SEARCH FOR CHARGED HIGGS BOSONS IN CDF

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We present results of a direct search for charged Higgs production from $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV at Fermilab's Tevatron collider using the CDF detector. An expanded Higgs sector containing charged Higgs bosons is a persistent feature of candidate theories to replace the Standard Model. The minimal supersymmetric extension of the Standard Model, for example, predicts that the dominant decay mode of the top quark is $t \to H^+ b \to \tau^+ \nu b$ for large values of $\tan\beta$. We use the hadronic decays of the tau lepton in this channel to exclude charged Higgs bosons with $M_{H^\pm} < 140$ GeV$/c^2$ for large $\tan\beta$.

Many extensions to the Standard Model contain an expanded Higgs sector. SUSY and E_6 models, for instance, contain two Higgs doublets where one doublet gives mass to the up-type quarks and the other gives mass to the leptons and down-type quarks.[1] After electroweak symmetry breaking, there are five physical Higgs bosons; three of which are neutral and two of which are charged.

Previous direct searches for charged Higgs bosons include analyses from LEP and CDF.[2] The LEP experiments search for pairs of charged Higgs bosons. The most recent published limits[3] exclude charged Higgs bosons with $M_{H^\pm} <$ 44 GeV$/c^2$.

Based on inclusive $b \to s\gamma$ cross-section, CLEO indirectly excludes charged Higgs bosons with

$$M_{H^\pm} < 244 + \frac{63}{(\tan\beta)^{1.3}} \ \mathrm{GeV}/c^2$$

where $\tan\beta$ is the ratio of the vacuum expectation values of the two Higgs doublets.[4] This limit, however, can degrade significantly if diagrams other than those involving the W and $H^\pm$ are allowed.[5]

The ratio $\tan\beta$ controls the dominant decay modes for the charged Higgs boson and top quark. For large $\tan\beta$, $t \to Hb$ and $H \to \tau\nu$ exclusively. This leads to distinctive events with two tau leptons, two b-jets, and large $\not\!\!E_T$. For smaller values of $\tan\beta$, the top decays are a mixture of $t \to Wb$ and $t \to Hb$.

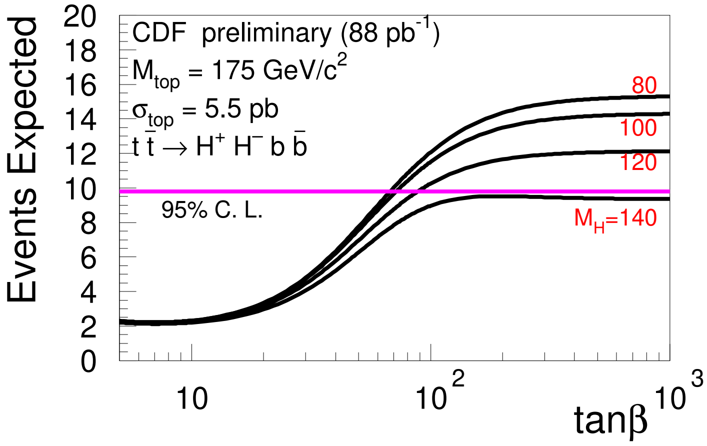

Figure 1: Expected number of charged Higgs events as a function of $\tan\beta$.

This search requires events with the topology $\tau jjX + \not{E}_T$ where the tau decays hadronically and X can be either an electron, muon, additional tau, or additional jet. At least one of the jets in the event must be b-tagged with CDF's silicon vertex detector. The $\not{E}_T$ must exceed 30 GeV and be isolated.

Identification of taus which decay hadronically is critical for this search. It begins with a jet having $E_T > 10$ GeV. The 10° cone about the jet axis must contain one or three charged particles and the region between the the 10° and a 30° cones must not contain any charged particle with $p > 1$ GeV$/c$. The invarient mass of the photons and charged particles associated with the cluster must be consistent with a tau lepton ($M < 1.8$ GeV$/c^2$). Finally, the cluster cannot be consistent with an electron.

After all analysis cuts, 8 events remain in a sample of 88 pb^{-1}. All have a $\tau + 3$ jet topology. Multiple jet events in which one jet fluctuates to low charged particle multiplicity and fakes a tau lepton comprise the dominant background. We expect 8.5 ± 1.7 background events including small contributions from electroweak processes and diboson production.

Fig. 1 shows the expected number of charged Higgs events vs. $\tan\beta$ for various charged Higgs masses. Also shown is the 95% C.L. upper limit from this search (9.8 events) calculated with Poisson statistics and using the errors on the background and signal estimates. Fig. 2 shows the limit in the M_H vs. $\tan\beta$ plane. For large values of $\tan\beta$ this search excludes charged Higgs bosons with $M_{H^\pm} < 140$ GeV$/c^2$.

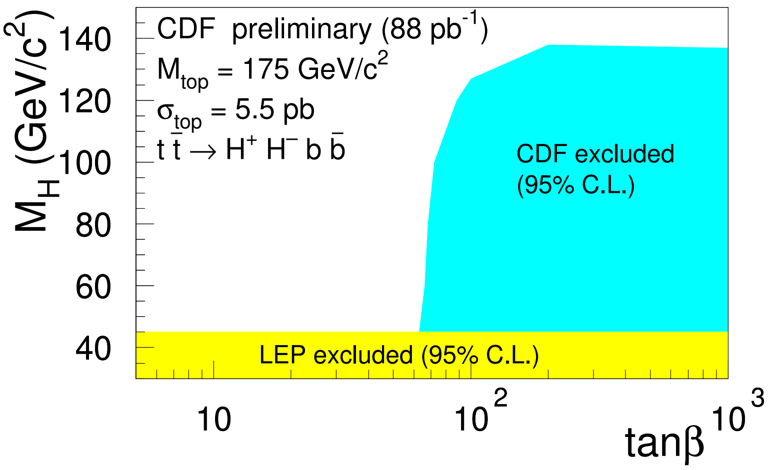

Figure 2: Excluded region in M_H vs. $\tan\beta$ plane.

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