Polarization aspects in radiative neutralino production

Olaf Kittel

University of Bonn, Germany

in collaboration with:
Herbi Dreiner and Ulrich Langenfeld

ILC-Valencia 06, November 9, 2006

Outline

- Introduction and motivation

- Radiative neutralino production
  - signal and background
  - production at LEP

- Radiative neutralino production at the ILC
  - longitudinally polarized beams
  - Can it be the only process to be observed?

- Summary and conclusions

1 Introduction and motivation

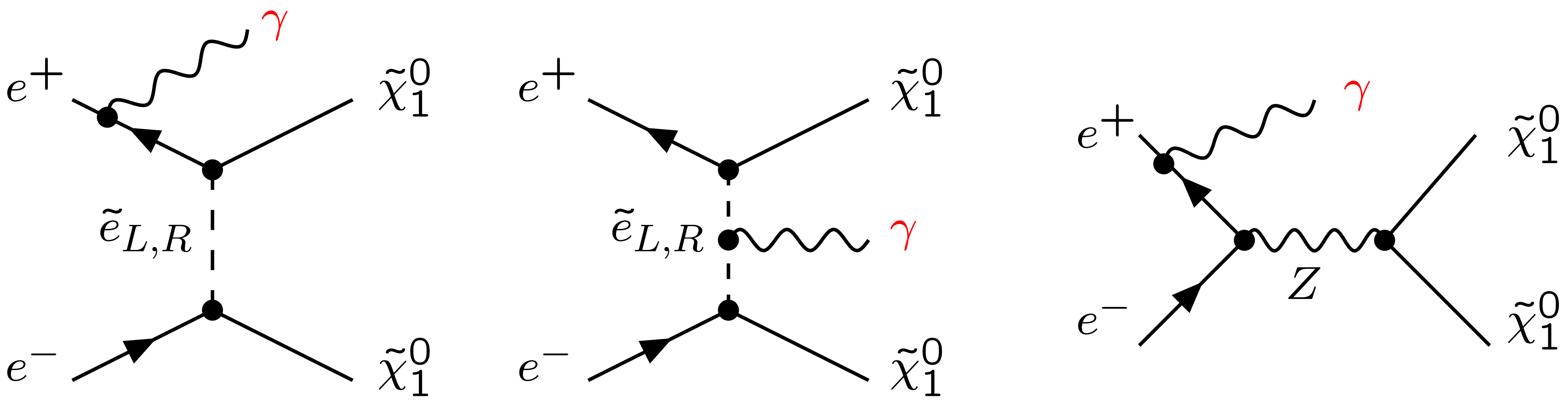
- Supersymmetry is attractive for Models beyond Standard Model.
- New supersymmetric particles have to be found at colliders.
- ILC: Lightest states can be studied first.
- Discovery at colliders (MSSM with R-parity conservation)
  indirect: **missing energy** due to a stable LSP
  direct: **pairs** of neutralinos, charginos, sleptons (ILC)

2 Radiative production of neutralinos

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

Proceeds via selectron $\tilde{e}_{L,R}$ and Z boson exchange

Signal: High energetic photon γ and missing energy



This is the lightest SUSY state to be produced!!!

Signal and Background

- Signal: $e^{+} + e^{-} \to \tilde{\chi}_1^0 + \tilde{\chi}_1^0 + \gamma$
- Background

– SM: $e^{+} + e^{-} \to \nu + \bar{\nu} + \gamma$

– MSSM: $e^{+} + e^{-} \to \tilde{\nu} + \tilde{\nu}^{*} + \gamma$

- Significance: $S = \frac{N_S}{\sqrt{N_B + N_S}}$ (should be larger than 1)
- Signal to background ratio: $\frac{N_S}{N_B}$ (should be larger than 1%)
- cross section σ: $N = \mathcal{L}\sigma$

– Luminosity at LEP: $\mathcal{L} \approx 100$ pb^{-1}

– at ILC: $\mathcal{L} \approx 500$ fb^{-1}

Radiative neutralino production at LEP II: $e^+ e^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \gamma$

$M_{\tilde{e}_{L,R}} = 200$ GeV

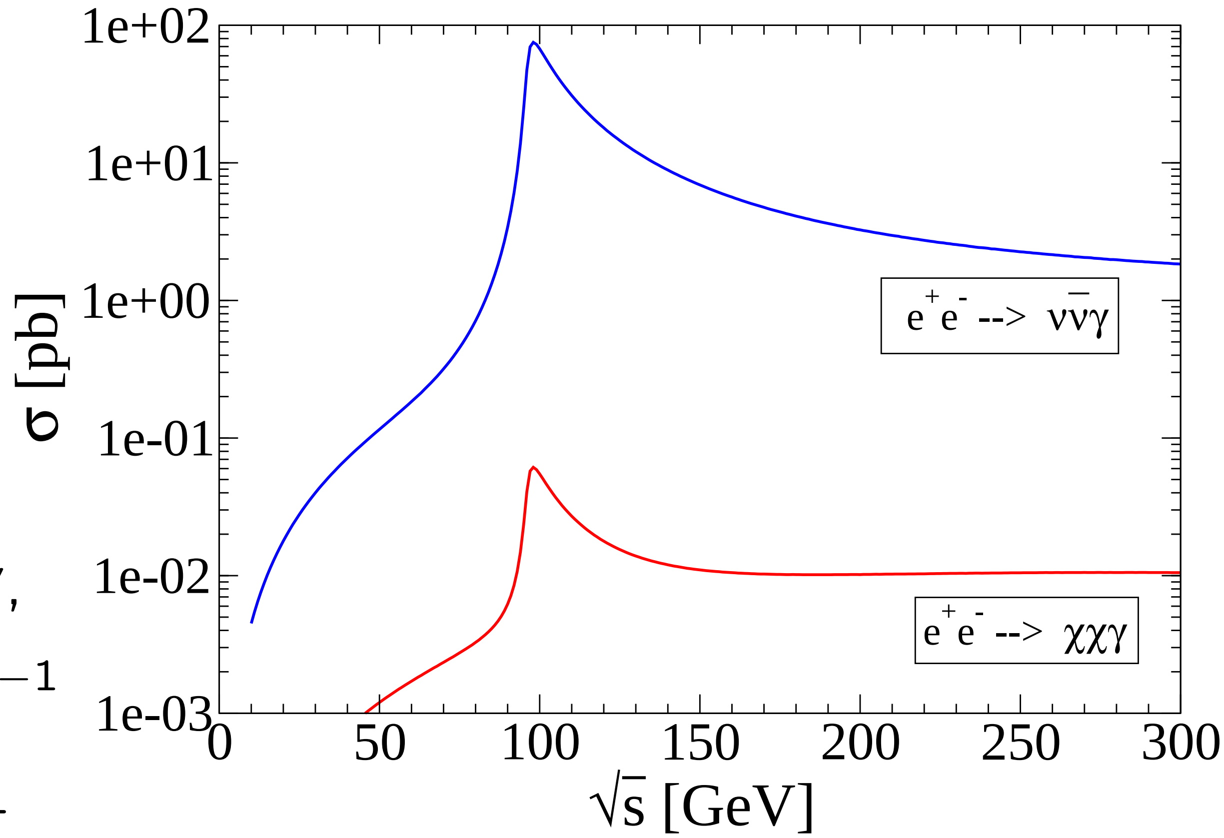
$M_2 = \mu = 200$ GeV

$\tan\beta = 10$

LEP II: $\sqrt{s} = 200$ GeV,

luminosity $\mathcal{L} = 100$ pb^{-1}

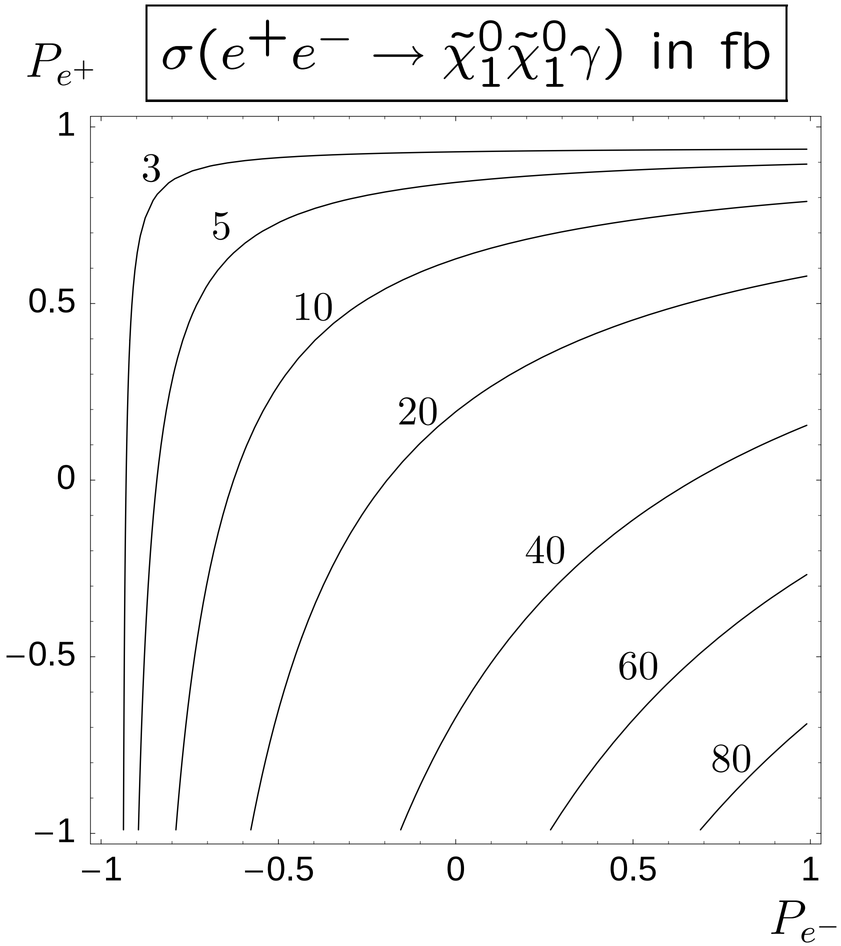
Significance: $\frac{N_S}{\sqrt{N_B}} < 0.1$

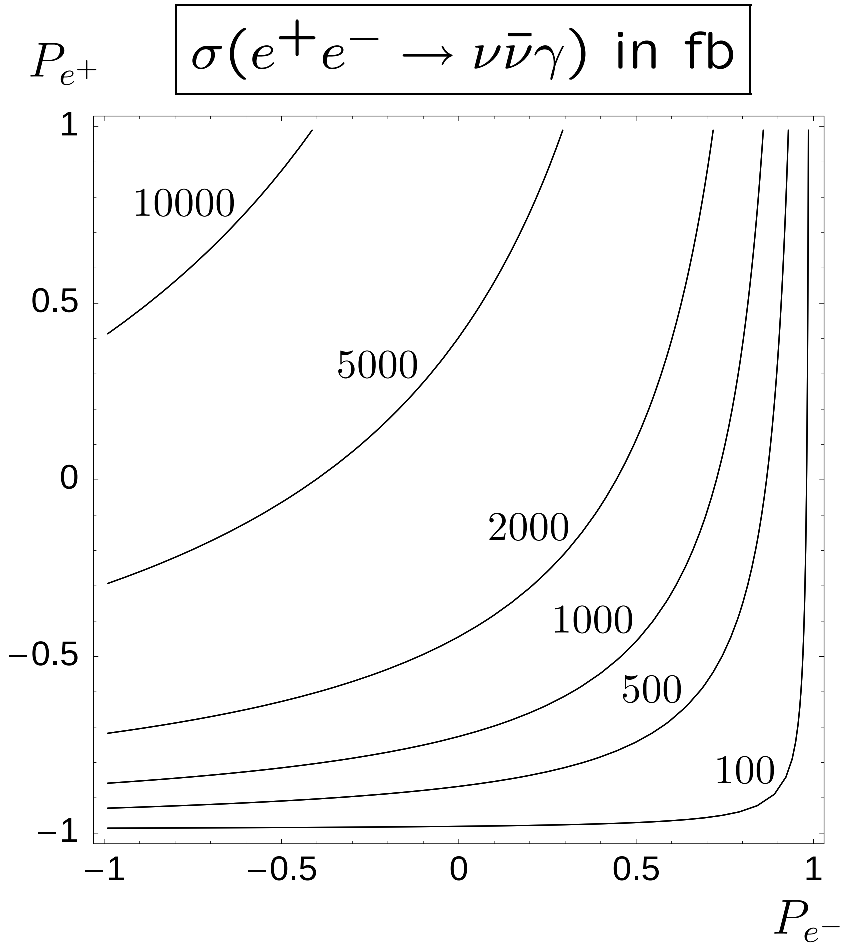


3 Radiative neutralino production at the ILC

- Radiative neutralino production cannot be measured at LEP.
- However, good prospects for the ILC!!
  - high luminosity: $\mathcal{L} = 500 \text{ fb}^{-1}$
  - polarized beams: $P_{e^-} = 80\%$ and $P_{e^+} = 60\%$

Beam polarization dependence





$\sqrt{s} = 500$ GeV, for SPS 1a scenario:

$\mu = 352$ GeV, $M_2 = 193$ GeV, $\tan\beta = 10$, $m_0 = 100$ GeV

Significance S for SPS 1a

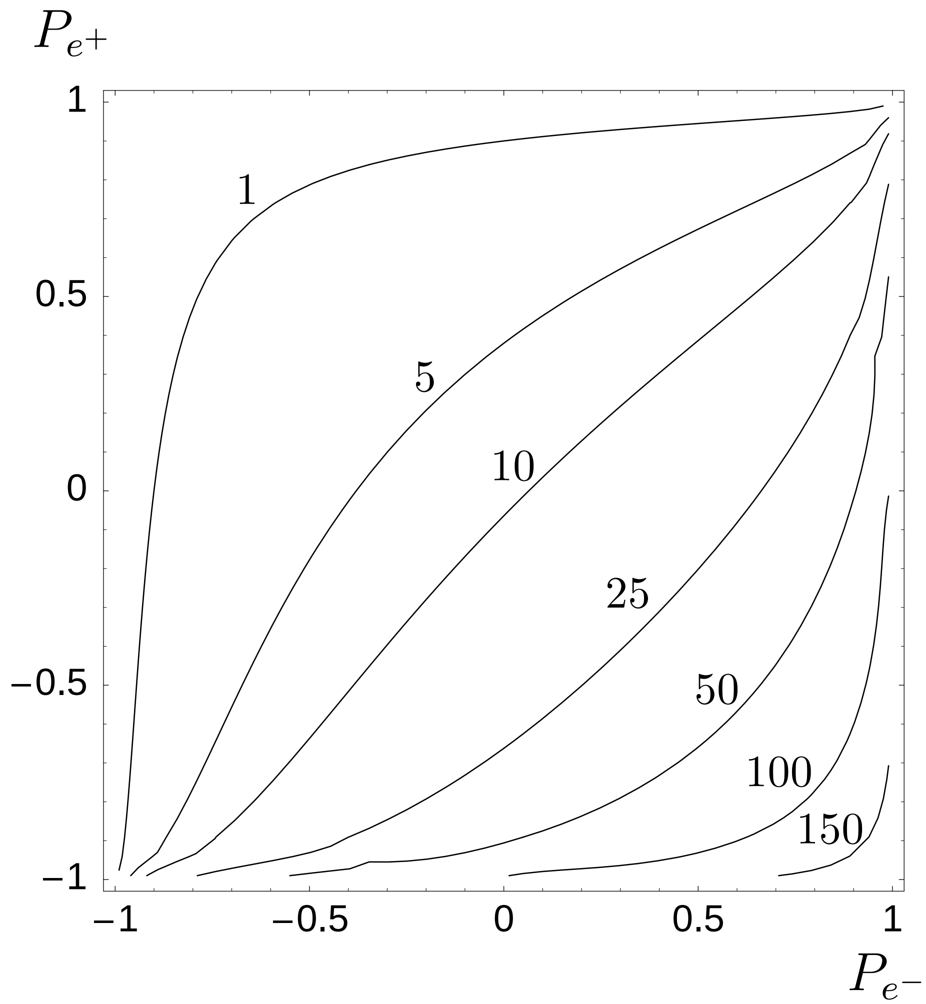
$$S = \frac{N_S}{\sqrt{N_S + N_B}} \quad \text{and} \quad N = \mathcal{L} \times \sigma$$

$$\Rightarrow S = \frac{\sigma}{\sqrt{\sigma + \sigma_B}} \sqrt{\mathcal{L}}$$

signal: $\sigma(e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \gamma) = 70$ fb

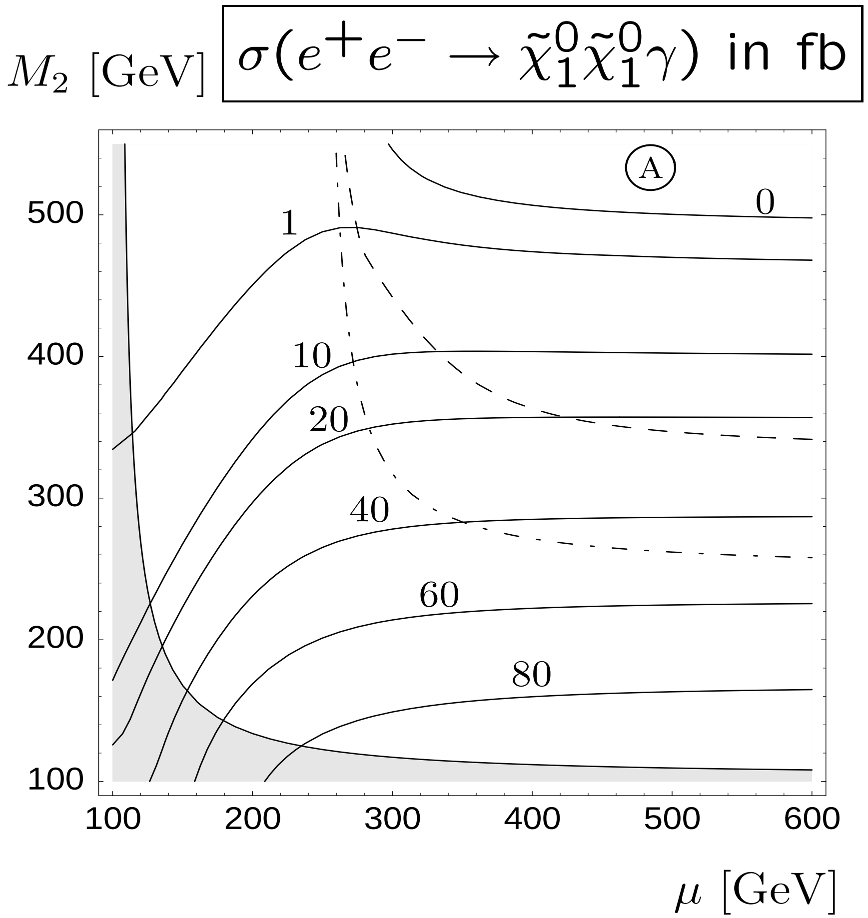
BG: $\sigma_B(e^+e^- \to \nu\bar{\nu}\gamma) = 330$ fb

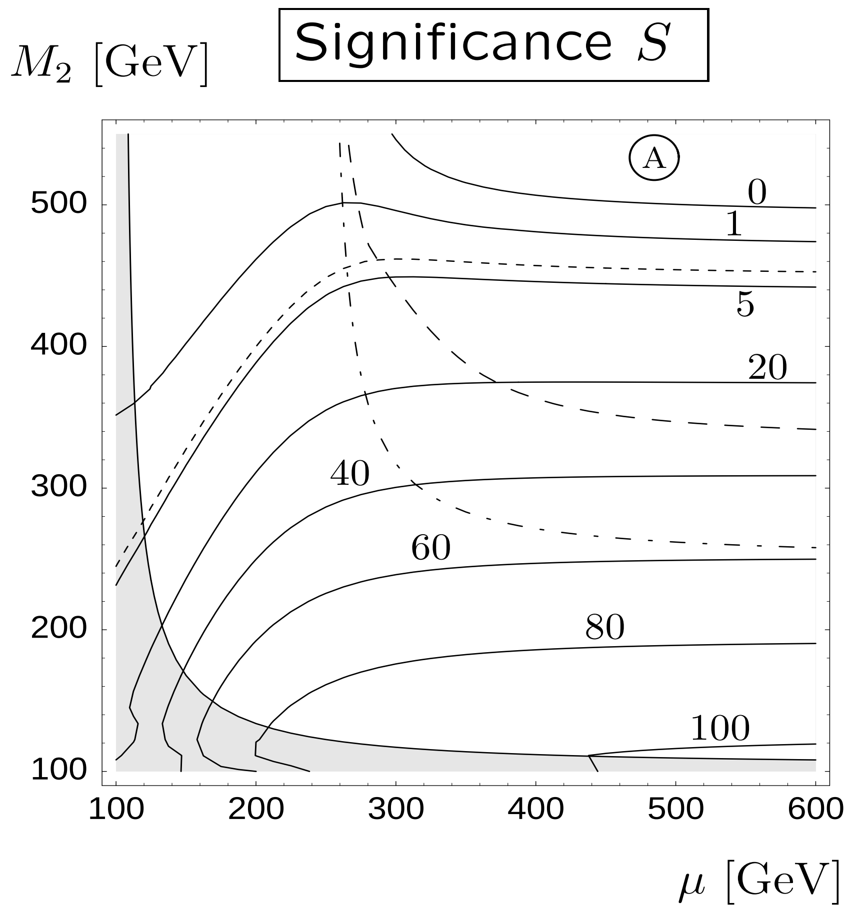
$$\Rightarrow S = 80 \text{ and } \frac{N_S}{N_B} = \frac{1}{5}$$



These results should motivate detailed Monte Carlo studies!

Dependence on μ and M_2



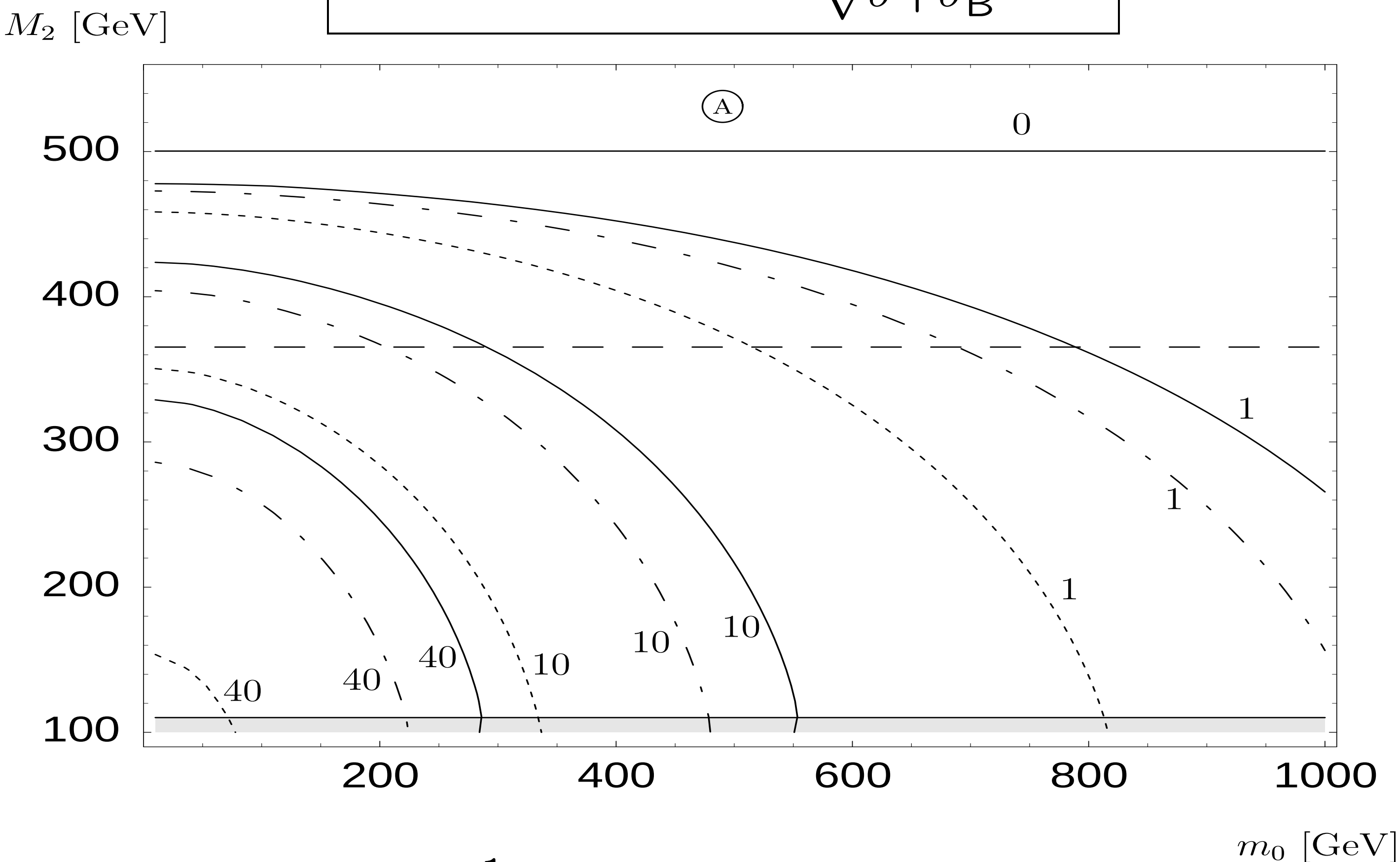


$\sqrt{s} = 500$ GeV, $\mathcal{L} = 500$ fb^{-1}; $(P_{e^-}, P_{e^+}) = (0.8, -0.6)$

kinematical limits: $e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_2^0$(dashed); $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-$(dot-dashed)

Dependence on $\tilde{e}_R$-mass for different beam polarizations

Significance $S = \frac{\sigma}{\sqrt{\sigma + \sigma_B}} \sqrt{\mathcal{L}}$



$\sqrt{s} = 500$ GeV, $\mathcal{L} = 500$ fb^{-1}; $\mu = 500$ GeV, $\tan\beta = 10$

dotted: $(P_{e^-}, P_{e^+}) = (0, 0)$; dot-dashed: $(0.8, 0)$; solid: $(0.8, -0.6)$

4 Summary and conclusions $e^+e^- \to \tilde{\chi}^0_1\tilde{\chi}^0_1\gamma$

- $\tilde{\chi}^0_1\tilde{\chi}^0_1\gamma$ is the lightest SUSY state to be produced

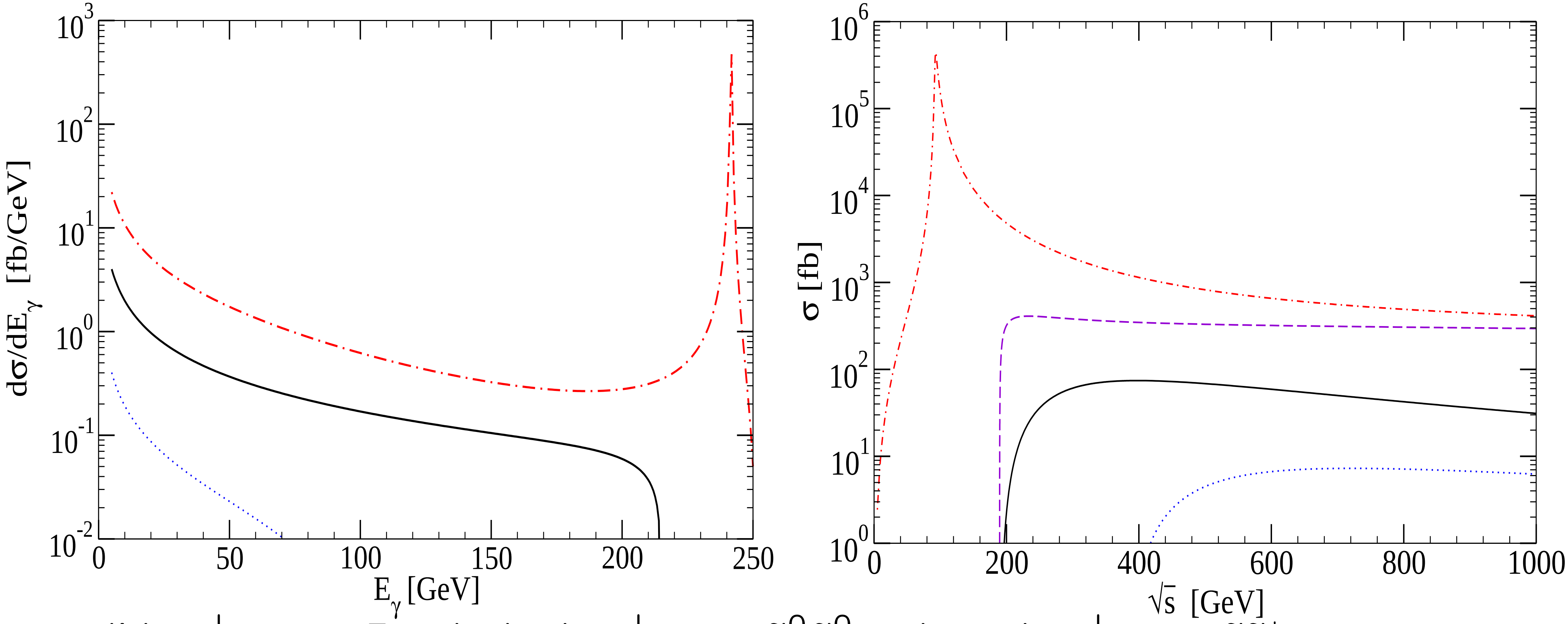
- Cannot be observed at LEP

- Polarized beams enhance signal and reduce background

- ILC: Significance up to 100, signal/background up to 1/5 possible (without polarization: $S = 10$, signal/background $= 1/200$)

- Positron beam polarisation needed in those parameter regions, where neutralinos, charginos and sleptons are too heavy to be pair-produced

Energy distribution and $\sqrt{s}$ dependence



solid: $e^+e^- \to \nu\bar{\nu}\gamma$, dashed: $e^+e^- \to \tilde{\chi}^0_1\tilde{\chi}^0_1\gamma$, dotted: $e^+e^- \to \tilde{\nu}\tilde{\nu}^*\gamma$

beam polarization: $(P_{e^-}, P_{e^+}) = (0.8, -0.6)$