SUSY SEARCHES AT THE TEVATRON

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We discuss some of the latest results from supersymmetry searches at the Tevatron.

1 Overview

DØ and CDF have already started collecting data from $p\overline{p}$ collisions at the Tevatron with the Main Injector in operation and at $\sqrt{s} \approx 2$ TeV. A number of recently completed SUSY searches using data from Run I are discussed.

2 Search for scalar top production in electron plus muon plus $\not\!\!E_T$ channel at DØ

This is a search for direct $\tilde{t_1}\bar{\tilde{t}}_1$ production where $\tilde{t_1} \to b\ell^{\pm}\tilde{\nu}$. The branching ratio for each of the decays $\tilde{t_1} \to be^{\pm}\tilde{\nu}$, $\tilde{t_1} \to b\mu^{\pm}\tilde{\nu}$ and $\tilde{t_1} \to b\tau^{\pm}\tilde{\nu}$ is 33.3%. The final state used in the search is an electron, a muon and missing transverse energy from the $\tilde{\nu}$'s.

The analysis uses 108±6 pb^{-1} of data collected with the DØ detector. The electron and muon are required to have E_T>15 GeV, $|\eta| < 2.5, 1.7$ respectively and be acoplanar. The missing energy is required to be $\not\!\!E_T$>15 GeV. The total number of expected Standard Model background events is 13.4±1.5 mostly from fakes, $Z \to \tau\tau$, $t\bar{t}$ and dibosons. The number of observed events in the data is 11. The analysis sets at 95% C.L. upper limit on the stop pair production cross section as a function of the stop mass. In the $M(\tilde{\nu})$ versus $M(\tilde{t_1})$ plane the bound is shown in Figure 1. Stop masses below 140 GeV/c^2 are excluded for sneutrino mass of 43 GeV/c^2 and below 130 GeV/c^2 for sneutrino mass of 85 GeV/c^2.

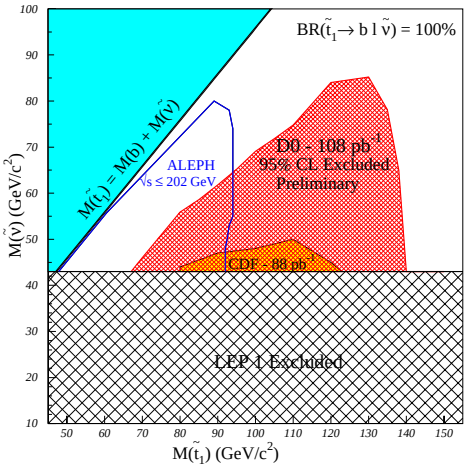

Figure 1: Excluded region for $M(\tilde{t_1})$ in the $M(\tilde{\nu})$ versus $M(\tilde{t_1})$ plane from $\tilde{t_1} \to be^{\pm}(\mu^{\pm})\tilde{\nu}$ at DØ.

3 Search for R-parity violating decays of the LSP in the dimuon plus 4 jets final state at DØ

The analysis uses 78 pb^{-1} of data collected with the DØ detector and complements the corresponding search of R-parity violating decays of the LSP in the dielectron plus 4 jets final state[1].

Each of the LSPs of the final state decays via a lepton violating process into a lepton and two jets ($\tilde{\chi}_1^0 \to e(\mu)qq'$). Two muons are required with P_T>15, 10 GeV/c respectively and four jets with E_T>15 GeV. The total standard model background is estimated to be 0.18±0.03±0.02 (mostly from $Z \to \mu\mu$+jets) events. There are no events passing the selection criteria in the data.

In the context of mSUGRA (with A_0=0, μ <0, tan β = 2) the resulting bound is given in the common gaugino mass ($m_{1/2}$) versus common scalar mass (m_0) plane as shown in Figure 2.

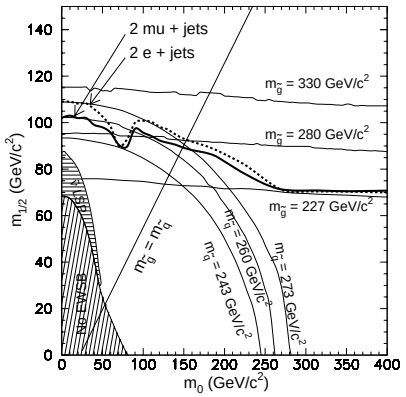

Figure 2: Exclusion curve in $m_{1/2}$ *vs* m_0 plane from LSP R-parity violating decays.

4 Search for R-parity violating decays of scalar top quarks in di-τ plus dijet events at CDF

This analysis searches for the scalar top quark pair production $\tilde{t_1}\bar{\tilde{t}}_1$ in which the stop decays via an R-parity violating process into $\tau^+\bar{b}$. The search results are based on the final state of one electron from the one τ decay, one hadronically decaying τ (τ_h) and two jets. The final state is the same as in the 3rd generation leptoquark analysis[2].

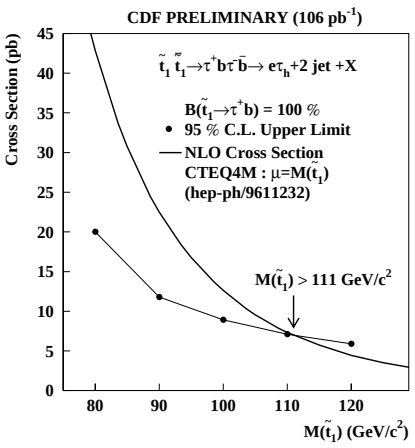

Figure 3: The upper limit on the $\tilde{t_1}\bar{\tilde{t}}_1$ cross section at 95% C.L. from $\tilde{t_1}\bar{\tilde{t}}_1 \to \tau^+b\tau^-\bar{b}$ and the theory calculation as a function of the $\tilde{t_1}$ mass.

Using a low P_T electron threshold (10 GeV) and a track based τ_h identification algorithm which includes π^0 reconstruction, this analysis improves significally the $Z \to \tau\tau$ acceptance. After the baseline selection, the dominant sources of ℓ+τ_h events are found to be $Z \to \tau\tau$, W+jets, and QCD events. For the selection of the $\tilde{t_1}\bar{\tilde{t}}_1$ signal events and to eliminate the above backgrounds it is required that the $(e, \not\!\!E_T)$ transverse mass be $\leq$ 35 GeV, the scalar sum $H_T \equiv E_T(e) + \not\!\!E_T + P_T(\tau_h) \geq$ 75 GeV and that the number of jets in the event is $N_{jet} \geq 2$. To avoid systematics mainly due to the modeling of the τ identification, the $\tilde{t_1}\bar{\tilde{t}}_1$ production cross section is measured relative to the $Z \to \tau\tau$ cross section using the corresponding data sample. No events survive the selection while the standard model expectation is 1.91±0.11±0.15 mainly from $Z \to \tau\tau$. The analysis excludes at 95% C.L. $\tilde{t_1}$ masses below 111 GeV/c^2 as shown in Figure 3.

5 A model independent search for new physics with leptons and photons in the final state at CDF

The unexplained $ee\gamma\gamma\not\!\!E_T$ event observed at CDF, pointed towards possible novel processes involving combinations of leptons and photons in the final state.

This analysis searches for anomalous production of events with a high E_T photon and a lepton (e or μ) in the final state.

The search is based on 86 pb^{-1} of data collected with the CDF detector during the 1994-95 Tevatron run. The cases with large $\not\!\!E_T$, additional photons or additional leptons in the final state are also analyzed.

A two-body photon-lepton, a multi-body photon-lepton sample, and several subsets of the multi-body photon-lepton sample with additional particles were studied and the results were consistent with standard model expectations with a possible exception in a subset of the multi-body photon- lepton sample, consisting of those events with $\not\!\!E_T > 25$ GeV. The results of the analysis of these samples are shown in Table 1[3].

Category	μ_{SM}	N_0	$P(N \geq N_0 \mid \mu_{SM})$ %
All $\ell\gamma X$	—	77	—
Z-like $e\gamma$	—	17	—
Two-Body $\ell\gamma X$	24.9 ± 2.4	33	9.3
Multi-Body $\ell\gamma X$	20.2 ± 1.7	27	10.0
Multi-Body $\ell\ell\gamma X$	5.8 ± 0.6	5	68.0
Multi-Body $\ell\gamma\gamma X$	0.02 ± 0.02	1	1.5
Multi-Body $\ell\gamma\not\!\!E_T X$	7.6 ± 0.7	16	0.7

Table 1: The results for all photon-lepton categories analyzed, including the mean number of events μ_{SM} predicted by the standard model, the number N_0 observed in CDF data, and the observation likelihood $P(N \geq N_0 \mid \mu_{SM})$.

6 Search for Gluinos and Scalar Quarks at CDF using the Missing Energy plus Multijets Signature

This analysis investigates whether the production and decay of gluinos and scalar quarks is observable in the rate of $\geq$3-jet events with large missing transverse energy at the CDF. The large missing energy would originate from the two LSPs in the final states of the squark and gluino decays. The three or more hadronic jets would result from the hadronic decays of the $\tilde{q}$ and/or $\tilde{g}$. The search is based on 84 ± 4 pb^{-1} of integrated luminosity recorded with the CDF detector during the 1994-95 Tevatron run.

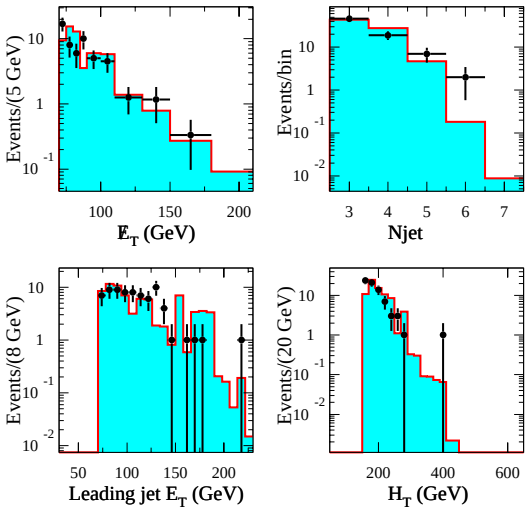

Figure 4: Comparison in the 'blind box' between data (points) and Standard Model predictions (histogram) of $\not\!\!E_T$, N_{jet}, leading jet E_T and H_T distributions. There are 74 events in each of these plots, to be compared with 76±13 SM predicted events.

The data sample was selected with an online trigger which requires $\not\!\!E_T \equiv |\vec{\not\!\!E}_T| > 30$ GeV. A two-stage preselection rejects accelerator-, detector-related backgrounds, beam halo, and cosmic ray events[4]. At least three jets with $E_T \geq 15$ GeV, at least one of them within $|\eta| < 1.1$, are then required in events that pass the preselection. In a QCD multijet event with large missing energy, the highest E_T jet is typically the most accurately measured. When the second or third jet is mismeasured because it lands partially in an uninstrumented region (a 'gap'), the $\not\!\!E_T$ is pulled close in ϕ to the mismeasured jet. A jet is considered non-fiducial if it is within 0.5 rad in ϕ of the $\not\!\!E_T$ direction and also points in η to a detector gap. In this analysis the second and third highest E_T jets in an event are required to be fiducial. The residual QCD component is eliminated by using the correlation in the $\delta\phi_1 = |\phi_{\text{leading jet}} - \phi_{\not\!\!E_T}|$ versus $\delta\phi_2 = |\phi_{\text{second jet}} - \phi_{\not\!\!E_T}|$ plane and by requiring the $\not\!\!E_T$ not be closer than 0.3 rad in ϕ to any jet in the event. The background con-

tribution from $W(\rightarrow e\nu)$+jets and $t\bar{t}$ production is reduced by requiring the two highest energy jets not be purely electromagnetic (jet electromagnetic fraction f_{em} <0.9). The two highest E_T jets in the event are required to be $E_{T(1)}$ ≥70 GeV and $E_{T(2)}$ ≥30 GeV.

To avoid potential *a posteriori* biases when searching for new physics in the tails of the missing transverse energy distribution, this analysis defines and seals the signal candidate data sample. This analysis approach is often referred to as a 'blind analysis' and the signal candidate data sample as a 'blind box'. The 'blind box' data are inspected only after the entire search path has been defined by estimating the total Standard Model backgrounds and optimizing the sensitivity to the supersymmetric signal. Three variables define the signal candidate region : $\not\!\!E_T$, $H_T \equiv E_{T(2)} + E_{T(3)} + \not\!\!E_T$, and isolated track multiplicity, N_{trk}^{iso} [4]. The 'blind box' contains events with $\not\!\!E_T \geq 70$ GeV, $H_T \geq 150$ GeV, and N_{trk}^{iso}=0. Events with large missing transverse energy and ≥3 jets in the final state are expected primarily from QCD, $Z(\rightarrow \nu\bar{\nu})+$ ≥3 jets, $W(\rightarrow \tau\nu)+$ ≥2 jets (the third jet originating from the hadronic τ decay) and $t\bar{t}$ processes. Of the 76 events predicted in the 'blind box', 41 come from QCD and 35 from electroweak processes. Of the latter ∼37% are expected from $Z \rightarrow \nu\bar{\nu}+ \geq 3$ jets, ∼20% from $W \rightarrow \tau\nu+ \geq 2$ jets, ∼20% from the combined $W \rightarrow e(\mu)\nu_e(\nu_\mu)+ \geq 3$ jets, and ∼20% from $t\bar{t}$ production and decays. The $\not\!\!E_T$ and H_T requirements are optimized to increase sensitivity to the signal in the context of MSSM and mSUGRA models and as a function of $\frac{m_{\tilde{q}}}{m_{\tilde{g}}}$.

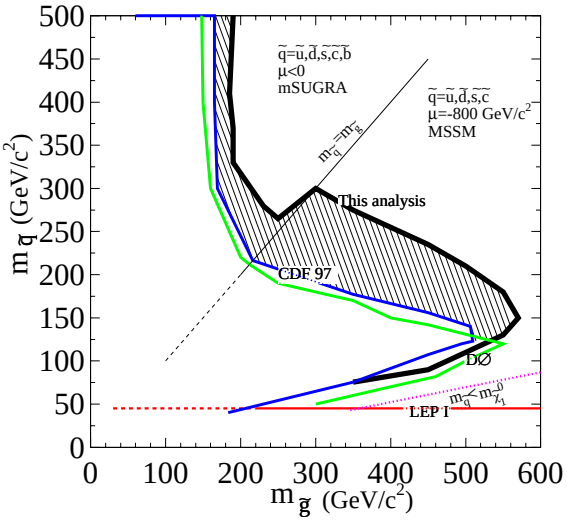

Figure 5: The 95% C.L. limit curve in the $m_{\tilde{q}} - m_{\tilde{g}}$ plane for $\tan\beta = 3$; the hatched area is newly excluded by this analysis. Results from some previous searches are also shown. The region labelled as $m_{\tilde{q}} < m_{\tilde{\chi}_1^0}$ is theoretically forbidden as the squarks are predicted to be lighter than the LSP.

In the 'blind box', where 76±13 Standard Model events are expected, 74 events are observed. In Figure 4 the predicted Standard Model kinematic distributions are compared with the distributions observed in the data. The derived 95% C.L. bound is shown on the $m_{\tilde{q}} - m_{\tilde{g}}$ plane in Figure 5. The search excludes gluino masses below 195 GeV/c^2 (95% C.L.), independent of the squark mass. For the case $m_{\tilde{q}} \approx m_{\tilde{g}}$, gluino masses below 300 GeV/c^2 are excluded.

Acknowledgments

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