6 The Dilepton Top Quark Search

6.1 Dilepton Data Selection

The dilepton decay modes are the cleanest channel in which one would expect to observe a heavy top quark. They suffer from the relatively small total branching fraction of $t\bar{t}$ into these modes (a total of 4%), and from the presence of two neutrinos in the final state that are not individually observable.

The dilepton searches break down into three separate channels, the e^+e^-, $\mu^+\mu^-$ and $e^\pm\mu^\mp$ final states. The CDF analysis requires two isolated lepton candidates, each with $P_T > 20$ GeV/c and with $|\eta| < 1.0$. The candidates must satisfy standard lepton quality requirements that ensure high efficiency and high rejection from energetic, isolated charged hadrons. There are 2079 ee candidates, 2148 $\mu\mu$ candidates and 25 $e\mu$ candidates after these kinematical cuts. The large ee and $\mu\mu$ candidate samples are the result of Z° and Drell-Yan production, as can be seen by examining the invariant mass (M_{ll}) distribution of the dilepton system. This background is removed by rejecting those events with

$$75 < M_{ll} < 105 \text{ GeV/c}^2. \tag{13}$$

This leaves 215, 233 and 25 candidate events in the ee, $\mu\mu$ and $e\mu$ channels, respectively..

In addition, the events are required to have $\not\!\!E_T > 25$ GeV and at least two jet clusters with $E_T > 10$ GeV and $|\eta| < 2.0$, since $t\bar{t}$ events are expected to have two energetic neutrinos and a b quark and anti-quark in the final state. This still leaves a background in the ee and $\mu\mu$ sample from Drell-Yan production where the $\not\!\!E_T$ signal arises from an accompanying jet that is mismeasured. The distribution of the opening angle between the missing transverse energy vector and the closest jet or charged lepton candidate in the event versus the missing transverse energy for each jet multiplicity is shown in Figs. 5 and 6 for the $\mu\mu$ and $e\mu$ channels, respectively. There is a clear cluster of events at small $\not\!\!E_T$-jet opening angles that extend to higher $\not\!\!E_T$ in the $\mu\mu$ (and ee) samples. The same enhancement is not present in the $e\mu$ sample, which has no Drell-Yan contamination. A stiffer $\not\!\!E_T$ cut requiring at least 50 GeV of missing transverse energy is imposed on those events that have $\not\!\!E_T$-jet opening angles less than 20°. The same region is occupied preferentially by backgrounds from $Z \rightarrow \tau^+\tau^-$ in the $e\mu$ sample so it is also removed.

This leaves a total of 7 candidate CDF events, 5 in the $e\mu$ channel and two in the $\mu\mu$ channel. No dielectron events survive the selection. One of the $\mu\mu$ events has an energetic photon candidate with a $\mu^+\mu^-\gamma$ invariant mass consistent with that of a Z°. Although the expected background from radiative $Z_\circ$ decay is only 0.04 events, the $\mu^+\mu^-\gamma$ candidate is removed from the sample in order to be conservative.

The DØ analysis requires two high P_T leptons; both leptons are required to have $P_T > 20$ GeV/c in the ee channel, $P_T > 15$ GeV/c in the $\mu\mu$ channel, and $P_T > 15(12)$ GeV/c for the electron (muon) in the $e\mu$ channel. A $\not\!\!E_T$ cut requiring at least 20 GeV