NEW PHENOMENA SEARCHES AT THE TEVATRON

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In this article results from the searches for the new phenomena at D0 and CDF are reported. SUSY searches for the charginos and neutralinos, and the GMSB models are described. In addition, searches for the new resonances, and the dark matter are shown. As no signs of the new physics for these models are observed, the most stringent limits to date are presented.

1 Introduction

In spite of the great success of the standard model in description of the natural phenomena, many questions still remained unanswered. Thus many new models have been proposed in the past. Experiments at the Tevatron collider, CDF and D0 developed vigorous program to search for many models over the years. Even after the first successful year of the LHC experiments, some of the results from the CDF and D0 are the most stringent. Some of these results are presented in this report.

2 SUSY Searches

CDF [1] updated the search for the production of charginos ($\tilde{\chi}^{\pm}$) and neutralinos ($\tilde{\chi}^{0}$) in the final states with at least three leptons with 5.8 fb^{-1} of data. The final states under consideration are eel and $\mu\mu l$, where l is an electron or a muon or a hadronic tau or an isolated track. Events are selected if they have at least one central electron or muon with the $p_T > 20$ GeV. The second and the third leptons are required to have $p_T > 5$ GeV. Main background is the Drell-Yan process, with smaller contributions from diboson and $t\bar{t}$ production. Background model is verified in dedicated control regions. Signal region is obtained requiring that missing E_T, $\not{E}_T > 15$ GeV, that there is no more than one jet in the event, and that the invariant mass of the two leptons is $M_{ll} < 76$ GeV and $M_{ll} > 106$ GeV. Figure 1(left) shows dielectron mass of the selected events, and Fig. 1(middle) $\not{E}_T$ in dimuon channel. In the absence of the signal, limits interpreted in mSUGRA, benchmark with $m_0 = 60$ GeV, $tan\beta = 3$, $A_0 = 0$, and $M_{1/2} = 160$ GeV are set (Figure 1(right)).

CDF [2] searched for the chargino and neutralino supersymmetric particles with the same signed dilepton and one hadronically decaying τ-lepton in the final state using 6.0 fb^{-1} of data. Results of this search are interpreted in simplified models of SUSY, where limits are set on the particle masses. Two models of the simplified SUSY were considered, one similar to the mSUGRA and another, similar to the GMSB. In the simplified gravity model, $\tilde{\chi}_1^{\pm} - \tilde{\chi}_2^{0}$ pairs are produced via electroweak interaction, and further decay into slepton ($\tilde{l}^{\pm}$) and neutrino (ν), and $\tilde{l}^{\pm}$ and lepton ($l^{\pm}$). To enhance production of the τ-leptons in final state, two branching ratios were selected: $BR(\tilde{\chi}_2^0, \tilde{\chi}_1^{\pm} \rightarrow \tilde{\tau}^{\pm} + X = 1, 1/3$. In a simplified gauge model, the LSP

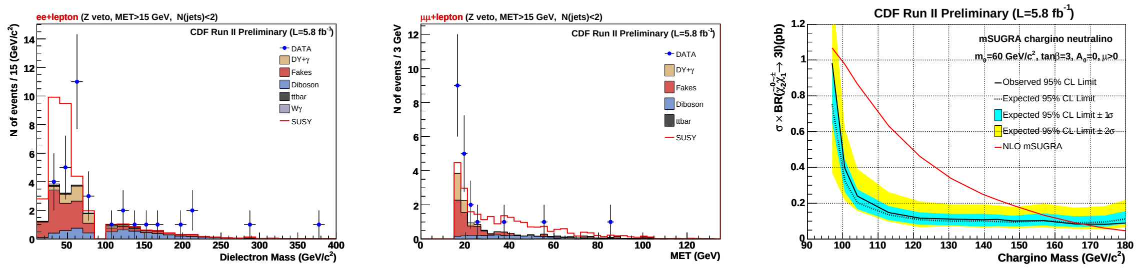

Figure 1: Invariant mass of the two leptons (left), the missing ET (middle) and the limit on chargino neutralino production as a function of chargino mass (right).

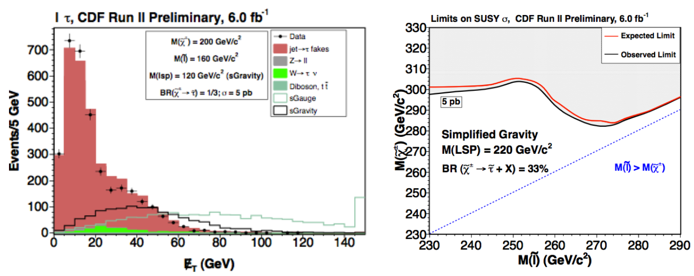

Figure 2: The $\not{E}_T$ (left) and the limit on the $\tilde{\chi}_1^{\pm}, \tilde{l}^{\pm}$ masses.

is gravitino which is very light, and charginos don't couple to the right handed leptons, thus $BR(\tilde{\chi}^{\pm}1 \to \tilde{\tau}_1^{\pm}\nu_\tau) = 1$. Events are selected if they contain pair of electrons and muons with $p_T > 10$ GeV with the same charge, and hadronic τ with $p_T > 15$ GeV. It is further required that the scalar sum of the p_T of the leptons, hadronic τ and missing E_T is greater than 45 GeV. Signal is searched in events with $\not{E}_T > 20$ GeV (Figure 2(left)), and since no significant excess is observed, limits on the masses of the $\tilde{\chi}_1^{\pm}, \tilde{l}^{\pm}$ (Figure 2(right)).

D0 [3] presented the first search for SUSY in $Z\gamma$ final states with large missing transverse energy using 6.2 fb^1. These signatures are predicted by GMSB SUSY models where the lightest neutralino, $NLSP$, is produced in pairs. They decay to either a Z boson or a photon and to a gravitino that escapes detection. The model considered in this search is parametrized by an effective SUSY breaking scale Λ. Events are selected if they contain pair of oppositely charged leptons consistent with a Z-boson, γ and large $\not{E}_T$ (Figure 3 (left)). Signal is further separated from backgrounds using Boosted Decision Tree (BDT) technique (Figure 3 (middle)). In the absence of any significant excess limits are set. A model with the $\Lambda < 87$ TeV is excluded and also the lightest neutralino with $m < 151$ GeV is excluded (Figure 3 (right)).

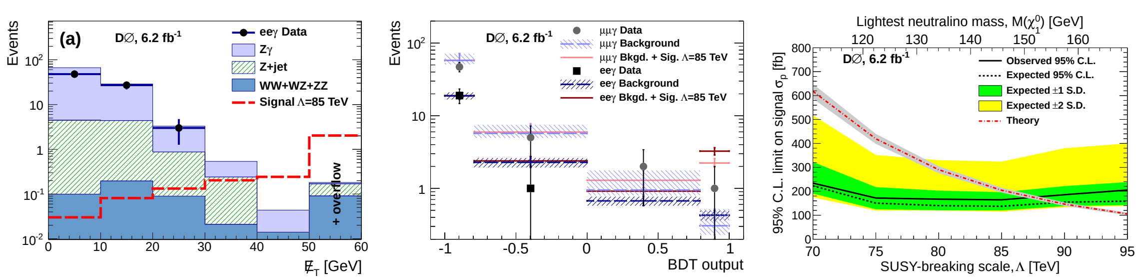

Figure 3: The missing E_T (left), output of the BDT middle, and the limit of the signal cross section as a function of the Λ (right).

3 Non SUSY Searches

3.1 Searches for resonances

CDF [4] searched for a high-mass resonances decaying into the Z boson pairs using data corresponding to the 6 fb^{-1}. Many theories present models with a resonance decaying to a pair of the Z bosons, for instance Randall Sundrum graviton (G^*), where the G^* couplings to light fermions and photons are heavily suppressed. The process examined in this search is $G^* \to ZZ \to ll + X$, where $X = ll$, jj or $\nu\nu$. Leptons are selected with $p_T > 20$ GeV, and jets with $p_T > 25$ GeV. In the $ZZ \to ll$ channel, it is required that leptons with the same flavor are consistent with a Z boson. Signal is searched as an in M_{ZZ}. In the $ZZ \to ll\nu\nu$ signal events are selected if $\not{E}_T > 100$ GeV and excess is looked for in the visible mass of the ZZ system, defined as the invariant mass of the sum of the two charged lepton four-momenta and the four-vector representing the $\not{E}_T, (\not{E}_T(x), \not{E}_T(y), 0, \not{E}_T)$ (Figure 4(middle)). In $ZZ \to lljj$ channel, selection of the $Z \to jj$ is done in the two steps. First, all pairs of jets with invariant mass between 70 and 110 GeV are kept. Then, the constrained fit is used to select the best candidate. The invariant mass of the two Z bosons is then used to search for the excess (Figure 4 in the $lljj$ final state (left) and $ll\nu\nu$ final state (middle)). Since no significant excess has been observed, the limit is set as shown on Figure 4(right).

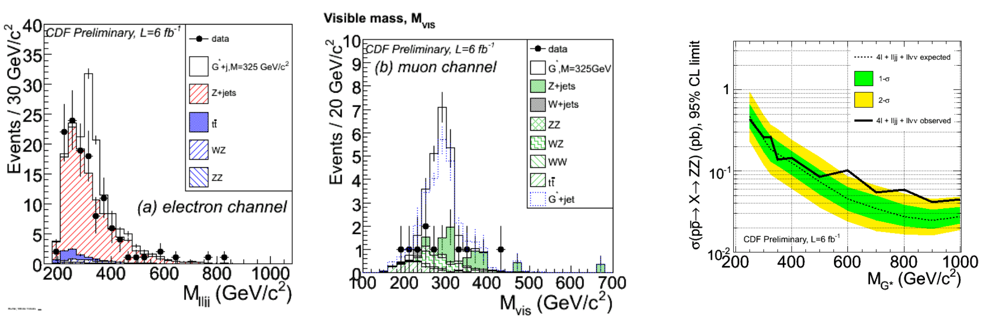

Figure 4: Invariant mass of the ZZ system in the $lljj$ final state (left) and the visible mass of the ZZ system $ll\nu\nu$ final state (middle). Limit on the graviton production as a function of its mass.

3.2 Searches for dark matter

CDF [5] searched for dark matter production in the monojet + missing transverse energy signature in 6.7 fb^{-1} of data. The process under study is $p\bar{p} \to \bar{\chi}\chi + jet$, where χ is the dark matter particle and the jet originates from initial state radiation. Events with significant missing E_T, $\not{E}_T > 60$ GeV and one energetic jet, $p_T > 60$ GeV are selected. Main background processes are multijets production obtained from data, and electroweak (W and Z) obtained from simulation, but normalized to data in the dedicated control region. Signal is searched in the the region of the high p_T of the jet as shown in Figure 5(left). In the absence of a significant excess, upper limits are set Figure 5(right). These limits are converted into constraints on the dark matter-nucleon cross section and they are comparable to the results of direct searches (Figure 6).

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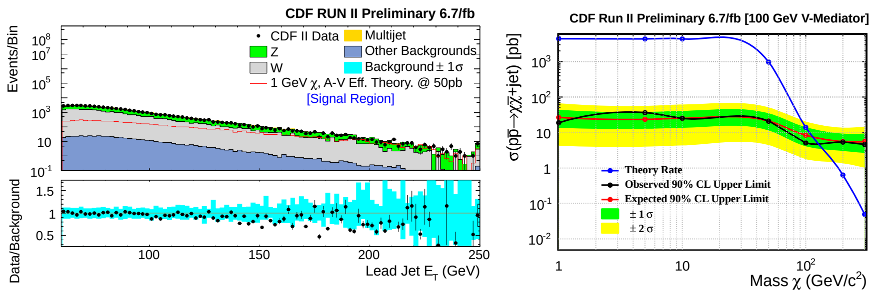

Figure 5: The leading jet p_T (left) and the limit on dark matter production as a function of its mass (right).

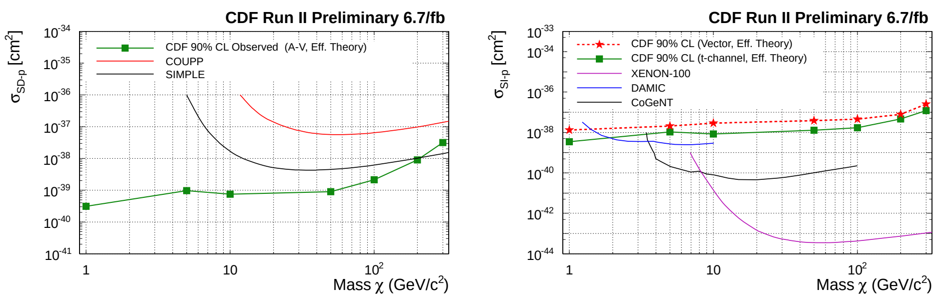

Figure 6: Limits on the dark matter-nucleon cross section compared with the results from direct searches.

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