TOP QUARK STUDY IN ALL-JETS CHANNEL AT DØ

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We report on the search for top quark decaying into all-jets at the Tevatron collider. We measure preliminary cross sections of $4.4 \pm 4.9 \text{ pb}$ and $3.9 \pm 9.8 \text{ pb}$ for $t\bar{t}$ production, using singly and doubly b-tagged all-jets channels, respectively.

6 Introduction

At the Tevatron collider, $t\bar{t}$ pairs are produced primarily through $q\bar{q}$ annihilation. Each top decays via the reaction $t \to W + b$. The $W$ bosons subsequently decay either leptonically or hadronically. In the all-jets mode, both $W$s decay hadronically. Although this represents the largest branching fraction of any decay channel (44%), extracting a signal is difficult due to the QCD multijet background.

7 Selection and Analysis of All-Jets Channel

The DØ detector has been described elsewhere. The data used in these analyses are from the '92-'96 data runs at the Tevatron collider (Run 1), and include 13 events/pb from Run 1a and 70 events/pb from Run 1b.

The multijet trigger required the presence of calorimeter energy, five or more jets (reconstructed using the R=0.3 cone algorithm) with $E_T > 10 \text{ GeV}$, and the scalar sum of $E_T$ of all jets ($H_T$) greater than 115 GeV. The efficiency for this trigger is greater than 90% for $m_t = 180 \text{ GeV}/c^2$. A total of 550,000 events were collected, with an expected top yield of approximately 200. Thus, the signal to background ratio is of order $10^{-4}$ at this stage.

7.1 Kinematic Variables

Variables were chosen to discriminate between $t\bar{t}$ events and QCD multijet background. QCD multijet events are dominated by $2 \to 2$ processes with additional gluon radiation. The additional jets are typically lower in $E_T$, and tend to lie in the plane consisting of the beam and the two leading jets. Conversely, $t\bar{t}$ events have jets which are more central, have higher $E_T$, and are less planar.

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Figure 2: Distributions (normalized to the same area) in kinematic parameters: (a) $H_T^3$, (b) $A$, (c) $C$, and (d) average jet count $N_{jets}^A$ are shown for data from Run 1b (shaded) and ISAJET $t\bar{t}$ Monte Carlo for $m_t = 180$ GeV/c$^2$ (normal histograms). Arrows show threshold points (looser for double tag, tighter value for single tag analysis).

These properties are used to define the following four kinematic variables which parameterize the event: $H_T^3$, the scalar sum of the $E_T$ of the jets, excluding the leading two; aplanarity ($A$), $3/2$ of the smallest eigenvalue of the normalized jet-momentum tensor; centrality ($C$), the ratio of the sums of transverse and total energies of all the jets; average jet count ($N_{jets}^A$), the number of jets with $E_T$ above a threshold, weighted by the threshold and averaged over a range of thresholds. Distributions of these variables for data, and the expected (Monte Carlo) distributions for $t\bar{t}$, are shown in Fig. 2. These variables provide effective discrimination between $t\bar{t}$ signal and background.

### 7.2 Optimizing Selection Criteria

Threshold requirements on the kinematic variables were chosen to optimize the signal to background ratio at a given acceptance for signal. We used the Random Grid Search technique to choose optimal values of these thresholds. These were chosen on the basis of the distribution of values in the data (for background) and in the $t\bar{t}$ ISAJET sample.
7.3 Soft-muon Tagging

The presence of a soft muon in a jet indicates that the jet was likely to have originated from a heavy \((b\) or \(c)\) quark. Requiring that at least one jet in each event have a \(b\)-tag, significantly improves our signal to background ratio. The \(t\bar{t}\) events are tagged roughly 20\% of the time, while only 3\% of the QCD background is tagged.

A tagging muon must have \(p_T \geq 4\) GeV/c, and pass the standard DØ muon requirements. In addition, the separation (\(\Delta R\)) between the muon and the reconstructed jet must be less than 0.5 units. In addition to improving the signal to background ratio, tagging also provides a means of estimating the background for events passing the kinematic criteria.

As a second method of estimating background, the tagging probability is extracted in a simultaneous fit to Eqns 1-2.

\[
N_i^{\text{tagged}} = e^{-\epsilon} N_i^{QCD} + 0.2 N_i^{\text{TOP}}
\]

\[
N_i^{\text{untagged}} = (1 - e^{-\epsilon}) N_i^{QCD} + 0.8 N_i^{\text{TOP}}
\]

where \(N_i^{\text{TOP}} = \mathcal{L} \sigma_{\text{TOP}} \varepsilon_i^{MC}\), \(N_i^{QCD}\) and \(N_i^{\text{TOP}}\) are the number of background and signal events passing some set of thresholds labeled \(i\), \(\mathcal{L}\) is the integrated luminosity, \(\sigma_{\text{TOP}}\) is the \(t\bar{t}\) cross section, \(\varepsilon_i^{MC}\) is the Monte Carlo acceptance times branching fraction for the chosen set of thresholds and 20\% is assumed for the signal tag-rate. Equations 1-2 were fitted to data for six statistically independent sets of event samples that passed different kinematic criteria, and as a result, we obtained \(\epsilon = 0.034 \pm 0.005, \sigma_{\text{TOP}} = 4.0 \pm 4.8\) pb (consistency check), and \(\chi^2/\text{dof} = 6.2 / 4\).

7.4 Results

We observe 15 candidate events in the singly-tagged channel, with an expected background of 10.9 \pm 2.3. This gives a cross section of 4.4 \pm 4.9 pb. In the doubly-tagged channel, we observe 2 events with an expected background of 1.4 \pm 0.4, giving a cross section of 3.9 \pm 9.8 pb.

References