DØNote 5050-CONF

Search for pair production of the supersymmetric partner of the top quark in $\tilde{t}_1\overline{\tilde{t}_1} \longrightarrow b\overline{b}\ e^{\pm}\mu^{\mp}\ \tilde{\nu}\overline{\tilde{\nu}},\ b\overline{b}\ \mu^{+}\mu^{-}\ \tilde{\nu}\overline{\tilde{\nu}}$ decay channels at DØ

The DØ Collaboration

URL http://www-d0.fnal.gov

(Dated: March 17, 2006)

A search for the lightest supersymmetric partner of the top quark $\tilde{t}_1$ is performed using data recorded with the DØ detector at a p$\overline{\text{p}}$ center-of-mass energy of 1.96 TeV at the Fermilab Tevatron Collider. This analysis considers final states with missing transverse energy and two leptons, where the two leptons are either two muons or a muon and an electron. No evidence for $\tilde{t}_1$ production is found in a dataset corresponding to an integrated luminosity of 350 pb^{-1}. We improve existing limits for both low and high $\tilde{t}_1$ masses.

Preliminary Results for Winter 2006 Conferences

I. INTRODUCTION

Supersymmetric theories (SUSY) [1] predict the existence of a scalar partner for each standard model fermion. Because of the large mass of the standard model top quark, the mixing between its chiral supersymmetric partners is the largest among all squarks; therefore the lightest supersymmetric partner of the top quark, $\tilde{t}_1$, might be the lightest squark, whose discovery would be an opening to the SUSY world.

Recent theoretical studies [2] have shown that the $\tilde{t}_1$ decays into charm quark and neutralino ($\tilde{\chi}_1^0$), which has been until now the most explored scenario for $\tilde{t}_1$ searches, might not be the dominant ones for $\tilde{t}_1$ masses accessible at the Tevatron. Furthermore, these studies favor three-body decays of the $\tilde{t}_1$ into $bW\tilde{\chi}_1^0$ and/or $bl\tilde{\nu}$ (where $\tilde{\nu}$ is a sneutrino) via a virtual chargino $\tilde{\chi}^{\pm}$. If the mass of the sneutrino $\tilde{\nu}$ is much greater than the W mass, the $bW\tilde{\chi}_1^0$ decays will dominate. However if the mass of the sneutrino is of the same order as the mass of the W, decays to $bl\tilde{\nu}$ will dominate. Since decays of the $\tilde{t}_1$ in the W-exchange scenario have very limited discovery potential for the Run II, we will in this note focus on the sneutrino-exchange scenario of the $\tilde{t}_1$:

$$
\begin{array}{lll}
\tilde{t}_1\overline{\tilde{t}_1} \to b\overline{b} & \tilde{\chi}^{\pm} & \tilde{\chi}^{\pm} \\
 & \hookrightarrow \mu\tilde{\nu} \to \mu\nu\tilde{\chi}_1^0 & \hookrightarrow \mu\tilde{\nu} \to \mu\nu\tilde{\chi}_1^0 \\
 & \hookrightarrow e\tilde{\nu} \to e\nu\tilde{\chi}_1^0 & \hookrightarrow \mu\tilde{\nu} \to \mu\nu\tilde{\chi}_1^0
\end{array}
$$

where a virtual chargino $\tilde{\chi}^{\pm}$ decays into a muon or an electron, and a sneutrino $\tilde{\nu}$ where the $\tilde{\nu}$ decays into a neutrino and a neutralino $\tilde{\chi}_1^0$, considered to be the Lightest Supersymmetric Particle (LSP). The Minimal Supersymmetric Standard Model (MSSM) is the theoretical framework for this search and R-parity is considered as conserved.

This note describes the combination of two analyses which search for the $\tilde{t}_1$ in the $e^{\pm}\mu^{\mp}$ $b\overline{b}$ + $\not{E}_T$ ($e\mu$ selection) and $\mu^+\mu^-$ $b\overline{b}$ + $\not{E}_T$ ($\mu\mu$ selection) final states from the $\tilde{t}_1$ pair production. These analyses are described in [3] and [4], where a description of the Data and MC samples, preselection and signal selection can be found.

II. RESULTS

Table I shows the number of expected background and signal events, as well as observed events in data in the $e\mu$ [3] and $\mu\mu$ [4] selections. Signal points with a low and high $\Delta m = M(\tilde{t}_1) - M(\tilde{\nu})$, such as ($M(\tilde{t}_1)$,$M(\tilde{\nu})$) = (110,80) GeV/$c^2$ (point I) and (145,50) GeV/c^2 (point II), have been chosen as benchmark signals of different kinematics.

A. Systematic uncertainties

The systematic uncertainties specific to the $e\mu$ selection [3] are as follows:

- an uncertainty due to the electron identification and trigger efficiency,
- an uncertainty due to the instrumental background,
- an uncertainty due to non-isolated tracks.

The systematic uncertainties specific to the $\mu\mu$ selection [4] are as follows:

- an uncertainty due to the jet reconstruction and identification efficiency,
- an uncertainty due to the jet taggability efficiency,
- an uncertainty due to b-tagging.

The systematic uncertainties common to the two selections are:

- the uncertainty due to the muon identification and efficiency,
- the uncertainty due to the JES uncertainty [5],
- the uncertainty on the integrated luminosity,
- the theoretical uncertainty on the signal cross section [6],
- the theoretical uncertainty on the Standard Model background cross sections among which the $t\overline{t}$ [7] and WW production.

TABLE I: Expected number of total background, observed data events and expected signal events (signal points I and II) in the $e\mu$ and $\mu\mu$ selections. The uncertainties are statistical.

Selection	Total Background	Data	I	II
$e\mu$ low Δm selection	23.0 ± 3.1	21	16.43 ± 1.07	
$e\mu$ high Δm selection	40.7 ± 4.4	42		16.70 ± 0.51
$\mu\mu$	$2.88 \pm 0.43^{+0.10}_{-0.04}$	1	3.30 ± 0.37	3.06 ± 0.18

B. Limits

After applying the quality and selection cuts (see Tab. I), no evidence for the $\tilde{t}_1$ production is observed.

We combine the information (expected number of signal events and their corresponding uncertainty, the expected number of background events and the number of observed events in data) from the two selections to calculate upper-limit cross sections at the 95% Confidence Level (CL) for various signal points, using the modified frequentist approach [8]. No duplicate data event is observed between the two selections, and the expected number of signal events surviving both selections are compatible with zero within one standard statistical deviation. Systematic and statistical errors are taken into account in the combination including their correlations (see Sec. II A).

Regions for which the calculated cross section upper limit is smaller than the NLO theoretical cross section [6] are 95% CL excluded. Considering the results for different $\tilde{\nu}$ and $\tilde{t}_1$ mass, we exclude a region in the $(M(\tilde{t}_1), M(\tilde{\nu}))$ surface as can be seen in the Fig. 1.

III. CONCLUSION

With relatively low p_{T} requirements on the leptons, and criteria disentangling signal of different kinematics from various backgrounds, the $e\mu$ selection extends the sensitivity for $\tilde{t}_1$ searches well beyond the Run I limits [9]. Because of the low p_{T} requirements on the muons and analysis cuts resulting in a low background level, the $\mu\mu$ selection is extending this sensitivity by approximately 9 or 15 GeV/c^2 depending on the sneutrino mass, also reaching sneutrino masses of 100 GeV/c^2.

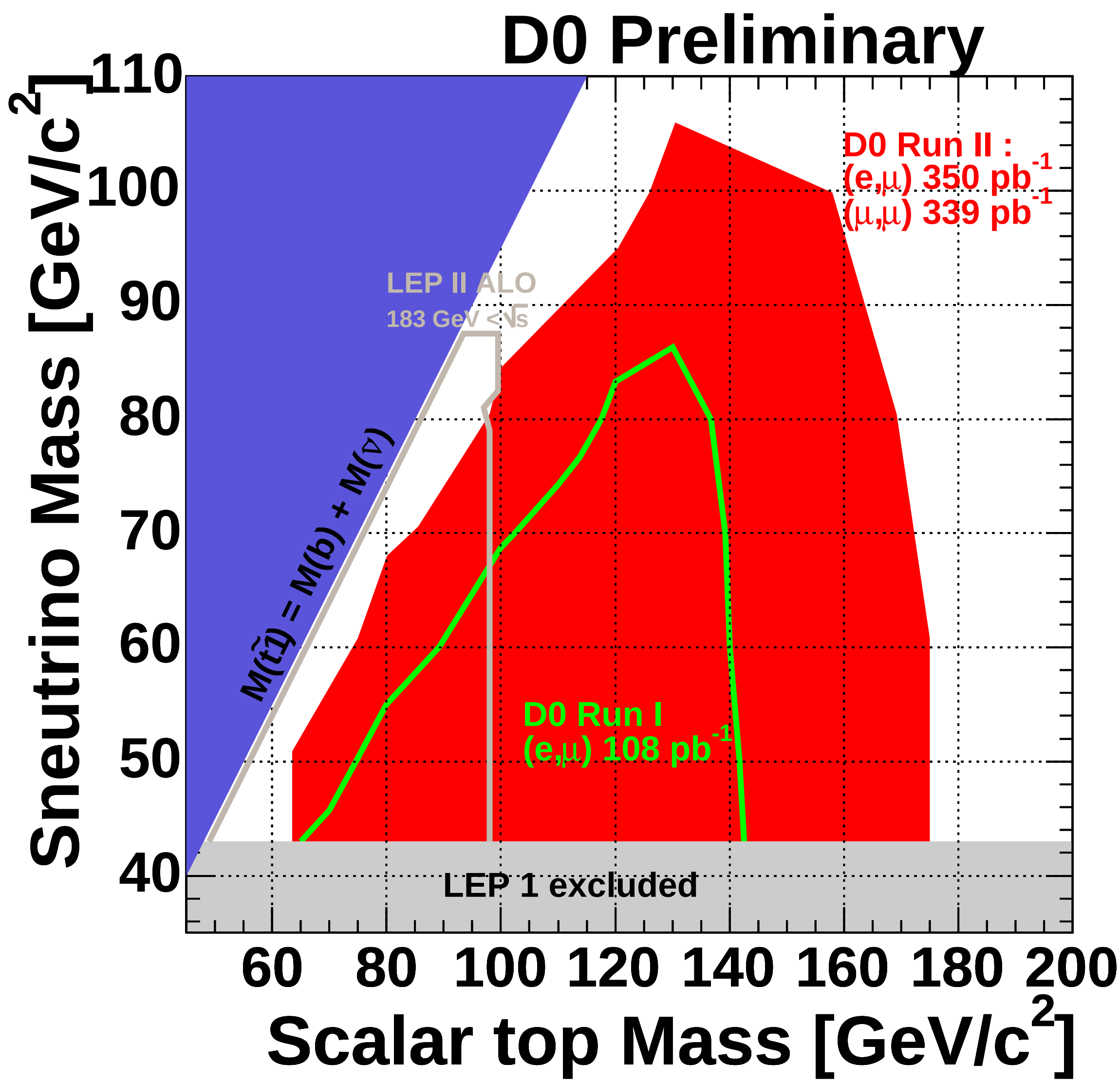

FIG. 1: 95% CL excluded region in the $(M(\tilde{t}_1), M(\tilde{\nu}))$ plan with 350 pb^{-1} and 339 pb^{-1} luminosity in the $e\mu$ and $\mu\mu$ final states respectively. Also shown is the DØ result obtained in Run I with 108 pb^{-1} luminosity in the $e\mu$ final state.

Acknowledgments

We thank the staffs at Fermilab and collaborating institutions, and acknowledge support from the DOE and NSF (USA); CEA and CNRS/IN2P3 (France); FASI, Rosatom and RFBR (Russia); CAPES, CNPq, FAPERJ, FAPESP and FUNDUNESP (Brazil); DAE and DST (India); Colciencias (Colombia); CONACyT (Mexico); KRF (Korea); CONICET and UBACyT (Argentina); FOM (The Netherlands); PPARC (United Kingdom); MSMT (Czech Republic); CRC Program, CFI, NSERC and WestGrid Project (Canada); BMBF and DFG (Germany); SFI (Ireland);

Research Corporation, Alexander von Humboldt Foundation, and the Marie Curie Program.

[1] H. P. Nilles, Phys. Rep. 32, 249 (1977).
[2] C. Boehm, A. Djouadi, Y. Mambrini, "Decays of the lightest top squark", Phys. Rev. **D 61**, 2000, 095006.
[3] DØ Collaboration, "Search for light scalar top squark pair production in the $b\bar{b}\ e^{\mp}\mu^{\pm}\ \tilde{\nu}\tilde{\nu}$ decay channel in p$\overline{\text{p}}$ Collisions at $\sqrt{s} = 1.96$ TeV with the DØ Detector", DØ note 5039-CONF.
[4] DØ Collaboration, "Search of the lightest scalar top $\tilde{t}_1$ in $b\bar{b}\ \mu^+\mu^-\ \tilde{\nu}\bar{\tilde{\nu}}$ decays at DØ", DØ note 4866-CONF
[5] V.M. Abazov et al., "Measurement of Dijet Azimuthal Decorrelations at Central Rapidities in p$\overline{\text{p}}$ Collisions at $\sqrt{s} = 1.96$ TeV", hep-ex/0409040.
[6] W. Beenakker, R. Hoepker, M. Spira, "PROSPINO, a program for the PROduction of Supersymmetric Particles In Next-to-leading Order QCD", hep-ph/9611232.
[7] N. Kidonakis and R. Vogt, Phys. Rev. **D 68** (2003) 114014.
[8] T. Junk, NIM A434, 435 (1999).
[9] V.M. Abazov et al. "A Search for the Scalar Top Quark in p$\overline{\text{p}}$ Collisions at $\sqrt{s} = 1.8$ TeV", Phys. Rev. Lett. **88**, 171802 (2002).