$t\bar{t}H$ $3\ell + \tau$ Run 2 analysis overview

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stuff

1 Object selection

2 Event selection

Signal region event selection:

1. Exactly 3 light leptons
2. At least 1 trigger-matched light lepton
3. Low-mass dilepton invariant mass cut ($m\ell\ell > 12$ GeV)
4. Z-mass dilepton invariant mass veto (Z mass = 91.2 GeV with 10 GeV window)
5. Exactly 1 hadronic tau
6. Total light lepton + hadronic tau charge == 0
7. At least 2 jets
8. At least 1 b-tagged jet

3 Baseline results

Signal region yields:

	ttH	top+X	Rare	VV	ttW (NLO)	ttZ (NLO)	Z+jets (NNPDF)	W+jets (NNPDF)	Sum bkg
Input	47.89 ± 0.50	6414.25 ± 49.72	84.56 ± 4.84	3981.13 ± 85.54	45.43 ± 0.62	99.38 ± 0.94	93527.96 ± 2260.91	273.74 ± 106.48	104426.45 ± 2265.58
CutBlind	47.89 ± 0.50	6414.25 ± 49.72	84.56 ± 4.84	3981.13 ± 85.54	45.43 ± 0.62	99.38 ± 0.94	93527.96 ± 2260.91	273.74 ± 106.48	104426.45 ± 2265.58
CutEventClean	47.89 ± 0.50	6414.25 ± 49.72	84.56 ± 4.84	3981.13 ± 85.54	45.43 ± 0.62	99.38 ± 0.94	93527.96 ± 2260.91	273.74 ± 106.48	104426.45 ± 2265.58
CutTrigger	42.72 ± 0.47	5760.55 ± 47.14	75.98 ± 4.57	3654.80 ± 82.85	41.76 ± 0.59	92.44 ± 0.90	85157.55 ± 2166.03	236.20 ± 92.38	95019.29 ± 2170.09
CutNLep3	2.82 ± 0.09	7.72 ± 1.74	6.40 ± 1.08	87.35 ± 5.39	0.81 ± 0.07	11.49 ± 0.25	29.09 ± 18.51	0.00 ± 0.00	142.86 ± 19.39
CutTrigMatch	2.80 ± 0.09	7.39 ± 1.71	6.39 ± 1.08	86.50 ± 5.36	0.81 ± 0.07	11.45 ± 0.25	29.09 ± 18.51	0.00 ± 0.00	141.62 ± 19.38
CutLowMass01	2.79 ± 0.09	7.39 ± 1.71	6.39 ± 1.08	86.72 ± 5.35	0.81 ± 0.07	11.43 ± 0.25	29.09 ± 18.51	0.00 ± 0.00	141.83 ± 19.37
CutLowMass02	2.77 ± 0.09	7.39 ± 1.71	6.38 ± 1.08	85.84 ± 5.34	0.81 ± 0.07	11.37 ± 0.25	29.09 ± 18.51	0.00 ± 0.00	140.88 ± 19.37
CutLowMass12	2.77 ± 0.09	7.39 ± 1.71	6.38 ± 1.08	85.84 ± 5.34	0.81 ± 0.07	11.37 ± 0.25	29.09 ± 18.51	0.00 ± 0.00	140.88 ± 19.37
CutZVeto01	2.59 ± 0.08	7.39 ± 1.71	3.26 ± 0.67	60.79 ± 4.56	0.75 ± 0.07	7.88 ± 0.21	20.06 ± 16.81	0.00 ± 0.00	100.13 ± 17.51
CutZVeto02	2.35 ± 0.08	7.22 ± 1.70	2.09 ± 0.45	45.40 ± 4.03	0.69 ± 0.07	5.75 ± 0.18	19.65 ± 16.80	0.00 ± 0.00	80.79 ± 17.37
CutZVeto12	2.35 ± 0.08	7.22 ± 1.70	2.08 ± 0.45	44.70 ± 3.99	0.69 ± 0.07	5.71 ± 0.18	19.65 ± 16.80	0.00 ± 0.00	80.06 ± 17.36
CutNTau1	2.36 ± 0.08	7.40 ± 1.73	2.12 ± 0.46	47.35 ± 4.31	0.69 ± 0.07	5.77 ± 0.18	19.65 ± 16.80	0.00 ± 0.00	82.97 ± 17.44
CutCharge0	2.11 ± 0.07	3.83 ± 1.33	1.82 ± 0.46	38.21 ± 3.35	0.34 ± 0.05	4.95 ± 0.17	16.93 ± 16.59	0.00 ± 0.00	66.07 ± 16.99
CutNJet	1.86 ± 0.07	1.35 ± 0.71	0.54 ± 0.04	7.65 ± 1.35	0.24 ± 0.04	4.43 ± 0.16	0.00 ± 0.00	0.00 ± 0.00	14.21 ± 1.54
CutNBJet	1.51 ± 0.06	0.90 ± 0.64	0.23 ± 0.03	0.33 ± 0.20	0.16 ± 0.04	3.58 ± 0.15	0.00 ± 0.00	0.00 ± 0.00	5.20 ± 0.69

Samples:

ttH	343365 343366 343367
top+X	410000 410011 410012 410013 410014 410025 410026
Rare	342284 342285 361620 361621 361622 361623 361624 361625 361626 361627 410049 410080 410081
VV	361063 361064 361065 361066 361067 361068 361069 361070 361071 361072 361073 361077 361091 361092 361093 361094 361095 361096 361097
ttW (NLO)	410155
ttZ (NLO)	410157 410218 410219 410220
Z+jets (NNPDF)	363102 363103 363104 363105 363106 363107 363108 363109 363110 363111 363112 363113 363114 363115 363116 363117 363118 363119 363120 363121 363122 363361 363362 363363 363364 363365 363366 363367 363368 363369 363370 363371 363372 363373 363374 363375 363376 363377 363378 363379 363380 363381 363382 363383 363384 363385 363386 363387 363388 363389 363390 363391 363392 363393 363394 363395 363396 363397 363398 363399 363400 363401 363402 363403 363404 363405 363406 363407 363408 363409 363410 363411
W+jets (NNPDF)	363331 363332 363333 363334 363335 363336 363337 363338 363339 363340 363341 363342 363343 363344 363345 363346 363347 363348 363349 363350 363351 363352 363353 363354 363436 363437 363438 363439 363440 363441 363442 363443 363444 363445 363446 363447 363448 363449 363450 363451 363452 363453 363454 363455 363456 363457 363458 363459 363460 363461 363462 363463 363464 363465 363466 363467 363468 363469 363470 363471 363472 363473 363474 363475 363476 363477 363478 363479 363480 363481 363482 363483

4 Fake estimate studies

Baseline strategy for estimating background contribution from events with a fake hadronic tau is as follows:

- Calculate fake tau scale factor in some high stats $2\ell OS + \tau$ control regions
  - Remaining orthogonal to $2\ell OS + \tau$ analysis signal region
- Apply scale factor in $3\ell + \tau$
- Perform closure test in ttbar MC

Challenges associated with this strategy:

- Closure tests in MC are very stats-limited in $3\ell + \tau$ region - difficult to assess closure
- Must use control regions orthogonal to $2\ell OS + \tau$ - ultimately may need to directly collaborate with analysis for control regions
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4.1 Baseline results

CR definition:

- Same objects as $3\ell + \tau$
- Exactly 2 leptons, opposite sign
- Exactly 1 tau, no sign requirement
- All other event cuts the same as the SR

$2\ell OS + \tau_{had}$ CR, Tight light leptons:

	AntiTau,VeryLoose	Medium Tau
ttbar MC	29047.87 ± 104.44	1824.09 ± 26.17

$2\ell OS + \tau_{had}$ CR, Loose light leptons:

	AntiTau,VeryLoose	Medium Tau
ttbar MC	32782.76 ± 112.37	2084.10 ± 28.33

- Apply $2\ell OS + \tau_{had}$ scale factors to extrapolate from $3\ell + \tau_{had}$(AntiTau) to SR
- Nominal signal region is Tight light leptons, Medium taus

$3\ell + \tau_{had}$, Tight light leptons def'n

	AntiTau VeryLoose	Medium Tau
MC (ttbar) prediction	9.16 ± 1.83	0.90 ± 0.64
Scaled MC	-	≈ 0.58

$3\ell + \tau_{had}$, Loose light leptons def'n

	AntiTau VeryLoose	Medium Tau
MC (ttbar) prediction	21.69 ± 2.79	0.70 ± 0.44
Scaled MC	-	≈ 1.35

4.2 Fake estimate control region flavour composition

$2\ell OS + \tau_{had}$ CR, Tight light leptons, at least 3 jets

	AntiTau,VeryLoose	Medium Tau
ttbar MC	14199.32 ± 72.60	892.27 ± 18.14

$2\ell OS + \tau_{had}$ CR, Tight light leptons, at least 4 jets

	AntiTau,VeryLoose	Medium Tau
ttbar MC	5740.30 ± 45.85	366.76 ± 11.58

$2\ell OS + \tau_{had}$ CR, Tight light leptons, at least 5 jets

	AntiTau,VeryLoose	Medium Tau
ttbar MC	2032.23 ± 27.06	128.13 ± 6.69

5 Yields with v26_02 group ntuples

3l1tau, LepTight, TauMedium

	ttbar	single top	Sum bkg
Input	6562.39 ± 53.40	488.94 ± 12.66	7051.33 ± 54.88
CutBlind	6562.39 ± 53.40	488.94 ± 12.66	7051.33 ± 54.88
CutEventClean	6562.39 ± 53.40	488.94 ± 12.66	7051.33 ± 54.88
CutTrigger	5424.63 ± 48.54	398.20 ± 11.32	5822.84 ± 49.84
CutNLep3	34.10 ± 4.82	2.01 ± 0.75	36.11 ± 4.88
CutTrigMatch	33.39 ± 4.80	2.01 ± 0.75	35.40 ± 4.86
CutLowMass01	32.28 ± 4.78	2.01 ± 0.75	34.29 ± 4.83
CutLowMass02	32.28 ± 4.78	2.01 ± 0.75	34.29 ± 4.83
CutLowMass12	32.28 ± 4.78	2.01 ± 0.75	34.29 ± 4.83
CutNTau1	32.71 ± 4.82	2.06 ± 0.77	34.77 ± 4.88
CutCharge0	16.70 ± 2.50	0.82 ± 0.42	17.53 ± 2.54
CutNJet	7.54 ± 1.62	0.00 ± 0.00	7.54 ± 1.62
CutNBJet	2.59 ± 0.92	0.00 ± 0.00	2.59 ± 0.92
CutZVeto01	2.34 ± 0.88	0.00 ± 0.00	2.34 ± 0.88
CutZVeto02	1.86 ± 0.81	0.00 ± 0.00	1.86 ± 0.81
CutZVeto12	1.86 ± 0.81	0.00 ± 0.00	1.86 ± 0.81
CutZVeto	1.86 ± 0.81	0.00 ± 0.00	1.86 ± 0.81

3l1tau, LepTightMVA, TauMedium

	ttbar	single top	Sum bkg
Input	6562.39 ± 53.40	488.94 ± 12.66	7051.33 ± 54.88
CutBlind	6562.39 ± 53.40	488.94 ± 12.66	7051.33 ± 54.88
CutEventClean	6562.39 ± 53.40	488.94 ± 12.66	7051.33 ± 54.88
CutTrigger	5424.63 ± 48.54	398.20 ± 11.32	5822.84 ± 49.84
CutNLep3	34.10 ± 4.82	2.01 ± 0.75	36.11 ± 4.88
CutPromptLep0	33.64 ± 4.81	2.01 ± 0.75	35.65 ± 4.87
CutPromptLep1	24.78 ± 4.53	1.38 ± 0.66	26.16 ± 4.58
CutPromptLep2	0.81 ± 0.47	0.00 ± 0.00	0.81 ± 0.47
CutTrigMatch	0.56 ± 0.40	0.00 ± 0.00	0.56 ± 0.40
CutLowMass01	0.56 ± 0.40	0.00 ± 0.00	0.56 ± 0.40
CutLowMass02	0.56 ± 0.40	0.00 ± 0.00	0.56 ± 0.40
CutLowMass12	0.56 ± 0.40	0.00 ± 0.00	0.56 ± 0.40
CutNTau1	0.56 ± 0.40	0.00 ± 0.00	0.56 ± 0.40
CutCharge0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutNJet	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutNBJet	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto02	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto12	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

3l1tau, LepLoose (Gradient Iso), TauMedium

	ttbar	single top	Sum bkg
Input	5408.77 ± 48.81	377.31 ± 11.20	5786.08 ± 50.08
CutBlind	5408.77 ± 48.81	377.31 ± 11.20	5786.08 ± 50.08
CutEventClean	5408.77 ± 48.81	377.31 ± 11.20	5786.08 ± 50.08
CutTrigger	4592.20 ± 44.73	320.11 ± 10.30	4912.32 ± 45.90
CutNLep3	9.65 ± 1.77	0.66 ± 0.48	10.31 ± 1.83
CutTrigMatch	9.38 ± 1.75	0.66 ± 0.48	10.04 ± 1.81
CutLowMass01	8.89 ± 1.71	0.66 ± 0.48	9.54 ± 1.78
CutLowMass02	8.89 ± 1.71	0.66 ± 0.48	9.54 ± 1.78
CutLowMass12	8.89 ± 1.71	0.66 ± 0.48	9.54 ± 1.78
CutNTau1	8.89 ± 1.71	0.66 ± 0.48	9.54 ± 1.78
CutCharge0	4.05 ± 1.13	0.24 ± 0.24	4.29 ± 1.15
CutNJet	2.11 ± 0.90	0.00 ± 0.00	2.11 ± 0.90
CutNBJet	1.15 ± 0.75	0.00 ± 0.00	1.15 ± 0.75
CutZVeto01	0.89 ± 0.70	0.00 ± 0.00	0.89 ± 0.70
CutZVeto02	0.89 ± 0.70	0.00 ± 0.00	0.89 ± 0.70
CutZVeto12	0.89 ± 0.70	0.00 ± 0.00	0.89 ± 0.70
CutZVeto	0.89 ± 0.70	0.00 ± 0.00	0.89 ± 0.70

3l1tau, LepLoose (Gradient Iso) MVA, TauMedium

	ttbar	single top	Sum bkg
Input	5408.77 ± 48.81	377.31 ± 11.20	5786.08 ± 50.08
CutBlind	5408.77 ± 48.81	377.31 ± 11.20	5786.08 ± 50.08
CutEventClean	5408.77 ± 48.81	377.31 ± 11.20	5786.08 ± 50.08
CutTrigger	4592.20 ± 44.73	320.11 ± 10.30	4912.32 ± 45.90
CutNLep3	9.65 ± 1.77	0.66 ± 0.48	10.31 ± 1.83
CutPromptLep0	9.65 ± 1.77	0.66 ± 0.48	10.31 ± 1.83
CutPromptLep1	7.96 ± 1.62	0.42 ± 0.42	8.38 ± 1.67
CutPromptLep2	0.77 ± 0.45	0.00 ± 0.00	0.77 ± 0.45
CutTrigMatch	0.50 ± 0.36	0.00 ± 0.00	0.50 ± 0.36
CutLowMass01	0.25 ± 0.25	0.00 ± 0.00	0.25 ± 0.25
CutLowMass02	0.25 ± 0.25	0.00 ± 0.00	0.25 ± 0.25
CutLowMass12	0.25 ± 0.25	0.00 ± 0.00	0.25 ± 0.25
CutNTau1	0.25 ± 0.25	0.00 ± 0.00	0.25 ± 0.25
CutCharge0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutNJet	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutNBJet	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto02	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto12	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

3l1tau, LepLoose (Loose iso), TauMedium

	ttbar	single top	Sum bkg
Input	7617.62 ± 57.41	571.96 ± 13.90	8189.58 ± 59.07
CutBlind	7617.62 ± 57.41	571.96 ± 13.90	8189.58 ± 59.07
CutEventClean	7617.62 ± 57.41	571.96 ± 13.90	8189.58 ± 59.07
CutTrigger	6078.41 ± 51.21	444.74 ± 11.89	6523.15 ± 52.57
CutNLep3	43.88 ± 5.26	2.07 ± 0.78	45.95 ± 5.31
CutTrigMatch	43.13 ± 5.24	2.07 ± 0.78	45.21 ± 5.30
CutLowMass01	40.97 ± 5.19	2.07 ± 0.78	43.04 ± 5.25
CutLowMass02	40.97 ± 5.19	2.07 ± 0.78	43.04 ± 5.25
CutLowMass12	40.97 ± 5.19	2.07 ± 0.78	43.04 ± 5.25
CutNTau1	41.50 ± 5.24	2.12 ± 0.79	43.62 ± 5.30
CutCharge0	21.81 ± 2.82	0.85 ± 0.43	22.66 ± 2.85
CutNJet	10.27 ± 1.89	0.00 ± 0.00	10.27 ± 1.89
CutNBJet	4.15 ± 1.18	0.00 ± 0.00	4.15 ± 1.18
CutZVeto01	3.89 ± 1.16	0.00 ± 0.00	3.89 ± 1.16
CutZVeto02	3.40 ± 1.10	0.00 ± 0.00	3.40 ± 1.10
CutZVeto12	3.40 ± 1.10	0.00 ± 0.00	3.40 ± 1.10
CutZVeto	3.40 ± 1.10	0.00 ± 0.00	3.40 ± 1.10

3l1tau, LepLoose (Loose iso) MVA, TauMedium

	ttbar	single top	Sum bkg
Input	7617.62 ± 57.41	571.96 ± 13.90	8189.58 ± 59.07
CutBlind	7617.62 ± 57.41	571.96 ± 13.90	8189.58 ± 59.07
CutEventClean	7617.62 ± 57.41	571.96 ± 13.90	8189.58 ± 59.07
CutTrigger	6078.41 ± 51.21	444.74 ± 11.89	6523.15 ± 52.57
CutNLep3	43.88 ± 5.26	2.07 ± 0.78	45.95 ± 5.31
CutPromptLep0	42.57 ± 5.22	2.07 ± 0.78	44.64 ± 5.28
CutPromptLep1	31.26 ± 4.89	1.42 ± 0.68	32.68 ± 4.94
CutPromptLep2	1.11 ± 0.56	0.00 ± 0.00	1.11 ± 0.56
CutTrigMatch	0.84 ± 0.49	0.00 ± 0.00	0.84 ± 0.49
CutLowMass01	0.58 ± 0.42	0.00 ± 0.00	0.58 ± 0.42
CutLowMass02	0.58 ± 0.42	0.00 ± 0.00	0.58 ± 0.42
CutLowMass12	0.58 ± 0.42	0.00 ± 0.00	0.58 ± 0.42
CutNTau1	0.58 ± 0.42	0.00 ± 0.00	0.58 ± 0.42
CutCharge0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutNJet	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutNBJet	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto01	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto02	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto12	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
CutZVeto	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00