



Expected
yields

F. Lemmi

Yields
crosscheck

b tags

Computation of expected yields for the 4tops analysis

Fabio Lemmi

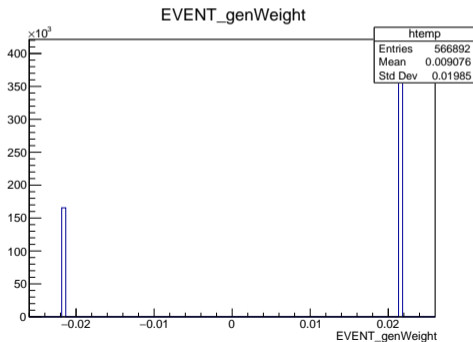
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Weighted events



- Some MC generators (e.g., MADGRAPH5_aMC@NLO) produce **weighted events**. They can differ from one and even be **negative**
- Signal sample TTTT_TuneCUETP8M2T4_13TeV-amcatnlo-pythia8.root:



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How to correctly compute expected yields



- Quoting from the [mc@nlo Twiki](#):
 - [...] propagate the sign of the weight through the entire chain and subtract them from final observables (like histograms).
- **My approach:**
 - ① Choose a variable (e.g., number of jets) and store it in a histogram
 - Make sure x-range is wide enough in order not to have underflow/overflow
 - ② Fill the histogram with weights:
`h->Fill(njets, gen_evt_weight);`
 - ③ Do this for each process i and signal category j
 - ④ Scale the histogram to the 2016 luminosity

$$\text{norm}_{i,j} = \sum w_j \times \frac{\sigma_i \cdot L_{2016}}{\sum w}$$

- `yield = h->Integral();`

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How to correctly compute expected yields



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$$\text{norm}_{i,j} = \sum w_j \times \frac{\sigma_i \cdot L_{2016}}{\sum w}$$

- **One remark:** in order to make this ratio equal to the branching ratio of a given category, $\sum w$ must be the sum of weights in the generated sample, **before any selection is applied**
- We **didn't have this info** in the ntuples
 - More precisely: it seems we are missing a small fraction of generated events in our counting
- We are working on producing this number in order to get more accurate yields



```
{ "GluGluHTo4L", 2.999},  
{ "GluGluHTobb", 32.10},  
{ "GluGluHToGG", 31.98}, // cross section for ggH(bb)  
{ "GluGluHToMuMu", 29.99}, // same holds for ggH(mumu)  
{ "GluGluHToTauTau", 30.52}, // same holds for ggH(tau)  
{ "GluGluHTo2L2Nu", 30.52}, // same  
{ "GluGluHToLNUqq", 29.99},
```

- Weird numbers in Higgs cross sections
- How can be $ggH(bb)$ comparable with $ggH(\gamma\gamma)$ or $ggH(\mu\mu)$ or $ggH(\tau\tau)$?
- **Where does these cross sections come from?**
- **Where to find **reliable** cross section values** for each process?

Event selection



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Category	ℓ	τ_h	N_{jets}	$N_{\text{b-jets}}$
1Tau0L	0	1	≥ 8	≥ 2
1Tau1e	1e	1	≥ 6	≥ 2
1Tau1 μ	1 μ	1	≥ 6	≥ 2
1Tau2OSL	2, opp. sign	1	≥ 4	≥ 2
1Tau2SSL	2, same sign	1	≥ 4	≥ 2
1Tau3L	3	1	≥ 2	≥ 2
2Tau0L	0	2	≥ 6	≥ 2
2Tau1e	1e	2	≥ 4	≥ 2
2Tau1 μ	1 μ	2	≥ 4	≥ 2
2Tau2OSL	2, opp. sign	2	≥ 2	≥ 2
2Tau2SSL	2, same sign	2	≥ 2	≥ 2

- Apply MET filters
- **Lepton ISO has been put back**
- Preselection:
 - At least 1 loose tau
 - At least 3 loose jets
 - 1 loose b tagged jet
- Split events in signal categories

Event yields: $1\tau 0L$



- Fabio's

```
##### 2016 expected yields for category 1tau0L #####
tttt =      10.848
tt  =     7790.1
ttX =     259.448
VV  =      0.320452
VVV =      1.4324
WJets = 0
DY  = 0
ST  =     205.2
H   =     7.88868
total bkg = 8264.39

##### 2016 expected statistics for category 1tau0L #####
tttt =      67082
tt  =     22352
ttX =     78980
VV  =      19
VVV =      98
WJets = 0
DY  = 0
ST  =     16702
H   =      240
total bkg = 118391
```

- Huiling's

```
Plotting jetsL_number1Tau0L
TTTT = 10.8483
TT   = 7790.1
TTX  = 259.449
VV   = 0.320452
VVV  = 1.63554
WJets = 0
DY   = 0
ST   = 205.2
H    = 7.88868
Total BKG = 8264.59

Statistics
TTTT = 553.931
TT   = 22352
TTX  = 106768
VV   = 1551.86
VVV  = 16.4162
WJets = 0
DY   = 0
ST   = 10968.6
H    = 1724.67
```

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Event yields: $1\tau 1e$



- Fabio's

```
2016 expected yields for category 1tau1e
tttt = 0.710397
tt = 982.476
ttX = 30.6845
VV = 0.0689465
VVV = 0.0116671
WJets = 0
DY = -4.06546
ST = 9.97903
H = 3.13497
total bkg = 1022.29

2016 expected statistics for category 1tau1e
tttt = 4110
tt = 2819
ttX = 8423
VV = 5
VVV = 2
WJets = 0
DY = 1
ST = 3016
H = 74
total bkg = 14340
```

- Huilings

```
Plotting jetsL_number1Tau1E.
TTTT = 0.710398
TT = 982.475
TTX = 30.6845
VV = 0.0689464
VVV = 0.0209007
WJets = 0
DY = -4.06545
ST = 9.97903
H = 3.13497
Total BKG = 1022.3

Statistics
TTTT = 36.274
TT = 2819
TTX = 12178.5
VV = 771.429
VVV = 0.339104
WJets = 0
DY = -0.00195151
ST = 1494.01
H = 44.8867
```

Expected yields

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Yields crosscheck

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Event yields: $1\tau 1\mu$



- Fabio's

```
##### 2016 expected yields for category 1tau1mu #####
tttt =      5.16206
tt  =     2041.28
ttX =     89.2167
VV  =     0.195331
VVV =     0.278344
WJets =      0
DY  =     4.06546
ST  =     51.1717
H   =     2.35755
total bkg = 2188.56

##### 2016 expected statistics for category 1tau1mu #####
tttt =     29687
tt  =     5857
ttX =     33796
VV  =      12
VVV =      31
WJets =      0
DY  =      1
ST  =     11066
H   =      158
total bkg = 50921
```

- Huilin's

```
Plotting jetsL_number1Tau1Mu
TTTT = 5.16214
TT   = 2041.28
TTX  = 89.2168
VV   = 0.195331
VVV  = 0.352213
WJets = 0
DY   = 4.06545
ST   = 51.1717
H    = 2.35755
Total BKG = 2188.63

Statistics
TTTT = 263.586
TT   = 5857
TTX  = 41040.2
VV   = 1161.64
VVV  = 3.43948
WJets = 0
DY   = 0.00195151
ST   = 5674.11
H    = 72.8396
```

Expected yields

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Yields crosscheck

b tags



- Fabio's

```
##### 2016 expected yields for category 1tau2OSL #####
tttt =    0.634314
tt  =    199.004
ttX =    17.2663
VV  =    0.0284793
VVV =    0.033825
WJets =    0
DY  =    4.06546
ST  =    11.4703
H   =    2.20371
total bkg = 234.073

##### 2016 expected statistics for category 1tau2OSL #####
tttt =    3690
tt  =    571
ttX =    7598
VV  =    3
VVV =    4
WJets =    0
DY  =    1
ST  =    5859
H   =    84
total bkg = 14120
```

- Huilings

```
Plotting jetsL_number1Tau2OS.p
TTTT = 0.634314
TT   = 199.004
TTX  = 17.2663
VV   = 0.0284793
VVV  = 0.0615257
WJets = 0
DY   = 4.06545
ST   = 11.4703
H    = 2.20371
Total BKG = 234.1

Statistics
TTTT = 32.389
TT   = 571
TTX  = 8217.56
VV   = 1152.64
VVV  = 0.425607
WJets = 0
DY   = 0.00195151
ST   = 1278.19
H    = 34.039
```

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- Fabio's

```
~~~~~ 2016 expected yields for category 1tau2SSL ~~~~~
tttt = 0.390676
tt = 131.392
ttX = 7.49934
VV = 0.0589669
VVV = 0.00880681
WJets = 0
DY = 0
ST = 7.8953
H = 0.27334
total bkg = 147.127

~~~~~ 2016 expected statistics for category 1tau2SSL ~~~~~
tttt = 2180
tt = 377
ttX = 3279
VV = 3
VVV = 2
WJets = 0
DY = 0
ST = 1440
H = 19
total bkg = 5120
```

- Huilin's

```
Plotting jetsL_number1Tau2SS.
TTTT = 0.390676
TT = 131.392
TTX = 7.49934
VV = 0.0589669
VVV = 0.027274
WJets = 0
DY = 0
ST = 7.8953
H = 0.27334
Total BKG = 147.146

Statistics
TTTT = 19.9485
TT = 377
TTX = 3747.01
VV = 386.214
VVV = 0.178618
WJets = 0
DY = 0
ST = 665.595
H = 4.60788
```

Expected
yields

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Yields
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Event yields: $1\tau 3L$



- Fabio's

```
~~~~~ 2016 expected yields for category 1tau3L ~~~~~
tttt = 0.0641154
tt = 2.78815
ttX = 0.888208
VV = 0
VVV = 0
WJets = 0
DY = 4.06546
ST = 0.0609147
H = 0.00435368
total bkg = 7.80709

~~~~~ 2016 expected statistics for category 1tau3L ~~~~~
tttt = 354
tt = 8
ttX = 481
VV = 0
VVV = 0
WJets = 0
DY = 1
ST = 164
H = 3
total bkg = 657
```

- Huiling's

```
Plotting jetsL_number1Tau3L.
TTTT = 0.0641153
TT = 2.78815
TTX = 0.888207
VV = 0
VVV = 0
WJets = 0
DY = 4.06545
ST = 0.0609147
H = 0.00435367
Total BKG = 7.80708

Statistics
TTTT = 3.27382
TT = 7.99999
TTX = 456.845
VV = 0
VVV = 0
WJets = 0
DY = 0.00195151
ST = 45.9456
H = 0.240379
```

Expected yields

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Yields crosscheck

b tags

Event yields: $2\tau 0L$



- Fabio's

```
##### 2016 expected yields for category 2tau0L #####
tttt =      0.592425
tt  =      866.767
ttX =      44.5095
VV  =      0.220513
VVV =      0.132549
WJets =      0
DY  =      0
ST  =      45.2963
H   =      4.93126
total bkg = 961.857

##### 2016 expected statistics for category 2tau0L #####
tttt =      3272
tt  =      2487
ttX =      18271
VV  =      12
VVV =      26
WJets =      0
DY  =      0
ST  =      14783
H   =      505
total bkg = 36084
```

- Huilings

```
Plotting jetsL_number2Tau0L
TTTT = 0.592425
TT   = 866.767
TTX  = 44.5095
VV   = 0.220513
VVV  = 0.243352
WJets = 0
DY   = 0
ST   = 45.2963
H    = 4.93126
Total BKG = 961.968

Statistics
TTTT = 30.2501
TT   = 2487
TTX  = 21061.2
VV   = 2311.29
VVV  = 2.49828
WJets = 0
DY   = 0
ST   = 5676.55
H    = 132.49
```

Expected yields

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Yields crosscheck

b tags

Event yields: $2\tau 1e$



- Fabio's

```
##### 2016 expected yields for category 2tau1e #####
tttt = 0.0252187
tt = 40.7767
ttX = 1.7919
VV = 0
VVV = 0.00235407
WJets = 0
DY = 4.06546
ST = 3.86618
H = 0.389582
total bkg = 50.8922

##### 2016 expected statistics for category 2tau1e #####
tttt = 143
tt = 117
ttX = 850
VV = 0
VVV = 1
WJets = 0
DY = 1
ST = 783
H = 35
total bkg = 1787
```

- Huilings

```
Plotting jetsL_number2Tau1E.
TTTT = 0.0252187
TT = 40.7767
TTX = 1.7919
VV = 0
VVV = 0.00208213
WJets = 0
DY = 4.06545
ST = 3.86618
H = 0.389582
Total BKG = 50.9107

Statistics
TTTT = 1.2877
TT = 117
TTX = 914.617
VV = 0
VVV = 0.143388
WJets = 0
DY = 0.00195151
ST = 280.365
H = 7.33364
```

Expected yields

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Yields crosscheck

b tags

Event yields: $2\tau 1\mu$



• Fabio's

```
##### 2016 expected yields for category 2tau1mu #####
tttt =      0.159434
tt  =      55.066
ttX =      10.2935
VV  =      0.00949312
VVV =     -0.0116671
WJets =      0
DY  =      0
ST  =      9.10027
H   =      0.587685
total bkg = 75.0453

##### 2016 expected statistics for category 2tau1mu #####
tttt =      889
tt  =      158
ttX =     4929
VV  =      1
VVV =      2
WJets =      0
DY  =      0
ST  =     3245
H   =      17
total bkg = 8352
```

• Huiling's

```
Plotting jetsL_number2Tau1Mu.
TTTT = 0.0252187
TT   = 40.7767
TTX  = 1.7919
VV   = 0
VVV  = 0.0208213
WJets = 0
DY   = 4.06545
ST   = 3.86618
H    = 0.389582
Total BKG = 50.9107

Statistics
TTTT = 1.2877
TT   = 117
TTX  = 914.617
VV   = 0
VVV  = 0.143388
WJets = 0
DY   = 0.00195151
ST   = 280.365
H    = 7.33364
```

Expected
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Yields
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b tags



- Fabio's

```
~~~~~ 2016 expected yields for category 2tau2OSL ~~~~~
tttt = 0.013678
tt = 0.348519
ttX = 0.628166
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 3.31703
H = 0.0479621
total bkg = 4.34168

~~~~~ 2016 expected statistics for category 2tau2OSL ~~~~~
tttt = 64
tt = 1
ttX = 244
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 76
H = 1
total bkg = 322
```

- Huilings

```
Plotting jetsL_number2Tau2OSL
TTTT = 0.0136779
TT = 0.348519
TTX = 0.628166
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 3.31703
H = 0.0479621
Total BKG = 4.34168

Statistics
TTTT = 0.698416
TT = 0.999999
TTX = 284.309
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 42.5483
H = 0.801995
```

Expected yields

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Yields crosscheck

b tags



- Fabio's

```
##### 2016 expected yields for category 2tau2SSL #####
tttt = 0.00940359
tt = 0.348519
ttX = 0.156707
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.0477854
H = 0.00145123
total bkg = 0.554463

##### 2016 expected statistics for category 2tau2SSL #####
tttt = 54
tt = 1
ttX = 90
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 47
H = 1
total bkg = 139
```

- Huilong's

```
Plotting jetsL_number2Tau2SSL.
TTTT = 0.00940358
TT = 0.348519
TTX = 0.156707
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.0477853
H = 0.00145122
Total BKG = 0.554463

Statistics
TTTT = 0.480161
TT = 0.999999
TTX = 90
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 23.9921
H = 0.0801265
```

Expected
yields

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Yields
crosscheck

b tags



- Huiling's and Fabio's yields are now perfectly consistent
- **Open question:** why the yield in $1e$ and 1μ categories is so unbalanced?

Our current category definition



- Inherit signal categories from $t\bar{t}H$ multilepton \implies 2 b tags
- **In $t\bar{t}t\bar{t}$ we expect more**

Category	ℓ	τ_h	N_{jets}	$N_{\text{b-jets}}$
1Tau0L	0	1	≥ 8	≥ 2
1Tau1e	1e	1	≥ 6	≥ 2
1Tau1 μ	1 μ	1	≥ 6	≥ 2
1Tau2OSL	2, opp. sign	1	≥ 4	≥ 2
1Tau2SSL	2, same sign	1	≥ 4	≥ 2
1Tau3L	3	1	≥ 2	≥ 2
2Tau0L	0	2	≥ 6	≥ 2
2Tau1e	1e	2	≥ 4	≥ 2
2Tau1 μ	1 μ	2	≥ 4	≥ 2
2Tau2OSL	2, opp. sign	2	≥ 2	≥ 2
2Tau2SSL	2, same sign	2	≥ 2	≥ 2

Expected
yields

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b tags

Playing with the number of b tags



Expected
yields

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Yields
crosscheck

b tags

- I played with the number of b tagged jets to see how **signal purity** in each category changes
- Very simple tries:
 - $N_{b\text{-jets}} \geq 3$
 - $N_{b\text{-jets}} \geq 4$
- **Showing** in the following only **S, B and $S/(S+B)$** for each category
- Full yields are in backup



- $1\tau 0L$

```
~~~~~ Evolution of purity with number of b jets for category 1tau0L ~~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	10.848	7.4161	2.99289
B	8264.39	2025.07	339.374
S/(S+B)	1.310901e-03	3.648775e-03	8.741754e-03

- $1\tau 1e$

```
~~~~~ Evolution of purity with number of b jets for category 1tau1e ~~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.710396	0.421451	0.131223
B	1022.29	181.007	20.7655
S/(S+B)	6.944247e-04	2.322956e-03	6.279577e-03



- $1\tau 1\mu$

```
~~~~ Evolution of purity with number of b jets for category 1tau1mu ~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	5.16205	3.27712	1.18357
B	2188.56	406.257	56.8092
S/(S+B)	2.353102e-03	8.002070e-03	2.040894e-02

- $1\tau 2\text{OSL}$

```
~~~~ Evolution of purity with number of b jets for category 1tau2OSL ~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.634313	0.361183	0.115408
B	234.072	17.8509	1.69238
S/(S+B)	2.702576e-03	1.983204e-02	6.383904e-02



- $1\tau 2SSL$

```
~~~~ Evolution of purity with number of b jets for category 1tau2SSL ~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.390676	0.223549	0.0713817
B	147.127	17.2743	1.85908
S/(S+B)	2.648326e-03	1.277579e-02	3.697644e-02

- $1\tau 3L$

```
~~~~ Evolution of purity with number of b jets for category 1tau3L ~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.0641153	0.0303479	0.00897614
B	7.80708	0.807893	0.00714741
S/(S+B)	8.145563e-03	3.620429e-02	5.567101e-01



- $2\tau 0L$

```
~~~~~ Evolution of purity with number of b jets for category 2tau0L ~~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.592424	0.340666	0.127803
B	961.857	180.113	21.9862
S/(S+B)	6.155384e-04	1.887829e-03	5.779286e-03

- $2\tau 1e$

```
~~~~~ Evolution of purity with number of b jets for category 2tau1e ~~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.0252187	0.0141054	0.00854871
B	50.8922	5.33792	0.73952
S/(S+B)	4.952861e-04	2.635521e-03	1.142770e-02



- $2\tau 1\mu$

```
~~~~ Evolution of purity with number of b jets for category 2tau1mu ~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.159434	0.0901889	0.0312028
B	75.0453	7.12918	0.156103
S/(S+B)	2.119994e-03	1.249264e-02	1.665872e-01

- $2\tau 2OSL$

```
~~~~ Evolution of purity with number of b jets for category 2tau2OSL ~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.0136779	0.00769384	0.00427435
B	4.34168	0.17081	0.00603035
S/(S+B)	3.140483e-03	4.310191e-02	4.147962e-01



- $2\tau 2SSL$

```
~~~~ Evolution of purity with number of b jets for category 2tau2SSL ~~~~
```

	2 b tagged	2 3 tagged	4 b tagged
S	0.00940358	0.00384692	0.00170974
B	0.554463	0.0282167	0
S/(S+B)	1.667696e-02	1.199775e-01	1.000000e+00



- The purities steadily increase when asking for more b tags
- The main $t\bar{t}$ **background is nicely killed**
- The **statistics may be too low** in some categories



Expected
yields

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3 b tags

4 b tags

Backup slides

Yields for 3 b tags signal categories



• $1\tau 0L$

```
~~~~~ 2016 expected yields for category 1tau0L ~~~~~  
tttt = 7.4161  
tt = 1890.72  
ttX = 81.6365  
VV = 0.00897203  
VVV = 0.237073  
WJets = 0  
DY = 0  
ST = 49.3823  
H = 3.09306  
total bkg = 2025.07  
  
~~~~~ 2016 expected statistics for category 1tau0L ~~~~~  
tttt = 44906  
tt = 5425  
ttX = 29852  
VV = 1  
VVV = 19  
WJets = 0  
DY = 0  
ST = 6605  
H = 67  
total bkg = 41969
```

• $1\tau 1e$

```
~~~~~ 2016 expected yields for category 1tau1e ~~~~~  
tttt = 0.421451  
tt = 170.426  
ttX = 7.24971  
VV = 0.00949311  
VVV = 0  
WJets = 0  
DY = 0  
ST = 1.52473  
H = 1.79774  
total bkg = 181.007  
  
~~~~~ 2016 expected statistics for category 1tau1e ~~~~~  
tttt = 2428  
tt = 489  
ttX = 2585  
VV = 1  
VVV = 0  
WJets = 0  
DY = 0  
ST = 845  
H = 13  
total bkg = 3933
```

Expected
yields

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3 b tags

4 b tags

Yields for 3 b tags signal categories



• $1\tau 1\mu$

```
~~~~~ 2016 expected yields for category 1tau1mu ~~~~~
tttt =    3.27712
tt  =   371.521
ttX =   20.4562
VV  =    0
VVV =  0.00931301
WJets =  0
DY  =    0
ST  =   13.9534
H   =    0.316797
total bkg = 406.257

~~~~~ 2016 expected statistics for category 1tau1mu ~~~~~
tttt =   18653
tt  =   1066
ttX =   9108
VV  =    0
VVV =    3
WJets =  0
DY  =    0
ST  =   2701
H   =    26
total bkg = 12904
```

• $1\tau 2OSL$

```
~~~~~ 2016 expected yields for category 1tau2OSL ~~~~~
tttt =    0.361183
tt  =   15.3348
ttX =    1.91624
VV  =    0
VVV =  0
WJets =  0
DY  =    0
ST  =   0.321993
H   =    0.277846
total bkg = 17.8509

~~~~~ 2016 expected statistics for category 1tau2OSL ~~~~~
tttt =   2143
tt  =    44
ttX =  1071
VV  =    0
VVV =    0
WJets =  0
DY  =    0
ST  =   618
H   =    13
total bkg = 1746
```

Expected
yields

F. Lemmi

3 b tags

4 b tags

Yields for 3 b tags signal categories



Expected yields

F. Lemmi

3 b tags

4 b tags

● $1\tau 2SSL$

```
2016 expected yields for category 1tau2SSL
tttt = 0.223549
tt = 15.6834
ttX = 1.09529
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.494213
H = 0.00145122
total bkg = 17.2743
```

```
2016 expected statistics for category 1tau2SSL
tttt = 1187
tt = 45
ttX = 515
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 186
H = 1
total bkg = 747
```

● $1\tau 3L$

```
2016 expected yields for category 1tau3L
tttt = 0.0303479
tt = 0.697038
ttX = 0.105532
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.00532247
H = 0
total bkg = 0.807893
```

```
2016 expected statistics for category 1tau3L
tttt = 193
tt = 2
ttX = 50
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 12
H = 0
total bkg = 64
```

Yields for 3 b tags signal categories



Expected yields

F. Lemmi

3 b tags

4 b tags

● $2\tau 0L$

```
##### 2016 expected yields for category 2tau0L #####
tttt = 0.340666
tt = 157.879
ttX = 9.92927
VV = 0.0280606
VVV = 0.0140212
WJets = 0
DY = 0
ST = 11.6221
H = 0.640779
total bkg = 180.113

##### 2016 expected statistics for category 2tau0L #####
tttt = 2039
tt = 453
ttX = 4545
VV = 1
VVV = 3
WJets = 0
DY = 0
ST = 2958
H = 93
total bkg = 8053
```

● $2\tau 1e$

```
##### 2016 expected yields for category 2tau1e #####
tttt = 0.0141054
tt = 4.87927
ttX = 0.355857
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.0969878
H = 0.0058049
total bkg = 5.33792

##### 2016 expected statistics for category 2tau1e #####
tttt = 87
tt = 14
ttX = 157
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 111
H = 4
total bkg = 286
```


Yields for 3 b tags signal categories



- $2\tau 1\mu$

```
~~~~~ 2016 expected yields for category 2tau1mu ~~~~~
tttt =    0.0901889
tt  =    4.87927
ttX =    1.84383
VV  =    0
VVV =    0
WJets = 0
DY  =    0
ST  =    0.355211
H   =    0.0500646
total bkg = 7.12918

~~~~~ 2016 expected statistics for category 2tau1mu ~~~~~
tttt =    529
tt  =    14
ttX =    828
VV  =    0
VVV =    0
WJets = 0
DY  =    0
ST  =    450
H   =    3
total bkg = 1295
```

- $2\tau 20SL$

```
~~~~~ 2016 expected yields for category 2tau20SL ~~~~~
tttt =    0.00769384
tt  =    0
ttX =    0.16342
VV  =    0
VVV =    0
WJets = 0
DY  =    0
ST  =    0.0073892
H   =    0
total bkg = 0.17081

~~~~~ 2016 expected statistics for category 2tau20SL ~~~~~
tttt =    38
tt  =    0
ttX =    42
VV  =    0
VVV =    0
WJets = 0
DY  =    0
ST  =    7
H   =    0
total bkg = 49
```

Expected yields

F. Lemmi

3 b tags

4 b tags

Yields for 3 b tags signal categories



- $2\tau 2SSL$

```
##### 2016 expected yields for category 2tau2SSL #####
```

```
tttt = 0.00384692
tt = 0
ttX = 0.0207323
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.00748446
H = 0
total bkg = 0.0282167
```

```
##### 2016 expected statistics for category 2tau2SSL #####
```

```
tttt = 27
tt = 0
ttX = 13
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 7
H = 0
total bkg = 20
```

Expected
yields

F. Lemmi

3 b tags

4 b tags

Yields for 4 b tags signal categories



Expected
yields

F. Lemmi

3 b tags

4 b tags

● $1\tau 0L$

```
~~~~~ 2016 expected yields for category 1tau0L ~~~~~  
tttt = 2.99289  
tt = 314.364  
ttX = 18.182  
VV = 0  
VVV = 0.015171  
WJets = 0  
DY = 0  
ST = 6.61348  
H = 0.199105  
total bkg = 339.374
```

```
~~~~~ 2016 expected statistics for category 1tau0L ~~~~~  
tttt = 18196  
tt = 902  
ttX = 8841  
VV = 0  
VVV = 4  
WJets = 0  
DY = 0  
ST = 1929  
H = 9  
total bkg = 11685
```

● $1\tau 1e$

```
~~~~~ 2016 expected yields for category 1tau1e ~~~~~  
tttt = 0.131223  
tt = 19.8656  
ttX = 0.697462  
VV = 0  
VVV = 0  
WJets = 0  
DY = 0  
ST = 0.201031  
H = 0.00145122  
total bkg = 20.7655
```

```
~~~~~ 2016 expected statistics for category 1tau1e ~~~~~  
tttt = 831  
tt = 57  
ttX = 560  
VV = 0  
VVV = 0  
WJets = 0  
DY = 0  
ST = 156  
H = 1  
total bkg = 774
```

Yields for 4 b tags signal categories



Expected yields

F. Lemmi

3 b tags

4 b tags

• $1\tau 1\mu$

```
~~~~~ 2016 expected yields for category 1tau1mu ~~~~~
tttt =    1.18357
tt =    50.1867
ttX =    3.67977
VV =    0
VVV =    0.00235408
WJets =    0
DY =    0
ST =    2.88364
H =    0.0566695
total bkg = 56.8092

~~~~~ 2016 expected statistics for category 1tau1mu ~~~~~
tttt =    6795
tt =    144
ttX =    2015
VV =    0
VVV =    1
WJets =    0
DY =    0
ST =    483
H =    7
total bkg = 2650
```

• $1\tau 2OSL$

```
~~~~~ 2016 expected yields for category 1tau2OSL ~~~~~
tttt =    0.115408
tt =    1.39408
ttX =    0.275535
VV =    0
VVV =    0
WJets =    0
DY =    0
ST =    0.0198696
H =    0.00290245
total bkg = 1.69238

~~~~~ 2016 expected statistics for category 1tau2OSL ~~~~~
tttt =    672
tt =    4
ttX =    105
VV =    0
VVV =    0
WJets =    0
DY =    0
ST =    37
H =    2
total bkg = 148
```

Yields for 4 b tags signal categories



Expected yields

F. Lemmi

3 b tags

4 b tags

● 1 τ 2SSL

```
~~~~~ 2016 expected yields for category 1tau2SSL ~~~~~
```

```
tttt = 0.0713817
tt = 1.74259
ttX = 0.097707
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.0173302
H = 0.00145122
total bkg = 1.85908
```

```
~~~~~ 2016 expected statistics for category 1tau2SSL ~~~~~
```

```
tttt = 361
tt = 5
ttX = 60
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 15
H = 1
total bkg = 81
```

● 1 τ 3L

```
~~~~~ 2016 expected yields for category 1tau3L ~~~~~
```

```
tttt = 0.00897614
tt = 0
ttX = 0.00714741
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0
H = 0
total bkg = 0.00714741
```

```
~~~~~ 2016 expected statistics for category 1tau3L ~~~~~
```

```
tttt = 55
tt = 0
ttX = 3
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0
H = 0
total bkg = 3
```

Yields for 4 b tags signal categories



Expected yields

F. Lemmi

3 b tags

4 b tags

• $2\tau 0L$

```
##### 2016 expected yields for category 2tau0L #####
tttt =    0.127803
tt  =   20.5626
ttX =    1.20948
VV  =    0
VVV =    0
WJets =    0
DY  =    0
ST  =    0.304387
H   =   -0.0902661
total bkg = 21.9862

##### 2016 expected statistics for category 2tau0L #####
tttt =    757
tt  =    59
ttX =   799
VV  =    0
VVV =    0
WJets =    0
DY  =    0
ST  =   353
H   =    12
total bkg = 1223
```

• $2\tau 1e$

```
##### 2016 expected yields for category 2tau1e #####
tttt =    0.00854871
tt  =    0.697038
ttX =    0.0350271
VV  =    0
VVV =    0
WJets =    0
DY  =    0
ST  =    0.00600385
H   =    0.00145122
total bkg = 0.73952

##### 2016 expected statistics for category 2tau1e #####
tttt =    28
tt  =    2
ttX =   19
VV  =    0
VVV =    0
WJets =    0
DY  =    0
ST  =   11
H   =    1
total bkg = 33
```

Yields for 4 b tags signal categories



Expected yields

F. Lemmi

3 b tags

4 b tags

• $2\tau 1\mu$

```
~~~~~ 2016 expected yields for category 2tau1mu ~~~~~
tttt = 0.0312028
tt = 0
ttX = 0.136123
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0.0199799
H = 0
total bkg = 0.156103

~~~~~ 2016 expected statistics for category 2tau1mu ~~~~~
tttt = 187
tt = 0
ttX = 78
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 27
H = 0
total bkg = 105
```

• $2\tau 2\text{OSL}$

```
~~~~~ 2016 expected yields for category 2tau2OSL ~~~~~
tttt = 0.00427435
tt = 0
ttX = 0.00603035
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0
H = 0
total bkg = 0.00603035

~~~~~ 2016 expected statistics for category 2tau2OSL ~~~~~
tttt = 16
tt = 0
ttX = 3
VV = 0
VVV = 0
WJets = 0
DY = 0
ST = 0
H = 0
total bkg = 3
```

Yields for 4 b tags signal categories



Expected
yields

F. Lemmi

3 b tags

4 b tags

● 2 τ 2SSL

```
##### 2016 expected yields for category 2tau2SSL #####
tttt =    0.00170974
tt =      0
ttX =     0
VV =      0
VVV =     0
WJets =   0
DY =      0
ST =      0
H =       0
total bkg = 0

##### 2016 expected statistics for category 2tau2SSL #####
tttt =     8
tt =      0
ttX =     0
VV =      0
VVV =     0
WJets =   0
DY =      0
ST =      0
H =       0
total bkg = 0
```