

Sensitivity to the gravitino mass from single photon spectrum at a $e^+ e^-$ Linear Collider

- Theoretical framework:
superlight gravitino
- LEP results
- Linear Collider sensitivity
- Conclusions

Superlight gravitino

- The \tilde{G} mass $m_{3/2}$ is related to the SUSY breaking scale $\sqrt{|F|}$:

$$m_{3/2} = \frac{F}{\sqrt{3}M_P} \sim 2.5 \text{ eV} \left(\frac{\sqrt{F}}{100 \text{ TeV}} \right)^2$$

- BFZ^a model: cross section for $f\bar{f} \rightarrow \tilde{G}\tilde{G}\gamma$ proportional to $\frac{s^3}{|F|^4}$ or to $\frac{s^3}{m_{3/2}^4}$
- cross-section very large if \tilde{G} very light:

$$\sigma = \frac{\alpha s^3}{320\pi^2|F|^4} \cdot I$$

- The photon Phase-Space \approx ISR
- At e^+e^- machines σ_{meas} depends on the integral over part of PS:

$$I(\mathbf{E}_{\gamma,\min}, \mathbf{E}_{\gamma,\max}, \cos\theta_{\gamma,\max})$$

^aA. Brignole, F. Ferruglio and F. Zwirner Nucl. Phys. B516 (1998) 13.

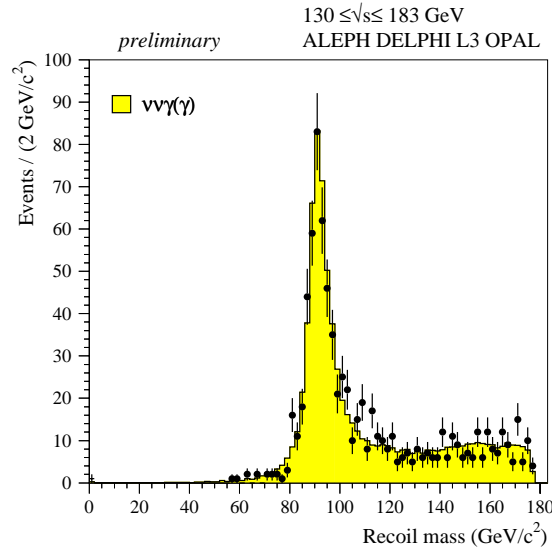
Background

- Irreducible S.M. background: $\nu\bar{\nu}\gamma(\gamma)$
- Signal detectable as an excess of events
- or limit if no excess is found:

$$m_{3/2} > 3.8 \cdot 10^{-6} \text{eV} \left[\frac{\sqrt{s}(\text{GeV})}{200} \right]^{\frac{3}{2}} \left[\frac{I}{\sigma_{\text{limit}}(\text{pb})} \right]^{\frac{1}{4}}$$

- Other backgrounds:
 - $e^+e^-\gamma$ with e^+e^- in the beam pipe removed with p_t cut
 - Cosmics
remove with HCAL, timing etc.

LEP results



Limits at 95 % Confidence Level

	$m_{3/2}$ (eV)	\sqrt{F} (GeV)
ALEPH	$1.10 \cdot 10^{-5}$	213
DELPHI	$0.91 \cdot 10^{-5}$	193
L3	$0.98 \cdot 10^{-5}$	202

- See $m_{3/2} > 1 \times 10^{-5}$ from Tevatron

Linear Collider sensitivity

- Selection: One photon with

$$E > E_{\gamma}^{\min}, \theta_{\gamma} > \theta_{\gamma}^{\min}, p_t < p_t^{\min}$$

- Effects of the cuts on the PS:

I	E_{γ}^{\min}	θ_{γ}^{\min}	$p_t/(\sqrt{s} - E_{\gamma})$
8.23	10	11	0.038
10.63	10	11	0.030
12.70	10	11	0.025
12.70	6	11	0.025
12.68	20	11	0.025
12.44	10	13	0.025
12.13	10	15	0.025
15.46	10	11	0.020

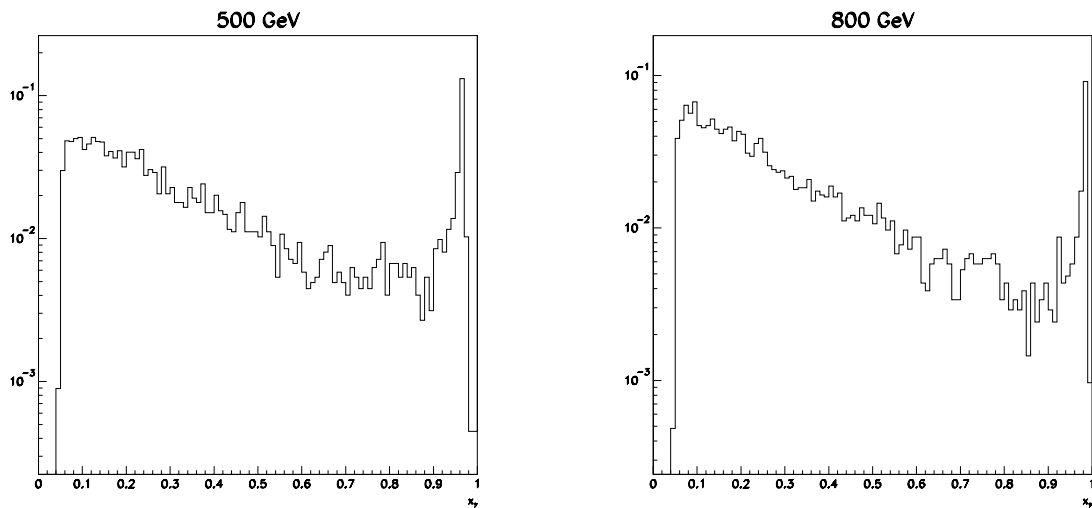
- p_t cut is dominant

relevant detector for the acceptance:

Luminometer

Background cross sections

- **Caveat:** KORALZ and NUNUGPV^a not guaranteed at these energies: precision 20% ÷ 30%



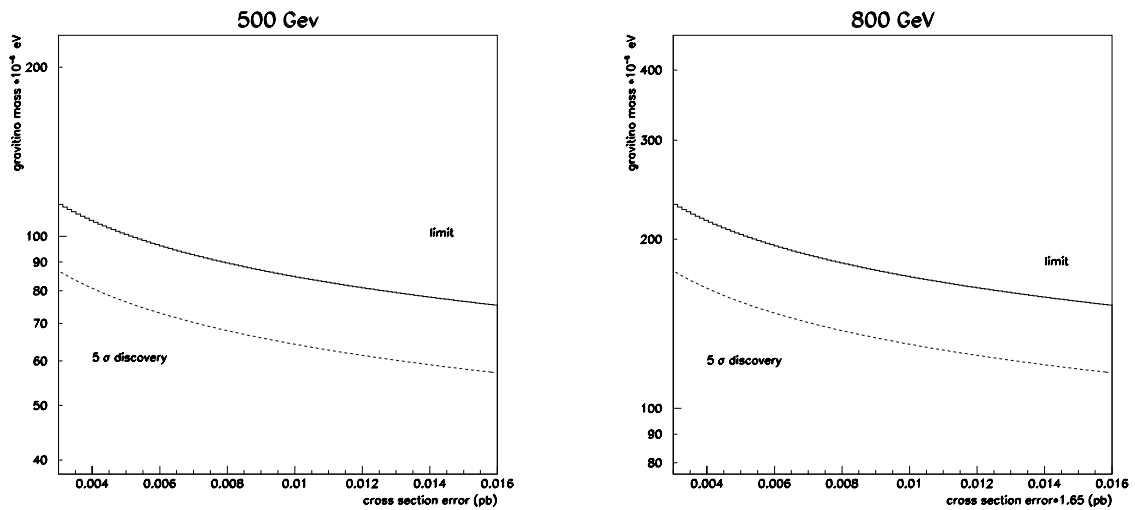
- Remove Z^0 peak by demanding $x_\gamma < .7$ negligible effect on the signal PS
- cross-section range: 1.45 ÷ 1.08 pb
- 500 fb⁻¹: 550 ÷ 750 × 10³ events
- Statistical error : 1.1 ÷ 1.3 × 10⁻³

^a thanks to A. DeMin, O. Nicosini

- Systematics?

Pessimistic CDR: $\Delta\mathcal{L}/\mathcal{L}=1\%$

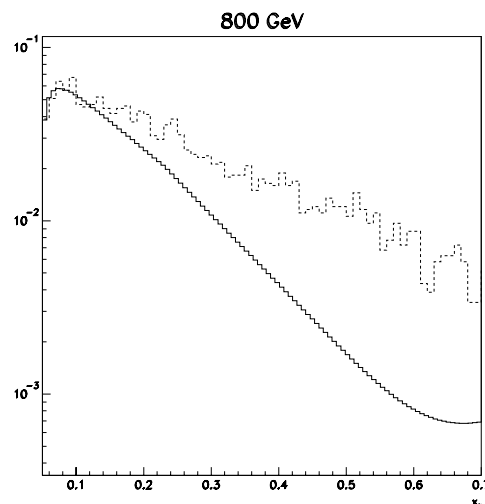
sensitivity vs $\Delta\sigma$



- At 800 GeV for $\Delta\sigma = 0.5\%$

$m_{3/2} > 1.8 \times 10^{-4}$ eV at 95 % C.L.

- Further improvement if Likelihood Ratio used:



Conclusions

- Anomalies in single photon spectrum:
signal of new physics
- From \sim ISR sensitivity to \tilde{G} production
- Similar analyses (i.e. extra dimension)
- Need more precise computations
- Preliminary result:

Sensitivity to $m_{3/2} \sim 1.5 \div 2.3 \times 10^{-4}$ eV
or to $\sqrt{|F|} \sim 790 \div 980$ GeV