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Search for narrow-width $t\bar{t}$ resonances in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV

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Abstract. We present a preliminary result on a search for narrow-width resonances that decay into $t\bar{t}$ pairs using 130 pb^{-1} of lepton + jets data in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV. No significant deviation is observed from prediction of the standard model, and upper limits at 95% confidence on the product of the production cross-section and its branching fraction to $t\bar{t}$ are presented for narrow-width resonances, as a function of resonance mass M_X. We also use these limits to exclude the existence of a leptophobic top-color particle, X, with $M_X < 560$ GeV/c^2 and width $\Gamma_X = 0.012 M_X$.

Particles with narrow width that decay to $t\bar{t}$ pairs are predicted by several theories beyond the standard model [1,2]. For instance, one of the scenarios of the top-color assisted technicolor model in ref. [2], predicts a heavy Z', that couples preferentially to the third quark generation, and not to leptons (leptophobic). The cross-section for the Z' in this model is large enough for it to be observed over a wide range of masses and widths in data available from the 1.8 TeV $p\bar{p}$ Tevatron collider at the Fermi National Accelerator Laboratory.

In searches for these heavy particles or $t\bar{t}$ resonances in the distribution of the invariant mass of the $t\bar{t}$ decay products, one seeks an excess beyond that predicted by the standard model. Previous searches from the Tevatron have limited a leptophobic Z' to a mass higher than 480 GeV/c^2 [3]. In this paper we present a preliminary result based on a direct search for $t\bar{t}$ narrow-width resonances in the inclusive decay modes $t\bar{t} \rightarrow \ell\,\nu + 4$ (or more) jets, where $\ell = e$ or μ, using 130 pb^{-1} of data recorded by the DØ experiment from 1992 to 1996.

We consider two orthogonal classes of events for this analysis, whose selection is based on: (a) a purely topological selection of lepton+jets events denoted as $e+$jets and $\mu+$jets, and (b) a selection based primarily in the presence of a muon contained within a jet (μ tag), and additional selections on the topology of the event. These events are denoted as $e+$jets/μ and $\mu+$jets/μ. The principal sources of background correspond to standard model $t\bar{t}$ production, production of a W boson in association with the requisite number of jets, with the W boson decaying into a lepton and its corresponding neutrino, and production of multijets ($N_j \sim 5$), in which one of the jets is misidentified as a lepton, with instrumental effects simulating sufficient missing transverse energy ($\not\!\!E_{\rm T}$) that satisfies the neutrino requirement. The selections used to reduce the contribution from non-$t\bar{t}$ sources are summarized in table 1.

Table 1. Summary of event selections.

	e+jets	μ+jets	e+jets/μ	μ+jets/μ
Lepton	$E_{\rm T} > 20$ GeV	$p_{\rm T} > 20$ GeV/c	$E_{\rm T} > 20$ GeV	$p_{\rm T} > 20$ GeV/c
(l)	$\|\eta\| < 2$	$\|\eta\| < 1.7$	$\|\eta\| < 2$	$\|\eta\| < 1.7$
$\not\!\!E_{\rm T}$	$\not\!\!E_{\rm T} > 20$ GeV	$\not\!\!E_{\rm T} > 20$ GeV	$\not\!\!E_{\rm T} > 20$ GeV	$\not\!\!E_{\rm T} > 20$ GeV
Jets	≥ 4 jets, $\|\eta\| < 2$	≥ 4 jets, $\|\eta\| < 2$	≥ 4 jets, $\|\eta\| < 2$	≥ 4 jets, $\|\eta\| < 2$
	$E_{\rm T} > 15$ GeV	$E_{\rm T} > 15$ GeV	$E_{\rm T} > 15$ GeV	$E_{\rm T} > 15$ GeV
μ tag	No	No	Yes	Yes
Other	$\|\not\!\!E_{\rm T}\| + \|E^l_{\rm T}\| > 60$ GeV	$\|\not\!\!E_{\rm T}\| + \|E^l_{\rm T}\| > 60$ GeV	$\not\!\!E_{\rm T} > 35$ GeV,	$\Delta\phi(\not\!\!E_{\rm T}, \mu) < 170°$,
	$\|\eta^W\| < 2$	$\|\eta^W\| < 2$	if $\Delta\phi(\not\!\!E_{\rm T}, \mu)$	if $\frac{\|\Delta\phi(\not\!\!E_{\rm T},\mu) - 90°\|}{90°}$
			$< 25°$	$< \frac{\not\!\!E_{\rm T}}{45\ \rm GeV}$
Events selected	42	41	4	3

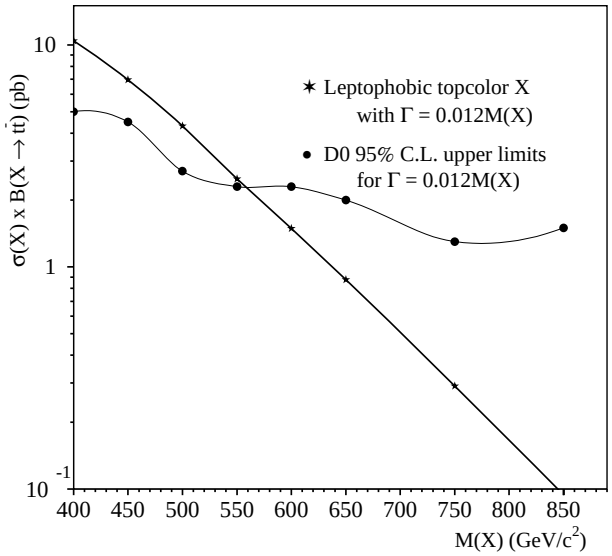

Figure 1. The DØ Run I 95% confidence level upper limits on $\sigma_X B$ as a function of resonance mass M_X. Included for reference are the predicted top color assisted technicolor cross-sections for a width $\Gamma_X = 1.2\%\ M_X$.

We perform a three-constraint (3C) kinematic fit to the $t\bar{t} \to l$ + jets, decay hypothesis [4], and require χ^2<10 to further reduce non-$t\bar{t}$ background, whereupon 41 events are left in the data sample, of which 4 are μ-tagged.

We consider the resonance signal ($X \to t\bar{t}$) at nine different masses M_X between 400–1000 GeV/c^2, with a width $\Gamma_X = 0.012 M_X$. We then use Bayesian statistics [5] to fit the data $m_{t\bar{t}}$ distribution to a three-source model comprised of signal ($X \to t\bar{t}$) at a resonance mass M_X, and the standard model backgrounds [4]. No significant

deviation is seen in the data $m_{t\bar{t}}$ distribution from standard model expectations for any of the resonance masses.

To conclude, after investigating 130 pb^{-1} of the data, we find no statistically significant evidence for a $t\bar{t}$ resonance, and establish upper limits at 95% confidence on the product of the production cross-section (σ_X) of the resonance, X, and its branching fraction (B) to $t\bar{t}$, for M_X between 400 and 1000 $\mathrm{GeV/c^2}$. These limits are used to constrain a model of top-color assisted technicolor and exclude at 95% confidence, the existence of a leptophobic Z' [2] with mass $M_X < 560$ $\mathrm{GeV/c^2}$ and width $\Gamma_X = 0.012 M_X$, as shown in figure 1.

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