CDF note 7795

Measurement of the $t\bar{t}$ Production Cross Section in the Jet Probability Tagged Sample in $p\bar{p}$ Collisions at $\sqrt{s} = 1.96\ TeV$

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We present a measurement of the $t\bar{t}$ production cross section in approximately 318 pb^{-1} of Run II data. The Jet Probability tagger is applied to events with a lepton + $\not\!\!E_T$ signature. To purify the data sample and improve the significance of the measurement, a cut on the scalar transverse energy sum, H_T, is applied. We also use the transverse mass of the leptonic W-boson, M_T^W, to further reduce the Non-W background. Backgrounds are computed from Run II data and Monte Carlo simulation. Signal acceptance is determined from Run II $t\bar{t}$ ($m_t = 178\ GeV/c^2$) Pythia Monte Carlo. When a jet probability cut of 1% is required, we measure a production cross section $\sigma^{jp<1\%}_{tags\geq 1} = 8.9^{+1.0}_{-1.0}(stat.)^{+1.1}_{-1.1}(syst.)\ pb$ in events with at least one tag and $\sigma^{jp<1\%}_{tags\geq 2} = 11.1^{+2.3}_{-1.9}(stat.)^{+1.9}_{-1.9}(syst.)\ pb$ in events with at least two tags. We also measure the $t\bar{t}$ production cross section by requiring a jet probability cut of 5%. We obtain $\sigma^{jp<5\%}_{tags\geq 1} = 9.6^{+1.0}_{-0.9}(stat.)^{+1.2}_{-1.2}(syst.)\ pb$ and $\sigma^{jp<5\%}_{tags\geq 2} = 11.6^{+1.7}_{-1.5}(stat.)^{+1.9}_{-1.9}(syst.)\ pb$ in events with at least one and two tags respectively.

Preliminary Results for Winter 2006 Conferences

I. INTRODUCTION

This note describes a measurement of the $t\bar{t}$ production cross section in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV with the CDF detector at the Fermilab Tevatron. The measurement uses a tagging algorithm based on the information from the Silicon detector for b-jet identification in order to reduce the background from W plus multijet production. This measurement provides a test of the QCD calculations of the $t\bar{t}$ cross section [1].

The CDF detector is described in detail in [2].

II. DATA SAMPLE & EVENT SELECTION

This analysis is based on an integrated luminosity of 318.5 pb^{-1} collected with the CDFII detector up to September 2004. They include only the subsample of data that contains good Silicon VerteX Detector (SVX) information. The data are collected with an inclusive lepton trigger that requires an electron or muon with E_T >18 GeV (P_T >18 GeV/c for the muon). From this inclusive lepton dataset we select events offline with a reconstructed isolated electron E_T (muon P_T) greater than 20 GeV, $\not{E}_T$ >20 GeV and at least 3 jets with E_T >15 GeV. We also require the transverse energy sum of the event, H_T, to be greater than 200 GeV.

The dataset selected above, called "lepton+jets", is dominated by QCD production of W bosons with multiple jets. To reduce the non-W background we apply a cut in the transverse mass of the leptonic W-boson M_T^W.

Furthermore, to improve the signal to background ratio, we identify events with one or more b-jets using a tagging algorithm based on the information provided by the SVX detector. This tagging algorithm is called Jet Probability (JP). We define a tagged jet as that jet whose Jet Probability is less than 1%. We also apply a looser cut of 5%. The numbers of observed events before and after tagging requirement are summarized in Table I as a function of the number of jets with E_T >15 GeV (using a cone of 0.4) and $|\eta|$ <4.

Jet Multiplicity	1 jet	2 jets	3 jets	$\geq$ 4 jets
Pretag events				
CEM	16897	2657	182	105
CMUP	8169	1175	83	44
CMX	4273	610	35	17
Total	29339	4442	300	166

Jet Mult.	1 jet	2 jets	3 jets	$\geq$ 4 jets
Single tagged events (JP<1%)				
CEM	207	106	33	36
CMUP	92	58	13	24
CMX	51	27	6	8
Total	350	191	52	68
Single tagged events (JP<5%)				
CEM	571	230	53	53
CMUP	256	105	24	29
CMX	148	50	10	11
Total	975	385	87	93

Jet Mult.	2 jets	3 jets	$\geq$ 4 jets
Double tagged events (JP<1%)			
CEM	8	7	9
CMUP	3	4	8
CMX	2	1	1
Total	13	12	18
Double tagged events (JP<5%)			
CEM	16	15	18
CMUP	9	4	17
CMX	3	3	4
Total	28	22	39

TABLE I: Yield of events in 318 pb^{-1} of Run II data.

A. Jet Probability Tagging Algorithm

Jet Probability is used to determine whether a jet has been produced from the hadronization process of a light or a heavy quark. The algorithm makes use of the information of the tracks that are associated to a jet to determine the probability for this ensemble of tracks to be consistent with coming from the primary vertex of the interaction. In particular, the track impact parameters and their uncertainties are used. The impact parameter of a track is assigned with a positive or negative sign depending on the position of the track's point of closest approach to the primary vertex with respect to the jet axis. The probability distribution of a set of tracks originating from the primary vertex is by construction uniformly distributed from 0 to 1. For a jet coming from heavy flavor hadronization, the distribution peaks at 0, due to tracks from long lived particles that have large impact parameter with respect to the primary vertex.

Particles in a jet coming from a light quark should originate from the primary vertex. Due to the finite tracking resolution, these tracks are reconstructed with a non-zero impact parameter and have equal probability to be either positive or negative signed. The width of the impact parameter distribution from these tracks is solely due to the tracking detector resolution and multiple scattering effects. The tracking resolution can be extracted from the data by fitting the negative side of the signed impact parameter distribution of primary jets which are the dominant component of QCD jet data.

The efficiency of the algorithm is measured in inclusive electron data and Monte-Carlo samples using a double-tag method. The average (over jet E_T) efficiency to tag a heavy flavor jet with $E_T > 15$ GeV is found to be 0.258 ± 0.018 for JetProb cut value of 0.01 and 0.334 ± 0.026 for a JetProb cut value of 0.05. Uncertainty includes both statistical and systematic errors. The relative difference in the efficiency measured in data and Monte-Carlo (scale factor) is 0.817 ± 0.070 for a JetProb cut value of 0.01 and 0.852 ± 0.072 for a JetProb cut value of 0.05. The scale factor for c-tagging efficiency has not been measured, there is no reason to expect it to be very different from the scale factor for b-tagging so we will assume the same value increasing the systematic error up to 50% to account for the extra uncertainty.

B. Total $t\bar{t}$ Acceptance

1. Geometric × Kinematic Acceptance

The total acceptance is measured in a combination of data and Monte Carlo. The geometric times kinematic acceptance of the basic lepton+jets event selection is measured using the PYTHIA Monte Carlo program [3]. The efficiency for identifying the isolated, high P_T lepton is scaled to the value measured in the data using the unbiased leg in Z-boson decays. The geometric times kinematic acceptance, for the different lepton types: Central electrons(CEM,$|\eta| < 1.0$) Central Muons (CMUP,$|\eta| < 0.6$), and Muon Extension (CMX,$0.6 < |\eta| < 1.0$), is shown in Table II.

Quantity	CEM	CMUP	CMX
$\epsilon_{t\bar{t}}$	3.665 ± 0.279	1.919 ± 0.147	0.751 ± 0.098

TABLE II: Selection efficiencies for $t\bar{t}$ events. Errors are statistical (0.7%) and systematics (7.6%).

2. Event Tagging Efficiency

The event tagging efficiency is evaluated requiring the events to be positively tagged and using the mistag matrix in $t\bar{t}$ events ($m_t = 178\ GeV/c^2$, PYTHIA Monte Carlo program) in order to compute the contribution from light jets. the mistag matrix to the light jets in $t\bar{t}$ events ($m_t = 178\ GeV/c^2$, PYTHIA Monte Carlo program). This includes, automatically, the effects of the fiducial requirements, light jet mistagging and charm jet tagging. The different tagging efficiency between data and Monte Carlo is taken into account through a scale factor, extracted as explained in Section II A.

The final $t\bar{t}$ acceptance is given in Table III. "Acc. No Tag" is the product of the kinematic acceptances, trigger and lepton-id efficiencies. For a JetProbability cut of 1%, the event tagging efficiency, including the tagging scale factor, is $(54.5 \pm 0.17 \pm 3.57)$%. The overall acceptance $\epsilon_{t\bar{t}}$ is $(2.00 \pm 0.01 \pm 0.20)$% for CEM, $(1.04 \pm 0.01 \pm 0.10)$% for CMUP and $(0.41 \pm 0.01 \pm 0.04)$% for CMX. Systematic errors include the 8.6% (12.9%) relative uncertainty due to the b-tagging (c-tagging) efficiency scale factor. The integrated luminosity is (318.5 ± 18.8) pb^{-1} for CEM and CMUP and (305.2 ± 18.0) pb^{-1} for CMX.

Quantity	CEM	CMUP	CMX
Acc. No Tag	3.665 ± 0.017 ± 0.279	1.919 ± 0.011 ± 0.147	0.751 ± 0.008 ± 0.057
Lum.(pb^{-1})	318.5 ± 18.8	318.5 ± 18.8	318.5 ± 18.8
Single tag, JP<1% (SF = 0.817 ± 0.070)			
Tag Eff.	54.70 ± 0.24 ± 3.59	54.05 ± 0.30 ± 3.54	55.21 ± 0.52 ± 3.57
Average Tag Eff.	54.5 ± 0.17 ± 3.57		
Acc. with Tag	2.00 ± 0.01 ± 0.20	1.04 ± 0.01 ± 0.10	0.41 ± 0.01 ± 0.04
$\epsilon_{t\bar{t}} \int$L dt	6.38 ± 0.04 ± 0.74	3.30 ± 0.03 ± 0.39	1.32 ± 0.02 ± 0.15
Double tag, JP<1% (SF = 0.817 ± 0.070)			
Tag Eff.	12.69 ± 0.16 ± 2.07	12.58 ± 0.20 ± 2.04	13.44 ± 0.35 ± 2.19
Average Tag Eff.	12.74 ± 0.12 ± 2.07		
Acc. with Tag	0.465 ± 0.006 ± 0.084	0.241 ± 0.004 ± 0.043	0.101 ± 0.003 ± 0.018
$\epsilon_{t\bar{t}} \int$L dt	1.48 ± 0.02 ± 0.28	0.77 ± 0.01 ± 0.15	0.32 ± 0.01 ± 0.06
Single tag, JP<5% (SF = 0.852 ± 0.072)			
Tag Eff.	68.8 ± 0.2 ± 3.7	68.6 ± 0.3 ± 3.7	69.6 ± 0.5 ± 3.7
Average Tag Eff.	68.8 ± 0.2 ± 3.7		
Acc. with Tag	2.5 ± 0.01 ± 0.23	1.315 ± 0.009 ± 0.123	0.523 ± 0.006 ± 0.049
$\epsilon_{t\bar{t}} \int$L dt	8.03 ± 0.05 ± 0.88	4.19 ± 0.03 ± 0.46	1.67 ±0.02 ± 0.18
Double tag, JP<5% (SF = 0.852 ± 0.072)			
Tag Eff.	24.4 ± 0.2 ± 3.6	24.1 ± 0.3 ± 3.6	25.2 ± 0.5 ± 3.7
Average Tag Eff.	24.4 ± 0.2 ± 3.6		
Acc. with Tag	0.895 ± 0.009 ± 0.148	0.462 ± 0.006 ± 0.0077	0.189 ± 0.004 ± 0.032
$\epsilon_{t\bar{t}} \int$L dt	2.85 ± 0.03 ± 0.50	1.47 ± 0.02 ± 0.26	0.60 ± 0.011 ± 0.11

TABLE III: Selection acceptance and tagging efficiency for $t\bar{t}$ events.

III. BACKGROUNDS

The dominant background for this analysis is QCD production of W-boson plus multijet events. These events enter the signal sample when either one of the jets is a b-jet, or a light quark jet is mis-identified as a b-jet. Besides, other background in this analysis comes from events without W bosons. These events are typically QCD jet events where one jet has faked a high-P_T lepton and mismeasured energies produce apparent missing E_T. We measure this "non-W" background by using the isolation distribution of leptons in the tagged events in the low $\not\!\!E_T$ region to extrapolate the number of events in our sample.

The contribution from real W-boson plus at least one heavy-flavor jet events is computed using two ingredients: a) the fraction of $Wb\bar{b}, Wc\bar{c}$ and Wc events in the W plus multijet sample, for each jet multiplicity bin, and b) the Jet Probability tagging efficiency for each of these event topologies. The fraction of heavy-flavor content relies on theory, ALPGEN Monte Carlo generator [4] has been used in this study. The number of events in the sample is normalized to the data sample before tagging requirement. Non-W events contribution has been subtracted from the pre-tagged sample.

We measure the contribution from light quarks by constructing a "mistag matrix" using negative tagged jets in 318.5 pb^{-1} of inclusive QCD jet events, as a function of the variables (E_T, N_{trk}, $\sum E_T^j$, η, Z_{vtx}) and ϕ. The mistag matrix parameterizes the probability that a jet with a given value for these variables will satisfy the Jet Probability requirement of negative JP <0.01 (JP <0.05). The overall mistag rate is 1.22 ± 0.08% (3.54 ± 0.18). This technique relies on the assumption that the tagging rate in the jets in QCD jet events is a good model for the tagging rate in the jets in W plus jet events. The ideal place to test this assumption would be Z plus jet events, but the statistics there are limited. Instead we test the accuracy of the mistag matrix for predicting tags by using it to predict the number of tags in a variety of independent samples. Finally, in order to take into account the fact that the mistag for positively tagged jets is higher than the negative tag rate, we scale the prediction of the mistag matrix by a factor of 1.57 ± 0.18 for a JetProbability cut of 1% and 1.27 ± 0.20 for a JetProbability cut of 5%.

Other small backgrounds from a variety of sources, mainly diboson, $Z \to \tau^+\tau^-$ and single top production, are estimated using the Monte Carlo predictions for acceptance and tagging efficiency and are normalized to the theoretical cross sections [5, 6].

The background expectations for a JetProbability cut of 1% as a function of jet multiplicity are summarized in Table IV.

Jet Multiplicity	1 jet	2 jet	3 jet	$\geq$ 4 jets
MC Derived Backgrounds				
WW	2.2 ± 0.3	5.0 ± 0.6	0.7 ± 0.1	0.28 ± 0.06
WZ	1.0 ± 0.1	2.0 ± 0.2	0.23 ± 0.04	0.09 ± 0.02
ZZ	0.027 ± 0.006	0.09 ± 0.01	0.012 ± 0.004	0.007 ± 0.002
Single top $W-g$	4.1 ± 0.5	4.9 ± 0.6	0.7± 0.09	0.20 ± 0.03
Single top W^*	1.3 ± 0.2	4.2 ± 0.5	0.60 ± 0.07	0.14 ± 0.02
$Z \to \tau^-\tau^+$	0.74 ± 0.3	0.4 ± 0.2	0.04 ± 0.04	0.0 ± 0.0
Total	9.3 ± 1.1	16.6 ± 1.9	2.3 ± 0.3	0.71 ± 0.09
W + Heavy Flavour				
Wbb	83.0 ± 23.4	47.2 ± 13.2	6.0 ± 1.6	3.3 ± 0.9
W$c\bar{c}$	31.2 ± 9.3	17.5 ± 5.2	2.3 ± 0.7	1.2 ± 0.4
Wc	86.4 ± 21.4	19.2 ± 5.0	1.4 ± 0.4	0.6 ± 0.2
Total	200.6 ± 42.2	83.8 ± 19.8	9.6 ± 2.4	5.2 ± 1.4
Others				
Mistag	149.7 ± 17.9	52.1 ± 6.2	8.6 ± 1.0	6.8 ± 0.8
non W	30.5 ± 15.6	8.6 ± 4.6	0.9 ± 0.6	0.5 ± 0.5
Total Background	390.2 ± 49.1	161.1 ± 22.0	21.5 ± 2.8	13.2 ± 1.7
$t\bar{t}$ (6.1 pb)	1.7 ± 0.4	14.0 ± 1.8	27.5 ± 3.3	39.6 ± 4.6
Data	350	191	52	68

TABLE IV: Summary of the background estimate in the single tagged sample, JP $<$ 1%.

IV. SYSTEMATIC UNCERTAINTIES

Systematic uncertainties in this analysis come from Monte Carlo modeling of the geometrical and kinematic acceptance, knowledge of the JP tagging efficiency, uncertainties on the background predictions and the uncertainty on the luminosity.

Monte Carlo modeling of geometrical and kinematic acceptance include effects of PDFs, ISR and FSR, and jet energy scale. These are estimated by comparing different choices for PDFs and varying ISR, FSR and the jet energy scale in the Monte Carlo. The total systematic uncertainty due to each one of these factors separately is shown in Table V. The choice of the Monte Carlo generator as well as the modeling of the lepton ID efficiency in events with multiple jets are also included.

There are several factors that contribute to the systematic uncertainty from the Jet Probability tagging algorithm used. As we discussed in Section II A, the data to Monte Carlo tagging scale factor for $b(c)$-jets is known with an uncertainty of 8.6 (12.9)%.

The heavy flavor contribution, including the uncertainty from the fraction of b/c-jets in the pretag sample, accounts for 30% systematic uncertainty.

Uncertainties on the non-W prediction are determined by studying the effect on the prediction when the missing E_T and isolation cuts are changed. A 50% systematic uncertainty is assigned to the non-W prediction.

Finally, a small contribution to the error on the the $t\bar{t}$ cross section measurement comes from the uncertainties in the cross sections for diboson, $Z \to \tau^+\tau^-$ and single top production.

The systematic uncertainties for the Jet Probability cut of 1% are summarized in Table V.

	Single tag, JP < 1%		Double tag, JP < 1%	
Source	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$
Central Electron ID	1.6%	0.97%	1.6%	0.96%
Central Muon ID	1.9%	0.61%	1.9%	0.60%
CMX Muon ID	1.8%	0.22%	1.8%	0.21%
PDF	2%	2.0%	2%	2.0%
Jet Energy Scale	4.2%	4.2%	4.2%	4.1%
Lepton Isolation	5%	4.9%	5%	4.8%
Initial and Final State Radiation	1.3%	1.3%	1.3%	1.3%
Monta Carlo Modeling	1.6%	1.6%	1.6%	1.6%
Z Vertex	2.0%	2.1%	2.0%	2.0%
Tagging Scale Factor (b's/c's)	8.6/12.9%	7.2%	8.6/12.9%	14.7%
Mistag Asimmetry	11.5%	1.0%	23.0%	0.07%
Non-W Fraction	50%	0.33%	50%	0.060%
Non-W Prediction	50%	0.71%	50%	0.13%
W+HF Prediction	30%	2.6%	30%	0.84%
Cross Sections (MC bkg.)	1.8%	0.056%	1.8%	0.027%
Luminosity	5.9%	5.7%	5.9%	5.7%
Total Systematic Uncertainty		12.2%		17.4%

TABLE V: Summary of systematic uncertainties for a Jet Probability cut of 1%.

V. RESULTS

Table IV shows a summary of the background estimates for each jet bin with the number of single tagged events with JP<1%. The total background and the $t\bar{t}$ expectation are also listed.

We calculate the cross section in the usual way as

$$\sigma_{t\bar{t}} = \frac{N_{obs} - N_{bckg}}{A_{t\bar{t}} \times \int \mathcal{L}dt} \tag{1}$$

where N_{obs} is the number of events with ≥ 3 tight jets that are tagged with at least one tag with JP $< 1\%$, N_{bckg} is the corrected background and $A_{t\bar{t}}$ is the total acceptance (geometrical times kinematic times tagging efficiency), taken from Tables II and III and correctly weighted for the different luminosities ($\int \mathcal{L}dt$) of the CEM, CMUP and CMX events.

An iterative procedure is applied in the cross section computation to correct the estimates for mistag and W+heavy flavor backgrounds, since they were normalized assuming no signal in the pretag sample.

For $t\bar{t}$ events in 3 or more jets, we find a cross section of

$$\sigma_{t\bar{t}} = 8.9^{+1.0}_{-1.0}\ \text{(stat)} \pm 1.1\ \text{(syst) pb},$$

where the first uncertainty is statistical and the second is systematic.

Figure 1 compares the numbers of observed data to background and signal expectations for a $t\bar{t}$ production cross section of $\sigma_{t\bar{t}}$=6.1 pb (theoretical value for a top mass $m_t = 178\ GeV/c^2$) and $\sigma_{t\bar{t}}$=8.9 pb (measured value).

VI. DOUBLE TAG ANALYSIS

The analysis of the events with two or more tagged jets follows the guideline of the analysis of the sample with at least one tag. Table I shows the number of events after double tagging requirement for ech jet multiplicity bin. Table III shows the efficiencies to tag two jets in signal events passing the pretag selection. In order to estimate the backgrounds, we need to take into account few differences:

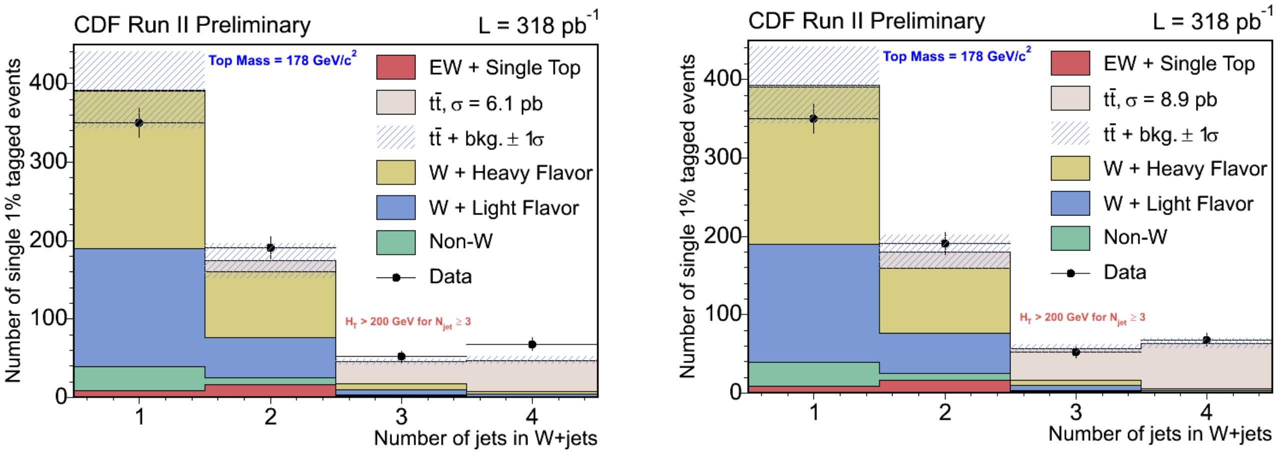

FIG. 1: Single tag (JP<1%) background contributions and results from data as a function of event jet multiplicity when the theoretical cross section for $t\bar{t}$ production at $m_t = 178\ GeV/c^2$ is assumed ($\sigma_{t\bar{t}}$=6.1 pb) in the left and when is assumed the measured cross section in the right.

- We define as mistag background the events with at least two mistagged jets. The negative tag rate matrix is applied to negative taggable jets in the event and the probability to have at least two mistagged jets is summed on all the events. Events with one real heavy flavor tag plus a mistag are taken into account in the other background sources. We scale the mistag prediction by the fraction of non-W, single top and electroweak backgrounds and by the mistag asymmetry as we did for the single tag analysis.

- In order to take into account the contribution of extra mistags in the jet probability efficiency for W+heavy flavor and Monte Carlo derived background, we apply the mistag rate matrix to light flavor jets in events with an extra real tag.

- Due to the lack of statistic, we need to change the way we estimate the non-W background. We compute a common tag rate for all the jet multiplicity bins by using data in the region B: we divide the total number of double tagged events observed by the sum of the number of pretag events in each jet multiplicity bin scaled by the multiplicity of couples of jets in the bin. Finally, we apply this tag rate to the pretag expectation in the signal region we derived.

The results for the background predictions are compared to the observed data and signal expectation in tab. VI. We finally obtain a cross section of

$$\sigma_{t\bar{t}} = 11.1^{+2.3}_{-1.9}\ (\text{stat.}) \pm 1.9\ (\text{syst.})\ \text{pb}.$$

Table V summarizes all the systematic contributions to the cross section uncertainty for a Jet Probability cut of 1%. Figure 2 shows the number of events with at least two tags in $W + 2, 3, \geq 4$ jet events together with a histogram representing the components of the background. The figure also shows the $t\bar{t}$ contribution to each jet bin, normalized to the theoretical (left) and the measured (right) cross section.

VII. SINGLE AND DOUBLE TAG ANALYSES WITH JP < 5%

We repeat the same analysis but loosing the Jet Probability cut to 5%. Table I shows the number of events after tagging requirement for each jet multiplicity bin. Table III shows the efficiencies to tag one or two jets in signal events passing the pretag selection. We finally measure a cross section of

$$\sigma_{t\bar{t}} = 9.6^{+1.0}_{-0.9}\ (\text{stat.}) \pm 1.2\ (\text{syst.})\ \text{pb}$$

for the single tag analysis and of

$$\sigma_{t\bar{t}} = 11.6^{+1.7}_{-1.5}\ (\text{stat.}) \pm 1.9\ (\text{syst.})\ \text{pb}.$$

Jet Multiplicity	2 jets	3 jets	$\geq$ 4 jets
MC Derived Backgrounds			
WW	0.048 $\pm$ 0.02	0.03 $\pm$ 0.018	0.006 $\pm$ 0.007
WZ	0.25 $\pm$ 0.06	0.033 $\pm$ 0.012	0.013 $\pm$ 0.006
ZZ	0.014 $\pm$ 0.005	0.001 $\pm$ 0.001	0.001 $\pm$ 0.001
Single top $W-g$	0.17 $\pm$ 0.03	0.12 $\pm$ 0.03	0.046 $\pm$ 0.011
Single top W^*	0.88 $\pm$ 0.17	0.14 $\pm$ 0.028	0.035 $\pm$ 0.008
$Z \to \tau^- \tau^+$	0.06 $\pm$ 0.06	0 $\pm$ 0	0 $\pm$ 0
Total	1.4 $\pm$ 0.3	0.33 $\pm$ 0.07	0.10 $\pm$ 0.02
W + Heavy Flavour			
W$b\bar{b}$	6.2 $\pm$ 2.0	0.89 $\pm$ 0.29	0.61 $\pm$ 0.21
W$c\bar{c}$	0.38 $\pm$ 0.17	0.13 $\pm$ 0.06	0.077 $\pm$ 0.046
Wc	0.13 $\pm$ 0.08	0.032 $\pm$ 0.026	0.020 $\pm$ 0.020
Total	6.7 $\pm$ 2.1	1.1 $\pm$ 0.3	0.71 $\pm$ 0.24
Others			
Mistag	0.21 $\pm$ 0.05	0.097 $\pm$ 0.022	0.12 $\pm$ 0.03
non W	0.19 $\pm$ 0.12	0.029 $\pm$ 0.018	0.045 $\pm$ 0.030
Total Background	8.5 $\pm$ 2.3	1.5 $\pm$ 0.4	0.97 $\pm$ 0.25
$t\bar{t}$ (6.1 pb)	2.2 $\pm$ 0.5	5.6 $\pm$ 1.1	10 $\pm$ 2.
Data	13	12	18

TABLE VI: Summary of the background estimate in the double tagged sample, JP $<$ 1%.

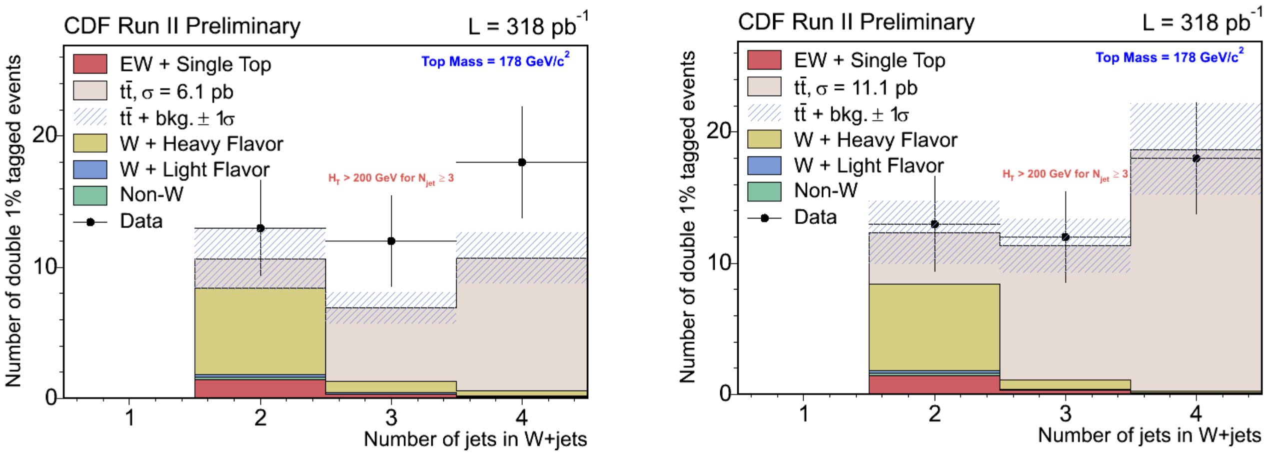

FIG. 2: Double tag (JP<1%) background contributions and results from data as a function of event jet multiplicity when the theoretical cross section for $t\bar{t}$ production at $m_t = 178\ GeV/c^2$ is assumed ($\sigma_{t\bar{t}}$=6.1 pb) in the left and when is assumed the measured cross section in the right.

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The results for the background predictions are compared to the observed data and signal expectation in tab. VII for the single tag analysis and in tab. VIII for the double tag.

Table IX summarizes all the systematic contributions to the cross section uncertainty for a Jet Probability cut of 5%. Figures 3 and 4 show, for the single and double tagged analyses with JP $<$ 5%, the number of events with at least two tags in $W+2, 3, \geq 4$ jet events together with a histogram representing the components of the background. The figures also show the $t\bar{t}$ contribution to each jet bin, normalized to the theoretical (left) and the measured (right) cross section.

Jet Multiplicity	1 jet	2 jets	3 jets	$\geq$ 4 jets
MC Derived Backgrounds				
WW	5.5 $\pm$ 0.6	12.5 $\pm$ 1.4	1.81 $\pm$ 0.22	0.74 $\pm$ 0.10
WZ	1.6 $\pm$ 0.2	3.3 $\pm$ 0.3	0.40 $\pm$ 0.05	0.16 $\pm$ 0.03
ZZ	0.049 $\pm$ 0.009	0.14 $\pm$ 0.02	0.027 $\pm$ 0.006	0.014 $\pm$ 0.004
Single top $W-g$	5.4 $\pm$ 0.7	6.5 $\pm$ 0.8	0.92 $\pm$ 0.10	0.26 $\pm$ 0.03
Single top W^*	1.7 $\pm$ 0.2	5.2 $\pm$ 0.6	0.74 $\pm$ 0.08	0.17 $\pm$ 0.02
$Z \to \tau^- \tau^+$	2.10 $\pm$ 0.5	1.1 $\pm$ 0.3	0.13 $\pm$ 0.10	0 $\pm$ 0
Total	16.3 $\pm$ 1.9	28.8 $\pm$ 3.1	4.0 $\pm$ 0.4	1.4 $\pm$ 0.2
W + Heavy Flavour				
Wbb	111.5 $\pm$ 31.4	60.6 $\pm$ 16.9	7.4 $\pm$ 2.0	4.1 $\pm$ 1.2
W$c\bar{c}$	67.9 $\pm$ 20.2	36.5 $\pm$ 10.8	4.6 $\pm$ 1.4	2.7 $\pm$ 0.8
Wc	183.6 $\pm$ 45.2	40.0 $\pm$ 10.1	3.2 $\pm$ 0.8	1.7 $\pm$ 0.5
Total	363.0 $\pm$ 74.5	137.1 $\pm$ 31.2	15.2 $\pm$ 3.6	8.5 $\pm$ 2.1
Others				
Mistag	584.8 $\pm$ 91.9	193.8 $\pm$ 30.5	28.2 $\pm$ 4.4	22.1 $\pm$ 3.5
non W	68.8 $\pm$ 34.8	21.4 $\pm$ 11.1	1.3 $\pm$ 0.9	0.79 $\pm$ 0.74
Total Background	1033.0 $\pm$ 124.6	381.1 $\pm$ 46.1	48.8 $\pm$ 5.9	32.7 $\pm$ 4.2
$t\bar{t}$ (6.1 pb)	2.3 $\pm$ 0.4	18.0$\pm$ 2.2	34.9 $\pm$ 4.0	50.0 $\pm$ 5.5
Data	975	385	87	93

TABLE VII: Summary of the background estimate in the single tagged sample, JP<5%.

Jet Multiplicity	2 jets	3 jets	$\geq$ 4 jets
MC Derived Backgrounds			
WW	0.29 $\pm$ 0.06	0.13 $\pm$ 0.04	0.073 $\pm$ 0.027
WZ	0.51 $\pm$ 0.11	0.063 $\pm$ 0.017	0.029 $\pm$ 0.010
ZZ	0.026 $\pm$ 0.007	0.0040 $\pm$ 0.0023	0.0016 $\pm$ 0.0013
Single top $W-g$	0.39 $\pm$ 0.07	0.23 $\pm$ 0.04	0.085 $\pm$ 0.017
Single top W^*	1.5 $\pm$ 0.3	0.26 $\pm$ 0.05	0.064 $\pm$ 0.012
$Z \to \tau^- \tau^+$	0.07 $\pm$ 0.07	0 $\pm$ 0	0 $\pm$ 0
Total	2.83 $\pm$ 0.5	0.70 $\pm$ 0.12	0.25 $\pm$ 0.05
W + Heavy Flavour			
Wbb	11.5 $\pm$ 3.7	1.8 $\pm$ 0.6	1.2 $\pm$ 0.4
W$c\bar{c}$	2.4 $\pm$ 0.91	0.61 $\pm$ 0.24	0.45 $\pm$ 0.19
Wc	0.98 $\pm$ 0.38	0.25 $\pm$ 0.11	0.19 $\pm$ 0.09
Total	14.9 $\pm$ 4.7	2.6 $\pm$ 0.8	1.9 $\pm$ 0.6
Others			
Mistag	2.7 $\pm$ 0.9	1.0 $\pm$ 0.3	1.3 $\pm$ 0.4
non W	0.63 $\pm$ 0.34	0.093 $\pm$ 0.052	0.14 $\pm$ 0.09
Total Background	21.1 $\pm$ 5.1	4.4 $\pm$ 0.9	3.5 $\pm$ 0.7
$t\bar{t}$ (6.1 pb)	3.9 $\pm$ 0.8	10.8 $\pm$ 2.0	19.3 $\pm$ 3.4
Data	28	22	39

TABLE VIII: Summary of the background estimate in the double tagged sample, JP<5%.

	Single tag, JP < 5%		Double tag, JP < 5%	
Source	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$
Central Electron ID	1.6%	0.98%	1.6%	0.96%
Central Muon ID	1.9%	0.61%	1.9%	0.60%
CMX Muon ID	1.8%	0.22%	1.8%	0.21%
PDF	2%	2.0%	2%	2.0%
Jet Energy Scale	4.2%	4.2%	4.2%	4.1%
Lepton Isolation	5%	5.0%	5%	4.8%
Initial and Final State Radiation	1.3%	1.3%	1.3%	1.3%
Monta Carlo Modeling	1.6%	1.6%	1.6%	1.6%
Z Vertex	2.0%	2.1%	2.0%	2.0%
Tagging Scale Factor (b's/c's)	8.5/12.7%	6.3%	8.5/12.7%	13.6%
Mistag Asimmetry	15.5%	3.0%	31.1%	0.44%
Non-W Fraction	50%	0.56%	50%	0.092%
Non-W Prediction	50%	0.79%	50%	0.21%
W+HF Prediction	30%	2.9%	30%	1.0
Cross Sections (MC bkg.)	1.8%	0.072%	1.8%	0.030%
Luminosity	5.9%	5.8%	5.9%	5.7%
Total Systematic Uncertainty		12.2%		16.5%

TABLE IX: Summary of systematic uncertainties for a Jet Probability cut of 5%.

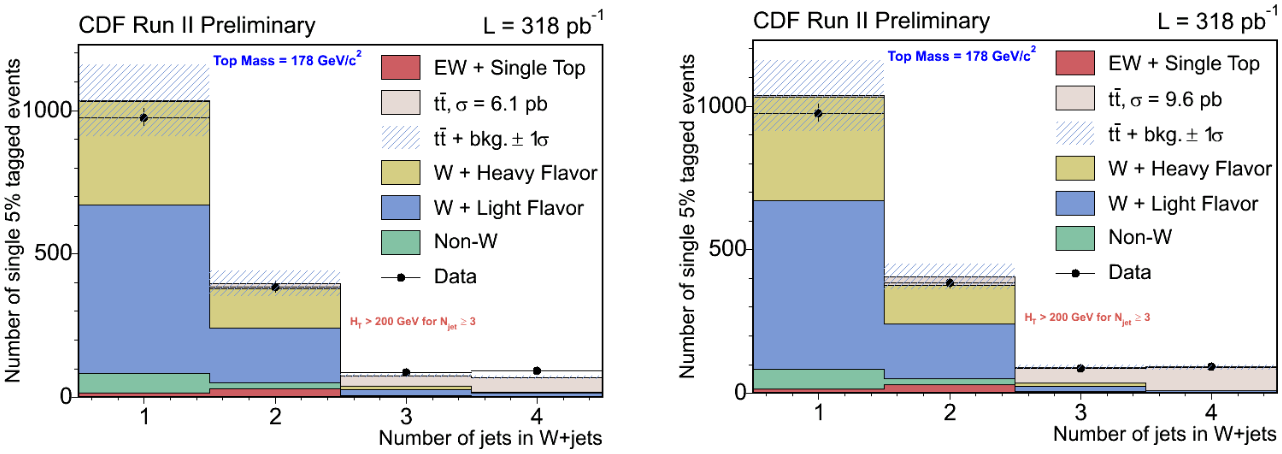

FIG. 3: Single tag (JP<5%) background contributions and results from data as a function of event jet multiplicity when the theoretical cross section for $t\bar{t}$ production at $m_t = 178\ GeV/c^2$ is assumed ($\sigma_{t\bar{t}}$=6.1 pb) in the left and when is assumed the measured cross section in the right.

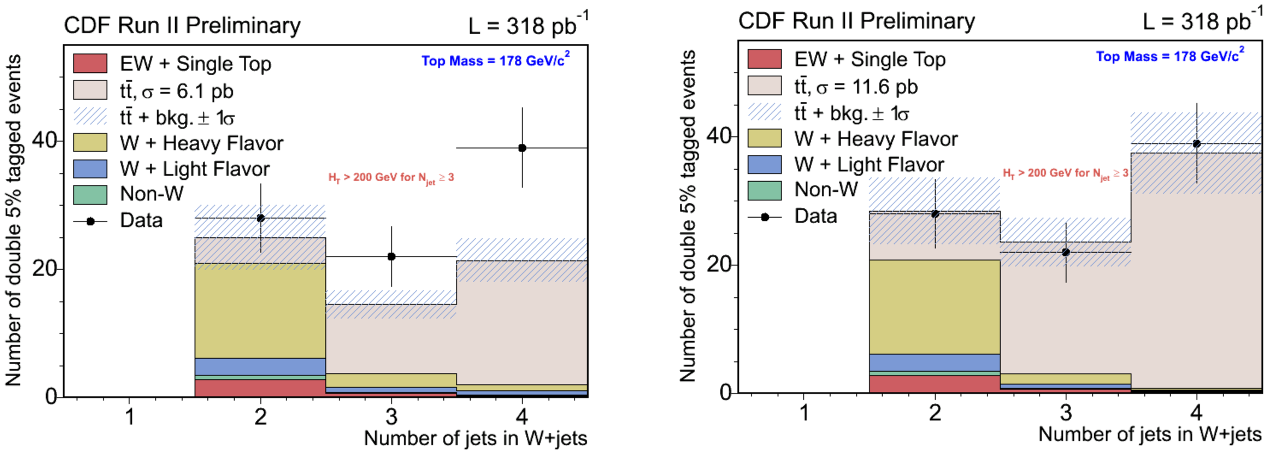

FIG. 4: Double tag (JP<5%) background contributions and results from data as a function of event jet multiplicity when the theoretical cross section for $t\bar{t}$ production at $m_t = 178\ GeV/c^2$ is assumed ($\sigma_{t\bar{t}}$=6.1 pb) in the left and when is assumed the measured cross section in the right.

VIII. COMPATIBILITY OF THE RESULTS

We observe a ratio of about 1.24 between the measured cross section in the single ant double tag channels. Even if the measurements are still compatible within the statistical uncertainty, we try to understand if we can identify a systematic effect behind this difference. We estimate the probability to measure a cross section greater or equal to the one we obtain in the double tag channel when we assume the cross section measured in the single tag channel to be the correct one. For each pseudoexperiment, we fluctuate our total background estimate for the double tag channel according to a gaussian distribution with a width equal to the total uncertainty on the prediction. Successively, we sum the obtained background to the signal expected by assuming the $t\bar{t}$ cross section we measured in the single tag channel and we fluctuate the total number of events obtained according to a poissonian distribution. We repeat this procedure 10,000 times and we count the number of pseudoexperiment in which we would have a result greater or equal to the one we observed on data. Results are summarized in table X and seem to suggest a higher value for the tagging scale factor even if the difference between the results in the single and double tag analyses is still compatible with a statistical fluctuation.

	SF - 1 σ	SF	SF + 1 σ
JP < 1%	4.5 %	13.2 %	30 %
JP < 5%	2.8 %	15.6 %	35 %

TABLE X: Probability to measure a cross section greater or equal to the one obtained in the double tag analysis when the $t\bar{t}$ cross section measured in the single tag analysis is assumed.

IX. SUMMARY

We have calculated the backgrounds to the Jet Probability tagged lepton + jets sample for 318 pb^{-1} requiring a tight (1%) and a looser cut (5%) of Jet Probability. We find good agreement with the observed number of tags in the 1 and 2 jet bins. The $t\bar{t}$ measured cross sections using the excess of events in the 3 and ≥ 4 jet bins are shown in table XI.

	$\geq$ 1 tag	$\geq$ 2 tags
JP < 1%	$8.9^{+1.0}_{-1.0}$ (stat.)$^{+1.1}_{-1.1}$(syst.) pb	$11.1^{+2.3}_{-1.9}$ (stat.)$^{+1.9}_{-1.9}$($syst.$) pb
JP < 5%	$9.6^{+1.0}_{-0.9}$ (stat.)$^{+1.2}_{-1.2}$(syst.) pb	$11.6^{+1.7}_{-1.5}$ (stat.)$^{+1.9}_{-1.9}$($syst.$) pb

TABLE XI: Measured $t\bar{t}$ cross sections for each analysis.

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