Search for flavor lepton number violation in slepton decays at LHC

N.V. Krasnikov
Institute for Nuclear Research, Moscow 117312

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Abstract

We show that in supersymmetric models with explicit flavor lepton number violation due to soft supersymmetry breaking mass terms there could be detectable flavor lepton number violation in slepton decays. We estimate LHC discovery potential of the lepton flavor number violation in slepton decays.

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Supersymmetric electroweak models offer the simplest solution of the gauge hierarchy problem [1]-[4]. In real life supersymmetry has to be broken and the masses of superparticles have to be lighter than $O(1)\text{ Tev}$ [4]. Supergravity gives natural explanation of the supersymmetry breaking, namely, an account of the supergravity breaking in hidden sector leads to soft supersymmetry breaking in observable sector [4]. For the supersymmetric extension of the Weinberg-Salam model soft supersymmetry breaking terms usually consist of the gaugino mass terms, squark and slepton mass terms with the same mass at Planck scale and trilinear soft scalar terms proportional to the superpotential [4]. For such ”standard” supersymmetry breaking terms the lepton flavor number is conserved in supersymmetric extension of Weinberg-Salam model. However, in general, squark and slepton soft supersymmetry breaking mass terms are not diagonal due to many reasons [5]-[15] (an account of stinglike or GUT interactions, nontrivial hidden sector, ..) and flavor lepton number is explicitly broken due to nondiagonal structure of slepton soft supersymmetry breaking mass terms. As a consequence such models predict flavor lepton number violation in $\mu$- and $\tau$-decays [4]-[13]. In our previous papers [16]-[18] we proposed to look for flavor lepton number violation at LEP2 and NLC in slepton decays.

In this paper we investigate the LHC ”discovery potential” of flavor lepton number violation in slepton decays. We find that at LHC it would be possible to discover lepton number violation in slepton decays for slepton masses up to 300 Gev provided that the mixing between sleptons is closed to the maximal one.

In supersymmetric extensions of the Weinberg-Salam model supersymmetry is softly broken at some high energy scale $M_{\text{GUT}}$ by generic soft terms

$$-L_{soft} = m_{3/2}(A_{ij}^u \tilde{u}_R \tilde{q}_L^i H_u + A_{ij}^d \tilde{d}_R \tilde{q}_L^i H_d +$$

$$A_{ij}^l \tilde{e}_R \tilde{l}_L H_d + h.c.) + (m_{\tilde{q}}^2)_{ij} \tilde{q}_L^i (\tilde{q}_L^j)^+ + (m_{\tilde{u}}^2)_{ij} \tilde{u}_R^i \tilde{u}_R^j +$$

$$(\tilde{u}_R^2)^+ + (m_{\tilde{d}}^2)_{ij} \tilde{d}_R^i (\tilde{d}_R^j)^+ + (m_{\tilde{l}}^2)_{ij} \tilde{l}_L^i (\tilde{l}_L^j)^+ + (m_{\tilde{e}}^2)_{ij} \tilde{e}_R^i \tilde{e}_R^j$$

$$(\tilde{e}_R^2)^+ + m_1^2 H_u H_u + m_2^2 H_d H_d +$$

$$(B m_{3/2}^2 H_u H_d + \frac{1}{2} m_a (\lambda \lambda)_a + h.c.) , \quad (1)$$

where $i, j, a$ are summed over 1,2,3 and $\tilde{q}_L, \tilde{u}_R, \tilde{d}_R$ denote the left- (right-)handed squarks,
\( \tilde{l}_L, \tilde{e}_R \) the left- (right-)handed sleptons and \( H_u, H_d \) the two Higgs doublets; \( m_a \) are the three gaugino masses of \( SU(3), SU(2) \) and \( U(1) \) respectively. In most analysis the mass terms are supposed to be diagonal at \( M_{GUT} \) scale and gaugino and trilinear mass terms are also assumed universal at \( M_{GUT} \) scale. The renormalization group equations for soft parameters \(^{19}\) allow to connect high energy scale with observable electroweak scale. The standard consequence of such analysis is that righthanded sleptons \( \tilde{e}_R, \tilde{\mu}_R \) and \( \tilde{\tau}_R \) are the lightest sparticles among squarks and sleptons. In the approximation when we neglect lepton Yukawa coupling constants they are degenerate in masses. An account of the electroweak symmetry breaking gives additional contribution to righthanded slepton square mass equal to the square mass of the corresponding lepton and besides an account of lepton Yukawa coupling constants in the superpotential leads to the additional contribution to righthanded slepton masses

\[
\delta M^2_{sl} = O\left( \frac{h_l^2}{16\pi^2} \right) M^2_{av} \ln \left( \frac{M_{GUT}}{M_{av}} \right) \tag{2}
\]

Here \( h_l \) is the lepton Yukawa coupling constant and \( M_{av} \) is the average mass of sparticles. These effects lead to the splitting between the righthanded slepton masses of the order of

\[
\frac{\left( m^2_{\tilde{e}_R} - m^2_{\tilde{\mu}_R} \right)}{m^2_{\tilde{e}_R}} = O(10^{-5}) - O(10^{-3}) , \tag{3}
\]

\[
\frac{\left( m^2_{\tilde{\tau}_R} - m^2_{\tilde{e}_R} \right)}{m^2_{\tilde{e}_R}} = O(10^{-3}) - O(10^{-1}) \tag{4}
\]

For nonzero value of trilinear parameter \( A \) after electroweak symmetry breaking we have nonzero mixing between righthanded and lefthanded sleptons, however the lefthanded and righthanded sleptons differ in masses (lefthanded sleptons are slightly heavier), so the mixing between righthanded and lefthanded sleptons (for \( \tilde{e}_R \) and \( \tilde{\mu}_R \)) is small and we shall neglect it. In our analysis we assume that the lightest stable particle is gaugino corresponding to \( U(1) \) gauge group that is now more or less standard assumption \(^{20}\). As it has been discussed in many papers \(^{5}\) - \(^{13}\) in general we can expect nonzero nondiagonal soft supersymmetry breaking terms in Lagrangian (1) that leads to additional contributions for flavor changing neutral currents and to flavor lepton number violation.
From the nonobservation of $\mu \rightarrow e + \gamma$ decay ($Br(\mu \rightarrow e + \gamma) \leq 5 \cdot 10^{-11}$) one can find that \[\frac{(\Delta m^2_{\mu\nu})_{RR}}{M_{av}^2} \equiv (\delta_{\mu\nu})_{RR} \leq 2k \cdot 10^{-1}M_{av}/(1 Tev)^2, \tag{5}\]
where $k = O(1)$. In our estimates we shall take $k = 1$. For $m_{\tilde{e}_R} = 70 GeV$ we find that $(\delta_{e\mu})_{RR} \leq 10^{-3}$. Analogous bounds resulting from the nonobservation of $\tau \rightarrow e\gamma$ and $\tau \rightarrow \mu\gamma$ decays are not very stringent [5, 6]-[23].

The mass term for righthanded $\tilde{e}_R$ and $\tilde{\mu}_R$ sleptons has the form

$$-\delta L = m^2_{1} \tilde{e}^+_R \tilde{e}_R + m^2_{2} \tilde{\mu}_R \tilde{\mu}_R + m^2_{12} (\tilde{e}^+_R \tilde{\mu}_R + \tilde{\mu}^+_R \tilde{e}_R) \tag{6}$$

After the diagonalization of the mass term (6) we find that the eigenstates of the mass term (6) are

$$\tilde{e}'_R = \tilde{e}_R \cos(\phi) + \tilde{\mu}_R \sin(\phi), \tag{7}$$
$$\tilde{\mu}'_R = \tilde{\mu}_R \cos(\phi) - \tilde{e}'_R \sin(\phi) \tag{8}$$

with the masses

$$M^2_{1,2} = (1/2)[(m^2_1 + m^2_2) \pm ((m^2_1 - m^2_2)^2 + 4(m^2_{12})^2)^{1/2}] \tag{9}$$

which practically coincide for small values of $m^2_1 - m^2_2$ and $m^2_{12}$. Here the mixing angle $\phi$ is determined by the formula

$$\tan(2\phi) = 2m^2_{12}(m^2_1 - m^2_2)^{-1} \tag{10}$$

The crucial point is that even for small mixing parameter $m^2_{12}$ due to the smallness of the difference $m^2_1 - m^2_2$ the mixing angle $\phi$ is in general not small (at present state of art it is impossible to calculate the mixing angle $\phi$ reliably). For the most probable case when the lightest stable superparticle is 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 $\mu_R$ and $e_R$ plus $U(1)$ gaugino $\lambda$. The corresponding term in the Lagrangian responsible for slepton decays is

$$L_1 = \frac{2g_1}{\sqrt{2}}(\tilde{e}_R \lambda_L \tilde{e}_R + \tilde{\mu}_R \lambda_L \tilde{\mu}_R + h.c.), \tag{11}$$
where $g_i^2 \approx 0.13$. For the case when mixing is absent the decay width of the slepton into lepton and LSP is given by the formula

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

(12)

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

(13)

where $M_{sl}$ and $M_{LSP}$ are the masses of slepton and the lightest superparticle ($U(1)$-gaugino) respectively. For the case of nonzero mixing we find that the Lagrangian (11) in terms of slepton eigenstates reads

$$
L_1 = \frac{2g_i}{\sqrt{2}} [\bar{e}^\prime_R \lambda_L (\bar{e}^\prime_R \cos(\phi) - \bar{\mu}^\prime_R \sin(\phi)) + \bar{\mu}^\prime_R \lambda_L (\bar{\mu}^\prime_R \cos(\phi) + \bar{e}^\prime_R \sin(\phi)) + h.c.]
$$

(14)

Let us now describe briefly the situation with the search for flavor lepton number violation in slepton decays at LEP2 and NLC. At LEP2 and NLC in the neglection of slepton mixing $\tilde{\mu}_R$ and $\tilde{\tau}_R$ sleptons pair production occurs \[21\] via annihilation graphs involving the photon and the $Z^0$ boson and leads to the production of $\tilde{\mu}_R^+ \tilde{\mu}_R^-$ and $\tilde{\tau}_R^+ \tilde{\tau}_R^-$ pairs. For the production of righthanded selectrons in addition to the annihilation graphs we also have contributions from the t-channel exchange of the neutralino \[23\]. In the absence of mixing the cross sections can be represented in the form

$$
\sigma(e^+e^- \rightarrow \tilde{\mu}_R^+ \tilde{\mu}_R^-) = kA^2,
$$

(15)

$$
\sigma(e^+e^- \rightarrow \tilde{e}^+_R \tilde{e}^-_R) = k(A + B)^2,
$$

(16)

where $A$ is the amplitude of s-exchange, $B$ is the amplitude of t-exchange and $k$ is the normalization factor. The corresponding expressions for $A$, $B$ and $k$ are contained in \[23\]. The amplitude $B$ is determined mainly by the exchange of the lightest gaugino and its account leads to the increase of selectron cross section by factor $k_{in} = (4 - 1.5)$. As it has been mentioned before we assume that righthanded sleptons are the lightest visible superparticles. So righthanded sleptons decay with 100 percent probability into leptons and LSP that leads to accoplanar events with missing transverse momentum. The perspectives for the detection of sleptons at LEP2 have been discussed in refs. \[23\]-\[24\] in the assumption of flavor lepton number conservation. The main background at
LEP2 energy comes from the $W$-boson decays into charged lepton and neutrino [21]. For $\sqrt{s} = 190$ Gev the cross section of the $W^+W^-$ production is $\sigma_{\text{tot}}(W^+W^-) \approx 26\,pb$. [22].

For selectrons at $\sqrt{s} = 190$ Gev, selecting events with electron pairs with $p_{T,mis} \geq 10$ Gev and the accoplanarity angle $\theta_{ac} \geq 34^\circ$ [21], the only background effects left are from $WW \to e\nu e\nu$ and $e\nu\tau\nu$ where $\tau \to e\nu\nu$. For instance, for $M_{\tilde{e}_R} = 85$ Gev and $M_{LSP} = 30$ Gev one can find that the accepted cross section is $\sigma_{ac} = 0.17\,pb$ whereas the background cross section is $\sigma_{\text{backgr}} = 0.17\,pb$ that allow to detect righthanded selectrons at the level of $5\sigma$ for the luminosity $150\,pb^{-1}$ and at the level of $11\sigma$ for the luminosity $500\,pb^{-1}$. For the detection of righthanded smuons we have to look for events with two accoplanar muons however the cross section will be (4 - 1.5) smaller than in the selectron case due to absence of t-channel diagram and the imposition of the cuts analogous to the cuts for selectron case allows to detect smuons for masses up to 80 Gev. Again here the main background comes from the $W$ decays into muons and neutrino. The imposition of more elaborated cuts allows to increase LEP2 righthanded smuon discovery potential up to 85 Gev on smuon mass [23, 24].

Consider now the case of nonzero mixing $\sin\phi \neq 0$ between selectrons and smuons. In this case an account of t-exchange diagram leads to the following cross sections for the slepton pair production (compare to the formulae (15,16)):

$$\sigma(e^+e^- \to \tilde{\mu}^+_R\tilde{\mu}^-_R) = k(A + B \sin^2(\phi))^2,$$

$$\sigma(e^+e^- \to \tilde{\tau}^+_R\tilde{\tau}^-_R) = k(A + B \cos^2(\phi))^2,$$

$$\sigma(e^+e^- \to \tilde{\tau}^+_R\tilde{\tau}^-_R) = kB^2 \cos^2(\phi) \sin^2(\phi)$$

Due to slepton mixing we have also lepton flavor number violation in slepton decays, namely:

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

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

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

$$\Gamma(\tilde{\tau}_R \to \mu + LSP) = \Gamma \sin^2(\phi)$$

6
Taking into account formulae (20-23) we find that

\[
\sigma(e^+e^- \rightarrow e^+e^- + LSP + LSP) = k[(A + B \cos^2(\phi))^2 \cos^4(\phi) + (A + B \sin^2(\phi))^2 \sin^4(\phi) + B^2 \sin^4(2\phi)/8],
\]

(24)

\[
\sigma(e^+e^- \rightarrow \mu^+\mu^- + LSP + LSP) = k[(A + B \cos^2(\phi))^2 \sin^4(\phi) + (A + B \sin^2(\phi))^2 \cos^4(\phi) + B^2 \sin^4(2\phi)/8],
\]

(25)

\[
\sigma(e^+e^- \rightarrow \mu^\pm + e^\mp + LSP + LSP) = \frac{\kappa \sin^2(2\phi)}{4} [(A + B \cos^2(\phi))^2 + (A + B \sin^2(\phi))^2 + B^2 (\cos^4(\phi) + \sin^4(\phi))].
\]

(26)

It should be noted that formulae (24-26) are valid only in the approximation of narrow decay width of sleptons

\[
2\Gamma m_{\widetilde{e}_R} \leq |m_{\widetilde{\mu}_R}^2 - m_{\widetilde{\mu}_{R'}}^2|
\]

(27)

For the case when the inequality (27) does not hold the effects due to the finite decay width are important and decrease the cross section with violation of flavor lepton number. The cross section for the reaction \(e^+e^- \rightarrow e^+\mu^- + LSP + LSP\) is proportional to

\[
\sigma \sim \sin^2(\phi) \cos^2(\phi) \int |D(p_1, m_{\widetilde{e}}, \Gamma)D(p_2, m_{\widetilde{e}}, \Gamma) - D(p_1, m_{\widetilde{\mu}}, \Gamma)D(p_2, m_{\widetilde{\mu}}, \Gamma)|^2 dp_1^2 dp_2^2,
\]

(28)

where

\[
D(p, m, \Gamma) = \frac{1}{p^2 - m^2 - i\Gamma m}
\]

(29)

and \(\Gamma_{\widetilde{e}} \approx \Gamma_{\widetilde{\mu}} = \Gamma\). The approximation (24-26) corresponds to the neglection of the interference terms in (28) and it is valid if the inequality (27) takes place. For smaller slepton masses difference an account of the interference terms in (28) is very important \cite{18, 25}. The integral (28) is approximately equal to

\[
\sigma \sim \sin^2(\phi) \cos^2(\phi) \frac{2\pi^2}{b^2} I_{\text{dil}},
\]

(30)

\[
I_{\text{dil}} = (1 - \frac{b^2(b^2 - \frac{a^2}{4})}{(b^2 + \frac{a^2}{4})^2}),
\]

(31)
where $a = m_{\tilde{e}_R}^2 - m_{\tilde{\mu}_R}^2$, $b = \Gamma \cdot (\frac{m_{\tilde{e}_R} + m_{\tilde{\mu}_R}}{2})$. Here $I_{\text{dil}}$ determines the effect of destructive interference. An account of the interference effects leads to the decrease of the cross section (26) by factors 1, 0.82, 0.52, 0.17 for $|m_{\tilde{e}}^2 - m_{\tilde{\mu}}^2| = 2\Gamma m_{\tilde{e}} 1.5\Gamma_{\tilde{e}}$, $\Gamma m_{\tilde{e}}$, $0.5\Gamma m_{\tilde{e}}$ respectively.

To be concrete consider the case of maximal selectron-smuon mixing ($m_1 = m_2$ in formula (6)). For this case bound (5) resulting from the absence of the decay $\mu \rightarrow e\gamma$ reads $\frac{|m_{12}^2|}{m_1^2} \leq 10^{-3}$ ($m_{\tilde{e}} = 70\text{Gev}$); $4.5 \cdot 10^{-3}$ ($m_{\tilde{e}} = 150\text{Gev}$); $8 \cdot 10^{-3}$ ($m_{\tilde{e}} = 200\text{Gev}$); $10^{-2}$ ($m_{\tilde{e}} = 225\text{Gev}$). From the requirement (27) of the absence of the destructive interference for the cross section with flavor lepton number violation we find that

$$\frac{|m_{12}^2|}{m_1^2} \geq 5 \cdot 10^{-3} \Delta_f \quad (32)$$

So we see that for LEP2 energies it is possible to improve $\mu \rightarrow e\gamma$ bound only for the case when LSP mass is closed to slepton mass. For instance, for $m_{\text{LSP}} = 0.95m_{\tilde{e}}$, $0.9m_{\tilde{e}}$, $0.8m_{\tilde{e}}$, $0.7m_{\tilde{e}}$, $0.6m_{\tilde{e}}$, $0.5m_{\tilde{e}}$, $\Delta_f$ is equal to 0.01, 0.036, 0.13, 0.26, 0.41, 0.56 respectively. For $m_{\tilde{e}} = 70\text{Gev}$ the destructive interference is not essential for $m_{\text{LSP}} \geq 0.74m_{\text{LSP}}$. For the Next Linear Collider energies and for $m_{\tilde{e}} \geq 100\text{Gev}$ the $\mu \rightarrow e\gamma$ bound (5) is not so stringent and it is possible to improve it even for the case of relatively small LSP masses when $\Delta_f \approx 1$.

The perspectives for the detection of righthanded sleptons at NLC (for the case of zero slepton mixing) have been discussed in ref.[26]. The standard assumption of ref.[26] is that righthanded sleptons are the NLSP, therefore the only possible decay mode is $\tilde{l} \rightarrow l + \text{LSP}$. One possible set of selection criteria is the following:

1. $\theta_{\text{acop}} \geq 65^\circ$.
2. $p_{T,\text{mis}} \geq 25$ Gev.
3. The polar angle of one of the leptons should be larger than 44°, the other 26°.
4. $(m_{ll} - m_Z)^2 \geq 100 \text{Gev}^2$.
5. $E_{l\pm} \geq 150$ Gev.

For $\sqrt{s} = 500$ Gev and for integrated luminosity 20 $fb^{-1}$, a $5\sigma$ signal can be found up to 225 Gev provided the difference between lepton and LSP is greater than 25 Gev [26].
Following ref.[26] we have analyzed the perspective for the detection of nonzero slepton mixing at NLC. In short, we have found that for \( M_{LSP} = 100 \) Gev it is possible to discover selectron-smuon mixing at the 5\( \sigma \) level for \( M_{sl} = 150 \) Gev provided that \( \sin 2\phi \geq 0.28 \). For \( M_{sl} = 200 \) Gev it is possible to detect mixing for \( \sin 2\phi \geq 0.44 \) and \( M_{sl} = 225 \) Gev corresponds to the limiting case of maximal mixing (\( \sin 2\phi = 1 \)) discovery.

It should be noted that up to now we restricted ourselves to the case of smuon selectron mixing and have neglected stau mixing with selectron and smuon. Moreover for the case of stau-smuon or stau-selectron mixings bounds from the absence of \( \tau \rightarrow \mu \gamma \) and \( \tau \rightarrow e\gamma \) decays for \( m_{\tilde{\tau}} \geq 70 \)Gev are not stringent [3, 8]-[21]. For instance, for the case of stau-smuon mixing in formulae (24-26) we have to put \( B = 0 \) (only s-exchange graphs contribute to the cross sections) and in final states we expect as a result of mixing \( \tau^\pm \mu^\mp \) accoplanar pairs. The best way to detect \( \tau \) lepton is through hadronic final states, since \( Br(\tau \rightarrow \text{hadrons} + \nu_\tau) = 0.74 \). Again, in this case the main background comes from W-decays into \( (\tau)^\pm (\mu)^\mp + \nu + \nu \) in the reaction \( e^+e^- \rightarrow W^+W^- \). The imposition of some cuts [23, 24] decreases W-background to 0.07 pb that allows to detect stau-smuon mixing for slepton masses up to 70 Gev. We have found that for \( m_{sl} = 50 \) Gev it would be possible to detect mixing angle \( \sin(2\phi_{\tau\mu}) \) bigger than 0.70. Other detectable consequence of big stau-smuon mixing is the decrease of accoplanar \( \mu^+\mu^- \) events compared to the case of zero mixing. For instance, for the case of maximal mixing \( \sin(2\phi_{\tau\mu}) = 1 \) the suppression factor is 2. In general we can’t exclude also big mixing between all three righthanded sleptons.

Consider now the possibility to discover lepton number violation in slepton decays at LHC. The possibility to discover sleptons at LHC have been discussed in refs.[27]-[29]. The main mechanism of slepton production at LHC is the Drell-Yan mechanism, so formulae (24-26) with \( B = 0 \) are valid in our case. We shall use the results of ref.[29] where concrete estimates have been made for CMS detector. To be concrete we consider two points of the ref.[29]:

Point A: \( m(\tilde{L}_L) = 314 \) Gev, \( m(\tilde{L}_R) = 192 \) Gev, \( m(\tilde{\nu}) = 308 \) Gev, \( m(\tilde{\chi}^0_1) = 181 \) Gev, \( m(\tilde{\chi}^0_2) = 358 \) Gev, \( m(\tilde{g}) = 1036 \) Gev, \( m(\tilde{q}) = 905 \) Gev, \( \tan(\beta) = 2 \), \( \text{sign}(\mu) = - \).

9
Point B: \( m(\tilde{t}_L) = 112 \text{ Gev}, m(\tilde{t}_R) = 98 \text{ Gev}, m(\tilde{\nu}) = 93 \text{ Gev}, m(\tilde{\chi}_1^0) = 39 \text{ Gev}, m(\tilde{\chi}_2^0) = 87 \text{ Gev}, m(\tilde{g}) = 254 \text{ Gev}, m(\tilde{q}) = 234 \text{ Gev}, \tan(\beta) = 2, \text{ sign}(\mu) = - \).

For point A the following cuts have been used: \( p_T \geq 50 \text{ Gev}, I_{sol} \leq 0.1, |\eta| \leq 2.5, E_{T}^{\text{miss}} \geq 120 \text{ Gev}, \Delta \phi(E_{T}^{\text{miss}}, ll) \geq 150^\circ, \) jet veto - no jets with \( E_{T}^{\text{jet}} \geq 30 \text{ Gev} \) in \( |\eta| \leq 4.5, Z\)-mass cut - \( M_Z \pm 5 \text{ Gev} \) excluded, \( \Delta \phi(l^+l^-) \leq 130^\circ, \) jet veto - no jets with \( E_{T}^{\text{jet}} \geq 30 \text{ Gev} \) in \( |\eta| \leq 4.5. \) With such cuts for the total luminosity \( L = 10^5 \text{ pb}^{-1} \) 91 events \( e^+e^- + \mu^+\mu^- \) resulting from slepton decays have been found. The standard WS model background comes from \( WW, t\bar{t}, Wt\bar{b}, WZ, \tau\tau \) and gives 105 events. No SUSY background have been found. The significance for the slepton discovery at point A is 6.5. Using these results it is trivial to estimate the perspective for the discovery of flavour violation in slepton decays. Consider the most optimistic case of maximal slepton mixings (for both righthanded and lefthanded sleptons) and neglect the effects of destructive interference. For the case of maximal selectron-smuon mixing the number of signal events coming from slepton decays is \( N_{\text{sig}}(e^+e^-) = N_{\text{sig}}(\mu^+\mu^-) = N_{\text{sig}}(\mu^+\mu^-) = 23. \) The number of background events is \( N_{\text{back}}(e^+e^-) = N_{\text{back}}(\mu^+\mu^-) = N_{\text{back}}(\mu^+\mu^-) = 53. \) The significance \( S = \frac{\text{Sleptons}}{\sqrt{\text{Background+Sleptons}}} \) is 5.2 for all dilepton modes. For the case of maximal smuon-selectron mixing we have the same number of \( e^+e^-, \mu^+\mu^-, e^+\mu^- \) signal events, whereas in the case of the mixing absence we don’t have \( e^+\mu^- \) events. For the case of the maximal stau-smuon mixing we expect 23 \( \mu^+\mu^- \) signal events and 46 \( e^+e^- \) signal events and 2 \( \mu^+e^- \) signal events whereas the background is the same as for the case of maximal smuon-selectron mixing. The significance is: 4.6(\( e^+e^- \) mode), 2.6(\( \mu^+\mu^- \) mode), 5.2(\( e^+e^- + \mu^+\mu^- \) - mode). The case of selectron-stau mixing is the similar to the case of smuon-stau mixing the single difference consists in the replacement of \( e \rightarrow \mu, \mu \rightarrow e. \) For the case of maximal selectron-smuon-stau mixing we expect 46 \( e^+e^- + \mu^+\mu^- + e^+\mu^- \) signal events and the significance is 2.8.

For the point B the cuts are similar to the point A, except \( p_T \geq 20 \text{ Gev}, E_{T}^{\text{miss}} \geq 50 \text{ Gev}, \Delta \phi(E_{T}^{\text{miss}}, ll) \geq 160^\circ \) For the total luminosity \( L_{\text{tot}} = 10^5 \text{ pb}^{-1} \) the number of \( e^+e^- + \mu^+\mu^- \) events resulting from direct slepton production has been found to be 323. The number of background events have been estimated equal to 989(standard model background) + 108(SUSY background)= 1092. The significance is 8.6. Our analysis for
the point B is similar to the corresponding analysis for the point A. For the case of maximal selectron-smuon mixing we have found that the significance for all delepton modes is 6.4. For the case of the maximal smuon-stau mixing the significance for $e^+e^- + \mu^+\mu^-$ mode is 6.6. The same significance is for the case of the maximal selectron-stau mixing. For the case of maximal selectron-smuon-stau mixing the significance for $e^+e^- + \mu^+\mu^- + e^\pm\mu^\mp$ mode is 3.0. For the total luminosity $L_{tot} = 10^5 pb^{-1}$ the significance is increased by factor $\approx 3.1$.

It is interesting to mention that at LHC the main mechanism of slepton pair production is the Drell-Yan mechanism and as a consequence for equal smuon and selectron masses the corresponding cross sections and the number of $e^+e^-$ and $\mu^+\mu^-$ signal events coincide. The corresponding cross sections depend rather strongly on slepton masses. If smuon and selectron masses differ by 20 percent the corresponding cross sections and as a consequence the number of $e^+e^-$ and $\mu^+\mu^-$ signal events will differ by factor $\approx 2$ that as it has been demonstrated on the example of points A and B is detectable at LHC. However the effect of 20 percent smuon and selectron mass difference will imitate the effect of selectron-stau or smuon-stau mixings. So the situation could be rather complicated. At any rate by the measurement of the difference in $\mu^+\mu^-$ and $e^+e^-$ events it would be possible to measure the difference of smuon and selectron masses with the accuracy $\approx 20\%$ that is very important because in MSSM smuon and selectron masses practically coincide for both righthanded and lefthanded sleptons.

Let us formulate the main result of this paper: in supersymmetric extension of standard Weinberg-Salam model there could be soft supersymmetry breaking terms responsible for flavor lepton number violation and slepton mixing. At LHC it would be possible to discover flavor lepton number violation in slepton decays for sleptons lighter than 300 Gev provided that the mixing among sleptons is closed to the maximal one. For the case of nonequal smuon and selectron masses the number of $e^+e^-$ and $\mu^+\mu^-$ events will be different that imitate the effect of stau-smuon or stau-selectron mivings. At any rate the observation (or nonobservation) of the $(\mu^+\mu^- - e^+e^-)$ difference allows to conclude that smuon and selectron masses differ(coincide) at least with the accuracy 20 percent or to make conclusion about the discovery of slepton mixing. Unfortunately it is rather difficult
to distinguish between these two possibilities. For the case of nonzero smuon-selectron mixing the number of $\mu^+\mu^-$ and $e^+e^-$ events is predicted to be the same and moreover for the case of maximal smuon-selectron mixing the number of $\mu^+e^-$ and $\mu^-e^+$ events coincide with the number of $\mu^+\mu^-$ and $e^+e^-$ events. Of course, it is clear that at NLC or $\mu^+\mu^-$ collider the perspectives for the flavor lepton number violation discovery are the most promising but unfortunately now it is too far from reality.

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