

Sgoldstino events in top decays at LHC

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Abstract

We study top-quark decays in models with light sgoldstinos. The off-diagonal entries in the squark mass matrices can lead to FCNC top two-body decays into sgoldstinos and $u(c)$ quarks. We compute the rates for these decays and discuss the corresponding signatures that could manifest the presence of sgoldstinos in top decays at LHC. We expect that a supersymmetry breaking scale \sqrt{F} up to a scale of order 10 TeV could be probed through this process, for a maximal squark mixing with the third generation. Justified by our preliminary analysis, a thorough study of the corresponding signal versus background and systematics in the LHC environment would be most welcome, in order to accurately assess the potential of this promising process in determining \sqrt{F} .

1 Introduction

Among the various supersymmetric extensions of the Standard Model of elementary particles, there is a set of models where the goldstino superpartners are fairly light, even lighter than the electroweak bosons. Such models emerge in the framework of no-scale supergravity [1] as well as in gauge mediation (see Ref. [2] and references therein). These goldstino superpartners — the scalar S and the pseudoscalar P — will be referred to as *sgoldstinos* in what follows. Their couplings to the SM fields are governed by ratios of some soft terms from the superpartner sector and the supersymmetry breaking parameter F . In general, sgoldstino coupling constants receive contributions from various terms in the Lagrangian of the underlying theory, but there are always contributions proportional to soft MSSM terms. In what follows we will consider only the latter contributions.

If sgoldstinos are light enough, they may appear in the products of decays of mesons (e.g., in $J/\psi \rightarrow S\gamma$ and $K^+ \rightarrow S\pi^+$). This issue was analyzed in Ref. [3]. Current experimental results on the measurements of meson rare-decay rates place strong bounds on light sgoldstino couplings. If the supersymmetry breaking soft terms are assumed to be of the order of the electroweak scale (as motivated by the supersymmetric solution to the gauge hierarchy problem of the SM), then the bounds on sgoldstino flavor-conserving coupling constants provide limits on \sqrt{F} of the order of several hundred GeV. Flavor-violating sgoldstino

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interactions might play a more important role in meson physics. The corresponding coupling constants are proportional to the off-diagonal entries in the squark soft squared mass matrices. Then, if the off-diagonal entries are of the order of the current limits coming from the absence of FCNC, the measurements of mesons decay rates can give bounds on sgoldstino flavor-violating couplings that are strong enough to probe a scale of supersymmetry breaking up to $\sqrt{F} \sim 10^7$ GeV [3].

Whereas the sgoldstino interactions with quarks of the first and second generations and with a b-quark could be measured in the mesons decays, the most direct way of determining sgoldstino flavor-violating couplings to the top-quark would be through anomalous top decays. This approach would be relevant even for sgoldstino masses $m_{S(P)} \gtrsim 10$ GeV, for which the constraints on \sqrt{F} arising from the analysis of the meson rare decays become invalid.

This is indeed the subject of the present letter. We study the anomalous top decays into a sgoldstino and an up-type quark $t \rightarrow cS(P)$ and $t \rightarrow uS(P)$. Subsequently, depending on the superpartner spectrum and the value of the $S(P)$ mass, sgoldstinos can decay into SM particles or gravitinos. Thus, different final states could be exploited as a signature of a sgoldstino coupled to the top quark. The sgoldstino masses m_S and m_P that will be relevant for our study are larger than a few GeV's and smaller than m_{top} .

In order to set the LHC potential, we recall that $10^7 \div 10^8$ top quarks are expected to be produced with $(10 \div 100)$ fb $^{-1}$ of integrated luminosity at LHC [4]. Then, on a purely statistical basis, one will be able to probe top branching ratios (BR) down to about $10^{-6} \div 10^{-7}$. In the following, we will assume this BR range to be the LHC *statistical threshold* for the observation of a particular top decay channel. Of course, background problems and systematics will considerably weaken this potential. Indeed, for some rare top decays that were analyzed through dedicated Monte Carlo's the corresponding reduction in the potential has been estimated to be of at least one order of magnitude [4].

In this paper, we first compute the top decay BR's for the channels $t \rightarrow cS, t \rightarrow uS, t \rightarrow cP, t \rightarrow uP$. Then, after reviewing the sgoldstino decay channels and the corresponding rates, we discuss the possible strategies for an experimental search for events with a top decaying into sgoldstinos at LHC.

2 Top decay rates into sgoldstinos

In this section, we work out the width for top decays into sgoldstinos through FCNC processes. The relevant effective Lagrangian reads [5, 6]

$$\mathcal{L}_{eff} = -\frac{(\tilde{m}_{U_{13}}^{LR})^2}{\sqrt{2}F} S\bar{u}t - \frac{(\tilde{m}_{U_{23}}^{LR})^2}{\sqrt{2}F} S\bar{c}t - i\frac{(\tilde{m}_{U_{13}}^{LR})^2}{\sqrt{2}F} P\bar{u}\gamma_5 t - i\frac{(\tilde{m}_{U_{23}}^{LR})^2}{\sqrt{2}F} P\bar{c}\gamma_5 t, \quad (1)$$

where $(\tilde{m}_{U_{ij}}^{LR})^2$ are the off-diagonal entries into the up-squark soft squared mass matrix (for convenience we consider these parameters to be real). Then, the relevant top decay widths are given by

$$\Gamma(t \rightarrow cS(P)) = \delta_{U_{32}}^2 \frac{m_t \tilde{m}_U^4}{32\pi F^2} \left(1 - \frac{m_{S(P)}^2}{m_t^2}\right)^2, \quad \Gamma(t \rightarrow uS(P)) = \delta_{U_{31}}^2 \frac{m_t \tilde{m}_U^4}{32\pi F^2} \left(1 - \frac{m_{S(P)}^2}{m_t^2}\right)^2, \quad (2)$$

where we ignore the final quark masses and introduce the parameters $\delta_{U_{ij}} = (\tilde{m}_{U_{ij}}^{LR})^2 / \tilde{m}_U^2$, with \tilde{m}_U being the average mass of up-squarks. These parameters can be constrained from the absence of FCNC [7] only for the sgoldstino couplings to the quarks of the first two

generations. For example, the current upper bound on $\delta_{U_{12}}$ at $\tilde{m}_U = M_3 = 500$ GeV is about $3 \cdot 10^{-2}$ [7]¹. However, for the couplings to top-squarks there is no such a constraint yet, and the corresponding value of $\delta_{U_{3j}}$ (with $j = 1, 2$) may be as large as 1.

In Figure 1 we present the top BR into a sgoldstino (either scalar or pseudoscalar) and a charm-quark (or up-quark) as a function of \sqrt{F} , for an average up-squark mass $\tilde{m}_U = 1$ TeV. The three curves refer to three different values of $\delta_{U_{3j}}$ (i.e., $10^{-2}, 10^{-1}, 1$). For the sgoldstino mass, we also assume $m_{S(P)} = 50$ GeV, that is a value quite far from where phase-space effects become important. Only one of the four channels $t \rightarrow cS, t \rightarrow uS, t \rightarrow cP, t \rightarrow uP$ is assumed to be open.

The quartic dependence on $1/\sqrt{F}$ of the width makes the BR for the top decay into a sgoldstino quite sensitive to the supersymmetry breaking scale. In the most promising case of maximal mixing (i.e., $\delta_{U_{3j}} = 1$), one gets $\text{BR}(t \rightarrow cS) > 10^{-4}$ for \sqrt{F} up to 10 TeV, that corresponds to more than 10^2 interesting decays occurring at LHC for a wide range of \sqrt{F} (from now on we refer to each of all the possible channels $t \rightarrow cS, t \rightarrow uS, t \rightarrow cP, t \rightarrow uP$ by simply indicating $t \rightarrow cS$, unless differently specified). On the other hand, decreasing the mixing $\delta_{U_{3j}}$ by a factor 10 reduces $\text{BR}(t \rightarrow cS)$ by a factor 10^2 . For $\delta_{U_{3j}} = 10^{-2}$, $\text{BR}(t \rightarrow cS)$ is more than 10^{-6} only up to $\sqrt{F} = 3$ TeV, when $\tilde{m}_U = 1$ TeV.

In Figures 2 and 3, we show the phase-space reduction of $\text{BR}(t \rightarrow cS)$ for heavier m_S values. We assume, respectively $\sqrt{F} = 4$ TeV and $\delta_{U_{3j}} = 1$ in Figure 2, and $\sqrt{F} = 2$ TeV and $\delta_{U_{3j}} = 0.1$ in Figure 3. The three curves in each figure correspond to different values (i.e., 0.5, 1, 1.5 TeV) for the average up-squark mass. One can see that going to values $m_S > 150$ GeV, a reduction of the BR by more than a factor 10, with respect to the massless case, makes the problem quite harder in general. On the other hand, at fixed relative mixing $\delta_{U_{3j}}$, a heavier up-squark mass \tilde{m}_U enhances BR remarkably. In general, larger values of \sqrt{F} will be explorable for higher values of $\delta_{U_{3j}}$ and \tilde{m}_U , and smaller m_S .

3 Possible signatures at LHC

In order to analyze the possible experimental signatures by which a top decaying into a sgoldstino would manifest at LHC, one has to consider the subsequent decay of the sgoldstino inside the experimental apparatus. Indeed, for the range of parameters that are relevant for this study, sgoldstinos are expected to decay inside the experimental apparatus, not far from the collision point [8]. Then, assuming that the supersymmetric partners (others than the gravitinos \tilde{G}) are too heavy to be relevant for the sgoldstino decays, the main decay channels are (for $m_t \gtrsim m_{S(P)}$):

$$S(P) \rightarrow gg, \gamma\gamma, \tilde{G}\tilde{G}, f\bar{f}, \gamma Z, WW. \quad (3)$$

The corresponding widths have been computed in [8].

For a sgoldstinos decaying into a pair of photons, one has

$$\Gamma(S(P) \rightarrow \gamma\gamma) = \frac{M_{\gamma\gamma}^2 m_{S(P)}^3}{32\pi F^2}, \quad (4)$$

where $M_{\gamma\gamma} = M_1 \cos^2 \theta_W + M_2 \sin^2 \theta_W$, and θ_W is the electroweak mixing angle.

For the two-gluons decay, one similarly finds

$$\Gamma(S(P) \rightarrow gg) = \frac{M_3^2 m_{S(P)}^3}{4\pi F^2}, \quad (5)$$

¹By M_1, M_2 and M_3 we denote the gaugino masses, the first two for the electroweak groups, and the third for $SU(3)_c$.

that, for $M_{\gamma\gamma} \sim M_3$, dominates over the photon channel due to the color factor enhancement.

For the \sqrt{F} values we are interested in, gravitinos are very light, with masses in the range $m_{\tilde{G}} = \sqrt{8\pi/3} F/M_{Pl} \simeq 10^{-3} \div 10^{-1}$ eV. Then, the sgoldstino decay rates into two gravitinos are given by

$$\Gamma(S(P) \rightarrow \tilde{G}\tilde{G}) = \frac{m_{S(P)}^5}{32\pi F^2}, \quad (6)$$

and become comparable with the rate into two photons for quite heavy sgoldstinos, such that $m_{S(P)} \sim M_{\gamma\gamma}$.

Sgoldstinos can also decay into fermion pairs, with rates

$$\Gamma(S \rightarrow f\bar{f}) = N_C \frac{A_f^2 m_f^2 m_S}{32\pi F^2} \left(1 - \frac{4m_f^2}{m_S^2}\right)^{1/2}, \quad \Gamma(P \rightarrow f\bar{f}) = N_C \frac{A_f^2 m_f^2 m_P}{32\pi F^2} \left(1 - \frac{4m_f^2}{m_P^2}\right)^{3/2}, \quad (7)$$

where A_f is the soft trilinear coupling constant, and $N_C = 3$ for quarks or $N_C = 1$ for leptons. One can see that, far from the threshold, the fermionic BR's are suppressed by a factor m_f^2/m_S^2 in general. Hence, the decay $S(P) \rightarrow f\bar{f}$ can be relevant for large trilinear couplings and/or if the sgoldstino mass happens to be not too far from m_f .

Finally, sgoldstinos lighter than the top quark can decay into massive vector bosons states. For $m_{S(P)} > M_Z$ and $m_{S(P)} > 2M_W$, the $Z\gamma$ and W^+W^- channels open up, respectively. The corresponding rates read

$$\Gamma(S(P) \rightarrow \gamma Z) = \frac{M_{\gamma Z}^2 m_{S(P)}^3}{16\pi F^2} \left(1 - \frac{M_Z^2}{m_{S(P)}^2}\right)^3, \quad \Gamma(P \rightarrow W^+W^-) = \frac{M_2^2 m_P^3}{16\pi F^2} \left(1 - \frac{4M_W^2}{m_P^2}\right)^{3/2}, \quad (8)$$

$$\Gamma(S \rightarrow W^+W^-) = \frac{1}{16\pi F^2 m_S} \left(M_2^2 (m_S^4 - 4m_S^2 m_W^2 + 6M_W^4) - 12M_2 \mu_a M_W^2 \left(\frac{m_S^2}{2} - M_W^2 \right) \right. \\ \left. + 2\mu_a^2 m_W^4 \left(\frac{m_S^4}{4M_W^4} - \frac{m_S^2}{m_W^2} + 3 \right) \right) \sqrt{1 - \frac{4M_W^2}{m_S^2}}, \quad (9)$$

where $M_{\gamma Z} = (M_2 - M_1) \cos\theta_W \sin\theta_W$, and the variable μ_a that enters $\Gamma(S \rightarrow W^+W^-)$ is the higgsino mixing mass parameter.

In Figure 4, we present the BR's for all the scalar sgoldstino decay modes for six different sets of the MSSM parameters M_1, M_2, M_3, A_b , and $\mu_a = -200$ GeV. The only channel that is affected by the parameter μ_a is $S \rightarrow WW$, that, since $m_S > 2M_W$, is anyhow suppressed in the chain $t \rightarrow Sc \rightarrow WWc$ by the small phase-space factor in the top decay BR. For this reason, in the Figure 4 we do not analyze the BR's dependence on μ_a , that was however chosen negative in order to enhance the corresponding BR($S \rightarrow WW$).

For a typical M_1, M_2, M_3 hierarchy, that corresponds to the gauge unification conditions in the MSSM, one finds that the S decay into gluons $S \rightarrow gg$ always dominates over the other channels. Then, the S decay into photons $S \rightarrow \gamma\gamma$ has a BR typically in the range $10^{-2} \div 10^{-1}$. Decays into $\tilde{G}\tilde{G}$, γZ and WW can be important for relatively large m_S that, however, are disfavored by the phase-space factor in the top decay BR (cf. Figures 2 and

3) ². On the other hand, the sgoldstino decay into b quarks $S \rightarrow b\bar{b}$ can have BR values in an interesting range when the soft trilinear coupling A_f is large enough, and for moderate m_S . For the parameter sets of Figures 4, c) and d), $\text{BR}(S \rightarrow b\bar{b})$ reaches values even larger than 10^{-1} , for $m_S < 50\text{GeV}$. Particularly interesting in view of the possibility of detecting a signal in a hadron collider (see also below) is the case where one drops the typical M_1, M_2, M_3 hierarchy of the MSSM, and allows M_1 and/or M_2 to be larger than M_3 . Representative examples of this case are considered in Figures 4, e) and f), where one reaches comparable values of $\text{BR}(S \rightarrow \gamma\gamma)$ and $\text{BR}(S \rightarrow gg)$, and even $\text{BR}(S \rightarrow \gamma\gamma) > \text{BR}(S \rightarrow gg)$. In the same framework, also the decay $S \rightarrow \gamma Z$ is enhanced up to values of order 10^{-1} , although part of the relevant m_S range is penalized by the top decay phase-space.

The main features of this discussion hold also for the pseudoscalar sgoldstino P . The major difference with respect to the S case lies in the $P \rightarrow WW$ width (that is independent of μ_a). Again, this channel is relevant only for m_P values penalized by the top decay phase space.

We now discuss the relevance of the different S decay channels in view of the possible detection of a $t \rightarrow Sc$ signal at LHC. A complete analysis will require a thorough study via Monte Carlo's that can treat each particular signal versus the complicated backgrounds and systematics of a hadronic machine.

Here, we will work out a few *qualitative* conclusions, based on the results of previous dedicated studies that set the threshold for the observation of top rare decays and Higgs decays at LHC [4, 9, 10]. These results sum up in the following assumptions for our analysis:

i) we require the production of 10 events for a given signature (or particular decay of S following $t \rightarrow Sc$) to be observable. On a purely statistical basis, this corresponds to a *total* top BR in that channel, given by the product $\text{BR}(t \rightarrow Sc) \cdot \text{BR}(S \rightarrow \dots)$, in the range $10^{-6} \div 10^{-7}$, for $10^7 \div 10^8$ top quarks produced at LHC.

ii) we assume that a generic *electroweak-like signature* (like the ones involving photons, Z 's, W 's and/or missing momentum) can be detected at LHC, and measured with an efficiency of the order of 10% due to the background subtraction and systematics. The same efficiency is assumed for the detection of a resonant $b\bar{b}$ system.

iii) we assume that a completely hadronic (non b -like) signature of a top rare decay will not be manageable at LHC because of the QCD backgrounds. This excludes from our study the $S(P) \rightarrow gg$ channel.

In this framework, in order to be able to detect a sgoldstino decaying into the channel $S \rightarrow X$ at LHC, one needs

$$\text{BR}(t \rightarrow Sc) \cdot \text{BR}(S \rightarrow X) \gtrsim \text{BR}_{th} = 10^{-5} \quad (10)$$

and “ X ” giving rise to either an *electroweak-like signature* or a $b\bar{b}$ system.

Let's go through some details on the detection of the possibly relevant S decay modes:

- $S(P) \rightarrow \gamma\gamma$

This sgoldstino decay mode gives rise to the total final state $t\bar{t} \rightarrow (W+b\text{-jet})+(\gamma\gamma+\text{jet})$ in top pair production at LHC. One should tag one of the top in the usual $(W+b\text{-jet})$

²Note that the three-body decay channels $S \rightarrow \gamma Z^*$ and WW^* (where Z^* and W^* are off-shell bosons decaying into a *real* fermion pair) could be significant in some interval below the corresponding thresholds for boson pairs, similarly to the Higgs boson case.

way. Then one has a hard hadronic jet plus a resonant two-photon system, with a total invariant mass of the $(2\gamma + jet)$ system of about m_t . A proper cut on the $\gamma\gamma$ invariant mass can help in suppressing the background through similar strategies to the ones worked out for the $H \rightarrow \gamma\gamma$ detection at LHC [9]. Assuming the threshold rate of Eq.(10) and a typical $\text{BR}(S(P) \rightarrow \gamma\gamma) \sim 10^{-2} \div 10^{-1}$, one can explore through this very distinctive signature a value for $\text{BR}(t \rightarrow Sc)$ down to $10^{-3} \div 10^{-4}$. In particular, for a maximal squark mixing and $\tilde{m}_U = 1$ TeV, one can probe \sqrt{F} up to about 10 TeV (cf. Figure 1). For a squark mixing 10^{-1} one can cover up to $\sqrt{F} \sim 3$ TeV. The dedicated assumptions of a broken M_1, M_2, M_3 hierarchy in Figures 4, e) and f), would translate into even more promising ranges, with $\text{BR}(t \rightarrow Sc)$ explorable down to 10^{-5} , and, correspondingly, into larger values of \sqrt{F} .

- $S(P) \rightarrow b\bar{b}$

In this case, the total final signature is $t\bar{t} \rightarrow (W + b\text{-jet}) + (2b\text{-jets} + jet)$ with a resonant $2b\text{-jets}$ system. For large soft trilinear couplings A_f and moderate m_S (i.e., less than about 50 GeV), one could explore $\text{BR}(t \rightarrow Sc)$ ranges down to $10^{-3} \div 10^{-4}$, assuming the threshold in Eq.(10). Hence, this channel could have a comparable potential to the $S(P) \rightarrow \gamma\gamma$ one, but for a restricted m_S range.

- $S(P) \rightarrow \tilde{G}\tilde{G}$

Gravitinos give rise to missing transverse energy in the event. The total final signature is then $(W + b\text{-jet} + jet + E_t^{mis})$. Assuming that the threshold in Eq.(10) is also effective in this case, this channel can be useful for intermediate values of m_S in the range $100 \div 150$ GeV. Indeed, the relevant S width rises as the fifth power of m_S and is typically of the order 10^{-2} or more in this range. Larger values of m_S are penalized by the phase-space factor in the top decay BR. Hence, through this channel, one can hope to investigate top BR's into a sgoldstino down to 10^{-3} in the m_S range $100 \div 150$ GeV.

- $S(P) \rightarrow \gamma Z$

This channel has a nice signature $(W + b\text{-jet} + Z\gamma + jet)$, with a resonant γZ system. On the other hand, $\text{BR}(S \rightarrow \gamma Z)$ is hardly larger than 10^{-3} , unless one breaks the gauge-unification hierarchy, assuming M_1 and/or M_2 larger than M_3 , [cf. Figures 4, e) and f)]. In the latter case, one can have $\text{BR}(S \rightarrow \gamma Z) \sim 10^{-1}$ at $m_S > 120$ GeV, with a corresponding reach of 10^{-4} for the top BR in the m_S range $120 \div 150$ GeV.

- $S(P) \rightarrow WW$

This channel can be interesting from the point of view of the $\text{BR}(S(P) \rightarrow WW)$ value that can easily reach the 10^{-1} level. On the other end, the complete signature $(W + b\text{-jet} + W + W + jet)$ is hardly viable, since it is relevant for a m_S range ($m_S > 160$ GeV) where the phase-space suppression of the top width is fully effective.

Note that one could also exploit the single-top production sample of top quarks, with a different final signature. This would enlarge the present statistics by about 15%-20% [4].

4 Conclusions

We considered the possibility to detect at LHC anomalous top decays into light sgoldstinos, proceeding through off-diagonal flavor-violating entries in the squark-mass matrices. We studied both the decay rates and the relevant experimental signatures. The most promising

signatures are the ones associated with the decay chains $t \rightarrow qS \rightarrow q\gamma\gamma$ and $t \rightarrow qS \rightarrow qb\bar{b}$, where q is either a c or a u quark. The first can be effective for the complete m_S range (from a few GeV up to about 150 GeV), while the latter can be useful for rather light sgoldstinos. Assuming a total 10% efficiency in the detection of these signatures versus backgrounds and systematics, $\text{BR}(t \rightarrow qS)$ values can be studied down to 10^{-4} , on the basis of the $10^7 \div 10^8$ top quarks produced with a $(10 \div 100) \text{ fb}^{-1}$ integrated luminosity at LHC [4].

For a maximal flavor-violating LR-mixing of the stop with the other up-type squark, one could then explore the scale of supersymmetry breaking \sqrt{F} up to about 10 TeV, that is, e.g., much further than what is reachable in searches for light gravitinos at LHC [11]. A dedicated and thorough analysis via Monte Carlo techniques will be required in order to accurately assess the potential of this promising process.

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References

- [1] J. Ellis, K. Enqvist and D. Nanopoulos, *Phys. Lett.* **B147** 99 (1984);
J. Ellis, K. Enqvist and D. Nanopoulos, *Phys. Lett.* **B151** 357 (1985);
T. Bhattacharya and P. Roy, *Phys. Rev.* **D38** 2284 (1988).
- [2] G. Giudice and R. Rattazzi, , *Phys. Rep.* **322** 419 (1999);
S. Dubovsky, D. Gorbunov and S. Troitsky, *Phys.-Usp.* **42** 705 (1999).
- [3] D. Gorbunov, *Light Sgoldstino: Precision Measurements versus Collider Searches*, hep-ph/0007325.
- [4] M.Beneke et al, *Top Quark Physics*, in: Proc. of the Workshop *Standard Model (and more) at the LHC*, CERN 2000-004, 9 May 2000, ed. G.Altarelli and M.L.Mangano, Geneve, 2000, p.491, hep-ph/0003033.
- [5] A. Brignole, E. Perazzi and F. Zwirner, *JHEP* **9909** (1999) 002.
- [6] E. Perazzi, G. Ridolfi and F. Zwirner, *Signatures of massive sgoldstinos at hadron colliders*, hep-ph/0005076.
- [7] F. Gabbiani *et al.*, *Nucl. Phys.* **B477** 321 (1996);
M. Ciuchini *et al.*, *JHEP* **9810** (1998) 008.
- [8] E. Perazzi, G. Ridolfi and F. Zwirner, *Nucl. Phys.* **B574** (2000) 3.
- [9] *ATLAS: Detector and Physics Performance Technical Design Report*. Vol. 2. CERN-LHCC-99-15, ATLAS-TDR-15, May 1999. 519pp;
S.Abdullin *et al.*, *Phys. Lett.* **B431** 410 (1998), hep-ph/9805341.
- [10] S. Catani et al, *QCD*, in: Proc. of the Workshop *Standard Model (and more) at the LHC*, CERN 2000-004, 9 May 2000, ed. G.Altarelli and M.L.Mangano, Geneve, 2000, p.97, hep-ph/0005025;
P.Aurenche et al. *The QCD and Standard Model Working Group: Summary Report (Physics at TeV Colliders, Les Houches, France 8-18 June 1999.)*, p.161, hep-ph/0005114.
- [11] A. Brignole, F. Feruglio, M.L. Mangano and F. Zwirner, *Nucl.Phys.* **B526** (1998) 135;
Erratum, *ibid* **B582** (2000) 759.

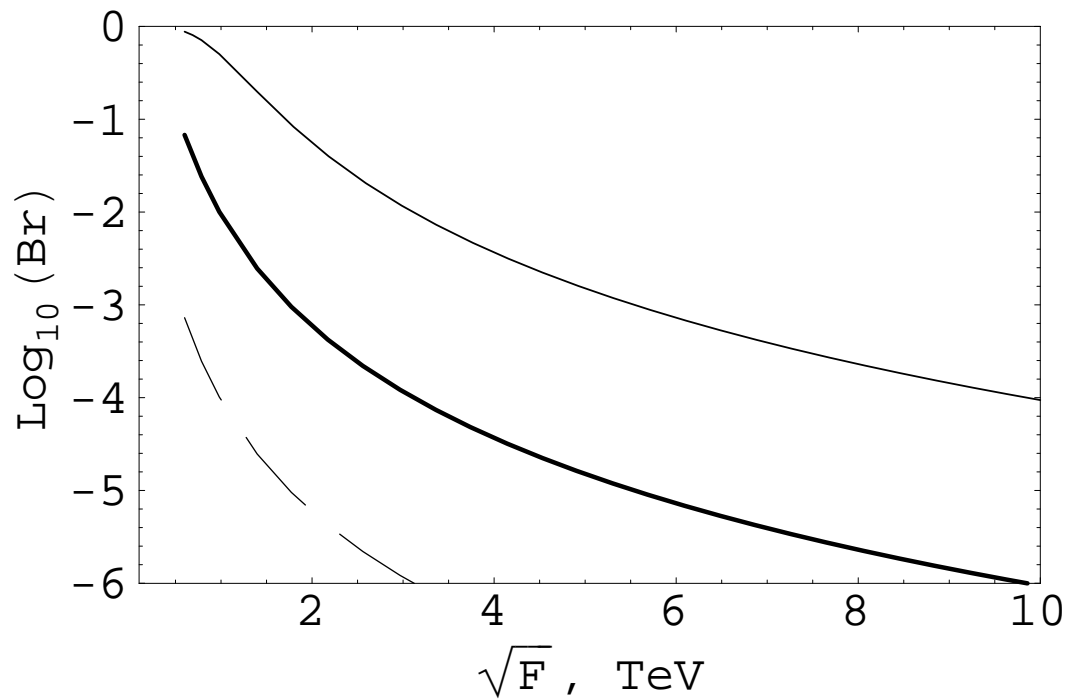


Figure 1: Branching ratio for the top quark decay into a sgoldstino and a charm (or up) quark for $\delta_{U_{3j}} = 1$ (thin line), $\delta_{U_{3j}} = 10^{-1}$ (thick line) and $\delta_{U_{3j}} = 10^{-2}$ (dashed line). The average up-squarks mass \tilde{m}_U is set to 1 TeV, and $m_{S(P)} = 50$ GeV.

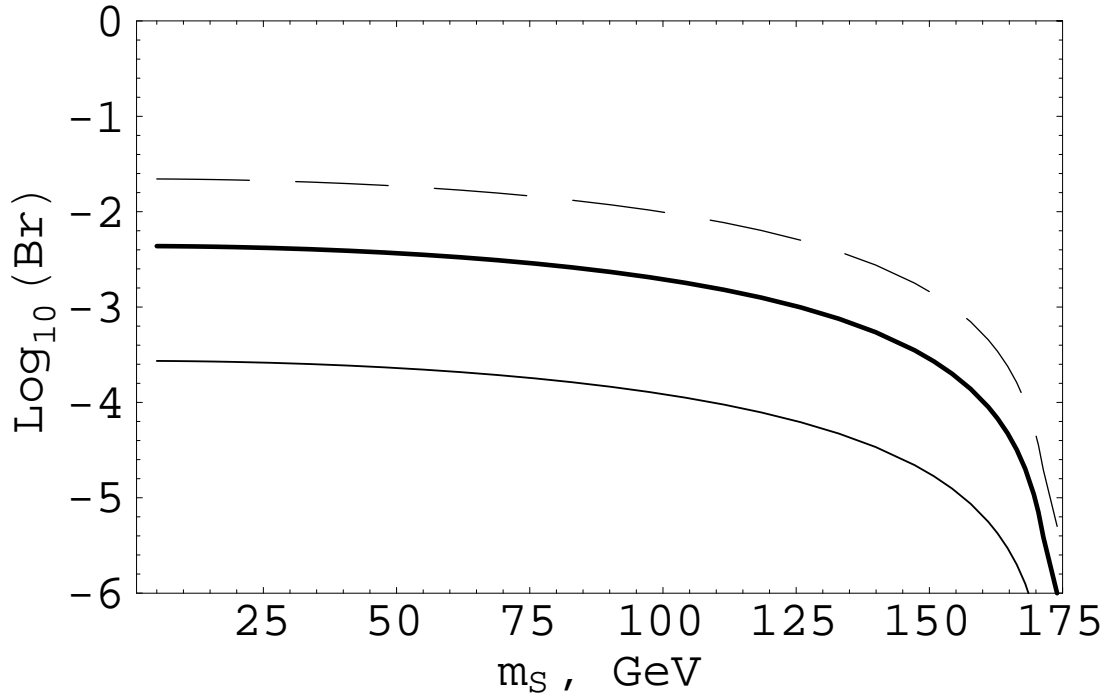


Figure 2: Branching ratio for the top quark decay into a sgoldstino and a charm (or up) quark for $\tilde{m}_U = 500$ GeV (thin line), $\tilde{m}_U = 1000$ GeV (thick line) and $\tilde{m}_U = 1500$ GeV (dashed line). The supersymmetry breaking scale \sqrt{F} is set to 4 TeV, and $\delta_{U_{3j}} = 1$.

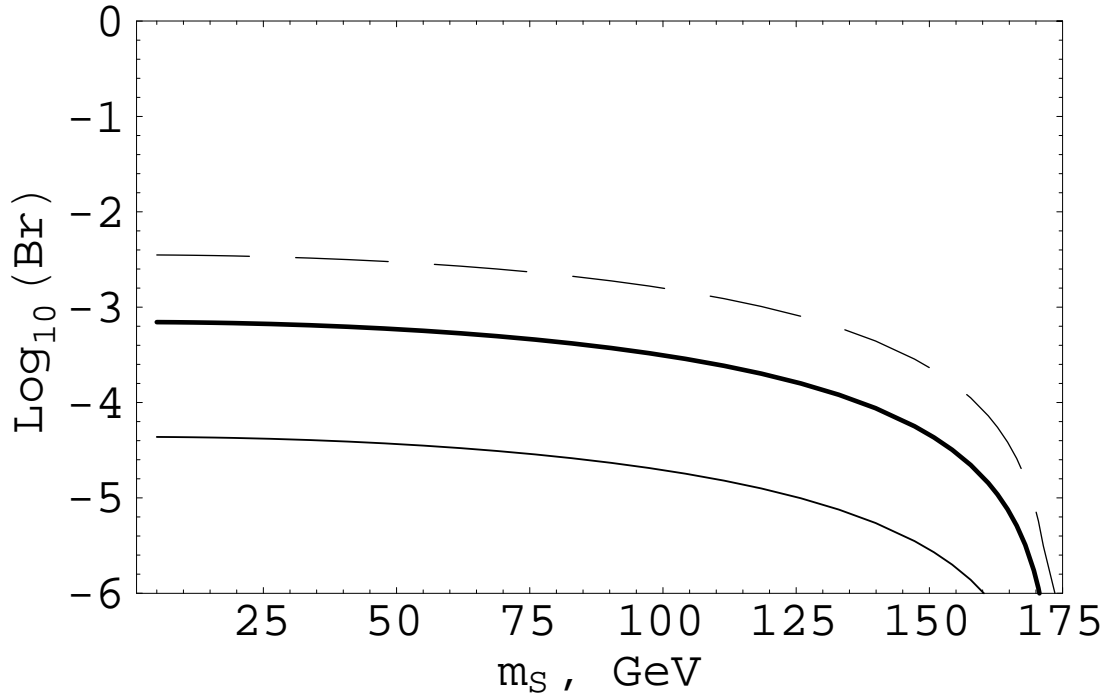


Figure 3: Branching ratio for the top quark decay into a sgoldstino and a charm (or up) quark for $\tilde{m}_U = 500$ GeV (thin line), $\tilde{m}_U = 1000$ GeV (thick line) and $\tilde{m}_U = 1500$ GeV (dashed line). The supersymmetry breaking scale \sqrt{F} is set to 2 TeV, and $\delta_{U_{3j}} = 0.1$.

