Any sign of new physics in 1999 L3 Data?

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Abstract
A brief status of the searches for new particles based on approximately 60 pb^{-1} of data collected by L3 experiment at $\sqrt{s} \simeq 192-196$ GeV is presented. The observed event rates in the studied search channels are consistent with the Standard Model expectations. All quoted results are preliminary.

1. Introduction

The increase center-of-mass energy, $\sqrt{s} \simeq 192 - 196$ GeV, in e^+e^- collisions at LEP, at openes a new window on the search for new physics. A preliminary analysis searching for the Standard Model Higgs Boson and for supersymmetric particles in a data sample collected by the L3 experiment is presented. The integrated luminosity at each energy corresponds to approximately 30 pb^{-1} .

2. Higgs Searches

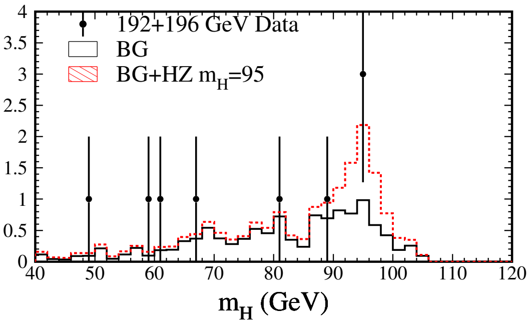
The dominant Higgs production modes is $e^+e^- \rightarrow Z^* \rightarrow HZ$. All significant signal decay mode are considered. The analysis procedure [1] is optimized for $H \rightarrow b\bar{b}$, which accounts about 85% of the Higgs branching fraction in the mass range of interest and Z decaying in $q\bar{q}$, $\nu\bar{\nu}$, e^+e^-, $\mu^+\mu^-$. The number of observed events is consistent with the background expectation over the entire studied interval of Higgs masses.

No evidence of a signal is seen in any of the channels.

For illustrative purposes, in Fig. 1(a) the reconstructed Higgs mass is shown for a sample of signal-like events selected, with mass-independent requirements, such as a large b-tag value. Combining these new results with those recently published a new limit on the Higgs boson mass is derived

$$m_H > 96 \text{ GeV at } 95\% \text{ CL}.$$

The exclusion confidence level as a function of the Higgs mass hypothesis is shown in Fig. 1(b). The range of Higgs masses from 80 to 100 GeV is considered in the present analysis.



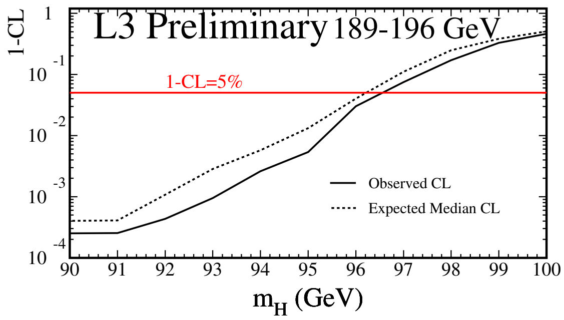


Figure 1. a) Reconstructed Higgs mass distribitions in 192-196 GeV data (with an integrated luminosity of 27.4 pb^{-1} and 27.9 pb^{-1} respectively for the most significant signal-like events) b) The observed and expected confidence level as a function of the Higgs mass.

3. SUSY searches

3.1. Scalar Leptons, Scalar Quarks, Charginos and Neutralinos

In this section, the search for new particles predicted by supersymmetric theories (SUSY) is

	Low ΔM		Medium ΔM		High ΔM		Combined	
	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}	N_{data}	N_{exp}
$\tilde{e}$	2	1.0	2	0.8	4	2.2	8	4.0
$\tilde{\mu}$	0	2.0	0	0.2	0	1.6	0	3.7
$\tilde{\tau}$	2	0.5	3	1.5	4	2.1	6	2.7
$\tilde{\chi}^{\pm}$	11	11.7	3	1.9	13	13.4	24	25.9
$\tilde{\chi}^0_2$	9	6.9	0	1.4	1	0.4	10	8.4
Combined	19	16.9	4	4.4	20	17.6	38	36.2

Table 1. Results for SUSY searches: N_{data} is the number of observed events and N_{exp} is the number of expected events from Standard Model backgrounds for 31 pb^{-1} of integrated luminosity collected at $\sqrt{s} \simeq 196$ GeV.

reported and limits in the Minimal Supersymmetric Standard Model (MSSM) framework are derived.

Besides the main characteristic of missing energy, supersymmetric particle signals can be further specified according to the number of leptons or the multiplicity of hadronic jets in the final state. Charginos, $\tilde{\chi}^{\pm}$, the supersymmetric partners of $W^{\pm}, H^{\pm}$ decay mainly to final states similar WW decay. For neutralinos, $\tilde{\chi}^0_2$, the supersymmetric partner of Z, γ and neutral Higgs boson we distinguish two classes of processes: $e^+e^- \rightarrow \tilde{\chi}^0_1\tilde{\chi}^0_2$ and $e^+e^- \rightarrow \tilde{\chi}^0_2\tilde{\chi}^0_2$. Both for charginos and neutralinos, the event energy is directly related to ΔM, ($\Delta M = M_{\mathrm{SUSY}} - M_{\tilde{\chi}^0_1}$), where the $\tilde{\chi}^0_1$ is the lightest stable supersymmetric particle (LSP).

Five types of selection criteria have been optimized for all possible decays of charginos [2] and used also for the selection of $\tilde{\chi}^0_2\tilde{\chi}^0_2$ events, which give rise to final states very similar to those of chargino pair production, even if with very different branching ratios.

The signal topologies and the associated background sources depend strongly on ΔM. Therefore all six selections are optimised separately for four different ΔM ranges: the very low ΔM range at $3-5$ GeV, the low ΔM range at $10-30$ GeV, the medium ΔM range at $40-70$ GeV and theΔM high range at $80-94$ GeV [3].

The scalar leptons, the supersymmetric partners of the right- and left- handed leptons, decay into their partner lepton and the neutralino $\tilde{\ell}^{\pm} \rightarrow \tilde{\chi}^0_1\ell^{\pm}$.

Their signatures are simpler since most of the time the final state is given by two acoplanar leptons of the same generation. To account for the three lepton types three different selections are performed. The dependence of the signals on ΔM is taken into account with three different optimisations for every selection: the low ΔM range at $3-5$ GeV, the medium ΔM range at $10-40$ GeV and the high ΔM range at $60-90$ GeV, as shown in Table 1.

In Figure 2a) and in Figure 2b), preliminary limits on chargino and neutralino pair production are swown.

At LEP energies the most important process involving scalar quarks are the production of $\tilde{t}_1$and $\tilde{b}_1$. The signal events of $\tilde{t}_1 \rightarrow c\tilde{\chi}^0_1$ and $\tilde{b}_1 \rightarrow b\tilde{\chi}^0_1$ are characterised by two high multiplicity acoplanar jets containing c- or b-quarks. In addition to the jets two leptons are present for $\tilde{t}_1 \rightarrow b\ell\tilde{\nu}$ and $\tilde{t}_1 \rightarrow b\tau\tilde{\nu}$ modes. The two $\tilde{\chi}^0_1$ in the final state escape the detector leading to missing energy in the event [5].

No excess of events relative to what is expected from Standard Model processes is observed in scalar leptons and scalar quarks searches. The collected luminosity does not allow to improve limits obtained at 189 GeV.

3.2. Models with light gravitinos

Search for scalar leptons, in the framework of the Gauge Mediated Supersymmetry Breaking (GMSB) models has been performed. The final state we are looking for is a pair of leptons plus a pair of high energy photons and missing energy. No evidence for a signal is found.

Single or two-photon events with missing energy could provide evidence for various processes involving supersymmetric particles like pair-production of neutralinos ($\tilde{\chi}^0_1\tilde{\chi}^0_1$, $\tilde{\chi}^0_1\tilde{\chi}^0_2$, $\tilde{\chi}^0_2\tilde{\chi}^0_2$, etc.), gravitinos ($\tilde{G}\tilde{G}$), or associated production of a neutralino and a gravitino ($\tilde{\chi}^0_1\tilde{G}$) [4]. Neutralinos, according to different supersymmetric models, can either decay as $\tilde{\chi}^0_2 \rightarrow \tilde{\chi}^0_1\gamma$ or to $\tilde{\chi}^0_1 \rightarrow \tilde{G}\gamma$. Pair-production of gravitinos can be accompanied by initial state radiation. The missing energy is carried away by the weakly interacting lightest supersymmetric particle (LSP). There are models, like LNZ, where the LSP is instead the gravitino. A light gravitino as LSP also appears in models with different SUSY breaking mechanisms like Gauge-Mediated SUSY Breaking (GMSB). In the Standard Model single or two-photon events with missing energy are produced via

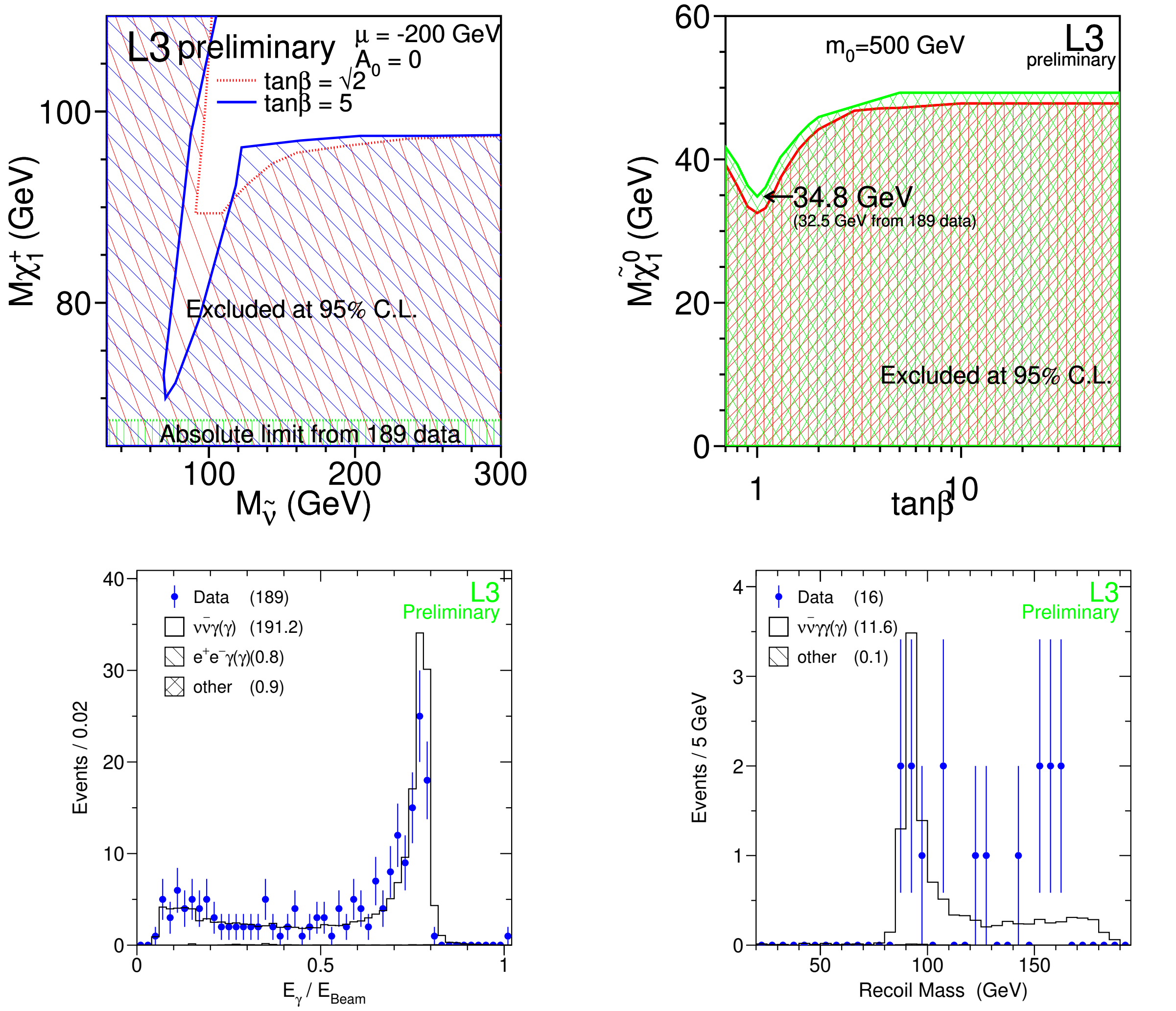


Figure 2. a) A lower limit on the chargino mass as a function ofthe sneutrino mass. b) Lower limit on the lightest neutralino mass $M_{\tilde{\chi}_1^0}$ as a function of $\tan\beta$ for large m_0, when combining all chargino and neutralino searches. The new exclusion (upper curve) is superimposed on the results from 189 GeV data (lower curve) c) Observed energy spectrum of the highest energetic photon normalised to the beam energy for single and multi-photon events at 192–196 GeV.d) Recoil mass distribution for the two-photon sample at 192–196 GeVwith an integrated luminosity of 62.8 pb^{-1}.

the reaction $e^+e^- \to \nu\bar{\nu}\gamma(\gamma)$. Figure 2c)d) shows the energy spectrum of the most energetic photon normalised to the beam energy for single and multi-photon events and the recoil mass for multiphoton events.

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