Search for Neutral Supersymmetric Higgs Bosons in $p\bar{p}$ Collisions at $\sqrt{s}$= 1.96 TeV

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We report results of searches for neutral supersymmetric Higgs Bosons in up to 2.7 fb^{-1} of data collected with the D0 detector at the Fermilab Tevatron. The final states include muons, taus, and jets from the decay of b hadrons. The searches observe no significant excess and set upper limits on neutral Higgs production cross sections. The limits are also translated into exclusions of MSSM parameter space.

1 Introduction

Supersymmetry (SUSY) [1] invokes a new symmetry between fermions and bosons and provides attractive solutions to some of the challenges to the Standard Model (SM) such as the hierarchy problem. In the Minimal Supersymmetric Standard Model (MSSM) there are two Higgs doublets, resulting in five physical Higgs bosons [2], two charged ($H^{\pm}$) and three neutral (h, H, A, collectively denoted ϕ). The ratio of the vacuum expectation values of the two doublets is denoted $\tan\beta$. The Higgs coupling to down-type fermions is enhanced by a factor $\propto \tan\beta$ meaning Higgs production in association with a b quark is enhanced by a factor $\propto \tan^2\beta$, giving potentially detectable signals at the Tevatron for large $\tan\beta$. Additionally, at least two of the three neutral Higgs bosons are nearly degenerate in mass, leading to a total cross section enhancement of $\sim 2 \times \tan^2\beta$. We report results of Higgs searches with the DØ detector at the Fermilab Tevatron in three main complementary search channels: $b\phi \to bb\bar{b}$, $b\phi \to b\tau\tau$, and $\phi \to \tau\tau$. The results have also been combined to yield additional exclusion in the MSSM parameter space.

2 Search Channels

2.1 $b\phi \to bb\bar{b}$ Search

The $b\phi \to bb\bar{b}$ channel offers the highest Higgs branching ratio (BR($H \to b\bar{b}$) ≈ 0.9) in an accessible channel ($\phi \to b\bar{b}$ is obscured by background). DØ has performed this search in 2.6 fb^{-1} of data [3]. Events with at least three b-tagged jets are selected. A likelihood discriminant is formed to reject background before using the invariant mass of the two jets with the highest transverse momenta as the final discriminating variable. No significant excess is observed and 95% C.L. limits are set on the production cross section, which are then translated in to an

exclusion in the $\tan\beta$ vs. m_A plane for several MSSM benchmark scenarios, one of which is shown in Figure 1a.

2.2 $b\phi \to b\tau\tau$ Search

The $b\phi \to b\tau\tau$ channel has a lower branching ratio than the $b\phi \to bb\bar{b}$ channel but offers a much cleaner final state due to the lower multijet background. The b-jet requirement also reduces the $Z \to \tau\tau + X$ background making this channel the most sensitive when $m_\phi \simeq m_Z$. DØ has performed a search in 2.7 fb^{-1} of data [4]. The detector signature is one muon (assuming one tau decays to $\nu_\tau\mu\nu_\mu$), one hadronic tau, and one b-jet. The final discriminant variable is the product of two multivariate techniques designed to discriminate multijet and $t\bar{t}$ production. There is no significant excess and 95% C.L. limits are set in the $\tan\beta$ vs. m_A plane shown in Figure 1b.

2.3 $\phi \to \tau\tau$ Search

The $\phi \to \tau\tau$ search is complementary to the other two main search channels and combines three distinct final states: electron-hadronic tau, muon-hadronic tau, and electron-muon (when both taus decay to leptons). DØ has performed these searches in 2.2 fb^{-1} of data [5]. The visible mass (invariant mass of the visible leptons and missing transverse energy) is the final discriminant variable. Again there is no significant excess; Figure 1c shows the $\tan\beta$ vs. m_A parameter space exclusion.

3 Combination

DØ has combined results in the three aforementioned channels (the $b\tau\tau$ result used in the combination has 1.2 fb^{-1} of data) to extend the MSSM parameter space exclusion [6]. Figure 2a shows the combined exclusion. The $\phi \to \tau\tau$ search as also been combined with a similar analysis from the CDF collaboration [7]. Figure 2b shows the combined exclusion from these analyses.

4 Summary

The DØ Collaboration has performed searches for neutral supersymmetric Higgs bosons using up to 2.7 fb^{-1} of data in three complementary search channels. No significant excess above background predictions has been observed and D0 sets upper limits on the Higgs production cross section at 95% C.L. The results have also been translated into exclusion of MSSM parameter space.

References

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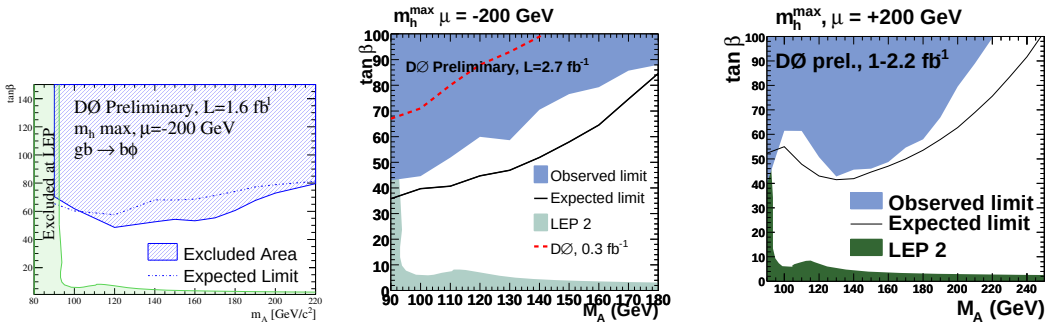
[5] D0 Collaboration, V. Abazov *et al.*, D0 Note 5740-CONF (2008).

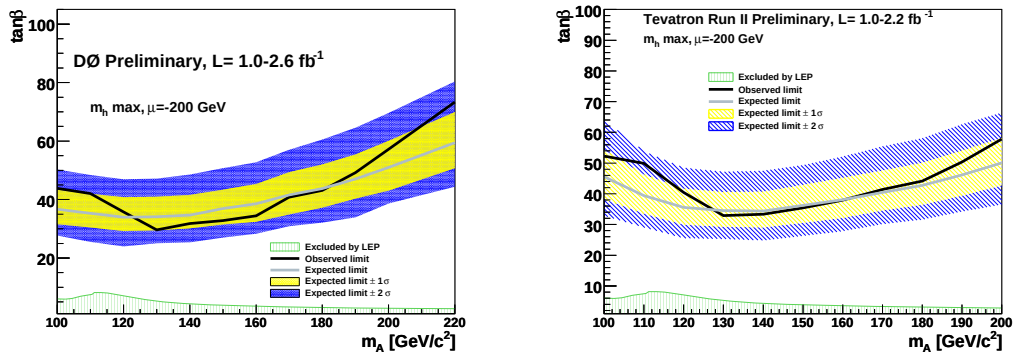
[6] D0 Collaboration, V. Abazov *et al.*, D0 Note 5935-CONF (2009).

[7] D0 Collaboration, V. Abazov *et al.*, D0 Note 5980-CONF (2009).



(a) (b) (c)

Figure 1: 95% C.L. limits in the $\tan\beta$ vs. m_A plane in the $b\phi \to bb\bar{b}$ (a), $b\phi \to b\tau\tau$ (b), and $\phi \to \tau\tau$ (c) analyses.



(a) (b)

Figure 2: 95% C.L. limits in the $\tan\beta$ vs. m_A plane for DØ combination (a) and the DØ+ CDF $\phi \to \tau\tau$ combination (b) analyses.