Progress Report on Tau Final States of TTTT

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Outline

1. Event Yield
2. 1Tau1E
3. 1tau1mu
4. 1tau1l

Pending Issue

- tau working points vs jets from medium to VVL
- check the btag and JES JER
- check jet removal in TOP tagger
- TTTT UL samples

EventSelection

- MET fillters
- HLT requirements
  - HLT_PFHT450_SixJet40_BTagCSV_p056==1, HLT_PFHT400_SixJet30_DoubleBTagCSV_p056==1
  - HLT_PFJet450
- loose preselection
  - tausL.size()>0, jets.size()>3, bjetsL.size()>1
  - HT>400
- Subchannel requirements

MC reweighting

- genWeight
- prefireWeight
- PileUp reweighting

Event Yield

```
1Tau0L
Raw entries:
TTTT          = 237121
TT            = 45781
TTX           = 37492
single top    = 3795
TX            = 7749
DYJets        = 0
VV            = 9
VVV           = 100
QCD           = 315
Total BKG     = 7787.43

Weighted:
TTTT          = 1727.4
TT            = 1.28087e+07
TTX           = 55298.6
single top    = 178.303
TX            = 7694.37
DYJets        = 0
VV            = 715.465
VVV           = 13.5586
QCD           = 279.102
Total BKG     = 13822.3

Event yield:
TTTT          = 9.46367
TT            = 6151.84
TTX           = 210.029
single top    = 115.069
TX            = 13.3408
DYJets        = 0
VV            = 0.138518
VVV           = 1.10301
QCD           = 7303.66
Total BKG     = 13822.3
```

```
1Tau1E
Raw entries:
TTTT          = 77566
TT            = 13243
TTX           = 9068
single top    = 2857
TX            = 2322
DYJets        = 0
VV            = 2
VVV           = 19
QCD           = 2
Total BKG     = 82.7719

Weighted:
TTTT          = 595.309
TT            = 1.7146e+06
TTX           = 11651.2
single top    = 122.716
TX            = 2319.02
DYJets        = 0
VV            = 414.893
VVV           = 1.58467
QCD           = 2.17447
Total BKG     = 939.704

Event yield:
TTTT          = 3.26143
TT            = 864.721
TTX           = 41.3281
single top    = 20.508
TX            = 3.12004
DYJets        = 0
VV            = 0.0328593
VVV           = 0.214777
QCD           = 2.35911
Total BKG     = 939.704
```

```
1Tau1Mu
Raw entries:
TTTT          = 96510
TT            = 15790
TTX           = 10364
single top    = 2222
TX            = 2782
DYJets        = 0
VV            = 6
VVV           = 9
QCD           = 0
Total BKG     = 80.0296

Weighted:
TTTT          = 750.823
TT            = 1.98864e+06
TTX           = 13395.7
single top    = 114.867
TX            = 2706.83
DYJets        = 0
VV            = 465.544
VVV           = 0.607881
QCD           = 0
Total BKG     = 1081.34

Event yield:
TTTT          = 4.11343
TT            = 1005.21
TTX           = 47.8719
single top    = 15.8239
TX            = 3.60391
DYJets        = 0
VV            = 0.0786659
VVV           = 0.0791417
QCD           = 0
Total BKG     = 1081.34
```

Event Yield

```
1Tau2OS
Raw entries:
TTTT          = 23961
TT            = 643
TTX           = 2855
single top    = 1971
TX            = 544
DYJets        = 0
VV            = 0
VVV           = 4
QCD           = 0
Total BKG     = 16.5438

Weighted:
TTTT          = 182.618
TT            = 46463.4
TTX           = 2931.36
single top    = 99.4306
TX            = 545.692
DYJets        = 0
VV            = 0
VVV           = 0.58492
QCD           = 0
Total BKG     = 40.9794

Event yield:
TTTT          = 1.00048
TT            = 29.7214
TTX           = 8.76248
single top    = 0.253072
TX            = 0.654548
DYJets        = 0
VV            = 0
VVV           = 0.0858097
QCD           = 0
Total BKG     = 40.9794
```

```
1Tau2SS
Raw entries:
TTTT          = 12092
TT            = 27
TTX           = 809
single top    = 315
TX            = 256
DYJets        = 0
VV            = 0
VVV           = 2
QCD           = 0
Total BKG     = 4.545

Weighted:
TTTT          = 94.3956
TT            = 2853.86
TTX           = 979.91
single top    = 15.3401
TX            = 253.566
DYJets        = 0
VV            = 0
VVV           = 0.140281
QCD           = 0
Total BKG     = 5.85803

Event yield:
TTTT          = 0.517152
TT            = 1.52205
TTX           = 3.23588
single top    = 0.0390438
TX            = 0.301209
DYJets        = 0
VV            = 0
VVV           = 0.0204025
QCD           = 0
Total BKG     = 5.85803
```

```
1Tau3L
Raw entries:
TTTT          = 2126
TT            = 0
TTX           = 207
single top    = 17
TX            = 16
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 0.737538

Weighted:
TTTT          = 15.9952
TT            = 0
TTX           = 210.881
single top    = 0.513722
TX            = 16.3469
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 0.707229

Event yield:
TTTT          = 0.0876306
TT            = 0
TTX           = 0.600291
single top    = 0.00130753
TX            = 0.0194532
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 0.707229
```

Event Yield

```
2Tau0L
Raw entries:
TTTT          = 11086
TT            = 2304
TTX           = 3752
single top    = 2406
TX            = 1461
DYJets        = 0
VV            = 1
VVV           = 3
QCD           = 2
Total BKG     = 33.9349

Weighted:
TTTT          = 88.8888
TT            = 398170
TTX           = 4361.21
single top    = 136.646
TX            = 1451.91
DYJets        = 0
VV            = 1.14961
VVV           = 0.234425
QCD           = 1.95001
Total BKG     = 224.176

Event yield:
TTTT          = 0.486983
TT            = 195.828
TTX           = 14.2938
single top    = 6.71497
TX            = 2.342
DYJets        = 0
VV            = 0.042014
VVV           = 0.0337287
QCD           = 1.41789
Total BKG     = 224.176
```

```
2Tau1E
Raw entries:
TTTT          = 2180
TT            = 84
TTX           = 571
single top    = 267
TX            = 230
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 3.24168

Weighted:
TTTT          = 16.5966
TT            = 8862.15
TTX           = 601.696
single top    = 27.1589
TX            = 225.445
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 7.5597

Event yield:
TTTT          = 0.0909252
TT            = 4.82358
TTX           = 1.8032
single top    = 0.0691251
TX            = 0.27607
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 7.5597
```

```
2Tau1Mu
Raw entries:
TTTT          = 2774
TT            = 98
TTX           = 609
single top    = 264
TX            = 273
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 3.47601

Weighted:
TTTT          = 21.1428
TT            = 11436.7
TTX           = 658.715
single top    = 12.4088
TX            = 262.325
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 8.96034

Event yield:
TTTT          = 0.115832
TT            = 5.92923
TTX           = 2.02265
single top    = 0.031583
TX            = 0.324465
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 8.96034
```

Event Yield

```
2Tau2OS
Raw entries:
TTTT          = 342
TT            = 1
TTX           = 49
single top    = 4
TX            = 22
DYJets        = 0
VV            = 0
VVV           = 1
QCD           = 0
Total BKG     = 0.358589

Weighted:
TTTT          = 2.00116
TT            = 66.1142
TTX           = 47.3123
single top    = 0.869543
TX            = 23.2668
DYJets        = 0
VV            = 0
VVV           = 0.0187778
QCD           = 0
Total BKG     = 0.246909

Event yield:
TTTT          = 0.0109635
TT            = 0.042666
TTX           = 0.134563
single top    = 0.00221317
TX            = 0.0245605
DYJets        = 0
VV            = 0
VVV           = 0.00269306
QCD           = 0
Total BKG     = 0.246909
```

```
2Tau2SS
Raw entries:
TTTT          = 140
TT            = 0
TTX           = 5
single top    = 1
TX            = 3
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 0.0300561

Weighted:
TTTT          = 1.33927
TT            = 0
TTX           = 4.63268
single top    = -0.00338024
TX            = 2.6815
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 0.0265256

Event yield:
TTTT          = 0.00733726
TT            = 0
TTX           = 0.013176
single top    = -8.60342e-06
TX            = 0.00283059
DYJets        = 0
VV            = 0
VVV           = 0
QCD           = 0
Total BKG     = 0.0265256
```

TMVA Setup

- ROOT version
  - Switched to ROOT6.12/07, TMVA version 4.3.0
  - New TMVA version comes with new feature
- Training setup
  - Signal: TTTT_TuneCP5;
  - Background: all bg excerpt H and HH and minor ones
  - 70% goes to training and 30% goes to testing
  - Global weight and event weight same in event yield calculation
  - have added more interesting variables:
    - sphericity, aplanarity
    - added some nonjets variables
  - Dealing with negetive weight events :InverseBoostNegWeights(Boost With inverse boostweight), Boost With inverse boostweight(Pair events with negative and positive weights in traning sample and *annihilate* them)
  - 4 boosting algorithm: BDT(A), BDTG, BDTB, BDTD (all use the default InverseBoostNegWeights)
- Hyperparameters
  - Using the default

Step by Step Correlation Selection

- Step 1: choose the 40 most powerful variables as input to BDT
- Step 2: remove bjetsT and bjetsL related varibles
- Step 3: keep only 1 variable from pairs with correlation>80, see the performance
- Step 4: further remove variables with correlation > 75, do the training
- Step 5: add 10 more variables on the basis of step 4
- Step 6: add the variables removed from step 2, 3 and 4 back

Backup

back up

1tau0l

TCut mycuts = "tausT_number==1 leptonsMVAT_number==0 jets_number>=8 bjetsM_num>=2" 1tau0l

Variable Importance

- A ranking of the BDT input variables is derived by counting how often the variables are used to split decision tree nodes, and by weighting each split occurrence by the separation gain-squared it has achieved and by the number of events in the node
- This ranking is known to be unstable and sub-optimal, but widely used within the community.
- correlation information is not accounted for in TMVA Ranking.

AUC

- AUC (area under curve),The AUC metric is the area under the signal versus background efficiency Receiver Operating Characteristic (ROC) curve, bounded by 0 and 1, where 1 is equivalent to perfect discrimination between signal and background, and 0.5 represents discrimination no better than random guessing.
- increase the number of input variables to see if we gain extra AUC
- we want to keep as small set of input variables as possible
- importance

Iterative Removal

- A hillclimbing algorithm solves the search problem by always going in the direction with the highest gradient. It can be naive in the sense that it might get stuck in a local maximum instead of a global one, but it is still a valuable and intuitive method
- Among the 21 variable lists produced this way, the one that performs the best indicates which variable, if removed, has the least impact on the performance. This variable is ranked as the least important, and this particular variable list is used to generate a new batch of variable lists by again removing each variable once.
- One potential method to reduce this tendency towards local maxima is to implement a beam search of a certain width W
- We have shown that despite its tendency to get stuck in local maxima, iterative removal performs reasonably well for the problem of variable selection and much better than the standard TMVA Ranking method in most cases.