universitätbonn
RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITÄT

The role of beam polarization for radiative neutralino production

Olaf Kittel

University of Bonn, Germany

in collaboration with:
Herbi Dreiner and Ulrich Langenfeld

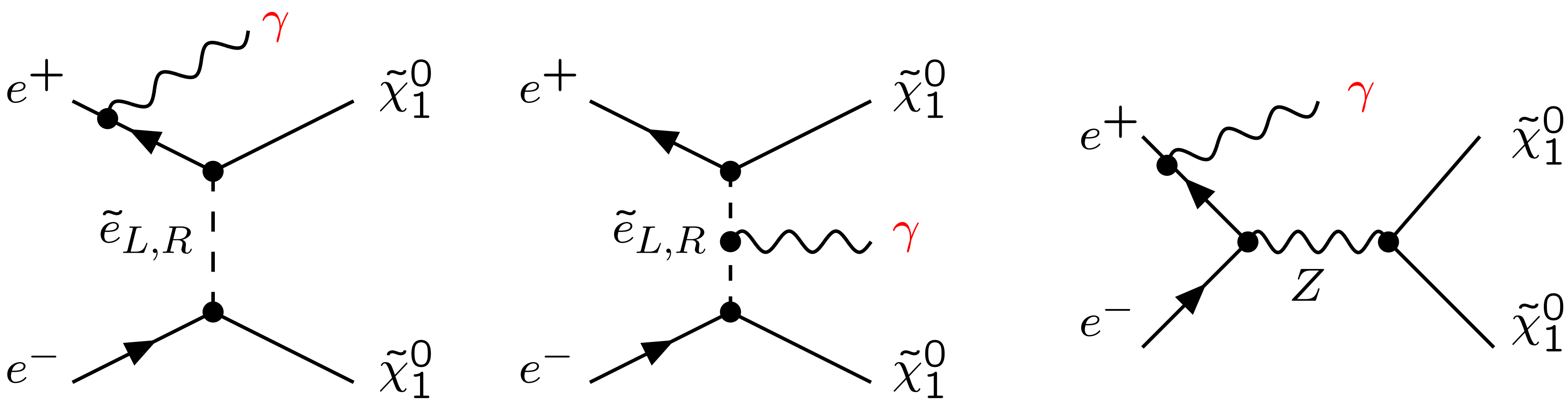
ILC 2007 DESY, June 1

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: $e^+ + e^- \to \nu + \bar{\nu} + \gamma$
- Significance: $S = \frac{N_S}{\sqrt{N_B + N_S}}$ (should be larger than 1)
- Signal to background ratio:

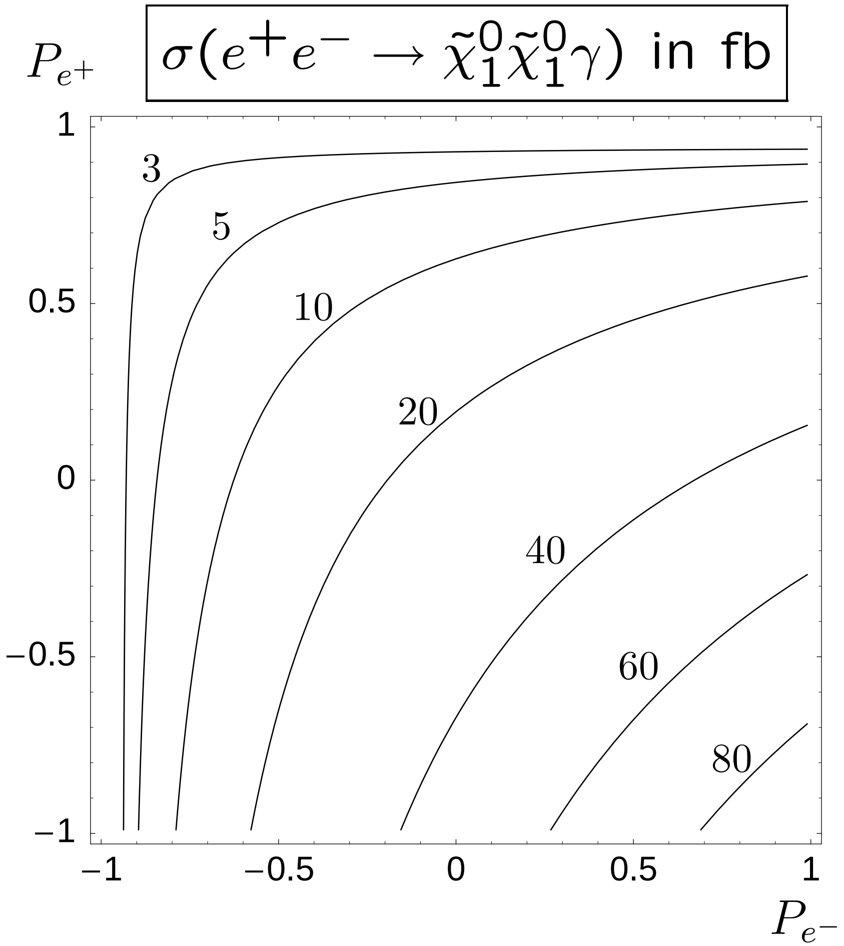
  $R = \frac{N_S}{N_B}$ (should be larger than theoretical error, say 1%)
- cross section σ: $N = \mathcal{L}\sigma$

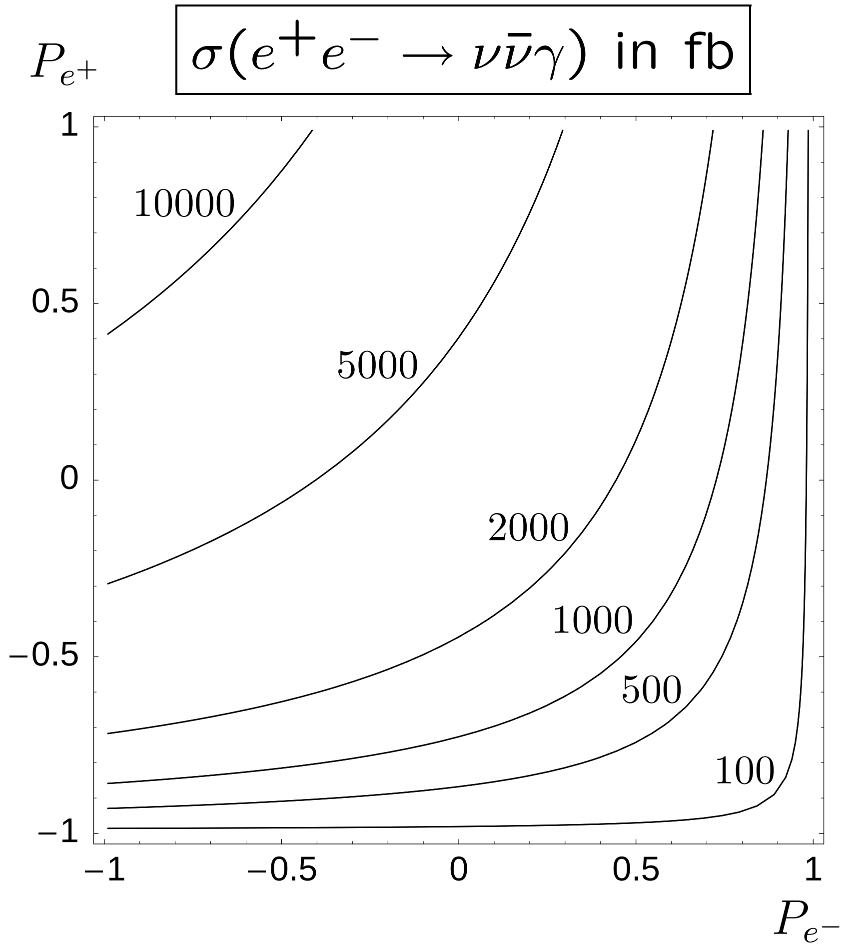
– Luminosity at LEP: $\mathcal{L} \approx 100$ pb^{-1} $\Rightarrow$ we find $S < 0.1$

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

$\Rightarrow$ Signal can well be observed!

Beam polarization dependence for SPS 1a





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

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

Significance S for SPS 1a

$S = \frac{N_{\mathsf{S}}}{\sqrt{N_{\mathsf{S}}+N_{\mathsf{B}}}}$ and $N = \mathcal{L} \times \sigma$

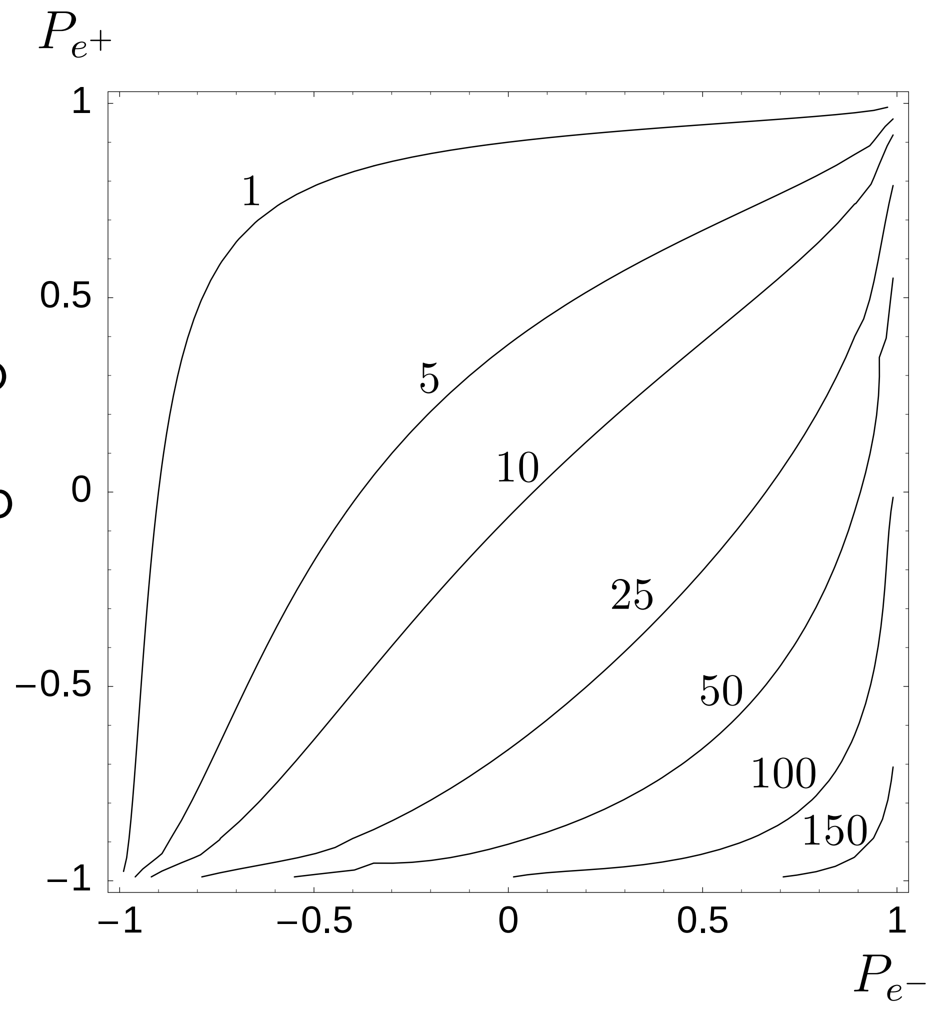
$\Rightarrow S = \frac{\sigma}{\sqrt{\sigma+\sigma_{\mathsf{B}}}}\sqrt{\mathcal{L}}$

signal: $\sigma(e^+e^- \to \tilde{\chi}^0_1\tilde{\chi}^0_1\gamma) =$ 56[70] fb

BG: $\sigma_{\mathsf{B}}(e^+e^- \to \nu\bar{\nu}\gamma) =$ 540[330] fb

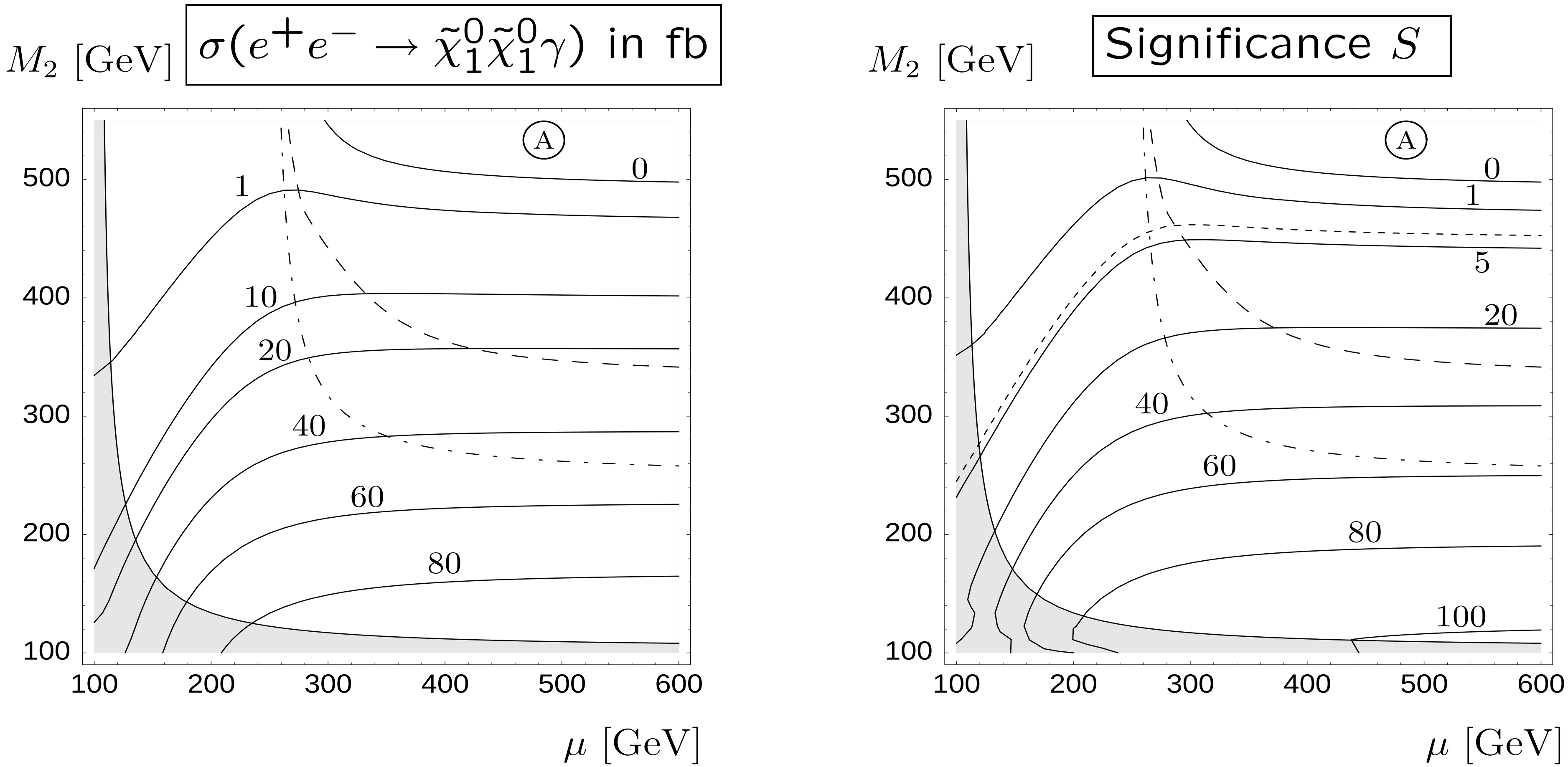
$\Rightarrow S =$ 50[80] and $\frac{N_{\mathsf{S}}}{N_{\mathsf{B}}} = \frac{1}{10}\left[\frac{2}{10}\right]$

$(P_{e^+}, P_{e^-}) = (-0.3, 0.8)\Big[(-0.6, 0.8)\Big]$



These results should motivate Monte Carlo studies!

Dependence on μ and M_2



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

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)

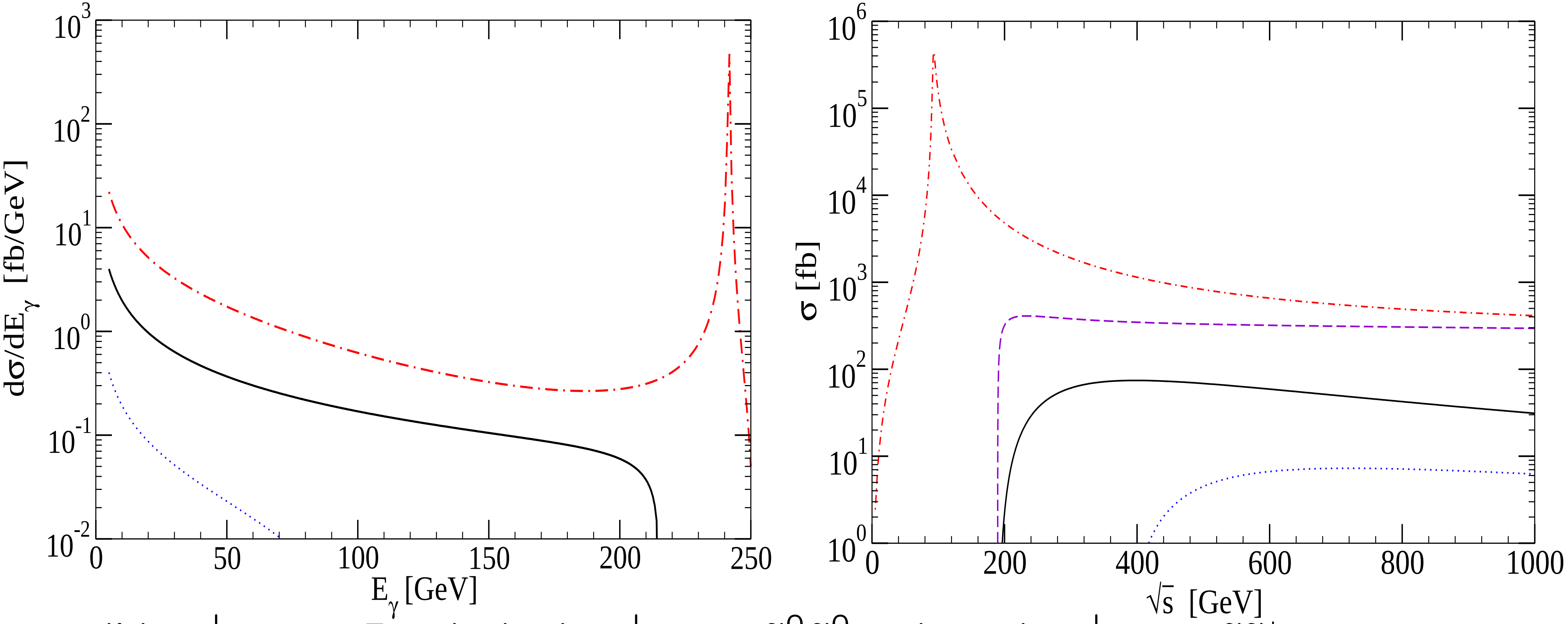
Summary and conclusions $e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0\gamma$

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

- Cannot be observed at LEP (low luminosity, no polarized beams).

- ILC:
  - Polarized beams enhance signal and reduce background simultaneously.
  - Significance up to 100, signal/background up to 1/5 possible.
  - $\tilde{\chi}_1^0\tilde{\chi}_1^0\gamma$ can be the only SUSY state at $\sqrt{s} = 500$ GeV.

Energy distribution and $\sqrt{s}$ dependence



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

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

$\tilde{\chi}_1^0\tilde{\chi}_1^0\gamma$ can be the only accessible SUSY state!

Consider $e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0\gamma$ at $\sqrt{s} = 500$ GeV in mSUGRA scenario:

M_0	$M_{1/2}$	A_0	$\tan\beta$	M_1	M_2	μ
200	415	-200	10	184	349	560

(mass parameters in GeV)

Neutralinos, charginos, sleptons are too heavy to be pair produced:

$m_{\tilde{\chi}_1^0}$	$m_{\tilde{\chi}_2^0}$	$m_{\tilde{\chi}_1^\pm}$	$m_{\tilde{\tau}_1}$	$m_{\tilde{e}_R}$	$m_{\tilde{e}_L}$	$m_{\tilde{\nu}}$
180	344	344	253	261	356	347

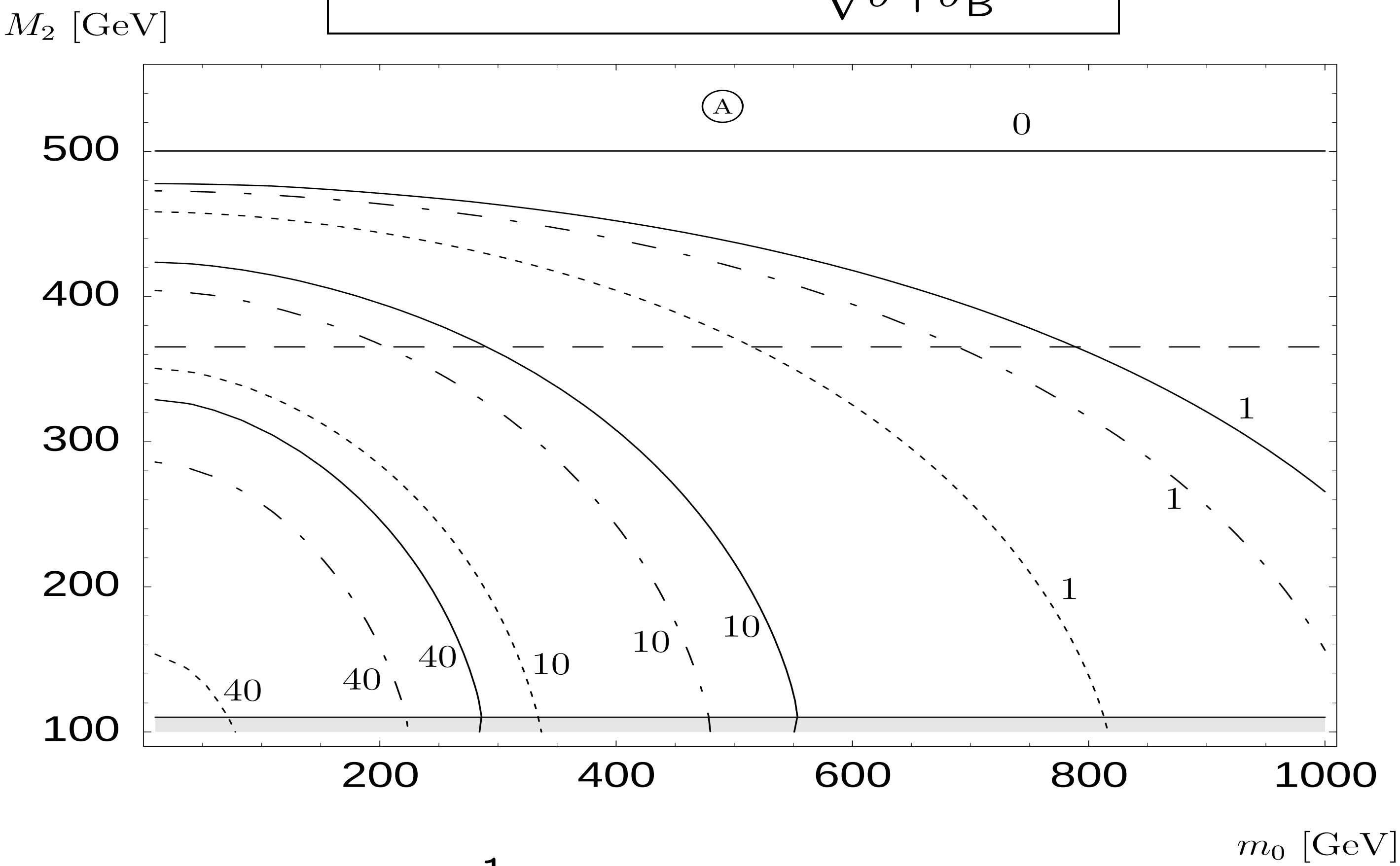
(masses in GeV)

Polarized beams enhance signal and reduce background:

(P_{e^+}, P_{e^-})	$(0\|0)$	$(0\|0.8)$	$(-0.3\|0.8)$	$(0\|0.9)$	$(-0.3\|0.9)$	$(-0.6\|0.8)$
$\sigma(\tilde{\chi}_1^0\tilde{\chi}_1^0\gamma)$	4.7 fb	8.2 fb	11 fb	8.6 fb	11.2 fb	13 fb
$\sigma_{\rm B}(\nu\bar{\nu}\gamma)$	3354 fb	689 fb	495 fb	356 fb	263 fb	301 fb
S	1.8	7	11	10	15	17
$R = \sigma/\sigma_{\rm B}$	0.1%	1.2%	2.2%	2.4%	4.3%	4.4%

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

Significance $S = \frac{\sigma}{\sqrt{\sigma + \sigma_{\rm B}}}\sqrt{\mathcal{L}}$



$\sqrt{s} = 500$ 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: $(0.8, -0.6)$