STATE RESEARCH CENTER OF RUSSIA
INSTITUTE FOR HIGH ENERGY PHYSICS

IHEP 97-67

The search for sleptons and flavour lepton number violation at LHC (CMS)

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Abstract

We study a possibility to detect sleptons and flavour lepton number violation at LHC (CMS). We investigate the production and decays of right- and left-handed sleptons separately. We have found that for $L = 10^5 pb^{-1}$ it would be possible to discover right-handed sleptons with a mass up to 350 GeV and left-handed ones with a mass up to 350 GeV. We also investigate a possibility to look for flavour lepton number violation in slepton decays due to the mixing of different generations sleptons. We find that for the maximal $(\tilde{\mu}_R - \tilde{e}_R)$ mixing it is possible to detect such effect for sleptons with a mass up to 250 GeV.

Protvino 1997

1 Introduction

As is well known, one of the supergoals of LHC is the supersymmetry discovery. In particular, it is very important to investigate a possibility to discover nonstrongly interacting superparticles (sleptons, higgsino, gaugino). In this paper we investigate the discovery potential for sleptons and for flavour lepton number violation in slepton decays at CMS.

This study is distinct from the previous ones [1, 2, 3] in several aspects. We do not use the minimal SUGRA-MSSM framework. Instead we investigate separately the production and decays of right-handed and left-handed sleptons. We believe that SUGRA-MSSM framework is very particular and very attractive model. However, the main assumption of SUGRA-MSSM model is that at GUT scale ($M_{GUT} = 2 \cdot 10^{16}\ GeV$) all the soft breaking scalar masses coincide could be, at best, a rough feature due to many reasons:

1. in superstring inspired models soft scalar supersymmetry breaking terms are not universal at Planck scale in general [4],
2. in supersymmetric SU(5) model an account of the evolution of soft supersymmetry breaking terms between Planck and GUT scale [5, 6] is very essential,
3. in models with additional relatively light vector like supermultiplet the mass formulae for superparticles can drastically differ [7] from the standard ones [8].

Therefore, we believe that it is more appropriate not to rely on the particular model but try to investigate model independent aspects of the sleptons search at LHC. The cross section for the production of the right(left)-handed sleptons depends mainly on the mass of right(left)-handed sleptons and the decay properties of the sleptons are determined mainly by the mass of the lightest superparticle (LSP).

The main signature for the search for sleptons at LHC is two same-flavour opposite-sign leptons $+E_T^{miss} + no\ jets$. Of course, there are SUSY strong ($\tilde{g}\tilde{g},\ \tilde{g}\tilde{q},\ \tilde{q}\tilde{q}$) and weak ($\chi_1^{\pm}\chi_2^0,\ \chi_1^{\pm}\chi_1^{\mp}$) backgrounds to the slepton signature. But, as a rule, they are not too large and they only increase the LHC discovery potential of new SUSY physics (however, in general, it could be nontrivial to separate a slepton signal from SUSY backgrounds).

As it has been mentioned above, we study separately both the right-handed slepton production and the signature and the left-handed slepton production and the signature. We also investigate the possibility to look for the flavour lepton number violation in slepton decays at LHC. We find that at LHC for $L = 10^5 pb^{-1}$ it is possible to discover right- and left-handed sleptons with a mass up to 350 GeV and the flavour number violation in right-handed slepton decays for slepton masses up to 250 GeV as well.

Our simulations are made at the particle level with parametrized detector responses based on the detailed detector simulation. All SUSY processes with full particle spectrum, couplings, production cross section and decays are generated with ISAJET 7.13, ISASUSY [9]. The Standard Model backgrounds are generated with PYIHIA 5.7 [10]. We have used cuts and estimates for the Standard Model backgrounds obtained in ref. [3]. The CMS detector simulation program CMSJET 3.2 [11] is used.

In Section 1 we describe slepton production and decay mechanisms. Section 2 is devoted to the discussion of the Standard Model backgrounds. In Sections 3, 4 and 5 we discuss the case of right-handed, left-handed and left- plus right-handed sleptons, correspondingly. Section 6 is devoted to the discussion of the search for flavour lepton violation in slepton decays.

2 Slepton production and decays

Relatively heavy sleptons with the masses larger than chargino and neutralino masses $\chi_1^{\pm}$, χ_2^0 can be produced at LHC only through a Drell-Yan mechanism, namely, pairs $\tilde{l}_L\ \tilde{l}_L$, $\tilde{l}_R\ \tilde{l}_R$, $\tilde{\nu}_L\ \tilde{\nu}_L$, $\tilde{\nu}_L\ \tilde{l}_L$ can be produced. In general, the decays of sleptons can be rather complicated. In this section we shall study the case when only right-handed sleptons are relatively light, whereas the left-handed sleptons are heavy and their contribution to the signature $l^+l^- + E_T^{miss} + no\ jets$ is small. In this case right-handed sleptons decay dominantly to LSP

$$\tilde{l}_R^- \longrightarrow l^- + \chi_1^0.$$

If decays to the second neutralino or first chargino are kinematically allowed, the signature $l^+l^- + E_T^{miss} + no\ jets$ can be realized as a result of the gaugino decays

$$\begin{aligned} &\chi_2^0 \longrightarrow \chi_1^0 + l^+l^- \\ &\chi_2^0 \longrightarrow \chi_1^0 + \nu\bar{\nu} \\ &\chi_2^0 \longrightarrow \chi_1^0 + Z \qquad\qquad (A) \end{aligned}$$

$$\chi_1^{\pm} \longrightarrow \chi_1^0 + l^{\pm} + \nu$$
$$\chi_1^{\pm} \longrightarrow \chi_1^0 + W^{\pm}.$$

For the case when χ_2^0, $\chi_1^{\pm}$ are heavier than sleptons, an indirect slepton production is possible

$$\begin{array}{l} \chi_2^0 \longrightarrow \tilde{l}_{L,R}^{\pm} l^{\mp} \\ \chi_2^0 \longrightarrow \tilde{\nu}_L \bar{\nu}_L \\ \chi_1^{\pm} \longrightarrow \tilde{\nu}_L l^{\pm} \\ \chi_1^{\pm} \longrightarrow \tilde{e}_L^{\pm} \nu_L. \end{array} \qquad \text{(B)}$$

The left-handed sleptons decay (if kinematically accessible) to charginos and neutralinos

$$\begin{array}{l} \tilde{l}_L^{\pm} \longrightarrow l^{\pm} + \chi_{1,2}^0 \\ \tilde{l}_L^{\pm} \longrightarrow \nu_L + \chi_1^{\pm} \\ \tilde{\nu}_L \longrightarrow \nu_L + \chi_{1,2}^0 \\ \tilde{\nu}_L \longrightarrow l^{\pm} + \chi_1^{\mp}. \end{array} \qquad \text{(C)}$$

In Section 2 we shall discuss the pure left-handed case. In our study we, as a rule, neglect indirect slepton production (case B). Inclusion of indirect slepton production or other SUSY backgrounds only increases the excess of the signal over background and improves the significance. Moreover, for many kinematical points indirect production is not too large. So, in the first approximation, we neglect cascade decays (case B) and (case C). For the lightest chargino and two lightest neutralinos in the assumption that at GUT scale $M_{GUT} \approx 2 \cdot 10^{16} GeV$ all gaugino masses coincide, the masses are determined by the common gaugino mass $m_{\frac{1}{2}}$ at GUT scale:

$$m(\chi_2^0) \approx m(\chi_1^{\pm}) \approx 2\ m(\chi_1^0) \approx m_{\frac{1}{2}}.$$

In MSUGRA model slepton masses are determined by formulae [8]:

$$m_{\tilde{l}_R}^2 = m_0^2 + 0.15\ m_{\frac{1}{2}}^2 - sin^2\theta_W M_Z^2 cos2\beta \qquad (1)$$

$$m_{\tilde{l}_L}^2 = m_0^2 + 0.52\ m_{\frac{1}{2}}^2 - \frac{1}{2}(1 - 2\ sin^2\theta_W) M_Z^2 cos2\beta \qquad (2)$$

$$m_{\tilde{\nu}}^2 = m_0^2 + 0.52\ m_{\frac{1}{2}}^2 - \frac{1}{2} M_Z^2 cos2\beta, \qquad (3)$$

where m_0 is the common scalar soft breaking mass at GUT scale. However, formulae (1-3) are valid only within MSUGRA model which can be considered, in the best case, as a first rough approximation (see discussion in the

Introduction) and will be wrong for more complicated models. In this paper we investigate only the signature $l^+l^- \; + \; E_T^{miss} \; + \; no\ jets$ which arises as a result of the slepton pairs production with their subsequent decays into leptons and LSP

$$pp \longrightarrow (\tilde{l}^{\pm} \to l^{\pm} + ...) + (\tilde{l}^{\mp} \to l^{\mp} + ...).$$

3 Standard Model backgrounds

The expected main Standard Model background should be $t\bar{t}$ production, with both W's decaying to leptons, or one of the leptons from W decay and the other from the $b-$decay of the same $t-$quark; the other SM backgrounds come from WW, WZ, $b\bar{b}$ and $\tau\tau$-pair production, with decays to electrons and muons. Standard model backgrounds for different kinematical cuts have been calculated [3] with the help of PYTHIA 5.7 code. In this paper we use the results from ref. [3].

The set of kinematical variables which are useful to extract the slepton signals and typical selection cuts are [1, 2, 3]:

i) for leptons :

- p_T-cut on leptons and lepton isolation (Isol), which is here defined as the calorimetric energy flow around the lepton in a cone $\Delta R \; < \; 0.5$ divided by the lepton energy;
- effective mass of two same-flavour opposite-sign leptons, to suppress WZ and potential ZZ backgrounds by rejecting events in a $m_Z \pm \delta m_Z$ band;
- $\Delta\Phi(l^+l^-)-$relative azimuthal angle between two same-flavour opposite-sign leptons;

ii) for E_T^{miss} :

- $E_T^{miss}-$cut,
- $\Delta\Phi(E_T^{miss}, ll)-$relative azimuthal angle between E_T^{miss} and the resulting dilepton momentum in the transverse plane;

iii) for jets :

- "jet veto"-cut : $N_{jet} \; = \; 0$ for some E_T^{jet} threshold, in some rapidity interval, typically $|\eta_{jet}| \; < \; 4.5$.

Namely, we adopt from the ref. [3] the set of cuts which in our notations look as follow :

Cut \ Set	1	2	3	4	5	6	7
P_L^l >	20 GeV	20 GeV	50 GeV	50 GeV	60 GeV	60 GeV	60 GeV
$Isol$ <	0.1	0.1	0.1	0.1	0.1	0.1	0.03
$\|\eta_l\|$ <	2.5	2.5	2.5	2.5	2.5	2.5	2.5
E_T^{miss} >	50 GeV	50 GeV	100 GeV	120 GeV	150 GeV	150 GeV	150 GeV
$\Delta\Phi(E_T^{miss}, ll)$ >	160^o	160^o	150^o	150^o	150^o	150^o	150^o
N_{jet} =	0	0	0	0	0	0	0
E_T^{jet} >	30 GeV	30 GeV	30 GeV	30 GeV	45 GeV	45 GeV	45 GeV
$\|\eta_{jet}\|$ <	4.5	4.5	4.5	4.5	4.5	4.5	4.5
$M_Z - cut$	yes	yes	yes	yes	yes	yes	yes
$\Delta\Phi(l^+l^-)$	$> 130^o$	no	$< 130^o$	$< 130^o$	$< 130^o$	$< 140^o$	$< 130^o$
N_B^{SM} [3]	992	2421	172	105	45	53	38

Here N_B^{SM} is the number of the Standard Model background events for $L = 10^4 pb^{-1}$ (cuts 1-2) and for $L = 10^5 pb^{-1}$ (cuts 3-7). $M_Z - cut$ is condition that $M_{l^+l^-} < 86\ GeV$ or $96\ GeV < M_{l^+l^-}$.

As has been mentioned above, we, as a rule, neglect indirect slepton production and also we neglect SUSY backgrounds which are mainly due to $\tilde{q}\tilde{q}$, $\tilde{g}\tilde{q}$, $\tilde{g}\tilde{g}$ production and with subsequent cascade decays with jets outside the acceptance or below the threshold. As has been demonstrated in ref. [3] by the example of MSUGRA model SUSY background is, as a rule, much less than the SM background and we shall neglect it. At any rate, the SUSY background increases an excess of a signal over the SM background and increases the LHC discovery potential of new physics.

4 Right-handed sleptons

In this section we study the possibility to search for right-handed sleptons at CMS. Namely, we consider the signature *dilepton* + E_T^{miss} + *no jets*. We don't consider the left-handed slepton contribution to this signature, i.e. we consider the situation when left-handed sleptons are much heavier than the right ones and it is possible to neglect them. In this case right-handed sleptons decay dominantly to an LSP

$$\tilde{l}_R^- \to l^- + \chi_1^0.$$

The cross section of the right-handed slepton production is determined mainly by the mass of the right-handed slepton. The dependence of the right-handed slepton cross section production for the case of 3-flavour degenerate right-handed sleptons is presented in Table 1 and in Fig.1.

Table 1: The cross section $\sigma(pp \to \tilde{L}_R \tilde{L}_R + ...)$ in pb for different values of right-handed slepton masses at LHC. Right-handed sleptons are assumed to be degenerate in mass.

$M(GeV)$	90	100	125	150	175	200	225
σ	0.41	0.27	0.13	0.068	0.039	0.024	0.016
$M(GeV)$	250	275	300	325	350	375	400
σ	0.011	0.0079	0.0055	0.0041	0.0032	0.0025	0.0020

The number of signal events passing through the cuts 1-7 depends rather strongly on the LSP mass $m_{\chi_1^0}$. The results of our calculations for different values of the slepton and the LSP masses are presented in Tables $3 - 14$. In Tables the significances S and $S_{1.5}$ are

$$S = \frac{N_S}{\sqrt{N_S \ + \ N_B^{SM}}}, \quad S_{1.5} = \frac{N_S}{\sqrt{N_S \ + \ 1.5 \ \cdot \ N_B^{SM}}}, \tag{4}$$

where N_B^{SM} have been calculated in ref. [3]. The significance $S_{1.5}$ is the significance for the case when the number of the SM background events is increased by a factor of 1.5 compared to N_B^{SM} calculated in ref. [3].

As it follows from Tables $3-14$ for $L \ = \ 10^5 pb^{-1}$, it is possible to discover the right-handed sleptons at 5 σ significance level with a mass up to 300 GeV. For the right-handed sleptons with a mass $90 \ GeV \ \leq \ m_{\tilde{l}_R} \ \leq \ 300 \ GeV$ it is possible to discover sleptons for not very large values of the LSP mass. Typically we must have $m_{\chi_1^0} \ \leq \ (0.4 \ - \ 0.6) m_{\tilde{l}_R}$.

It should be noted that the SM background coming from $W\,W$, $\bar{t}\,t$, $\bar{\tau}\,\tau$ production with subsequent leptonic decays predicts the equal number of $\mu^+ \, \mu^-$, $e^+ \, e^-$, $\mu^+ \, e^-$ and $e^+ \, \mu^-$ events up to statistical fluctuation whereas the signal contains an equal number of $\mu^+ \, \mu^-$ and $e^+ \, e^-$ pairs coming from

$$p \; p \to \tilde{\mu}_R^+ \, \tilde{\mu}_R^- \ + \ \ldots \ \to \mu^+ \, \mu^- \ + \ 2 \ LSP$$

and

$$p\,p \to \tilde{e}_R^+\,\tilde{e}_R^- \;+\; \ldots \;\to \mu^+\,\mu^- \;+\; 2\,LSP.$$

We have found that the reaction

$$p\,p \to \tilde{\tau}_R^+\,\tilde{\tau}_R^- \;+\; \ldots \;\to \mu^+\,\mu^-,\; e^+\,e^-,\; e^+\,\mu^-,\; \mu^+\,e^- \;+\; \ldots$$

practically does not contribute to the number of signal events. So, we can neglect it, i.e. practically at LHC using the signature *dilepton* + E_T^{miss} + *no jets*, we study the production and decays of the first 2 generations of sleptons. Therefore, we have qualitative consequence of the existence of slepton signal – the excess of $\mu^+\,\mu^-$ and $e^+\,e^-$ events over $e^+\,\mu^-$ and $\mu^+\,e^-$ events.

This excess is other estimation of N_s with the statistical fluctuation at 1 σ level equal to $\sqrt{N_s + 2N_b}$. If we combine two estimations of N_s and adopt 5σ criterium for new physics discovery, we find that the signal events passing cuts 1-7 have to be greater than 143, 220, 64, 52, 38, 40, 35 events, correspondingly. This is an additional criterium for new physics discovery for the case of standard slepton production. According to this criterium it is possible to discover right-handed sleptons for a mass up to 350 GeV (see Table 14, $m_{\chi_1^0} = 119$ GeV). If we increase the SM background by a factor of 1.5 which takes into account some uncertainties in the calculations of the SM background, the number of signal events passing through the cuts 1-7 has to be greater than 174, 267, 77, 62, 44, 47, 40 events, correspondingly, and the right-handed sleptons can be discovered with masses up to 325 GeV. At any rate, this criterium serves as an additional check for sleptons discovery.

5 Left-handed sleptons

In this section we study the case when the right-handed sleptons are much heavier than the left-handed ones (of course, this situation looks pathological since in MSUGRA approach the left-handed sleptons are heavier than the right-handed ones, however, in a general case we can't exclude such a possibility) and we can neglect them. The dependence of the left-handed slepton cross section production is presented in Table 2 and in Fig.1. The results of our calculations for different values of the sleptons and the LSP masses are presented in Tables 15-20. The notations are similar to the case of the right-handed sleptons. As follows from Tables 15-20, it is possible to discover left-handed sleptons with a mass up to 350 GeV. The discovery potential of the left-handed sleptons depends as in the case of the right-handed

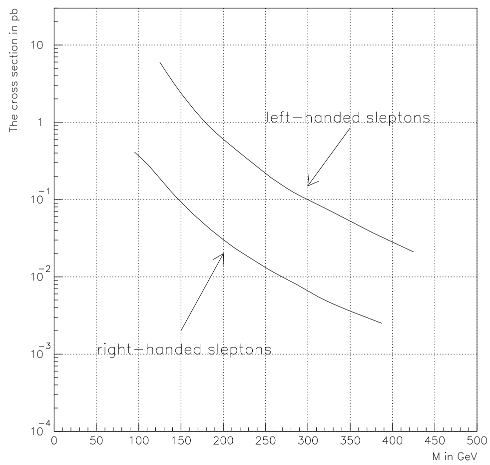

Figure 1: The cross section $\sigma(pp \to \tilde{L}_R \tilde{L}_R + ...)$ in pb for different values of right-handed slepton masses at LHC (right-handed sleptons are assumed to be degenerate in mass) and the cross section $\sigma(pp \to \tilde{L}_L \tilde{L}_L + ...)$ in pb for different values of left-handed slepton masses for $tan\beta = 2$ at LHC (left-handed sleptons masses are assumed to be degenerate in flavour).

sleptons on the mass of LSP. The LSP masses $m_{\chi_1^0} = (0.4 - 0.6)m_{\tilde{l}_L}$ give the maximal number of events which passed cuts unlike the case of the right-handed sleptons when small LSP masses are the most preferable from the LHC sleptons discovery point of view. Again, if we use the criterium based on the estimation of the difference $N(e^+e^- + \mu^+\mu^-) - N(e^+\mu^- + \mu^+e^-)$ events we find that it is possible to discover the left-handed sleptons with a mass up to 350 GeV (Table 20, $m_{\chi_1^0} = 196\ GeV$).

Table 2: The cross section $\sigma(pp \to \tilde{L}_L\tilde{L}_L + ...)$ in pb for different values of left-handed slepton masses for $tan\beta = 2$ at LHC. Left-handed sleptons masses are assumed to be degenerate in flavour.

$M(GeV)$	100	150	200	250	300	350	400	450
σ	6.0	1.1	0.36	0.14	0.073	0.038	0.021	0.013

6 Right-handed plus left-handed sleptons

As has been mentioned in the Introduction, in general, we can expect that MSUGRA model, in the best case, gives qualitative description of the sparticle spectrum. So, in general masses of the LSP, the right-handed and the left-handed sleptons are arbitrary. However, in many models the left-handed sleptons are, as a rule, heavier than the right-handed ones. Moreover, with a good accuracy the right-handed and the left-handed sleptons give an additive contribution to the signal event, i.e.

$$N(signal) = N_{Left}(signal) + N_{Right}(signal).$$

To obtain some flavour we have studied the direct sleptons production for the case when $m_{\tilde{l}_L} = m_{\tilde{l}_R} + 50GeV$, $tan\beta = 2$. The results of our investigation are presented in Tables 21-24. As follows from Tables 21-24, it is possible to discover sleptons with a mass of the right-handed slepton up to 350GeV (see Table 24). The inclusion of the left-handed sleptons increases the sleptons discovery potential, moreover, it is possible to discover sleptons in a wider range of LSP masses. Again the criterium based on the difference between $(e^+e^- + \mu^+\mu^-)$ and $(e^+\mu^- + \mu^+e^-)$ events gives additional information about the existence of new physics related with slepton production.

7 The search for flavour lepton number violation in slepton decays

As has been mentioned above in MSUGRA the scalar soft supersymmetry breaking terms are postulated to be universal at GUT scale. For such "standard" supersymmetry breaking terms the lepton flavour number is conserved in supersymmetric extension of the Weinberg-Salam model. However, in general, squark and slepton supersymmetry breaking mass terms are not diagonal due to many reasons [12] (an account of stringlike or GUT interactions, nontrivial hidden sector ...) and flavour lepton number is explicitly broken due to nondiagonal structure of slepton soft supersymmetry breaking mass terms. As a consequence such models predict flavour lepton number violation in $\mu-$ and $\tau-$ decays [12]. In ref. [13, 14, 15] it has been proposed to look for flavour lepton number violation in slepton decays at LEP2 and NLC. In ref. [16] the possibility to look for flavour lepton number violation in slepton decays at LHC has been studied with 2 points of ref. [3]. It has been shown that LHC will be able to discover flavour lepton number violation in slepton decays for the case of maximal mixing.

In this paper we investigate this problem in a more careful way. To be specific, consider the case of the mixing between the right-handed selectron and the right-handed smuon. The mass term for the right-handed $\tilde{e}'_R$ and $\tilde{\mu}'_R$ sleptons has the form

$$-\Delta\mathcal{L} \ = \ m_1^2\tilde{e}_R^{+\prime}\tilde{e}'_R \ + \ m_2^2\tilde{\mu}_R^{+\prime}\tilde{\mu}'_R \ + \ m_{12}^2(\tilde{e}_R^{+\prime}\tilde{\mu}'_R \ + \ \tilde{\mu}_R^{+\prime}\tilde{e}'_R). \qquad (5)$$

In formula (5) the last term explicitly violates lepton flavour number. After the diagonalization of the mass term (5), we find that the eigenstates of the mass term (5) are

$$\tilde{e}_R \ = \ \tilde{e}'_R cos(\phi) \ + \ \tilde{\mu}'_R sin(\phi), \qquad (6)$$

$$\tilde{\mu}_R \ = \ \tilde{\mu}'_R cos(\phi) \ - \ \tilde{e}'_R sin(\phi), \qquad (7)$$

with the masses

$$M_{12}^2 \ = \ \frac{1}{2}[(m_1^2 + m_2^2) \pm (\ (m_1^2 - m_2^2)^2 + 4(m_{12}^2)^2 \ )^{\frac{1}{2}}], \qquad (8)$$

which practically coincide for small values of $m_1^2 - m_2^2$ and m_{12}^2. Here the mixing angle is determined by the formulae

$$tan(2\phi) \;=\; \frac{2m_{12}^2}{m_1^2 - m_2^2}. \tag{9}$$

The crucial point is that even for a small mixing parameter m_{12}^2 due to the smallness of $(m_1^2 - m_2^2)$ the mixing angle ϕ is, in general, not small (at the present state of art, it is impossible to calculate the mixing angle ϕ reliably). For the most probable case when the lightest superparticle is the superpartner of the $U(1)$ gauge boson plus some small mixing with other gaugino and higgsino, the sleptons $\tilde{\mu}_R$, $\tilde{e}_R$ decay mainly into leptons μ and e plus $U(1)$ gaugino λ. The corresponding terms in the Lagrangian responsible for slepton decays are

$$L_1 \;=\; \frac{2g_1}{\sqrt{2}}(\bar{e}_R\lambda_L\tilde{e}_R' \;+\; \bar{\mu}_R\lambda_L\tilde{\mu}_R' \;+\; h.c.), \tag{10}$$

where $g_1^2 \approx 0.13$. For the case when mixing is absent the decay width of the right-handed slepton into lepton plus LSP is given by the formulae

$$\Gamma = \frac{g_1^2}{8\pi}M_{sl}\Delta_f \approx 5 \cdot 10^{-3}M_{sl}, \tag{11}$$

$$\Delta_f = (1 - \frac{M_{LSP}^2}{M_{sl}^2})^2, \tag{12}$$

where M_{sl} and M_{LSP} are the masses of the slepton and the lightest superparticle ($U(1)-$gaugino) respectively. For the case of nonzero mixing the Lagrangian (10) in terms of the slepton eigenstates reads

$$L_1 \;=\; \frac{2g_1}{\sqrt{2}}[\bar{e}_R\lambda_L(\tilde{e}_Rcos(\phi) - \tilde{\mu}_Rsin(\phi)) + \bar{\mu}_R\lambda_L(\tilde{\mu}_Rcos(\phi) - \tilde{e}_Rsin(\phi)) + h.c.). \tag{13}$$

Due to nonzero slepton mixing ($sin(\phi) \neq 0$) we have lepton flavour number violation in slepton decays, namely:

$$\Gamma(\tilde{\mu}_R \to \mu + LSP) \;=\; \Gamma cos^2(\phi), \tag{14}$$

$$\Gamma(\tilde{\mu}_R \to e + LSP) \;=\; \Gamma sin^2(\phi), \tag{15}$$

$$\Gamma(\tilde{e}_R \to e + LSP) \;=\; \Gamma cos^2(\phi), \tag{16}$$

$$\Gamma(\tilde{e}_R \to \mu + LSP) \ = \ \Gamma sin^2(\phi). \tag{17}$$

At LHC the right-handed sleptons are produced mainly through the Drell-Yan mechanism which is flavour blind in such a way that even for nonzero slepton mixing, the cross section $\sigma(p\,p \ \to \ \tilde{\mu}_R^{\pm}\tilde{e}_R^{\mp} + ...)$ vanishes and the single manifestation of the flavour lepton number violation are sleptons decays with violation of lepton flavour number.

To be specific, we consider here the most optimistic case of maximal slepton mixing ($\phi \ = \ \frac{\pi}{2}$) and neglect the effects related to destructive interference [14, 15, 16]. For the case of maximal selectron-smuon mixing, the number of signal events coming from slepton decay is (up to statistical fluctuations)[1]

$$N_{sig}(e^+e^-) \ = \ N_{sig}(\mu^+e^-) \ = \ N_{sig}(\mu^-e^+) \ = \ \frac{1}{4}N_{sig}^{no\ mix}(e^+e^- \ + \ \mu^+\mu^-). \tag{18}$$

Therefore, for the case of maximal $(\tilde{\mu} - \tilde{e})$ slepton mixing we expect equal number of e^+e^-, $\mu^+\mu^-$, $e^+\mu^-$, μ^+e^- events with E_T^{miss} and with little jet activity unlike the case of the mixing absence where signal events are only e^+e^- and $\mu^+\mu^-$ and, as a consequence, for the case of zero mixing we have an excess of $(e^+e^- + \mu^+\mu^-)$ events over $(e^+\mu^- + \mu^+e^-)$ events due to nonzero signal events. The number of signal $(e^+e^- + \mu^+\mu^- + e^+\mu^- + \mu^+e^-)$ events for the case of maximal mixing coincides (up to statistical fluctuations) with the number of $(e^+e^- + \mu^+\mu^-)$ signal events for the mixing absence. Therefore, in our estimates we can use the results of our calculations performed for the case of zero mixing. We compare the number of background events

$$N_B^{SM}(e^+e^- + \mu^+\mu^- + e^+\mu^- + \mu^+e^-) \ = \ 2N_B^{SM}(e^+e^- + \mu^+\mu^-)$$

with the number of signal events

$$N_{signal}(e^+e^- + \mu^+\mu^- + e^+\mu^- + \mu^+e^-) \ = \ N_{signal}^{no\ mix}(e^+e^- + \mu^+\mu^-).$$

The significance is determined by the formulae

$$S = \frac{N_{signal}^{mix}}{\sqrt{N_{signal}^{mix} + N_B^{mix}}} = \frac{N_S}{\sqrt{N_S + 2\ N_B^{SM}}}, \tag{19}$$

[1]As has been mentioned above, the contribution of $\tilde{\tau}_R-$sleptons into the $l^+l^- \ + \ E_T^{miss} \ + \ no\ jets$ signature is practically zero and we neglect it.

where N_S and N_B^{SM} are the numbers of the signal and the background events for the case of zero mixing. We adopt the standard criterium according to which the sleptons will be discovered provided the significance is bigger than $S \geq 5$. As it follows from formulae (19), the maximal $(\tilde{\mu} - \tilde{e})$ mixing will be discovered provided the significance for the detection of $(e^+e^- + \mu^+\mu^-)$ events for the case of the mixing absence is larger than 7. We have found that for the case of the right-handed sleptons the $(\tilde{\mu} - \tilde{e})$ mixing and, hence, flavour lepton number violation can be detected for the slepton masses up to 250 GeV. For the case of the left-handed sleptons we can also search for the mixing effects. In this case, the $(\tilde{\mu} - \tilde{e})$ mixing can also be detected for the slepton mass up to 250 GeV.

With the maximal stau-smuon mixing the corresponding formulae are similar to those given above for the selectron-smuon mixing. In this case we expect the number of e^+e^- signal events to be twice greater than the number of $\mu^+\mu^-$ signal events and twice smaller than the number of the $e^+e^- + \mu^+\mu^-$ signal events for the case of the mixing absence. Then the significance is

$$S = \frac{N_S(e^+e^-) + N_S(\mu^+\mu^-)}{\sqrt{N_S(e^+e^- + \mu^+\mu^-) + N_S(e^+e^-) + N_S(\mu^+\mu^-)}} = \frac{\frac{3}{4}N_S}{\sqrt{\frac{3}{4}N_S + N_B}}, \quad (20)$$

where N_S and N_B are the numbers of signal and background events for the case of the mixing absence. Again, if the significance for the case of zero mixing is larger than 6.6, then the significance (20) will be larger than 5.

For the case of $(\tilde{e} - \tilde{\tau})$ mixing we don't expect $\mu^\pm e^\mp$ signal events as in the case of the mixing absence. However, for the case of $(\tilde{e} - \tilde{\tau})$ mixing we expect the excess of $\mu^+\mu^-$ events over e^+e^- events.

In the Standard Model the difference $N^{back}(e^+e^-) - N^{back}(\mu^+\mu^-)$ is zero up to statistical fluctuations. At 1 σ level the statistical fluctuation is $\sqrt{N_B^{SM}}$, where N_B^{SM} is the number of $e^+e^- + \mu^+\mu^-$ background events, whereas $N^{sig}(e^+e^-) - N^{sig}(\mu^+\mu^-) = 0.25\ N^{sig}$ (zero mixing). Therefore, it is very difficult to distinguish at the 5 σ level between the mixing absence case and the $(\tilde{\mu} - \tilde{\tau})$ mixing case.

The case of selectron-stau mixing is similar to that of smuon-stau mixing, the only difference being the interchange $e \to \mu, \quad \mu \to e$.

For the case of maximal selectron-smuon-stau mixing, we expect the equal number e^+e^-, $\mu^+\mu^-$, $e^+\mu^-$ and μ^+e^- signal events. Therefore, this case is very similar to that of the maximal $(\tilde{\mu}-\tilde{e})$ mixing. The sole difference is the number of signal events

$$N_S(e^+e^- + \mu^+\mu^- + e^+\mu^- + e^-\mu^+) \; = \; \tfrac{2}{3}N_S^{zero\ mixing}(e^+e^- + \mu^+\mu^-).$$

So, the significance is $S \; = \; \frac{\frac{2}{3}N_S}{\sqrt{2N_B+N_S}}$, where N_S and N_B is the number of signal events for the case of zero mixing. The significance S for the maximal $(\tilde{\mu}-\tilde{e}-\tilde{\tau})$ mixing will be greater than 5 provided the corresponding significance for the case of zero mixing is larger than 10. So, at CMS it would be extremely difficult to detect the $(\tilde{\mu}-\tilde{e}-\tilde{\tau})$ mixing.

8 Conclusion

Let us state the main results of this paper. We have studied separetely the possibility to detect the right-handed sleptons, the left-handed sleptons and right- plus left-handed sleptons at CMS.

For the right-handed sleptons the number of signal events passing through cuts depends on the mass of the slepton and the mass of the LSP. We have found that for $L_t \; = \; 10^5 pb^{-1}$ it would be possible to discover the right-handed sleptons for a mass up to 300 GeV using the standard significance criterium $S \; = \; \frac{N_S}{\sqrt{N_S+N_B}} \; \geq \; 5$. However, taking into account the fact that the SM background has an equal number of $(e^+e^- + \mu^+\mu^-)$ and $(e^+\mu^- + \mu^+e^-)$ events and the signal contributes only to $(e^+e^- + \mu^+\mu^-)$ events, we can compare the difference $\Delta N \; = \; N(e^+e^- + \mu^+\mu^-) - N(e^+\mu^- + \mu^+e^-)$. Only signal events contribute to ΔN. In the Standard Model ΔN is equal to zero up to statistical fluctuations. Requiring that $\Delta N^{signal} \; \geq \; 5\Delta N^{fluct} \; = \; 5\sqrt{2N_B}$, we have found that it is possible to detect the right-handed sleptons by the measurement of the ΔN with a mass up to 350 GeV. At any rate, nonzero ΔN is an independent and very important check for the sleptons discovery at LHC. For the case when only the left-handed sleptons contribute to signal events, we have found that it is possible to discover the left-handed sleptons with a mass up to 350 GeV. Again, the measurement of the difference ΔN allows one to detect the sleptons with a mass up to 350 GeV (Table 20, $m_{\chi_1^0} = 196\ GeV$).

For the right-handed sleptons we have found that the number of signal events decreases with the increase of the LSP mass and, typically, it is possible to detect the right-handed sleptons provided the LSP mass $m_{LSP} \; \leq \; 0.4 \; m_{\tilde{l}_R}$.

For the left-handed sleptons we have found that the number of the signal events is maximal for $m_{LSP} = (0.4 - 0.6)\ m_{\tilde{l}_L}$. For the LSP masses in this interval, the CMS left-handed slepton discovery potential is the maximal one. Note that these results are in agreement with the similar observations of ref. [3].

We have also studied the case of flavour lepton number violation in slepton decays. For the case of maximal $(\tilde{\mu}_R - \tilde{e}_R)$ mixing we have found that the signature qualitatively differs from the case of zero mixing, namely, in this case we don't have an excess of $\Delta N = N(e^+e^- + \mu^+\mu^-) - N(e^+\mu^- + \mu^+e^-)$ events unlike the case of zero mixing where $\Delta N > 0$. So, it is possible to distinguish zero mixing and maximal mixing. We have found that it is possible to detect the maximal $(\tilde{\mu}_R - \tilde{e}_R)$ mixing for the right-handed sleptons with a mass up to 250 GeV. We also considered the cases of $(\tilde{\mu} - \tilde{\tau})$ and $(\tilde{\mu} - \tilde{e} - \tilde{\tau})$ mixings. However, for such mixing at $L = 10^5 pb^{-1}$ it is not so easy to distinguish the mixings from the case of the mixing absence. Our conclusion about the possibility to detect sleptons with a mass up to 300 GeV is in qualitative agreement with the similar results of ref. [3]. However, in our paper we have studied more general situation (we have not assumed MSUGRA model, which as it has been explained in the Introduction is, at best, only a rough description of the sparticle spectrum). In fact, the number of signal events passing the cuts depends mainly on the masses of the right- and the left-handed sleptons and on the LSP mass. So, those 3 parameters determine the possibility to detect sleptons at CMS. As a rule, we neglecte cascade neutralino or chargino decays resulting in the dilepton signature. However, we have checked that (especially for cuts 3-7) their contribution is generally not very large and, moreover, an account of such contribution increases the significance. The reason why we have neglected gaugino decays is that, in general, the masses of $\chi_2^0,\ \chi_1^{\pm}$ are model dependent (they are determined from standard but an "ad hoc" assumption that at GUT scale all gaugino masses coincide).

Acknowledgments

We are indebted to the participants of Daniel Denegri seminar on physics simulations for useful discussions. We would like to thank Luly Rurua for providing us her code of the events selections.

The research described in this publication was made possible in part by Award No RP1-187 of the U.S. Civilian Research and Development Foundation for the Independent States of the Former Soviet Union(CRDF).

References

[1] F.del Aguila and L.I.Ametller, Phys.Lett. **B261**(1991)325.

[2] H.Baer, C.Chen, F.Paige and X.Tata, Phys.Rev. **D49**(1994)3283.

[3] D.Denegri, L.Rurura and N.Stepanov, *Detection of Sleptons in CMS, Mass Reach,* CMS Note CMS TN/96-059, October 1996.

[4] V.S.Kaplunovsky and J.Louis, Phys.Lett. **B306**(1993)269.

[5] N.Polonsky and A.Pomarol, Phys.Rev.Lett. **73**(1994)2292.

[6] N.V.Krasnikov and V.V.Popov, *PLANCSUSY - new program for SUSY masses calculations: from Planck scale to our reality,* Preprint INR 976TH/96.

[7] C.Kolda and J.March-Russel, Phys.Rev. **D55**(1997)4252.

[8] As a review see, for instance:
R.Barbieri, Riv.Nuovo Cimento **11**(1988)1; A.B.Lahanus and D.V.Nanopoulos, Phys.Rep. **145**(1987)1;
H.E.Haber and G.L.Lane, Phys.Rep. **117**(1985)75;
H.P.Nilles, Phys.Rep.**110**(1984)1;
N.V.Krasnikov and V.A.Matveev, Physics at LHC, Preprint INR 0940/97;
hep-ph/9703204.

[9] H.Baer, F.Paige , S.Protopesku and X.Tata, *Simulating Supersymmetry with ISAJET 7.0/ISASUSY 1.0,* Florida State University Preprint EP-930329(1993).

[10] T.Sjostrand, PYTHIA 5.7 and ISAJET 7.4, Physics and Manual, CERN-TH.7112/93.

[11] S.Abdullin, A.Khanov and N.Stepanov, *CMSJET 3.2, CMSJET 3.5,* CMS Note CMS TN/94-180.

[12] F.Barzumanti and A.Masieno, Phys.Rev.Lett. **57**(1986)961;
G.K.Leontanis, K.Tamvakis and J.D.Vergados, Phys.Lett. **B171**(1986)412;
J.Hagelin, S.Kelley and T.Tanaka, Nucl.Phys. **B415**(1994)293;
F.Gabriani and A.Masiero, Nucl.Phys. **B322**(1989)235;

I.Antoniadis, J.Ellis, J.S.Hagelin and D.V.Nanopoulos, Phys.Lett. **B231**(1989)65;
S.Kelley, J.L.Lopez, D.V.Nanopoulos and H.Pois, Nucl.Phys. **B358**(1991)27.

[13] N.V.Krasnikov, Mod.Phys.Lett **A9**(1994)2825.

[14] N.V.Krasnikov, Phys.Lett **B388**(1996)783.

[15] Nima Arkani-Hamed, Hsin-Chia Cheng, J.L.Feng and L.J.Hall, Phys.Rev.Lett. **77**(1996)1937.

[16] N.V.Krasnikov, Zhetp.Lett **65**(1997)139.

Received October 13, 1997

Table 3: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 96\ GeV,\ L = 10^4 pb^{-1}$.

	cut 1	cut 2
$m_{\chi 1} = 24\ GeV$	243	463
S	6.9	8.6
$S_{1.5}$	5.8	7.2
$m_{\chi 1} = 38\ GeV$	89	180
S	2.7	3.5
$S_{1.5}$	2.2	2.9
$m_{\chi 1} = 53\ GeV$	34	34
S	2.7	3.5
$S_{1.5}$	2.2	2.9

Table 4: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 100\ GeV,\ L = 10^4 pb^{-1}$.

	cut 1	cut 2
$m_{\chi 1} = 24\ GeV$	195.	366.
S	5.7	6.9
$S_{1.5}$	4.8	5.8
$m_{\chi 1} = 38\ GeV$	171.	316.
S	5.0	6.0
$S_{1.5}$	4.2	5.0
$m_{\chi 1} = 53\ GeV$	120.	219.
S	3.6	4.3
$S_{1.5}$	3.0	3.5
$m_{\chi 1} = 69\ GeV$	48.	79.
S	1.5	1.6
$S_{1.5}$	1.2	1.3

Table 5: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 125\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 26\ GeV$	1086.	2091.	189.	79.	12.	27.	12.
S	10.4	12.9	9.9	5.8	1.6	3.0	1.7
$S_{1.5}$	8.6	10.7	8.9	5.1	1.3	2.6	1.4
$m_{\chi_1} = 54\ GeV$	806.	1632.	50.	19.	0.	6.	1.
S	7.8	10.2	3.4	1.7	0.0	0.8	0.2
$S_{1.5}$	6.4	8.4	2.8	1.4	0.0	0.6	0.1
$m_{\chi_1} = 85\ GeV$	446.	845.	0.	0.	0.	0.	0.
S	4.4	5.3	0.0	0.0	0.0	0.0	0.0
$S_{1.5}$	3.6	4.4	0.0	0.0	0.0	0.0	0.0

Table 6: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 150\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 24\ GeV$	626.	1209.	185.	127.	38.	60.	38.
S	6.1	7.6	9.8	8.3	4.2	5.6	4.4
$S_{1.5}$	5.0	6.2	8.8	7.5	3.7	5.1	3.9
$m_{\chi_1} = 53\ GeV$	595.	1183.	149.	83.	15.	23.	15.
S	5.8	7.4	8.3	6.1	1.9	2.6	2.1
$S_{1.5}$	4.8	6.1	7.4	5.4	1.7	2.3	1.8
$m_{\chi_1} = 69\ GeV$	472.	922.	23.	5.	0.	1.	0.
S	4.6	5.8	1.6	0.5	0.0	0.1	0.0
$S_{1.5}$	3.8	4.8	1.4	0.4	0.0	0.1	0.0

Table 7: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 175\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 26\ GeV$	345.	679.	155.	130.	73.	92.	72.
S	3.4	4.3	8.6	8.5	6.7	7.6	6.9
$S_{1.5}$	2.8	3.5	7.6	7.7	6.2	7.0	6.3
$m_{\chi_1} = 54\ GeV$	289.	648.	137.	108.	49.	61.	49.
S	2.9	4.1	7.8	7.4	5.1	5.7	5.3
$S_{1.5}$	2.3	3.4	6.9	6.6	4.5	5.1	4.8
$m_{\chi_1} = 85\ GeV$	317.	647.	83.	47.	7.	17.	7.
S	3.1	4.1	5.2	3.8	1.0	2.0	1.0
$S_{1.5}$	2.6	3.4	4.5	3.3	0.8	1.7	0.9

Table 8: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 200\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 24\ GeV$	229.	506.	170.	152.	110.	128.	110.
S	2.3	3.2	9.2	9.5	8.8	9.5	9.0
$S_{1.5}$	1.9	2.6	8.2	8.6	8.3	8.9	8.5
$m_{\chi_1} = 53\ GeV$	248.	476.	117.	106.	75.	96.	75.
S	2.5	3.0	6.9	7.3	6.8	7.9	7.1
$S_{1.5}$	2.0	2.5	6.0	6.5	6.3	7.2	6.5
$m_{\chi_1} = 85\ GeV$	231.	447.	90.	73.	40.	55.	40.
S	2.3	2.8	5.6	5.5	4.3	5.3	4.5
$S_{1.5}$	1.9	2.3	4.8	4.8	3.9	4.7	4.1
$m_{\chi_1} = 119\ GeV$	81.	175.	1.	0.	0.	0.	0.
S	0.8	1.1	0.1	0.0	0.0	0.0	0.0
$S_{1.5}$	0.7	0.9	0.1	0.0	0.0	0.0	0.0

Table 9: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 225\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 26\ GeV$	150.	268.	81.	76.	69.	87.	69.
S	1.5	1.7	5.1	5.6	6.5	7.4	6.7
$S_{1.5}$	1.2	1.4	4.4	5.0	5.9	6.7	6.1
$m_{\chi_1} = 54\ GeV$	140.	264.	84.	82.	63.	75.	62.
S	1.4	1.7	5.3	6.0	6.1	6.6	6.2
$S_{1.5}$	1.1	1.4	4.5	5.3	5.5	6.0	5.7
$m_{\chi_1} = 85\ GeV$	156.	306.	85.	78.	54.	66.	53.
S	1.6	2.0	5.3	5.8	5.4	6.1	5.6
$S_{1.5}$	1.3	1.6	4.6	5.1	4.9	5.5	5.1
$m_{\chi_1} = 119\ GeV$	135.	277.	68.	55.	28.	33.	28.
S	1.3	1.8	4.4	4.3	3.3	3.6	3.4
$S_{1.5}$	1.1	1.4	3.8	3.8	2.9	3.1	3.0

Table 10: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 250\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi 1} = 24\ GeV$	128.	237.	84.	78.	81.	92.	81.
S	1.3	1.5	5.3	5.8	7.2	7.6	7.4
$S_{1.5}$	1.0	1.2	4.5	5.1	6.6	7.0	6.9
$m_{\chi 1} = 53\ GeV$	125.	232.	82.	76.	78.	91.	78.
S	1.2	1.5	5.1	5.6	7.0	7.6	7.2
$S_{1.5}$	1.0	1.2	4.4	5.0	6.5	7.0	6.7
$m_{\chi 1} = 85\ GeV$	117.	220.	78.	73.	68.	80.	68.
S	1.2	1.4	4.9	5.5	6.4	6.9	6.6
$S_{1.5}$	1.0	1.2	4.3	4.8	5.8	6.3	6.1
$m_{\chi 1} = 119\ GeV$	116.	217.	66.	61.	49.	56.	49.
S	1.2	1.4	4.3	4.7	5.1	5.4	5.3
$S_{1.5}$	0.9	1.1	3.7	4.1	4.5	4.8	4.8
$m_{\chi 1} = 157\ GeV$	94.	187.	43.	31.	15.	18.	15.
S	0.9	1.2	2.9	2.7	1.9	2.1	2.1
$S_{1.5}$	0.8	1.0	2.5	2.3	1.7	1.8	1.8

Table 11: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 275\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 25\ GeV$	73.	130.	45.	44.	40.	49.	40.
S	0.7	0.8	3.1	3.6	4.3	4.9	4.5
$S_{1.5}$	0.6	0.7	2.6	3.1	3.9	4.3	4.1
$m_{\chi_1} = 54\ GeV$	68.	139.	53.	52.	49.	59.	49.
S	0.7	0.9	3.5	4.2	5.1	5.6	5.3
$S_{1.5}$	0.6	0.7	3.0	3.6	4.5	5.0	4.8
$m_{\chi_1} = 85\ GeV$	60.	115.	35.	32.	31.	34.	31.
S	0.6	0.7	2.4	2.7	3.6	3.6	3.7
$S_{1.5}$	0.5	0.6	2.0	2.3	3.1	3.2	3.3
$m_{\chi_1} = 119\ GeV$	91.	169.	56.	54.	47.	57.	46.
S	0.9	1.1	3.7	4.3	4.9	5.4	5.0
$S_{1.5}$	0.7	0.9	3.2	3.7	4.4	4.9	4.5

Table 12: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 300\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 24\ GeV$	64.	134.	59.	59.	56.	65.	56.
S	0.6	0.9	3.9	4.6	5.6	6.0	5.8
$S_{1.5}$	0.5	0.7	3.3	4.0	5.0	5.4	5.3
$m_{\chi_1} = 52\ GeV$	59.	117.	50.	46.	45.	53.	45.
S	0.6	0.8	3.4	3.7	4.7	5.1	4.9
$S_{1.5}$	0.5	0.6	2.8	3.2	4.2	4.6	4.5
$m_{\chi_1} = 85\ GeV$	55.	118.	49.	46.	45.	54.	45.
S	0.6	0.8	3.3	3.7	4.7	5.2	4.9
$S_{1.5}$	0.5	0.6	2.8	3.2	4.2	4.7	4.5
$m_{\chi_1} = 119\ GeV$	56.	114.	46.	44.	41.	48.	41.
S	0.6	0.7	3.1	3.6	4.4	4.8	4.6
$S_{1.5}$	0.5	0.6	2.6	3.1	3.9	4.3	4.1
$m_{\chi_1} = 157\ GeV$	54.	112.	38.	36.	33.	40.	33.
S	0.5	0.7	2.6	3.0	3.7	4.1	3.9
$S_{1.5}$	0.4	0.6	2.2	2.6	3.3	3.7	3.5
$m_{\chi_1} = 196\ GeV$	52.	105.	29.	25.	13.	16.	13.
S	0.5	0.7	2.0	2.2	1.7	1.9	1.8
$S_{1.5}$	0.4	0.6	1.7	1.9	1.4	1.6	1.6

Table 13: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 325\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 53\ GeV$	24.	72.	35.	35.	36.	45.	35.
S	0.2	0.5	2.4	3.0	4.0	4.5	4.1
$S_{1.5}$	0.2	0.4	2.0	2.5	3.5	4.0	3.6
$m_{\chi_1} = 85\ GeV$	44.	89.	39.	38.	40.	51.	40.
S	0.4	0.6	2.7	3.2	4.3	5.0	4.5
$S_{1.5}$	0.4	0.5	2.3	2.7	3.9	4.5	4.1
$m_{\chi_1} = 119\ GeV$	32.	74.	37.	36.	33.	43.	33.
S	0.3	0.5	2.6	3.0	3.7	4.4	3.9
$S_{1.5}$	0.3	0.4	2.2	2.6	3.3	3.9	3.5
$m_{\chi_1} = 157\ GeV$	34.	76.	31.	29.	28.	37.	28.
S	0.3	0.5	2.2	2.5	3.3	3.9	3.4
$S_{1.5}$	0.3	0.4	1.8	2.1	2.9	3.4	3.0
$m_{\chi_1} = 196\ GeV$	32.	73.	28.	26.	19.	26.	19.
S	0.3	0.5	2.0	2.3	2.4	2.9	2.5
$S_{1.5}$	0.3	0.4	1.7	1.9	2.0	2.5	2.2
$m_{\chi_1} = 233\ GeV$	30.	62.	17.	13.	4.	6.	4.
S	0.3	0.4	1.2	1.2	0.6	0.8	0.6
$S_{1.5}$	0.2	0.3	1.0	1.0	0.5	0.6	0.5

Table 14: The number of events and significances S and $S_{1.5}$ for the case of right-handed sleptons, $m_{\tilde{l}_R} = 350\ GeV$, $L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi_1} = 53\ GeV$	33.	68.	33.	33.	33.	40.	33.
S	0.3	0.4	2.3	2.8	3.7	4.1	3.9
$S_{1.5}$	0.3	0.4	1.9	2.4	3.3	3.7	3.5
$m_{\chi_1} = 119\ GeV$	32.	69.	35.	34.	35.	36.	35.
S	0.3	0.4	2.4	2.9	3.9	3.8	4.1
$S_{1.5}$	0.3	0.4	2.0	2.5	3.5	3.3	3.6
$m_{\chi_1} = 196\ GeV$	30.	65.	31.	31.	27.	27.	27.
S	0.3	0.4	2.2	2.7	3.2	3.0	3.3
$S_{1.5}$	0.2	0.3	1.8	2.3	2.8	2.6	2.9
$m_{\chi_1} = 233\ GeV$	27.	61.	25.	23.	18.	18.	18.
S	0.3	0.4	1.8	2.0	2.3	2.1	2.4
$S_{1.5}$	0.2	0.3	1.5	1.7	1.9	1.8	2.1
$m_{\chi_1} = 270\ GeV$	23.	56.	12.	7.	3.	3.	3.
S	0.2	0.4	0.9	0.7	0.4	0.4	0.5
$S_{1.5}$	0.2	0.3	0.7	0.5	0.4	0.3	0.4

Table 15: The number of events and significances S and $S_{1.5}$ for the case of left-handed sleptons, $m_{\tilde{l}_L} = 100\ GeV,\ \ L = 10^4 pb^{-1}$.

	cut 1	cut 2
$m_{\chi 1} = 24\ GeV$	132.	546.
S	3.9	10.0
$S_{1.5}$	3.3	8.4
$m_{\chi 1} = 38\ GeV$	122.	372.
S	3.7	7.0
$S_{1.5}$	3.0	5.9
$m_{\chi 1} = 53\ GeV$	421.	602.
S	11.2	10.9
$S_{1.5}$	9.6	9.3
$m_{\chi 1} = 69\ GeV$	209.	291.
S	6.0	5.6
$S_{1.5}$	5.1	4.6

Table 16: The number of events and significances S and $S_{1.5}$ for the case of left-handed sleptons, $m_{\tilde{l}_L} = 150\ GeV,\ \ L = 10^5 pb^{-1}$.

	cut 1	cut 2	cut 3	cut 4	cut 5	cut 6	cut 7
$m_{\chi 1} = 24\ GeV$	682.	1815.	302.	131.	32.	41.	32.
S	6.6	11.3	13.9	8.5	3.6	4.2	3.8
$S_{1.5}$	5.5	9.3	12.8	7.7	3.2	3.7	3.4
$m_{\chi 1} = 53\ GeV$	663.	1762.	143.	111.	113.	120.	113.
S	6.4	10.9	8.1	7.6	9.0	9.1	9.2
$S_{1.5}$	5.3	9.0	7.1	6.8	8.4	8.5	8.7
$m_{\chi 1} = 85\ GeV$	951.	2029.	72.	11.	2.	23.	2.
S	9.1	12.5	4.6	1.0	0.3	2.6	0.3
$S_{1.5}$	7.6	10.4	4.0	0.8	0.2	2.3	0.3
$m_{\chi 1} = 119\ GeV$	273.	485.	2.	1.	1.	2.	1.
S	2.7	3.1	0.2	0.1	0.1	0.3	0.2
$S_{1.5}$	2.2	2.5	0.1	0.1	0.1	0.2	0.1