Progress Report on Tau Final States of TTTT

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Outline

1. Object Difinition
2. Separation Power
3. MVA Study

Sample List

Process	Sample Name	*CrossSection[pb]*	notes
TTTT	TTTT_TuneCUETP8M2T4_13TeV-amcatnlo-pythia8	1.197×10^{-2}	signal
TTJets	TTJets_TuneCUETP8M2T4_13TeV-amcatnloFXFX-pythia8	7.467×10^{2}	major bg
TTGJets	TTGJets_TuneCUETP8M1_13TeV-amcatnloFXFX-madspin-pythia8	3.773×10^{0}	
ttZJets	ttZJets_13TeV_madgraphMLM-pythia8	$6.559 \times 10-1$	
ttWJets	ttWJets_13TeV_madgraphMLM	2.014×10^{-1}	
ttH	ttH_4f_ctcvcp_TuneCP5_13TeV_madgraph_pythia8	3.372×10^{-1}	
ttbb	ttbb_4FS_ckm_amcatnlo_madspin_pythia8	1.393×10^{1}	major
WZ	WZ_TuneCUETP8M1_13TeV-pythia8	2.343×10^{1}	major
WW	WWTo2L2Nu_DoubleScattering_13TeV-pythia8	1.697×10^{-1}	
WpWpJJ	WpWpJJ_EWK-QCD_TuneCUETP8M1_13TeV-madgraph-pythia8	5.390×10^{-2}	
ZZ	ZZ_TuneCUETP8M1_13TeV-pythia8	1.016×10^{1}	
WG	WGJets_MonoPhoton_PtG-40to130_TuneCUETP8M1_13TeV-madgraph	1.269×10^{1}	major
ZG	ZGJetsToLLG_EW_LO_13TeV-sherpa	1.319×10^{-1}	
WWW	WWW_4F_TuneCUETP8M1_13TeV-amcatnlo-pythia8	2.086×10^{-1}	
WWZ	WWZ_TuneCUETP8M1_13TeV-amcatnlo-pythia8	1.651×10^{-1}	
WWG	WWG_TuneCUETP8M1_13TeV-amcatnlo-pythia8	2.147×10^{-1}	
ZZZ	ZZZ_TuneCUETP8M1_13TeV-amcatnlo-pythia8	1.398×10^{-2}	
WZZ	WZZ_TuneCUETP8M1_13TeV-amcatnlo-pythia8	5.565×10^{-2}	

Table: 2016 MC Samples Part1

Sample List

Process	Sample Name	$CrossSection[pb]$	notes
WZG	WZG_TuneCUETP8M1_13TeV-amcatnlo-pythia8	4.123×10^{-2}	
WGG	WGG_5f_TuneCUETP8M1_13TeV-amcatnlo-pythia8	1.819×10^{0}	
ZGG	ZGGJets_ZToHadOrNu_5f_LO_madgraph_pythia8	3.717×10^{-1}	
WJets	WJetsToLNu_TuneCUETP8M1_13TeV-madgraphMLM-pythia8	$5.030 \times 10^{+4}$	
DY	DYJetsToTauTau_ForcedMuEleDecay_M-50_TuneCUETP8M1_13TeV-amcatnloFXFX-pythia8_ext1	$1.983 \times 10^{+3}$	
single top	tZq_ll_4f_ckm_NLO_TuneCP5_PSweights_13TeV-amcatnlo-pythia8	7.358×10^{-2}	
	tZq_nunu_4f_13TeV-amcatnlo-pythia8_TuneCUETP8M1	0000	could't get xsection
	ST_tW_antitop_5f_inclusiveDecays_13TeV-powheg-pythia8_TuneCUETP8M2T4	$3.806 \times 10^{+1}$	
	ST_tW_top_5f_inclusiveDecays_13TeV-powheg-pythia8_TuneCUETP8M2T4	$3.809 \times 10^{+1}$	
TG	TGJets_TuneCUETP8M1_13TeV_amcatnlo_madspin_pythia8	$2.967 \times 10^{+0}$	
TH	THW_ctcvcp_HIncl_M125_TuneCP5_13TeV-madgraph-pythia8	1.467×10^{-1}	
	THQ_ctcvcp_Hincl_13TeV-madgraph-pythia8_TuneCUETP8M1	8.816×10^{-1}	
Z/W+H	VHToNonbb_M125_13TeV_amcatnloFXFX_madspin_pythia8	$2.137 \times 10^{+0}$	
	ZHToTauTau_M125_13TeV_powheg_pythia8	7.524×10^{-1}	
	ZH_HToBB_ZToLL_M125_13TeV_powheg_pythia8	7.523×10^{-2}	
ggFH	GluGluHToZZTo4L_M125_13TeV_powheg2_JHUgenV6_pythia8	$2.999 \times 10^{+1}$	
	GluGluHToBB_M125_13TeV_amcatnloFXFX_pythia8	$3.210 \times 10^{+1}$	
	GluGluHToGG_M125_13TeV_amcatnloFXFX_pythia8	$3.198 \times 10^{+1}$	
	GluGluHToMuMu_M-125_TuneCP5_PSweights_13TeV_powheg_pythia8	$2.999 \times 10^{+1}$	
	GluGluHToTauTau_M125_13TeV_powheg_pythia8	$3.052 \times 10^{+1}$	
	GluGluHToWWTo2L2Nu_M125_13TeV_powheg_JHUgen_pythia8	$3.052 \times 10^{+1}$	
	GluGluHToWWToLNuQQ_M125_13TeV_powheg_JHUGenV628_pythia8	$2.999 \times 10^{+1}$	

Table: 2016 MC Samples Part 2

Sample List

Process	Sample Name	*CrossSection*[*pb*]
VBFH	VBFHToWWToLNuQQ_M125_13TeV_powheg_JHUGenV628_pythia8	$3.769 \times 10^{+0}$
	VBFHToWWTo2L2Nu_M125_13TeV_powheg_JHUgenv628_pythia8	$3.769 \times 10^{+0}$
	VBFHToTauTau_M125_13TeV_powheg_pythia8	
	VBFHToMuMu_M-125_TuneCP5_PSweights_13TeV_powheg_pythia8	
	VBFHToGG_M125_13TeV_amcatnlo_pythia8_v2	$3.992 \times 10^{+0}$
	VBFHToBB_M-125_13TeV_powheg_pythia8_weightfix	
	VBF_HToZZTo4L_M125_13TeV_powheg2_JHUgenV6_pythia8	$3.769 \times 10^{+0}$

Table: 2016 MC Samples Part3

Object Definition

- Electron:loose fakeble tight (SS of TTTT)
  - identification
    - MVANoIso94XV2 recommended by SUSY lepton(SS used Spring16_GeneralPurpose_V1 instead)
      definiton in the backup
    - tight, VLoose, VLooseFO
    - $\eta<|2.5|$
  - isolation
    - $I_{mini} < I_1 \wedge (p_T^{ratio} > I_2 \vee p_T^{rel} > I_3)$ (same as SS of TTTT)
    - loose, medium, tight WP(tight WP kill most electrons. not used) check out backup
  - impact parameter
  - HLT emulation(need to understand this, not implemented yet)
  - charge(not implemented yet)
    - missing inner hits;conversion veto;tight charge not avalible on ntuple

electron	loose	fakeble	tight
ID	Loose	VLoose	Tight
Iso	loose	loose	loose(tight in SS)
HLT emulation	not implemented	not implemented	not implemented
d_0 (cm)	0.05	0.05	0.05
d_z (cm)	0.1	0.1	0.1
SIP_3D	-	<4	<4

Table: electron definition. blue text means different from SS

Object Definition

- Muon: loose, fakeble, tight(SS of TTTT)
  - ID
    - muon POG Loose ID;muon Medium Id(use POG medium Id instead)
    - $|\eta|$<2.4
  - loose and medium WP
  - IP(not implemented,code reason)
  - quality of the charge reconstruction (not implemented)

Object Definition

- Tau: loose , fakeble, tight(ttH)
  - kinematic properties pt>20, $|\eta|$<2.3
  - tau ID:DeepTauv2
    - the tight WP of the discriminant against jets in ttH is channel specific
    - here we adopt tight WP of 1tau1l in ttH, that is medium WP vs jets
  - overlap removal
    - the tau are required not to overlap, within $\triangle R < 0.3$, with any electron or muon passing the loose lepton selection criteria.(not apllied yet)

Object Definition

- Jet(ttH)
  - pt>25
  - loose jet(recommended by JETMET)
  - not to overlap with fakeable electrons/muons or loose tau.(not applied yet)
- Forward Jet(ttH)
  - 2.4<|η|<5
  - pt>25; pt>60(2.7<|η|<3)
  - not to overlap with electrons, muons or tau that pass the fakeable object selection criteria.(not applied yet)
- B Jet: loose , medium , tight
  - use Deep Flavour B tagging algorithm
  - use the recommended working points
- Top
  - use SUSY HOT TopTagger
  - resolved

Event Selection Pre-preselection

- MET filters

filter	*appliedtoMC*	*appliedtodata*
`Flag_goodVertices`	√	√
`Flag_globalSuperTightHalo2016Filter`	√	√
`Flag_HBHENoiseFilter`	√	√
`Flag_HBHENoiseIsoFilter`	√	√
`Flag_EcalDeadCellTriggerPrimitiveFilter`	√	√
`Flag_BadPFMuonFilter`	√	√
`Flag_eeBadScFilter`	×	√

Table: MET Filters

- At least 1 loose tau
- At least 3 loose jet
- At least 1 loose b jet
- Apply no HLT yet

Subchannel Categorization

channel	subchannl	lepton	tau	Ljet	M b jet
1Tau 0L	1Tau 0L	0 tight electrons or muons	1 tight tau	>= 8	>= 2
1Tau1L	1Tau 1E	exact 1 tight electron	1 tight tau	>= 6	>= 2
	1Tau 1Mu	1 tight muon	1 tight tau	>= 6	>= 2
1Tau>=2L	1Tau 2OSL	2 tight leptons of the opposite charge	1 tight tau	>= 4	>=2
	1Tau 2SSL	2 tight leptons of the same charge	1 tight tau	>= 4	>= 2
	1Tau 3L	3 tight letons	1 tight tau	>= 2	>= 2
2Tau+anything	2Tau 0L	0 tight electrons or muons	2 tight tau	>= 6	>= 2
	2Tau 1L	exact 1 tight electron or 1 tighy moun	2 tight tau	>= 4	>= 2
	2Tau 2OSL	2 tight leptons of the opposite charge	2 tight tau	>= 2	>= 2
	2Tau 2SSL	2 tight leptons of the same charge	2 tight tau	>= 2	>= 2

Table: Subchannel difinition

- For tau, we changed the fakeble tau to tight tau for channel categorization.
- B jet is medium b jet.

Subchannel Categorization

- channel difinition from ttH

channel	lepton	tau	jet	b jet
1Tau 0L	no difinition			
1Tau1L	1 eleT or 1 muT $\|\eta\|$<2.1, pt>30(25) (within the geometric acceptance of the lepton+tau cross-trigger)	1 tau pass fakeble and medium WP of identification pt>30	>=4 pt>25,$\|\eta\|$<2.4	>= 2 bjetsL or 1 bjetM
1Tau2OSL	2 eleT or 2 muT(opposite charge,leading pt>25,subleading pt > 30(25)) $\|m_{ll} - m_Z\| < 10$	1 tauF and veryT WP of tauID	>=3 jets(pt>25,$\|\eta\|$<2.4)	>=2 bjetL or >=1 bjetM
1Tau2SSL	2 lepT (same charge, highest(lowest)pt >25(14)) (if the second highest pT lepton is a muon, the pT requirement is relaxed to pT>10) (charge of all fakeable electrons and muons to be well measured(supress ttjets)) $\|m_{ll} - m_Z\| < 10$	1 tau pass veryL id (tau chrge opposite to leptons) do not have 2 tauL passing M WP id(not overlap with 2l2tau)	>=3 jets(pt>25,$\|\eta\|$<2.4)	>=2 bjetL or >=1 bjetM
1Tau3L	3 lepT (lep pt > 20, >15, >10;charge sum = 0) $\|m_{ll} - m_Z\| < 10$	1 tau passing veryL WP	>=2 jets requirements on $E_T^{miss}LD > 30$ depending on jet	>=2 L bjets or >=1 M bjets
2Tau0L	0 lepT $\|\eta\|$<2.1, pt>30(25) veto >=1 lepT(overlap 2tau1l and 2tau 2l)	2 tauF and L WP id opposite charge(H decay); both pt>40(ttjets)	>=4 jets	>=2 L WP bjets or >=1 M WP bjets
2Tau1L	1 eleT or 1 muonT $\|\eta\|$<2.1, pt>30(25) (within the geometric acceptance of the lepton+tau cross-trigger) veto >1 leptonT (overlap with 2tau2L)	2 tau of M WP id opposite charge(H decay) higher tau pt>30(ttJets)	>=3 jets pt>25,|eta|<2.4	>=2 bjetsL or 1 bjetsM
2Tau2L	2 leptonsT first pt> 25,2nd pt > 15(10) ele(muon) veto $\|m_{ll} - m_Z\| < 10$ (ttZ)	2 tau M WP id charge sum of the two leptons and the 2 tau = zero	2 jets requirements on $E_T^{miss}LD > 30$ depending on jet	>=2 L bjet or >=1 M bjet

Table: Subchannel difinition

Separation Power of Variables

- Definition of separation power

$$s = \int \frac{(y_s(x) - y_b(x))^2}{y_s(x) + y_b(x)} dx \qquad (1)$$

  - $y_s(x)$ and $y_b(x)$ are the distribution of variable x in signal and background.
  - $y_s(x)$ and $y_b(x)$ should be normalized to 1.

Variable List - - leptons

variables	notes	in ttH DNNs	in ttH BDTs
muonsL_number muonsF_number muonsT_number muonsT_1pt muonsT_1eta muonsT_3phi	loose muon,L for loose F for fakeble T for tight up to 3pt up to 3eta up tp 3phi		
elesMVAL_number elesMVAF_number elesMVAT_number	loose MVA electron		
leptonsMVAT_transMass leptonsMVAT_1pt leptonsMVAT_1eta leptonsMVAT_1phi leptonsMVAT_2pt leptonsMVAT_2eta leptonsMVAT_2phi leptonsMVAT_3pt leptonsMVAT_3eta leptonsMVAT_3phi	also for leptonsMVAF,leptonsMVAL pt of leading lepton η of leading lepton ϕ of leading lepton pt of second largest pt		

Table: variable list

Variable List - - tau

variables	notes	in ttH DNNs	in ttH BDTs
tausL_number	also for F T		
tausL_MHT	also for F T		
tausL_HT	also for F T		
tausL_invariantMass	F T		
tausL_minDeltaR	F and T		
tausF_leptonsT_transMass	tausL and tausL		
tausF_leptonsT_invariantMass	tausL and tausT		
tausF_leptonsT_chargeSum			
tausF_leptonsTMVA_minDeltaR	tausL and tausT		
tauL_1pt	up to 3pt		
tauL_1eta	up to 3eta		
tauL_1phi	up to 3phi		

Table: variable list

Variable List- - jets

variables	notes	in ttH DNNs	in ttH BDTs
jetsL_number			
jetsL_MHT			
jetsL_HT			
jetsL_invariantMass			
jetsL_transMass	transeverse mass of jets definiton in the backup		
jetL_minDeltaR			
jetsL_centrality			
jetsL_bScore	b score of all jets		
jetsL_average_deltaR			
jetsL_4largestBscoreSum	sum of 4 largest b score of jets		
jetsL_1pt	up to 11pt		
jetsL_1eta	up tp 11eta		
jetsL_1phi	up to 11phi		
jetsL_HTDividedByMet			
MetDividedByHT			
jetsL_MHTDividedByMet			
jetsL_leptonsMVAT_minDeltaR			
jetsL_tausF_minDeltaR			

Table: variable list

Variable List- - Bjets and Forwardjet

variables	notes	in ttH DNNs	in ttH BDTs
bjetsL_num	M and T		
bjetsL_HT	M and T		
bjetsL_MHT	M and T		
bjetsL_invariantMass	M and T		
bjetsL_transMass	M and T		
bjetsL_minDeltaR	M and T		
bjetsL_1pt	up to 4pt, also for M and T		
bjetsL_1eta	up to 4eta,also for M and T		
bjetsL_1phi	up to 4phi,also for M and T		
bjetsL_leptonsMVAT_minDeltaR	bjetsM and bjetsT		
bjetsL_tausF_minDeltaR	bjetsM and bjetsT		
forwardJets_num			
forwardjet_1pt			
forwardjet_1eta			
forwardjet_1phi			
forwardjet1_jetsL_minDeltaEta			

Table: variable list

Variable List - - Met and Top

variables	notes	in ttH DNNs	in ttH BDTs
Met_pt Met_phi			
toptagger_num toptagger_MHT toptagger_HT toptagger_invariantMass toptagger_transMass toptagger_minDeltaR_v1 toptagger_1pt toptagger_1eta toptagger_1phi toptagger_scoreAllTops toptagger_leptonsMVAT_minDeltaR	 up to 3pt up to 3eta up to 3phi		

Table: variable list

1Tau0L

- TTTT event yield in 2016

$$35.9fb^{-1} \times 0.01197pb = 35.9 \times 11.97 = 430 \quad (2)$$

- BR for 1Tau0L:

$$\frac{1}{9} \times \frac{2}{3} \times \frac{2}{3} \times \frac{2}{3} \times 4 = \frac{32}{243} = 0.1317 \quad (3)$$

- Event yield in 1Tau0L: 56.6

1Tau0L

```
Plotting jetsL_number1Tau0L_
TTTT   = 36.0512
TTJets = 105130
TTX    = 1596.05
ttbb   = 962.819
VV     = 1.20778
VVV    = 4.89656
WJets  = 244.734
DY     = 20.3273
ST     = 849.986
H      = 44.8843
Total BKG = 108855

Statistics
TTTT   = 84343
TTJets = 59509
TTX    = 189223
ttbb   = 21722
VV     = 72
VVV    = 390
WJets  = 14973.7
DY     = 82.6395
ST     = 55010
H      = 866
```

```
channel_1Tau0L_v2==1
jetsL_number = 0.329999
jetsL_transMass = 0.327606
jetsL_HT = 0.323084
jetsL_8pt = 0.321636
jetsL_6pt = 0.315368
jetsL_7pt = 0.302445
jetsL_5pt = 0.28129
bjetsL_HT = 0.280251
bjetsL_transMass = 0.274658
jetsL_bScore = 0.261205
jetsL_4pt = 0.259662
jetsL_9pt = 0.234798
bjetsL_invariantMass = 0.234673
jetsL_3pt = 0.229524
jetsL_4largestBscoreSum = 0.229218
jetsL_invariantMass = 0.222423
bjetsL_3pt = 0.21591
bjetsM_HT = 0.215453
bjetsM_invariantMass = 0.210638
bjetsM_transMass = 0.208998
bjetsM_num = 0.207496
bjetsL_num = 0.199664
bjetsL_2pt = 0.196168
bjetsL_4pt = 0.187781
jetsL_2pt = 0.187182
toptagger_transMass = 0.171425
toptagger_HT = 0.165734
bjetsL_1pt = 0.159278
jetsL_10pt = 0.158946
jetsL_1pt = 0.15539
bjetsM_2pt = 0.139737
bjetsT_HT = 0.139078
bjetsT_transMass = 0.138343
toptagger_invariantMass = 0.133409
bjetsT_num = 0.132433
bjetsM_3pt = 0.1313
toptagger_scoreAllTops = 0.128403
```

1Tau0L

Figure: removed ttbb background here

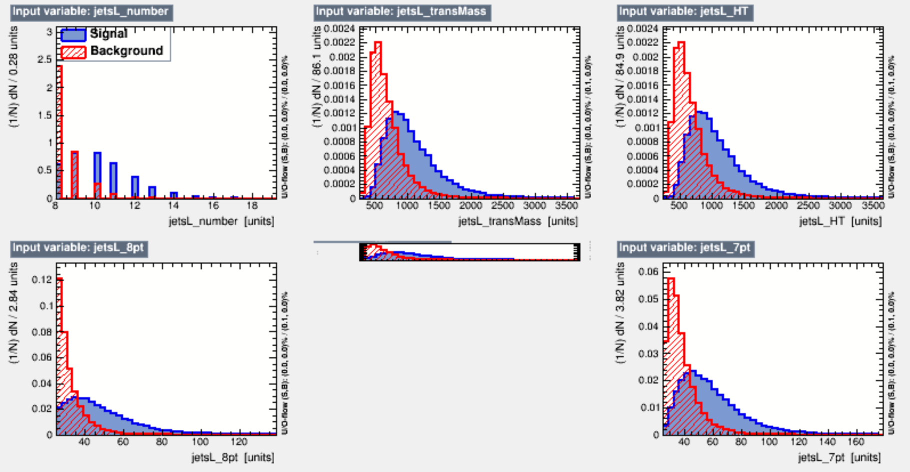
```
Plotting jetsL_number1Tau0L_v2.
TTTT   = 36.0512
TTJets = 105130
TTX    = 1596.05
VV     = 1.20778
VVV    = 4.89656
WJets  = 244.734
DY     = 20.3273
ST     = 849.986
H      = 44.8843
Total BKG = 107892

Statistics
TTTT   = 84343
TTJets = 59509
TTX    = 189223
VV     = 72
VVV    = 390
WJets  = 14973.7
DY     = 82.6395
ST     = 55010
H      = 866
```

```
channel_1Tau0L_v2==1
jetsL_number = 0.331482
jetsL_transMass = 0.329308
jetsL_HT = 0.324774
jetsL_8pt = 0.323078
jetsL_6pt = 0.316839
jetsL_7pt = 0.303842
jetsL_5pt = 0.282643
bjetsL_HT = 0.282201
bjetsL_transMass = 0.276617
jetsL_4pt = 0.261002
jetsL_bScore = 0.257169
bjetsL_invariantMass = 0.236641
jetsL_9pt = 0.236565
jetsL_3pt = 0.230782
jetsL_4largestBscoreSum = 0.229548
jetsL_invariantMass = 0.223809
bjetsL_3pt = 0.217487
bjetsM_HT = 0.217206
bjetsM_invariantMass = 0.212765
bjetsM_transMass = 0.210735
bjetsM_num = 0.210118
bjetsL_num = 0.20148
bjetsL_2pt = 0.19739
bjetsL_4pt = 0.189615
jetsL_2pt = 0.188291
toptagger_transMass = 0.171734
toptagger_HT = 0.165982
jetsL_10pt = 0.160865
bjetsL_1pt = 0.160324
jetsL_1pt = 0.156372
bjetsM_2pt = 0.140678
bjetsT_HT = 0.140378
bjetsT_transMass = 0.139663
bjetsT_num = 0.134544
toptagger_invariantMass = 0.133657
bjetsM_3pt = 0.13337
toptagger_scoreAllTops = 0.127233
bjetsM_1pt = 0.126856
bjetsT_invariantMass = 0.12255
```

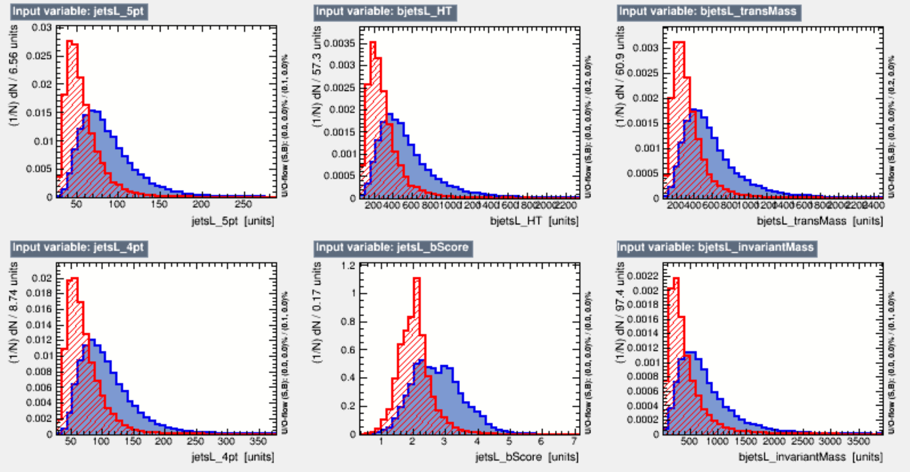
MVA Set Up (1Tau0L)

- MVA method: CutsSA, BDTA, BDTG
- 50% go to training and 50% go to test
- Signal:TTTT; background: all the major backgrounds
- Input variables: 29 most high ranking variables

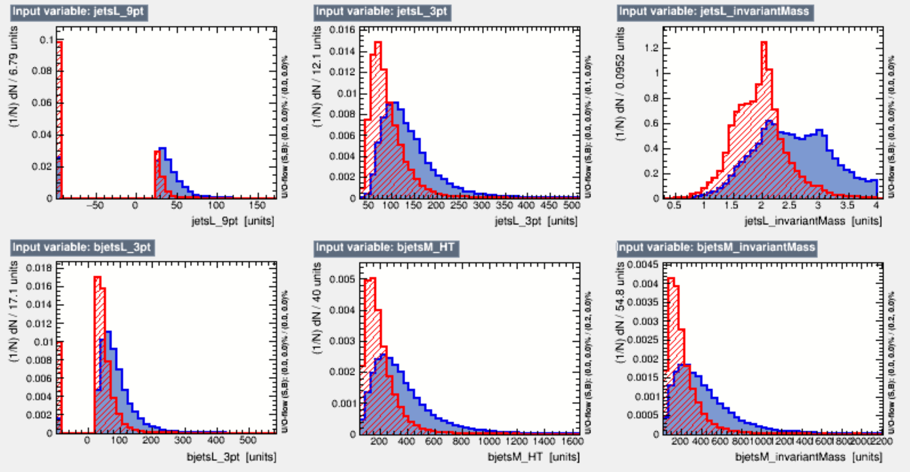
MVA Input Variable Properties (1Tau0L)



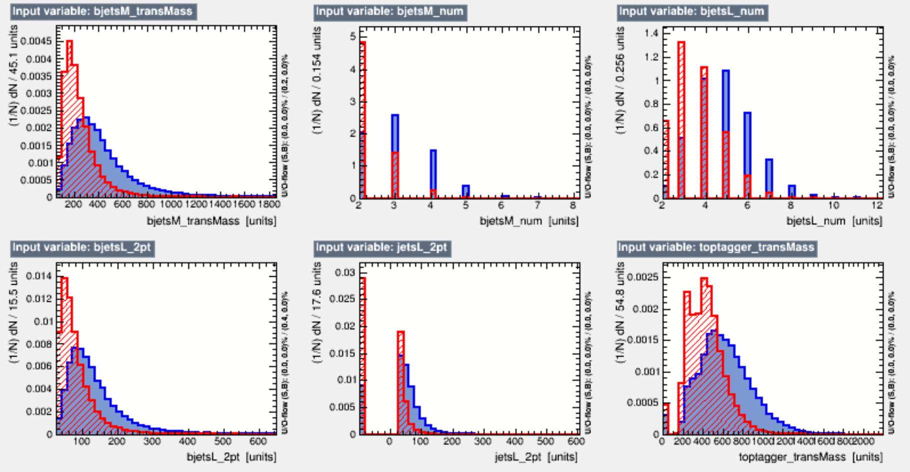
MVA Input Variable Properties (1Tau0L)



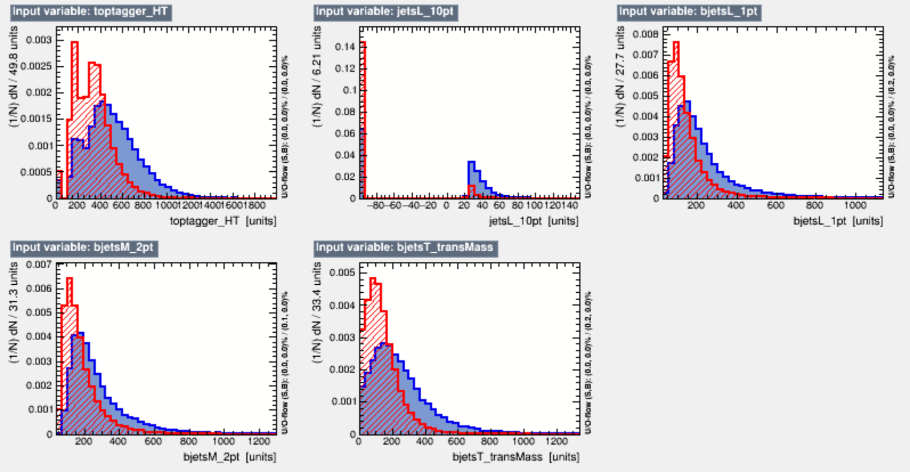
MVA Input Variable Properties (1Tau0L)



MVA Input Variable Properties (1Tau0L)



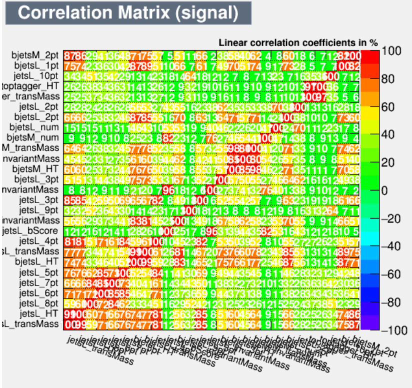
MVA Input Variable Properties (1Tau0L)

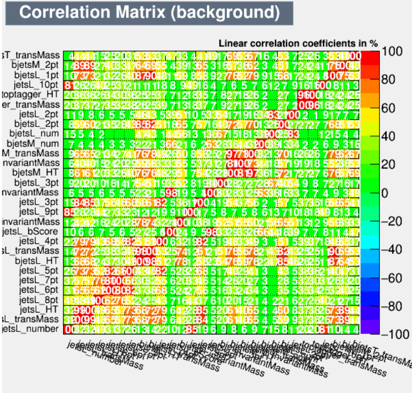


MVA Input Variable Properties (1Tau0L)

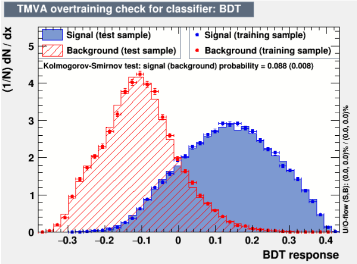
Rank	Variable	Separation
1	jetsL_9pt	3.409e-01
2	jetsL_8pt	3.359e-01
3	jetsL_number	3.334e-01
4	jetsL_7pt	3.324e-01
5	jetsL_transMass	3.267e-01
6	jetsL_HT	3.221e-01
7	jetsL_6pt	3.177e-01
8	jetsL_5pt	2.968e-01
9	jetsL_10pt	2.855e-01
10	bjetsL_HT	2.778e-01
11	bjetsL_transMass	2.719e-01
12	jetsL_4pt	2.659e-01
13	jetsL_bScore	2.617e-01
14	bjetsL_3pt	2.457e-01
15	jetsL_2pt	2.362e-01
16	bjetsL_invariantMass	2.330e-01
17	jetsL_3pt	2.323e-01
18	jetsL_invariantMass	2.296e-01
19	bjetsM_HT	2.151e-01
20	bjetsM_transMass	2.095e-01
21	bjetsM_invariantMass	2.090e-01
22	bjetsM_num	2.087e-01
23	bjetsL_num	2.000e-01
24	bjetsL_2pt	1.952e-01
25	toptagger_transMass	1.717e-01
26	toptagger_HT	1.659e-01
27	bjetsL_1pt	1.583e-01
28	bjetsM_2pt	1.527e-01
29	bjetsT_transMass	1.383e-01

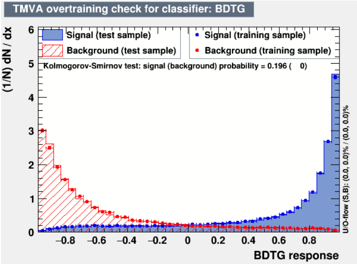
MVA Input Variable Properties (1Tau0L)





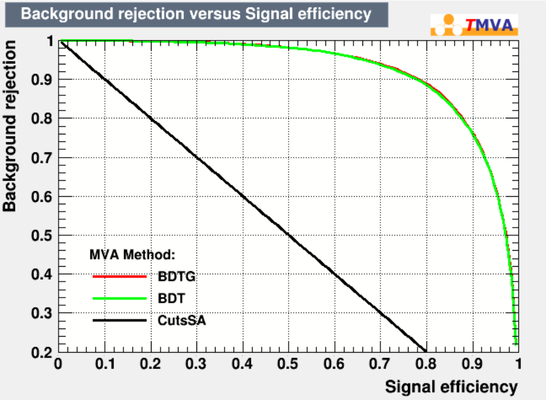
BDT Output (1Tau0L)





- No sign of over training

ROC Curve (1Tau0L)



Optimal Cut (1Tau0L)

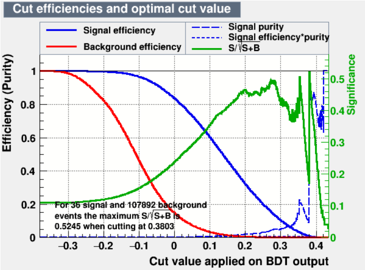
Classifier	#signal	#backgr.	Optimal-cut	S/sqrt(B)	NSig	NBkg	EffSig	EffBkg
CutsSA:	36	107892	0.1750	0.365 +- 0.146	6.30574	298.0276	0.1752	0.002762
BDTG:	36	107892	0.9872	1.58 +- 5.13	0.3943755	0.06243509	0.01095	5.787e-07
BDT:	36	107892	0.3809	1.35 +- 5.13	0.3184028	0.05528086	0.008845	5.124e-07

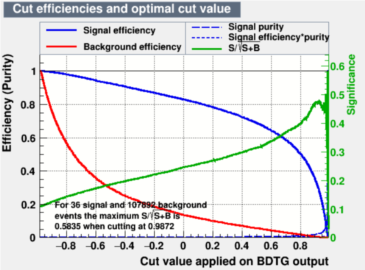
t [1] --- ==

Classifier	#signal	#backgr.	Optimal-cut	S/sqrt(S+B)	NSig	NBkg	EffSig	EffBkg
CutsSA:	36	107892	0.1750	0.361461	6.30574	298.0276	0.1752	0.002762
BDTG:	36	107892	0.9872	0.583501	0.3943755	0.06243509	0.01095	5.787e-07
BDT:	36	107892	0.3803	0.524462	0.3312072	0.06760853	0.0092	6.266e-07

- Signal efficiency very low for BDTA and BDTG, why? What can we do about it?
  - maybe aplly a tighter cut for this channel? Like b jets number >= 3?
  - try make signal and bg events to be same in training stage
- TTJets event yield is 5 times larger than ZhangYu's result

Optimal Cut (1Tau0L)





Questions

- Maybe we should exclude ttbb process
  - already excluded
- How do determine best set of input variables? how to do with correlation
  - try to remove variables with high correlation
- It seems that when statistic is low, seperation power is no longer a good indicator
- Why not use $\frac{S}{\sqrt{S+B}}$ as significance?
- What is AddSpectator doing in TMVAClassification?
- d0 and dz

Next Step

- Check more kinematics variables and their combinations
  - Variables in SS AN might be promising
  - For example, invariant mass of leading two jets, Ratio of HT of first four leading jets to rest,
- Try a 70% and 30% of training and testing
- Add QCD background

Electron ID

SUSY eletron MVA recommendation

Figure: Cuts/Equations for MVA Ids (94X MVA)

Cuts/Equations for MVA (2016 - MVANoIso94XV2)

6

Different from 2017/2018

Tight

Region	MVA value, 10<ePt<40	MVA value ePt>=40
$|\eta| < 0.8$	> 3.447 + 0.063(pt - 25)	> 4.392
$0.8 \leq |\eta| < 1.479$	> 2.522 + 0.058(pt - 25)	> 3.392
$1.479 \leq |\eta| < 2.5$	> 1.555 + 0.075(pt - 25)	> 2.680

VLoose

Region	ePt: 5-10	10<ePt<25	ePt>=25
$|\eta| < 0.8$	> 1.309	> 0.887 + 0.088(pt - 25)	> 0.887
$0.8 \leq |\eta| < 1.479$	> 0.373	> 0.112 + 0.099(pt - 25)	> 0.112
$1.479 \leq |\eta| < 2.5$	> 0.071	> -0.017 + 0.137(pt - 25)	> -0.017

VLooseFO

Region	ePt: 5-10	10<ePt<25	ePt>=25
$|\eta| < 0.8$	> -0.259	> -0.388 + 0.109(pt - 25)	> -0.388
$0.8 \leq |\eta| < 1.479$	> -0.256	> -0.696 + 0.106(pt - 25)	> -0.696
$1.479 \leq |\eta| < 2.5$	> -1.630	> -1.219 + 0.148(pt - 25)	> -1.219

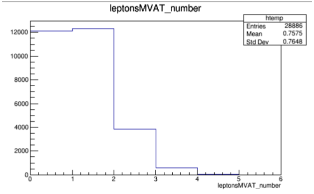
Electron Iso

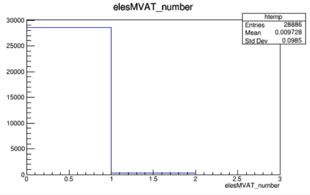
Figure: electron ISO in SS

Table 7: Isolation working points

2016

isolation value	loose WP (e/μ)	μ (Medium) WP	e (Tight) WP
I_1	0.4	0.16	0.12
I_2	0	0.76	0.80
I_3	0	7.2	7.2





Tau in ttH

Hadronic τ			
Observable	Loose	Fakeable	Tight
p_T	> 20 GeV	> 20 GeV	> 20 GeV
$\|\eta\|$	< 2.3	< 2.3	< 2.3
$\|d_z\|$	< 0.2 cm	< 0.2 cm	< 0.2 cm
Decay mode finding	New	New	New
Decay modes	All	All except 2-prong$(+\pi^0)^1$	All except 2-prong$(+\pi^0)^1$
DeepTau vs. jets	> WP-VVLoose	> WP-VVLoose	Channel-dependent
DeepTau vs. muons	–	> WP-VLoose	> WP-VLoose
DeepTau vs. electrons	–	> WP-VVVLoose	> WP-VVVLoose

Variable definition

- transverse energy

$$E_T^2 = m^2 + (\vec{p_T})^2 \tag{4}$$

- transverse mass

$$M_T^2 = (E_{T1} + E_{T2})^2 - (\vec{p_{T1}} + \vec{p_{T2}})^2 \tag{5}$$