The Lower Mass Limit on the Lightest Supersymmetric Particle, using ALEPH data up to 188.6 GeV

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The Lightest Supersymmetric Particle (LSP) is expected to be stable, massive and neutral. Direct searches for supersymmetric particles in the context of the minimal supersymmetric extension to the standard model have been performed with the ALEPH detector. Using about 175 pb^{-1} of data with centre-of-mass energies near 189 GeV a limit on the mass of the LSP of $M_{\rm LSP} > 32.3$ GeV/c^2 at 95% confidence can be derived, assuming R-parity is conserved.

1. Introduction

The ALEPH detector at LEP collected close to 175 pb^{-1} data at a centre-of-mass energy of 188.6 GeV. Searches in this data for the decays of Supersymmetric particles have shown no evidence for supersymmetry. This data can be interpreted as excluded regions in the MSSM parameter space. All conventions and notations are consistent with reference [1], where the searches for charginos and neutralinos using data taken at centre-of-mass energies near 183 GeV are reported. These exclusions extend the previous results using the ALEPH data given in references [1,2]. The results of the searches are interpreted as exclusions in the MSSM parameter space assuming that R-parity is conserved and the neutralino is the LSP. Sneutrino masses of less than 42 GeV/c^2 are already excluded by limits on Γ_Z [3].

2. Search for gauginos

The search for gauginos was performed first under the assumption of high slepton mass. The visible topologies and energy in gaugino pair production depend on the decay chain of the gaugino to LSP and on the mass difference between the gaugino and the LSP. Various topological searches are used, described in reference [1]. The selections were reoptimised to give the best expected limit (in the absence of a signal) for the higher energy and luminosity.

In total 25 chargino and 41 neutralino candidates were observed in at least one of the selections with the expected backgrounds from standard model processes being 23.0 and 44.3 events respectively. For the case of high sfermion mass the chargino will predominately decay via a W^* to the neutralino and the next to lightest neutralino (χ') will decay via a Z^*. For the topologies sensitive to these cases the number of data events were 10 (4) for chargino (neutralino) selections with an expectation of 6.8 (5.3) events from standard model processes. The data sample is consistent with the standard model expectations and so limits on the production cross-sections of charginos and neutralinos are derived. Only in the case of the WW background to the acoplanar lepton search are the expected backgrounds corrected for in the limits.

The limits for gaugino production close to the kinematic limit are shown in figures 1,2 for the case of heavy sfermions. These limits are shown as excluded contours in the μ v M_2 parameter space for $\tan\beta = \sqrt{2}$ in 3. Using these exclusions all points in the MSSM parameter space with neutralino masses of less than 32.3 GeV/c^2 are excluded for any $\tan\beta$ and $m_0 = 500$ GeV/c^2.

3. Search with low slepton mass

The case of low slepton mass is also considered. The chargino and neutralino pair production cross-sections have a dependence on the value of m_0 due to the s-channel exchange of a

$(Z/\gamma)^*$ and t-channel interference terms for the exchange of a $\tilde{\nu}_e$ or $\tilde{e}$. Also the branching ratio of leptonic decays are enhanced and invisible modes, for example $\chi' \to \nu\tilde{\nu}$, become kinematically allowed. The search for direct slepton production does however allow additional exclusions and the LEP 1 limit on the non-standard model contributions to Γ_Z [3] also excludes part of the parameter space. The combined exclusion for $m_0 = 75$ GeV/c^2 is shown in figure 4. Using the combination of these searches all points in parameter space with $M_\chi < 32.3$ GeV/c^2 are excluded for all m_0.

4. Conclusion

The overall limit limit on the LSP mass in the MSSM for the entire μ, M_2, tanβ and m_0 parameter space is $M_{LSP} > 32.3$ GeV/c^2. This limit is set at the point of large m_0, tan$\beta = 1$, $M_2 = 54.5$ GeV/c^2 and $\mu = -68.3$ GeV/c^2, here the lightest Higgs mass is above 96 GeV/c^2 for large m_A and stop mixing. The sensitivity of the ALEPH Higgs boson searches [4] at 189 GeV does not allow the exclusion of this point.

REFERENCES

1. ALEPH Collaboration, *Search for charginos and neutralinos in* e^+e^- *collisions at centre-of-mass energies near 183 GeV and constraints on the MSSM parameter space* CERN EP/99-014, Submitted to Euro. Phys. J. **C**.
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3. ALEPH Collaboration, *Searches for New Particles in Z Decays using the ALEPH Detector*, Phys. Rep. **216** (1992) 253.
4. ALEPH Collaboration, *Search for the neutral Higgs bosons of the Standard Model and the MSSM in* e^+e^- *collisions at 188.6 GeV* , ALEPH 99-007, CONF 99-003

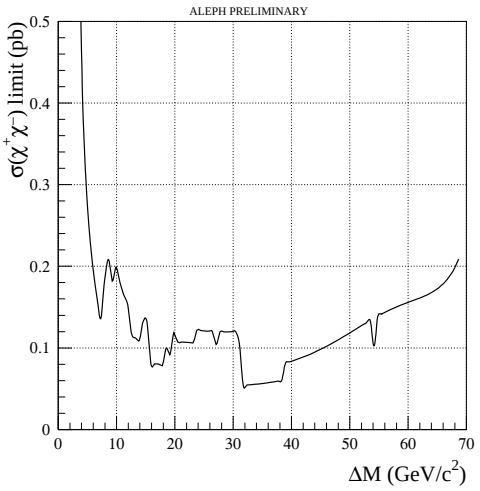

Figure 1. The plot shows the 95% confidence level upper limit on the $\chi^+\chi^-$ production cross-section as a function of $\Delta M = M_{\chi^\pm} - M_\chi$ for $M_{\chi^\pm} = 94$ GeV/c^2.

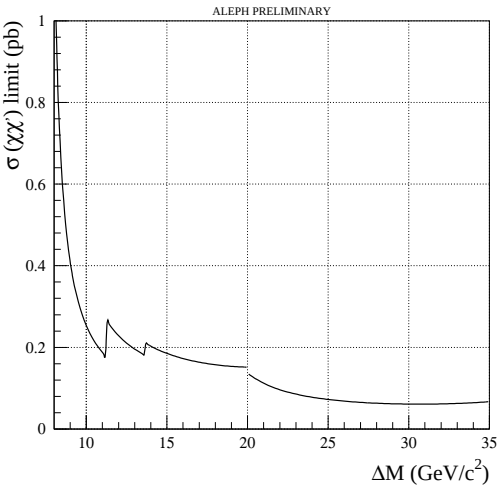

Figure 2. The plot shows the 95% confidence level upper limit on $\chi'\chi$ production as a function of $\Delta M = M_{\chi'} - M_\chi$ near the kinematic limit.

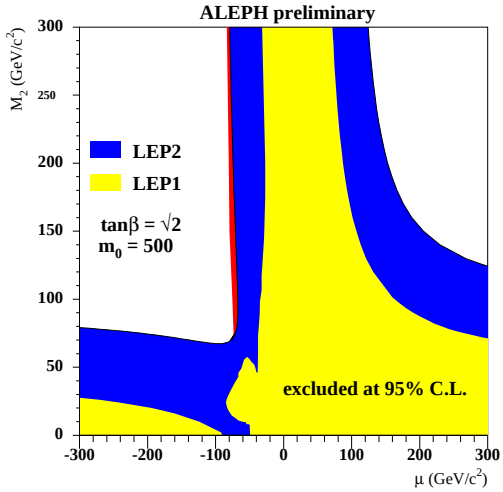

Figure 3. These are the 95% confidence level exclusion contour in the μ v M_2 plane for tanβ = $\sqrt{2}$ and m_0 = 500 GeV/c^2. The dark shading is excluded by chargino searches, the lighter band at negative μ is the additional exclusion from neutralino searches.

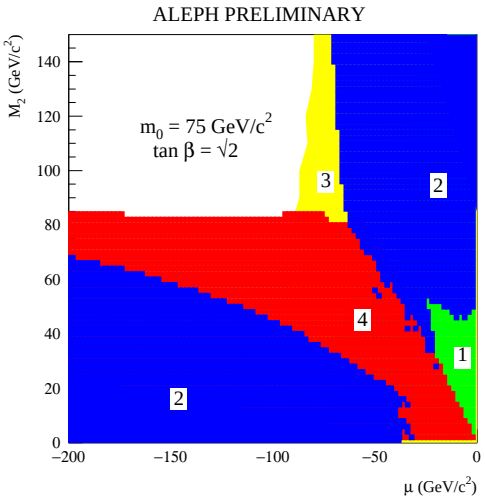

Figure 4. These are the excluded regions in the μ v M_2 plane for tan$\beta = \sqrt{2}$ and $m_0 = 75$ GeV/c^2, the exclusion are from (1) LEP 1 constraints and searches for (2) charginos, (3) neutralinos and (4) sleptons.