Summary

The Standard Model describes extraordinarily well the known elementary particles and their interactions. Several strong arguments, however, like the hierarchy problem, favour the interpretation of the Standard Model as a low-energy effective limit of a more fundamental theory at higher energy scales. Several of the proposed extensions of the Standard Model predict new physics to be observed at the TeV energy scale. This energy domain will be explored by the Large Hadron Collider (LHC) at CERN, of which the start-up is foreseen at the end of 2007.

An appealing example of such a Standard Model extension introduces supersymmetry, which relates bosons and fermions and solves many of the shortcomings of the Standard Model. Among the predicted new particles are several Higgs bosons that are needed to provide mass terms in the theory. In a minimal scenario two Higgs doublets are needed, giving rise to five Higgs bosons of which two are charged.

In this thesis the observability for a heavy charged Higgs boson is studied in the $H^\pm \rightarrow t\bar{b}$ decay channel with the CMS experiment at the LHC. Two strategies based on the tagging of either three or four $b$ jets are considered. In this context a novel method to calibrate $b$-tagging algorithms is presented. It consists of using $t\bar{t}$ pairs, which are abundantly produced at the LHC, to isolate jet samples with a highly enriched $b$-jet content. On these selected samples the $b$-tagging performance can be measured.

A multivariate technique is used to balance the systematic and statistical uncertainty, resulting in an optimal expected precision on the measurement of the $b$-tagging performance. For 1 fb$^{-1}$ (10 fb$^{-1}$) of integrated luminosity the relative accuracy on the $b$-jet identification efficiency is expected to be about 6% (4%) in the barrel region and about 10% (5%) in the endcaps. The obtained result reflects the best current estimate of the expected $b$-tagging uncertainties in the CMS experiment, and it is used as a benchmark for systematic uncertainties in all analyses employing $b$-jet identification.

The analysis of the charged Higgs-boson identification via the $H^\pm \rightarrow t\bar{b}$ decay illustrates the importance of calibrating $b$-tagging algorithms. In this study the combinatorial complexity in the signal is tackled with a multivariate approach, but despite the optimization the charged Higgs-boson mass reconstruction proves to be very challenging. Additional difficulties arise from the $t\bar{t} + \text{jets}$ background, which is very large and dominated by events with additional non-$b$ jets that are mis-identified as $b$ jet. Including systematic uncertainties on the background cross section leaves no relevant sensitivity for this channel in two-Higgs-doublet models during the low-luminosity phase of the LHC. This result is interpreted in the context of the minimal supersymmetric extension of the Standard Model including other decay channels and neutral Higgs boson searches at the LHC.