RECENT PHYSICS RESULTS FROM CDF II

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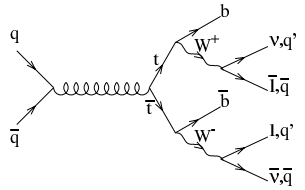
Top Quark Physics at CDF

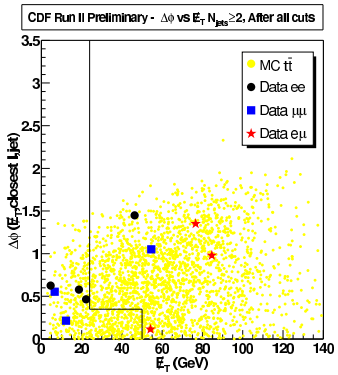
Studies of the top quark, discovered in 1995 by CDF and D0, are unique to the Tevatron experiments. Current work focuses on determining the properties of top, including production rates, mass, and couplings. The top quark is produced singly and (predominantly) in pairs and to decay almost exclusively to $W+b$, resulting in a $W^+W^-b\bar{b}$ state. Further combinations of W decays to electrons, muons, and jets result in final state fractions of 5%, 30%, and 44% for the dilepton, lepton+jets, and fully hadronic signatures, respectively.



Top Dilepton Production

If both W bosons decay leptonically, the top signature is two leptons, two jets, and missing E_T. This dilepton production channel has the advantage of excellent signal-to-noise ratio (7:1 before b-tagging), but it suffers from low statistics.

The analysis requires both high-P_T electrons or muons to be isolated, and it rejects events consistent with Z decay. It also requires at least 25 GeV of missing E_T and a $\Delta\phi$ separation of at least 20° to ensure the leptons do not come from the same parent. A cut $H_T > 200$ GeV, where H_T is the transverse energy sum of the jets, leptons, and missing E_T, selects high-mass events consistent with top production. The missing E_T-$\Delta\phi$ cut is illustrated graphically below.



The table below gives the results of the data selection along with expectations from backgrounds and $t\bar{t}$ dilepton production.

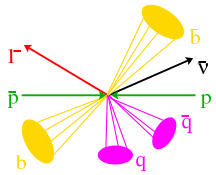
Source	Selected events in 72 pb^{-1}
Total Background	0.30 ± 0.12
Total $t\bar{t} \to \ell\nu\ell\nu b\bar{b}$ signal	2.5 ± 0.3
Expected	2.8 ± 0.3
Data	5

The top production cross section calculated from this channel is 13.2 ± 5.9 (stat.) ± 1.5 (syst.) pb, compared to the NLO theory calculation of 6.70 ± 0.8 pb.

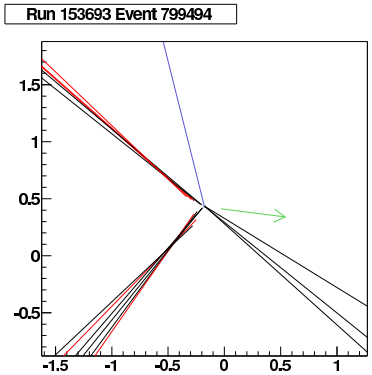
Top Lepton + Jets Production

When one W decays leptonically and the other W decays to light quark jets, the signature is a high-P_T lepton with jets and missing E_T.

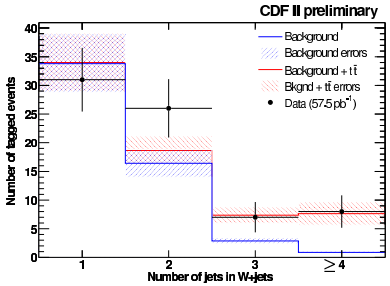
This channel benefits from an enhanced branching fraction compared to the dilepton channel.



The additional background from light quark jets can be reduced by requiring one b jet be tagged. The tagging algorithm seeks tracks within a jet which form a secondary vertex significantly separated from the primary vertex. Resolving vertices millimeters apart is possible only with the silicon detector.
An event display for a doubly vertex-tagged lepton + jets event is shown below in a zoomed view of the primary and secondary vertices. The high-P_T muon is drawn as the dashed blue line, and the missing E_T vector is represented by the green arrow. Axes are labelled in centimeters.



The number of jets with $E_T > 15$ GeV and $|\eta| < 2.0$ in an event are plotted below for expected background and $t\bar{t}$ signal contributions. Most of the $t\bar{t}$ signal events have three or more selected jets, while most background events do not have more than 2 jets.

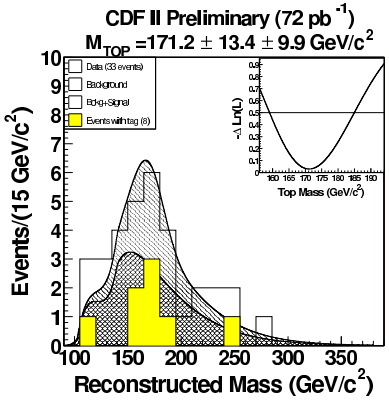


The $t\bar{t}$ production cross section measured from the 3- and $\geq$4-jet bins is 5.3 ± 1.9 (stat.) ± 0.8 (syst.) pb.

Top Mass Measurements

The top quark mass is a fundamental electroweak parameter whose value has implications for the mass of the Higgs boson. We measure the top mass in a sample of lepton + jet events with at least 4 jets, each with $E_T > 15$ GeV. Within these events, the assignment of the jets to the W and t is ambiguous. Therefore, a kinematic fit is applied to each combination of jet-parton assignment, and the combination with the lowest χ^2 is selected.

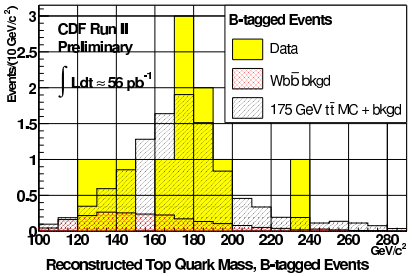
The expected mass distributions for background events and for a spectrum of top quark mass hypotheses are constructed (below), and a maximum likelihood fit is employed to extract the top mass value (inset below).



Currently, the largest contribution to the systematic uncertainty on the mass measurement is the calorimeter energy scale. We are actively pursuing the sources of this uncertainty, and we are confident that this contribution will decrease for future measurements.

A cross-check of the event selection and fit has been performed, adding the additional requirement of a secondary vertex b-tag in at least one of the jets. with the b-tag requirement, the E_T cut on the fourth-highest energy jet is relaxed to 8 GeV.

The mass distribution for b-tagged events is quite similar to the distribution above, but the relative contribution of the $t\bar{t}$ signal is enhanced with respect to the background.



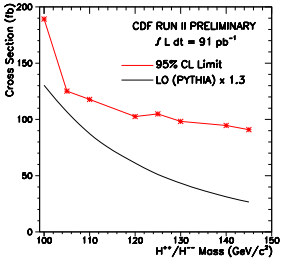
We anticipate a top mass measurement from the b-tagged sample in the near future.

Searches for Exotic Particles

At the Tevatron, the world's highest energy collider, CDF II is pursuing a varied program of exotic physics, including searches for new particles.

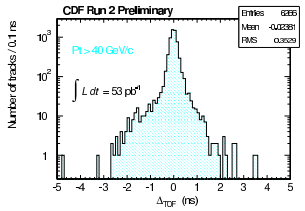
Search for Doubly-Charged Higgs Bosons

Doubly-charged Higgs bosons are predicted by models with Higgs triplets. A same-sign dielectron search with sliding mass windows yields the cross section limit shown below.

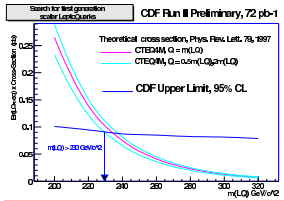


Search for Charged Massive Particles

The new Time-Of-Flight (TOF) system in CDF II is used to identify slow massive particles (stop quarks, for example). The CHAMP signal would be expected to have large time of flight in the distribution below.



A counting experiment for events with Δ(TOF) > 2.5 ns is used to derive a mass limit of 108 GeV/c^2 for isolated stops at 95% confidence level.

Search for Scalar Leptoquarks

This search focuses on first-generation leptoquarks, which are assumed to be pair-produced and to decay to eq. In the signature of 2 electrons + 2 jets, leptoquarks with masses less than 230 GeV/c^2 are excluded at 95% confidence level, assuming leptoquarks decay exclusively to eq.