Fermilab FERMILAB-CONF-06-499-E

Searches For Scalar Top And Scalar Bottom Quarks At The Tevatron

Shaohua Fu (for the CDF and DØ Collaborations)

Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510-0500, USA

Abstract. We report on the searches for the production of scalar top quarks and scalar bottom quarks using data taken during Run II of the Fermilab Tevatron colliders in $p\bar{p}$ collisions at a center of mass energy of 1.96 TeV. We find our data to be consistent with the Standard Model expectations and derive 95% confidence level limits on the masses of scalar top quark and scalar bottom quark.

Keywords: Supersymmetry, Scalar Top, Scalar Bottom, R-parity.
PACS: 12.38.Qk, 12.60.Jv, 13.85.-t, 13.85.Rm, 14.80.Ly.

INTRODUCTION

Supersymmetry (SUSY) overcomes some of the theoretical problems in the Standard Model (SM) by introducing new degrees of freedom. In the Minimal Supersymmetric extension of the Standard Model (MSSM), a scalar supersymmetric partner is assigned to every SM fermion, and a fermionic superpartner to every SM boson. The large top quark mass can induce a large mixing between the superpartners of the left and right helicity states of the top quark and consequently can lead to a substantial mass splitting between the two scalar top mass eigenstates. Thus it is likely that the lighter scalar top ($\tilde{t}_1$) may be the lightest squark. If $\tan\beta$ is large, then there can be a large mass splitting in the sbottom sector, yielding low mass for one of the $\tilde{b}$ which could be in the reach of the Tevatron energy.

At the Tevatron, scalar top (and scalar bottom) quarks are expected to be produced in pairs via gg fusion and $q\bar{q}$ annihilation. Scalar top quark can decay in various modes [1].

SCALAR TOP SEARCH AT DØ

DØ performed a search for scalar top pair production decaying into $\tilde{t}_1\bar{\tilde{t}}_1 \to b\bar{b}l^+l^-\tilde{\nu}\tilde{\nu}$ in the $\mu^+\mu^-$ final state [2], using an integrated luminosity of 339 pb^{-1}. We select events with two muons ($p_T(\mu) > 8, 6$ GeV), missing transverse energy ($\not{E}_T$ > 20-50 GeV), at least one jet ($E_T(j) > 15$ GeV) with b-tag (based on the impact parameter of the tracks in the jet). The main Standard Model background includes: $Z/\gamma^* \to \mu\mu/\tau\tau$, QCD multi-jet events, $\Upsilon(1S) \to \mu\mu$, WW, and $t\bar{t}$ production. After the selection requirements, we observe 1 event in the data, which is in agreement with the expected $2.88 \pm 0.43^{+0.10}_{-0.04}$ events from the Standard Model background. Assuming the decay Branching Ratio $BR(\tilde{t}_1 \to bl\tilde{\nu}) = 100\%$ and equal BR in three lepton flavors, we calculate upper-limit cross sections at the 95% Confidence Level (CL) for various signal points. Considering

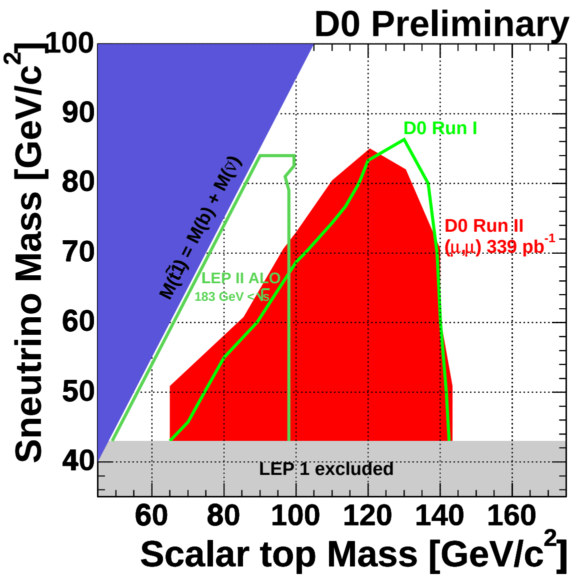

FIGURE 1. 95% CL excluded region in the $M(\tilde{t}_1)$-$M(\tilde{\nu})$ plane with 339 pb^{-1} luminosity in the $\mu\mu$ final state. Also shown is the DØ result obtained in Run I with 108 pb^{-1} luminosity in the $e\mu$ final state.

the results for different $\tilde{\nu}$ and $\tilde{t}_1$ mass, we can exclude a region in the $M(\tilde{t}_1)$-$M(\tilde{\nu})$ plane as shown in Figure 1. However, the preferred channel (as in the Run I analysis) is $e\mu$ final state, where we would have twice of the BR and much lower Z/Drell-Yan background, and we expect significant improvement by new analysis in $e\mu$ channel.

SCALAR TOP SEARCH AT CDF

A search for $\tilde{t}_1\bar{\tilde{t}}_1 \to \tau\tau b\bar{b}$ in the framework of R-parity violation SUSY has been performed by CDF [3], using an integrated luminosity of 332 pb^{-1}. The final state consists of either an electron or a muon from the $\tau \to l\nu_l\nu_\tau$ ($l = e$ or μ) decay, a hadronically decaying tau (τ_{had}), and two or more jets. The major backgrounds are QCD process, W/Z + jets, top quark, and di-boson productions. The event selection requires one lepton (e or μ, $p_T(l) > 10$ GeV), one τ_{had} ($p_T(\tau) > 15$ GeV), at least two jets ($E_T(j) > 20$ GeV), veto Z and W, and finally $S_T \equiv |p_T(l)| + |p_T(\tau)| + |\not{E}_T| > 110$ GeV. In $e+\tau$ channel, 1 event is observed in data while $1.27^{+0.29}_{-0.18}$ is expected from the SM background. In $\mu+\tau$ channel, 1 event is observed and $0.99^{+0.35}_{-0.13}$ background is expected. With no excess of events observed, we obtain 95% CL cross section limits, assuming $BR(\tilde{t}_1 \to b\tau) = 100\%$. We find a nominal mass limit of $m(\tilde{t}_1) > 155$ GeV, and a conservative one of $m(\tilde{t}_1) > 151$ GeV considering the uncertainties in the theoretical cross section calculation. The previously published limit of $m(\tilde{t}_1) > 122$ GeV by CDF Run I (with 106 pb^{-1} luminosity) should be compared to 155 GeV.

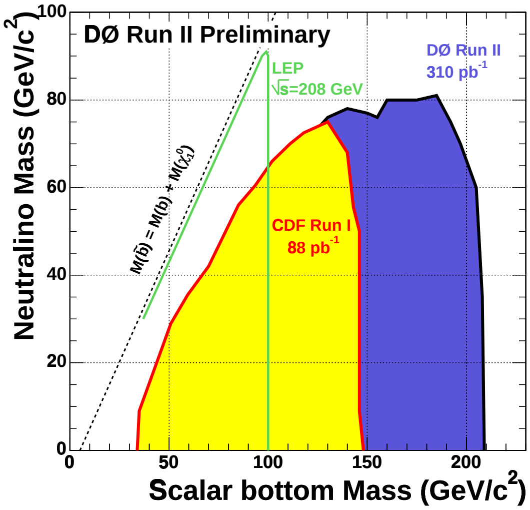

FIGURE 2. 95% CL exclusion contour in the $M(\tilde{b})$-$M(\tilde{\chi}_1^0)$ plane.

SCALAR BOTTOM SEARCH AT DØ

This analysis [2] searches for the pair production of scalar bottom quarks ($\tilde{b}$) at DØ in the final state of $\tilde{b}\bar{\tilde{b}} \to b\bar{b}\tilde{\chi}_1^0\bar{\tilde{\chi}}_1^0$. The data sample has an integrated luminosity of 310 pb^{-1}. In event selection, we require two high E_T acoplanar jets (3rd jet allowed) and high $\not{E}_T$, veto events with isolated e, μ, or track (τ), and require single b-tag. We observe 36 events in data and we expect 38.6 ± 2.8 events from the SM background. Furthermore we optimize jet E_T and $\not{E}_T$ cuts depending on the $\tilde{b}$ mass. Since data are consistent with the SM background, we set limits on the $\tilde{b}\bar{\tilde{b}}$ cross sections assuming $BR(\tilde{b} \to b\tilde{\chi}_1^0) = 100\%$. The results are summarized in the 95% CL exclusion contour displayed in Figure 2.

CONCLUSION

CDF and DØ have searched for scalar top and scalar bottom quarks in various channels using an integrated luminosity of up to 340 pb^{-1}, and obtained improvement over Tevatron Run I results and extension of LEP excluded regions. We have accumulated over 1 fb^{-1} data, hoping for a discovery by analyzing these, otherwise there will be substantial improvement of the limits.

REFERENCES

1. C. Boehm, A. Djouadi, Y. Mambrini, "Decays of the lightest top squark", *Physical Review D*, **61**, 095006 (1990).
2. DØ Collaboration, http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm .
3. CDF Collaboration, http://www-cdf.fnal.gov/physics/exotic/r2a/20050728.jtau_rpvstop/ .