

Impact of the recent results by the CMS and ATLAS collaborations at the CERN Large Hadron Collider on an effective minimal supersymmetric extension of the standard model

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We discuss the impact for light neutralinos in an effective minimal supersymmetric extension of the standard model of the recent results presented by the CMS and ATLAS Collaborations at the CERN Large Hadron Collider for a search of supersymmetry in proton-proton collisions at a center-of-mass energy of 7 TeV with an integrated luminosity of 35 pb⁻¹. We find that, in the specific case of light neutralinos, efficiencies for the specific signature searched by ATLAS (jets + missing transverse energy and an isolated lepton) imply a lower sensitivity compared to CMS (which searches for jets+ missing transverse energy). Focusing on the CMS bound, if squark soft masses of the three families are assumed to be degenerate, the combination of the ensuing constraint on squark and gluino masses with the experimental limit on the $b \rightarrow s + \gamma$ decay imply a lower bound on the neutralino mass m_χ that can reach the value of 11.9 GeV, depending on the gluino mass. On the other hand, when the universality condition among squark soft parameters is relaxed, the lower bound on m_χ is not constrained by the CMS measurement and then remains at the value 7.5 GeV derived in previous papers.

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I. INTRODUCTION

The CMS and ATLAS Collaborations have presented their results of a search for supersymmetry (SUSY) in proton-proton collisions at the CERN Large Hadron Collider (LHC) at a center-of-mass energy of 7 TeV with an integrated luminosity of 35 pb⁻¹ [1,2]. The CMS investigation [1] consists in a search for events with jets and missing transverse energy, while ATLAS [2] searched for final states containing jets, missing transverse energy, and one isolated electron or muon. Both signatures would be significant of processes due to the production in pairs of squarks and gluinos, subsequently decaying into quarks, gluons, other standard model (SM) particles, and a neutralino (interpreted as the lightest supersymmetric particle) in a R -parity-conserving SUSY theory. As reported in Refs. [1,2], in both analyses, the data appear to be consistent with the expected SM backgrounds; thus, constraints are derived on the model parameters in the case of a minimal supergravity model (mSUGRA, also denoted as the constrained minimal supersymmetric standard model) [3] for the specific standard benchmark with trilinear coupling $A_0 = 0$, ratio of vacuum expectation values (VEVs) $\tan\beta = 3$, and Higgs-mixing parameter $\mu > 0$ in the plane of the universal scalar and gaugino mass parameters $m_0 - m_{1/2}$. In Ref. [1], constraints are also discussed in terms of two of the conventional benchmarks within SUGRA models: those denoted by LM1 and LM0 (or SU4) in the literature [4–6]. Although these constraints depend on the specific sets of the mSUGRA parameters employed in the phenomenological analysis, the general outcome of

Refs. [1,2] is that the lower bounds on the squark and gluino masses are sizably higher, as compared to the previous limits established by the experiments of D0 [7] and CDF [8] at the Tevatron.

In this paper, we consider the implications of the results of Refs. [1,2] for the supersymmetric scheme discussed in Refs. [9–11], i.e., for an effective minimal supersymmetric standard model (MSSM) scheme at the electroweak scale with the following independent parameters: M_1 , M_2 , M_3 , μ , $\tan\beta$, m_A , $m_{\tilde{q}}$, $m_{\tilde{l}}$, and A . Notations are as follows: M_1 , M_2 , and M_3 are the U(1), SU(2), and SU(3) gaugino masses (these parameters are taken here to be positive); μ is the Higgs-mixing mass parameter; $\tan\beta$ is the ratio of the two Higgs VEVs; m_A is the mass of the CP -odd neutral Higgs boson; $m_{\tilde{q}}$ is a squark soft mass common to all squarks; $m_{\tilde{l}}$ is a slepton soft mass common to all sleptons; and A is a common dimensionless trilinear parameter for the third family, $A_{\tilde{b}} = A_{\tilde{t}} \equiv Am_{\tilde{q}}$ and $A_{\tilde{\tau}} \equiv Am_{\tilde{l}}$ (the trilinear parameters for the other families being set equal to zero). Since no gaugino-mass unification at a grand unified scale is assumed (at variance with one of the major assumptions in mSUGRA), in this model, the neutralino mass is not bounded by the lower limit $m_\chi \gtrsim 50$ GeV that is commonly derived in mSUGRA schemes from the LEP lower bound on the chargino mass (of about 100 GeV). In Refs. [9–11], it is shown that, if R parity is conserved, a light neutralino (i.e., a neutralino with $m_\chi \lesssim 50$ GeV) is a very interesting candidate for cold dark matter (CDM), due to its relic abundance and its relevance in the interpretation of current experiments of search for relic particles; in Refs. [9–11], also, a lower bound, $m_\chi \gtrsim 7$ –8 GeV, is

obtained from the cosmological upper limit on CDM. The compatibility of these results with all experimental searches for direct or indirect evidence of SUSY (prior to the results of Refs. [1,2]) and with other precision data that set constraints on possible effects due to supersymmetry is discussed in detail in Ref. [11] (for the compatibility of very light neutralino masses with various laboratory bounds, see also Ref. [12]). The SUSY model described above will hereafter be denoted as the light neutralino model (LNM); within this model, the so-called scenario \mathcal{A} [11] will be considered in the present analysis, since it is the scenario relevant to establishing the absolute lower bound on the neutralino mass. The main features of this scenario are i) m_A must be light: $90 \text{ GeV} \leq m_A \leq (200\text{--}300) \text{ GeV}$ (90 GeV being the lower bound from LEP searches); ii) $\tan\beta$ has to be large: $\tan\beta = 20\text{--}45$; and iii) the $\tilde{B} - \tilde{H}_1^\circ$ mixing needs to be sizeable, which, in turn, implies small values of μ : $|\mu| \sim (100\text{--}200) \text{ GeV}$. The purpose of this paper is to establish the novelties introduced by the outcomes of the recent CMS and ATLAS investigations on the features of the LNM, with special emphasis on the aspects concerning the neutralino as a CDM candidate. For detailed discussions of LNM models, see Refs. [9,10], and especially Ref. [11].

First, we recall that the neutralino, defined as the linear superposition of bino \tilde{B} ; wino $\tilde{W}^{(3)}$; and of the two Higgsino states $\tilde{H}_1^\circ, \tilde{H}_2^\circ$; $\chi \equiv a_1\tilde{B} + a_2\tilde{W}^{(3)} + a_3\tilde{H}_1^\circ + a_4\tilde{H}_2^\circ$, of lowest mass m_χ , is described within the minimal supersymmetric extension of the SM only through a subset of the SUSY model parameters, namely, M_1, M_2, μ , and $\tan\beta$. The neutral Higgs mass m_A and the slepton mass $m_{\tilde{l}}$ are instead crucial parameters intervening in the neutralino-nucleon scattering and in the neutralino pair-annihilation processes (and then also in the neutralino relic abundance) [9–11]. The three remaining parameters characterizing the LNM, $M_3, m_{\tilde{q}}$, and A , enter into play when the large host of experimental results that constrain supersymmetry are implemented into the model [11]. This experimental information is derived from 1) the searches at accelerators for Higgs bosons and supersymmetric charged particles (sleptons and charginos at LEP, squarks and gluinos at hadron colliders); 2) the B -meson rare decays at the Tevatron and the B factories; 3) the muon anomalous magnetic moment; and 4) the $b \rightarrow s\gamma$ decay. One further crucial requirement which guarantees that the neutralino can be interpreted as a relic particle in the Universe is that its relic abundance satisfies the cosmological bound $\Omega_\chi h^2 \leq (\Omega_{\text{CDM}} h^2)_{\text{max}} \approx 0.12$. All these data set significant constraints on the model parameters and also entail sizable correlations among some of them. In particular, various constraints and correlations involving the SUSY parameters follow from the loop correction terms, due to supersymmetry, that can affect the physical quantities involved in the items (2–4) above.

The ranges of the MSSM parameters used in the figures shown in the following sections, appropriately narrowed in order to explore this scenario, are $20 \leq \tan\beta \leq 45$, $105 \text{ GeV} \leq \mu \leq 160 \text{ GeV}$, $5 \text{ GeV} \leq M_1 \leq 20 \text{ GeV}$, $300 \text{ GeV} \leq M_2 \leq 2000 \text{ GeV}$, $250 \text{ GeV} \leq m_{\tilde{q}} \leq 800 \text{ GeV}$, $115 \text{ GeV} \leq m_{\tilde{l}} \leq 2000 \text{ GeV}$, $90 \text{ GeV} \leq m_A \leq 115 \text{ GeV}$, and $0.15 \leq A \leq 1$.

II. CORRELATIONS BETWEEN $m_{\tilde{q}}$ AND OTHER SUSY PARAMETERS WITHIN THE LNM

One of the most important constraints among those mentioned above is the one established by the branching ratio of the $b \rightarrow s + \gamma$ decay process. Indeed, in the LNM, this branching ratio lies in its experimental range if the contribution of a loop diagram with a charged Higgs and the top quark is compensated by the contribution of a loop diagram with a chargino and a top squark [13]. Since our LNM (in scenario \mathcal{A}) entails both a light charged Higgs (of mass $m_{H^\pm}^2 \approx m_A^2 + m_W^2$) and a light chargino (of mass $m_{\chi^\pm} \sim \mu \sim 100\text{--}200 \text{ GeV}$), also $m_{\tilde{q}}$ has to be not too heavy. A strong correlation implied by the $b \rightarrow s + \gamma$ decay process between m_A (through m_{H^\pm}) and $m_{\tilde{q}}$ is shown in Fig. 1, where a scatter plot for a light neutralino population is represented by black dots when the $b \rightarrow s + \gamma$ constraint is not implemented, and by red crosses when this constraint is applied. In this second case, it turns out that i) $m_{\tilde{q}}$ and m_A are rather strongly correlated, and ii) the squark mass is limited by the upper bound $m_{\tilde{q}} \lesssim 800 \text{ GeV}$.

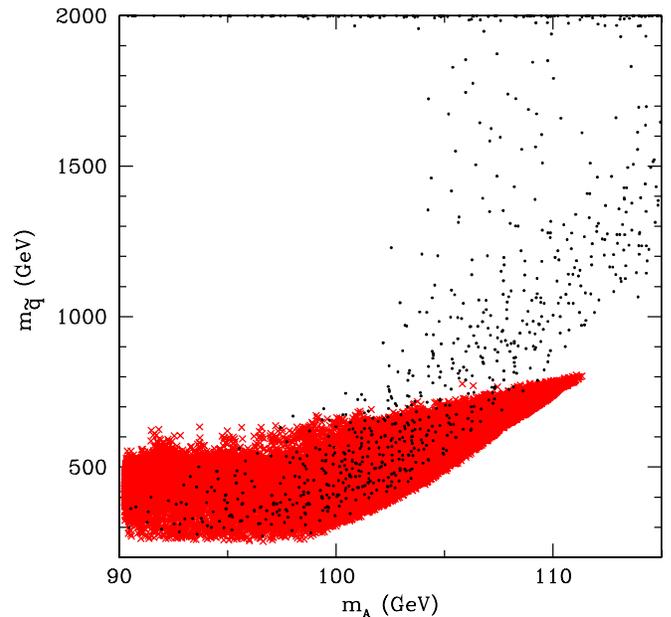


FIG. 1 (color online). Scatter plot of the light neutralino population shown in the plane $m_A - m_{\tilde{q}}$. For black dots, the $b \rightarrow s + \gamma$ constraint is not implemented, while, for red crosses, the constraint is applied.

Notice that the variation in the density of points of Fig. 1 is just due to a different sampling of the regions of interest in the parameter space. The relaxation of the $b \rightarrow s\gamma$ constraint is only considered here in connection with Fig. 1, for illustration purposes. This constraint is implemented in all our further discussions and results.

Since the lower bound on the neutralino mass, implied by the cosmological bound $\Omega_\chi h^2 \leq (\Omega_{\text{CDM}} h^2)_{\text{max}}$, increases as m_A^2 [11], the correlation between $m_{\tilde{q}}$ and m_A entails also a correlation between $m_{\tilde{q}}$ and m_χ , as displayed in Fig. 2.

These correlations imply that a lower bound on $m_{\tilde{q}}$, derived from accelerator measurements, could potentially have the consequence of increasing the lower bound on m_χ , as compared to the one of about 7–8 GeV, previously established within the LNM [11]. Thus, it is important to establish which lower limit on $m_{\tilde{q}}$ can be actually derived from the CMS and ATLAS results [1,2].

Before we come to an analysis of this point, let us just remark that a loop involving the chargino and the stop, as the one relevant for the $b \rightarrow s + \gamma$, is also responsible for a potentially sizable SUSY contribution to the branching ratio for the decay $B_s \rightarrow \mu^+ + \mu^-$. Indeed, this loop correction behaves as $\tan^6 \beta$ [14]; thus, at large $\tan \beta$, it can overshoot the experimental upper bound: $BR(B_s \rightarrow \mu^+ \mu^-) < 5.8 \times 10^{-8}$ [15]. This can actually occur in SUGRA models, with the effect of constraining the neutralino phenomenology drastically [16]. In Ref. [11], it is shown that, in the LNM, this is not the case, since (a) the chargino intervening in the relevant loop is light, and

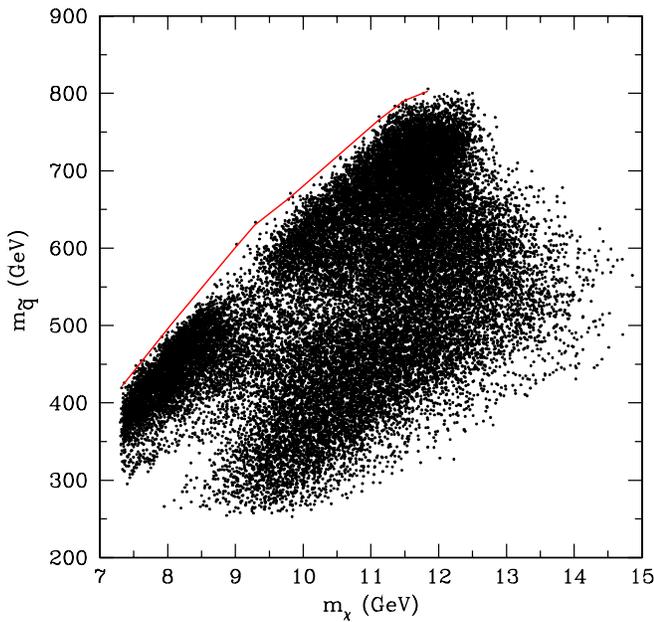


FIG. 2 (color online). Scatter plot of the light neutralino population shown in the plane $m_\chi - m_{\tilde{q}}$. The red line represents an interpolation of the lower boundary on m_χ as a function of $m_{\tilde{q}}$.

(b) the splitting in the top mass eigenstates can be small (a condition that is met whenever $|A| \ll m_{\tilde{q}}/m_t$). This last requirement is exemplified by the lower frontier of the scatter plot of Fig. 3 displaying the correlation between A and $m_{\tilde{q}}$. In this figure, the upper bound on $m_{\tilde{q}}$ is due, as already mentioned, to the bound on the $b \rightarrow s + \gamma$ decay. The point we wish to stress here is that, as shown in the numerical analysis of Ref. [11], the constraint imposed by the branching ratio for the decay $B_s \rightarrow \mu^+ + \mu^-$ is compatible with the constraints due to the branching ratio of the $b \rightarrow s + \gamma$ decay process, a feature which is not trivial, due to the different role played by the parameter $m_{\tilde{q}}$ in the two processes. However, it is clear from Fig. 3 that, as the squark soft mass parameter $m_{\tilde{q}}$ gets close to its upper bound, the interplay of the two constraints entails a growing tuning of the A trilinear coupling for the highest values of $m_{\tilde{q}}$. In the same figure, black dots show configurations for which all constraints are applied, while, for red crosses, the bound from $B \rightarrow \tau\nu$ measurements is not implemented. As discussed in Ref. [11], this latter bound is somewhat less robust than other constraints, due to the uncertainties affecting both theoretical estimates and experimental determinations related to B -meson decays. As can be seen from Fig. 3, when the $B \rightarrow \tau\nu$ constraint is not implemented, the tuning affecting the trilinear coupling is eased and the upper bound on $m_{\tilde{q}}$ weakened.

We recall that the role of the various experimental results mentioned at the end of Sec. I in constraining the LNM is discussed in detail in Ref. [11].

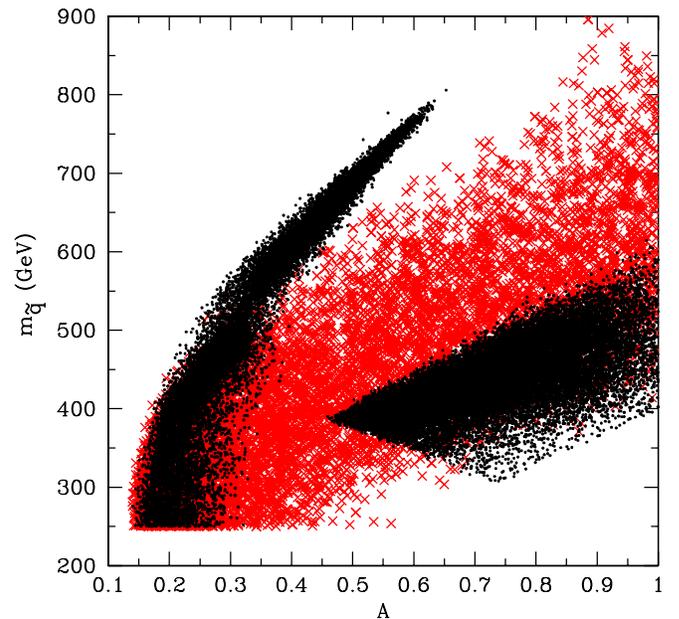


FIG. 3 (color online). Scatter plot of the light neutralino population shown in the plane $A - m_{\tilde{q}}$. Black dots show configurations for which all constraints are applied, while, for red crosses, the bound from $B \rightarrow \tau\nu$ measurements [11] is not implemented.

III. LOWER LIMIT TO $m_{\tilde{q}}$ IMPLIED BY THE CMS AND ATLAS RESULTS WITHIN THE LNM

After appropriate cuts to reject the background and to reduce the probability of jet mismeasurements, the CMS search for events with jets and missing transverse energy derived an upper bound $N_{\max}^{\text{CMS}} = 13$ events at 95% confidence level in the signal region for an integrated luminosity $\mathcal{L} = 35 \text{ pb}^{-1}$. This upper bound is related to the total SUSY production cross section σ by the relation $N_{\max} = \epsilon \times \mathcal{L} \times \sigma$, where ϵ is the total efficiency due to selection cuts. In order to estimate ϵ_{CMS} for the CMS signature, we have simulated a few LNM benchmarks on the low- $m_{\tilde{\chi}}$ boundary shown in Fig. 2 using ISAJET [17], applying the same kinematic cuts as described in Ref. [1]. In this way, we obtained the range $0.07 \lesssim \epsilon_{\text{CMS}} \lesssim 0.2$ for the total efficiency, that can be used to convert N_{\max}^{CMS} into an upper bound $\sigma_{\text{CMS}}^{\max}$ on the cross section, with $1.86 \text{ pb} < \sigma_{\text{CMS}}^{\max} < 5.31 \text{ pb}$. On the other hand, the ATLAS Collaboration searched for jets + missing transverse energy and one isolated electron or muon and derived an upper bound $N_{\max}^{\text{ATLAS}} = 2.2$ events at 95% confidence level in the electron signal region (with a similar result in the muon channel) for the same integrated luminosity of CMS. Following the same procedure used for CMS and for the same LNM benchmarks, we estimated ϵ_{ATLAS} for the ATLAS signature, applying the same kinematic cuts as described in Ref. [2]. In this way, we found the range $2 \times 10^{-4} \lesssim \epsilon_{\text{ATLAS}} \lesssim 5 \times 10^{-3}$, that, when converted into an upper bound on the cross section $\sigma_{\text{ATLAS}}^{\max}$, implies $12.6 \text{ pb} < \sigma_{\text{ATLAS}}^{\max} < 314.3 \text{ pb}$. Since $\sigma_{\text{ATLAS}}^{\max} \gg \sigma_{\text{CMS}}^{\max}$, we conclude that, within the LNM scenario, the CMS analysis is significantly more sensitive than that from ATLAS.¹ As a consequence of the above discussion, in the following, we will concentrate only on the discussion of the CMS bound.

In Fig. 4, the solid red line shows the contour plot for $\sigma = \sigma_{\text{CMS}} = 1.86 \text{ pb}$, while the dashed blue one represents the corresponding curve for $\sigma = \sigma_{\text{CMS}} = 5.31 \text{ pb}$; we have calculated the total SUSY production cross section for the process $p + p \rightarrow$ gluinos, squarks as a function of the squark mass $m_{\text{squark}} \simeq m_{\tilde{q}}$, and the gluino mass M_3 using PROSPINO [18] with CTEQ-TEA CT10 parton distribution functions [19]. The shaded area below the red solid line would be excluded adopting $\epsilon_{\text{CMS}} = 0.2$ and represents the maximal impact of the CMS measurement on the LNM parameter space. It is important here to point out that, at variance with the SUGRA scenario, within the LNM model, the gluino mass M_3 is not related to the other gaugino masses, and, in particular, to $m_{\tilde{\chi}} \simeq M_1$ by grand unified theory relations. Moreover, M_3 enters in the calcu-

¹We find that the particular suppression of ϵ_{ATLAS} is due to the cut on the angle between the missing transverse momentum vector and the jets, applied by ATLAS to reduce the probability of jet mismeasurement [2].

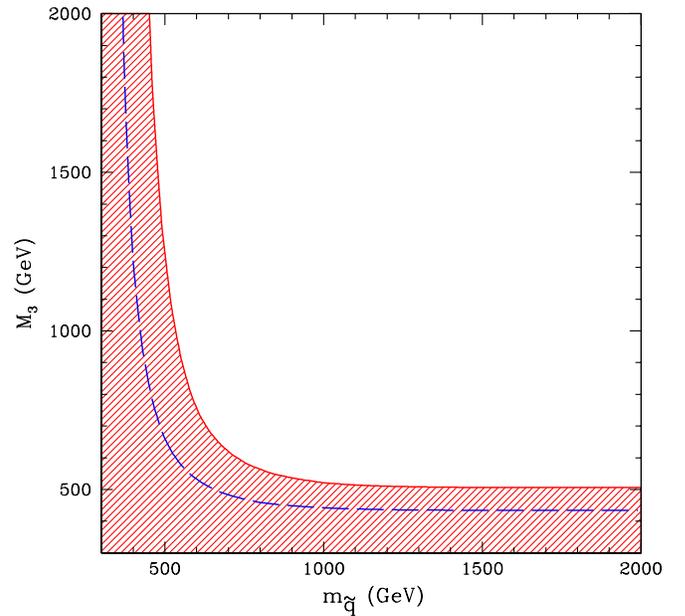


FIG. 4 (color online). Shaded area representing the region in the $m_{\tilde{q}} - M_3$ parameter space where the total SUSY production cross section at the LHC with $\sqrt{s} = 7 \text{ TeV}$ is larger than 1.86 pb, corresponding to the CMS upper bound of 13 SUSY events [1] and assuming an average total efficiency due to kinematic cuts equal to 0.2 for the LNM scenario. The blue dashed line represents the contour plot for $\sigma = \sigma_{\text{CMS}} = 5.31 \text{ pb}$, the value corresponding to the upper bound on the cross section when $\epsilon_{\text{CMS}} = 0.07$ (see text).

lation of observables for the relic neutralino only at the loop level (through radiative corrections of Higgs couplings [20]), so that, within the LNM, M_3 is very weakly correlated to the other parameters. This implies that, within the LNM, the absolute lower bound $m_{\tilde{q}} \gtrsim 450(370) \text{ GeV}$ can be obtained from the contour plot of Fig. 4 by taking the limit $M_3 \rightarrow \infty$ and for $\epsilon_{\text{CMS}} = 0.2(0.07)$.

IV. LOWER LIMIT TO $m_{\tilde{\chi}}$ IMPLIED BY THE CMS RESULTS WITHIN THE LNM FOR DEGENERATE SQUARK SOFT MASSES

As already mentioned before, within the LNM, the $m_{\tilde{q}}$ parameter is correlated to the neutralino mass $m_{\tilde{\chi}}$, as shown by the scatter plot of Fig. 2. As a consequence, the lower bound on $m_{\tilde{q}}$ discussed in the previous section can be converted into a lower bound on $m_{\tilde{\chi}}$. This is shown as a function of M_3 in Fig. 5, where the solid red line corresponds to $\epsilon_{\text{CMS}} = 0.2$ and the dashed blue one to $\epsilon_{\text{CMS}} = 0.07$. In both cases, the boundary shown in Fig. 2 has been used to convert the bound on $m_{\tilde{q}}$ into a limit on $m_{\tilde{\chi}}$. Notice that, assuming degenerate soft squark masses, in the LNM, the CMS limit can be combined to the upper bound $m_{\tilde{q}} < 800 \text{ GeV}$ obtained from the $b \rightarrow s + \gamma$ decay process to get the absolute limit $M_3 > 560(460) \text{ GeV}$ for $\epsilon_{\text{CMS}} = 0.2(0.07)$. For this reason, the bound of Fig. 5

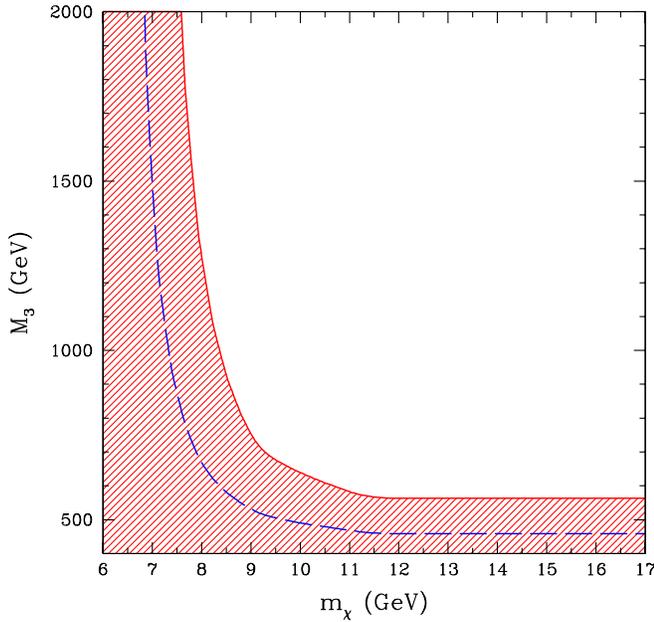


FIG. 5 (color online). Lower bound on the neutralino mass m_χ as a function of the gluino mass M_3 , which can be derived from the CMS data [1] when soft mass parameters of squarks of the three families are assumed to be degenerate in the LNM. The solid red line is obtained adopting the efficiency $\epsilon_{\text{CMS}} = 0.2$, and the dashed blue one corresponds to the case $\epsilon_{\text{CMS}} = 0.07$.

becomes a flat line for $m_\chi \gtrsim 11.8(11.9)$ GeV. From this figure, we also notice that the absolute lower bound on m_χ is 7.6 (6.8) GeV. This bound is increased to 11.8 (11.9) GeV when the gluino mass is close to its lower limit of 560 (460) GeV. In Fig. 5, the shaded area below the red solid line would be excluded, adopting $\epsilon_{\text{CMS}} = 0.2$, and represents the maximal impact of the CMS measurement on the LNM parameter space.

V. EXTENSION OF THE LNM BY REMOVING THE DEGENERACY IN $m_{\tilde{q}}$

According to the previous derivations, we can conclude that, within the LNM described in terms of the eight SUSY parameters, the squark mass parameter has to stay in the range $(370)450 \text{ GeV} \lesssim m_{\tilde{q}} \lesssim 800 \text{ GeV}$, with the further feature that, in the high side of this range, the model requires some fine-tuning. These properties are strictly related to the choice we have made before of taking a single soft mass parameter $m_{\tilde{q}}$ for all squarks—a choice originally taken to keep the number of SUSY parameters as low as possible. We consider here a minimal extension of the previous LNM, by removing this degeneracy in $m_{\tilde{q}}$. A natural (SUGRA-inspired) hierarchy among the soft squark masses might consist in introducing a common soft mass for the first two families, $m_{\tilde{q}_{12}}$, larger than the soft mass parameter for the third family, $m_{\tilde{t}}$. We expect this splitting to reduce the fine-tuning discussed in the previous

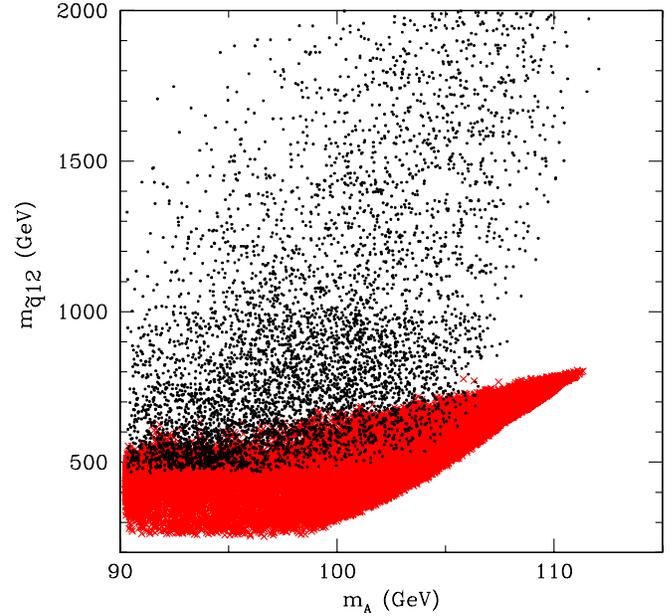


FIG. 6 (color online). Scatter plot of the light neutralino population in the plane $m_A - m_{\text{squark}}$. For red crosses, the squark soft mass parameters are assumed to be degenerate, $m_{\tilde{q}_{12}} = m_{\tilde{t}} \equiv m_{\tilde{q}}$, while, for black dots, $m_{\tilde{q}_{12}}$ and $m_{\tilde{t}}$ are allowed to float independently.

sections because LHC physics is mainly sensitive to squarks of the first two families (which correspond to the flavors more abundant in colliding protons), while the dominant contribution to the $b \rightarrow s + \gamma$ decay is driven by the large Yukawa coupling of the top squark. This is confirmed by the scatter plot in Fig. 6, where red crosses represent the same configurations shown in Fig. 1 with $m_{\tilde{q}_{12}} = m_{\tilde{t}} \equiv m_{\tilde{q}}$, while black dots show configurations where $m_{\tilde{q}_{12}}$ and $m_{\tilde{t}}$ are allowed to float independently. In this latter case, the $m_{\tilde{q}_{12}}$ parameter is no longer constrained from above for all values of m_A . As a consequence, in this case, m_χ is no longer constrained by the CMS measurement.

An analysis of the capability of the LHC in exploring SUSY regions where the first-generation squarks are very heavy compared to the other superpartners is performed in Ref. [21], but for models different from LNM.

VI. CONCLUSIONS

In this paper, we have discussed the impact for light neutralinos in an effective minimal supersymmetric extension of the standard model of the recent results presented by the CMS and ATLAS Collaborations at the CERN Large Hadron Collider for a search of supersymmetry in proton-proton collisions at a center-of-mass energy of 7 TeV with an integrated luminosity of 35 pb^{-1} . Within the LNM model, we found that CMS is significantly more sensitive than ATLAS, due to the different signatures searched by the two experiments. In particular, we

estimated a detection efficiency at CMS $0.07 \lesssim \epsilon_{\text{CMS}} \lesssim 0.2$ after kinematic cuts, corresponding to an upper bound for the total SUSY production cross section that varies from 1.86 to 5.31 pb. Taking the limit $M_3 \gg m_{\tilde{q}}$, this implies an absolute lower bound of 450 (370) GeV for the squark mass when $\epsilon_{\text{CMS}} = 0.2(0.07)$. If squark soft masses of the three families are assumed to be degenerate, we found that the combination of the CMS bound on the squark mass with the experimental constraints on the $b \rightarrow s + \gamma$ and the $B_s \rightarrow \mu^+ + \mu^-$ decays entail some tuning of the A trilinear coupling at high values of $m_{\tilde{q}}$. Moreover, when combining the CMS bound to the $b \rightarrow s + \gamma$ constraint, the lower bound on the neutralino mass m_χ varies between 6.8 and 11.9 GeV, depending on the gluino mass. On the other hand, if the universality condition among squark soft parameters is relaxed, the CMS measurement implies no constraint on the lower limit on m_χ , which remains at the value 7.5 GeV as derived in Ref. [11].

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Note added.—After submission of this paper, a new preprint by the ATLAS Collaboration appeared [22], where the results of a search for squarks and gluinos, using final states with jets and missing transverse momentum in proton-proton collisions at LHC, are reported. The center-of-mass energy and luminosity are the same as those previously considered. We have employed these results to determine an upper bound on the production cross section σ for our LNM benchmarks and for the four signal regions defined in Ref. [22], as done in our previous analysis. We have found the upper bound $\sigma < 15$ pb, larger than the upper limit employed in our previous analysis. Thus, the results discussed in the present paper remain unaltered. After submission of the present paper, the preprint [23] appeared where the CMS Collaboration reports a search for neutral MSSM Higgs bosons decaying into tau pairs. They reported no evidence for such processes, which might imply a slight increase in the neutralino mass lower bound from 7.5 to 8.7 GeV in the case of the scheme described in Sec. V. A detailed analysis of the consequences of these new data is under consideration, and the results will be presented elsewhere.

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