NON-STANDARD MODEL HIGGS SEARCHES AT THE TEVATRON

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The CDF and D0 experiments at Fermilab's Tevatron have been actively searching for the Higgs bosons that appear in extensions of the minimal standard model. Here we present the results of searches for the neutral and charged Higgs bosons of the minimal supersymmetric standard model, as well as searches for doubly charged Higgs bosons that are predicted by other types of extensions. Up to 900 pb^{-1} of Run 2 data have been analyzed and have provided no signs of Higgs boson production; these null results are used to set limits on Higgs production scenarios within the context of particular models.

Keywords: Higgs; MSSM; Tevatron.

1. Introduction

Electroweak symmetry breaking is effected in the standard model (SM) by the "Higgs mechanism," in which a scalar doublet field with non-zero vacuum expectation value spontaneously breaks the $SU(2)\otimes U(1)$ symmetry and enables the W and Z bosons to acquire their measured mass. This mechanism also gives rise to a scalar particle (the Higgs boson) of unspecified mass. Direct searches for the SM Higgs boson at LEP2 have bounded the mass from below at 114 GeV/c^2;[1] precision electroweak measurements have bounded it from above at 166 GeV/c^2.[2]

Higgs bosons are also predicted in the many extensions of the SM that have been conceived to address its shortcomings. One of these extensions is the minimal supersymmetric standard model (MSSM), in which massive superpartners of the SM particles serve to cancel the quadratic divergences of the loop corrections to the Higgs mass-squared. In the MSSM two scalar doublet Higgs fields are required, giving rise to five physical bosons: the CP-even h^0 and H^0 (with $m_h < m_H$ by definition), the CP-odd A^0, and the charged $H^\pm$. The neutral Higgs bosons are often referred to collectively as ϕ^0.

A free parameter of the MSSM that plays an important part in determining the phenomenology of the Higgs sector is $\tan\beta$, the ratio of the vacuum expectation values of the two doublet fields. Large (small) values of $\tan\beta$ enhance the Higgs couplings to down-type (up-type) fermions. Small values of $\tan\beta$ are strongly disfavored by LEP2 data;[3] the consequences of this at the Tevatron are (for example) that we expect ϕ^0 to decay predominantly to $b\bar{b}$ and $\tau^+\tau^-$, and that the cross section for $gg, bb \to \phi^0$ production can be on the order of 10 pb. Another important consequence of the MSSM is that there is an upper limit on m_h of around 135 GeV/c^2.

2. Experimental considerations

The efficient identification of bottom quarks and tau leptons form the linchpin of MSSM Higgs search strategies, given the expected ϕ^0 decay modes mentioned above. Bottom quarks are typically tagged by exploiting the long lifetime of B-hadrons; the presence of displaced secondary vertices and/or tracks with large impact parameters with respect to the primary vertex can signal the presence of a b quark. Large-acceptance sili-