KA-TP-26-2000

Some results on top quark decays in the MSSM

JAUME GUASCH
Institut für Theoretische Physik, Universität Karlsruhe, D-76128 Karlsruhe, Germany

Abstract

We present results on the top quark partial decay widths $\Gamma(t \to bH^+)$ and $\Gamma(t \to \tilde{t}_1\chi_1^0)$, presented in the TESLA TDR top-quark chapter.

We present some results on non-standard top quark decays in the Minimal Supersymmetric Standard Model (MSSM). See [1] for a review on the subject. In Fig. 1a we present a contour plot of the branching ratio $BR(t \to bH^+)$ in the $\tan\beta - m_{H^\pm}$-plane. This plot includes all the present knowledge on the radiative corrections to the partial decay width $\Gamma(t \to bH^+)$. Concretely it includes: the resumed QCD (gluonic) corrections, computed using the running quark masses; the resumed SUSY leading corrections [2]; the rest of the sub-leading one-loop MSSM radiative corrections [3].

The partial width is computed as:

$$\Gamma_{\rm MSSM}(t \to bH^+) = \Gamma^{\rm res}_{\rm MSSM}(t \to bH^+) + \Delta\Gamma_{\rm MSSM}(t \to bH^+)\ , \tag{1}$$

where $\Gamma^{\rm res}_{\rm MSSM}(t \to bH^+)$ is computed using the tree-level expression, but using the effective MSSM quark masses in the Yukawa couplings:

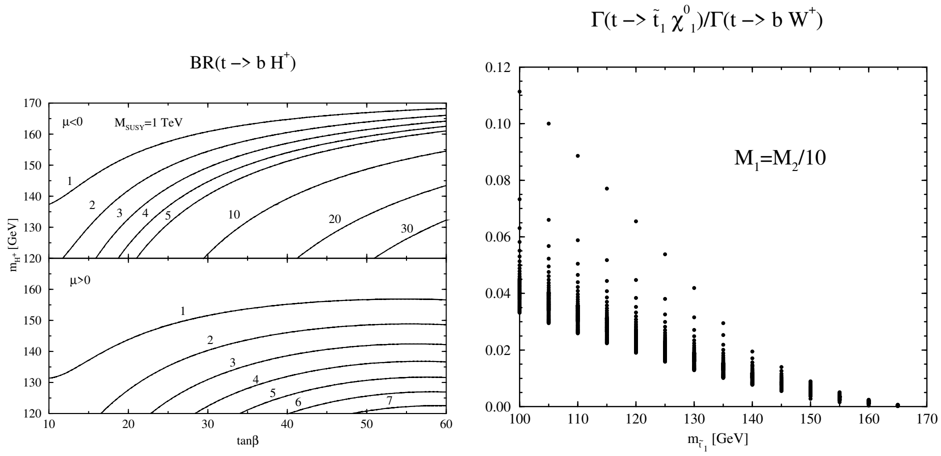
$$m_q^{\rm eff} = \frac{m_q(m_t)}{1+\Delta m_q}\ , \tag{2}$$

here $m_q(mt)$ is the QCD running quark mass, and Δm_q is the non-decoupling leading correction to the quark Yukawa coupling in the MSSM [2]. $\Delta\Gamma_{\rm MSSM}(t \to bH^+)$ includes all the one-loop corrections (two- and three-point one-loop Green's functions, with SUSY particles and Higgs bosons in the loops), with the one-loop part of the leading terms (Δm_q) subtracted to avoid double counting. We present two scenarios, characterized by the sign of the higgsino mass parameter μ. We have used in both cases a heavy SUSY spectrum, to show that the quantum effects can be very large, even with large SUSY masses. The input parameters in the quark sector are

$$m_t^{\rm pole} = 175\ {\rm GeV}\ ,\ m_b^{\rm pole} = 4.7\ {\rm GeV}\ . \tag{3}$$

As for the SUSY sector we have chosen:

$$\begin{aligned}\mu = \pm 500\ {\rm GeV}\ ,\ M_2 = 500\ {\rm GeV}\ ,\ M_1 = \frac{5}{3}\tan^2\theta_W M_2,\ m_{\tilde{g}} = 1000\ {\rm GeV}\ ,\\ m_{\tilde{q}} = 1000\ {\rm GeV}\ ,\ A_t = -{\rm sign}(\mu)\,500\ {\rm GeV}\ ,\ A_q = 500\ {\rm GeV}\ ,\end{aligned} \tag{4}$$



(a) (b)

Figure 1: **(a)** Contour plots for $BR(t \to bH^+)$ (in %) in the $\tan\beta - m_{H^\pm}$ plane for two scenarios: $\mu < 0$ (upper) and $\mu > 0$ (lower), with a SUSY spectrum around $M_{\rm SUSY} =$ 1 TeV; **(b)** Tree-level prediction for the top quark non-standard partial decay width $\Gamma(t \to \tilde{t}_1 \chi_1^0)$.

where $m_{\tilde{q}}$, A_q are common to all squarks. We use this spectrum for the sake of simplicity.

In Fig. 1b we present the results on the partial width $\Gamma(t \to \tilde{t}\chi_1^0)$ as compared to the Standard Model width $\Gamma(t \to bW^+)$, as a function of the lightest stop mass $m_{\tilde{t}_1}$. In this case we use the lightest allowed masses after LEP2 ($m_{\tilde{t}}, m_{\chi^+} > 100$ GeV). If the usual GUT relation between M_1 and M_2 (see eq. (4)) is assumed, the allowed portion of the parameter space in which this decay is possible is very small. Therefore we deviate from this scenario, and choose $M_1 = M_2/10$. We use the tree-level prediction for the partial decay width, the QCD corrections are negative and small ($< 10\%$) for most of the parameter space [1, 4]. The scatter plot in Fig. 1b has been obtained in the following way: for each value of the stop mass, we make a scan of the parameter space,

$$-600 \text{ GeV} < \mu < 600 \text{ GeV} \ , \ 0 < M_2 < 800 \text{ GeV} \ , \qquad (5)$$

as for the rest of the parameters, we have fixed $\tan\beta = 4$, and $A_t = -\text{sign}(\mu)\, 200$ GeV. The stop mixing angle is fixed by using $m_{\tilde{b}_1} = 200$ GeV, $\theta_b = \pm\pi/4$, $A_b = 200$ GeV. For each value of μ we find the minimum value of M_2 permitted by the constraint $m_{\chi^+} > 100$ GeV, and plot a dot for the value of $\Gamma(t \to \tilde{t}\chi_1^0)/\Gamma(t \to bW^+)$ in this point of the parameter space. We would like to note that using the GUT relation (4) the results obtained are similar, but of course, the partial decay width becomes negligible for $m_{\tilde{t}} \simeq 125$ GeV due to phase space exhaustion.

Acknowledgments: I would like to thank J. Kühn for discussions, and D. Garcia for providing part of the numerical code. This work has been supported by the European Union under contract Nr. HPMF-CT-1999-00150.

References

[1] J. Guasch, W. Hollik, J.I. Illana, C. Schappacher, J. Solà, *Top quark production and decay in the MSSM*, LC-TH-2000-030, [hep-ph/0003109], and references therein.

[2] M. Carena, D. Garcia, U. Nierste, C. E. Wagner, *Nucl. Phys.* **B577** (2000) 88 [hep-ph/9912516].

[3] J. A. Coarasa, D. Garcia, J. Guasch, R. A. Jiménez, J. Solà, *Eur. Phys. J.* **C2** (1998) 373, [hep-ph/9607485].

[4] A. Djouadi, W. Hollik, C. Jünger, *Phys. Rev.* **D54** (1996) 5629–5635, [hep-ph/9605340].