1304: Supersymmetry Searches at the Tevatron

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Abstract. Searches continue for evidence of supersymmetric particles in both the fixed-target and collider experiments at the Tevatron at Fermilab. The results of recent searches place new limits on the masses of squarks, gluinos, charginos, neutralinos, and the charged Higgs.

1 Tevatron Runs

The CDF and D0 experiments at Fermilab amassed a very large sample of data from proton-antiproton collisions at $\sqrt{s} = 1.8$ TeV in the years 1992-1996. These data have led to many new physics results, including the discovery of the top quark [1], precision measurements of the W mass, and searches for new phenomena. This talk covers some of the recent results in the searches for supersymmetric particles at CDF and DØ, and also a new result from the KTeV fixed-target experiment which collected data in the years 1996-1997.

2 KTeV Light Gluino Search

If supersymmetry gives rise to new fermion and boson partners in nature, and R-parity is conserved, there exists the possibility that the gluino (the fermionic partner of the gluon) could form a bound state with a gluon in a relatively stable neutral bound state. [2] This state, denoted R^0, would be pair-produced strongly, and could have a lifetime of up to milliseconds.

The KTeV detector comprises a kaon decay vacuum region with an active regenerator, a charged particle magnetic spectrometer, CsI electromagnetic calorimeter, and muon shield and scintillator hodoscopes. If R^0 particles are produced in the primary target, then if their lifetime is short enough to decay before reaching the spectrometer and not so short that the decay products miss the spectrometer, their decay to (for example) ρ plus photino will give two charged pions in the final state.

Figure 1 shows the region of R^0 mass and photino mass excluded by KTeV, using one day's worth of data.[3] The plot also shows the regions excluded on cosmological grounds. With more data and refined cuts, KTeV plans to extend this search to lower R^0 masses and other decay modes.

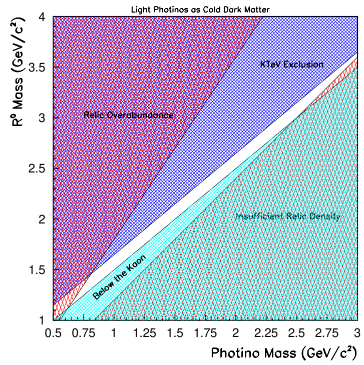

Fig. 1. KTeV and cosmological limits at 95% CL in the space of R^0 mass and photino mass.

3 Search for Squarks/Gluinos

At hadron colliders the production of squarks and gluinos proceeds via their strong coupling. The classic method is to look in final states with hadronic jets and missing transverse energy carried away by the lightest supersymmetric particle to which the squarks and gluinos ultimately decay. But there can be final states with leptons in addition, with relatively small backgrounds, which complement the search in the jets plus missing $\mathrm{E_T}$ final state.

The D0 collaboration has performed updated searches for squark-gluino production in the final states either having two electrons, two jets, and missing $\mathrm{E_T}$, or having multiple high-$\mathrm{E_T}$ jets with large missing $\mathrm{E_T}$. The number of events observed agrees well with the expected background from standard model processes. One can set limits in either the squark mass-gluino mass plane or in the plane of the assumed SUGRA unification masses m_0 and $m_{1/2}$, as shown in figure 2.

4 Chargino/Neutralino Search

Chargino-neutralino production in $\bar{p}p$ annihilation can lead to distinctive final states with three leptons and missing transverse energy. One lepton comes from the decay of the chargino, and two others come from the neutralino. The only standard model background which can contribute significantly to this channel is WZ production, which can be rejected with a mass requirement on same-flavor oppositely charged leptons.

CDF has updated the search for this process; the selection requirements retain no events from the full 107-pb^{-1} data sample. The remaining background processes would be expected to contribute 1.2±0.3 events. Figure 3

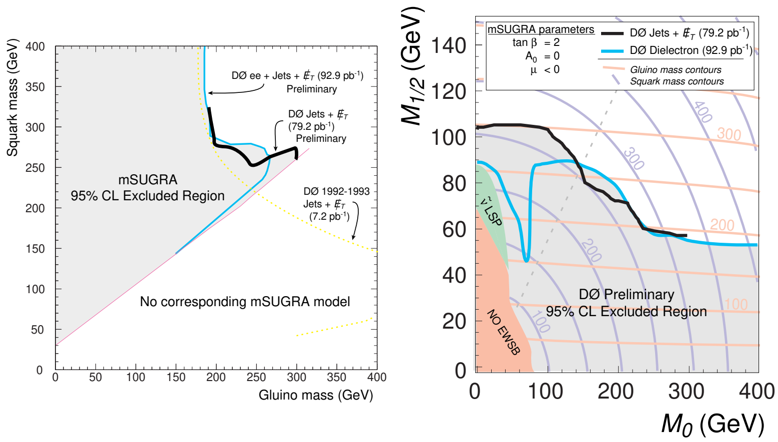

Fig. 2. Limits at 95% CL on (left) the masses of the squark and gluinos, and (right) on the parameters $m_{1/2}$ and m_0.

shows the resulting 95% CL limits on this process as a function of chargino mass, assuming the SUGRA unification mass relationships and branching ratios. The limit on chargino mass lies in the range 70-80 GeV/c^2, depending on the parameters μ and $\tan\beta$ of the model.

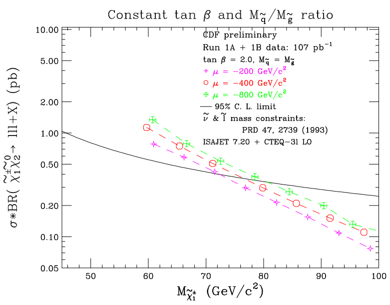

Fig. 3. CDF limits at 95% CL on chargino/neutralino production as a function of the chargino mass.

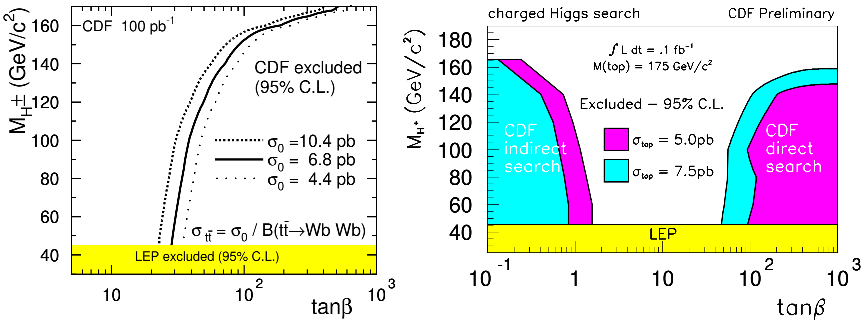

Fig. 4. Regions in plane of m_{Higgs} versus $\tan\beta$ excluded by the searches, (left) allowing the $t\bar{t}$ cross section to increase with $\tan\beta$ so as to maintain consistency with the top quark discovery, and (right) for the searches at low and high $\tan\beta$ with constant top cross sections.

5 Charged Higgs

Charged Higgs bosons arise in extensions to the standard model (such as supersymmetry) with two Higgs doublets. If the charged Higgs is less massive than the top quark, and if the parameter $\tan\beta$ (the ratio of the vacuum expectation values of the two Higgs doublets) is large, then the top can decay predominantly to the charged Higgs and a b quark. In this regime, the charged Higgs decays almost exclusively to $\tau\nu$.

CDF has performed a search for such events[4] by selecting those events with large missing E_T a hadronically decaying tau, two jets (one of which must be b-tagged), and a fourth object which can be either an e, μ, another hadronically decaying τ, or a third jet. Seven events pass the selection, with 7.4±2.0 expected from background.

Figure 4 shows the region of the m_H versus $\tan\beta$ plane excluded by the search. The direct search excludes the high-$\tan\beta$ region; the observed $t\bar{t}$ lepton plus jets events exclude the low $\tan\beta$ region.

References

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