Four-jet events in ALEPH

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Abstract

An excess of events in the four-jet topology has been observed in the ALEPH data collected at 130 – 136 GeV during the autumn of 1995. The properties of these events are reported.

In the data sample of 5.7 pb^{-1} collected by ALEPH at LEP at centre-of-mass energies of 130 and 136 GeV, less than three events from the reaction $e^+e^- \to hA$ were expected to be produced for large $\tan\beta$ and Higgs masses of 53 GeV/c^2. The motivation of a search for four-jet final states was therefore more to assess the virtues of the algorithms for background rejection than to hope for a discovery. The $hA \to b\bar{b}b\bar{b}$ signal is characterized by its four-jet topology, by an accumulation in the di-jet mass spectrum at the common h and A mass, and possibly by the jet flavour content and by angular distributions reflecting the scalar nature of the Higgs bosons. At 136 GeV, the main background is by far from $e^+e^- \to q\bar{q}gg$. The following is a brief summary of the analysis which is described in detail in Ref. [1].

A simple four-jet selection based on the Durham clustering algorithm leads to a sample of 35 events while 30 are expected from standard processes. A rescaling procedure is applied to improve the resolution on the jet energies. Requiring large di-jet masses, large individual jet masses and large jet multiplicities leaves 16 events for 8.6 expected. Even if the two Higgs masses are not equal, a peak in the sum of di-jet masses is expected when the jet pairing giving the smallest di-jet mass difference is chosen. The distribution of the di-jet mass sum for the 16 events selected is shown in Fig. 1, where a binning of 3.15 GeV/c^2 corresponding to twice the resolution is used. Nine events cluster within two consecutive bins around 105 GeV/c^2, an occurrence with a probability of 0.01%, given the expected background shape.

Whether this accumulation of nine events is only due to a statistical fluctuation can be answered if these events show other properties radically different from those of the standard background. To investigate this, the parton dynamics and the individual jet charges are studied in the full four-jet event sample containing 35 events. The QCD matrix element is constructed for each event from the jet directions. Compared to the distribution expected from standard processes, an accumulation at low values is observed, as can be seen in Fig. 2, with a probability of 1%. This is a general feature for exotic

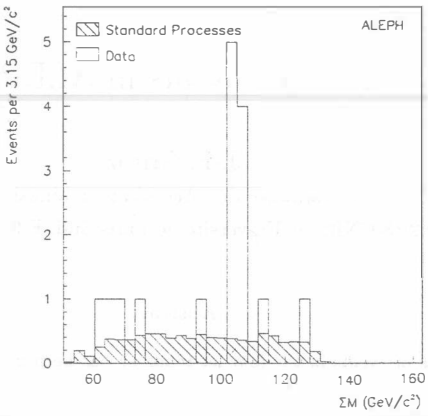

Figure 1: Di-jet mass sum

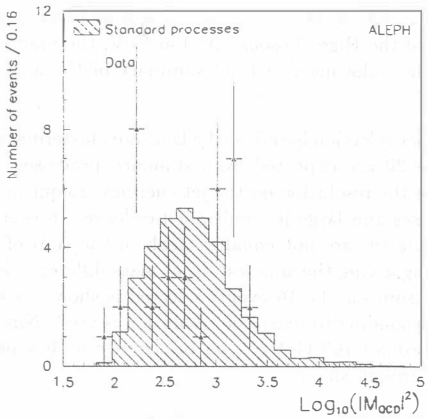

Figure 2: QCD matrix element squared

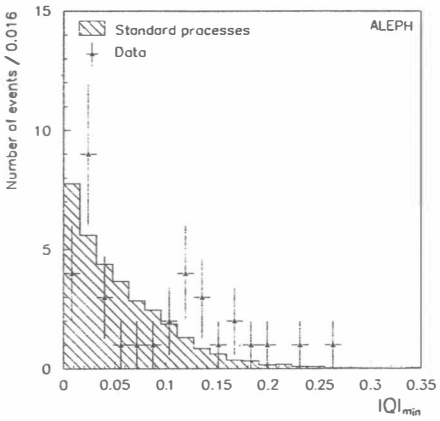

Figure 3: Minimum jet charge

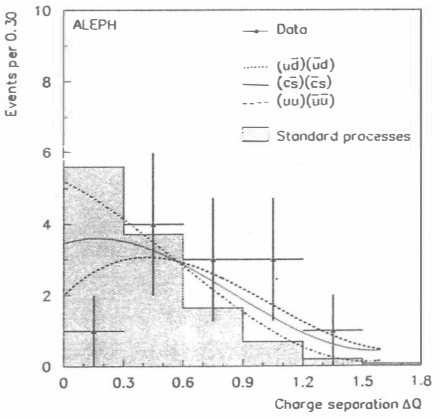

Figure 4: Di-jet charge separation