

# Progress Report on Tau Final States of TTTT

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# Outline

# Subchannel Categorization

- channel definition not the different from ttH

channel	subchannel	lepton	tau	Ljet	M b jet
1Tau 0L	1Tau 0L	0 tight electrons or muons	1 fakeble tau	$\geq 8$	$\geq 2$
1Tau1L	1Tau 1E	exact 1 tight electron	1 fakeble tau	$\geq 6$	$\geq 2$
	1Tau 1Mu	1 tight muon	1 fakeble tau	$\geq 6$	$\geq 2$
1Tau $\geq$ 2L	1Tau 2OSL	2 tight leptons of the opposite charge	1 fakeble tau	$\geq 4$	$\geq 2$
	1Tau 2SSL	2 tight leptons of the same charge	1 fakeble tau	$\geq 4$	$\geq 2$
	1Tau 3L	3 tight leptons	1 fakeble tau	$\geq 2$	$\geq 2$
2Tau+anything	2Tau 0L	0 tight electrons or muons	2 fakeble tau	$\geq 6$	$\geq 2$
	2Tau 1L	exact 1 tight electron or 1 tight muon	2 fakeble tau	$\geq 4$	$\geq 2$
	2Tau 2OSL	2 tight leptons of the opposite charge	2 fakeble tau	$\geq 2$	$\geq 2$
	2Tau 2SSL	2 tight leptons of the same charge	2 fakeble tau	$\geq 2$	$\geq 2$

Table: Subchannel definition

# Subchannel Categorization

- channel definition from ttH

channel	lepton	tau	jet	b jet
1Tau 0L	no definition			
1Tau1L	1 eleT or 1 muT	1 tau pass fakeble and medium WP of identification pt-30	$\geq 4$ pt>25, eta <2.4	$\geq 2$ bjetsL or 1 bjetM
1Tau2OSL	2 eleT or 2 muT (opposite charge, leading pt>25, subleading pt > 30(25)) $ m_1 - m_2  < 10$	1 tauF and veryT WP of tauID	$\geq 3$ jets(pt>25, eta <2.4)	$\geq 2$ bjetL or $\geq 1$ 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_1 - m_2  < 10$	1 tau pass veryL id (tau chrg opposite to leptons) do not have 2 tauL passing M WP id(not overlap with 2l2tau)	$\geq 3$ jets(pt>25, eta <2.4)	$\geq 2$ bjetL or $\geq 1$ bjetM
1Tau3L	3 lepT (lep pt > 20, >15, >10; charge sum = 0) $ m_1 - m_2  < 10$	1 tau passing veryL WP	$\geq 2$ jets requirements on $E_T^{miss} LD > 30$ depending on jet	$\geq 2$ L bjets or $\geq 1$ M bjets
2Tau0L	0 lepT  eta <2.1, pt>30(25) veto $\geq 1$ lepT(overlap 2tau1l and 2tau 2l)	2 tauF and L WP id opposite charge(H decay); both pt>40(ttjets)	$\geq 4$ jets	$\geq 2$ L WP bjets or $\geq 1$ 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 $\geq 1$ leptonT (overlap with 2tau2L)	2 tau of M WP id opposite charge(H decay) higher tau pt>30(Ljets)	$\geq 3$ jets pt>25, eta <2.4	$\geq 2$ bjetsL or 1 bjetsM
2Tau2L	2 leptonsT first pt> 25, 2nd pt > 15(10) ele(muon) veto $ m_1 - m_2  < 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	$\geq 2$ L bjet or $\geq 1$ M bjet

Table: Subchannel definition

# Variable List - - leptons

variables	<i>inttHDNNs</i>	in ttH BDTs	notes
number of electrons	✓		NumOfLeptonsFMVA T
eta of leptons	✓		leading_leptoHsMVAT_eta (leading to third)
phi of leptons	✓		leading_leptonsMVAT_phi (leading to third)
transverse mass of leptons	✓		leptonsTMVA_transMass
transverse mass of l and taus' system	✓		
invariant mass of leptons' and taus' system	✓		
charge sum of leptons and taus	✓		
min delta R of leptons and jets	✓		jetsL_leptonsMVAT_minDeltaR
lepton pt(LFT)			leadingEleMVAF_pt (leading to fourth)
number of mouns (LT)			number of mouns(T)
NumOfElectronsMVAL(LFT)			number of electrons (LFT)
min deltaR of leptons and taus			

Table: variable list

# Variable List - - tau

variables	in ttH DNNs	in ttH BDTs	notes
leadingTauL_pt leadingTauL_eta leadingTauL_phi transverse mass of l and taus' system charge sum of leptons and taus min delta R of taus and jets min delta R of taus and jets			tau pt (from first to third) tau eta tau phi
number of taus (LFT) MHT of Taus(LFT) HT of Taus(LFT) InvariantMass of Taus(LFT) minDeltaR of taus (LFT) transverse mass of taus			

Table: variable list

# Variable List- - jets

variables	in ttH DNNs	in ttH BDTs	name in code
number of jets pt of jets eta of jets phi of jets jets average delta R			from leading to tenth
InvariantMass of Jets MHT of jets HT of jets transMass of jets minDeltaR of jets Centrality of Jets HTDividedByMET MetDividedByHT MHTDividedByMET BScoreOfAllJetsL b score of four leading jets MinDeltaPhi of Jets			b score of four leading jets

Table: variable list

# Variable List- - bjets and forwardjet

variables	<i>inttHDNNs</i>	in ttH BDTs	notes
number of bjets (LM)	✓		
InvariantMass of BJets(LM)	✓		
number of forward jets			
pt of leading forward jet			
eta  of leading forward jet			
min delta eta of leading forward jet and jets			
InvariantMass of BJetsT			
Num of BJetsT			
transMass of Bjets			
minDeltaR of b jets			
LeadingBJetMPt			
leading to fourth HT of BJetT			
MHT of bjets			
leading forwardjet pt			

Table: variable list



# Variable List - - met and top

variables	<i>inttHDNNs</i>	in ttH BDTs	notes
Met_pt Met_phi Num of Tops LeadingTop Pt SecondTop Pt TopTaggerScore of AllTops MinDeltaR of Tops			

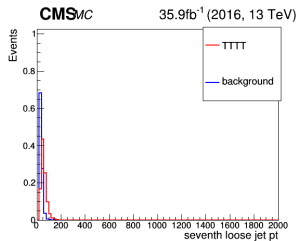
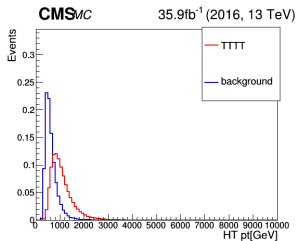
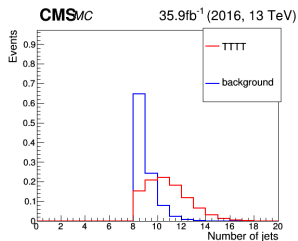
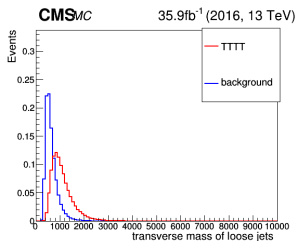
Table: variable list

# 1Tau0L

```
Plotting jetsL_number1Tau0L_v2.png
TTTT = 111.302
TTJets = 714656
TTX = 9558.2
ttbb = 4526.16
VV = 20.1861
VVV = 83.5149
WJets = 7953.85
DY = 382.153
ST = 6018.42
H = 897.451
Total BKG = 744096
```

```
channel_1Tau0L_v2==1
jetsL_transMass = 0.363738
jetsL_HT = 0.357222
jetsL_number = 0.354585
jetsL_8pt = 0.340196
jetsL_6pt = 0.337764
jetsL_7pt = 0.320317
bjetsL_HT = 0.317039
bjetsL_transMass = 0.311071
jetsL_5pt = 0.306009
jetsL_4pt = 0.285704
jetsL_bScore = 0.284971
bjetsL_invariantMass = 0.261088
bjetsM_HT = 0.259326
jetsL_4largestBscoreSum = 0.257571
jetsL_3pt = 0.255341
jetsL_9pt = 0.254243
bjetsM_transMass = 0.251459
jetsL_invariantMass = 0.250166
bjetsM_invariantMass = 0.24965
bjetsM_num = 0.242788
bjetsL_num = 0.22969
jetsL_2pt = 0.210705
bjetsL_1pt = 0.189495
jetsL_1pt = 0.181666
jetsL_10pt = 0.180226
bjetsT_HT = 0.17558
bjetsT_transMass = 0.171381
bjetsT_num = 0.159874
bjetsT_invariantMass = 0.156992
toptagger_scoreAllTops = 0.150291
toptagger_num = 0.142428
```

# 1Tau0L

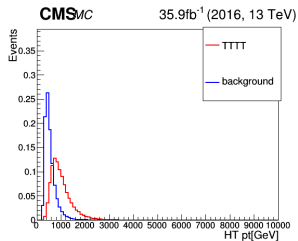
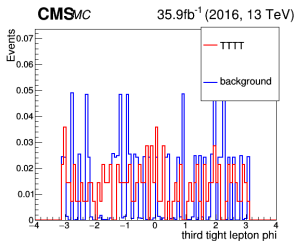
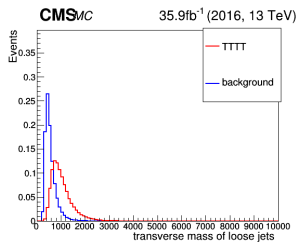
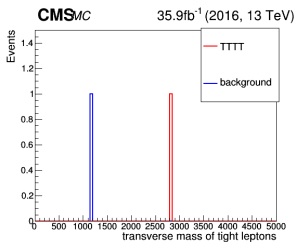


# 1Tau1Mu

```
Plotting jetsL_number1Tau1Mu_v2.  
TTTT = 63.0142  
TTJets = 575590  
TTX = 6020.38  
ttbb = 2615.95  
VV = 34.0076  
VVV = 72.7186  
WJets = 14316.9  
DY = 6041.26  
ST = 6541.55  
H = 1143.54  
Total BKG = 612377
```

```
channel_1Tau1Mu_v2==1  
leptonsTMVA_transMass = 1  
leptonsMVAT_3phi = 0.474669  
jetsL_transMass = 0.420552  
jetsL_HT = 0.415598  
jetsL_number = 0.413198  
leptonsMVAT_3eta = 0.4027  
jetsL_6pt = 0.40141  
jetsL_7pt = 0.371995  
jetsL_5pt = 0.362919  
jetsL_4pt = 0.341726  
jetsL_8pt = 0.310585  
bjetsL_HT = 0.309827  
bjetsL_transMass = 0.306887  
jetsL_3pt = 0.304598  
jetsL_invariantMass = 0.297552  
bjetsM_HT = 0.269525  
jetsL_bScore = 0.267348  
bjetsM_transMass = 0.264016  
jetsL_2pt = 0.25081  
bjetsM_invariantMass = 0.24509  
jetsL_9pt = 0.228691  
bjetsM_num = 0.221633  
jetsL_1pt = 0.21414  
bjetsL_invariantMass = 0.214061  
bjetsL_1pt = 0.196436  
toptagger_scoreAllTops = 0.188826  
bjetsT_HT = 0.188438  
bjetsT_transMass = 0.18576  
bjetsL_num = 0.184601  
toptagger_num = 0.172823  
jetsL_10pt = 0.16455  
bjetsT_invariantMass = 0.158244
```

# 1Tau1Mu



# 1Tau1E

```
Plotting jetsL_number1Tau1E_v2.  
TTTT = 9.33519  
TTJets = 103662  
TTX = 1108.93  
ttbb = 530.078  
VV = 7.02542  
VVV = 12.1219  
WJets = 2508.52  
DY = 841.549  
ST = 1281.19  
H = 286.621  
Total BKG = 110238
```

```
channel_1Tau1E_v2==1hello  
jetsL_transMass = 0.405408  
jetsL_HT = 0.396514  
jetsL_6pt = 0.374477  
jetsL_number = 0.354527  
jetsL_5pt = 0.337161  
jetsL_7pt = 0.334838  
jetsL_4pt = 0.317697  
bjetsL_transMass = 0.294389  
bjetsL_HT = 0.293428  
jetsL_3pt = 0.291143  
jetsL_8pt = 0.286116  
jetsL_invariantMass = 0.278301  
jetsL_bScore = 0.259011  
bjetsM_HT = 0.255923  
bjetsM_transMass = 0.25245  
jetsL_2pt = 0.241967  
bjetsM_invariantMass = 0.229465  
jetsL_9pt = 0.228396  
jetsL_1pt = 0.215797  
bjetsM_num = 0.210267  
bjetsL_invariantMass = 0.203467  
bjetsL_1pt = 0.190133  
bjetsT_HT = 0.180276  
bjetsT_transMass = 0.177858  
leptonsMVAT_3eta = 0.171313  
bjetsL_num = 0.168126  
jetsL_10pt = 0.166669  
bjetsT_invariantMass = 0.150805  
bjetsT_num = 0.149894  
leptonsMVAT_3phi = 0.145633  
toptagger_scoreAllTops = 0.142868  
jetsL_11pt = 0.132181
```

# 1Tau2OS

```
Plotting jetsL_number1Tau2OS_v2.png
TTTT = 8.77739
TTJets = 64877.7
TTX = 764.726
ttbb = 273.882
VV = 34.8938
VVV = 19.3922
wJets = 2630.89
DY = 11029.6
ST = 1247.8
H = 1418.54
Total BKG = 82297.3
```

```
channel_1Tau2OS_v2==1
jetsL_transMass = 0.654589
jetsL_number = 0.653605
jetsL_HT = 0.649883
jetsL_4pt = 0.566987
jetsL_invariantMass = 0.560948
jetsL_5pt = 0.524985
jetsL_3pt = 0.521376
bjetsL_HT = 0.489778
bjetsL_transMass = 0.488833
jetsL_6pt = 0.473537
jetsL_2pt = 0.444436
bjetsM_HT = 0.391338
bjetsM_transMass = 0.390024
jetsL_1pt = 0.388795
jetsL_bScore = 0.388784
bjetsL_invariantMass = 0.376465
bjetsL_num = 0.371947
toptagger_scoreAllTops = 0.358878
toptagger_num = 0.341805
bjetsL_1pt = 0.341442
bjetsM_invariantMass = 0.335939
bjetsM_num = 0.323619
jetsL_7pt = 0.323449
jetL_minDeltaR = 0.287854
bjetsT_HT = 0.282149
bjetsT_transMass = 0.281743
jetsL_8pt = 0.275188
bjetsT_num = 0.219904
jetsL_11phi = 0.212168
jetsL_9pt = 0.211199
bjetsT_invariantMass = 0.210086
```

# 1Tau2SS

```
Plotting jetsL_number1Tau2SS_v2.  
TTTT = 1.30411  
TTJets = 14419.2  
TTX = 136.377  
ttbb = 64.1377  
VV = 1.84226  
VVV = 2.60936  
WJets = 917.752  
DY = 459.396  
ST = 251.566  
H = 95.0705  
Total BKG = 16348
```

```
channel_1Tau2SS_v2==1  
jetsL_transMass = 0.632792  
jetsL_HT = 0.628456  
jetsL_number = 0.614185  
jetsL_4pt = 0.540098  
jetsL_invariantMass = 0.53566  
jetsL_5pt = 0.505241  
jetsL_3pt = 0.50297  
jetsL_1lphi = 0.483814  
bjetsL_transMass = 0.468065  
jetsL_6pt = 0.463731  
bjetsL_HT = 0.460753  
jetsL_2pt = 0.424889  
jetsL_1leta = 0.401428  
jetsL_1pt = 0.374126  
bjetsM_HT = 0.364576  
jetsL_bScore = 0.362493  
bjetsM_transMass = 0.359202  
bjetsL_invariantMass = 0.350399  
jetsL_7pt = 0.342632  
bjetsL_num = 0.340182  
toptagger_scoreAllTops = 0.328074  
bjetsL_1pt = 0.316968  
toptagger_num = 0.312746  
bjetsM_invariantMass = 0.310435  
jetsL_8pt = 0.303656  
bjetsM_num = 0.29343  
jetL_minDeltaR = 0.267761  
jetsL_9pt = 0.250989  
bjetsT_HT = 0.249723  
bjetsT_transMass = 0.247224  
jetsL_10phi = 0.213207
```



# 2Tau0L

```
Plotting jetsL_number2Tau0L_v2
TTTT = 15.6843
TTJets = 264123
TTX = 2685.6
ttbb = 859.631
VV = 31.6387
VVV = 48.5105
WJets = 5995.98
DY = 670.8
ST = 3879.54
H = 822.948
Total_BKG = 270110
```

```
channel_2Tau0L_v2==1
jetsL_number = 0.573301
jetsL_transMass = 0.555278
jetsL_HT = 0.549633
jetsL_6pt = 0.5117
jetsL_5pt = 0.457408
jetsL_invariantMass = 0.45408
jetsL_4pt = 0.436953
bjetsL_transMass = 0.412473
bjetsL_HT = 0.410718
jetsL_7pt = 0.402757
jetsL_3pt = 0.396312
jetsL_8pt = 0.341981
bjetsL_invariantMass = 0.340025
jetsL_bScore = 0.337975
jetsL_2pt = 0.335571
bjetsL_num = 0.316024
bjetsM_HT = 0.310539
bjetsM_transMass = 0.309984
jetsL_1pt = 0.298796
bjetsM_invariantMass = 0.28196
bjetsM_num = 0.27371
bjetsL_1pt = 0.259505
toptagger_scoreAllTops = 0.254778
jetsL_9pt = 0.25078
toptagger_num = 0.244802
bjetsT_HT = 0.209654
bjetsT_transMass = 0.20907
jetsL_10pt = 0.177687
bjetsT_num = 0.176232
jetL_minDeltaR = 0.175639
bjetsT_invariantMass = 0.173345
bjetsL_minDeltaR = 0.164285
jetsL_11pt = 0.126730
```

# Next Step

- check more kinematics variables and their combinations
- tmva