Supersymmetric Leptons Search at ILC

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Abstract

The processes of supersymmetric lepton (slepton) pairs production by means of two-photon mechanism in electron–positron collisions at ILC (International Linear Collider) energies are considered. Here we obtained total and differential cross sections of above mentioned processes in dependence on various variables and parameters.

1 Introduction

We studied slepton production possibility on ILC and CLIC because one of the main tasks of planned ILC machine is search of "new physics", in particular so-called superpartners, predicted by numerous SUSY models (see for review, for instance [1, 2, 3]). In this article we calculate total and differential cross sections for slepton pair production by means of two-photon mechanism in framework of minimal supersymmetric extension of Standard Model (MSSM).This process studied in detail for hadron production (see, for example, [4, 5, 6, 7, 8, 9, 10]). We are using of the equivalent photons method (Weizsacker-Williams approximation) for ultrarelativistic collisions, which allows us to consider virtual photons as real ones and essentially simplifies the calculation of observable values. The processes of slepton pairs production by two-photon mechanism can be measured with high accuracy at modern colliders [11, 12, 13] and have bright signature. Therefore they will represent interest for the "new physics" search.

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2 Two-photon Processes of Slepton Pairs Production at ILC

Broken supersymmetry remains the best applying proposal for physics beyond the Standard Model Physics. First of all, it account for the mass hierarchy. Now the best restrictions for the SUSY particles mass are given by LHC experiments. Recent LHC data are very effective in ruling out the existence of coloured SUSY particles (gluino and the first two generation of squarks). They gave the mass restrictions of the object about 1 TeV. However, such constraints are less restrictive for sleptons and other noncolours particles because of difficulties to produce them by pp or $p\bar{p}$ collisions. So, future $e\bar{e}$–colliders will be the good place to produce and study noncoloured SUSY objects. Let us consider the processes of SUSY scalar lepton and antilepton production in electron–positron collisions by means of twophoton mechanism in leading order (see FIG. 1). We will use all of the time Weizsacker–Williams approximation [14, 15].

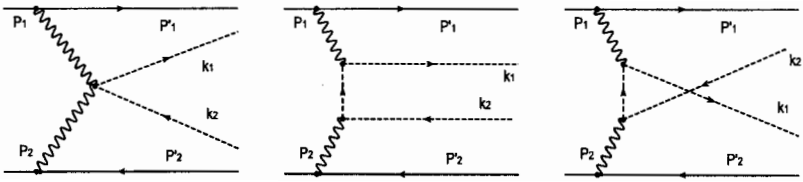

Figure 1: Feynman diagrams of the considered processes. P_1 (P_1') and P_2 (P_2') are 4-momenta of initial (final) electrons and positrons; k_1, k_2 are 4-momenta of sleptons.

The program Mathematica and packages FeynArts3.4 and FeynCalc8.1 were used to obtain amplitudes and square module matrix element on the basis of Feynman rules for SUSY (see for overview [16]). The different parameters of masses of the supersymmetric leptons are given in TABLE 1 [17].

$m_{\tilde{e}}$ GeV	LM1	LM2	LM6
$\tilde{e}_L^-$	184	301	283
$\tilde{e}_R^-$	118	229	175

Table 1: Masses of SUSY leptons for different cases.

3 Total and differential cross section

Photon distribution density in Weizsacker–Williams is given[18]

$$\gamma(x) = \frac{\alpha}{\pi}((1 - x + \frac{x^2}{2}) - (1 - x)(1 - \frac{q^2_{min}}{q^2_{max}})), \quad (1)$$

where $q^2_{min} = m_e \cdot x^2/(1-x)$, m_e–mass electron, $q^2_{max} = 2GeV^2$. This distribution density was used to obtain total and differential cross section. To have total and differential cross section we used Monte–Carlo method[19][20] in SusyGen generator written C++. Values of considered total cross–section of processes are represented in (see TABLE 2). Differential cross–sections of the process are given in Fig. 2–4.

$\sqrt{s}$ GeV	LM1	LM2	LM6
500	0.2629fb	–	–
700	0.5135fb	0.0617fb	0.0866fb
1000	0.9268fb	0.1495fb	0.1899fb
3000	3.6496fb	0.7937fb	0.9665fb

Table 2: Total cross-section for different energies of the processes at ILC.

4 Conclusion

We investigated SUSY slepton pair production at ILC in twophoton mechanism. One can see that for groups of parameters LM1, LM2, LM6 total cross section increase with increasing total energy of colliding electrons and positrons. Obtained data show that the most suitable energy research slepton production in twophoton mechanism in the electron–positron accelerators ILC and CLIC are $\sqrt{s} = 1$ TeV and $\sqrt{(s)} = 3$ TeV.

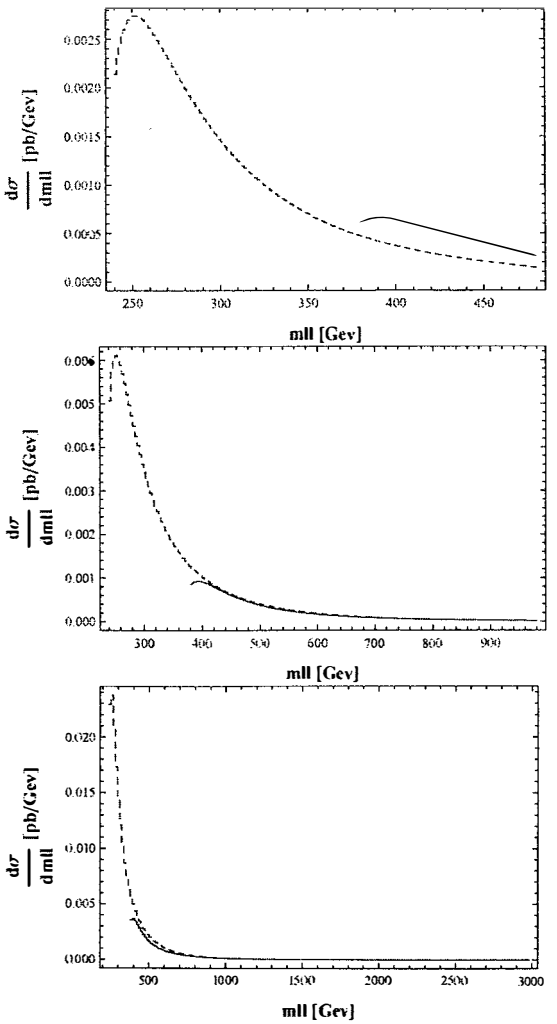

Figure 2: Differential cross section of $\tilde{e}^+\tilde{e}^-$ production in dependence of invariant mass $\sqrt{\hat{s}} = m_{\tilde{e}\tilde{e}}$ at $\sqrt{S} = 500$ (upper), 1000 (middle) and 3000 (lower) GeV for $m_{\tilde{e}_L} = 184\,GeV$ and $m_{\tilde{e}_R} = 118\,GeV$ for LM1.

References

[1] A. Bilal. Introduction to Supersymmetry, hep-th:0101055v1.

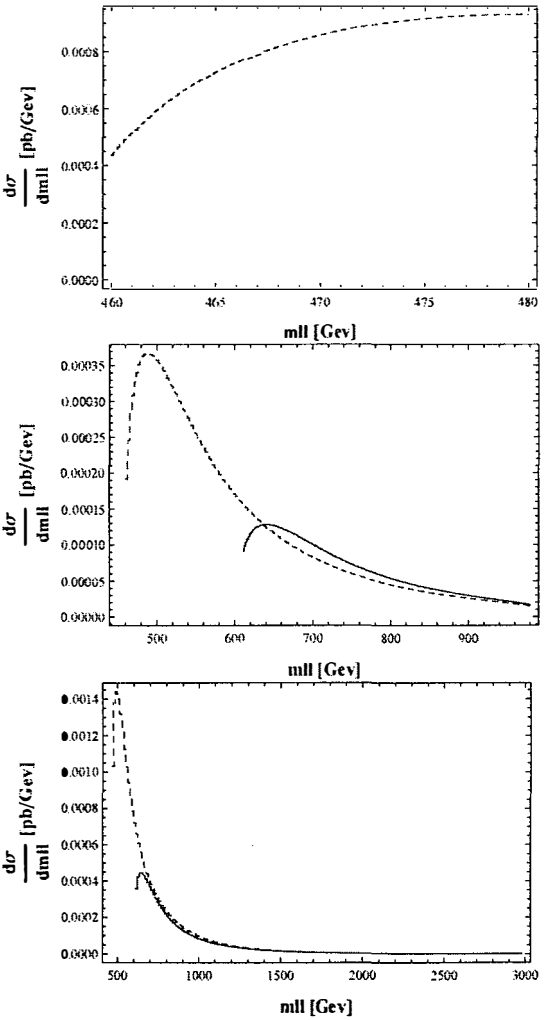

Figure 3: Differential cross section of $\tilde{e}^+\tilde{e}^-$ production in dependence of invariant mass $\sqrt{\hat{s}} = m_{\tilde{e}\tilde{e}}$ at $\sqrt{S} = 500$ (upper), 1000 (middle) and 3000 (lower) GeV for $m_{\tilde{e}_L} = 301\,GeV$ and $m_{\tilde{e}_R} = 229\,GeV$ for LM2.

[2] J. D. Lykken. Introduction to Supersymmetry hep-th:9612114v1.

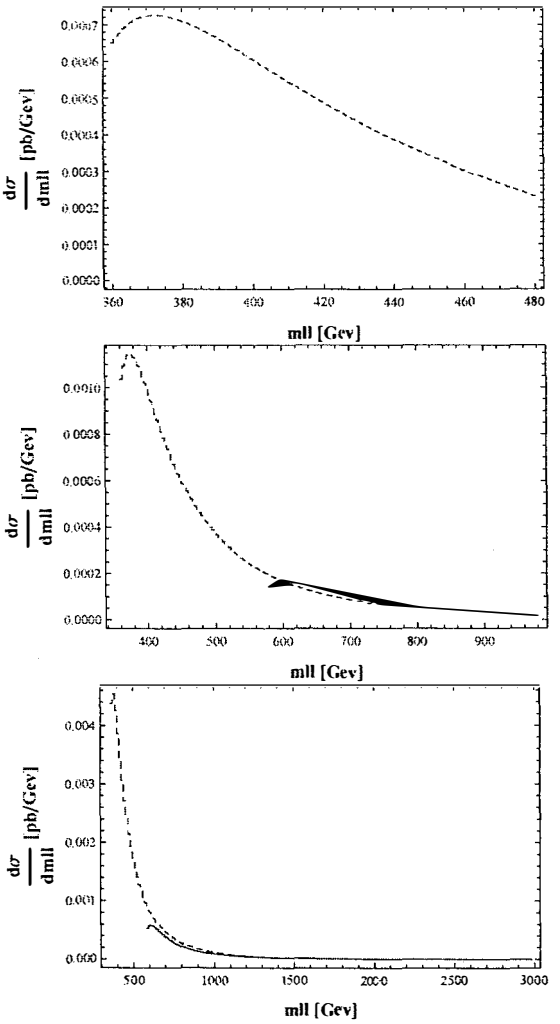

Figure 4: Differential cross section of $\tilde{e}^+\tilde{e}^-$ production in dependence of invariant mass $\sqrt{\hat{s}} = m_{\tilde{e}\tilde{e}}$ at $\sqrt{S} = 500$ (upper), 1000 (middle) and 3000 (lower) GeV for $m_{\tilde{e}_L} = 283\,GeV$ and $m_{\tilde{e}_R} = 175\,GeV$ for LM6.

[3] M. Drees. An Introduction to Supersymmetry, hep-th:9611409v1.

[4] V.M. Budnev et al. JETP Letters, **12** (1970), 249.

[5] V.M. Budnev et al. PEPAN, **4** (1973), 239.

[6] V.E.Balakin et al. JETP Letters, **11** (1970), 559.

[7] C.Pisano. The Polarized and unpolarized photon content of the nucleon /thesis/, hep-ph:0512306.

[8] ATLAS Collaboration. Search for direct slepton and gaugino production in final states with two leptons and missing transerse momentum with the ATLAS detector in pp collssions at $\sqrt{s} = 7$ TeV.

[9] K. Piotrzkowski and N. Schul. Two-photon production of supersymmetric pairs at the LHC, hep-th:0910.0202v1.

[10] J. de Favereau de Jeneret et al. High energy photon interations at LHC hep-th:0908.2020v1.

[11] CDF Collaboration. Observation Exclusive Charmonium Production and $\gamma\gamma \rightarrow \mu^-\mu^+$ in $p\bar{p}$ Collisions at $\sqrt{s} = 1.96\ TeV$, hep-ex:0902.1271v4.

[12] CMS Collaboration. Observation of Exclusive Electron-Positron Production in Hadron-Hadron Collisions, hep-ex:0611040v2.

[13] CMS Collaboration. Exclusive diphoton production of dimuon pairs in proton-proton collisions at $\sqrt{s} = 7.0\ TeV$, hep-ex:1111.5536v1.

[14] C.F.Weizsäcker. Z.Phys., **88** (1934), 612.

[15] E.J.Williams. Phys.Rev., **45** (1934), 729.

[16] J. Risiek. Complete set of Feynman rules for minimal supersymmetric extension of standard model; erratum J. Rosiek Complete set of Feynman rules for MSSM, hep-ph/9511250v3.

[17] M. Battaglia et al. Eur. Phys. J. (2004), 273-296.

[18] V.M.Budnev et al. Phys.Rep., **C15** (1975), 181.

[19] E.Byckling, K.Kajantie. Particle Kinematics. John Wiley and sons, 1973.

[20] S.Weinzierl. Introduction to Monte Carlo methods, hep-ph:0006229v1.