



## Improved sensitivity to charged Higgs searches on top quark decays $t \rightarrow bH^+ \rightarrow b(\tau^+\nu_\tau)$ at the LHC using $\tau$ polarisation and multivariate techniques

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We present an analysis with improved sensitivity to the light charged Higgs ( $m_{H^+} < m_t - m_b$ ) searches in the top quark decays  $t \rightarrow bH^+ \rightarrow b(\tau^+\nu_\tau) + c.c.$  in the  $t\bar{t}$  and single  $t/\bar{t}$  production processes at the LHC. In the Minimal Supersymmetric Standard Model (MSSM), one anticipates the branching ratio  $calB(H^+ \rightarrow \tau^+\nu_\tau) \simeq 1$  over almost the entire allowed  $\tan\beta$  range. Noting that the  $\tau^+$  arising from the decay  $H^+ \rightarrow \tau^+\nu_\tau$  are predominantly right-polarized, as opposed to the  $\tau^+$  from the dominant background  $W^+ \rightarrow \tau^+\nu_\tau$ , which are left-polarized, a number of  $H^+/W^+ \rightarrow \tau^+\nu_\tau$  discriminators have been proposed and studied in the literature. We consider hadronic decays of the  $\tau^\pm$ , concentrating on the dominant one-prong decay channel  $\tau^\pm \rightarrow \rho^\pm\nu_\tau$ . The energy and  $p_T$  of the charged prongs normalised to the corresponding quantities of the  $\rho^\pm$  are convenient variables which serve as  $\tau^\pm$  polariser. We use the distributions in these variables and several other kinematic quantities to train a boosted decision tree (BDT). Using the BDT classifier, and a variant of it called BDTD, which makes use of decorrelated variables, we have calculated the BDT(D)-response functions to estimate the signal efficiency vs. the rejection of the background. We argue that this chain of analysis has a high sensitivity to light charged Higgs searches up to a mass of 150 GeV in the decays  $t \rightarrow bH^+$  (and charge conjugate) at the LHC. For the case of single top production, we also study the transverse mass of the system determined using Lagrange multipliers.

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