Search for Charged Higgs Bosons Decaying via $H^+ \to \tau\nu$ in 7 TeV pp Collisions with the ATLAS Detector

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Charged Higgs bosons (H^+, H^-) are predicted by several non-minimal Higgs scenarios, such as the Minimal Supersymmetric Standard Model (MSSM), and their discovery would be clear evidence for new physics beyond the Standard Model. If the mass of the charged Higgs boson, m_{H^+}, is less than the top quark mass, the main production mode at the LHC is via top quark decays, $t \to H^+ b$ in $t\bar{t}$ production. For values of $\tan\beta > 2$, the decay mode $H^+ \to \tau\nu$ is dominant in the MSSM. Using 4.6 fb^{-1} taken by the ATLAS detector [1] at $\sqrt{s} = 7$ TeV in 2011, three different final states have been investigated [2], taking into account various combinations of leptonically or hadronically decaying τ leptons (arising from the charged Higgs boson decay) and W boson decays (resulting from the second top quark decay). The three final states are the lepton+jets, the τ+lepton and the τ+jets channel.

In the lepton+jets channel, leptonically decaying τ leptons arising from the H^+ decay and hadronically decaying W bosons are considered. The background contribution from misidentified or non-isolated leptons is estimated in a data-driven way using a matrix method. All other background contributions are estimated using simulation, with the normalization of the $t\bar{t}$ background being taken from data. A transverse mass [3] of the charged Higgs boson is used as final discriminating variable.

In the τ+lepton channel, events containing hadronically decaying τ leptons originating from the H^+ decay and leptonically decaying W bosons are considered. The background contribution from misidentified or non-isolated leptons is estimated in the same way as for the lepton+jets channel. Events containing electrons and jets misidentified as τ leptons are estimated using their misidentification probabilities measured from data. Only the background contribution with true τ leptons is estimated using simulation. Missing transverse momentum, E_T^{miss}, is used as a final discriminating variable.

In the τ+jets channel, both the τ lepton arising from the charged Higgs boson decay and the W boson decay hadronically. In this final state, all background contributions are estimated using data-driven methods. Electrons and jets misidentified as τ jets are estimated in the same way as in the τ+lepton channel. Multijet background events are estimated using a template fit in E_T^{miss}. The background contribution including true τ jets is estimated with an embedding method. A transverse mass

calculated from E_T^{miss}, the transverse momentum of the τ jet and the angle between these two is used as final discriminating variable.

Data and background estimation agree well in all three channels, thus no evidence for charged Higgs bosons is found. Exclusion limits at a 95% confidence level [4] are set on the branching ratio $B(t \to H^+b)$ assuming $B(H^+ \to \tau\nu) = 1$. For charged Higgs boson masses between 90 and 160 GeV the limits range from 5% to 1% (Fig. 1, left). These limits are interpreted in the m_h^{max} scenario of the MSSM [5] . For $90 < m_{H^+} < 150\,\text{GeV}$, values of $\tan\beta$ between 1 and 2 and as much as between 1 and 6 are excluded and values of $\tan\beta$ above 26 to 12 are excluded (Fig. 1, right).

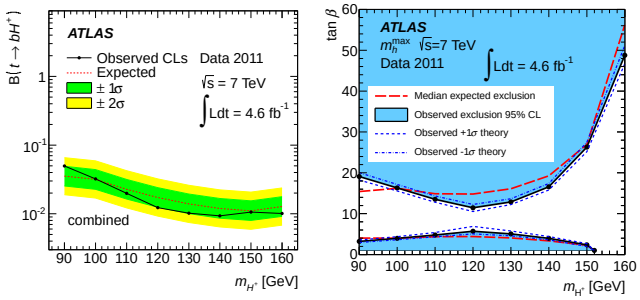

Figure 1: Exclusion limit on the branching ratio $B(t \to H^+b)$ assuming $B(H^+ \to \tau\nu) = 1$ for all three final states combined (left) and interpretation in the $m_{H^+} - \tan\beta$-plane of the m_h^{max} scenario of the MSSM (right)[2].

References

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