Current Analysis Status Summary

Search for Four top in Tau Final States

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Outline

1. Run2 Analysis
   - B tag working point
   - B tag shape
   - Results: b tagging shape Vs working point
2. First Look into Run3

Section 1

Run2 Analysis

Summary of b tag study

- In 1tau1l we used either btag shape or WP as input to BDT, conclusion: after consider systematics the b tag WP a better choice.
- Need to remeasure HLT efficiency, previously measured with btag shape correction

Section 1

Run2 Analysis

1.1 B tag working point

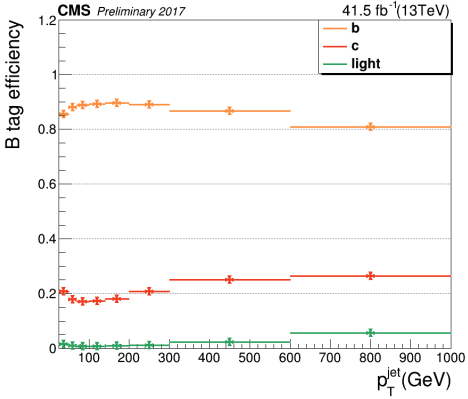
B tag working point

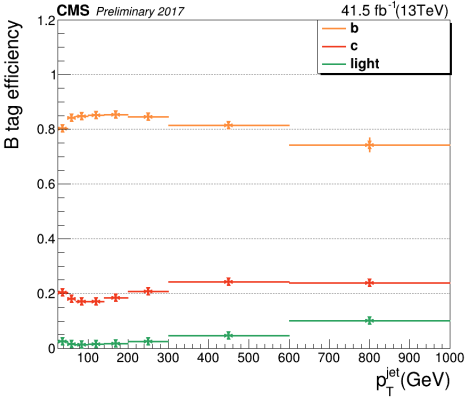
- https://twiki.cern.ch/twiki/bin/view/CMS/BTagSFMethods
- Using method 1a) to correct for event yield in MC
  - $P(MC) = \prod_{i=tagged} \epsilon_i \prod_{j=nottagged}(1-\epsilon_j)$?
  - $P(Data) = \prod_{i=tagged} SF_i\epsilon_i \prod_{j=nottagged}(1-SF_j\epsilon_j)$?
  - $w = \frac{P_{data}}{P_{MC}} = \prod_{i=tagged} SF_i \prod_{j=nottagged}(1-SF_j\epsilon_j)/(1-\epsilon_j)$
  - Consider every possible mapping from b tagged to genguine jet one by one
  - Should correct for the number of bjets distribution
- if we use both tight and medium WP

B tag efficiency measurement

- Definition: b tag efficiency = the probability of b jets passing a cerntain b tagger WP
- Measure b tag efficiency for b and c and light jets respectively
  - Jet flavour: b(5), c(4), udsg(0)
- Measure as a function of $jet(pt, \eta)$, and jet flavour
- Measurement region : Baseline withou b tag, plus tau>=1
  - ~~Baseline region: jet>=6, bJet>=1, leading 6 jet pt>40, HT>500 GeV~~
  - jet>=6, leading 6 jets pt>40, HT>500, tau>=1
- MC correction: JES, HLT , tau efficiency
- MC samples for measuring: TTbar_0l
- Try to use TEfficiency class to measure:
  - It seems TEfficiency class can only accept histograms with no event weight, what should we do about weighted histograms

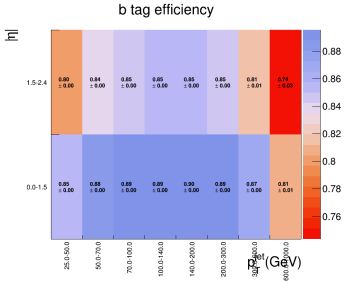
B tag efficiency overlay

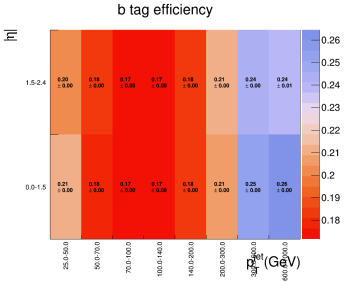


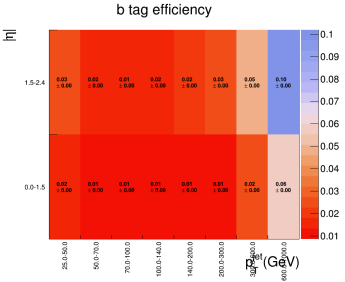


- left: eta<1.5; right>1.5

B tag efficiency 2D

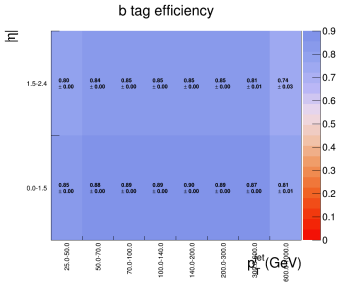


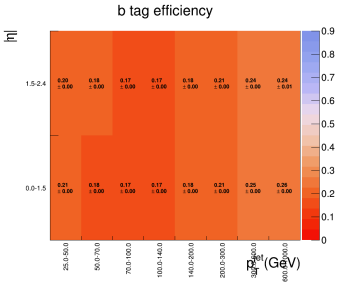


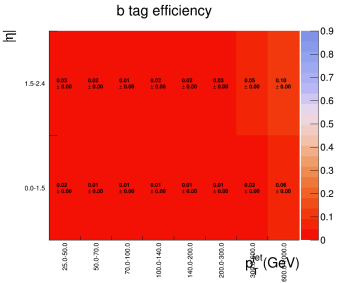


- B; c, light jet

B tag efficiency 2D

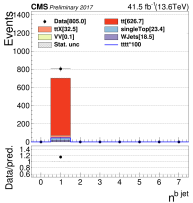


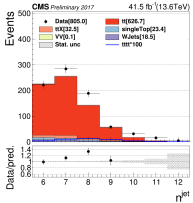


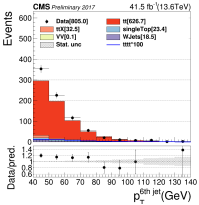


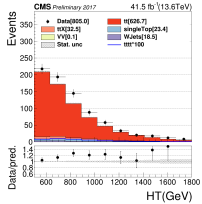
- B; c, light jet

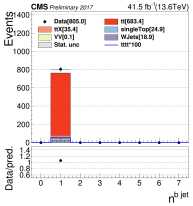
Closue test for b tag event weight: CR1

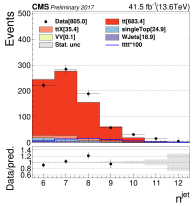


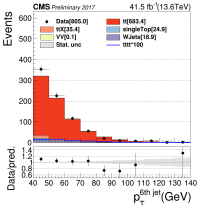


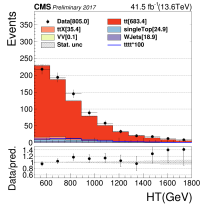






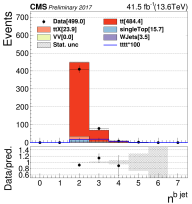


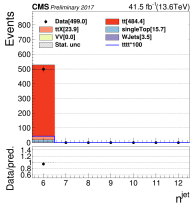


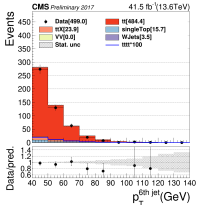


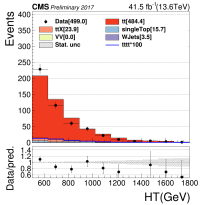
- Before and after applying b tag event weight for WP
- Before MC correction:

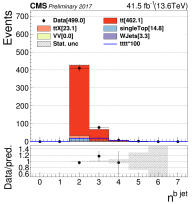
Closue test for b tag event weight: CR2

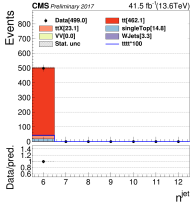


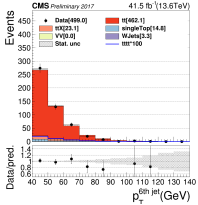


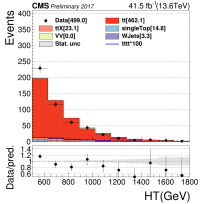












- Before and after applying b tag event weight for WP
- Before MC correction: prefiring, Pileup, HLT efficiency SF, tau ID, lepton efficiency

Section 1

Run2 Analysis

1.2 B tag shape

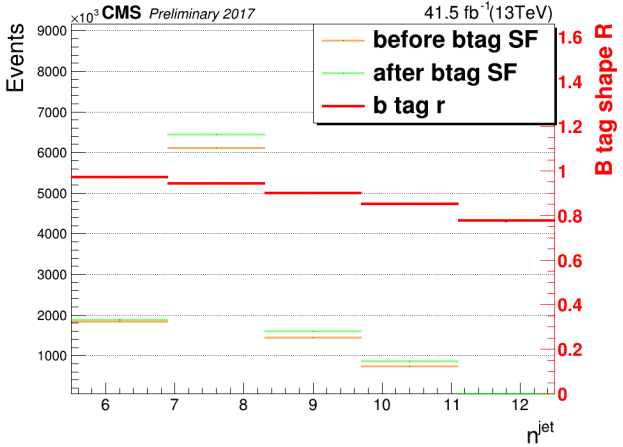
B tag shape

- Relationship of btag R and HLT efficiency
  - When measure HLT efficiency, we have the b tag shape SF applied.
  - Might have to remeasure HLT efficiency using WP weight
  - $w = r\prod_i SF_i$

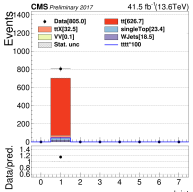
B tag shape r measurement

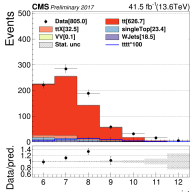
- Measurement region: Baseline-bjet+(>=1tau)
- As a function of jet multiplicity
- MC sample: ttbar hardronic

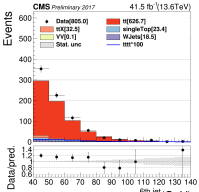
B tag r vs jet multiplicity

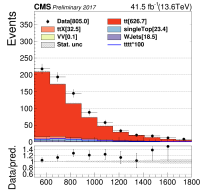


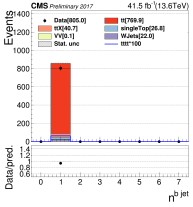
Closue test for b tag event weight: CR1

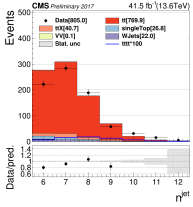


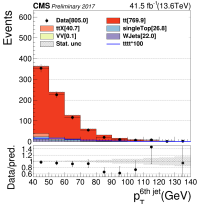


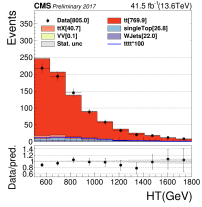






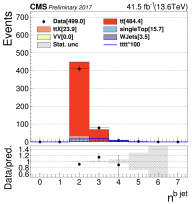


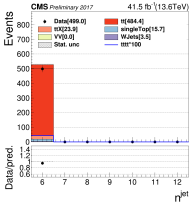


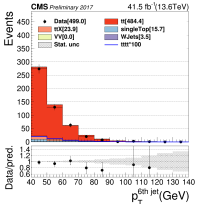


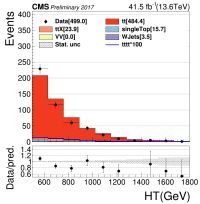
- Before and after applying b tag event weight for WP
- Before MC correction:

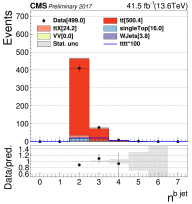
Closue test for b tag event weight: CR2

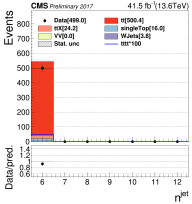


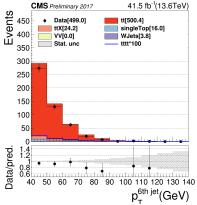


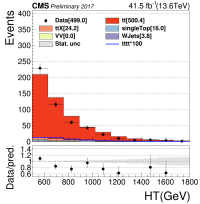












- Before and after applying b tag event weight for WP
- Before MC correction:

Section 1

Run2 Analysis

1.3 Results: b tagging shape Vs working point

Input list to BDT

variables	variable definition
jet related	m_T^{jets}
	n_{jet}
	$p_T^{5th\ jet}$
	$p_T^{6th\ jet}$
	$p_T^{7th\ jet}$
	$avg\Delta R(all\ jet\ pairs)$
	$HT_{leading\ 4\ jets}/HT_{all\ jets}$
b-jet related	$p_T^{2nd\ bjet}$
	$min(\delta R)_{bjets}$
	n_{bjet}
	m_{bjets}
	HT_{bjets}
tau and lep related	$p_T^{1st\ \tau}$
	$m_{lep\ and\ \tau}$
	$charge_{lep} * charge_\tau$

Table 1: Final input variables(16)

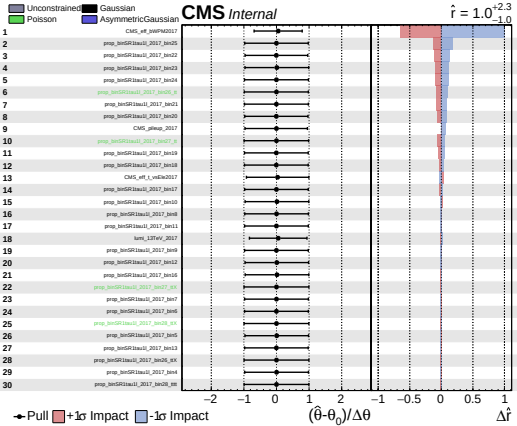
variables	variable definition
jet related	m_T^{jets}
	n_{jet}
	$p_T^{5th\ jet}$
	$p_T^{6th\ jet}$
	$p_T^{7th\ jet}$
	$avg\Delta R(all\ jet\ pairs)$
	$bscore_{deepJet}^{1st\ jet}$
	$HT_{leading\ 4\ jets}/HT_{all\ jets}$
	$\sum_{i=all\ jets} score_i^{btag}$
b-jet related	$p_T^{2nd\ bjet}$
	$min(\delta R)_{bjets}$
	n_{bjet}
	m_{bjets}
tau and lep related	$p_T^{1st\ \tau}$
	$m_{lep\ and\ \tau}$
	$charge_{lep} * charge_\tau$

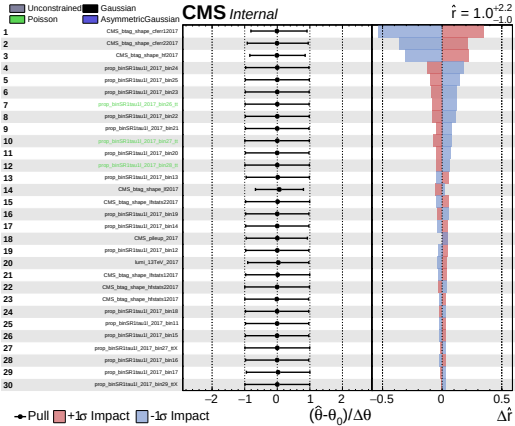
Table 2: Final input variables(16)

Results

- Significance before systematic :
  - Significance: 0.68, limit: 3.56(2.44, 5.25) shape
  - sig: 0.67, limit: 3.81(2.60, 5.60) WP
- Significance after systematic:
  - Sig: 0.58, limit: 4.32(2.93, 6.48) shape
  - Sig: 0.61 , limit: 4.54(3.07, 6.81)WP

Impacts

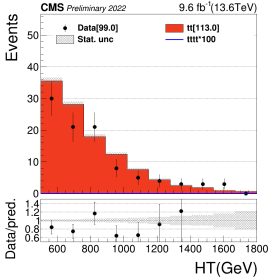

Unconstrained
Gaussian
Poisson
AsymmetricGaussian
CMS Internal
r̂ = 1.0 +2.3 −1.0
1 CMS_eff_bWPM2017
2 prop_binSR1tau1l_2017_bin25
3 prop_binSR1tau1l_2017_bin22
4 prop_binSR1tau1l_2017_bin23
5 prop_binSR1tau1l_2017_bin24
6 prop_binSR1tau1l_2017_bin26
7 prop_binSR1tau1l_2017_bin21
8 prop_binSR1tau1l_2017_bin20
9 CMS_pileup_2017
10 prop_binSR1tau1l_2017_bin27_jk
11 prop_binSR1tau1l_2017_bin19
12 prop_binSR1tau1l_2017_bin18
13 CMS_eff_t_vvEle2017
14 prop_binSR1tau1l_2017_bin17
15 prop_binSR1tau1l_2017_bin16
16 prop_binSR1tau1l_2017_bin8
17 prop_binSR1tau1l_2017_bin11
18 lumi_13TeV_2017
19 prop_binSR1tau1l_2017_bin9
20 prop_binSR1tau1l_2017_bin12
21 prop_binSR1tau1l_2017_bin10
22 prop_binSR1tau1l_2017_bin7_jk
23 prop_binSR1tau1l_2017_bin7
24 prop_binSR1tau1l_2017_bin6
25 prop_binSR1tau1l_2017_bin28_jk
26 prop_binSR1tau1l_2017_bin5
27 prop_binSR1tau1l_2017_bin13
28 prop_binSR1tau1l_2017_bin26_jk
29 prop_binSR1tau1l_2017_bin4
30 prop_binSR1tau1l_2017_bin28_jk
−2 −1 0 1 2
−1 −0.5 0 0.5 1
Pull
+1σ Impact
-1σ Impact
(θ̂-θ0)/Δθ
Δr̂

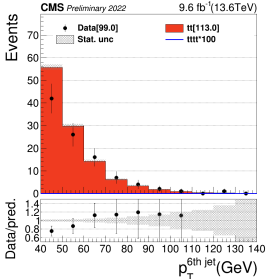

Unconstrained
Gaussian
Poisson
AsymmetricGaussian
CMS Internal
r̂ = 1.0 +2.2 −1.0
1 CMS_btag_shape_cferr12017
2 CMS_btag_shape_cferr22017
3 CMS_btag_shape_hf2017
4 prop_binSR1tau1l_2017_bin24
5 prop_binSR1tau1l_2017_bin25
6 prop_binSR1tau1l_2017_bin23
7 prop_binSR1tau1l_2017_bin26_jk
8 prop_binSR1tau1l_2017_bin22
9 prop_binSR1tau1l_2017_bin21
10 prop_binSR1tau1l_2017_bin27_jk
11 prop_binSR1tau1l_2017_bin20
12 prop_binSR1tau1l_2017_bin28_jk
13 prop_binSR1tau1l_2017_bin13
14 CMS_btag_shape_lf2017
15 CMS_btag_shape_lfstats12017
16 prop_binSR1tau1l_2017_bin19
17 prop_binSR1tau1l_2017_bin14
18 CMS_pileup_2017
19 prop_binSR1tau1l_2017_bin12
20 lumi_13TeV_2017
21 CMS_btag_shape_lfstats22017
22 CMS_btag_shape_hfstats22017
23 CMS_btag_shape_hfstats12017
24 prop_binSR1tau1l_2017_bin18
25 prop_binSR1tau1l_2017_bin11
26 prop_binSR1tau1l_2017_bin15
27 prop_binSR1tau1l_2017_bin27_jk
28 prop_binSR1tau1l_2017_bin16
29 prop_binSR1tau1l_2017_bin17
30 prop_binSR1tau1l_2017_bin29_jk
−2 −1 0 1 2
−0.5 0 0.5
Pull
+1σ Impact
-1σ Impact
(θ̂-θ0)/Δθ
Δr̂

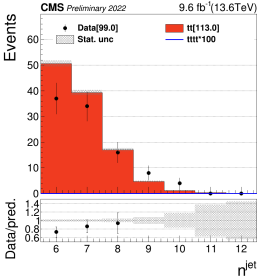
Section 2

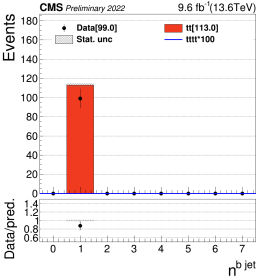
First Look into Run3

1tau1l CR1

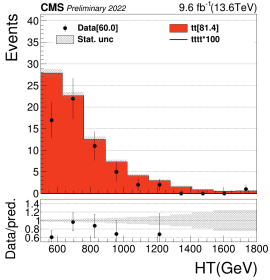

CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[99.0]
Stat. unc
tt[113.0]
tttt*100
Events
Data/pred.
HT(GeV)

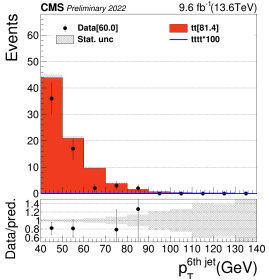

CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[99.0]
Stat. unc
tt[113.0]
tttt*100
Events
Data/pred.
p_T^6th jet(GeV)

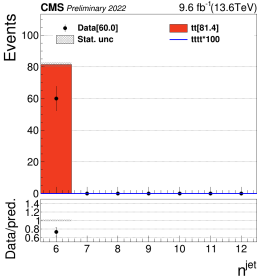

CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[99.0]
Stat. unc
tt[113.0]
tttt*100
Events
Data/pred.
n^jet

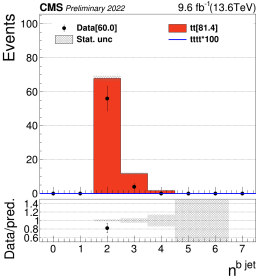

CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[99.0]
Stat. unc
tt[113.0]
tttt*100
Events
Data/pred.
n^b jet

1tau1l CR2


CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[60.0]
tt[81.4]
Stat. unc
tttt*100
Events
Data/pred.
HT(GeV)


CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[60.0]
tt[81.4]
Stat. unc
tttt*100
Events
Data/pred.
p_T^6th jet(GeV)


CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[60.0]
tt[81.4]
Stat. unc
tttt*100
Events
Data/pred.
n^jet


CMS Preliminary 2022
9.6 fb-1(13.6TeV)
Data[60.0]
tt[81.4]
Stat. unc
tttt*100
Events
Data/pred.
n^b jet

Next step

- Remeasure HLT efficiency
  - Currently using btag shape SF when mesuring HLT efficiency
  - Optimize binning
- Add all the systematics
- Full results on Run2(TTX meeting Aug 15th)

Section 3

Back up