Search for Supersymmetry in the Trilepton Channel $q\bar{q} \rightarrow \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \rightarrow 3\ell + \not\!\!E_T$ with the DØ Detector at TeVatron Run II

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In the mSUGRA unified model, the lighter charginos ($\tilde{\chi}_1^{\pm}$) and the lighter neutralinos ($\tilde{\chi}_1^0, \tilde{\chi}_2^0$) are typically less massive than gluinos and squarks. Therefore, the signal with three leptons and missing transverse energy ($3\ell + \not\!\!E_T$) in the final state, from associated production and decay of $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ is one of the most promising channels for supersymmetric (SUSY) particles searches at the TeVatron $p\bar{p}$ collider [1]. The $\tilde{\chi}_1^{\pm}$ $\tilde{\chi}_2^0$ decays can proceed via electroweak bosons Z^*, W^*(Fig. 1) or via sleptons.

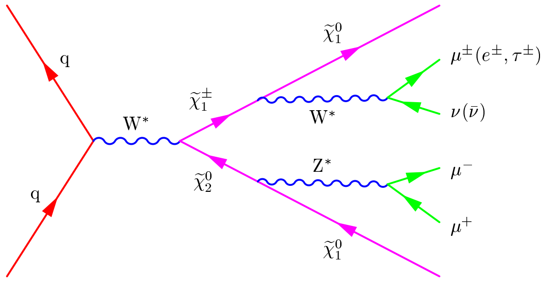

Fig. 1: Feynman diagram for associated $\tilde{\chi}_1^{\pm}$ $\tilde{\chi}_2^0$ production and subsequent decay to $3\ell + \not\!\!E_T$ final state.

In this analysis only the decay channel with two muons, an additional charged lepton and $\not\!\!E_T$ in the final state is investigated.

At the DØ experiment muons are detected in the muon system and matched to tracks identified with the inner detector. The muon detector itself consists of scintillator counters and drift tubes, with effectively complete coverage out to $|\eta| \leq 2$. The detector is split at $|\eta| = 1$ into a central and forward system. [2,3].

The most important backgrounds for this selection are $Z \rightarrow \mu\mu$ and $Z \rightarrow \tau\tau$ decays and multijet background which can be greatly reduced with a cut-based selection. Backgrounds from $tt \rightarrow \mu\mu$, $WW \rightarrow \mu\nu\mu\nu$ and $WZ \rightarrow \mu(e,\tau)\nu\mu\mu$ are irreducible but negligible due to their small cross section. Events from $W \rightarrow \mu\nu$ (including $W \rightarrow \mu\nu + b\bar{b}$) were also taken into account. The multijet background has been determined directly from data by modifying the selection to require non-isolated muons instead of isolated muons. The sample was normalized at an early stage of the selection in a region of phase space dominated by multijet production.

In this analysis the data sample collected with the DØ detector from August 2002 till June 2004 was used, corresponding to the integrated luminosity of L = 300 pb^{-1}.

The supersymmetric (SUSY) signal has three isolated leptons with rather low transverse momenta in the range of $5 \leq \mathrm{p_T}[\mathrm{GeV}] \leq 30$. For one particular mSUGRA point the transverse momenta of the three leptons (only muons) is shown in Figure 2. The mSUGRA parameter values are $m_{1/2} = 170$ GeV, $m_0 = 76$ GeV and $\tan\beta = 3$ ($A_0 = 0$, $sign(\mu) > 0$).

The preselection consists of events with two muons tracks satisfying the muon quality cuts. The two leading p_T muons must have a transverse momentum of $\mathrm{p_T} > 11$ GeV and $\mathrm{p_T} > 5$ GeV and must be isolated. After the preselection and excluding the Z resonance the missing transverse energy spectra are shown in Figure 3 (SM backgrounds are normalized to the integrated luminosity).

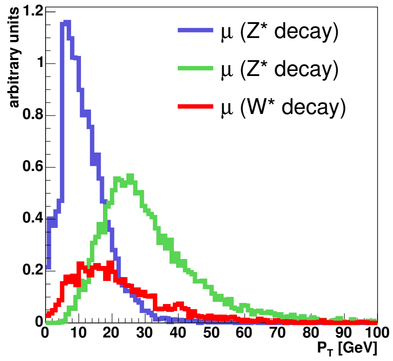

Fig. 2: Transverse momenta of the muons from the subsequent decay of $\tilde{\chi}_1^{\pm}$ (red line) and $\tilde{\chi}_2^0$ (blue and green line)

The expected backgrounds from SM processes agree with the data, the signal (red line) shows an high amount of missing transverse energy (due to the stable lightest supersymmetric particle $\tilde{\chi}_1^0$ and the neutrino).

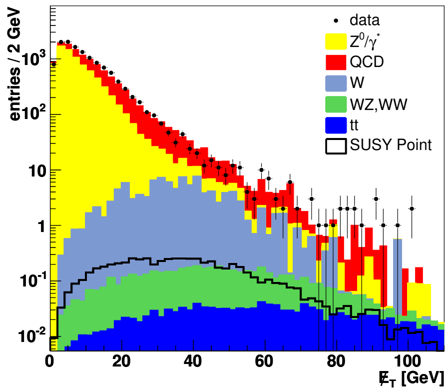

Fig. 3: The missing transvers energy spectra after exluding the Z resonance for SM background and data.

Only events with a third track (originating from a muon, electron or tau) and large missing transverse energy are selected for the final analysis. These cuts eliminate most of the expected SM background processes. After all cuts, 2 events remain in the data to be compared with 1.75±0.34(stat.)±0.46(syst.) expected from background processes. No evidence for supersymmetry production has been found and limits on the product of production cross section and leptonic branching fraction of typically 1.0 pb have been set.

References

[1] V. Barger, C.E.M. Wagner *et al.*, hep-ph/0003154
[2] DØ Collaboration, B. Baldwin *et al.*, DØ note 3365
[3] DØ Collaboration, G. Alexeev *et al.*, DØ note 3366