SUPERSYMMETRY RESULTS AT THE TEVATRON

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The results for searches for Supersymmetry by the CDF and DØ collaborations in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV are presented here. Searches for chargino/neutralino and the lightest stop, as well as scenarios with R-parity violation are focused here. The integrated luminosity analyzed ranges from 300 to 800 pb^{-1} depending on the search. Further informations can be found on the public web pages of the two experiments [1, 2].

1. Supersymmetry

Supersymmetry (SUSY) predicts the existence of a new particle for each of the Standard Model (SM) particles, differing by half a unit in spin but otherwise sharing same quantum numbers. A discrete multiplicative symmetry, called R-parity, is defined as $Rp = (-1)^{(2S+3B+L)}$ where B is the baryon number, L is the lepton number and S is the spin of the particle, such that a SM particle carries $Rp = +1$ and a SUSY particle $Rp = -1$. Supersymmetric particles have not been observed yet implying that SUSY is a broken symmetry. In Rp conserving models, supersymmetric particles are produced in pair and the lightest supersymetric particle (LSP) is stable. The masses for the proposed superpartners are potentially accessible at the Tevatron.

2. Charginos and neutralinos

2.1. *Multilepton final state*

In the mSUGRA scenario the superparticles are produced in pairs and the lighter charginos and neutralinos, mixed state of electroweak gauginos and higgsinos, and the sleptons, are less massive than gluinos and squarks. The LSP is the $\tilde{\chi}_1^0$. In the case where charginos and neutralinos decay leptonically, $\tilde{\chi}_1^\pm \rightarrow \ell^\pm \nu_\ell \tilde{\chi}_1^0$ and $\tilde{\chi}_2^0 \rightarrow \ell^\pm \ell^\mp \tilde{\chi}_1^0$, very clean final states of three leptons plus missing energy ($\not\!\!E_T$) caused by the $\tilde{\chi}_1^0$'s and the neutrino are expected. Very few SM processes contribute to such a signature, the dominant being Drell-Yan plus a misidentified jet or a $\gamma \to e^+e^-$ conversion, and real WZ production. New CDF results on trileptons are summarized in Table 1. No significant excess is observed. A previous DØ analysis sets a limit of 117 GeV/c^2 on the $\tilde{\chi}_1^\pm$ mass considering a mSUGRA scenario with sleptons slightly heavier than the $\tilde{\chi}_1^\pm$ and no sleptons mixing.

Table 1. CDF results of search for $\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to \ell^\pm\ell^\mp + X$. LS means Like Sign.

Channel	$\mu\mu+\ell$	$\mu e+\ell$	LS ee	LS $\mu\mu$	LS μe
Luminosity	745 pb^{-1}	700 pb^{-1}	704 pb^{-1}	704 pb^{-1}	704 pb^{-1}
SM expectation	0.64 ±0.18	0.78 ±0.11	2.6 ±0.4	3.5±0.6	0.7 ±0.1
observed	1	0	4	5	0

2.2. *Diphotons*

In another SUSY model, Gauge Mediated Supersymmetry Breaking (GMSB), the LSP is the gravitino, the super partner of the graviton. Each of the $\tilde{\chi}_1^0$'s from chargino-neutralino production will decay into a gravitino and a photon. The signal is a final state with two energetic photons and large $\not\!\!E_T$. The physical backgrounds are estimated negligible. Instrumental backgrounds come from QCD processes with either real γ or jets misidentified as γ and $W(\to e\nu)\gamma$ and $W(\to e\nu)jet$ production where the electron and the jet are misidentified as a photon. DØ has searched for this signature in 760 pb^{-1} of data. 2 events are observed with an expected background of 2.1 ± 0.7 events. An upper limit, see Figure 1, is set on GMSB SUSY production.

3. Squarks and gluinos

3.1. *Stops*

In many scenarios, the lightest stop quark, $\tilde{t}_1$, is expected to be the lightest of all the squarks. Due to their strong couplings, squarks and gluinos are expected to be produced abundantly at hadron colliders. DØ has looked for final states $e^\pm\mu^\mp + b\bar{b}+ \not\!\!E_T$ and $\mu^\pm\mu^\mp + b\bar{b}+ \not\!\!E_T$, which is the signature of $\tilde{t}_1$ pair production, followed by $\tilde{t}_1 \to b\ell\tilde{\nu}$, which is expected to be the dominant decay mode when $m_{\tilde{\nu}} \approx m_W$. For the $e\mu$ final state, two regions of $\Delta M = m_{\tilde{t}_1} - m_{\tilde{\nu}}$ are examined. The expected number of total background is 23.0±3.1 (40.7±4.4) for 21(42) observed in the $e\mu$ low Δm (high Δm) region. In the $\mu\mu$ final state the expectation from SM is $2.88{\pm}0.43^{+0.10}_{-0.04}$ while 1 event is observed. All the results are compatible with SM expectations. The regions for which the calculated cross section upper limit is smaller than the theoritical cross section are 95% C.L. excluded and are shown in Figure 2.

4. R-parity violation

CDF looked for *Rp* violating SUSY in the multilepton channel. The search is performed under the assumption that SUSY particles are pair produced and decay under *Rp* conservation while only the LSP can decay into two charged leptons plus a neutrino via the λ_{121} or λ_{122} coupling. Both the 3 and 4 leptons signatures, $ee\ell(\ell)$ and $\mu\mu\ell(\ell)$ with $\ell = e\,\mathrm{or}\,\mu$, were investigated and the observation is compatible with the expectation. As an example, Figure 4 shows the invariant mass distribution of the leading leptons. The channels are combined and upper limits at 95% C.L. on the cross sections, $\sigma < 0.21$ pb for $\lambda_{121} > 0$ and $\sigma < 0.11$ pb for $\lambda_{122} > 0$, are obtained.

4.1. *Long-lived LSP*

D∅ looked for the decay of the neutralino to leptons and a neutrino in 383 pb^{-1} of data. The analysis focuses on the scenario where the *Rp* coupling is weak and the LSP would travel ≥ 5 cm before decaying. This possibility was inspired by an excess in dimuon events reported by NuteV. No events are observed with an expectation of $0.8 \pm 1.1 \pm 1.1$ from backgrounds and the limit set excludes the possibility that the NuteV events are due to neutralino decay.

5. Conclusions

CDF and D∅ have searched for SUSY and no deviation from the Standard Model have been found. SUSY parameter regions have been excluded. High luminosity samples, corresponding to 1 fb^{-1} are being analyzed.

References

1. http://www-cdf.fnal.gov/physics/exotic/exotic.html
2. http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm

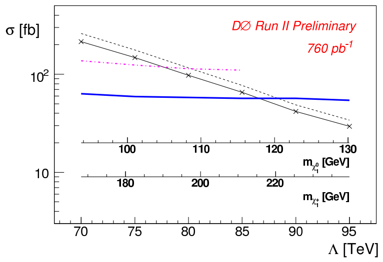

Figure 1. 95% C.L. limit on GMSB SUSY Snowmass Slope obtained in the analysis (thick blue line) and in the previous DØ result (dot-dashed) purple-line. SUSY LO (NLO) cross-section is shown in black solid (dashed) line.

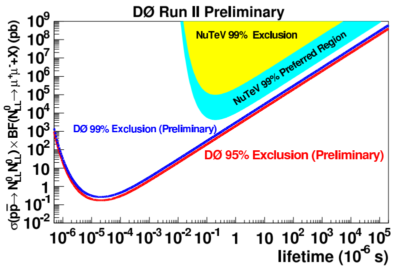

Figure 3. The red curve is the 95% C.L. limit on pair production of neutral, long-lived particles.

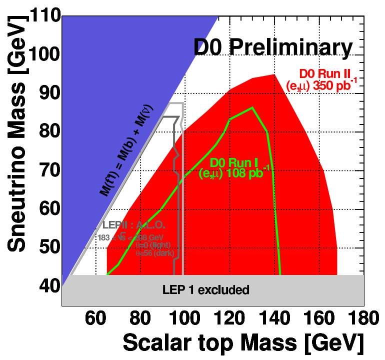

Figure 2. 95% C.L. excluded region in the stop search for the combination of $e\mu$ and $\mu\mu$ final state.

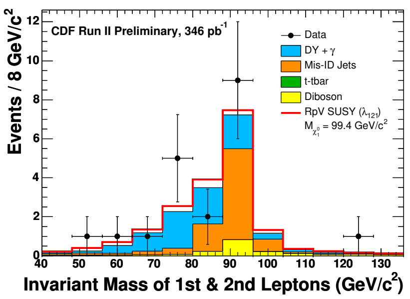

Figure 4. Search for *Rp* violating SUSY in the multilepton channel. Invariant mass distribution of the leading leptons.