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SEARCH FOR ASSOCIATE CHARGINO NEUTRALINO PRODUCTION IN TRILEPTON FINAL STATES

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Searches have been performed for the trilepton decay signature from the associated production of the lightest chargino and the next-to-lightest neutralino in leptonic channels with (a) two electrons and a lepton, (b) an electron, a muon and a lepton (c) two muons and a lepton and (d) two like-sign muons. The searches use data taken with the DØ detector at the Fermilab Tevatron proton-antiproton collider at a center-of-mass energy of 1.96 TeV corresponding to an integrated luminosity of 147 pb^{-1} to 249 pb^{-1}.

1. Introduction

In R-parity-conserving minimal supersymmetric extensions of the Standard Model [1], the charged and the neutral partners of the gauge and Higgs bosons, charginos($\chi^{\pm}$) and neutralinos (χ^0) are produced in pairs at $p\bar{p}$ colliders and decay into fermions and the Lightest Supersymmetric Particle (LSP).

Up to spring 2004, the DØ experiment at the $p\bar{p}$ collider Tevatron at Fermilab has collected data corresponding to an integrated luminosity of about 250 pb^{-1}at the center-of-mass energy of 1.96 TeV. This article summarizes the results of four analyses which search for the associated production of the lightest chargino and the second-lightest neutralino in final states with three leptons and large missing transverse energy ($\not{E}_T$):

- (1) final states with two electrons and a third lepton (249 pb^{-1})
- (2) final states with an electron a muon and a third lepton(235 pb^{-1})
- (3) final states with two muons and a third lepton (221 pb^{-1})
- (4) final states with two like sign muons (147 pb^{-1}).

2. Analysis strategy

The analyses require two tightly identified leptons with minimal transverse momentum (p_T) in the range of 5 to 15 GeV. Figure 1 shows the distribution of the dimuon mass at this stage. A low-mass window is selected and back-to-back leptons are rejected.

As opposed to most of the standard model background, typical SUSY events have large natural $\not{E}_T$ due to neutrinos and the LSP, which escape detection and are hence enriched by requiring $\not{E}_T$ in excess of 15-20 GeV (see Figure 1). Background

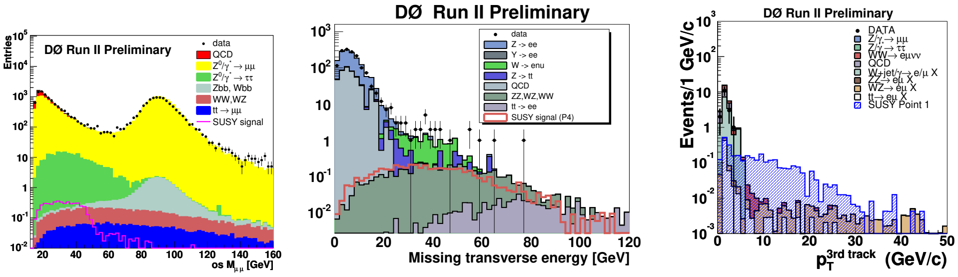

Fig. 1. From left to right: Dimuon mass (analysis 3), missing transverse energy (analysis 1) and transverse momentum of the 3rd track (analysis 2) in data (points with error bars) and expected background (hisograms). A SUSY signal with $m_{\chi^\pm} \approx 105$ GeV is added

events with large-$\not\!\!E_T$ due to resolution effects are reduced by requiring a minimum angle with the leptons, a minimum transverse mass and a large ratio of $\not\!\!E_T$ and the expected impact of the jet resolution.

The analyses 1 to 3 make use of the third, mostly soft, lepton in the signal by requiring a well reconstructed and isolated track with a mimimum p_T in the range of 5 GeV (see Figure 1). Final purification of the signal is done by requiring a large product of $\not\!\!E_T$ and p_T(track) and a balanced p_T sum of the tree leptons and the $\not\!\!E_T$ in the signal.

3. Results

Number of candidate events observed and standard model background expected after all cuts applied are listed in Table 1. Selected data agrees with the standard model expectation.

Table 1. Number of candidate events observed and background and signal events expected in the four analysis channels

Analysis	Data	Total Background	mSUGRA		
			$m_{\chi^\pm} = 97GeV$	$m_{\chi^\pm} = 105GeV$	$m_{\chi^\pm} = 114GeV$
e+e+ℓ	1	0.68 ± 0.40 ± 0.32	2.21±0.11±0.09	1.65±0.07±0.09	1.39±0.06±0.08
e+μ+ℓ	0	0.29 ± 0.33 ± 0.02	1.51±0.07±0.08	1.18±0.05±0.06	0.86±0.03±0.05
μ+μ +ℓ	1	1.83 ± 0.40 ± 0.21	1.28±0.06±0.14	1.06±0.04±0.12	0.70±0.03±0.07
LS μ+μ	1	0.13 ± 0.06 ± 0.02	0.39±0.03±0.03	0.37±0.03±0.03	0.24±0.02±0.02

As a guideline, the results are interpreted in the minimal supergravity model (mSUGRA) with chargino and neutralino masses mainly following the relation $m_{\chi_1^\pm} \approx m_{\chi_2^0} \approx 2m_{\chi_1^0}$. The points in mSUGRA parameter space considered here are characterized by low slepton masses, which lead to an enhanced leptonic branching fraction. In Table1, the numbers of SUSY events expected are listed exemplarily

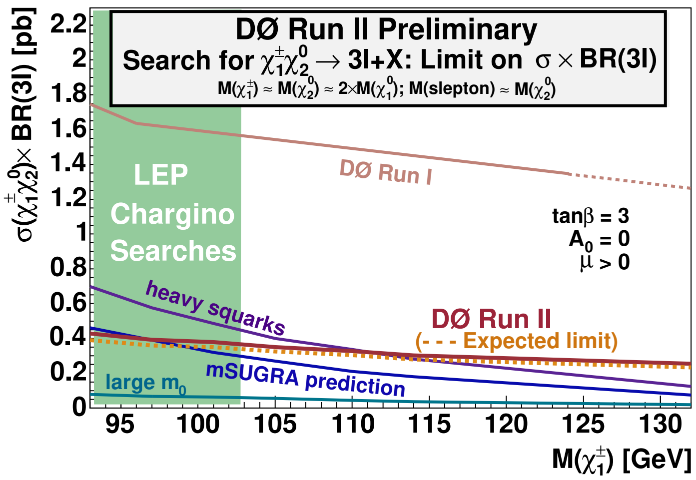

Fig. 2. Limits on the total cross section ($\sigma\times$BF) for associated chargino and neutralino production with leptonic final states set by DØ in Run I (top line) and in this analysis (second from top) in comparison with the expected limit (dashed line). Reference lines show the $\sigma\times$ BF(leptons) for models with heavy squark masses and low slepton masses (top line), mSUGRA with low slepton mases (middle line) and large m_0 scenarios (bottom line). Chargino masses below 103 GeV are excluded by direct searches at LEP.

for three model points with chargino masses in the region of the LEP II chargino limit [3] of 103 GeV.

The resulting cross-section limits are shown in Figure 2 as a function of the chargino mass. Beyond the reach of LEP chargino searches, the limit set by the combination of the four analyses is improving significantly on the DØ Run I result [4] and on the CDF Run I result [5]. The analysis excludes chargino masses below 97 GeV with comparable chargino, neutralino and slepton masses. The analysis is nearly sensitive to cross sections beyond the LEP chargino limit predicted within minimal SUGRA. The current results can be used though to constrain more generic SUSY models with compatible mass hierarchies in the slepton, chargino and neutralino sector. By dropping the sfermion mass universality, for example, squarks can be heavy while sleptons remain light. Within this scenario, chargino masses below 111 GeV are excluded by the present analysis.

References

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