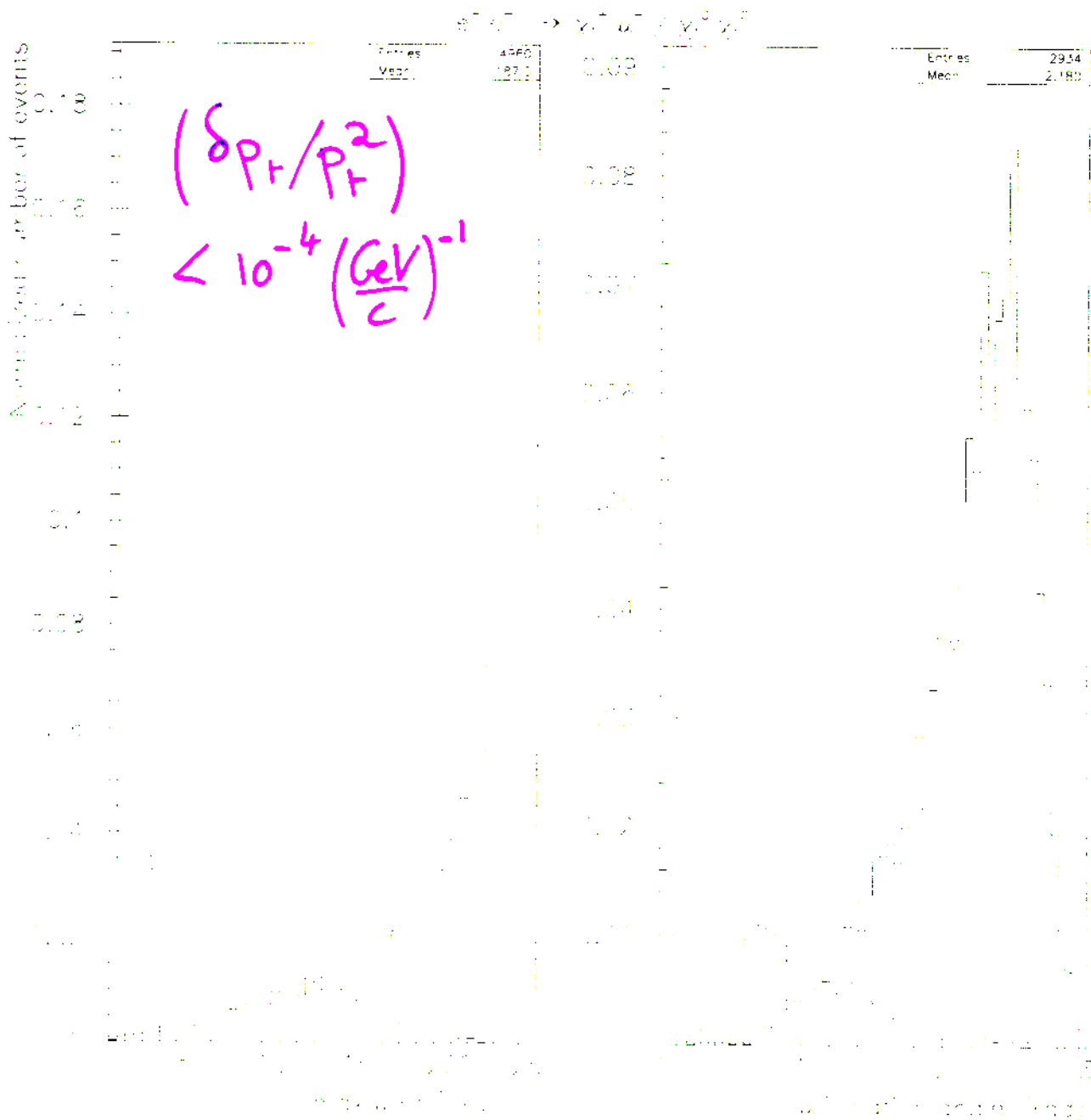
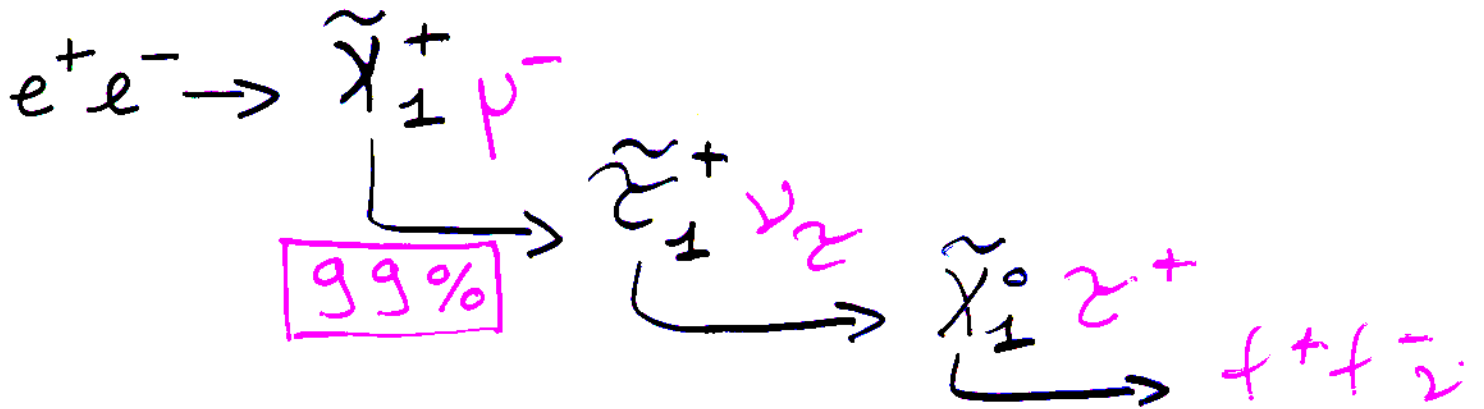
SUSY background:

$$e^+e^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0, \tilde{\chi}_1^0 \tilde{\chi}_p \rightarrow \begin{cases} e^+e^- \nu_\mu \bar{\nu}_\mu \\ e^+e^- \nu_\tau \bar{\nu}_\tau \\ e^+ \mu^- \nu_e \bar{\nu}_e \\ e^- \mu^+ \nu_e \bar{\nu}_e \end{cases}$$

(4 x 25%)

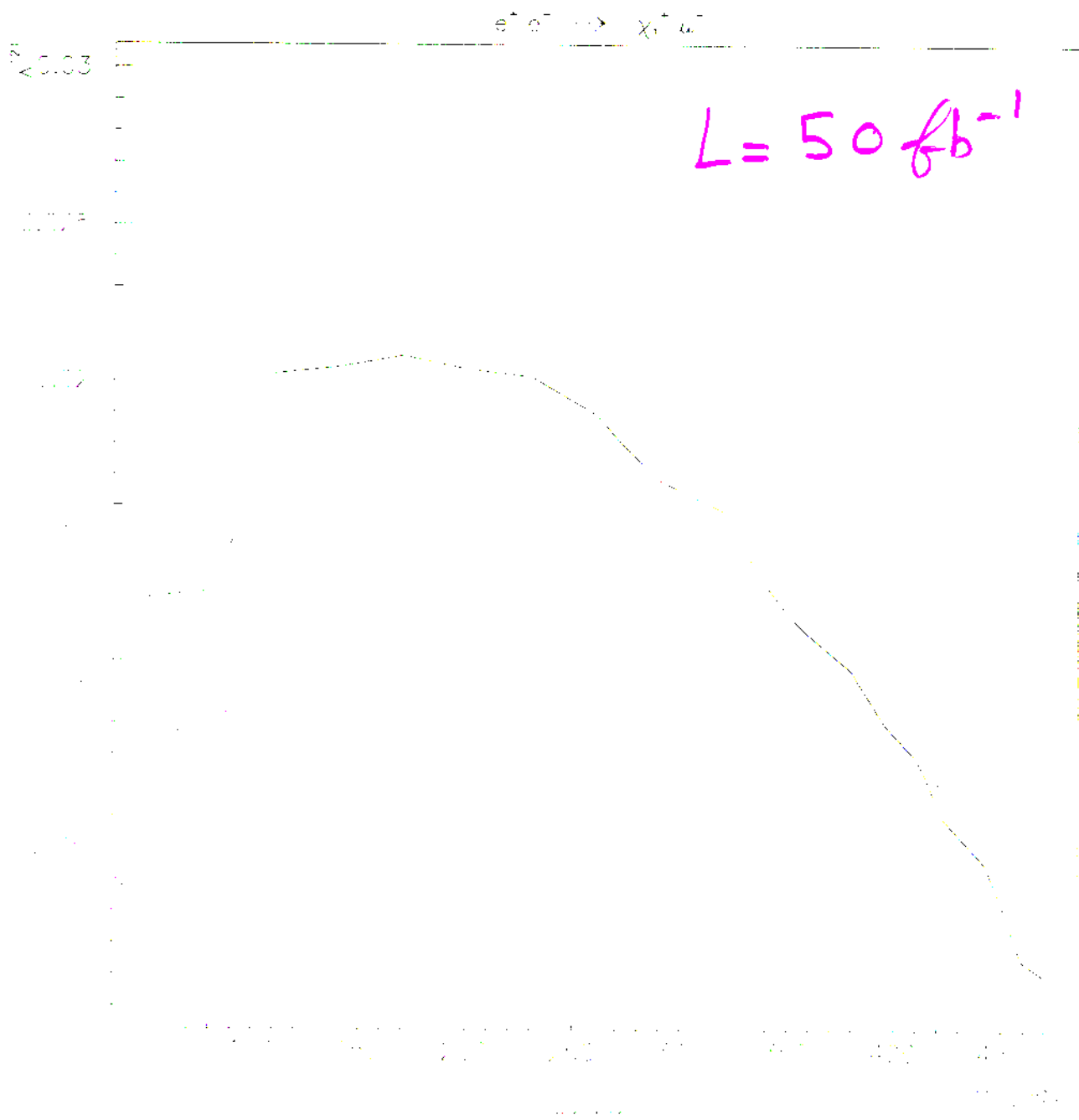
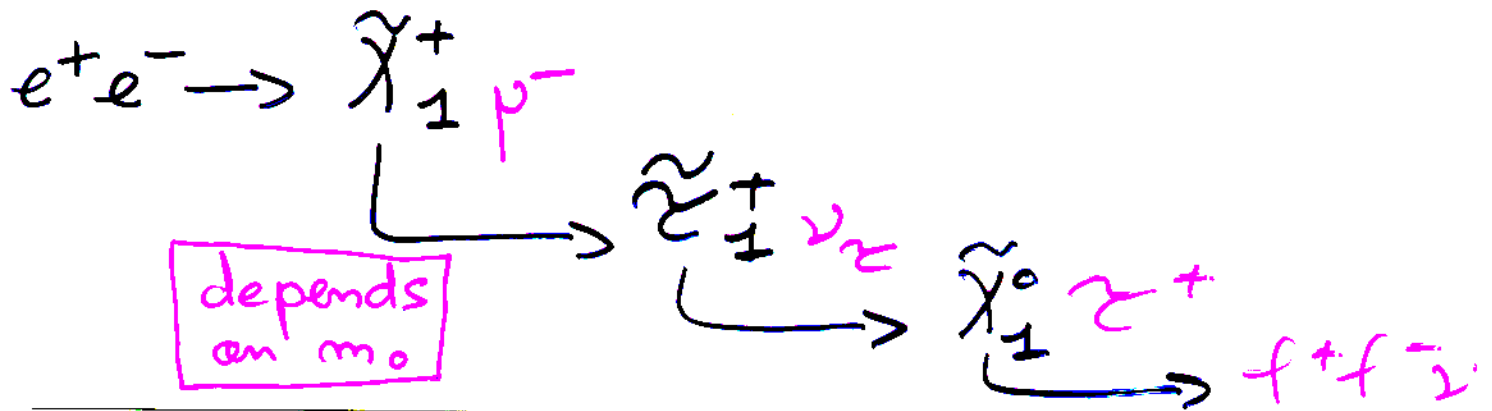
Energy: $\sqrt{s} = 500 \text{ GeV}$

$$\begin{cases} \tan \beta = 2 & M_2 = 150 \text{ GeV} \\ \mu = 400 \text{ GeV} & m_0 = 50 \text{ GeV} \end{cases}$$



5000 events

$$\begin{cases} \tan \beta = 2 & M_2 = 150 \text{ GeV} \\ \mu = 400 \text{ GeV} \end{cases}$$



CONCLUSION

Summary

Single production = good test for R_p .

- Important cross sections.
- SM background: decay channels
⇒ multi-leptonic final states.
- MSSM background: Monte Carlo
⇒ selection of the signal.
- Beam polarization:
⇒ reduce SM & MSSM backgrounds.
- No MSSM background for:

$$\begin{array}{l}
 m_{\tilde{\chi}^\pm, \tilde{\chi}^0, \tilde{\nu}} < \sqrt{s} < 2 m_{LSP} \\
 m_{\tilde{p}, W, Z^0} < \sqrt{s} < 2 m_{LSP}
 \end{array}
 \left\{
 \begin{array}{l}
 p^+ p^- \rightarrow \tilde{\chi}^\pm p_m^\mp \\
 p^+ p^- \rightarrow \tilde{\chi}^0 \nu_m \\
 p^+ p^- \rightarrow \tilde{\nu}_{mL} \gamma \\
 \\
 p^+ p^- \rightarrow \tilde{p}_{mL}^\mp W^\pm \\
 p^+ p^- \rightarrow \tilde{\nu}_{mL} Z^0
 \end{array}
 \right.$$

