



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, May 31

Outline

- Introduction and motivation
- Signal and background
- Beam polarization dependence (SPS 1a)
- $\mu - M_2$ dependence
- $\tilde{\chi}_1^0 \tilde{\chi}_1^0 \gamma$ could be the only state accessible at $\sqrt{s} = 500$ GeV
- Summary and conclusions

Introduction and motivation

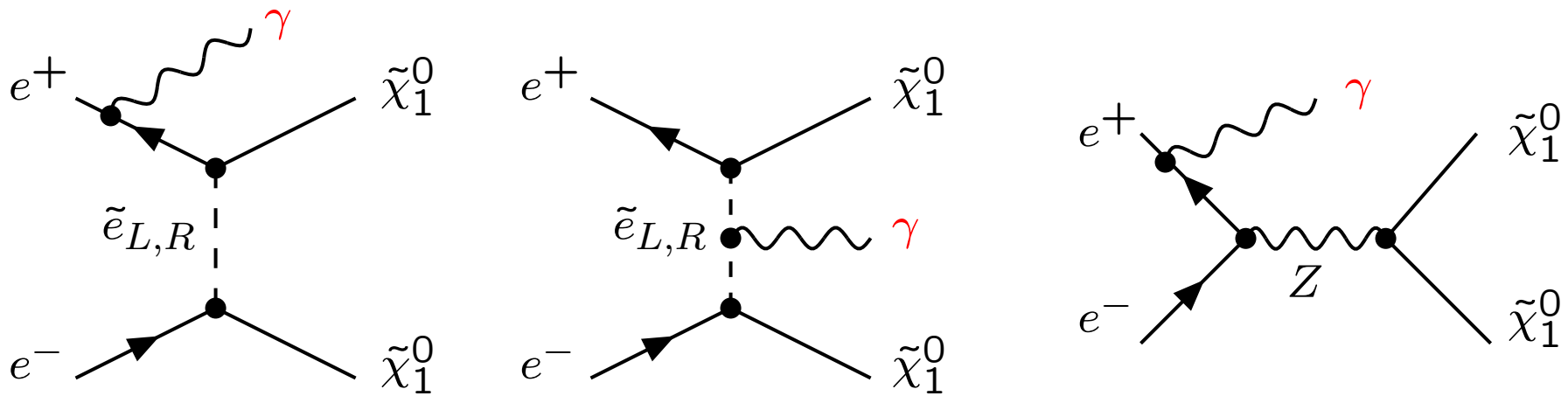
- Supersymmetry is attractive for Models beyond Standard Model.
- New supersymmetric particles have to be found at colliders.
- ILC: Lightest states can be studied first.
- Discovery at colliders (MSSM with R-parity conservation)
indirect: **missing energy** due to a stable LSP
direct: **pairs** of neutralinos,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

Radiative production of neutralinos

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

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

Signal: High energetic photon γ and missing energy

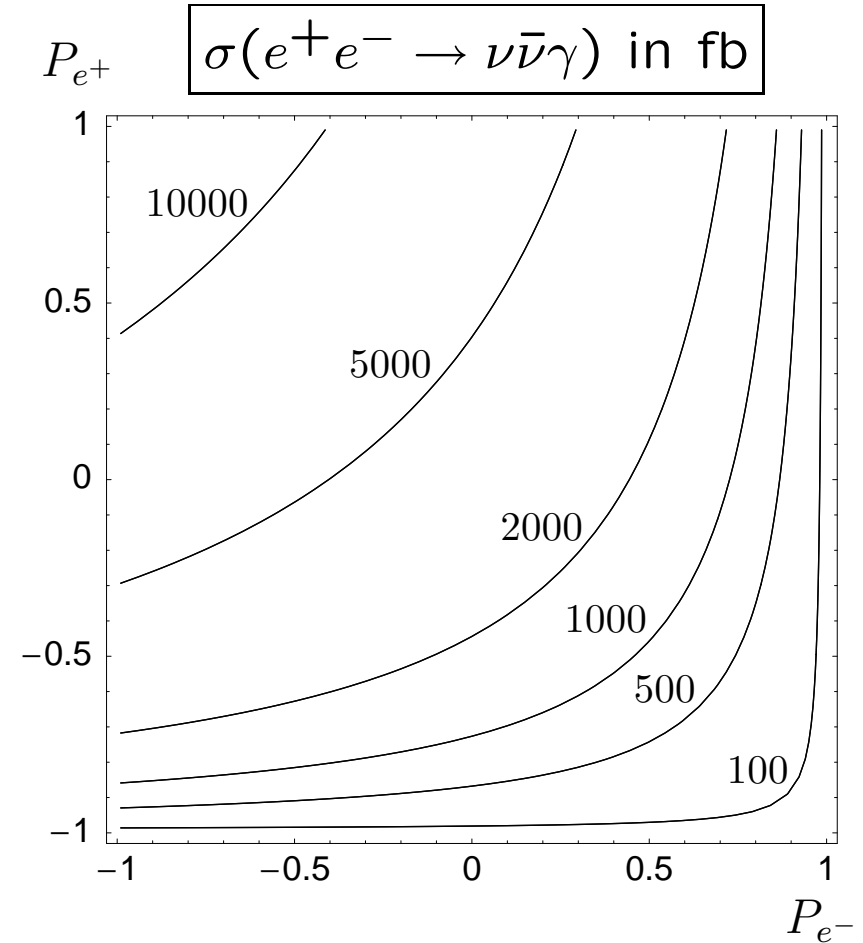
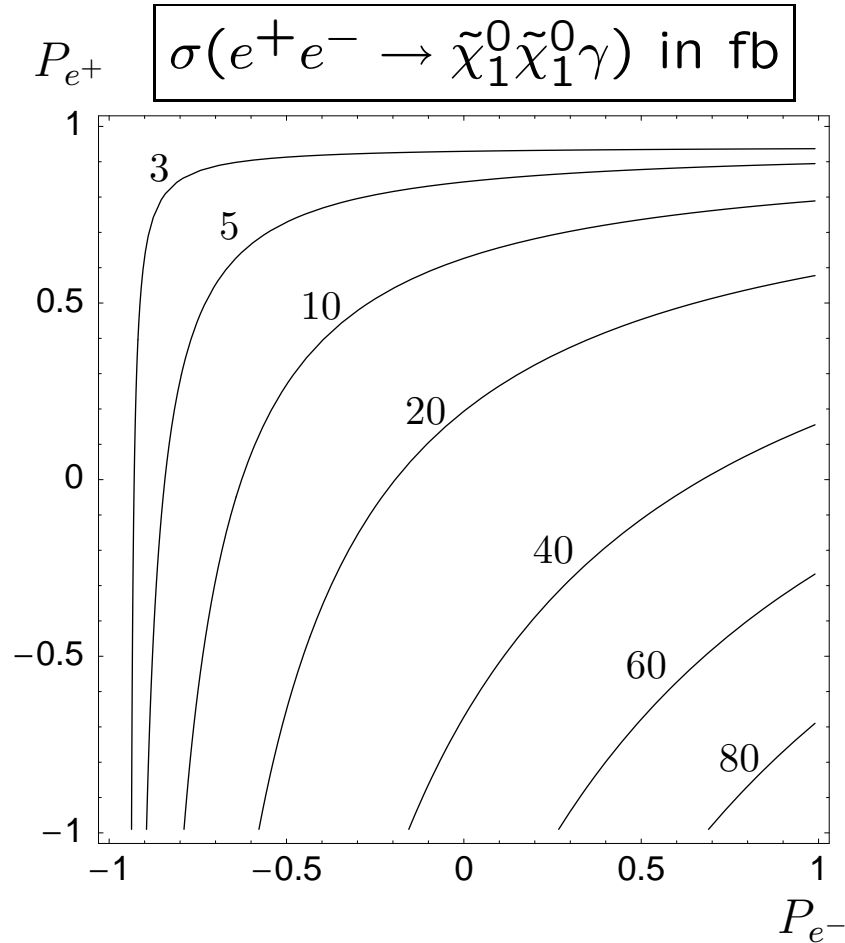


This is the lightest SUSY state to be produced!!!

Signal and Background

- Signal: $e^+ + e^- \rightarrow \tilde{\chi}_1^0 + \tilde{\chi}_1^0 + \gamma$
- Background
 - SM: $e^+ + e^- \rightarrow \nu + \bar{\nu} + \gamma$
 - MSSM: $e^+ + e^- \rightarrow \tilde{\nu} + \tilde{\nu}^* + \gamma$
- 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: $\mathcal{L} \approx 100 \text{ pb}^{-1} \Rightarrow$ we find $S < 0.1$
 - at ILC: $\mathcal{L} \approx 500 \text{ fb}^{-1}$ 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

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

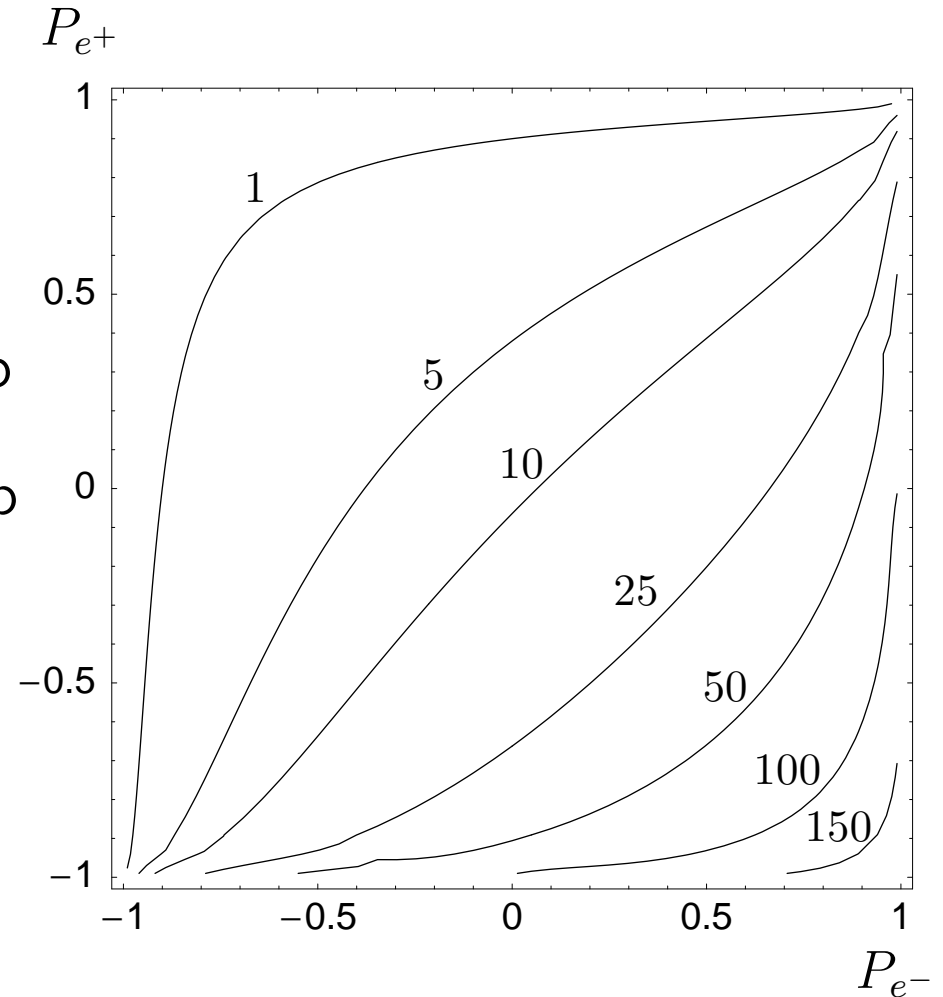
$$\Rightarrow S = \frac{\sigma}{\sqrt{\sigma + \sigma_B}} \sqrt{\mathcal{L}}$$

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

BG: $\sigma_B(e^+e^- \rightarrow \nu\bar{\nu}\gamma) = 540[330] \text{ fb}$

$$\Rightarrow S = 50[80] \quad \text{and} \quad \frac{N_S}{N_B} = \frac{1}{10} \left[\frac{2}{10} \right]$$

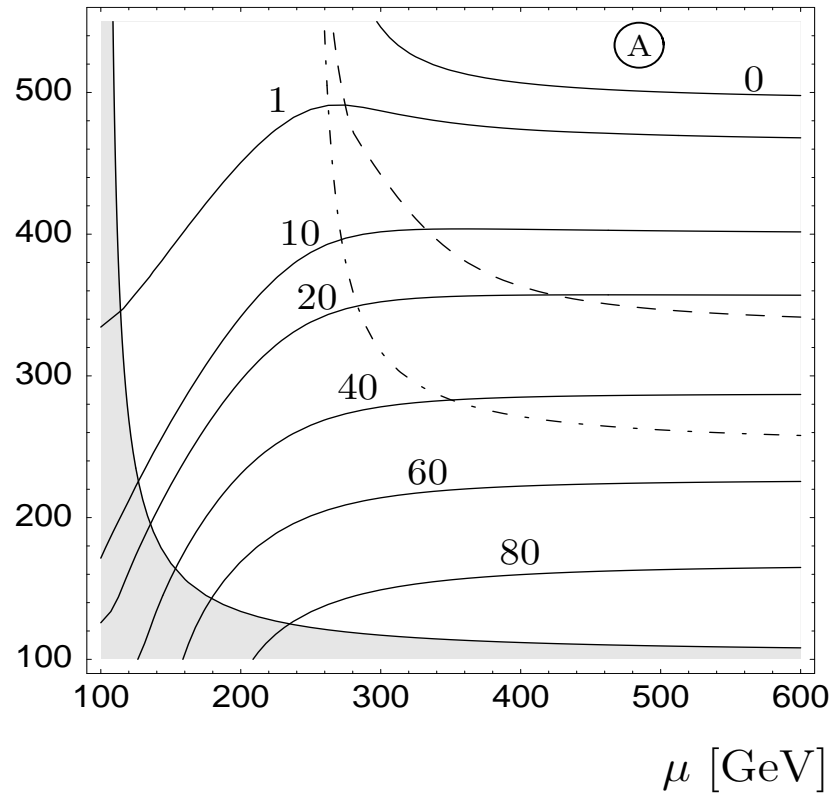
$$(P_{e^+}, P_{e^-}) = (-0.3, 0.8) \left[(-0.6, 0.8) \right]$$



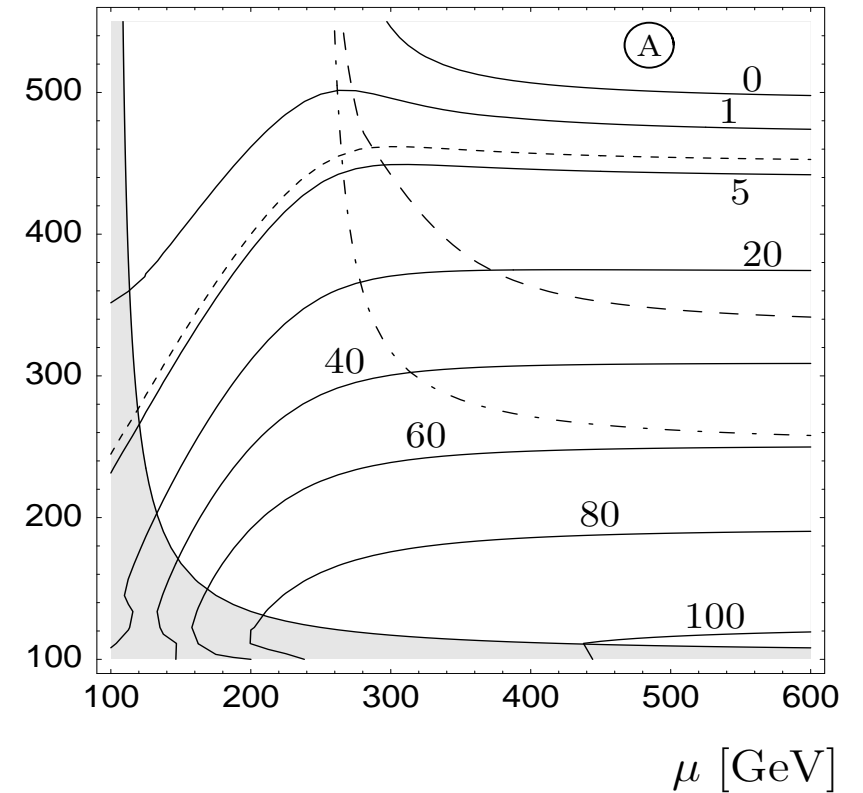
These results should motivate Monte Carlo studies!

Dependence on μ and M_2

M_2 [GeV] $\sigma(e^+e^- \rightarrow \tilde{\chi}_1^0 \tilde{\chi}_1^0 \gamma)$ in fb



M_2 [GeV] Significance S



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

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

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

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

M_0	$M_{1/2}$	A_0	$\tan \beta$	M_1	M_2	μ	(mass parameters in GeV)
200	415	-200	10	184	349	560	

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

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

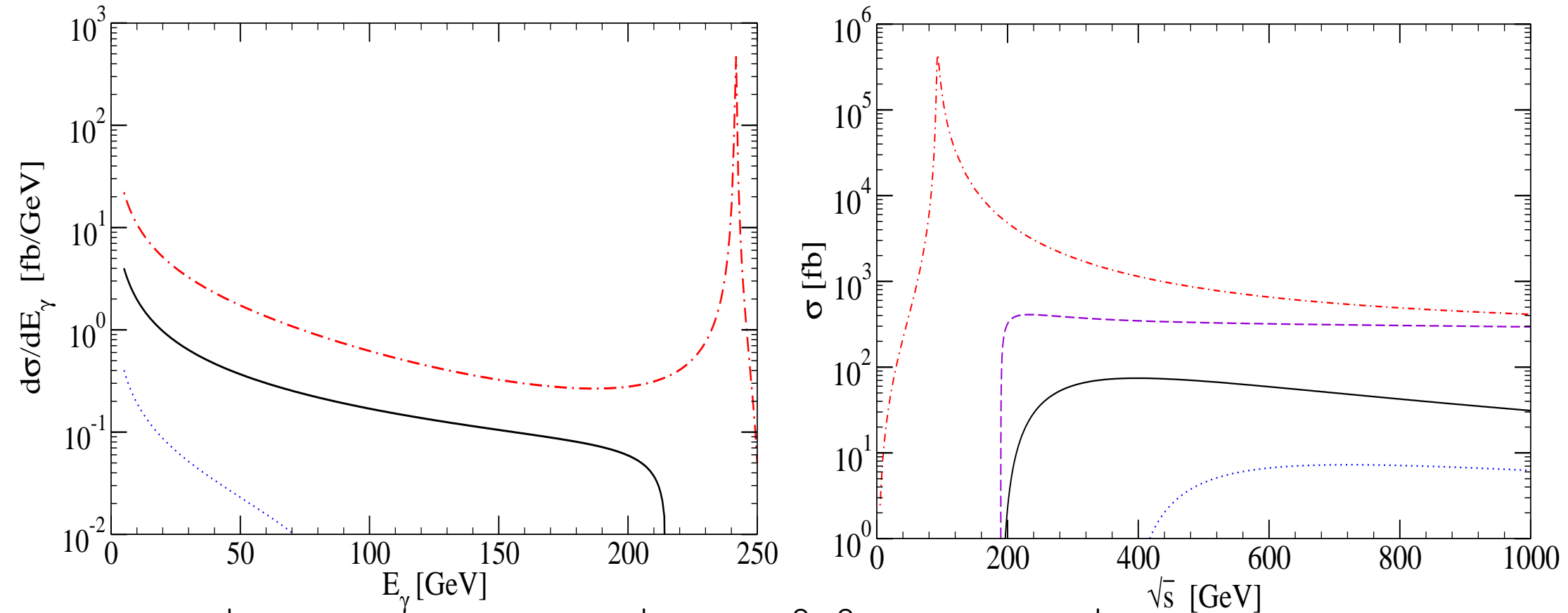
Polarized beams enhance signal and reduce background:

(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
$\sigma_B(\nu \bar{\nu} \gamma)$	3354 fb	689 fb	495 fb	356 fb	263 fb	301 fb
S	1.8	7	11	10	15	17
$R = \sigma/\sigma_B$	0.1%	1.2%	2.2%	2.4%	4.3%	4.4%

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

- $\tilde{\chi}_1^0\tilde{\chi}_1^0\gamma$ 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

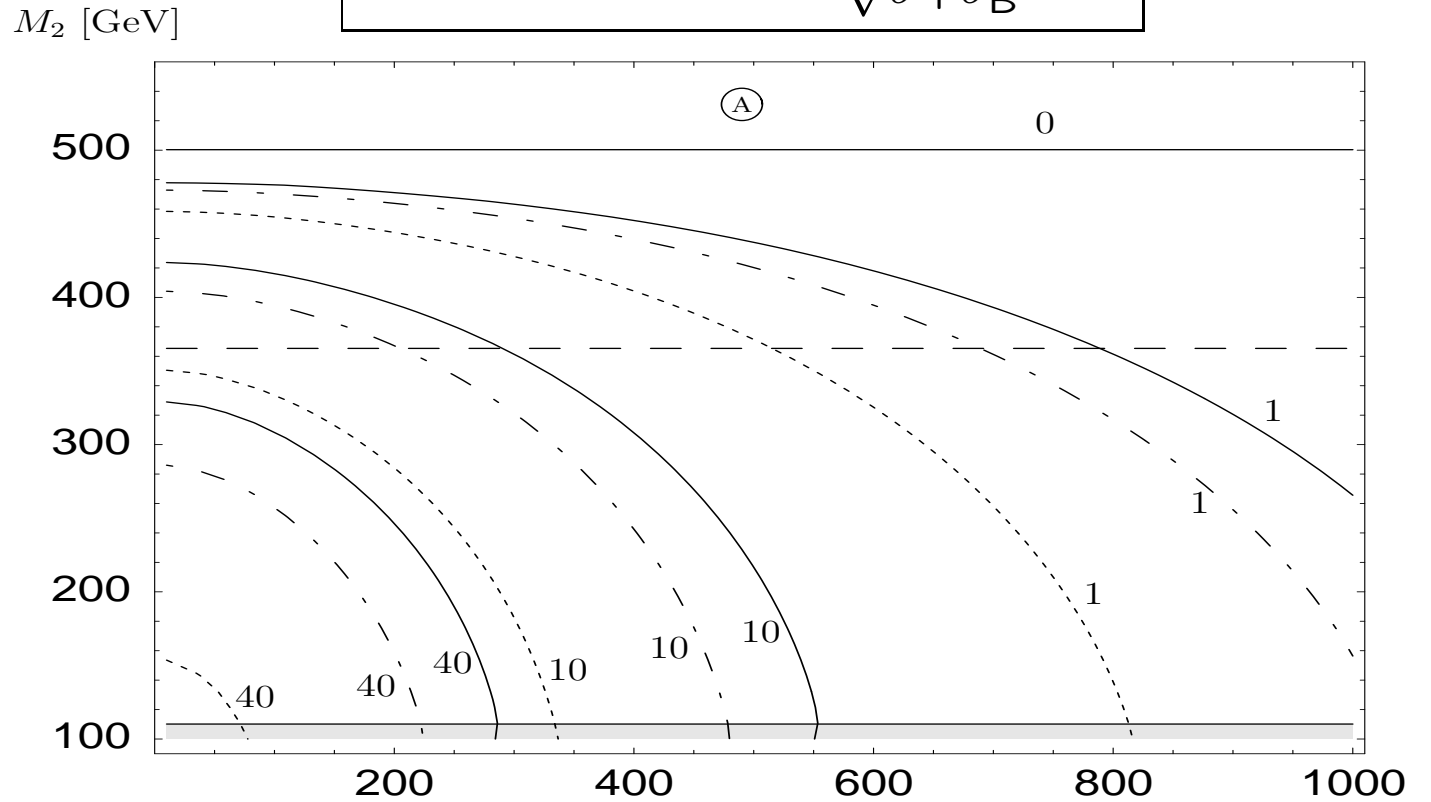


solid: $e^+e^- \rightarrow \nu\bar{\nu}\gamma$, dashed: $e^+e^- \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0\gamma$, dotted: $e^+e^- \rightarrow \tilde{\nu}\tilde{\nu}^*\gamma$

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

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

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



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