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$t\bar{t}$ Production Cross Section for 110 pb^{-1}

Tony Liss, Rob Roser
University of Illinois

1 Introduction

In this note we describe the calculation of the $t\bar{t}$ cross section for 110 pb^{-1}. The calculation is based on the technique described in several previous CDF notes [1]. Here we include the entirety of the data collected in runs 1A and 1B as well as various other improvements and changes to the 1B input numbers as described below. Numbers used for run 1A are unchanged.

2 What's New

2.1 Lepton+Jets Acceptance

Several improvements and changes have been made to the lepton+jets acceptance, which includes all lepton+jets selection criteria save the tagging requirement. New acceptance numbers have been calculated with better Monte Carlo statistics (primarily by Doug Glenzinski) and documented in CDF 3403. These numbers include a term for the efficiency of the Z-vertex cut (95%) which was previously not included.

We have used the muon trigger simulation (see CDF 2998) to calculate a revised muon level 1 $\times$ level 2 trigger efficiency based on trigger prescale values appropriate for the 90.1pb^{-1} of run 1B (thanks to Doug Benjamin for help). In addition, the inclusive CMX and CMU/CMP level 1 and level 2 trigger efficiencies in the simulation have been updated to agree with those measured by Glenzinski and Schlabach and documented in CDF 2954. The previously used values were a few percent lower. The net result of these updates is to change the muon trigger efficiencey from 0.857$\pm$0.009 to 0.874$\pm$0.009. As before we assume that the electron trigger efficiency, from an OR of CEM_16* and MET_20, is 100%.

In past $t\bar{t}$ cross section calculations, the level 3 muon trigger efficiency has been assumed to be 100%. This has now been measured by Roser to be 0.978$\pm$0.005 (CDF 3440), and we include this here in the overall muon trigger efficiency. The cross section calculation uses the weighted average of the electron and muon trigger efficiencies of 0.92$\pm$.09, where, as before, we have taken the overall uncertainty on the number to be 10% .

In previous work we have split the $t\bar{t}$ acceptance into three terms: A term which included the branching fraction and all kinematic cuts, which was therefore

$A_{t\bar{t}}$	0.0994±0.0095
ϵ_{trig}	0.92±0.09

Table 1: Acceptance terms for the lepton+jets analysis evaluated at M_{top}=175 GeV/c^2

	1A	1B
Tagged Events	4	30
Estimated Background	1.68±0.39	7.68±1.36
Corrected Background	1.47±0.37	6.49±1.32
Tagging Efficiency	0.32±0.096	0.41±0.04

Table 2: Summary of SECVTX results

common to runs 1A and 1B, a term giving the product of the acceptance of the lepton ID, fiducial and trigger requirements, and a term for the tagging efficiency. The latest and greatest acceptance measurement can also be expressed as a product of three terms, but of course they are not the same three terms, they are tagging, trigger, and everything else. In order to easily make use of this improved acceptance measurement, we have redefined our three terms to agree with these. Tagging and trigger numbers are separate for 1A and 1B, while the remaining acceptance term is common between 1A and 1B. Table 1 summarizes the lepton+jets acceptance terms used in this calculation. The factor $A_{t\bar{t}}$ includes all selection criteria other than the trigger (and tagging) and is evaluated at M_{top}=175 GeV/c^2. For a top mass of 160 GeV/c^2 this number gets multiplied by 0.928, while for a top mass of 190 GeV/c^2 we multiply by 1.05 . The trigger and tagging efficiencies are independent of top mass in this range.

2.2 SVX

We use the latest tag counts from CDF 2965. There are 30 SECVTX tagged events for run 1B from a total of 274 $W+3$ or more jet events. We use Unal's latest SVX background calculation, documented in CDF 3389 and 3513. The total SVX background for run 1B is 7.68±1.36 events. As before (see CDF-2482) we correct this number for the $t\bar{t}$ content of the $W+3$ or more jet events, giving a corrected background of 6.49±1.32 events. We use the latest tagging efficiency measurement (0.466±0.005, statistical uncertainty only), with the new scale factor determination, also from Unal (CDF 3563), of 0.87±0.07. We use an overall tagging efficiency uncertainty of 10%, giving an efficiency for tagging at least one b-jet in a $t\bar{t}$ event of 0.405±0.040 . Note that the previously used 1B value was 0.42±0.05. The 1A and 1B SVX results are summarized in Table 2. The 1A numbers are the same as those used in CDF 2992 and 3111.

	1A+1B
Tagged Events	40
Estimated Background	25.8±3.7
Corrected Background	24.3±3.5
Tagging Efficiency	0.20±0.02

Table 3: Summary of SLT results

	1A+1B
Candidate Events	10
Estimated Background	2.1±0.4
Total Acceptance (M_{top}=175 GeV/c^2)	0.0078±0.0008

Table 4: Summary of dilepton results

2.3 SLT

Because the SLT algorithm used on 1A and 1B data is the same, we combine 1A and 1B tagging and background numbers in the cross section calculation. For run 1A there are 6 events tagged by SLT, and for 1B there are 34. We use the most recent background calculation done by David Kestenbaum for 110 pb^{-1}. The total 1A+1B background is 25.8±3.7 . This value is nearly identical to what is obtained by scaling from the 67 pb^{-1} number in the PRL. As explained in CDF 3111, because the SLT tagging efficiency is defined as the probability for tagging a *real* electron or muon in a $t\bar{t}$ event, it is only necessary to correct the background estimate for $t\bar{t}$ events with both a real tag and a mistag, rather than for the entire $t\bar{t}$ content of the $W+3$ or more jet sample, as is done for SVX. The corrected background is 24.3±3.5 . The SLT efficiency for tagging at least one b in a $t\bar{t}$ event remains unchanged at 0.20±0.02 . The SLT results are summarized in Table 3.

2.4 Dileptons

The latest dilepton results are documented in CDF 3203 and CDF 3482 . Here also, we combine the 1A and 1B results. There are 10 candidate events with a background of 2.1±0.4 . The acceptance for $t\bar{t}$ has been measured to be 0.0078±0.0008 at M_{top}=175 GeV/c^2. For a top mass of 160 GeV/c^2 we multiply this by 0.94 and for 190 GeV/c^2 by 1.02 . The dilepton results are summarized in Table 4

2.5 All Hadronic

The $t\bar{t}$ production cross section from the all hadronic mode is documented in CDF 3464 . Recently the tagging efficiency has been re-evaluated (CDF-3544) and found

	1A+1B
Candidate Events	192
Estimated Background	147.6±9.7
Corrected Background	137.1±11.3
Tagging Efficiency	0.472±0.045

Table 5: Summary of the all hadronic results

to be (47.2±4.7)%, compared to (40.5±4.0)% for the lepton plus jets analysis. The difference is understood to be due to the kinematic selection in the all hadronic mode and the presence of the extra W→ $c\bar{s}$ decays. We use the results presented in CDF 3464 to calculate the $t\bar{t}$ production cross section by combining the all hadronic mode with SVX, SLT and dileptons. There are 192 candidate events with a background of 147.6±9.7 . As for the SECVTX analysis, this background estimate must undergo a correction for the $t\bar{t}$ content of the 192 events, resulting in a corrected background of 137.1±11.3 . The acceptance, before b-tagging and evaluated at M_{top}=175 GeV/c^2, is $0.099^{+0.030}_{-0.036}$.

We note that at this time there are still unresolved issues regarding correlation of uncertainties in the acceptance and background as well as tagging. For the time being we tacitly assume that the uncertainties on the acceptance and background for the all hadronic mode are independent of those for lepton+jets and that the tagging efficiency uncertainty is 100% correlated (although we *do* use different efficiencies for the two). The result presented here is only intended to demonstrate how much improvement there is in the overall uncertainty when the all hadronic result is added, and is by no means a final number.

The all hadronic results are summarized in Table 5.

3 Cross Section Results

We calculate the individual and combined $t\bar{t}$ production cross section in the usual way, first described in CDF 2392. The cross section results, using the input numbers summarized above, are shown in Table 6.

Using the dilepton and lepton+jets acceptances at 160 and 190 GeV/c^2, we calculate the combined SVX+SLT+DIL cross section at those masses. The result, including the 175 GeV/c^2 value is shown in Table 7.

In Figure 3 we compare the combined SVX+SLT+DIL cross section at 175 GeV/c^2 with the latest theoretical prediction [2]. The horizontal error bar represents the uncertainty in our measured M_{top}, and its tilt represents the change in the central value of the measured cross section as a function of M_{top} .

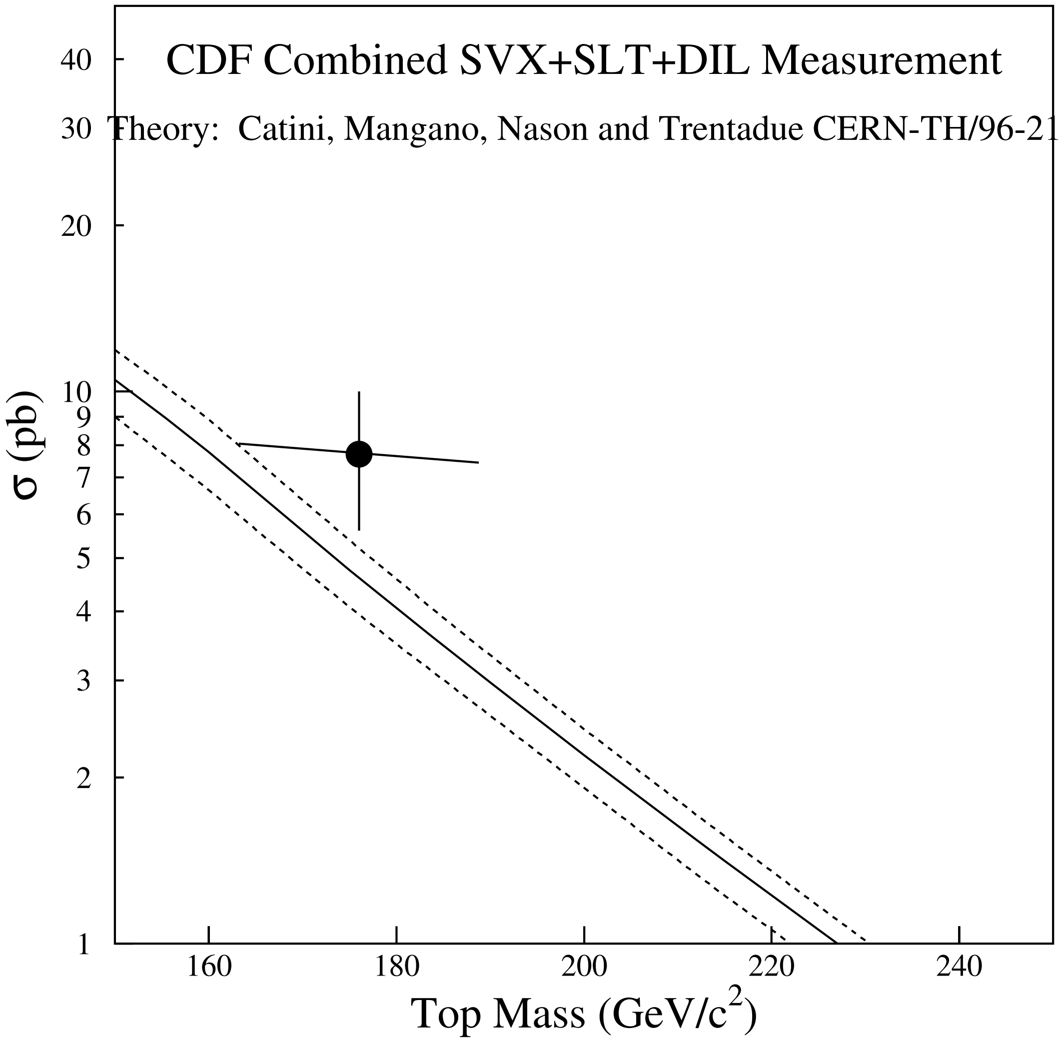

Figure 1: CDF measured cross section at M_{top}=175 GeV/c^2 compared with the latest theoretical calculation.

SVX	$6.8^{+2.3}_{-1.8}$ pb
SLT	$8.0^{+4.4}_{-3.6}$ pb
DIL	$9.3^{+4.4}_{-3.4}$ pb
HAD	$10.7^{+7.6}_{-4.0}$ pb
SVX+SLT+DIL	$7.5^{+1.9}_{-1.6}$ pb
SVX+SLT+DIL+HAD	$8.2^{+1.9}_{-1.6}$ pb

Table 6: Cross section results at M_{top}=175 GeV/c^2 for 110 pb^{-1}

M_{top}	160 GeV/c^2	175 GeV/c^2	190 GeV/c^2
$\sigma_{t\bar{t}}$	$8.0^{+2.1}_{-1.7}$ pb	$7.5^{+1.9}_{-1.6}$ pb	$7.2^{+1.9}_{-1.5}$ pb

Table 7: SVX+SLT+DIL cross section results at M_{top}=160, 175 and 190 GeV/c^2 for 110 pb^{-1}

References

[1] CDF notes 2392,2482,2992,3111 .

[2] S. Catani et al., CERN preprint CERN-TH/96-21.
hep-ph/9602208