The Reach of LHC (CMS) for Models with Effective Supersymmetry and Nonuniversal Gaugino Masses

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Abstract

We investigate squark and gluino pair production at LHC (CMS) with subsequent decays into quarks, leptons and LSP in models with effective supersymmetry where third generation of squarks is relatively light while the first two generations of squarks are heavy. We consider the general case of nonuniversal gaugino masses. Visibility of signal by an excess over SM background in $(n \geq 2)jets+(m \geq 0)leptons+E_T^{miss}$ events depends rather strongly on the relation between LSP, second neutralino, gluino and squark masses and it decreases with the increase of LSP mass.

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1 Introduction

One of the LHC supergoals is the discovery of the supersymmetry. In particular, it is very important to investigate a possibility to discover strongly interacting superparticles (squarks and gluino). In ref.[1] (see, also references [2]) the LHC squark and gluino discovery potential has been investigated within the minimal SUGRA-MSSM framework [3] where all sparticle masses are determined mainly by two parameters: m_0 (common squark and slepton mass at GUT scale) and $m_{\frac{1}{2}}$ (common gaugino mass at GUT scale). The signature used for the search for squarks and gluino at LHC is $(n \geq 2) jets + (m \geq 0)$ leptons + E_T^{miss} events. The conclusion of ref. [1] is that LHC is able to detect squarks and gluino with masses up to (2 - 2.5) TeV. In ref. [4] the LHC SUSY discovery potential has been investigated for the case of nonuniversal gaugino masses with universal squark masses for the first, second and third generations. The conclusion of the ref. [4] is that visibility of signal by an excess over SM background in $(n \geq 2) jets + E_T^{miss}$ events depends rather strongly on the relation between LSP, gluino and squark masses and it decreases with the increase of LSP mass. For relatively heavy LSP mass closed to squark or gluino masses and for $(m_{\tilde{q}}, m_{\tilde{g}}) \geq 1.5\ TeV$ signal is too small to be observable.

In this paper we investigate the squark and gluino pair production at LHC (CMS) with subsequent decays into quarks, leptons and LSP in models with effective supersymmetry [5] where third generation of squarks is relatively light while the first two generations of squarks are heavy. Note that in ref. [15] ATLAS detector discovery potential of mSUGRA with focus point effective supersymmetry for $tan\beta = 10$ and $\mu < 0$ has been studied for signature $n \geq 2$ jets + 1 isolated lepton plus E_T^{miss}. We consider the general case of nonuniversal gaugino masses. Visibility of signal by an excess over SM background in $(n \geq 2)$jets + $(m \geq 0)$ leptons + E_T^{miss} events depends rather strongly on the relation between LSP, second neutralino, gluino and squark masses and it decreases with the increase of LSP mass.

Despite the simplicity of the SUGRA-MSSM framework it is a very particular model. The mass formulae for sparticles in SUGRA-MSSM model are derived under the assumption that at GUT scale ($M_{GUT} \approx 2 \cdot 10^{16}$ GeV) soft supersymmetry breaking terms are universal. However, in general, we can expect that real sparticle masses can differ in a drastic way from sparticle masses pattern of SUGRA-MSSM model due to many reasons, see for instance refs. [6, 7, 8, 9, 10]. Therefore, it is more appropriate to investigate the LHC SUSY discovery potential in a model-independent way.

The cross section for the production of strongly interacting superparticles

$$pp \to \tilde{g}\tilde{g}, \tilde{q}\tilde{g}, \tilde{q}\tilde{q} \tag{1}$$

depends on gluino and squark masses. Within SUGRA-MSSM model the following approximate relations among sparticle masses take place:

$$m^2_{\tilde{q}} \approx m^2_0 + 6m^2_{\frac{1}{2}}, \tag{2}$$

$$m_{\tilde{\chi}^0_1} \approx 0.45 m_{\frac{1}{2}}, \tag{3}$$

$$m_{\tilde{\chi}^0_2} \approx m_{\tilde{\chi}^\pm_1} \approx 2m_{\tilde{\chi}^0_1}, \tag{4}$$

$$m_{\tilde{g}} \approx 2.5 m_{\frac{1}{2}} \tag{5}$$

The decays of squarks and gluino depend on the relation among squark and gluino masses. For $m_{\tilde{q}} > m_{\tilde{g}}$ squarks decay mainly into gluino and quarks

- $\tilde{q} \to \tilde{g}q$

and gluino decays mainly into quark-antiquark pair and gaugino

- $\tilde{g} \to q\bar{q}\tilde{\chi}^0_i$
- $\tilde{g} \to q\bar{q}' \tilde{\chi}^\pm_1$

For $m_{\tilde{q}} < m_{\tilde{g}}$ gluino decays mainly into squarks and quarks

- $\tilde{g} \to \bar{q}\tilde{q}, q\bar{\tilde{q}}$

whereas squarks decay mainly into quarks and gaugino

- $\tilde{q} \to q\tilde{\chi}^0_i$
- $\tilde{q} \to q' \tilde{\chi}^\pm_1$

The lightest chargino $\tilde{\chi}^\pm_1$ has several leptonic decay modes giving a lepton and missing energy:

three-body decay

- $\tilde{\chi}^\pm_1 \longrightarrow \tilde{\chi}^0_1 + l^\pm + \nu,$

two-body decays

- $\tilde{\chi}_1^\pm \longrightarrow \tilde{l}^\pm_{L,R} + \nu,$

  $\hookrightarrow \tilde{\chi}_1^0 + l^\pm$
- $\tilde{\chi}_1^\pm \longrightarrow \tilde{\nu}_L + l^\pm,$

  $\hookrightarrow \tilde{\chi}_1^0 + \nu$
- $\tilde{\chi}_1^\pm \longrightarrow \tilde{\chi}_1^0 + W^\pm.$

  $\hookrightarrow l^\pm + \nu$

Leptonic decays of $\tilde{\chi}_2^0$ give two leptons and missing energy:
three-body decays

- $\tilde{\chi}_2^0 \longrightarrow \tilde{\chi}_1^0 + l^+ l^-,$
- $\tilde{\chi}_2^0 \longrightarrow \tilde{\chi}_1^\pm + l^\mp + \nu,$

  $\hookrightarrow \tilde{\chi}_1^0 + l^\pm + \nu$

two-body decay

- $\tilde{\chi}_2^0 \longrightarrow \tilde{l}^\pm_{L,R} + l^\mp.$

  $\hookrightarrow \tilde{\chi}_1^0 + l^\pm$

As a result of chargino and second neutralino leptonic decays besides classical signature

- $(n \geq 2)$ jets plus E_T^{miss}

signatures

- $(n \geq 2)$ jets plus $(m \geq 1)$ leptons plus E_T^{miss}

with leptons and jets in final state arise. As mentioned above, these signatures have been used in ref. [1] for investigation of LHC(CMS) squark and gluino discovery potential within SUGRA-MSSM model, in which gaugino masses $m_{\tilde{\chi}_1^0}$, $m_{\tilde{\chi}_2^0}$ are determined mainly by a common gaugino mass $m_{\frac{1}{2}}$.

In our study we consider the models with effective supersymmetry [5] in which first and second squark generations are heavy while the third squark generation is relatively light. Models with effective supersymmetry solve in natural way the problems with flavour-changing neutral currents, lepton flavor violation, electric dipole moments of electron and neutron and proton decay. In such models there are two mass scales: gauginos, higgsinos and third generation squarks are rather light to stabilize electroweak scale, while the first two generations of squarks and sleptons are heavy with masses $\approx (5-20)\ TeV$. We investigate the general case when the relation among gaugino masses is arbitrary. We study the detection of supersymmetry using classical signature $(n \geq 2)$ jets + $(m \geq 0)$leptons + E_T^{miss}. We find that the SUSY discovery potential depends rather strongly on the relation among squarks, gluino, LSP and second neutralino masses and it decreases with the increase of LSP mass.

2 Simulation of detector response

Our simulations are made at the particle level with parametrized detector responses based on a detailed detector simulation. To be concrete our estimates have been made for the CMS(Compact Muon Solenoid) detector. The CMS detector simulation program CMSJET 7.4 [11] is used. The main aspects of the CMSJET relevant to our study are the following.

- Charged particles are tracked in a 4 T magnetic field. 90 percent reconstruction efficiency per charged track with $p_T > 1$ GeV within $|\eta| < 2.5$ is assumed.

- The geometrical acceptances for μ and e are $|\eta| < 2.4$ and 2.5, respectively. The lepton number is smeared according to parametrizations obtained from full GEANT simulations. For a 10 GeV lepton the momentum resolution $\Delta p_T/p_T$ is better than one percent over the full η coverage. For a 100 GeV lepton the resolution becomes $\sim (1-5)\cdot 10^{-2}$ depending on η. We have assumed a 90 percent triggering plus reconstruction efficiency per lepton within the geometrical acceptance of the CMS detector.

- The electromagnetic calorimeter of CMS extends up to $|\eta| = 2.61$. There is a pointing crack in the ECAL barrel/endcap transition region between $|\eta| = 1.478 - 1.566$ (6 ECAL crystals). The hadronic calorimeter covers $|\eta| < 3$. The Very Forward calorimeter extends from $|\eta| < 3$ to $|\eta| < 5$. Noise terms have been simulated with Gaussian distributions and zero suppression cuts have been applied.

- e/γ and hadron shower development are taken into account by parametrization of the lateral and longitudinal profiles of showers. The starting point of a shower is fluctuated according to an exponential law.
- For jet reconstruction we have used a slightly modified UA1 Jet Finding Algorithm, with a cone size of $\Delta R = 0.8$ and 25 GeV transverse energy threshold on jets.

3 Backgrounds. SUSY kinematics

All SUSY processes with full particle spectrum, couplings, production cross section and decays are generated with ISAJET 7.42, ISASUSY [12]. The Standard Model backgrounds are generated by Pythia 5.7 [13].

The following SM processes give the main contribution to the background: WZ, ZZ, $t\bar{t}$, Wtb, $Zb\bar{b}$, $b\bar{b}$ and QCD ($2 \to 2$) processes.

As it has been mentioned above in this paper we consider signature ($n \geq m$) jets plus ($m \geq k$) isolated leptons plus E_T^{miss}, where $m = 2, 3, 4$ and $k = 0, 1, 2, 3$. Namely we have considered signatures :

- ($n \geq m$) jets plus E_T^{miss},
- ($n \geq m$) jets plus E_T^{miss} plus no isolated leptons,
- ($n \geq m$) jets plus E_T^{miss} plus 1 isolated lepton,
- ($n \geq m$) jets plus E_T^{miss} plus l^+l^- pair of isolated leptons,
- ($n \geq m$) jets plus E_T^{miss} plus $l^{\pm}l^{\pm}$ pair of isolated leptons,
- ($n \geq m$) jets plus E_T^{miss} plus 3 isolated leptons.

For leptons we use cut $P_{lT} \equiv \sqrt{p_{l1}^2 + p_{l2}^2} \geq P_{lT_0} = 20GeV$. Our definition of isolated lepton coincides with the definition used in CMSJET code [11]. We use two sets of cuts (a and b) for E_T^{miss} and $E_{Tjet,k}$ ($k = 1, 2, 3, 4$). Cuts a and b are presented in tables 1 and 2, correspondingly. Besides we require that $\frac{N_s}{N_b} \geq 0.25$. We have calculated SM backgrounds for different values of E^0_{Tjet1}, E^0_{Tjet2}, E^0_{Tjet3}, E^0_{Tjet4}, E^0_{Tmiss} using PYTHIA 5.7 code [13]. We have considered two values of $tan\beta = 5$ and $tan\beta = 35$ $(tan\beta \equiv \frac{<H_t>}{<H_b>})$. We considered both cases of heavy and relatively light gluino. We considered different values of LSP and second neutralino masses. In our calculations we took the value of the masses of the first and second squark generations equal to $m_{\tilde{q}_{1,2}} = 3800 GeV$. However for $m_{\tilde{q}_{1,2}} \geq 3000 GeV$ the result practically do not depend on the value of $m_{\tilde{q}_{1,2}}$.

4 Results

The results of our calculations are presented in tables (3-24). In estimation of LHC (CMS) SUSY discovery potential we took total luminosity equal to $L_t = 10^5 pb^{-1}$. There is a crucial difference between "future" experiment and "real" experiment [14]. In the "real" experiment the total number of events N_{ev} is a given number and we compare it with expected N_b when we test the validity of standard physics. In the condition of the "future" experiment we know only the average number of the background events N_b and the average number of signal events N_s, so we have to compare the Poisson distributions $P(n, N_b)$ and $P(n, N_b + N_s)$ to determine the probability to find new physics in future experiment. According to common definition new physics discovery potential corresponds to the case when the probability that background can imitate signal is less than $5 \cdot \sigma$ or in terms of the probability less than $\Delta = 5.6 \cdot 10^{-7}$. So we require that the probability $\beta(\Delta)$ of the background fluctuations for $n > n_0(\Delta)$ is less than Δ, namely,

$$\beta(\Delta) = \sum_{n=n_0(\Delta)+1}^{\infty} P(n, N_b) \leq \Delta$$

The discovery probability $1 - \alpha(\Delta)$ that the number of signal events will be bigger than $n_0(\Delta)$ is equal to

$$1 - \alpha(\Delta) = \sum_{n=n_0(\Delta)+1}^{\infty} P(n, N_b + N_s).$$

We require that $1 - \alpha(\Delta) \geq 0.5$.

As it follows from our results for fixed values of squark and gluino masses the visibility of signal decreases with the increase of the LSP mass. This fact has trivial explanation. Indeed, in the rest frame of squark or gluino the jets spectrum becomes more soft with the increase of LSP mass. Besides in parton model pair produced squarks and gluino are produced with total transverse momentum closed to zero. For high LSP masses partial cancellation of missing transverse momenta from two LSP particles takes place.

Note that for the case of relatively light 3^{rd} squark generation b-quarks in the final state dominate. However, in our calculations we have not used b-tagging to suppress the background and to make signal more observable.

5 Conclusion

In this paper we have presented the results of the investigation of LHC (CMS) SUSY discovery potential for the models with effective supersymmetry. We have considered general case of nonuniversal gaugino masses. We have found that the visibility of signal by an excess over SM background in $jets + isolated\ leptons + E_T^{miss}$ events depends rather strongly on the relation between LSP, second neutralino, gluino and 3^{rd} generation squark masses and it decreases with the increase of LSP mass. For the case when gluino is heavy it would be possible to detect SUSY for 3^{rd} generation squark masses up to $1\ TeV$.

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Table 1: Cuts a.

# of cut	p_{t1} [GeV]	p_{t2} [GeV]	p_{t3} [GeV]	p_{t4} [GeV]	E_t^{miss} [GeV]
1	40.0	40.0	40.0	40.0	200.0
2	100.0	100.0	100.0	100.0	200.0
3	100.0	150.0	150.0	150.0	200.0
4	50.0	100.0	100.0	100.0	200.0
5	200.0	200.0	200.0	200.0	400.0
6	200.0	300.0	300.0	300.0	400.0
7	100.0	200.0	200.0	200.0	400.0
8	300.0	300.0	300.0	300.0	600.0
9	300.0	450.0	450.0	450.0	600.0
10	150.0	300.0	300.0	300.0	600.0
11	400.0	400.0	400.0	400.0	800.0
12	400.0	600.0	600.0	600.0	800.0
13	200.0	400.0	400.0	400.0	800.0
14	500.0	500.0	500.0	500.0	1000.0
15	500.0	750.0	750.0	750.0	1000.0
16	250.0	500.0	500.0	500.0	1000.0
17	600.0	600.0	600.0	600.0	1200.0
18	600.0	900.0	900.0	900.0	1200.0
19	300.0	600.0	600.0	600.0	1200.0

Table 2: Cuts b.

# of cut	p_{t1} [GeV]	p_{t2} [GeV]	p_{t3} [GeV]	p_{t4} [GeV]	E_t^{miss} [GeV]
1	40.0	40.0	40.0	40.0	200.0
2	100.0	125.0	150.0	150.0	200.0
3	166.7	208.3	250.0	250.0	200.0
4	233.3	291.7	350.0	350.0	200.0
5	300.0	375.0	450.0	450.0	200.0
6	100.0	125.0	150.0	150.0	400.0
7	166.7	208.3	250.0	250.0	400.0
8	233.3	291.7	350.0	350.0	400.0
9	300.0	375.0	450.0	450.0	400.0
10	100.0	125.0	150.0	150.0	600.0
11	166.7	208.3	250.0	250.0	600.0
12	233.3	291.7	350.0	350.0	600.0
13	300.0	375.0	450.0	450.0	600.0
14	100.0	125.0	150.0	150.0	800.0
15	166.7	208.3	250.0	250.0	800.0
16	233.3	291.7	350.0	350.0	800.0
17	300.0	375.0	450.0	450.0	800.0
18	100.0	125.0	150.0	150.0	1000.0
19	166.7	208.3	250.0	250.0	1000.0
20	233.3	291.7	350.0	350.0	1000.0
21	300.0	375.0	450.0	450.0	1000.0
22	100.0	125.0	150.0	150.0	1200.0
23	166.7	208.3	250.0	250.0	1200.0
24	233.3	291.7	350.0	350.0	1200.0
25	300.0	375.0	450.0	450.0	1200.0

Table 3: The discovery potential of CMS for $L = 10^5$ pb^{-1} and for different signatures and for different values of $m_{\tilde{q}_3}$, $m_{\tilde{g}}$ and $tan\ \beta$. All masses are in GeV. Here + (−) means that signal is detectable (nondetectable). $m_{\tilde{q}_3} = 800$, $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.15$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
133,1800	+	+	-	-	+	-
400,1800	-	-	-	-	-	-
600,1800	-	-	-	-	-	-
720,1800	-	-	-	-	-	-
133,266	-	-	-	-	+	-
133,600	+	+	-	-	-	-
400,720	-	-	-	-	-	-
450,540	-	-	-	-	-	-

Table 4: $m_{\tilde{q}_3} = 750$, $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.2$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
125,1800	+	+	-	-	+	-
375,1800	-	-	-	-	+	+
560,1800	-	-	-	-	-	-
675,1800	-	-	-	-	-	-
125,250	-	-	-	-	+	-
125,560	+	-	-	-	+	+
375,675	-	-	-	-	-	-
560,675	-	-	-	-	-	-

Table 5: $m_{\tilde{q}_3} = 700$, $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.28$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
117,1800	+	+	-	-	-	-
350,1800	+	+	-	-	-	-
525,1800	-	-	-	-	-	-
630,1800	-	-	-	-	-	-
117,234	-	-	-	+	-	-
117,525	+	+	-	-	-	-
350,525	-	-	-	-	-	-
350,630	-	-	-	-	-	-
525,630	-	-	-	-	-	-

Table 6: $m_{\tilde{q}_3} = 650$, $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.42$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
108,1800	+	+	-	-	-	-
325,1800	+	+	-	-	-	-
490,1800	-	-	-	-	-	-
585,1800	-	-	-	-	-	-
108,216	+	+	-	+	+	+
325,490	-	-	-	-	-	-
325,585	+	+	-	-	-	-
490,585	-	-	-	-	-	-
108,490	+	+	-	-	-	-

Table 7: $m_{\tilde{q}_3} = 600$, $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.7$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
100,1800	+	+	-	-	-	-
300,1800	+	+	-	-	-	-
450,1800	-	-	-	-	-	-
540,1800	-	-	-	-	-	-
100,200	-	-	-	-	-	-
100,450	+	+	-	-	-	-
300,540	+	+	-	-	-	-
450,540	-	-	-	-	-	-
20,1800	+	+	+	-	-	-

Table 8: $m_{\tilde{q}_3} = 1000$, $m_{\tilde{g}} = 2000$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.03$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
170,1800	+	+	-	-	-	-
500,1800	-	-	-	-	-	-
750,1800	-	-	-	-	-	-
900,1800	-	-	-	-	-	-
170,330	-	-	-	-	-	-
170,750	+	+	-	-	-	-
500,900	-	-	-	-	-	-
750,900	-	-	-	-	-	-

Table 9: $m_{\tilde{q}_3} = 1000$, $m_{\tilde{g}} = 1750$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.036$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
170,1800	+	+	-	-	-	-
500,1800	-	-	-	-	-	-
750,1800	-	-	-	-	-	-
900,1800	-	-	-	-	-	-
170,330	+	-	-	-	-	-
170,750	+	-	-	-	-	-
500,900	+	-	-	-	-	-
750,900	-	-	-	-	-	-

Table 10: $m_{\tilde{q}_3} = 1000$, $m_{\tilde{g}} = 1500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.038$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
166,1800	+	+	-	-	-	-
500,1800	+	+	-	-	-	-
750,1800	-	-	-	-	-	-
900,1800	-	-	-	-	-	-
166,332	+	-	+	-	-	-
166,750	+	+	+	-	+	-
500,900	+	+	-	-	-	-
750,900	-	-	-	-	-	-

Table 11: $m_{\tilde{q}_3} = 1000$, $m_{\tilde{g}} = 1250$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.075$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^\pm$	l^+l^-	$l^\pm l^\pm$	3 l
166,1800	+	+	+	+	+	-
500,1800	+	+	-	-	+	-
750,1800	+	-	-	-	+	-
900,1800	-	-	-	-	-	-
166,332	+	+	-	-	+	-
166,750	+	+	+	+	+	+
500,900	+	+	-	-	-	-
750,900	+	+	-	-	+	-

Table 12: $m_{\tilde{q}_3} = 1200$, $m_{\tilde{g}} = 1500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.017$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^\pm$	l^+l^-	$l^\pm l^\pm$	3 l
200,1800	+	+	-	-	-	-
600,1800	+	-	-	-	-	-
900,1800	-	-	-	-	-	-
1080,1800	-	-	-	-	-	-
200,400	+	-	-	-	-	-
200,600	+	-	-	-	+	-
600,900	+	-	-	-	-	-

Table 13: $m_{\tilde{q}_3} = 800$, $m_{\tilde{g}} = 2000$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.14$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^\pm$	l^+l^-	$l^\pm l^\pm$	3 l
133,1800	+	+	-	-	-	-
400,1800	+	+	-	-	-	-
600,1800	-	-	-	-	-	-
720,1800	-	-	-	-	-	-
133,266	+	-	-	+	+	-
133,600	+	+	-	-	-	-
600,720	-	-	-	-	-	-

Table 14: $m_{\tilde{q}_3} = 800$, $m_{\tilde{g}} = 1500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.15$pb, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
133,1800	+	+	+	+	+	+
400,1800	+	+	-	+	+	+
600,1800	+	+	-	-	+	+
720,1800	+	+	-	-	-	-
133,266	+	+	+	+	+	-
133,600	+	+	+	+	+	+

Table 15: $m_{\tilde{q}_3} = 800$, $m_{\tilde{g}} = 1000$, $m_{\tilde{q}_{1,2}} = 3800$, $tan\ \beta = 5$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
133,1800	+	+	+	+	+	+
400,1800	+	+	+	-	+	+
600,1800	+	+	-	-	+	-
720,1800	+	+	-	-	+	-
133,266	+	+	+	+	+	+
133,600	+	+	+	+	+	+
400,720	+	+	-	-	+	+
600,720	+	+	-	-	+	-

Table 16: $m_{\tilde{q}_3} = 3800$, $m_{\tilde{g}} = 3500$, $m_{o3} = 1000$, $\sigma = 0.03$pb, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
166,1800	+	-	-	-	-	-
500,1800	-	-	-	-	-	-
750,1800	-	-	-	-	-	-
850,1800	-	-	-	-	-	-
166,322	-	-	-	-	-	-
166,750	+	-	-	-	-	-
500,750	-	-	-	-	-	-
500,900	-	-	-	-	-	-
750,900	-	-	-	-	-	-

Table 17: $m_{\tilde{q}_3} = 3800$, $m_{\tilde{g}} = 3500$, $m_{o3} = 900$, $\sigma = 0.07$pb, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
150,1800	+	+	-	-	-	-
450,1800	-	-	-	-	-	-
675,1800	-	-	-	-	-	-
750,1800	-	-	-	-	-	-
150,300	-	-	-	-	+	-
150,675	+	+	-	-	-	-
450,675	-	-	-	-	-	-
450,810	-	-	-	-	-	-
675,810	-	-	-	-	-	-

Table 18: $m_{\tilde{q}_{1,2}} = 3800$, $m_{\tilde{g}} = 3500$, $m_{o3} = 800$, $\sigma = 0.18$pb, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
133,1800	+	+	-	-	-	-
400,1800	-	-	-	-	-	-
600,1800	-	-	-	-	-	-
720,1800	+	+	+	-	-	-
133,266	-	-	-	-	+	+
133,600	+	+	-	+	+	+
400,600	-	-	-	-	-	-
400,720	-	-	-	-	-	-
450,540	-	-	-	-	+	+

Table 19: $m_{\tilde{q}_3} = 750$, $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.28$pb, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	$3\ l$
125,1800	+	+	+	+	-	-
375,1800	+	+	+	+	-	-
560,1800	+	+	+	+	-	-
675,1800	+	+	+	+	-	-
125,250	+	+	+	+	+	+
125,560	+	+	+	+	+	+
375,560	+	+	-	-	+	-
560,675	-	-	-	-	-	-

Table 20: $m_{\tilde{q}_3} = 650$, $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 1$pb, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	$3\ l$
108,1800	+	+	-	+	-	-
325,1800	+	+	+	+	-	-
487,1800	+	+	+	+	-	-
585,1800	+	+	+	+	-	-
108,216	-	-	-	+	+	+
108,487	+	+	-	+	-	+
487,585	+	+	+	+	-	+

Table 21: $m_{o3} = 1200$, $m_{\tilde{g}} = 1500$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.02$pb, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	$3\ l$
200,1800	+	+	-	-	-	-
600,1800	+	-	-	-	-	-
900,1800	-	-	-	-	-	-
1080,1800	+	+	-	-	-	-
200,400	+	-	-	-	-	-
200,600	+	-	+	-	+	-
600,900	+	-	-	-	-	-
900,1080	-	-	-	-	-	-

Table 22: $m_{o3} = 800$, $m_{\tilde{g}} = 1000$, $m_{\tilde{q}_{1,2}} = 3800$, $\sigma = 0.5$pb, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
133,1800	+	+	+	+	+	+
400,1800	+	+	+	+	+	-
600,1800	+	+	-	-	+	-
720,1800	+	+	+	+	+	+
133,266	+	+	+	+	+	+
133,600	+	+	+	+	+	+
400,600	+	+	+	+	+	+
400,720	+	+	+	+	+	-

Table 23: $m_{o3} = 800$, $m_{\tilde{g}} = 1500$, $m_{\tilde{q}_{1,2}} = 3800$, $tan\ \beta = 35$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
133,1800	+	+	-	-	+	-
400,1800	+	+	-	-	-	-
600,1800	-	-	-	-	+	-
720,1800	+	+	-	-	-	-
133,266	+	+	+	+	+	+
133,600	+	+	+	+	+	+
400,600	+	+	-	-	+	-
400,720	+	-	-	+	+	+
600,720	+	-	-	+	+	+

Table 24: $m_{\tilde{g}} = 3500$, $m_{\tilde{q}_{1,2}} = 3800$.

$m_{\tilde{\chi}_1}, m_{\tilde{\chi}_2}$	$tan\ \beta$		incl	no lept.	$l^{\pm}$	l^+l^-	$l^{\pm}l^{\pm}$	3 l
166,1800	5	$m_{\tilde{q}_3}$=1000	+	+	-	-	-	-
$\frac{m_{\tilde{q}_3}}{6}$,1800	5	$m_{\tilde{q}_3}$=1100	-	-	-	-	-	-
$\frac{m_{\tilde{q}_3}}{6}$,1800	5	$m_{\tilde{q}_3}$=1200	-	-	-	-	-	-
$\frac{m_{\tilde{q}_3}}{6}$,1800	5	$m_{\tilde{q}_3}$=1300	-	-	-	-	-	-
$\frac{m_0}{6}$,1800	35	m_0=1000	-	-	-	-	-	-
$\frac{m_0}{6}$,1800	35	m_0=1100	-	-	-	-	-	-
$\frac{m_0}{6}$,1800	35	m_0=1200	-	-	-	-	-	-
$\frac{m_0}{6}$,1800	35	m_0=1300	-	-	-	-	-	-