SUSY SEARCHES AT TEVATRON

GIANLUCA DE LORENZO
Institut de Fisica d'Altes Energies (IFAE), Edifici Cn. Facultat Ciencies, Universitat Autonoma de Barcelona, E-08193 Bellaterra (Barcelona), Spain

This contribution provides a review of the latest results of searches for Supersymmetry (SUSY) by the CDF and DØ experiments with integrated luminosities up to 4.1 fb^{-1}. No evidence of new physics has been found and results were translated into exclusion limits on the investigated SUSY phase space parameters.

1 Direct Searches for Squarks and Gluinos

1.1 Inclusive Search for Squarks and Gluinos

The inclusive search for squarks ($\tilde{q}$) and gluinos ($\tilde{g}$) has been developed within the framework of minimal supergravity (mSUGRA) characterized by only five free parameters: M_0, $M_{1/2}$, A_0, tanβ, and sign(μ). The assumption of R-parity conservation implies that squarks and gluinos are produced in pairs and ultimately decay into energetic jets and large $\not\!\!E_T$ due to the LSP neutralinos ($\tilde{\chi}_1^0$) in the final state. Depending on the masses of squarks ($M_{\tilde{q}}$) and gluinos ($M_{\tilde{g}}$), different event topologies are expected. CDF [5] and DØ [6] collaborations performed several analyses with different jet requirements and optimizing the final selection cuts to enhance the signal over background separation for different gluino and squark mass configurations. No significant deviation from SM predictions has been found by CDF and DØ in 2 and 2.1 fb^{-1} of data, respectively. The results have been translated into 95% C.L. limits on the squark/gluino production cross section as a function of their masses. Figure 1 (left) shows the CDF 95% C.L. excluded region in the squark-gluino mass plane. Masses up to 392 GeV/c^2 are excluded in the region where $M_{\tilde{q}} \sim M_{\tilde{g}}$, and $M_{\tilde{g}} > 280$ GeV/c^2 for any $M_{\tilde{q}}$. Similar exclusion limits have been found by the DØ collaboration.

1.2 Searches for Scalar Bottom Quarks

In a constraint MSSM scenario, large values of tanβ lead to large mixing between the chiral states of the sbottom squark and result in a significant mass difference between mass eigenstates in the sbottom squark sector with a rather light $\tilde{b}_1$ mass state. Assuming a SUSY particle mass hierarchy such that the sbottom decays exclusively as $\tilde{b}_1 \to b\tilde{\chi}_1^0$, the expected signal for direct sbottom pair production contains two b-jets and large missing transverse energy $\not\!\!E_T$ from the two LSPs in the final state. The DØ [10] experiment searched for direct sbottom pair production in 4.0 fb^{-1} of data. Specific cuts were implemented to reject contamination from beam-halo and cosmic particles as well as SM processes. Events with b-jets in the final state were selected with a NN based b-tagging algorithm. The dominant source of background in the analysis is due to events with a light-flavor jet which is misidentified as a b-jet (mistags). Other backgrounds with

heavy-flavor jets in the final state come from SM QCD multijet processes, W and Z production in association with jets, $t\bar{t}$, single top, and diboson decays. All the background contributions have been estimated with MC simulation, except for mistags and QCD modelled with data driven techniques. Final selection cuts were optimized to enhance the signal over background separation for different values of the sbottom mass $M_{\tilde{b}_1}$. CDF[9] performed a very similar analysis in 2.65 fb^{-1} of data. None of the two experiments observed any significant deviation from the background predictions and the results have been translated into 95% exclusion limits on sbottom pair production cross section and sbottom-neutralino masses. Figure 1 (right) shows the DØ exclusion limit on the neutralino/sbottom mass plane and compares the latest results with previous limits from CDF and DØ in Run I and Run II. DØ excludes sbottom masses up to 250 GeV/c^2 with the $M_{\tilde{\chi}_1^0} < 70$ GeV; in the same range of neutralino masses CDF excludes sbottom masses below 232 GeV/c^2.

1.3 Searches for Scalar Top Quarks

In a constraint MSSM scenario, the large top quark mass leads to a substantial splitting between the masses of the two stop states, allowing $\tilde{t}_1$ to be the lightest squark. Due to the conservation of R-parity, scalar tops are pair produced and can decay into a neutralino and a charm quark. CDF[7] searched for the production of stop pairs decaying into a final state of two c-jets and large missing transverse energy coming from the LSP neutralinos. The heavy flavour tagging efficiency was enhanced with a NN-based flavour separator and the final selection was optimized for best sensitivity at different stop masses. Good agreement has been found between the number of events observed in 2.6 fb^{-1} of data and the SM predictions, and CDF set exclusion limits on the production cross sections for different values of the neutralino-stop masses. With the assumption that $\tilde{t}_1$ decays 100% of the times into a charm quark and a neutralino, CDF excludes stop masses up to 180 GeV/c^2 for $M_{\tilde{\chi}_1^0} \sim 90$ GeV/c^2. DØ[8] searched for stop in 3.1 fb^{-1} of data and assuming a different MSSM scenario, with $BR(\tilde{t}_1 \to b\tilde{\nu}\ell) = 100\%$. In this case, the sneutrino $\tilde{\nu}$ is the LSP and generates $\not\!\!E_T$ in the final state with two opposite sign leptons and two jets coming from the hadronization of the bottom quarks. No evidence of SUSY has been found and the extracted 95% C.L. limit excludes stop masses up to 200 GeV/c^2 for sneutrino masses below 100 GeV/c^2.

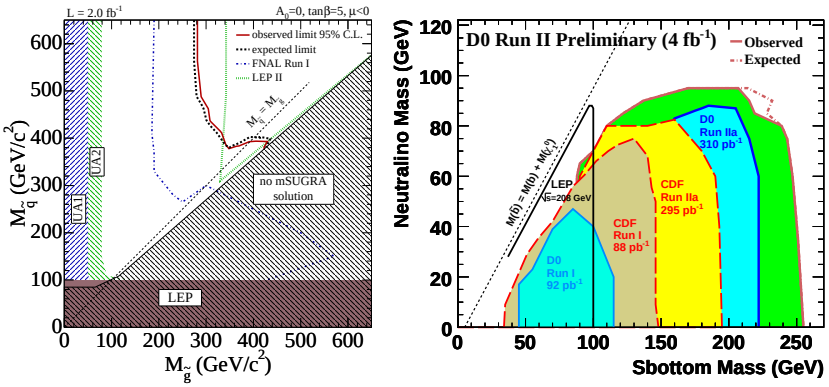

Figure 1: LEFT: CDF 95%C.L. exclusion limit on the gluino-squark production in the squark-gluino mass plane. RIGHT: The DØ 95%C.L. sbottom pair production exclusion contour in $(M_{\tilde{b}_1}, M_{\tilde{\chi}_1^0})$ mass plane.

2 Searches for Charginos and Neutralinos

2.1 Search for Charginos and Neutralinos in Trilepton Decays

After the Supersymmetry breaking, charginos and neutralinos can have low mass and a no negligible cross section at Tevatron. In a scenario with light enough sleptons, the two leptonic decays $\tilde{\chi}^{\pm} \rightarrow \ell\nu\tilde{\chi}_1^0$ and $\tilde{\chi}_2^0 \rightarrow \ell^+\ell^-\tilde{\chi}_1^0$ are enhanced, and the final state contains three isolated leptons and large missing $\not\!\!E_T$. CDF [12] and DØ [11] searched for charginos and neutralinos in events with three identified leptons in the final state, and accepting also events with only two identified leptons plus an isolated track. The observed data were found to be consistent with SM predictions and 95%C.L. exclusion limits on the production cross section and leptonic branching fraction have been extracted. Results have been interpreted within the framework of mSUGRA, where exclusion limits on the stop production cross section lead to the exclusion of a range of M_0 and $M_{1/2}$ values. Figure 2 (left) shows the DØ excluded region on the M_0-$M_{1/2}$ plane.

2.2 Search for GMSB Charginos and Neutralinos

When the SUSY breaking mechanism is gauge mediated (GMSB), the LSP is the gravitino $\tilde{G}$ with a very low mass of just few KeV. At Tevatron, analyses developed in a GMSB framework focus on the search for gauginos pair production with the assumption that the neutralino is the NLSP and decays as $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$. Depending on the value of their lifetime, neutralinos might decay with a signature of one or two photons and large $\not\!\!E_T$ due to the presence of gravitinos in the final state. The latest results from CDF [13] collaboration include a search for short-lived neutralinos in the di-photon final state, using 2.6 fb^{-1} of data. No event survived the analysis cuts and the null observation was consistent with the prediction of 1.2 ± 2.6 events from SM background. A specific set of GMSB parameters, the one that corresponds to the *Snowmass Slope* constraint SPS8 [14], has been set as a benchmark for the optimization of the final thresholds and the interpretation of the results Considering neutralino lifetimes up to 2 ns 95%C.L. limits on production cross section and masses have been set, with neutralinos lighter than 149 GeV/c^2 excluded for lifetimes below 1 ns .

3 Search for SUSY Hidden Valley

DØ [18] performed a search for a new light gauge boson called dark photon (γ_D) within a SUSY hidden valley framework [17] in which particles are produced in pairs and decay into SM particles and the lightest neutralino $\tilde{\chi}_1^0$. In this scenario $\tilde{\chi}_1^0$ is not the LSP and can further decay into a so called darkino $\tilde{\text{X}}$ (the hidden sector state) plus a photon or a dark photon. γ_D ultimately decays into a pair of spatially closed fermions and, if $BR(\tilde{\chi}_1^0 \rightarrow \gamma_D\tilde{\text{X}})$ is small enough, the final state signature is analogous as in GMSB models with jets or leptons plus $\not\!\!E_T$ in the final state. Since the expected backgrounds from SM jets is enormous, the search was optimized for a signature with spatially closed lepton pairs, opposite charged electrons or muons. No evidence of dark photon signal has been found in the 4.1 fb^{-1} of data analyzed and the resulting 95%C.L. limit on production cross section excludes chargino masses up to 230 GeV/c^2 for M_{γ_D} below 0.5 GeV/c^2.

4 Search for RPV Scalar Neutrinos

In some SUSY scenarios the R-parity is not conserved and the LSP can decay into SM particles, no longer providing a valid cold dark matter candidate. Tevatron analyses developed in RPV scenarios focus on the search for resonant scalar particles decaying into a pair of leptons of different flavors. The latest searches from CDF [16] and DØ [15] were optimized for a dilepton final state coming from the decay of a heavy sneutrino. CDF results are based on 1 fb^{-1} and assume

a signal of $e\mu$, $e\tau$, and $\mu\tau$. DØ used 4.1 fb^{-1} of data and assumed a final state with only $e\mu$ from $\tilde{\nu}_t$ decay. Results were found to be consistent with SM predictions and with no evidence of SUSY, 95%C.L. exclusion limits on the production cross section times branching ratio (see Figure 2 (right) for DØ) have been extracted.

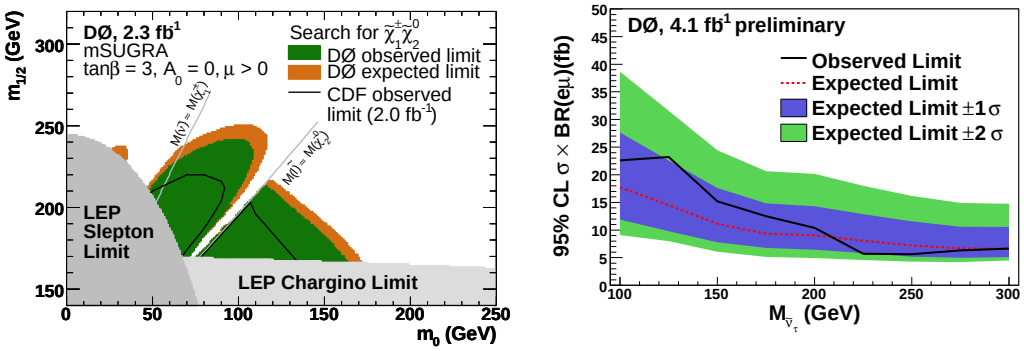

Figure 2: LEFT: DØ chargino-neutralino excluded region as a function of M_0-$M_{1/2}$ mSUGRA parameters (green). RIGHT: DØ limits on RPV sneutrino production cross section times branching ratio ($\sigma \times$ BR).

5 Summary

This contribution reports on the most recent results of searches for Supersymmetry at the Tevatron. The review includes analyses performed by the CDF and DØ collaborations using up to 4.1 fb^{-1} of data. None of the searches have found hints of new physics and the results have been translated into 95%C.L. exclusion limits on the free parameters of several SUSY scenario.

References

1. J. Wess and B. Zumino, *Nucl. Phys.* B **70**, 39 (1974).
2. J. R. Ellis, S. Kelley, and D.V. Nanopolous, *Phys. Lett.* B **260**, 131 (1991).
3. A.H. Chamseddine, R. Arnowitt, and P. Nath, *Phys. Rev. Lett.* **49**, 970 (1982).
4. S. Ambrosiano, G.L. Kane, G.D. Kribs, S.P. Martin and S. Mrenna, *Phys. Rev.* D **54**, 5395 (1996).
5. CDF Collaboration, T. Aaltonen et al, *Phys. Rev. Lett.* **102**, 121801 (2009).
6. DØ Collaboration, V.M. Abazov et al, *Phys. Lett.* B **660**, 449 (2008).
7. DØ Collaboration, V.M. Abazov et al, *Phys. Lett.* B **665**, 1 (2008).
8. DØ Collaboration, V.M. Abazov et al, *Phys. Lett.* B **665**, 1 (2008).
9. CDF Collaboration, *Public Note* **9834**, (2009)
10. DØ Collaboration, *Conference Note* **5931**, (2009)
11. DØ Collaboration, V.M. Abazov et al, *Phys. Lett.* B **680**, 34 (2009).
12. CDF Collaboration, *Public Note* **9817**, (2009)
13. CDF Collaboration, *Public Note* **9625**, (2009)
14. B.C. Allanach et al., *European Physical Journal* C **25**, 1 (2002)
15. DØ Collaboration, *Conference Note* **5894**, (2009)
16. CDF Collaboration, *Public Note* **9430**, (2009)
17. T. Han, Z. Si, K. Zurek, and M. Strassler, JHEP 0807, 008 (2008); M. Strassler and K. Zurek, *Phys. Rev. Lett.* **B**, 651 (374)2007.
18. DØ Collaboration, V.M. Abazov et al, *Phys. Rev. Lett.* **103**, 081802 (2009).