Search for Single Top-quark Production at LEP2

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The top-quark is the heaviest known elementary particle: its mass has been measured at the Tevatron Collider to be 174.3±5.1 GeV. Therefore, it could only be produced at LEP2 at a center-of-mass energy $\sqrt{s} \geq 180$ GeV via flavor changing neutral currents (FCNC) in the reactions $e^+e^- \rightarrow \bar{t}c(u)$.

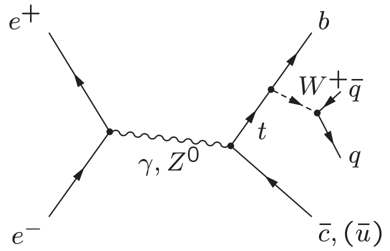

Fig. 1: The hadronic channel of single top production via FCNC in e^+e^-collisions.

In the Standard Model such processes are forbidden at tree level and can only occur via loops with cross sections $\leq 10^{-9}$ pb. Extensions of the Standard Model could lead to enhancement of such transitions and to measurable effects [1,2]. For our analysis we assume that the top decays into bW in 100 % of the cases. In principle a FCNC coupling could also lead to a sizable decay of the top-quark into Z^0c(u) or γc(u). A recent CDF measurement gives a limit of 33 % for the branching ratio of such decays [3].

A search for single top-quark production in the hadronic channel of the W is performed using data taken by the OPAL detector at LEP2. The data analyzed so far were accumulated at a center-of-mass energy of 189 GeV.

At this energy the top is produced very close to threshold. This leads to nearly fixed values of energies of the final t-,c-(u-),b-quarks and W-bosons in the reaction (fig. 1). The top is produced practically at rest ($E_{\text{top}} \approx m_{\text{top}}$), the light quark has a small energy and the b and W from the top decay are almost mono energetic.

The analysis looks for four jet events, produced by the b-,c-quark and the two quarks coming from the W. The event selection proceeds in two steps. It begins with a cut based pre-selection designed to remove most of the leptonic events and suppress events with $q\bar{q}$ in the final state. After this pre-selection the final candidate events are then identified using a relative likelihood discriminator.

In the pre-selection the charged multiplicity must be larger than one and the total number of charged tracks must be greater than 15. Events with high energetic leptons ($E_l < 40$ GeV) have been removed. The Durham algorithm has been applied to perform the events clusterization into jets. Each event was forced into 4 jets. To discriminate between 3 and 4-jet events, a cut on the jet resolution parameter $y_{34} > 0.001$ has been applied. The visible energy in the event has to be greater than 150 GeV. The background from events with $q\bar{q}$ in the final state is further reduced with a cut on the event-shape parameter C (C > 0.4).

After the pre-selection, the background consists of $q\bar{q}$ events with a four jet topology and four quark final state events. The jet energies are rescaled by using 4-C (constrained) kinematic fit, which requires energy and momentum conservation. The c-jet is identified as the least energetic one. To identify the b-jet, the jet with the highest output of a b-tagger based on an artificial neural net is used. The b-tagger uses the characteristic long lifetime of b-hadrons to find jets originated from a b-quark. The remaining two jets are assigned to the W-boson. A 6-C kinematic fit is applied, which requires in addition to the 4-C-fit two mass constraints for the W-boson and the top-quark. With a set of five variables: C-variable, χ^2 of the 6-C-fit, p_W/E_W, energy of the c-jet and the maximum of the ANN b-tagging output, a likelihood for each event has been calculated. A cut on the likelihood output is applied, to discriminate between signal and background. In fig. 2 the distribution of the reconstructed invariant top mass is plotted. Data and the expected background from the Monte Carlo are in good agreement. The open histogram is the expected signal Monte Carlo assuming a cross section of 0.6 pb (observed limit ALEPH collaboration [4]).

With the additional data taken in 1999 and during 2000 at $\sqrt{s} = 192$, 196, 200 and 202 GeV we will calculate a limit on the cross section for such a FCNC process.

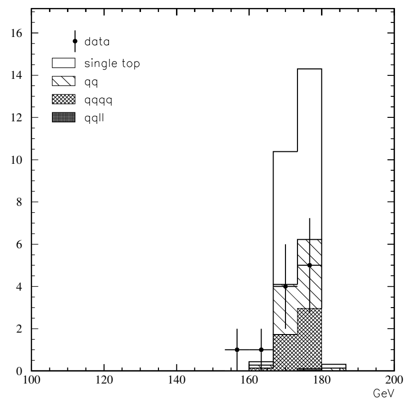

Fig. 2: Distribution of the invariant top mass, after likelihood selection. The hatched histograms are background Monte Carlo subdivided in the $q\bar{q}$, 4q and $q\bar{q}ll$ final states. The open histogram is the FCNC Monte Carlo with $m_{\text{top}} = 174$ GeV and a cross section of 0.6 pb. The points are data collected at $\sqrt{s} = 189$ GeV.

References

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