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THE SEARCH FOR TOP AT CDF

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ABSTRACT

We present results on the search for the top quark in $\bar{p}p$ collisions at $\sqrt{s}$ = 1.8 TeV. The data sample collected during the 1988-89 run with the Collider Detector at Fermilab (CDF) includes more than 4 pb^{-1}. We report here on an extension of previously published searches for the top quark in electron + jets and the dilepton channel electron-muon. The 95% confidence level limit on the top mass is 89 GeV/c^2.

1. Introduction

The top quark is required to complete the Standard Model's three families but to date has not been detected. Considerable experimental evidence points to its existence, including for example the lack of flavor changing neutral currents in bottom quark decays. This same phenomenon, observed in strange quark decays, was used 20 years ago to predict the existence of the charm quark. Electroweak radiative corrections, which are necessary to explain the observed values of the W and Z boson masses, also require the existence of the top quark. The most recent precision measurements of the electroweak parameters predict a top mass of 144 ± 30 GeV/c^2.[1]

Top quark production at the Fermilab collider occurs mainly via gluon fusion into top pairs $\bar{p}p \to t\bar{t} + X$. The top pairs then decay via t→Wb where the W is real or virtual depending on the top mass. The signature of top production is then events consistent with the decay of a pair of W bosons and, if it is possible to identify them, a pair of bottom quarks.

Because of the high center of mass energy and large integrated luminosity, the 1988-89 CDF run has provided the best opportunity so far for the direct observation of the top quark. Previously published limits[2,3] based on our initial searches in the electron + jets and $e\mu$ channels put the top mass at greater than 77 GeV/c^2. We report here on results obtained through two extensions of the previous searches. The lepton + jets

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of the shower as seen in the strip chambers embedded in the central electromagnetic calorimeter must match in both ϕ and z with the extrapolated track. The loose electron cuts require, in addition to the isolation cut, only that the hadronic energy deposition be less than 11% of the total. In $e\mu$ events, the electron must pass the tight cuts, but in ee events, one electron must pass the tight cuts and one the loose cuts. Muon candidates are required to be consistent with loose minimum ionization criteria with less than 2.0 GeV deposition in the electromagnetic calorimeter and 6.0 GeV in the hadronic calorimeter. In addition, a track extrapolated to the muon chambers must match the hits there within 10.0 cm in the drift direction.

The $e\mu$ channel is free from backgrounds due to Z^0 decay and Drell-Yan. This is not true of the ee and $\mu\mu$ channels so additional cuts are made, in these channels only, to reject these backgrounds. Dielectron and dimuon events with invariant masses between 75 and 105 GeV/c^2 are rejected as being consistent with Z^0 decay. In addition, these events are required to have missing transverse energy greater than 20 GeV and the azimuthal angular separation between the two leptons must lie in the range $20° \leq \Delta\phi_{l^+l^-} \leq 160°$. The last two cuts reject Drell-Yan events and any residual Z^0 decays which might pass the invariant mass cut.

From our previous experience with the $e\mu$ channel, we define a top quark signal region with $E_t > 15$ GeV and $P_t > 15$ GeV/c. This requirement eliminates any remaining $b\bar{b}$ background. The distribution of $\Delta\phi_{l^+l^-}$ versus missing E_t for ee and $\mu\mu$ events is shown in Figure 1. There are no events in the signal region defined by the dashed lines. For the $e\mu$ sample one event passes all cuts. This is the same event that has

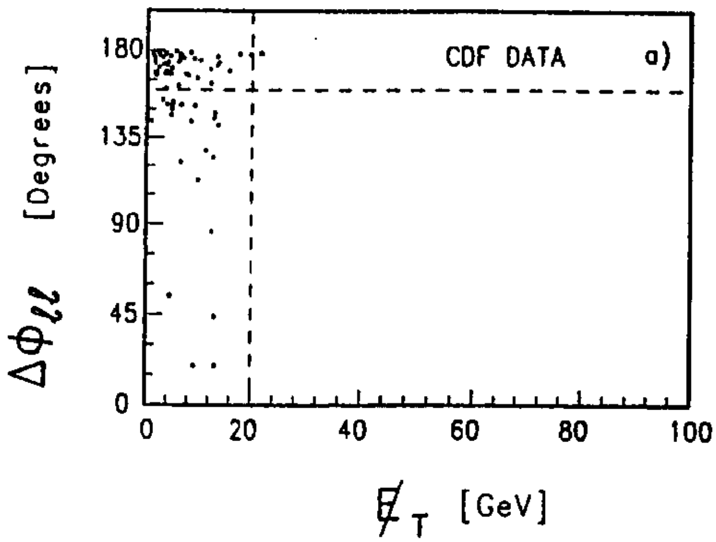

Figure 1: Azimuthal opening angle vs. missing E_t for ee & $\mu\mu$ events

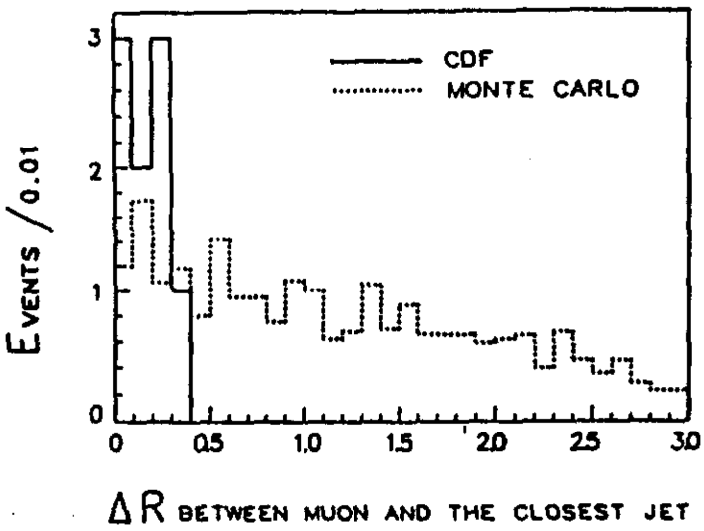

Figure 2: ΔR distribution of low P_t muons in lepton + jets events

(1.26< $|\eta|$ <2.2) which increases the total acceptance by about 20%. In addition, systematic uncertainties will be significantly reduced over those reported here. For instance, the dominant 15% luminosity uncertainty has been reduced to 6.8% . The overall effect of these improvements is expected to be an increase in the lower mass limit of 1-2 GeV/c^2.

7. Discovery Reach in Future Runs

The CDF detector will be significantly upgraded for the run beginning in the winter of 1992, including a silicon vertex detector capable of significantly improving our b tagging efficiency, additional steel and more muon chambers in the central region and an extension of the muon coverage to $|\eta|<1.0$. With an expected 25 pb^{-1} delivered, our discovery reach for top will be about 120 GeV/c^2. With 100 pb^{-1} on tape, which is expected by the end of 1993, we should be able to find a top quark of mass 170 GeV/c^2. In the era of the Fermilab main injector, when CDF hopes to accumulate as much as 500 pb^{-1}, our reach surpasses 200 GeV/c^2.

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