Tau Dilepton Analysis UPDATE

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$$t\bar{t} \rightarrow WWbb \rightarrow e\tau_{had}\nu_\tau\nu_e bb$$

- Event Selection
- Tuning Cuts
- Acceptance
- Backgrounds

Event Selection

1. **One Central Tight Electron above 20GeV**
   - We use the Baseline Analysis Cuts used by the Dilepton Working Group for Winter Conferences.
2. **Tau Cuts**
3. $\not{E}_{\mathrm{T}} >$ **20 GeV**
   - This is 5GeV lower than the cut used for the ee, $e\mu$, $\mu\mu$ Dilepton Analyis because the $e\tau$ $\not{E}_{\mathrm{T}}$ spectrum is softer than the $\not{E}_{\mathrm{T}}$ spectrum in the other Dilepton Analyses.
   - We use $\not{E}_{\mathrm{T}}$ corrected for tight muons, event vertex, the corrections due to the two central jets (b-jet candidates)
4. **Veto events with 65GeV** $< M_{e,\tau} <$**115GeV**
   - This cut is only made on a class of events passing an angular requirement as described in the $Z \to \tau\tau jj$ background discussion
5. $\geq$ **2 jets with** $E_T >$ **10 GeV,** $|\eta| <$ **2**
   - relative, energy-scale, and time corrections have been applied to jet energies

Event Selection

6. $H_T >$ **180GeV**
   - using corrected $\not\!\!E_{\rm T}$ and jet energies
7. **opposite charge of tau and electron**
   - The tau charge is the sum of charges of tracks within the tau cone. Note that the tau cone depends on tau E_T.

Acceptance: $\epsilon_{t\bar{t}}^{MC}$

- $N_{Geom,eID}$: requires the electron to pass the Winter Conference baseline cuts on electrons within the CEM
- $N_{Geom,\tau ID}$: requires the tau to pass our tau ID cuts with $|$—$|$ < 1.1
- $N_{\not{E}_{\mathrm{T}}}$: requires the corrected $\not{E}_{\mathrm{T}}$ to be above 20GeV
- $N_{H_T>180}$/$N_{H_T>195}$: requires H_T to be above 180GeV (before optimization)/ 190GeV (after optimization
- N_{1jet}: requires a minimum of one extra jet in the event that does not match to the electron or the tau (in a cone of radius 0.4) that has $|\eta| < 2.0$ and $E_T >$15GeV
- N_{2jet}: requires a minimum of two extra jets in the event that do not match to the electron or the tau that have $|\eta| < 2.0$ and $E_T >$15GeV
- $N_{oppcharge}$: requires the sum of the charged tracks in the tau cone to be the opposite charge of the electron/positron
- $N_{Zmass\ veto}$: requires the event to survive our Mass Reconstruction veto cut

Acceptance

Cut	$eebb$	$\mu\mu b\bar{b}$	$\tau\tau b\bar{b}$	$e\mu b\bar{b}$	$e\tau b\bar{b}$	$\mu\tau b\bar{b}$	$eq\bar{q}b\bar{b}$	$\mu q\bar{q}b\bar{b}$	$\tau q\bar{q}b\bar{b}$	$q\bar{q}q\bar{q}b\bar{b}$	Total
Sample Size	4802	4802	4781	9739	9604	9701	57894	57481	57899	173293	389996
$N_{Geom,eID}$	2978	0	255	3829	3856	299	21613	35	1703	190	34758
$N_{Geom,\tau ID}$	57	0	29	4	434	0	319	0	31	4	878
$N_{\not{E}_T}$	50	0	25	4	387	0	291	0	30	2	789
$N_{H_T>180}$	44	0	19	3	339	0	270	0	28	2	705
$N_{H_T>195}$	40	0	15	3	310	0	254	0	24	2	648
N_{1jet}	40	0	15	3	310	0	254	0	24	2	648
N_{2jet}	35	0	15	3	288	0	252	0	24	2	754
$N_{oppcharge}$	34	0	15	0	283	0	199	0	22	0	553
$N_{Zmass\ veto}$	33	0	13	0	273	0	192	0	20	0	531
$\epsilon_{t\bar{t}}^{MC}$	531/389996 = 0.00136										

Table 1: Inclusive ttbar acceptance from Herwig 6.4 Monte Carlo processed with 4.9.1 of the offline code. There is no matching between HEPG objects and reconstructed objects and no requirement that the taus decay hadronically. The "signal channel", though without the hadronic tau requirement, is highlighted in blue.

$$\epsilon_{t\bar{t}}^{MC} = \text{Total } N_{Zmass\ veto} \text{ / Total Sample Size}$$

- Our $\epsilon_{t\bar{t}}^{MC}$ is therefore 531/389996 = 0.00136 BEFORE applying scale factor
- We've measured jet fake rates in the data and we know that they are much smaller than what we see here from the Monte Carlo in the e+jets channel
- We need to measure the rates in MC as a function of E_T in order to have the correct fake rate

Acceptance

- Other Scale Factors/Systematics
  - Efficiency of the Central Electron 18 Trigger
  - Efficiency of Electron ID
  - Efficiency of Tau ID
  - Energy scale
  - $\not{E}_{\mathrm{T}}$ resolution
  - opposite sign cut
  - PDFs
  - ISR and FSR

Acceptance

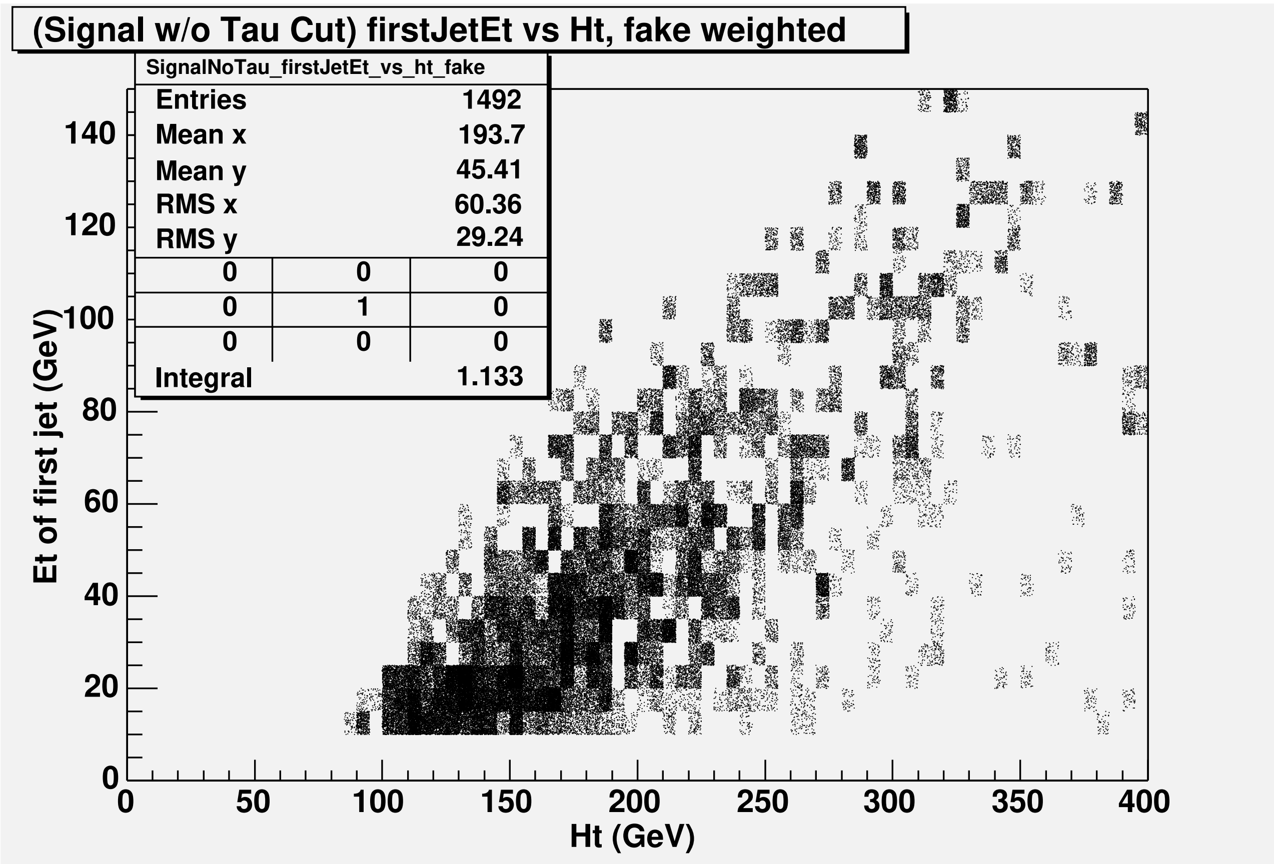
- While our acceptance has a large contribution from ttbar that isn't in our signal channel, we restrict ourselves to looking at our signal channel when we tune our cuts
- Below is a table for only our signal events (with a hadronically decaying tau and an electron as our dileptons)

Cut	$e\tau_{had}bb$
Sample Size	6427
N_{eID}	2504
$N_{\tau ID}$	426
$N_{\not{E}_T}$	381
$N_{H_T>180}$	334
$N_{H_T>195}$	306
N_{1jet}	306
N_{2jet}	285
$N_{oppcharge}$	280
$N_{Zmass\ veto}$	270

Table 2: ttbar acceptance from Herwig 6.4 Monte Carlo with version 4.9.1 of the offline software. There is no matching between HEPG objects and reconstructed objects. These events are all in the "signal channel", where one W decays to an electron and the other W decays to a hadronically decaying tau.

Tuning Cuts

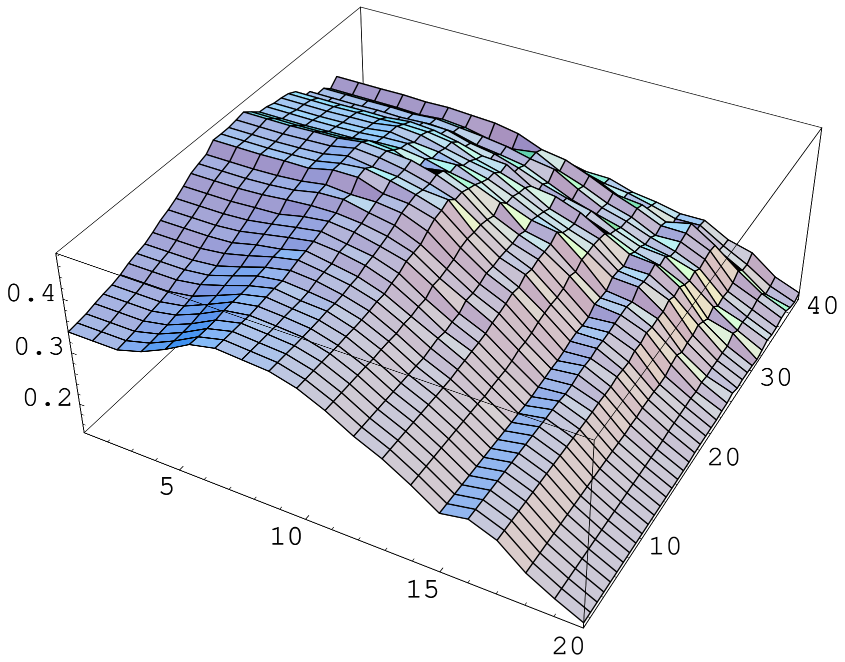
- The Cuts with the most power to discriminate between our signal and the fake background are the E_T of the extra jets and the event H_T (highly correlated)
- With no H_T requirement and a requirement on the E_T of both jets of 10GeV, here is the fake-rate-weighted first Jet E_T vs event H_T
- The integral of this plot gives the background contribution in 72pb^{-1}, before further cuts the background would be 1.33 events



Tuning Cuts

- A 2-D optimization (Signal over Root Background) gives us
  - an H_T cut value at 200GeV (from 180GeV)
  - an E_T of first jet cut value at 30GeV (from 10GeV)
  - the decrease in signal is 13%
  - the decrease in w+jet background is 33%

stb−2d.nb



Background: Electron Fakes

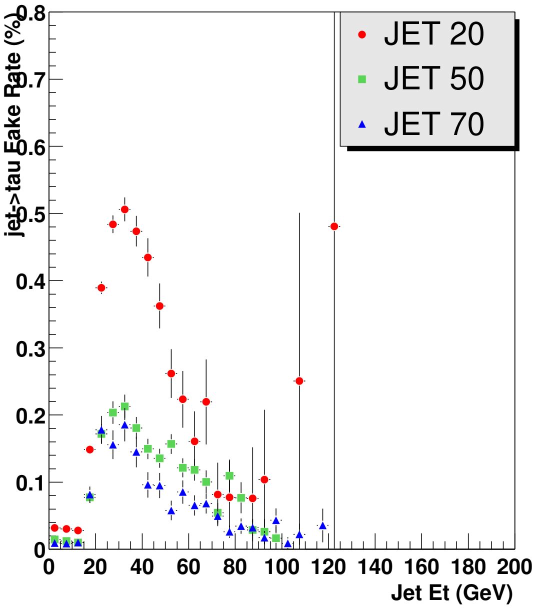
$E_{had}/\Sigma P$ value	# Events Passing cut	Electron Fake Rate
no cut	990	100%
0.05	98	10.1 ±1.0%
0.075	54	5.5 ±0.7%
0.10	36	3.6 ±0.6%
0.125	21	2.1 ±0.5%
0.15	12	1.2 ±0.4%

Table 3: From CDF Note 6408: Electron Fake Rates for different vales of the $E_{had}/\sum P$ cut measured from Z→ ee events in data.

- Measure Electron to Tau relative fake rates as a function of our electron veto variable using $Z \rightarrow ee$ events in the Data (CDF Note 6408)
- $E_{had}/\Sigma P$ is demonstrated to be independent of $\not\!\!E_T$
- Fake rate is relative because denominator includes all other tau cuts

Jet Fakes: Dijets

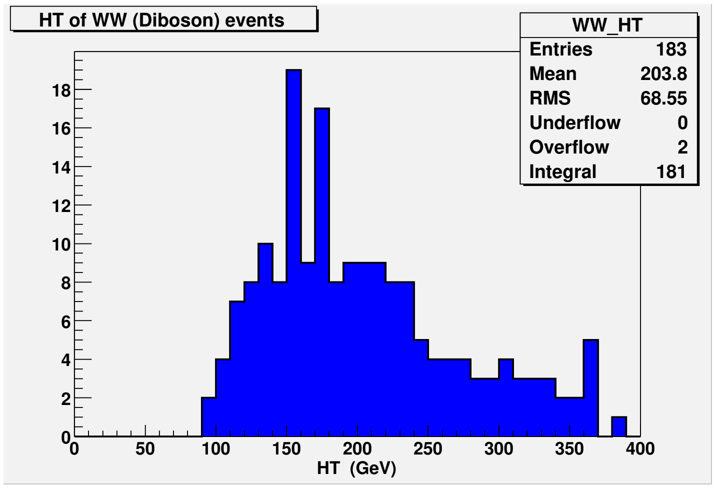
- Use Jet20, Jet50, Jet70 data
- Remove trigger bias (with L1 and L2 trigger jet info)
- Removing trigger bias at L3 is tricky - our analysis uses a cone of 0.4 while we trigger on jets with a cone of 0.7



- We use an average of Jet20 and Jet50 and the difference between the two will be considered a systematic error
- Differences thought to be due to quark/gluon and heavy flavor content differences between samples as well as residual trigger bias

WW Background

- Use Pythia WW sample representing $562 fb^{-1}$ (828,000 events with both W's being forced to decay leptonically)
  - 183 events before H_T cut and after all other cuts
  - 97 events after H_T cut (at 180GeV)
  - total background in 72pb^{-1} is 0.013 ($\pm$ 0.002) events (error is satistical only, value is as much as 30$\%$ too low because of 2-jet scale factor)
- Compare with e, μ Dilepton analysis with same luminosity
  - WW background of 0.066 ($\pm$ 0.003) events (error is statistical)
  - have to take into account $\tau \rightarrow hadron$ branching ratio, lowertau ID efficiency



Background Summary

- Summary of Backgrounds (H_T cut at 180GeV, Jet E_T cut at 20GeV)

	# of Events (72pb^{-1})
$Z/\gamma^* \to \tau^+\tau^- + jets$	0.11±0.05
τ fakes	0.59
WW	0.013±0.002
$Z \to e^+e^-$	0.05 ± 0.02

Plans

- Should have new data ntuplized in the next 24 hours
- Should have new MC (ttbar inclusive and $Z \rightarrow \tau\tau$) soon
- Finalize cuts (H_T and Jet E_T) so an NJet analysis can be done before looking at data

Backup Slides

Tau ID Cuts

- We begin with a Cdf Tau Candidate, found with TauFinderModule (Fedor, Anton et al)

Tau Variable	Cut
Cluster E_T	$>$ 15 GeV
z_0	$<$ 60 cm
Cal Mass	$<$ 4.0 GeV/c^2
(Track + π^0) Mass	$<$ 1.8 GeV/c^2
Cal Iso: ΔR=0.4/$E_T^{cluster}$	$<$ 0.06
# tracks in Iso Annulus	0
# π^0's in Iso Annulus	0
# tracks in Tau Cone	$<$ 4
$\mid\Sigma$(track charge) in Tau Cone$\mid$	1
μ veto	no stubs in 15 degree cone
e veto: E_{HAD}/SUM (P)	$>$ 0.15

Table 4: Tau Cuts: The tau cone and isolation annulus depend on the energy of the tau candidate.

Corrections

- Jet Energies are corrected for
  - η dependence (relative corrections)
  - Energy Scale
- $\not{E}_{\mathrm{T}}$ is corrected for
  - Beam constrained tight muons
  - Jet corrections (raw Jet Et added in, corrected Jet Et subtracted out) of two b-jet candidates (unless noted)
- H_T is calculated with
  - corrected Jets as described
  - corrected $\not{E}_{\mathrm{T}}$ as described
- Corrections are applied before analysis, at the level of event selection

Electron Fake Rate Details

- Require one tight central, isolated electron with $E_T >$ 20GeV
- For 2nd electron:
  - must be back-to-back with first electron ($\Delta\phi < (\pi - 0.5)$)
  - must match to CdfTau Object that passes tau cuts
- no other jets in event >8GeV
- invariant mass of the two EM Objects $>$ 75GeV ($\not\!\!E_T$ is added to the second ele if it is less than $\Delta\phi$ of 0.7 away)