



BDT in 1tau1l with B Tag WP Variables

Search for Four top in Tau Final States

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Outline

- 1 2016
Validation of input variables
BDT training
- 2 2017
Validation of input variables
BDT training and results
- 3 2018
Validation of input variables
BDT training and results
- 4 Combining 3 years

BDT updates

- Training with **b tag WP variables**, no btag shape variables
- **B tag medium WP efficiency measured** and btag WP correction applied in all Run2
- First run2 1tau1l combination results with **systematic**

Input

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

Section 1

2016

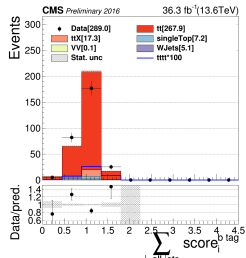
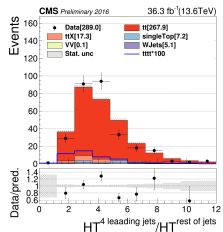
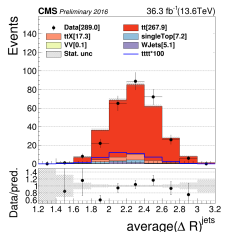
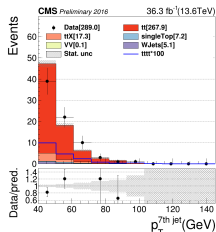
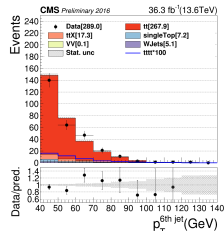
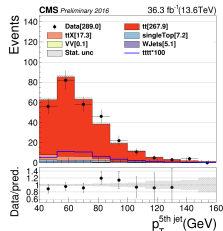
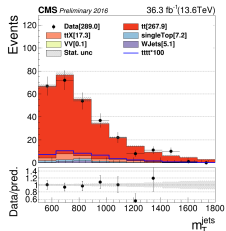
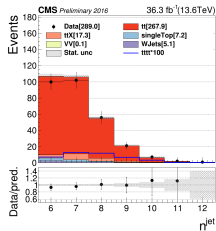


Section 1

2016

1.1 Validation of input variables

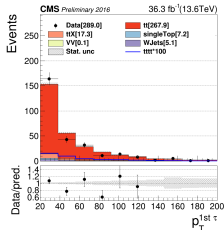
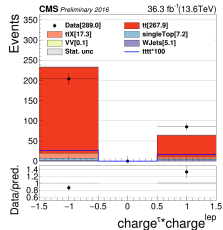
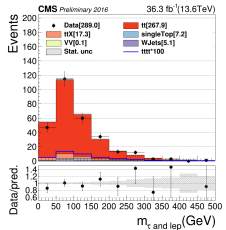
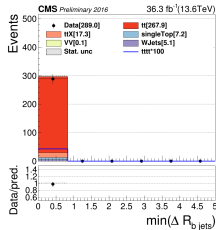
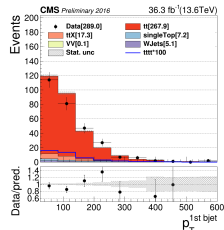
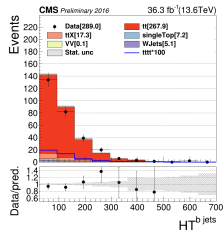
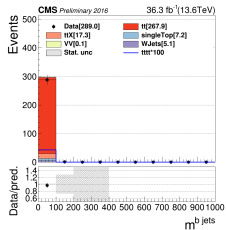
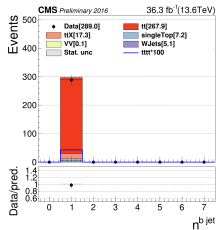




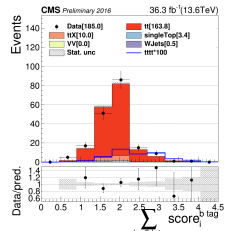
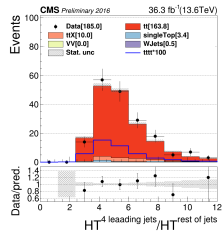
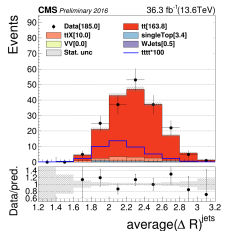
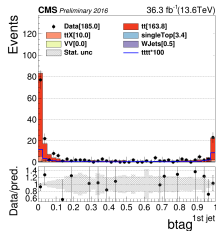
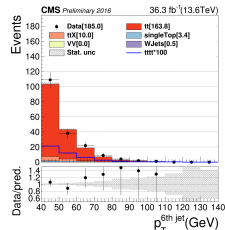
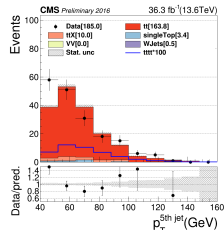
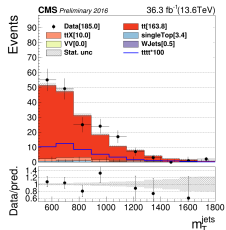
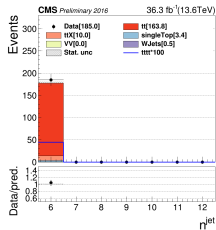
● MC correction: prefring, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency

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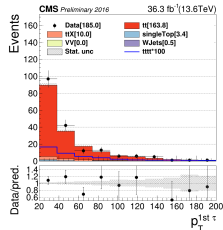
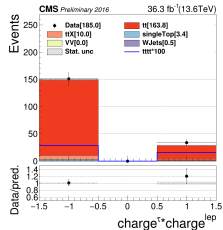
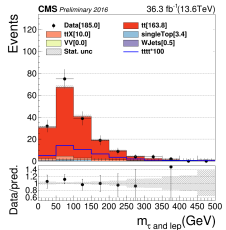
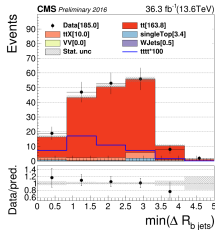
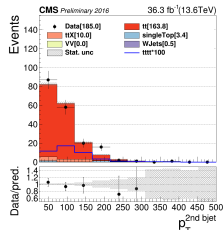
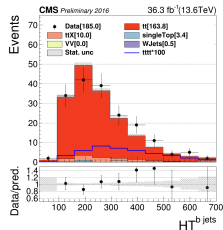
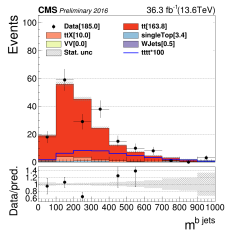
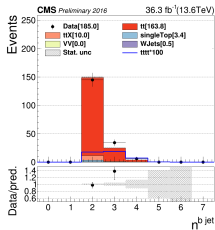
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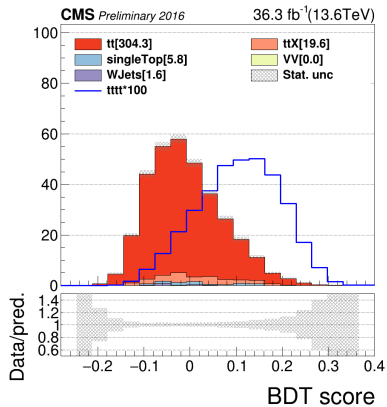
● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency



● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency



- MC correction: prefring, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency



Datacard

```
imax * number of bins
jmax * number of processes minus 1
kmax * number of nuisance parameters
```

```
shapes * SR1tau11_2016 /publicfs/cms/user/huahuil/tau0fTTTT_NanoAOD/forMVA/2016/v3btagWeightGood_v61fixesLepRemovalBug/mc/variableHists_v1traingWithBtagWP/com
```

```
bin SR1tau11_2016
observation -1
```

bin	SR1tau11_2016	SR1tau11_2016	SR1tau11_2016	SR1tau11_2016	SR1tau11_2016
process	tttt	singleTop	tt	ttX	WJets
process	0	1	2	3	4
rate	-1	-1	-1	-1	-1

lumi_13TeV_2016 lnN	1.012	1.012	1.012	1.012	1.012
CMS_pileup_2016 shape	1	1	1	1	1
CMS_prefiring_2016 shape	1	1	1	1	1
CMS_eff_t_vsJet_2016 shape	1	1	1	1	1
CMS_eff_t_vsMu_2016 shape	1	1	1	1	1
CMS_eff_t_vsEle_2016 shape	1	1	1	1	1
CMS_tttt_eff_e_2016 shape	1	1	1	1	1
CMS_tttt_eff_m_2016 shape	1	1	1	1	1
CMS_eff_bWPM_2016 shape	1	1	1	1	1
CMS_tttt_eff_hlt_stats_2016 shape	1	1	1	1	1

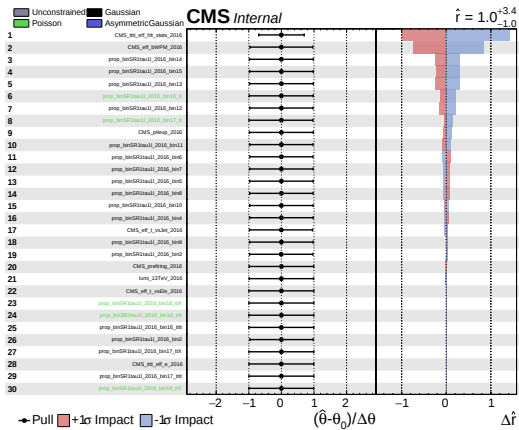
```
SR1tau11_2016 autoMCStats 10 0 1
```

/Users/hua/syncFolder/forMVA/2017/v1btagWPWeightUpdated_v61fixesLepRemovalBug/mc/variableHists_v1traingWithBtagWP/combine/datacardSys/datacard_1tau11Sys.txt

Results

- Before systematic
- After systematic
 - Expected significance: 0.36
 - Expected limit: 6.97(4.79, 10.33)
 - Datacard: /publicfs/cms/user/huahuil/-tauOfTTTT_NanoAOD/forMVA/2016/v3btagWeightGood_v61fixesLepRemovalBug/mc/variabl

Impacts



Section 2

2017

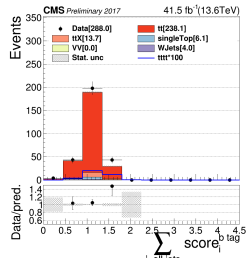
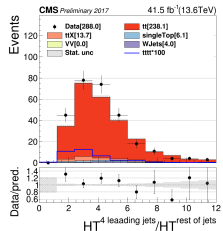
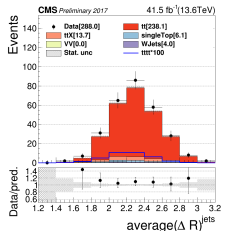
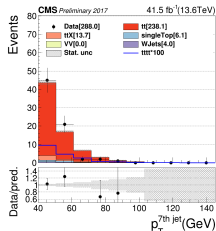
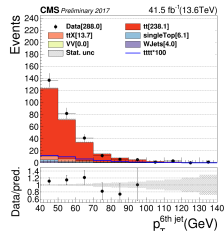
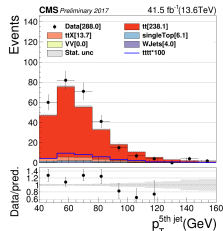
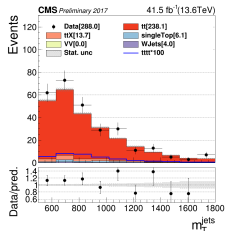
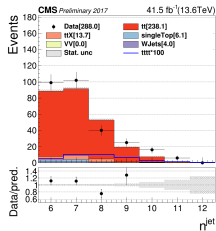


Section 2

2017

2.1 Validation of input variables

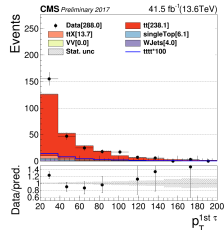
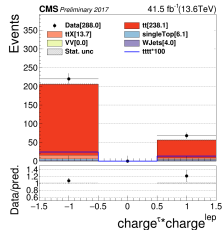
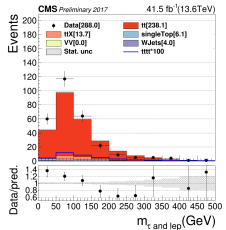
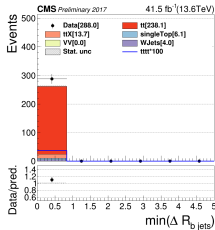
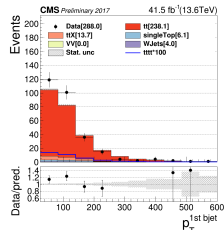
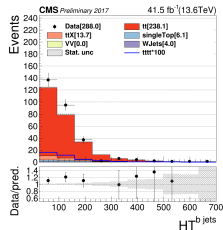
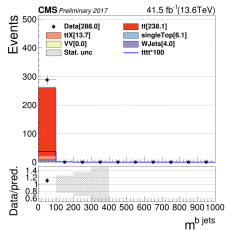
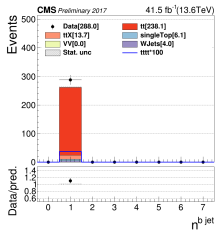




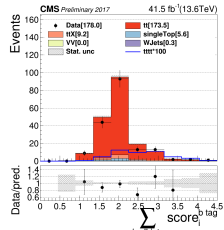
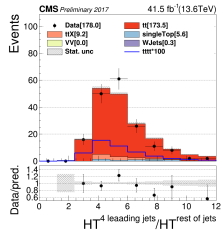
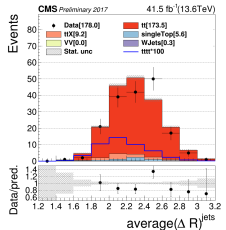
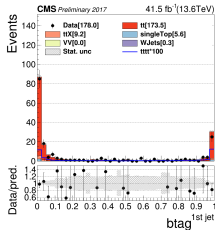
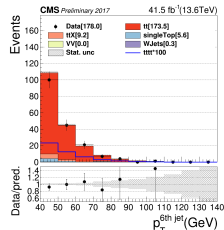
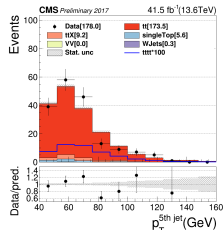
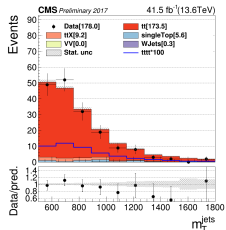
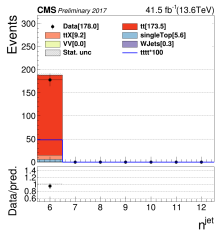
● MC correction: prefring, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency

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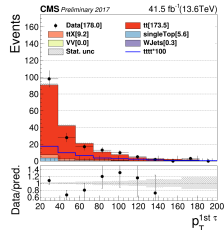
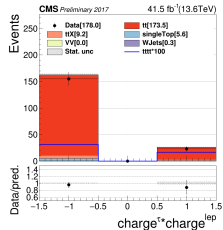
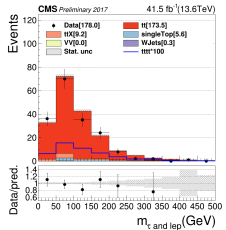
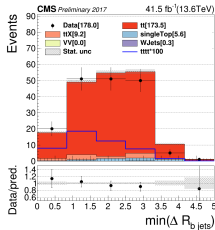
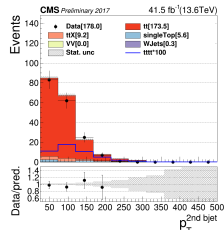
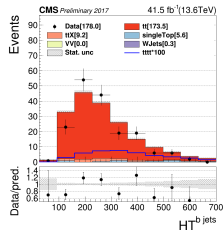
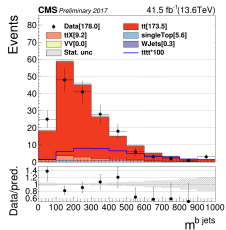
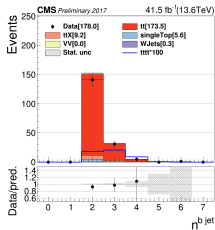
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● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency



● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency



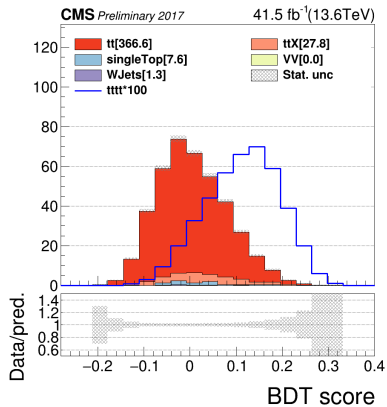
● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency

Section 2

2017

2.2 BDT training and results





Datacard

```
imax * number of bins
jmax * number of processes minus 1
kmax * number of nuisance parameters
```

```
shapes * SR1tau11_2017 /publicfs/cms/user/huahuil/tau0fTTTT_NanoAOD/forMVA/2017/v1btagWPWeightUpdated_v61fixesLepRemovalBug/mc/variableHists_v1traingWithBtagWP
```

```
bin SR1tau11_2017
observation -1
```

bin	SR1tau11_2017	SR1tau11_2017	SR1tau11_2017	SR1tau11_2017	SR1tau11_2017
process	tttt	singleTop	tt	ttX	WJets
process	0	1	2	3	4
rate	-1	-1	-1	-1	-1

lumi_13TeV_2017 lnN	1.023	1.023	1.023	1.023	1.023
CMS_pileup_2017 shape	1	1	1	1	1
CMS_prefiring_2017 shape	1	1	1	1	1
CMS_eff_t_vsJet_2017 shape	1	1	1	1	1
CMS_eff_t_vsMu_2017 shape	1	1	1	1	1
CMS_eff_t_vsEle_2017 shape	1	1	1	1	1
CMS_tttt_eff_e_2017 shape	1	1	1	1	1
CMS_tttt_eff_m_2017 shape	1	1	1	1	1
CMS_eff_bWPM_2017 shape	1	1	1	1	1
CMS_tttt_eff_hlt_stats_2017 shape	1	1	1	1	1

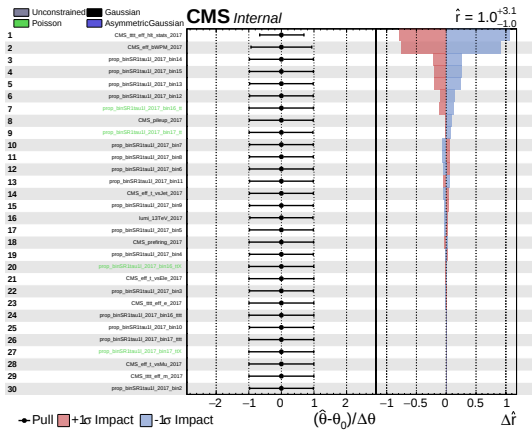
```
SR1tau11_2017 autoMCStats 10 0 1
```

/Users/hua/syncFolder/forMVA/2017/v1btagWPWeightUpdated_v61fixesLepRemovalBug/mc/variableHists_v1traingWithBtagWP/combine/datacardSys/datacard_1tau11Sys.txt

Results

- Before systematic
- After systematic
 - Expected significance: 0.41
 - Expected limit: 6.22(4.25, 9.27)
 - Dacard: /publicfs/cms/user/huahuil/-
tauOfTTTT_NanoAOD/forMVA/2016/v3btagWeightGood_v61fixesLepRemovalBug/mc/variabl

Impacts



Section 3

2018

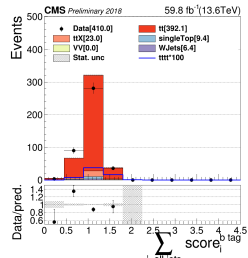
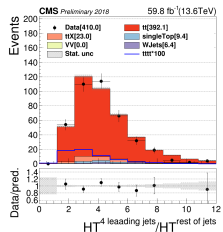
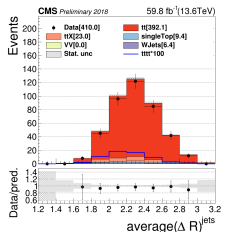
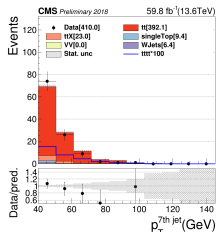
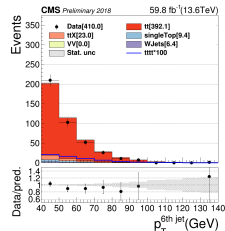
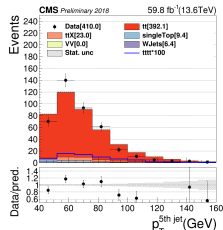
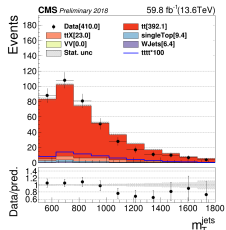
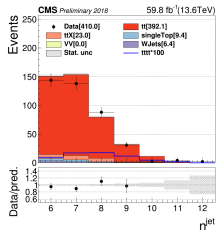


Section 3

2018

3.1 Validation of input variables



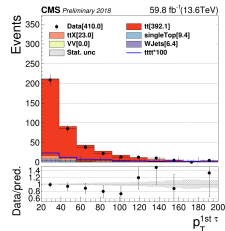
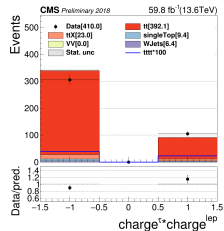
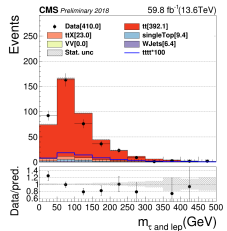
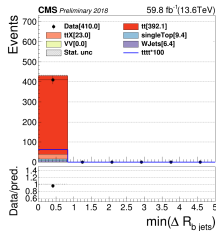
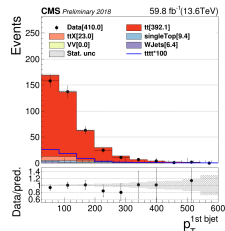
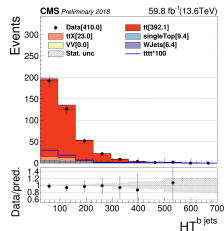
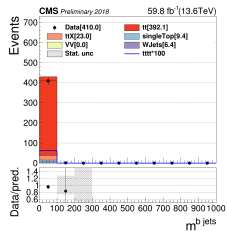
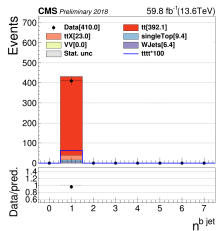


● MC correction: prefring, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency

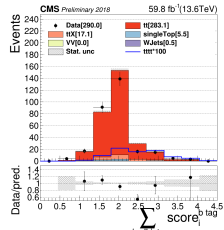
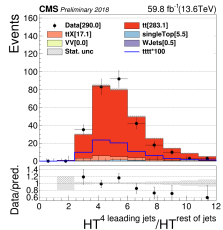
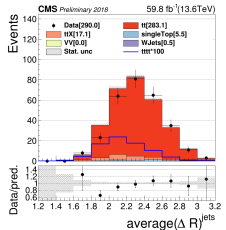
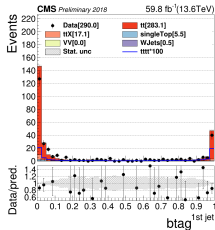
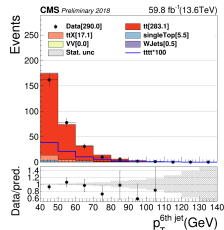
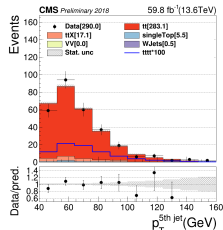
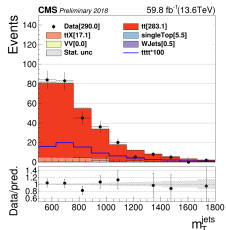
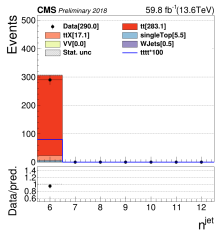
huahl@ihep.ac.cn

Huiling Hua

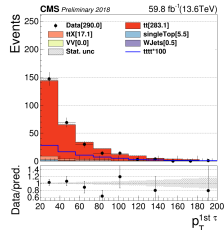
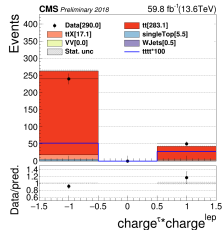
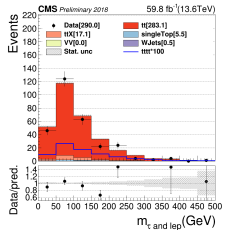
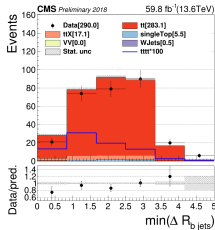
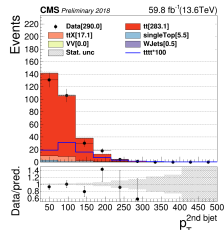
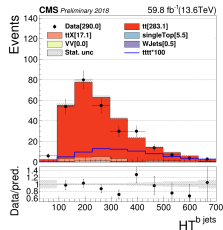
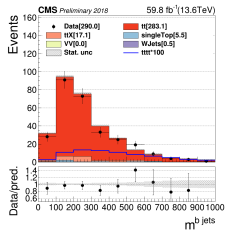
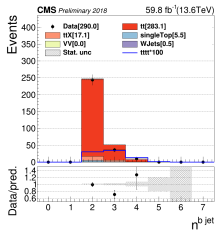
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● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency



● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency



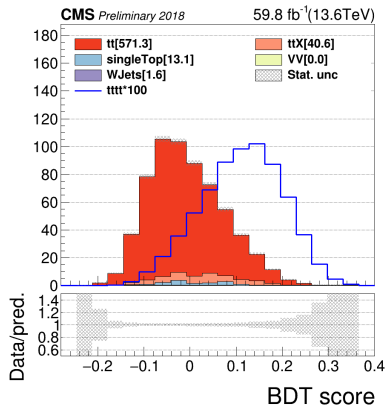
● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency

Section 3

2018

3.2 BDT training and results





Datacard

```
imax * number of bins
jmax * number of processes minus 1
kmax * number of nuisance parameters
```

```
shapes * SR1tau11_2018 /publicfs/cms/user/huahuil/tauOfTTTT_NanoAOD/forMVA/2018/v1btagWPandRUpdated_v61fixesLepRemovalBug/mc/variableHists_v1traingWithBtagWP/
```

```
bin SR1tau11_2018
observation -1
```

```
bin SR1tau11_2018 SR1tau11_2018 SR1tau11_2018 SR1tau11_2018 SR1tau11_2018
process tttt singleTop tt ttX WJets
process 0 1 2 3 4
rate -1 -1 -1 -1 -1
```

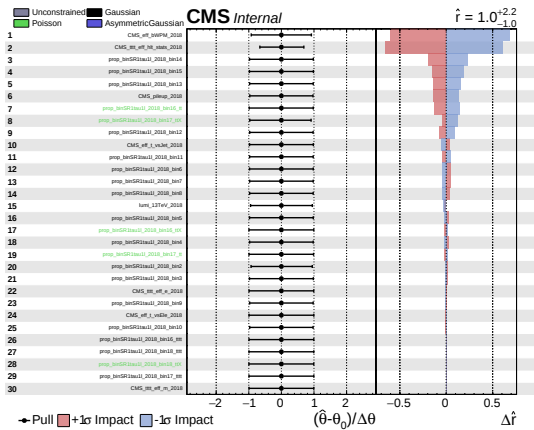
```
lumi_13TeV_2018 lnN 1.025 1.025 1.025 1.025 1.025
CMS_pileup_2018 shape 1 1 1 1 1
CMS_prefiring_2018 shape 1 1 1 1 1
CMS_eff_t_vsJet_2018 shape 1 1 1 1 1
CMS_eff_t_vsMu_2018 shape 1 1 1 1 1
CMS_eff_t_vsEle_2018 shape 1 1 1 1 1
CMS_tttt_eff_e_2018 shape 1 1 1 1 1
CMS_tttt_eff_m_2018 shape 1 1 1 1 1
CMS_eff_bWPM_2018 shape 1 1 1 1 1
CMS_tttt_eff_hlt_stats_2018 shape 1 1 1 1 1
```

```
SR1tau11_2018 autoMCStats 10 0 1
```

Results

- Before systematic
- After systematic
 - Expected significance: 0.52
 - Expected limit: 4.38(3.04, 6.35)
 - Datacard: /publicfs/cms/user/huahuil/-tauOfTTTT_NanoAOD/forMVA/2016/v3btagWeightGood_v61fixesLepRemovalBug/mc/variabl

Impacts



Section 4

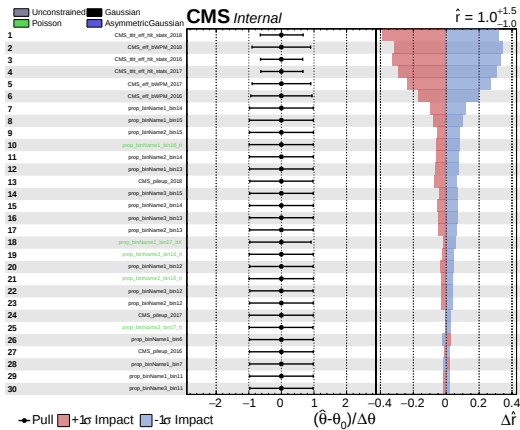
Combining 3 years



Combination results of Run2

- After systematics
 - Sig: 0.75
 - limit: 2.98(2.08, 4.29)
 - Correlation no considered yet
- Before systematics
 - Sig: 0.91
 - limit: 2.27(1.67, 3.40)

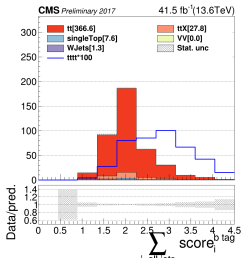
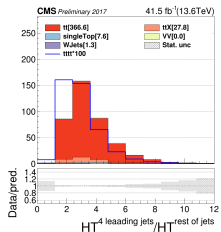
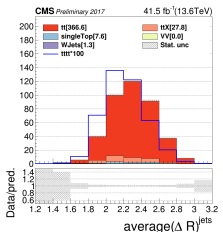
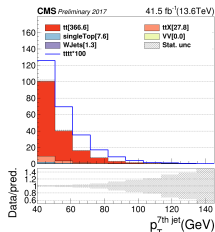
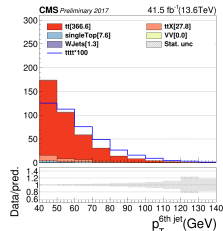
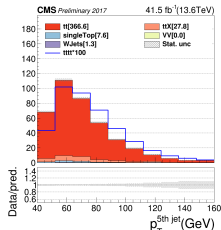
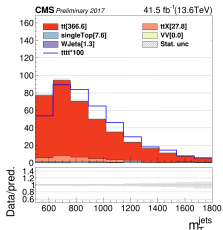
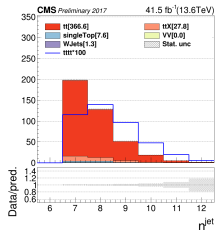
Impacts

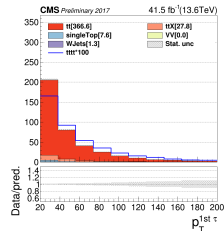
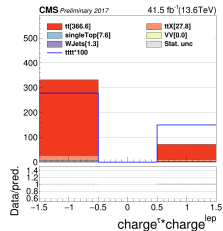
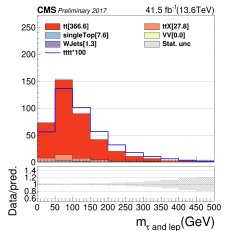
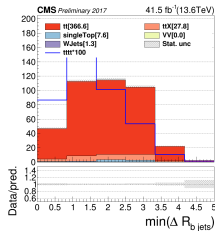
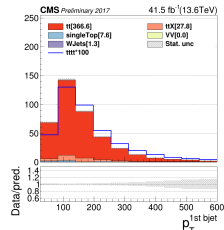
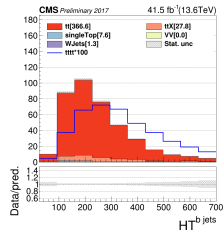
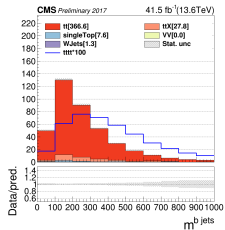
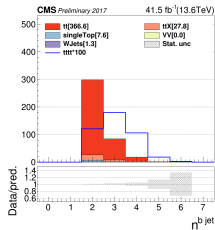


Section 5

Back up







● MC correction: prefling, Pileup, HLT efficiency, JES JER, b tag WP efficiency, lepton efficiency, TES, tau ID efficiency