Is there new physics in the 1999 ALEPH data?

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Abstract
The first results on searches performed by ALEPH on the 1999 data sample are presented here. They are based on an integrated luminosity of about 54 pb$^{-1}$ collected at the two centre-of-mass energies of 192 and 196 GeV. Preliminary results on searches for supersymmetric particles and for the neutral Higgs bosons are shown.

1. Introduction
The LEP accelerator moved away from the Z peak in 1995 towards unexplored domains in high energy physics. In this new phase of LEP the experimental interest of the four LEP collaborations has been focused, in addition to the precise measurements of the W properties, on the search for new phenomena within (the Higgs boson) and beyond the Standard Model (SM). Since then every year the performance of LEP has gradually improved both in energy and in luminosity.

In 1998 ALEPH has collected 175 pb$^{-1}$ at a centre-of-mass energy of about 189 GeV. In 1999 LEP has performed an excellent start up delivering, up to now, an integrated luminosity of about 54 pb$^{-1}$ almost equally shared between the two centre-of-mass energies of 192 and 196 GeV. This start up is the best one since LEP has been switched on and it seems reasonable to expect that this year the machine will be able to deliver more than 200 pb$^{-1}$ at centre-of-mass energies up to 200 GeV.

In this paper the fresh results on searches obtained by ALEPH by analysing this first bunch of data are given. The two main streams of the ALEPH searches are updated starting from searches for Supersymmetric (SUSY) particles in the three possible SUSY breaking scenarios, followed by the update of the neutral Higgs bosons hunt for both the SM and the Minimal Supersymmetric extension of the SM (MSSM) scenarios. Needless to stress the preliminary content of this paper. As general comment all the limits given here refer to a confidence level of 95%. A more detailed description of the results reported in this paper is given in [1, 2].

2. Search for SUSY.
This section describes the update of the SUSY results at 192-196 GeV in the three different scenarios: gravity mediated MSSM, Gauge Mediated Susy Breaking (GMSB) and Supersymmetry with R-parity violating coupling (RPV). More details on the ALEPH analyses on which these results are based can be found in [3, 4, 5, 6].

2.1. Search for SUSY in the MSSM scenario.
In this update the SUSY searches can be divided into two categories: particles which have a small cross section close to thresholds (this is the case for the scalars, like sleptons and squarks) and particles which have a quite large cross section close to threshold (this is the case of charginos when the sleptons are quite heavy).

For the first category the new data, due to the small additional luminosity, are not expected to largely improve the sensitivity of the 189 GeV sample reported in [1]. For both sleptons and squark searches a good agreement between expected background from the SM processes and data candidates has been observed and new limits have been obtained by combining all the data up to the maximal energy. As expected the updated lower limits on the sleptons and squarks masses are not much different from the ones obtained at 189 GeV. The improvement on the 189 GeV limits ranges between 0 and 1 GeV.

The situation is quite different for the second category where the increase in the centre-off-mass energy is expected to give a sizable improvement on the sensitivity to the gaugino masses. For large slepton masses in absence of a signal, the
chargino exclusion goes up to the kinematic limit (i.e., half of the centre-of-mass energy) with few inverse pb of collected luminosity, which means that an improvement of about 3.5 GeV on the chargino mass lower limit is expected. Both chargino and neutralino searches did not find any deviation from the SM expected background and new limits have been derived under the assumption of large slepton masses \( m > 500 \text{ GeV} \): chargino masses lower than \( \sim 98 \text{ GeV} \) are excluded for a large fraction of the MSSM parameter space and the LSP mass lower limit is increased to about 34 GeV.

2.2. Search for SUSY in the GMSB scenario.

In the GMSB scenario the lightest neutralino is expected to decay, mainly, into a photon plus a gravitino. If the lifetime associated to this decay is small the experimental topology consists of two acoplanar and energetic photon. This search has been updated and one candidate has been observed to be compared with 0.7 background events expected from SM processes (mainly \( \gamma \nu \bar{\nu} \)). Another characteristic topology of GMSB are long lived sleptons. This analysis has been updated on 192-196 GeV sample and no events survived the cuts, to be compared with about 0.2 expected background events.

2.3. Search for SUSY in the RPV scenario.

In this scenario the LSP is expected to decay in SM particles. In this case the experimental signature depends crucially on the type of the dominant RPV coupling. Three main types of RPV couplings are expected: LLE, LQD and UDD. In each search only one RPV coupling is assumed to be present. Searches for all the possible dominating couplings have been updated and no deviation from the SM has been observed. Similarly to the R-parity conserving scenario only the chargino mass limits are improved sensibly with respect to 189 GeV results reaching the new kinematic limit of about 98 GeV.

3. Search for the neutral Higgs bosons.

The searches for the SM and MSSM neutral Higgs bosons have been updated. The update of the search for the SM Higgs is of particular interest since in 1998 data ALEPH has observed a slight excess of Higgs candidates. \( \tan \beta \) plane has been updated and a new lower limit

| Channel       | N-bkg | N-sig | N-obs |
|---------------|-------|-------|-------|
| \( \nu \nu \)  | 8.5 / 6.6 | 4.6 / 3.7 | 7 / 5  |
| \( h\ell \)     | 2.4 / 2.7 | 1.6 / 1.4 | 3 / 4  |
| \( \ell \ell \)  | 5.5     | 0.8     | 7      |
| \( \tau \tau \)  | 1.7     | 0.4     | 1      |
| Total \( NN/Cut \) | 18.1 / 16.1 | 7.4 / 6.3 | 18 / 17 |

Table 1. Expected SM background, Expected signal events \( (M_h=95 \text{ GeV}) \) and number of data candidates for the SM Higgs search at 192-196 GeV for the different channels and for the two main streams of ALEPH analyses (cut based and neural network based).
of 83.8 GeV on the mass of lightest MSSM Higgs has been obtained (valid for $\tan \beta > 1$).

4. Conclusions.

The data collected by ALEPH in the first period of the 1999 run has been analysed to search for new physics. In SUSY no deviation from the SM has been observed in the three different studied scenarios (MSSM, GMSB and RPV). Due to the low luminosity collected up to now (less than 1/3 of the 1998 run) only the chargino limits are sensibly improved: $M_{\tilde{\chi}^\pm} \geq 98$ GeV for large $m_0$.

For the SM Higgs the excess observed in last year data sample has not been confirmed. A SM Higgs lighter then 94.9 GeV is excluded at 95% CL by the ALEPH data. The typical MSSM Higgs topologies have been updated with no deviation from the SM and a lower limit of 83.8 GeV on $M_h$ has been derived.

I want to conclude with an optimistic remark: the LEP experiments are now exploring a very interesting region both for the SM Higgs (the actual preferred value of the EW fit is below 100 GeV) and for SUSY where the “natural” SUSY mass spectrum is expected to be close to the EW energy scale (i.e., very close to the LEP2 energy scale). Up to know we didn’t succeed to enter into this new domain but the chance that these last two years of LEP running could bring us there is still very high.

References

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