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Update on Backgrounds to Top Searches Using SVX b-Tagging

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Abstract

In this note, we present an update to CDF note 2092, covering studies of the physical backgrounds (those involving true heavy flavor tagging) to the top search using an SVX b-tag. Backgrounds processes investigated in this note include $Wb\bar{b}$, $Wc\bar{c}$, Wc, $Z \to \tau\tau$, and diboson production. Mistags (background due to errors in tracking and tagging) and background from non-W processes ($b\bar{b}$) are not explicitly discussed in this note. This note primarily lists the 'numbers' needed to calculate the b-tag background. CDF note 2252, a companion note to this one, explains some of the details of how the background is calculated.

1 Introduction

In this CDF note, we calculate the physical background to top searches using an SVX b-tag. This includes $Wb\bar{b}$, $Wc\bar{c}$, Wc, Z, and diboson production. The methods used are applicable to any of the SVX b-tagging algorithms. In particular, we give results for the JETVTX, JPBTAG, and BTDPHI b-tagging algorithms. Mistags (background due to errors in tracking and tagging) and background from non-W processes ($b\bar{b}$) are not explicitly discussed in this note. Tag rates are given in terms of tags per event and tags per jet. In calculating tags per jet, the denominator is jets with $E_T > 15GeV$ and $|\eta| < 2$, no SVX track requirements are made. Summaries of mistags can be found in CDF notes on each tagging algorithm. The 'philosophy' behind the background calculations is discussed in CDF note 2252. CDF 2252 also gives more details on how some of the numbers used in this note were derived. A summary of studies for non-W can be found in CDF note 2027.

The numbers presented in this note use a MET cut of $20GeV$. For backgrounds scaled to the number of events observed before b-tagging, the difference between a MET cut of 20 and 25 is negligible compared to the statistical errors. For backgrounds calculated using an absolute cross section, the difference is small. For $Wb\bar{b}$ and $Wc\bar{c}$ using the Mangano absolute cross section, the lower MET cut gives an increase of $\sim 8\%$ in the cross section. For the diboson background, the lower MET cut gives an increase of $\sim 5 \sim 10\%$ in the cross section.

2 Monte Carlo Tuning

In this note, MCQTUNE [1] is used on Monte Carlo datasets to better reproduce the observed SVX tracking efficiencies. Also, to accurately simulate the effect of dead channels in the SVX, an actual SVX deadlist from the 1992-93 run is incorporated into the simulation and reconstruction of the Monte Carlo events. The default MC uses the SVX deadlist for run 1, which lists the dead channels at the time of construction ($\sim$ March 1992). In practice, the addition of these two tuning effects to the simulation tends to reduce the tagging rate of heavy flavor jets. Since the physical backgrounds in this note arise from processes with real heavy flavor, the background tagging rates calculated without MCQTUNE and/or an SVX deadlist are expected to be higher than the actual rates. Therefore, the 'untuned' tagging rates can be considered an 'upper limit' on the background tagging rate. The 'tuned' rates can be considered our current best guess.

The MCQTUNE parameters used in this note decrease the SVX cluster efficiency by 15.2, 3, 4, and 2.5% in layers 0 through 3, respectively. In addition, XSMEAR was turned on. For the most part, we use run 43070 for the SVX deadlist, which corresponds to data from early Jan 93. A small set of our Monte Carlo samples use the default SVX deadlist 1. When possible, Monte Carlo tagging efficiencies are given for both default CDFSIM and CDFSIM+MCQTUNE.

3 $Wb\bar{b}$ and $Wc\bar{c}$ Background

3.1 Background Fraction Before Tagging

We use Herwig+QFL and Isajet+QFL [2] Monte Carlo to produce $W+$ jets samples. We use these samples to study the relative rate of $Wb\bar{b}$ and $Wc\bar{c}$ in $W+$ jets before tagging. Table 1 lists F_n, the fraction of $Wb\bar{b}$ in the sample as a function of n, the jet multiplicity in the event.

$$F_n = \frac{B_n(MC)}{N_n(MC)} \tag{1}$$

where $B_n(MC)$ is the number of $Wb\bar{b}$ n jet events in the MC, and $N_n(MC)$ is the number of generic $W+n$ jet events in the MC. From this, we can estimate $B_n(data)$, the number of $Wb\bar{b}$ events in the data:

$$B_n(data) = N_n(data) \times F_n \tag{2}$$

where $N_n(data)$ is the number of n jet events observed in the data. Table 2 lists F_n for $Wc\bar{c}$.

Another method of calculating the $Wb\bar{b}$ background is to use the absolute prediction from the Mangano Monte Carlo. [3] The overall cross section for $Wb\bar{b}$, with $W \to e\nu$, is calculated to be $5.5pb$. To calculate the number of events after the kinematic cuts, we use Mangano+CDFSIM. From M. Mangano's preprint IFUP-TH 36/92, the overall uncertainty in the rate is within a factor of two. To account for this uncertainty, we apply a correction factor K to the expected cross sections. By comparing the calculated W cross section to the observed cross section, a reasonable range would be $K = 1.2 \pm 0.3$. [4] The cross sections after $W+$ jets cuts are listed in table 3. Corresponding values for $Wc\bar{c}$ are given in table 4.

We check the jet multiplicity distributions for generic $W+$ jets Monte Carlo and compare to data. The results are summarized in table 5.

[1] B. Harral, G Houk, CDF note 2211: This module allows tuning of the SVX Monte Carlo in PAD format.

[2] In Isajet, we set $Q_t W = 0$.

[3] M. Mangano, preprint IFUP-TH 36/92. We use $Q^2 = M_{bb}^2$ and $m_b = 4.75 GeV/c^2$.

[4] CDF2252 and R. Hamberg *et al.*, Nucl. Phys. B359 (1991) 343.

Fraction of $Wb\bar{b}$		
Jet mult	Herwig	Isajet
1 jet	$0.53 \pm 0.02\%$	$2.0 \pm 0.1\%$
2 jets	$1.04 \pm 0.08\%$	$4.3 \pm 0.5\%$
3 jets	$2.11 \pm 0.30\%$	$5.5 \pm 1.5\%$
4 jets	$2.5 \pm 1.2\%$	$8.3 \pm 5.9\%$

Table 1: Estimate of F_n, the fraction of $Wb\bar{b}$ in $W + n$ jets before tagging. The Herwig and Isajet generators are used. QFL is used to simulate the events.

Fraction of $Wc\bar{c}$		
Jet mult	Herwig	Isajet
1 jet	$1.19 \pm 0.04\%$	$4.8 \pm 0.1\%$
2 jets	$2.45 \pm 0.13\%$	$7.9 \pm 0.7\%$
3 jets	$3.45 \pm 0.48\%$	$12.3 \pm 2.2\%$
4 jets	$2.7 \pm 1.5\%$	$20.1 \pm 8.1\%$

Table 2: Estimate of F_n, the fraction of $Wc\bar{c}$ in $W + n$ jets before tagging. The Herwig and Isajet generators are used. QFL is used to simulate the events.

Jet mult	$\sigma(pb)$ with $K = 1$	$\sigma(pb)$ with $K = 1.2 \pm 0.3$
no cut	5.5	6.6 ± 1.7
1 jet	0.283 ± 0.008	$0.34 \pm 0.010 \pm 0.085$
2 jets	0.044 ± 0.003	$0.053 \pm 0.004 \pm 0.013$
3 jets	0.0019 ± 0.0007	$0.0023 \pm 0.0008 \pm 0.0006$
4 jets	0.0002 ± 0.0002	$0.0002 \pm 0.0002 \pm 0.0001$

Table 3: Mangano estimate of the $Wb\bar{b} \to e\nu b\bar{b}$ cross sections before and after the $W + n$ jets cuts have been applied. K is the correction factor to the overall cross section.

Jet mult	$\sigma(pb)$ with $K = 1$	$\sigma(pb)$ with $K = 1.2 \pm 0.3$
no cut	22.6	27.1 ± 6.8
1 jet	0.698 ± 0.021	$0.838 \pm 0.025 \pm 0.209$
2 jets	0.074 ± 0.007	$0.089 \pm 0.008 \pm 0.022$
3 jets	0.007 ± 0.002	$0.008 \pm 0.002 \pm 0.002$
4 jets	0.0013 ± 0.0009	$0.0016 \pm 0.0011 \pm 0.0004$

Table 4: Mangano estimate of the $Wc\bar{c} \to e\nu c\bar{c}$ cross sections before and after the $W + n$ jets cuts have been applied. K is the correction factor to the overall cross section.

Jet mult	Herwig	Isajet	Mangano	$W \to e\nu$ data
2 jets	$16.8 \pm 0.4\%$	$15.4 \pm 0.3\%$	$15.4 \pm 1.1\%$	17.4%
3 jets	$1.8 \pm 0.1\%$	$1.8 \pm 0.1\%$	$0.7 \pm 0.2\%$	2.7%
4 jets	$0.18 \pm 0.05\%$	$0.21 \pm 0.04\%$	$< 0.08\%$	0.6%

Table 5: Percentage of events as a function of jet multiplicity in Herwig and Isajet generic W Monte Carlo and $W \to e\nu$ data. The Mangano numbers are for $Wb\bar{b}$ only. Jet requirements are $E_T > 15GeV$ and $|\eta| < 2$. Percentages are normalized to 100% in the 1 jet bin.

3.2 Background Tagging Probability

To estimate the number of $Wb\bar{b}$ events after SVX tagging, we compute the tagging rate using the Mangano Monte Carlo with CDFSIM and CLEOMC. Table 6 lists the tagging rate ϵ as a function of jet multiplicity for $Wb\bar{b}$ Monte Carlo. The denominator used in calculating the jet tag rates is all jet with $E_T > 15GeV$ and $|\eta| < 2$, no SVX requirement is made on the jets. The corresponding rates for $Wc\bar{c}$ is given in table 7. The expected number of $Wb\bar{b}$ events after tagging in the $W + n$ jet sample is then given by:

$$\#\text{tagged} = N_n(data) \times F_n \times \epsilon \qquad (3)$$

In the $W + 2$ jet bin, we find in $\sim 65\%$ of the $Wb\bar{b}$ MC, the two identified jets are both b jets. In the remaining 35%, only one of the jets is a b jet.

4 Wc Background

In CDF note 2092, we studied the relative rate of Wc events in the $W+$ jets data. The parton level fraction (F_{Wc}) as a function of jet multiplicity from that note is reprinted in table 8. These numbers must be converted from the parton level to the observed level before calculating the expected background to the top search. To compute this correction factor C, we use Herwig+QFL to generate Wc and generic $W + 1$ jet events. We find $C = 1.11 \pm 0.03$. [5]

Estimates of ϵ_{Wc}, the tagging rate in Wc events, are made using Herwig+CDFSIM+CLEOMC. The results are listed in table 9. For comparison, we use Isajet+CDFSIM+CLEOMC to estimate the same tagging rates. The Isajet results are listed in table 10. [6]

The number of expected Wc background events for each jet multiplicity bin can be computed as:

$$N_{Wc}(n) = N_n \times F_{Wc}(n) \times (1.11 \pm 0.03) \times \epsilon_{Wc} \qquad (4)$$

where $N_{Wc}(n)$ is the expected number of Wc events after tagging, N_n is the number of generic $W + n$ jet events observed before tagging, $F_{Wc}(n)$ is the relative rate of Wc to $W + n$ jets at the parton level, and ϵ_{Wc} is the Wc tagging rate (including SVX acceptance).

[5] In CDF note 2092, a lower statistics sample gave $C = 1.3 \pm 0.1$. In deriving $C = 1.3$, the effect of the $|\eta| < 2$ cut on the jets was inadvertently double counted.

[6] In CDF note 2092, there was a typographical error in the Isajet Wc tagging rates.

Event Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.22222 ± 0.01878	0.24286 ± 0.01963	0.25873 ± 0.02027
2 jets	0.32692 ± 0.05607	0.35577 ± 0.05849	0.30769 ± 0.05439
3 jets	0.28571 ± 0.20203	0.28571 ± 0.20203	0.28571 ± 0.20203
Event Tag Rate (With MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.20952 ± 0.01824	0.20952 ± 0.01824	0.20476 ± 0.01803
2 jets	0.29808 ± 0.05354	0.30769 ± 0.05439	0.25962 ± 0.04996
3 jets	0.42857 ± 0.24744	0.42857 ± 0.24744	0.28571 ± 0.20203
Jet Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.22222 ± 0.01878	0.24286 ± 0.01963	0.25873 ± 0.02027
2 jets	0.19712 ± 0.03078	0.23077 ± 0.03331	0.17308 ± 0.02885
3 jets	0.09524 ± 0.06734	0.09524 ± 0.06734	0.09524 ± 0.06734
Jet Tag Rate (With MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.20952 ± 0.01824	0.20952 ± 0.01824	0.20476 ± 0.01803
2 jets	0.17788 ± 0.02924	0.18750 ± 0.03002	0.13942 ± 0.02589
3 jets	0.14286 ± 0.08248	0.14286 ± 0.08248	0.09524 ± 0.06734

Table 6: Tagging rate in $Wb\bar{b}$ Monte Carlo as a function of jet multiplicity. SVX deadlist 43070 was used in generating the MC.

Event Tag Rate (with MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.06221 ± 0.00760	0.05014 ± 0.00682	0.04085 ± 0.00616
2 jets	0.05217 ± 0.02130	0.07826 ± 0.02609	0.02609 ± 0.01506
3 jets	0.09091 ± 0.09091	0.09091 ± 0.09091	0.09091 ± 0.09091
Jet Tag Rate (with MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.06221 ± 0.00760	0.05014 ± 0.00682	0.04085 ± 0.00616
2 jets	0.03043 ± 0.01150	0.03913 ± 0.01304	0.01304 ± 0.00753
3 jets	0.03030 ± 0.03030	0.03030 ± 0.03030	0.03030 ± 0.03030

Table 7: Tagging rate in $Wc\bar{c}$ Monte Carlo as a function of jet multiplicity.

Jet mult	F_{Wc}
1 jet	$5.3 \pm 1.3\%$
2 jets	$7.5 \pm 1.5\%$
3 jets	$8.0 \pm 1.5\%$

Table 8: Estimate of F_{Wc}, the parton level fraction of Wc as a function of jet multiplicity. To convert from F_{Wc} to the expected fraction in $W+$ jets, a parton-to-observed scaling factor of $C = 1.11 \pm 0.03$ must be used.

Event Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.04741 ± 0.00514	0.05466 ± 0.00552	0.02621 ± 0.00382
2 jets	0.06085 ± 0.01269	0.06085 ± 0.01269	0.02910 ± 0.00877
3 jets	0.03125 ± 0.03125	0.03125 ± 0.03125	0.03125 ± 0.03125
Event Tag Rate (With MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.03960 ± 0.00470	0.03458 ± 0.00439	0.01840 ± 0.00320
2 jets	0.05026 ± 0.01153	0.04762 ± 0.01122	0.02910 ± 0.00877
3 jets	0.03125 ± 0.03125	0.03125 ± 0.03125	0.00000 ± 0.00000
Jet Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.04741 ± 0.00514	0.05466 ± 0.00552	0.02621 ± 0.00382
2 jets	0.03042 ± 0.00634	0.03042 ± 0.00634	0.01455 ± 0.00439
3 jets	0.01042 ± 0.01042	0.01042 ± 0.01042	0.01042 ± 0.01042
Jet Tag Rate (With MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.03960 ± 0.00470	0.03458 ± 0.00439	0.01840 ± 0.00320
2 jets	0.02513 ± 0.00577	0.02381 ± 0.00561	0.01455 ± 0.00439
3 jets	0.01042 ± 0.01042	0.01042 ± 0.01042	0.00000 ± 0.00000

Table 9: ϵ_{Wc}, the tagging rate in Wc Herwig Monte Carlo, as a function of jet multiplicity. SVX deadlist 43070 was used in generating the MC.

Event Tag Rate (With MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.03810 ± 0.00778	0.04286 ± 0.00825	0.01905 ± 0.00550
2 jets	0.06557 ± 0.03279	0.06557 ± 0.03279	0.01639 ± 0.01639
3 jets	0.20000 ± 0.14142	0.20000 ± 0.14142	0.10000 ± 0.10000
Jet Tag Rate (With MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.03810 ± 0.00778	0.04286 ± 0.00825	0.01905 ± 0.00550
2 jets	0.03279 ± 0.01639	0.03279 ± 0.01639	0.00820 ± 0.00820
3 jets	0.06667 ± 0.04714	0.06667 ± 0.04714	0.03333 ± 0.03333

Table 10: ϵ_{Wc}, the tagging rate in Wc Isajet Monte Carlo, as a function of jet multiplicity.

5 $Z \to \tau\tau$ Background

Another possible source of non-W events in the $W+$ jets sample is $Z \to \tau\tau$, where one τ decays to an electron or muon, and the other has a three prong decay. This background will predominately affect only the $W+$ 1 jet sample. We investigate this using Isajet+CLEO+CDFSIM to generate $Z \to \tau\tau$. From the ratio of W and Z cross sections, we can normalize the Monte Carlo results to our data in the following way:

$$N_1(Z \to \tau\tau) = N_1 \times \frac{1}{R} \times \frac{Br(Z \to \tau\tau)}{Br(Z \to ee)} \times \frac{\epsilon_Z}{\epsilon_W} \tag{5}$$

where $N_1(Z \to \tau\tau)$ is the predicted number of $Z \to \tau\tau$ events passing the $W + 1$ jet cuts, N_1 is the number of observed events passing the $W + 1$ jet cuts, and

$$R = \frac{\sigma(p\bar{p} \to W \to e\nu)}{\sigma(p\bar{p} \to Z \to ee)} \tag{6}$$

$$\epsilon_Z = \frac{\#\text{ of } Z \to \tau\tau \text{ events passing } W + 1 \text{ jet cuts in MC}}{\#\text{ of } Z \to \tau\tau \text{ events generated in MC}} \tag{7}$$

$$\epsilon_W = \frac{\#\text{ of } W \to e\nu \text{ events passing } W + 1 \text{ jet cuts in MC}}{\#\text{ of } W \to e\nu \text{ events generated in MC}} \tag{8}$$

The ratio of Z and W cross sections has been measured by CDF to be $R = 10.2 \pm 0.8 \pm 0.4$. [7] We take $Br(Z \to \tau\tau)/Br(Z \to ee)$ to be 1. ϵ_Z and ϵ_W are estimated from Monte Carlo. The absolute efficiency calculations will have some systematic error due to the fact we need to use CDFSIM (necessary for the SVX simulation) instead of QFL. However, since we are interested only in ratio of the efficiencies, many of the systematics fall out to the first order. We estimate $\epsilon_W \sim 0.98 \pm 0.04\%$ and $\epsilon_Z \sim 0.033 \pm 0.005\%$. We then expect $N_1 \times (0.0033 \pm 0.006)$ background events from $Z \to \tau\tau$ in the $W + 1$ jet sample before tagging. The $Z \to \tau\tau$ tagging rates are listed in table 11. Assuming the probability of observing extra jets in $Z \to \tau\tau$ events is similar to generic high P_T lepton events in our sample, then the fraction of $Z \to \tau\tau$ background should remain constant as a function of jet multiplicity.

[7] Phys. Rev. Lett. **64**, 152 (1990)

Event Tag Rate (With MCQTUNE)			
	JETVTX	JPBTAG	BTDPHI
1 jets	0.016 ± 0.012	0.008 ± 0.008	0.008 ± 0.008

Table 11: Tagging rate in $Z \rightarrow \tau\tau$ Monte Carlo.

6 Diboson Background

Diboson production may be expected to give a small contribution to the background after tagging from events in which one of the boson deays to a lepton (electron or muon) and the other bosons decays to long-lived particles (*e.g.* b, c, or τ). We take the WW and WZ production cross sections to be $\sigma(WW) = 9.5 \pm 0.5 \pm 0.5pb$ and $\sigma(WZ) = 2.6 \pm 0.3 \pm 0.3pb$, where the first error is due to the uncertainty in structure functions and the second from Q^2. [8]

To estimate the rate before tagging, we use Isajet+QFL to simulate the processes $WW \rightarrow e\nu c\bar{s}$ and $WZ \rightarrow e\nu b\bar{b}$. From this MC, we calculate ϵ_{kin}, the kinematic cut efficiency (jet cuts, MET cut, isolation cut, and geometrical acceptance). The results are listed in table 12. The lepton ID efficiency is listed separately. For the electron identification cuts, we take the efficiency to be $\epsilon_e = (84 \pm 3\%) \times 93\% \times 95\% = 74\%$, where the first factor is the offline e ID efficiency, and the second factor is the trigger efficiency, and the third the conversion removal. For muons, we take $\epsilon_\mu = 95\% \times 87\% = 83\%$, where the first factor is the muon ID and the second is the CMU trigger. For CMX, we take $\epsilon_\mu = 60\% \times 82\% \times 98\% = 48\%$, where the first factor is the L2 trigger efficiency, the second the usable luminosity, and the third the muon ID. σ_N, the cross section of background events before tagging, is given by:

$$\sigma_N = [\sigma \times Br] \times \epsilon_{kin} \times \epsilon_l \qquad (9)$$

where Br is the branching ratio and $Br(WW \rightarrow e\nu c\bar{s}) = 0.074$ or $Br(WZ \rightarrow e\nu b\bar{b}) = 0.02$, and ϵ_l is ϵ_e or ϵ_μ. Table 13 lists σ_N as a function of jet multiplicity. In this table, we take the overall error on σ_N to be 30% of itself for the 1 and 2 jet bins, and 40% in the 3 and 4 jet bins.

To estimate the tagging rate for these diboson processes, we use Isajet+CDFSIM+CLEOMC. The calculated rates are listed in table 14 and 15.

7 Mistags in the Physical Background MC

In principle, the tagging rates derived from the background Monte Carlo include tags due to real heavy flavor and mistags (errors in tracking and tagging). For the top b-tagging algorithms, mistags are estimated using the tag rates from the inclusive jets data. By summing the background estimated from the inclusive jets data to that from the background Monte Carlo, we may be double counting the mistags in the background MC. Since the MC probably underestimates the mistag rate, any such double counting is expected to be small.

As a check, we investigate the source of the tags in $Wb\bar{b}$ MC. We label an observed jet as a $b[c]$ jet if $\cos(\phi) > 0.9$, where ϕ is the opening angle between the jet axis and the closest MC $b[c]$ flavored hadron. In a sample of 215 jets tagged by JETVTX, we find only 3 jets are not associated with a b or c hadron. In a similar study of 123 jets tagged by JETVTX in $Wc\bar{c}$

[8] Phys. Rev. D44, 1403 (1991); Phys. Rev. D44 3477 (1991).

Inclusive Electron Mode		
Jet mult	WW (%)	WZ (%)
1 jet	12.3 ± 0.4	10.4 ± 0.4
2 jets	14.9 ± 0.8	13.8 ± 0.8
3,4 jets	5.9 ± 0.5	4.8 ± 0.5
Inclusive Muon Mode: CMU		
Jet mult	WW (%)	WZ (%)
1 jet	6.4 ± 0.5	6.3 ± 0.5
2 jets	8.1 ± 0.6	6.7 ± 0.5
3,4 jets	3.3 ± 0.4	2.4 ± 0.3
Inclusive Muon Mode: CMU+CMX		
Jet mult	WW (%)	WZ (%)
1 jet	9.7 ± 0.6	9.0 ± 0.6
2 jets	11.6 ± 0.7	10.3 ± 0.7
3,4 jets	4.4 ± 0.5	3.6 ± 0.4

Table 12: ϵ_{kin}, the kinematical cut efficiency in percent, for WW and WZ events as a function of jet multiplicity.

Inclusive Electron Mode		
Jet mult	$\sigma_N(WW)(pb)$	$\sigma_N(WZ)(pb)$
1 jet	0.064 ± 0.019	0.004 ± 0.001
2 jets	0.077 ± 0.024	0.005 ± 0.002
3,4 jets	0.031 ± 0.012	0.002 ± 0.001
Inclusive Muon Mode: CMU		
Jet mult	$\sigma_N(WW)(pb)$	$\sigma_N(WZ)(pb)$
1 jet	0.037 ± 0.011	0.003 ± 0.001
2 jets	0.047 ± 0.014	0.003 ± 0.001
3,4 jets	0.019 ± 0.008	0.001 ± 0.001
Inclusive Muon Mode: CMU+CMX		
Jet mult	$\sigma_N(WW)(pb)$	$\sigma_N(WZ)(pb)$
1 jet	0.048 ± 0.014	0.004 ± 0.001
2 jets	0.059 ± 0.018	0.004 ± 0.001
3,4 jets	0.023 ± 0.009	0.001 ± 0.001

Table 13: Diboson cross section in pb before tagging.

Event Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.02612 ± 0.00974	0.02612 ± 0.00974	0.01119 ± 0.00643
2 jets	0.04023 ± 0.01490	0.03448 ± 0.01383	0.01724 ± 0.00987
3 jets	0.00000 ± 0.00000	0.07317 ± 0.04067	0.02439 ± 0.02409
Jet Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.02612 ± 0.00974	0.02612 ± 0.00974	0.01119 ± 0.00643
2 jets	0.02011 ± 0.00753	0.01724 ± 0.00698	0.00862 ± 0.00496
3 jets	0.00000 ± 0.00000	0.02439 ± 0.01391	0.00813 ± 0.00810

Table 14: Tagging rate in WW Monte Carlo as a function of jet multiplicity.

Event Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.18077 ± 0.02387	0.16154 ± 0.02282	0.16154 ± 0.02282
2 jets	0.32642 ± 0.03375	0.34715 ± 0.03427	0.22798 ± 0.03020
3 jets	0.36842 ± 0.07825	0.34211 ± 0.07696	0.23684 ± 0.06897
4 jets	0.38889 ± 0.11490	0.22222 ± 0.09799	0.33333 ± 0.11111
Jet Tag Rate (No MCQTUNE)			
Jet mult	JETVTX	JPBTAG	BTDPHI
1 jets	0.18077 ± 0.02387	0.16154 ± 0.02282	0.16154 ± 0.02282
2 jets	0.19430 ± 0.02014	0.21244 ± 0.02082	0.12176 ± 0.01664
3 jets	0.14912 ± 0.03336	0.13158 ± 0.03166	0.09649 ± 0.02765
4 jets	0.11111 ± 0.03704	0.06944 ± 0.02996	0.08333 ± 0.03257

Table 15: Tagging rate in WZ Monte Carlo as a function of jet multiplicity.

Monte Carlo, 4 jets are not associated with a b or c hadron. In Wc Monte Carlo, 10 jets out of 134 JETVTX tags are not associated with a b or c hadron.

8 Conclusions

Tables 16, 17, and 18 summarize the expected number of background events from the sources in the preceding sections. In calculating these numbers, we normalize to the number of $W+$ jet events passing all cuts before tagging. In the first row, we list the assumed number of observed $W+$ jets events before tagging in $21pb^{-1}$ of data. For background estimates relying on calculated absolute cross sections (Mangano and diboson), we use $21pb^{-1}$. In tables 19, 20, and 21, we list the expected number of tagged jets. For higher jet multiplicities, the tagging rates from the 2 jet bin are used when statistics are low. [9]

In calculating the number of background events, the tagging rates from MCQTUNE are used. [10] An overall factor of $K_{MC} = 0.71 \pm 0.15$ is used to rscale all tagging rates. K_{MC} accounts for the overefficiency in the Monte Carlo b-tagging rates compared to that measured in the inclusive electron sample. [11]

The $Wb\bar{b}$ and $Wc\bar{c}$ backgrounds are computed in three ways: Herwig, Isajet, and Mangano. In calculating these backgrounds using Herwig, a scaling factor of $K_H = 1.4$ is used. [12] The resultant estimate from Herwig is our current 'best guess'. Note that the Mangano numbers are derived using the inclusive electron cross sections only. The muon contributions are NOT included.

These background numbers can be used to estimate the total expected background, as discussed in CDF 2252. In doing so, one must also include mistags and background from non-W processes ($b\bar{b}$).

[9] The tagging rates per jet in the higher jet multiplicities have not been correctly rescaled to account for the extrapolation of the lower jet multiplicity tag rates to the higher multiplicity bins. The result is the listed number of background jets may be too high (tables 19-21). This will be fixed in the future. The tables listing the number of expected background events are correct (tables 16-18).

[10] Due to technicalities, the non-MCQTUNE numbers for the dibosons are used. Since the number of background events from WW and WZ is small in either case, the difference between non-MCQTUNE and MCQTUNE does not affect the overall background calculation greatly.

[11] CDF 2249. K_{MC} was calculated using JETVTX. We assume the other tagging algorithms have a similar scaling factor.

[12] CDF 2252: This factor comes from a comparison of Herwig and Mangano in the 1 jet bin.

source	1 jet	2 jets	3 jets	4+ jets
no tag	2059	321	51	10
$Wb\bar{b}$ Herwig	2.272 ± 0.741	0.989 ± 0.401	0.319 ± 0.140	0.074 ± 0.058
$Wb\bar{b}$ Isajet	6.125 ± 2.017	2.920 ± 1.237	0.593 ± 0.325	0.176 ± 0.189
$Wb\bar{b}$ Mangano	1.496 ± 0.362	0.332 ± 0.090	0.014 ± 0.005	0.001 ± 0.001
$Wc\bar{c}$ Herwig	1.515 ± 0.526	0.407 ± 0.266	0.091 ± 0.062	0.014 ± 0.014
$Wc\bar{c}$ Isajet	4.365 ± 1.506	0.938 ± 0.619	0.232 ± 0.161	0.074 ± 0.064
$Wc\bar{c}$ Mangano	1.095 ± 0.272	0.097 ± 0.036	0.009 ± 0.004	0.002 ± 0.001
Wc	3.406 ± 1.502	0.952 ± 0.451	0.161 ± 0.075	0.032 ± 0.015
$Z \rightarrow \tau\tau$	0.077 ± 0.087	0.012 ± 0.014	0.002 ± 0.002	0.000 ± 0.000
WW	0.061 ± 0.023	0.115 ± 0.043	0.038 ± 0.016	0.008 ± 0.003
WZ	0.030 ± 0.008	0.062 ± 0.018	0.023 ± 0.012	0.008 ± 0.006

Table 16: Number of expected background events before and after tagging in $\sim 21pb^{-1}$. The JETVTX algorithm is used.

source	1 jet	2 jets	3 jets	4+ jets
no tag	2059	321	51	10
$Wb\bar{b}$ Herwig	2.272 ± 0.741	1.021 ± 0.411	0.329 ± 0.144	0.076 ± 0.060
$Wb\bar{b}$ Isajet	6.125 ± 2.017	3.015 ± 1.269	0.613 ± 0.334	0.181 ± 0.195
$Wb\bar{b}$ Mangano	1.496 ± 0.362	0.342 ± 0.093	0.015 ± 0.005	0.001 ± 0.001
$Wc\bar{c}$ Herwig	1.220 ± 0.435	0.611 ± 0.342	0.137 ± 0.080	0.021 ± 0.020
$Wc\bar{c}$ Isajet	3.516 ± 1.248	1.408 ± 0.801	0.348 ± 0.212	0.112 ± 0.089
$Wc\bar{c}$ Mangano	0.882 ± 0.222	0.146 ± 0.049	0.013 ± 0.005	0.003 ± 0.002
Wc	2.967 ± 1.316	0.903 ± 0.432	0.153 ± 0.072	0.030 ± 0.014
$Z \rightarrow \tau\tau$	0.039 ± 0.056	0.006 ± 0.009	0.001 ± 0.001	0.000 ± 0.000
WW	0.061 ± 0.023	0.098 ± 0.038	0.033 ± 0.014	0.007 ± 0.003
WZ	0.027 ± 0.007	0.066 ± 0.019	0.022 ± 0.011	0.007 ± 0.005

Table 17: Number of expected background events before and after tagging in $\sim 21pb^{-1}$. The JPBTAG algorithm is used.

source	1 jet	2 jets	3 jets	4+ jets
no tag	2059	321	51	10
$Wb\bar{b}$ Herwig	2.220 ± 0.725	0.861 ± 0.359	0.278 ± 0.125	0.065 ± 0.051
$Wb\bar{b}$ Isajet	5.985 ± 1.974	2.544 ± 1.105	0.517 ± 0.288	0.153 ± 0.165
$Wb\bar{b}$ Mangano	1.462 ± 0.354	0.289 ± 0.080	0.013 ± 0.005	0.001 ± 0.001
$Wc\bar{c}$ Herwig	0.994 ± 0.365	0.203 ± 0.177	0.045 ± 0.040	0.007 ± 0.008
$Wc\bar{c}$ Isajet	2.863 ± 1.047	0.468 ± 0.409	0.116 ± 0.104	0.037 ± 0.038
$Wc\bar{c}$ Mangano	0.718 ± 0.184	0.049 ± 0.023	0.004 ± 0.002	0.001 ± 0.001
Wc	1.582 ± 0.743	0.552 ± 0.294	0.094 ± 0.049	0.018 ± 0.010
$Z \rightarrow \tau\tau$	0.039 ± 0.056	0.006 ± 0.009	0.001 ± 0.001	0.000 ± 0.000
WW	0.026 ± 0.013	0.049 ± 0.024	0.016 ± 0.008	0.003 ± 0.002
WZ	0.027 ± 0.007	0.043 ± 0.013	0.015 ± 0.008	0.005 ± 0.004

Table 18: Number of expected background events before and after tagging in $\sim 21pb^{-1}$. The BTDPHI algorithm is used.

source	1 jet	2 jets	3 jets	4+ jets
no tag	2059	642	153	40
$Wb\bar{b}$ Herwig	2.272 ± 0.741	1.180 ± 0.463	0.458 ± 0.407	0.142 ± 0.156
$Wb\bar{b}$ Isajet	6.125 ± 2.017	3.485 ± 1.432	0.853 ± 0.808	0.337 ± 0.445
$Wb\bar{b}$ Mangano	1.496 ± 0.362	0.396 ± 0.106	0.021 ± 0.011	0.002 ± 0.002
$Wc\bar{c}$ Herwig	1.515 ± 0.526	0.475 ± 0.292	0.160 ± 0.102	0.033 ± 0.032
$Wc\bar{c}$ Isajet	4.365 ± 1.506	1.095 ± 0.682	0.406 ± 0.268	0.174 ± 0.145
$Wc\bar{c}$ Mangano	1.095 ± 0.272	0.114 ± 0.041	0.015 ± 0.006	0.004 ± 0.003
Wc	3.406 ± 1.502	0.952 ± 0.449	0.100 ± 0.132	0.026 ± 0.035
$Z \rightarrow \tau\tau$	0.077 ± 0.087	0.024 ± 0.027	0.006 ± 0.006	0.001 ± 0.002
WW	0.061 ± 0.023	0.115 ± 0.043	0.057 ± 0.024	0.015 ± 0.006
WZ	0.030 ± 0.008	0.073 ± 0.021	0.028 ± 0.015	0.013 ± 0.009

Table 19: Number of expected background jets before and after tagging in $\sim 21pb^{-1}$. The JETVTX algorithm is used.

source	1 jet	2 jets	3 jets	4+ jets
no tag	2059	642	153	40
$Wb\bar{b}$ Herwig	2.272 ± 0.741	1.244 ± 0.484	0.458 ± 0.407	0.142 ± 0.156
$Wb\bar{b}$ Isajet	6.125 ± 2.017	3.675 ± 1.498	0.853 ± 0.808	0.337 ± 0.445
$Wb\bar{b}$ Mangano	1.496 ± 0.362	0.417 ± 0.111	0.021 ± 0.011	0.002 ± 0.002
$Wc\bar{c}$ Herwig	1.220 ± 0.435	0.611 ± 0.342	0.205 ± 0.121	0.042 ± 0.040
$Wc\bar{c}$ Isajet	3.516 ± 1.248	1.408 ± 0.801	0.522 ± 0.318	0.223 ± 0.177
$Wc\bar{c}$ Mangano	0.882 ± 0.222	0.146 ± 0.049	0.020 ± 0.008	0.005 ± 0.003
Wc	2.967 ± 1.316	0.903 ± 0.432	0.100 ± 0.132	0.026 ± 0.035
$Z \rightarrow \tau\tau$	0.039 ± 0.056	0.012 ± 0.018	0.003 ± 0.004	0.001 ± 0.001
WW	0.061 ± 0.023	0.098 ± 0.038	0.049 ± 0.021	0.013 ± 0.005
WZ	0.027 ± 0.007	0.080 ± 0.023	0.025 ± 0.013	0.011 ± 0.008

Table 20: Number of expected background jets before and after tagging in $\sim 21pb^{-1}$. The JPBTAG algorithm is used.

source	1 jet	2 jets	3 jets	4+ jets
no tag	2059	642	153	40
$Wb\bar{b}$ Herwig	2.220 ± 0.725	0.919 ± 0.378	0.305 ± 0.323	0.095 ± 0.117
$Wb\bar{b}$ Isajet	5.985 ± 1.974	2.713 ± 1.165	0.569 ± 0.630	0.224 ± 0.324
$Wb\bar{b}$ Mangano	1.462 ± 0.354	0.308 ± 0.084	0.014 ± 0.008	0.002 ± 0.001
$Wc\bar{c}$ Herwig	0.994 ± 0.365	0.203 ± 0.177	0.068 ± 0.061	0.014 ± 0.016
$Wc\bar{c}$ Isajet	2.863 ± 1.047	0.468 ± 0.409	0.174 ± 0.157	0.074 ± 0.077
$Wc\bar{c}$ Mangano	0.718 ± 0.184	0.049 ± 0.023	0.007 ± 0.003	0.002 ± 0.001
Wc	1.582 ± 0.743	0.550 ± 0.292	0.100 ± 0.132	0.026 ± 0.035
$Z \rightarrow \tau\tau$	0.039 ± 0.056	0.012 ± 0.018	0.003 ± 0.004	0.001 ± 0.001
WW	0.026 ± 0.013	0.049 ± 0.024	0.024 ± 0.013	0.007 ± 0.003
WZ	0.027 ± 0.007	0.046 ± 0.014	0.018 ± 0.010	0.008 ± 0.006

Table 21: Number of expected background jets before and after tagging in $\sim 21pb^{-1}$. The BTDPHI algorithm is used.