Yields check of 4top and ttW

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2/28/2024

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EB requests

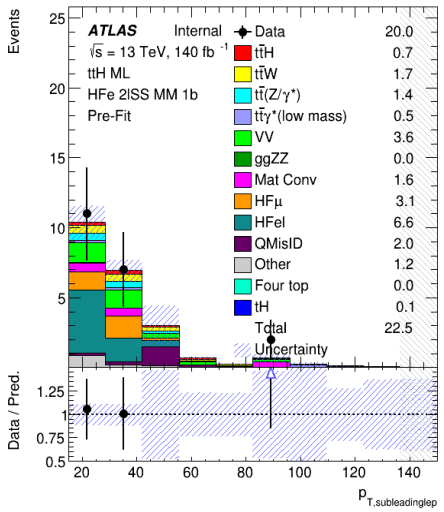
- Action items from the EB meeting on 08.02.2024 (https://indico.cern.ch/event/1378031/):
- Shape comparison of the **subleading lepton pt and eta** in the **SR** (and highest BDT bins of the SR), **ttW CR and HFe/mu CR** (divided by the bin width maybe). The goal is to make sure the scale factors extracted from the HF CR represent well the events in the SR
- Similar shape comparison (lepton pT and eta) of the lower pt SS lepton in the **conversion CR and SR and ttW CR**
- Check the selection efficiency of tH and tWH in the different regions and compare it with the efficiencies in the **2tau** channel. Also look at Njets in the SR in the 2 channels. Ultimately, tH and tWH should be treated in the same way for all ttH channels in this paper
- plot the region of 4top events: MC/Data agreement within uncertainties
- Check of the ttW background: plots of Njets, Ht, pT and other QCD emission related variable of the ttW system at **truth level** in the different CR and SR

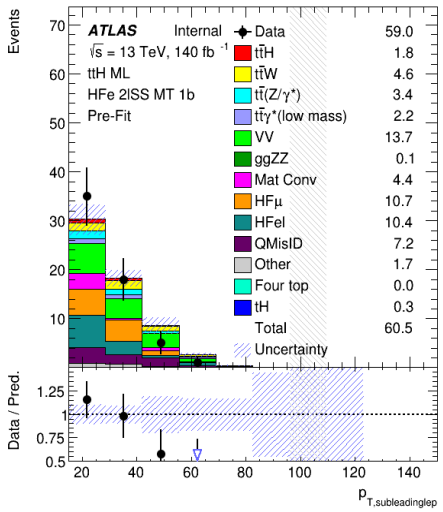
Lep_pT_1 in HF CRs, SR, ttW CR

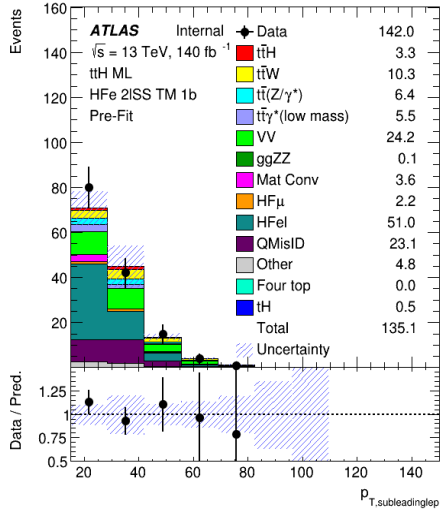
Pre-fit

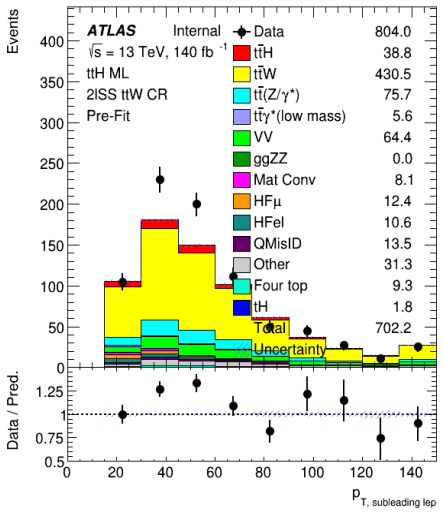
NF_HFmu:1.04

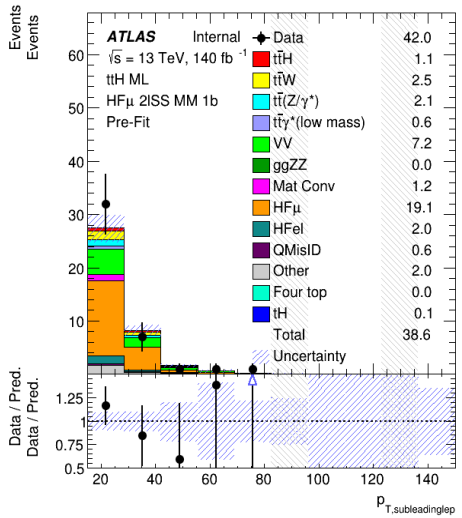
NF_HFel:1.22

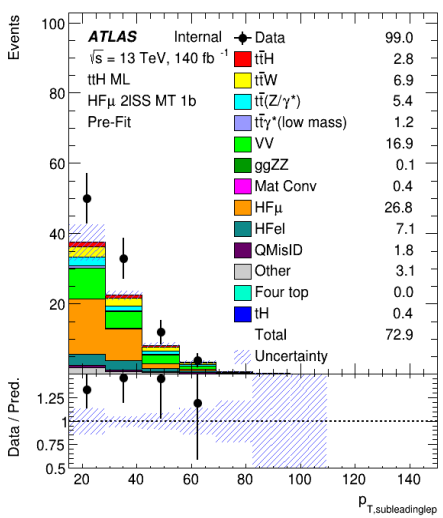


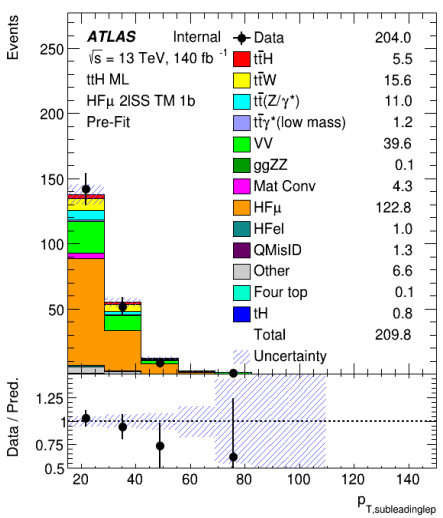


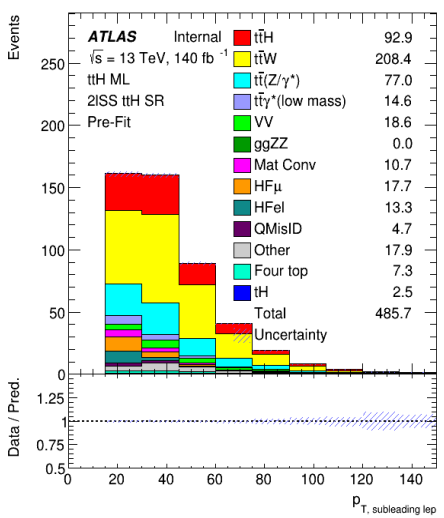






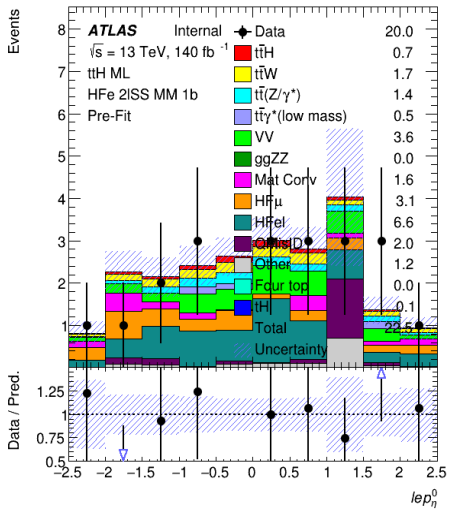


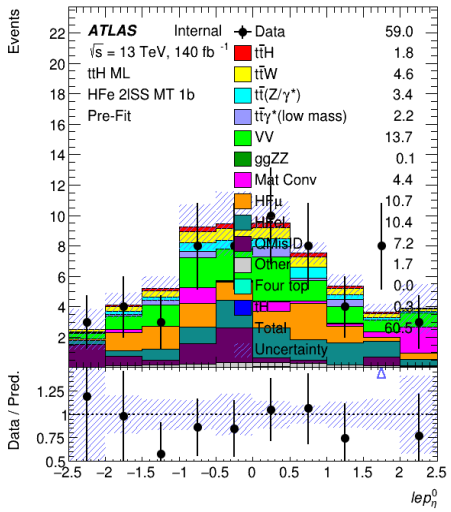


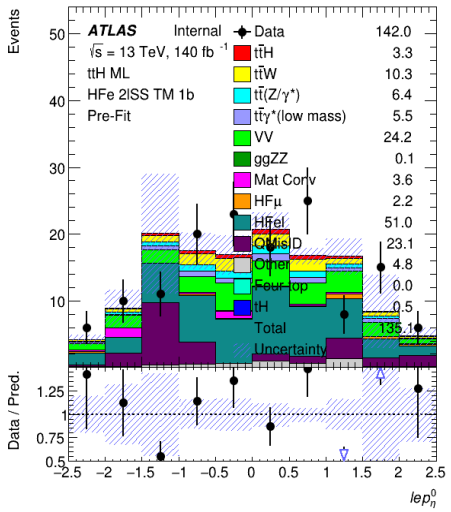


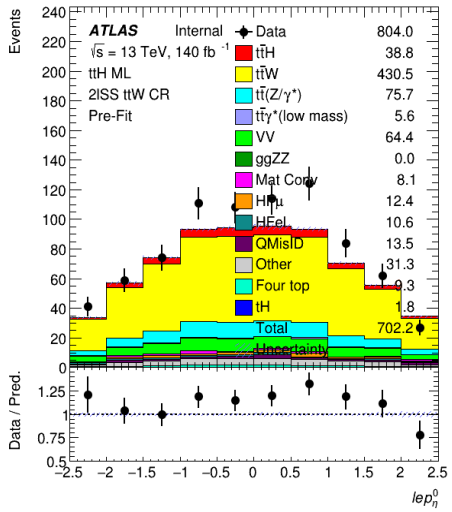
Lep_Eta_0 in HF CRs, SR, ttW CR

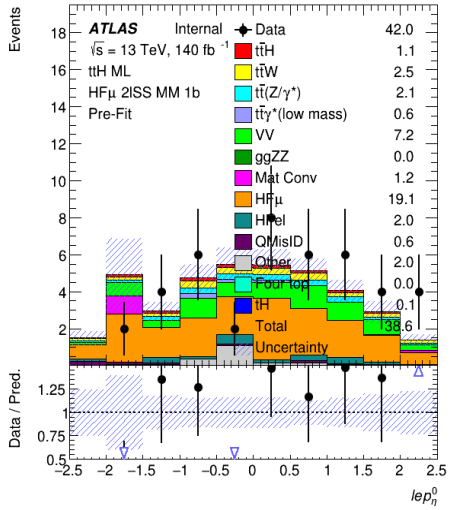
Pre-fit

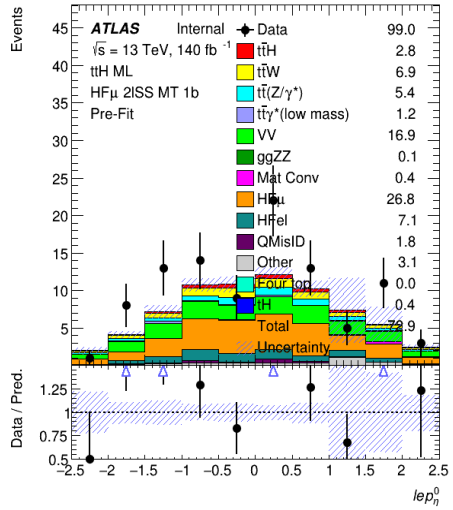


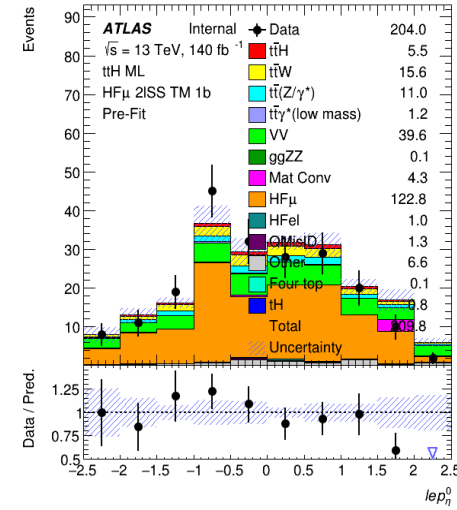


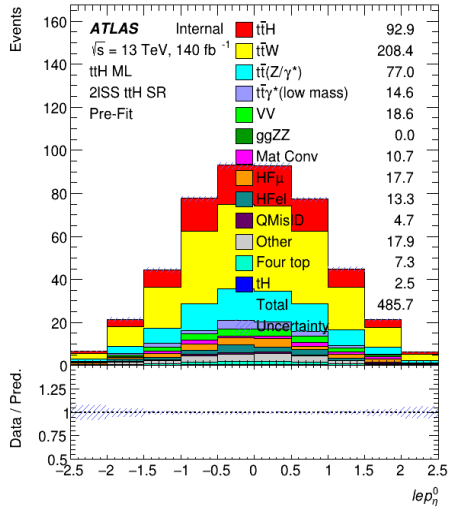








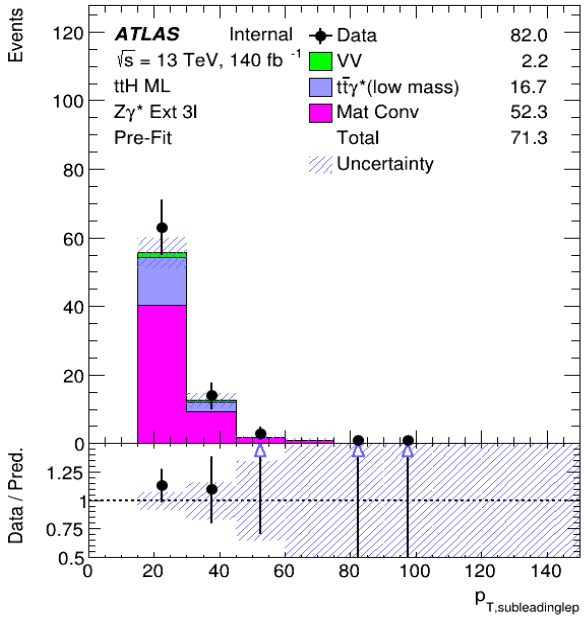


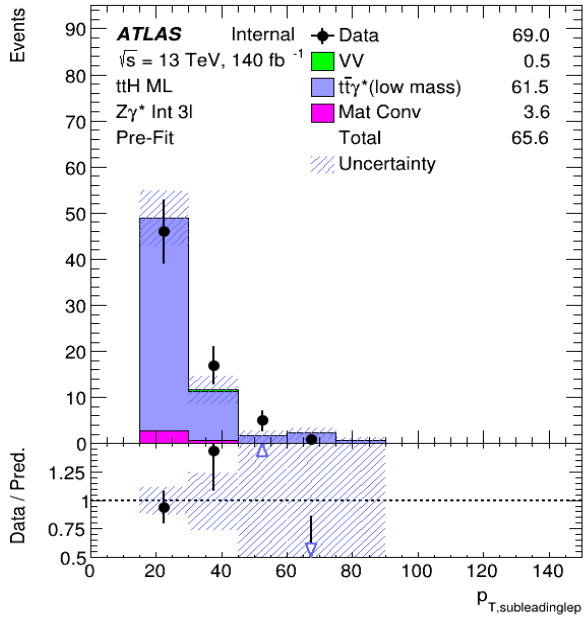


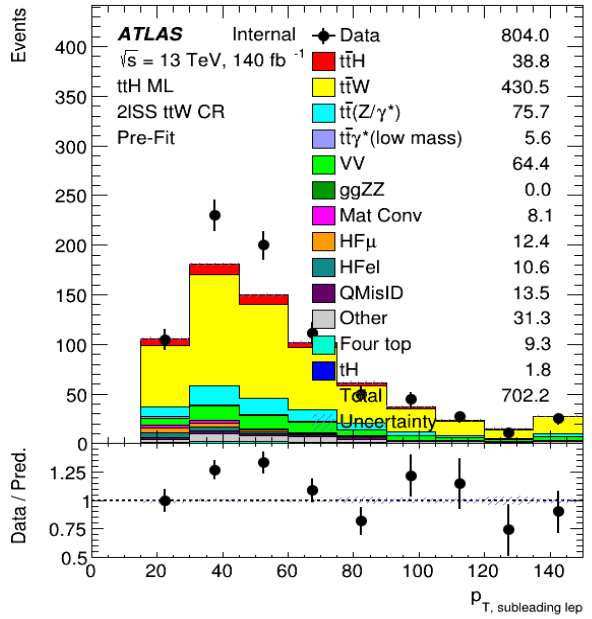
Lep_pT_1 in conversion CRs, ttW CR, SR

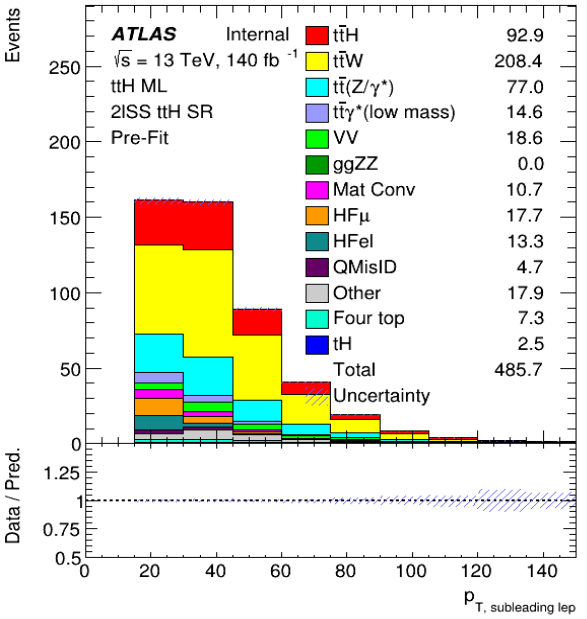
Pre-fit

- NF_IntC:1.05; NF_Ext:1.18
- Leptons have larger pT in the SR and ttW CR, as expected.







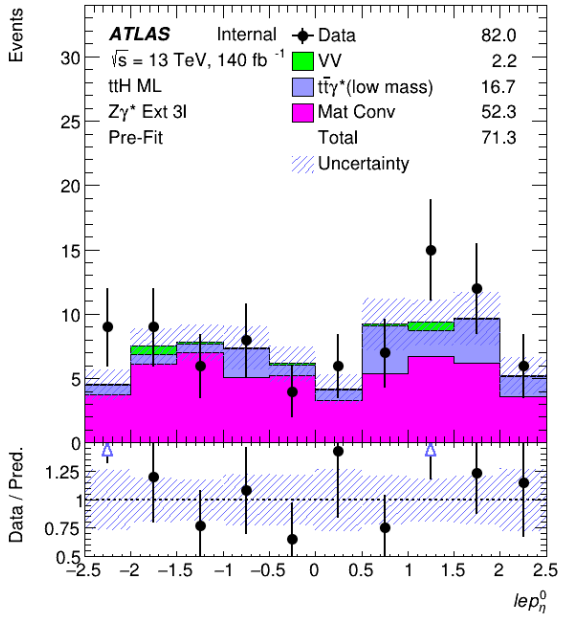


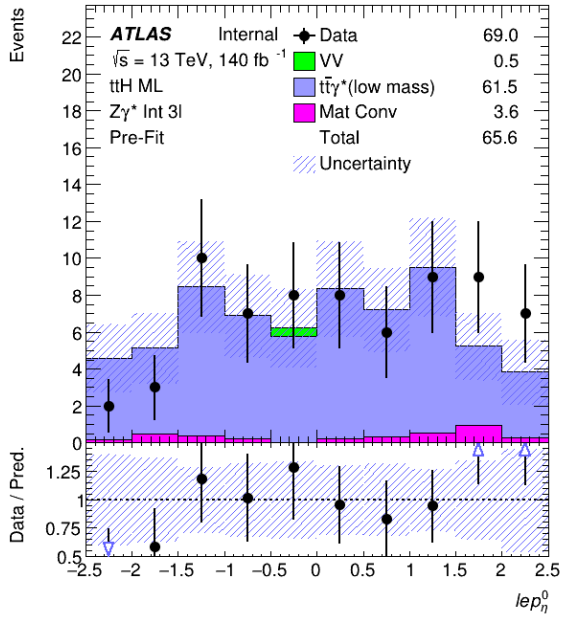
Lep_Eta_0 in conversion CRs, ttW CR, SR

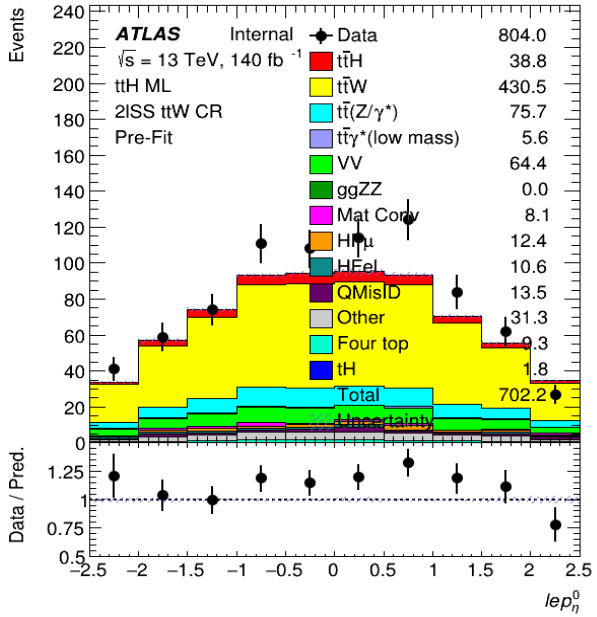
Pre-fit

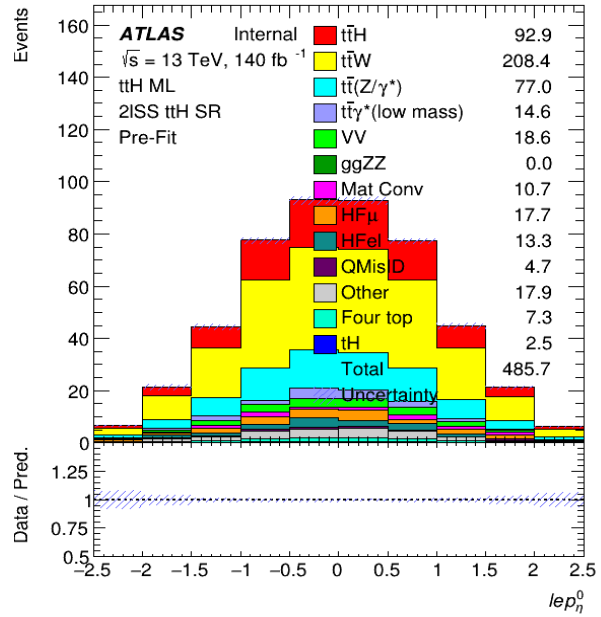
NF_IntC:1.05

NF_Ext:1.18



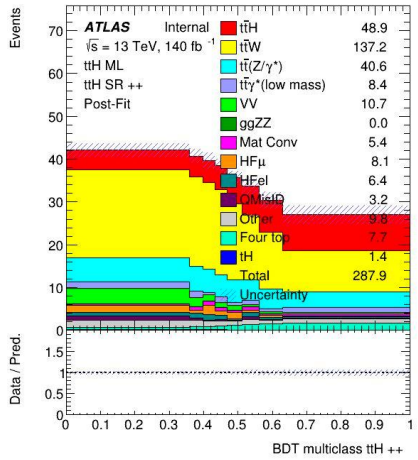


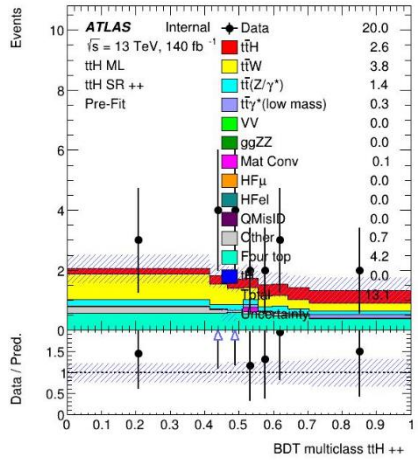


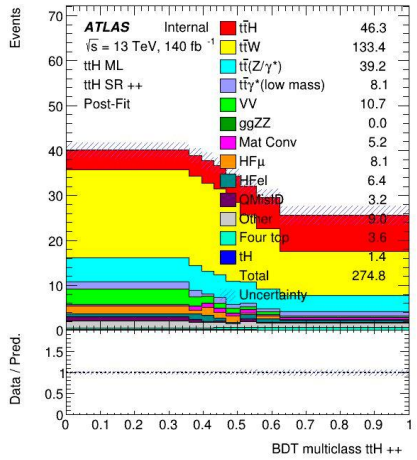


Yields comparison

ttH ++ SR

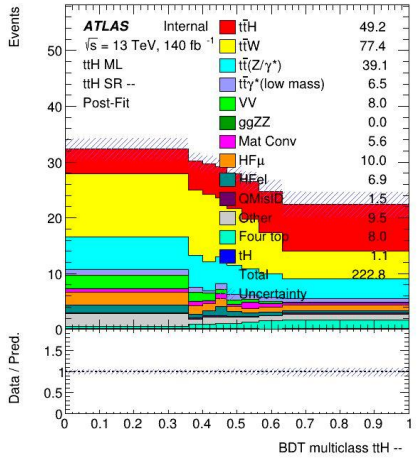


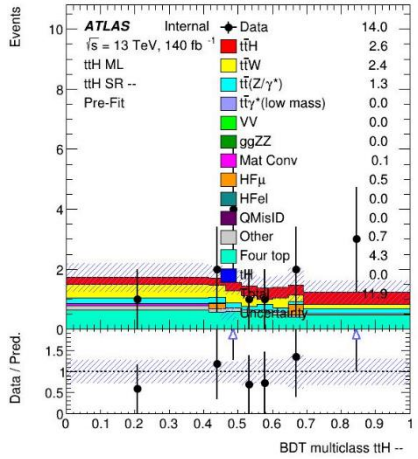


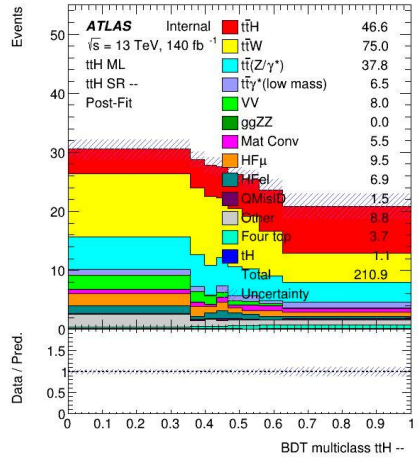


Original ***nJets_OR>=6 && nJets_OR_DL1r_77>=3*** ***!(nJets_OR>=6 && nJets_OR_DL1r_77>=3)***

ttH -- SR







Yields comparison(4top cut)

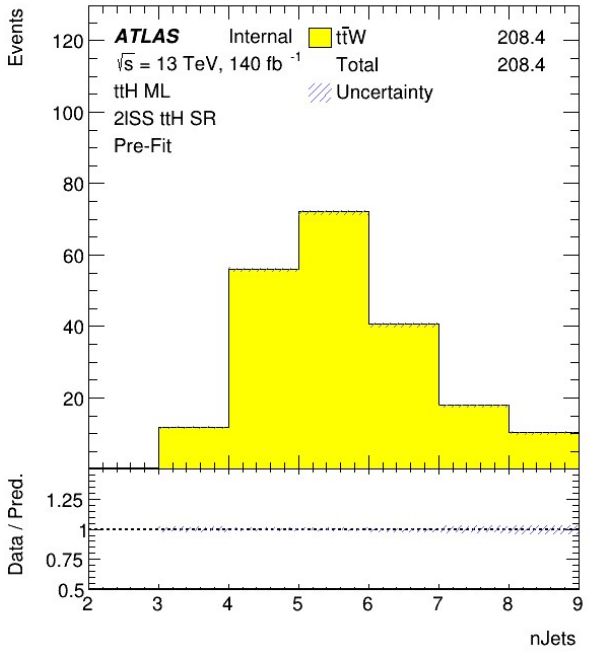
- In ttH SR, the yield of 4top has been dropped more than 50% while signal only drops by 5%

	ttH ++ SR			tH -- SR		
	ttH	ttW	4top	ttH	ttW	4top
original	48.9	137.2	7.7	49.2	77.4	8
After cutting	46.3	133.4	3.6	46.6	75.0	3.7
Cutted	2.6	3.8	4.1	2.6	2.4	4.3

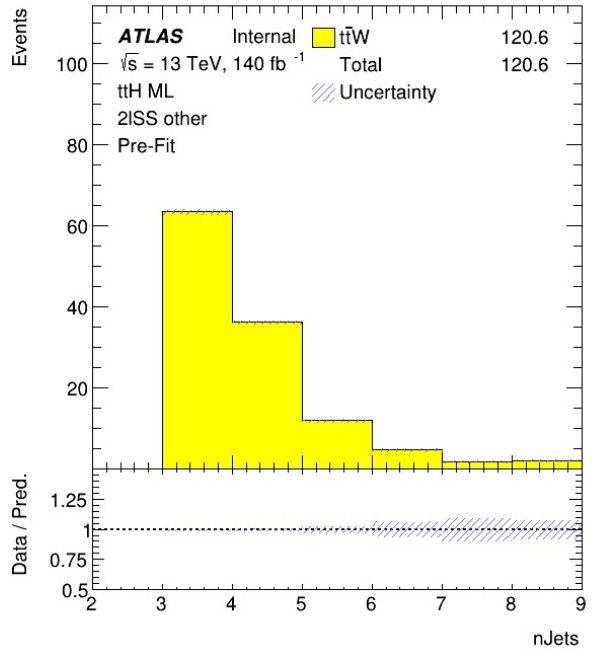
Njets_OR

- Check of the ttW background: plots of Njets, Ht, pT and other QCD emission related variable of the ttW system at **truth level** in the different CR and SR

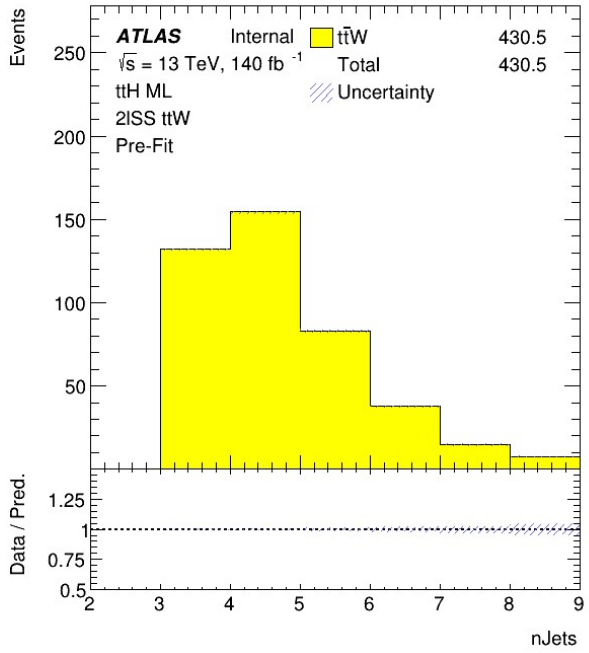
- ttW events have more jets in ttH SR than ttW CR.
- Recoil variables be shown(Truth variables are adding now…)



SR



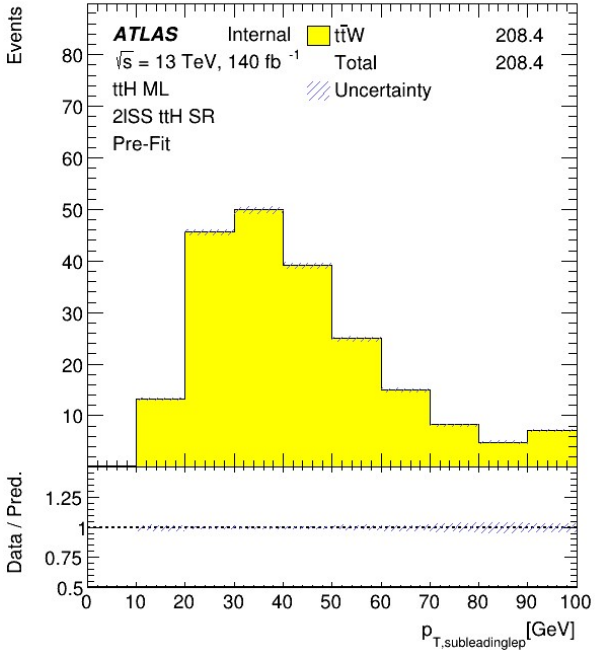
Other CR



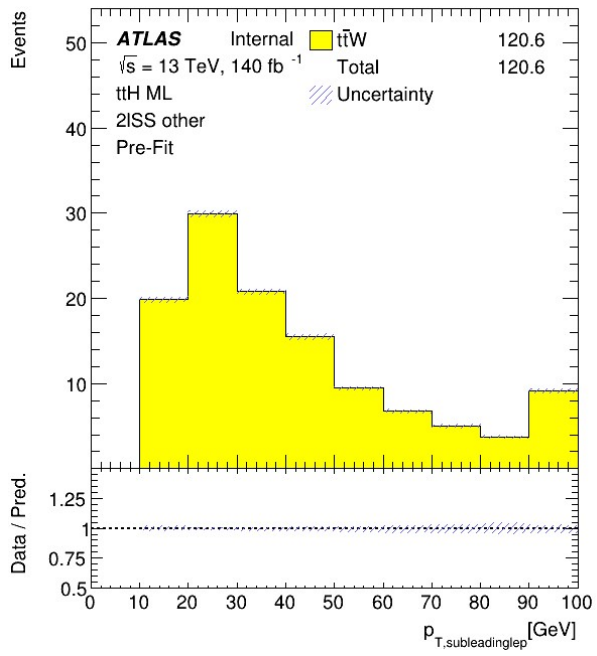
ttW CR

Lep_pT_1

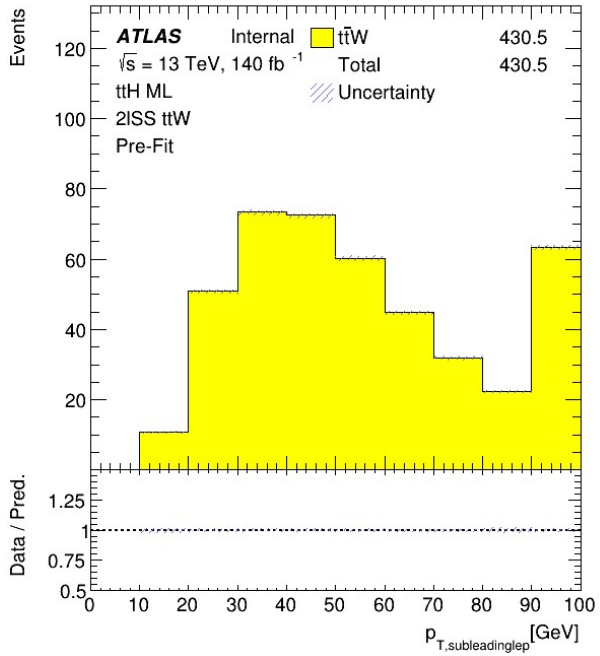
- ttW CR has higher subleading lep pT than other CR and SR



SR



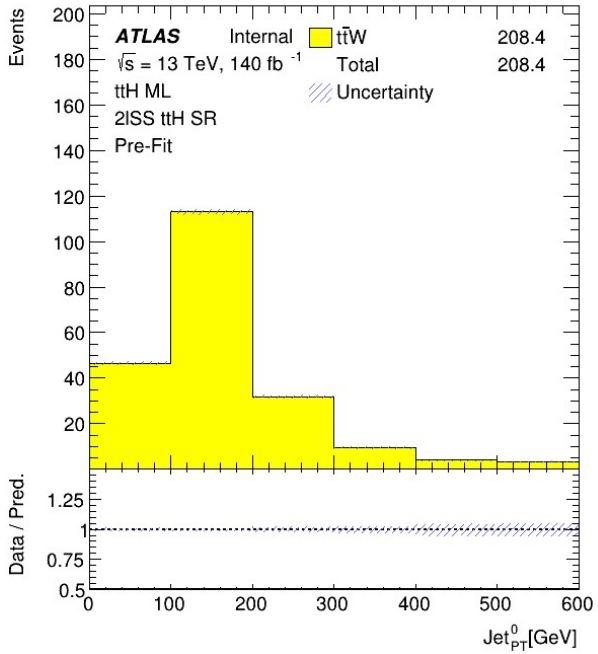
Other CR



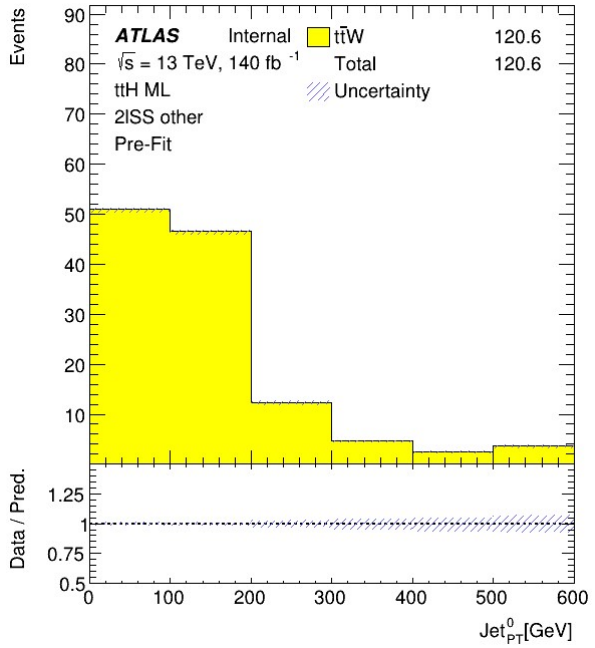
ttW CR

Jet_pT_0

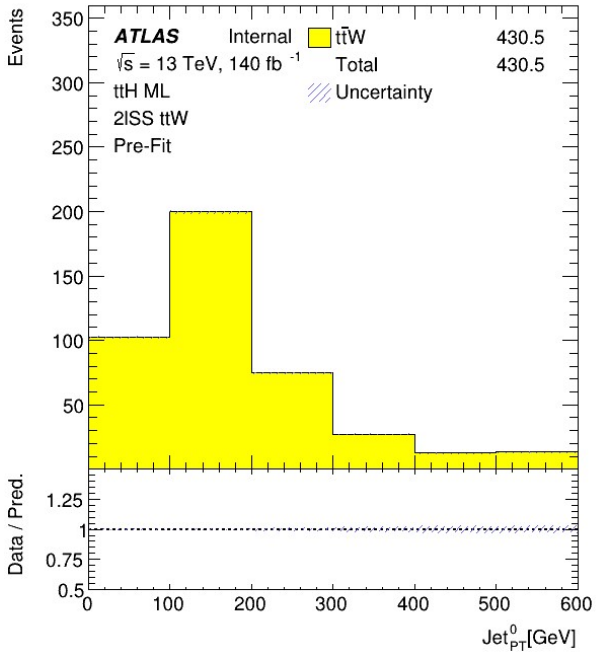
- No big difference between SR and ttW CR of jet_pt0 distribution.



SR



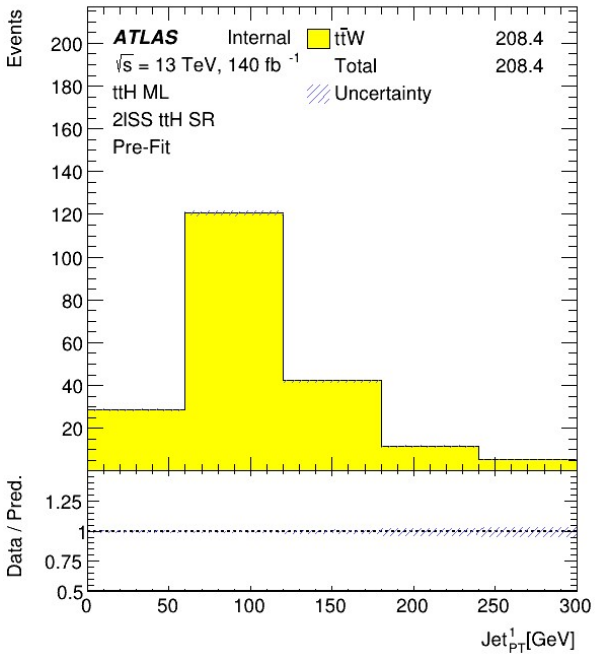
Other CR



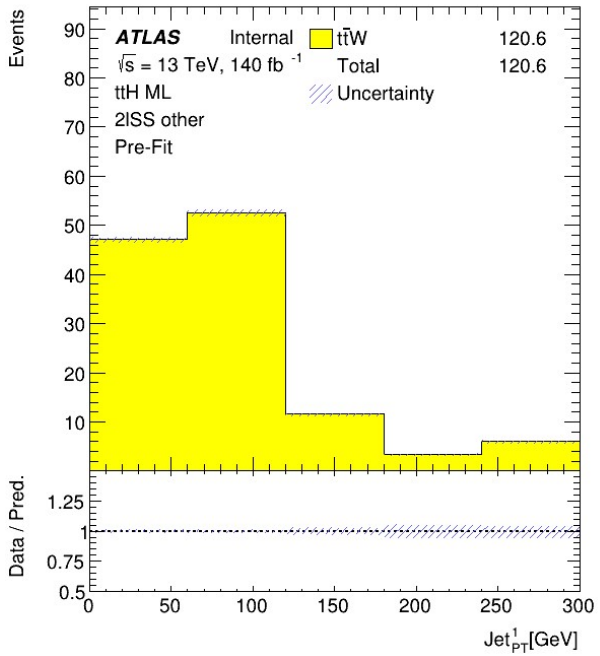
ttW CR

Jet_pT_1

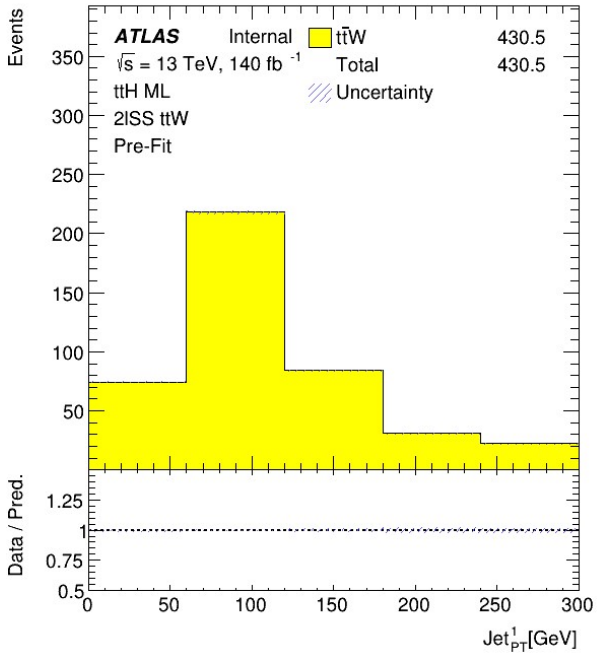
- No big difference between SR and ttW CR of jet_pt1 distribution.



SR



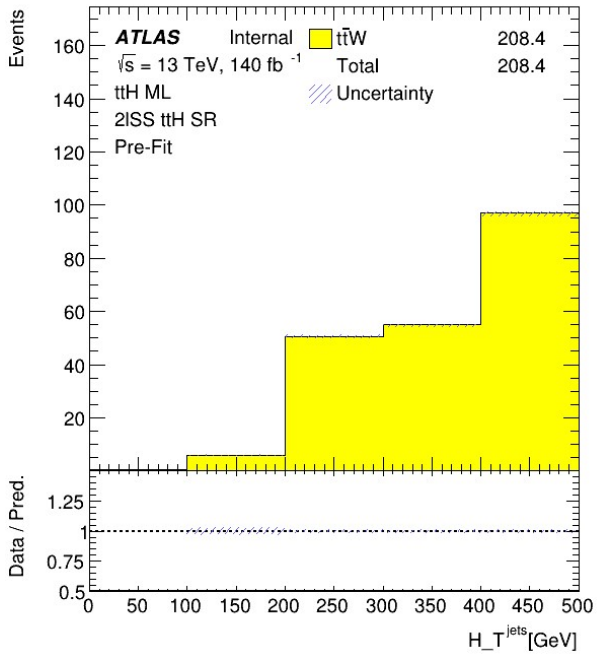
Other CR



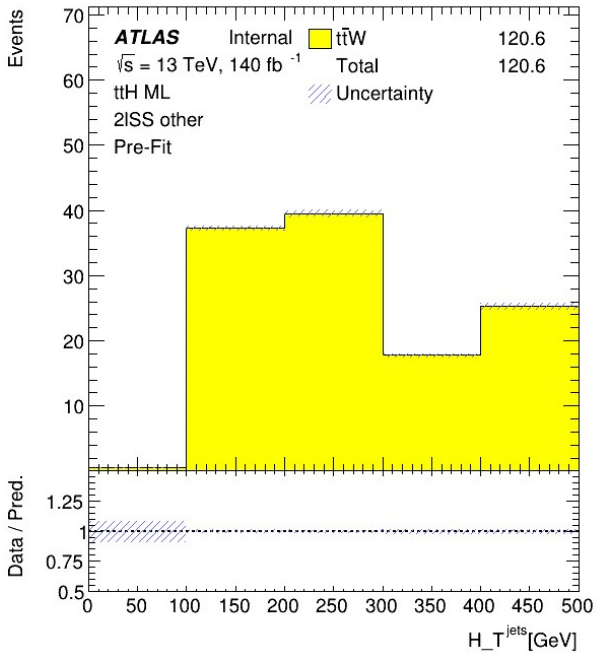
ttW CR

HT_jets

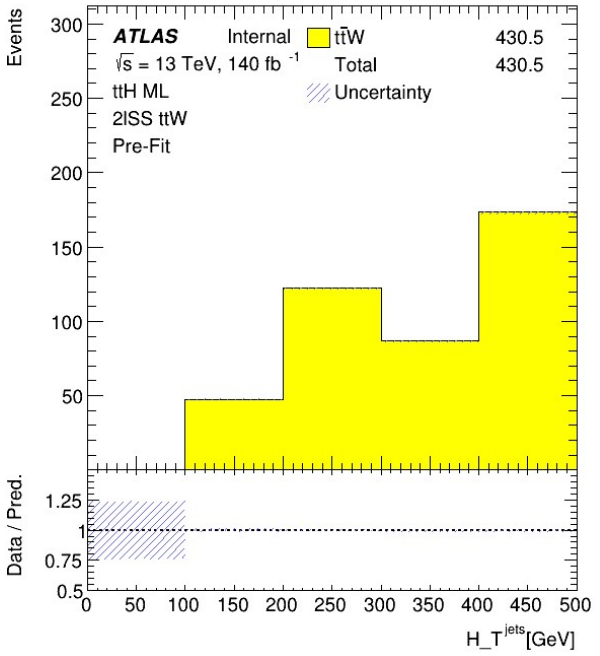
- ttW CR has higher HT jets than the SR



SR



Other CR



ttW CR

tH and tWH vs 2tau channel(TBD)

- ttH xs:5.697E-01pb
- tH: 7.731E-02pb

- In 2lSS0tau ttH SR:
- tHq: 0.8
- tWH: 1.7

Tables from 2tau report

Channels	Selections
$1\ell+2\tau_{\text{had}}$	exactly one light lepton (electron or muon): p_{T} >27 GeV, $\|\eta\| < 2.5$ exactly two RNN medium τ_{had} with opposite-sign: $p_{\text{T}} > 20$ GeV, $\|\eta\| < 2.5$ number of jets and b-jets: $N_{\text{jets}} \geq 3$ and $N_{\text{b-jet}} > 0$ (@ 77% WP)
$2\ell + 2\tau_{\text{had}}$	exactly two light leptons with opposite-sign: $p_{\text{T}} > 10$ GeV, $\|\eta\| < 2.5$ exactly two RNN medium τ_{had} with opposite-sign: $p_{\text{T}} > 20$ GeV, $\|\eta\| < 2.5$ invariant dilepton mass: $m_{\ell\ell} > 12$ GeV Z-veto ($\|m_{\ell\ell} - m_Z\|$ >10 GeV) for same-flavor leptons $N_{\text{b-jet}} > 0$ (@ 77% WP)

	ttH1ℓ2τ			ttH2ℓ2τ			tH1ℓ2τ		
	OS Asimov	OS($BDT < 0.1$) Bonly-fit	SS Bonly-fit	OS Asimov	OS($BDT < 0.1$) Bonly-fit	SS Bonly-fit	OS Asimov	OS($BDT < 0.1$) Bonly-fit	SS Bonly-fit
tth	36.6 ± 2.6	8.9 ± 0.6	6.6 ± 1.0	6.6 ± 0.6	1.2 ± 0.17	0.3 ± 0.05	5.7 ± 0.6	3.0 ± 0.3	1.5 ± 0.14
th	3.6 ± 0.3	1.3 ± 0.14	0.5 ± 0.07	-	-	-	4.9 ± 0.5	0.9 ± 0.1	0.5 ± 0.07
top	6.2 ± 8.7	4.2 ± 6.0	3.0 ± 4.2	-	-	-	-	-	-
ttV	31.0 ± 4.4	11.6 ± 1.7	4.4 ± 0.9	5.2 ± 0.7	2.3 ± 0.3	0.07 ± 0.02	8.1 ± 1.5	5.6 ± 1.1	2.7 ± 0.6
Diboson	12.1 ± 1.8	5.4 ± 0.8	0.8 ± 0.1	0.76 ± 0.09	0.5 ± 0.1	0.01 ± 0.01	18.2 ± 2.5	10.7 ± 1.5	1.9 ± 0.4
Vjets	-	-	-	-	-	-	-	-	-
Others	7.4 ± 1.7	3.5 ± 0.2	0.9 ± 0.1	-	-	-	8.8 ± 0.3	5.7 ± 0.5	1.2 ± 0.1
Fakes	597 ± 80	492 ± 69	546 ± 73	18.0 ± 3.4	14 ± 3	14.5 ± 2.7	768 ± 103	673 ± 91	784 ± 104
Total	694 ± 81	527 ± 69	562 ± 73	30.5 ± 3.5	18 ± 3	15.0 ± 2.7	814 ± 103	699 ± 91	791 ± 104
Data		502	545		25	20		626	715

Summary

- The 4top cut on ttH SR has negligible impact on ttH SR.
- Get the kinematics variables ttW distributions in CRs and SR.

Next to do

- Check the truth level kinematics variables distribution of ttW system.

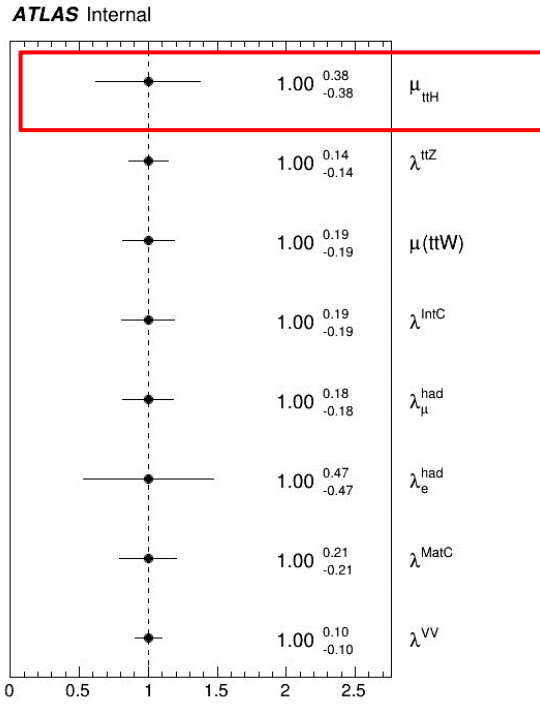
Backup

EB meeting 19-JAN 2024 Hide
https://indico.cern.ch/event/1366801/

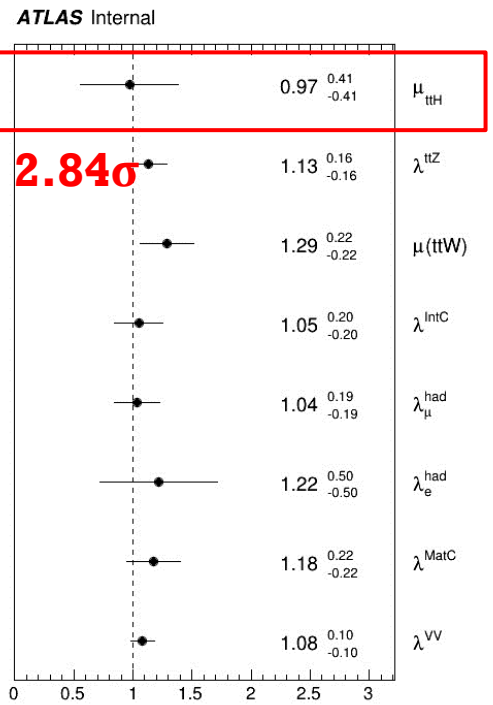
TODO:
- plot the region of 4top events: MC/Data agreement within uncertainties
- 1tau2LSS BDT: try to check which Higgs decay channel the BDT is targeting more
- add : tau fake composition for CR and SR for all tau channels
- 2tau: add the composition uncertainty on the tau fake plot (slide 25)
- 4L: change the ZZ veto to 115-130
  (https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/HIGG-2018-28/fig_01.png)
- 4L: add studies in the INT note with the different variables tested in the CR (slide 30)
- Test in the combined fit to correlate ttW as well in the 2tau channel
- Add also the hybrid combination results
- Test the impact from each channel in each STXS bins (impact of the mis-reconstruction from the 3L channel)
- Fraction of tH signal in the tH region vs kappa and alpha
- Check of the ttW background: plots of Njets, Ht, pt and other QCD emission related variable of the ttW system at truth level in the different CR and SR
- MC/Data agreement of the input variables of the MVA in ttW CRs.

NFs results

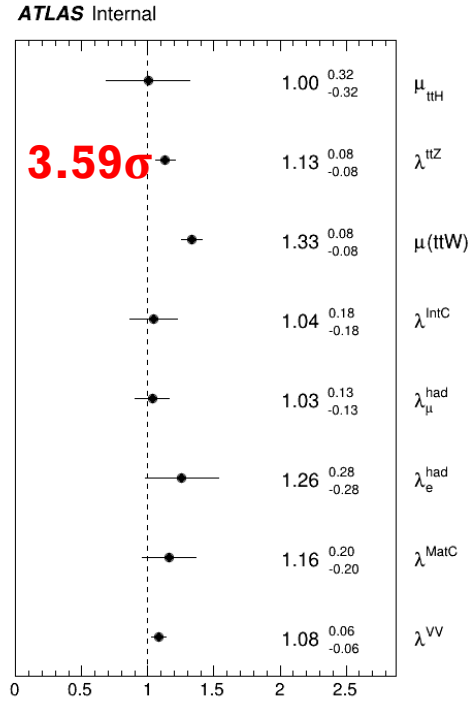
- Consider tH as SR. Only one POI: $\mu t\bar{t}H$.
- Hybrid: NP values propagated from CRONLY fit and then do Asimov fit
- $\mu t\bar{t}H = 0.97 \pm 0.41$ in hybrid fit and the significance is **2.84σ** with all systematics



Full Asimov



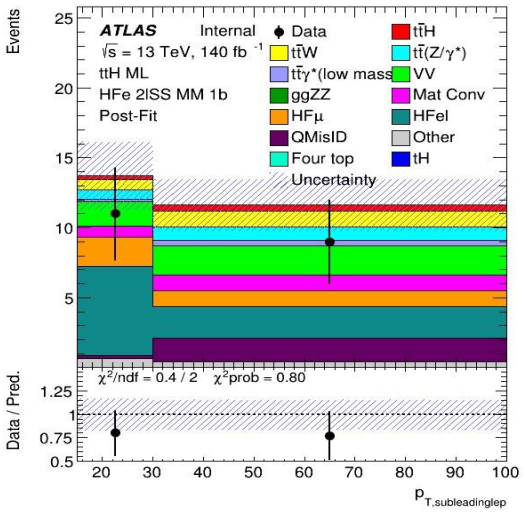
Hybrid

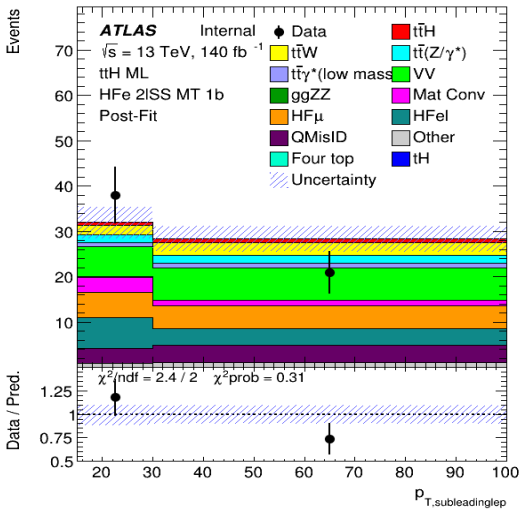


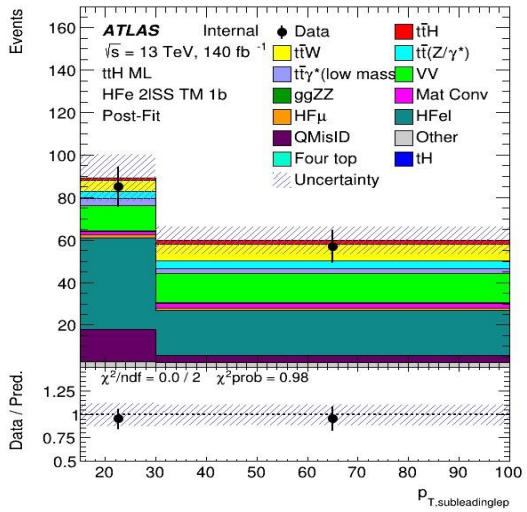
Hybrid Stat-only

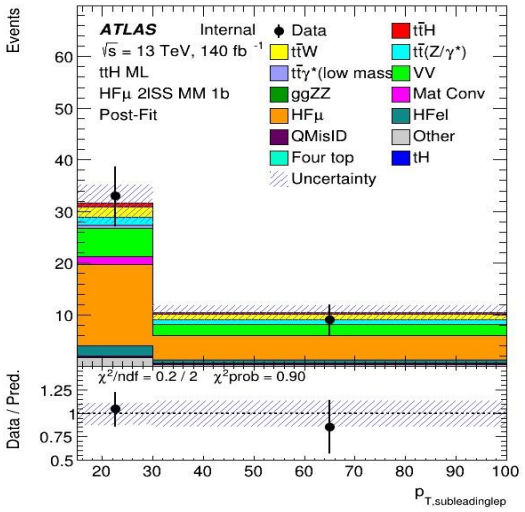
HF CRs

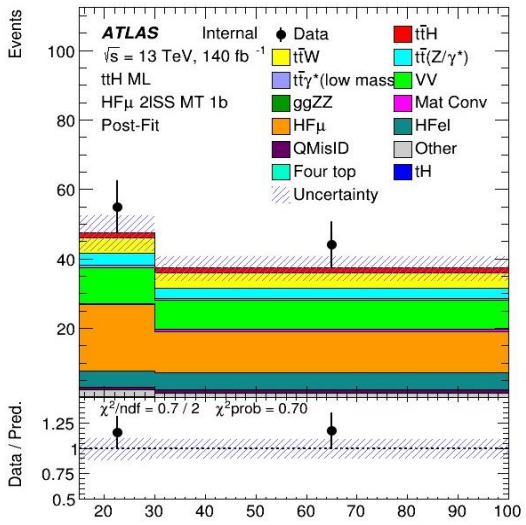
Post-fit

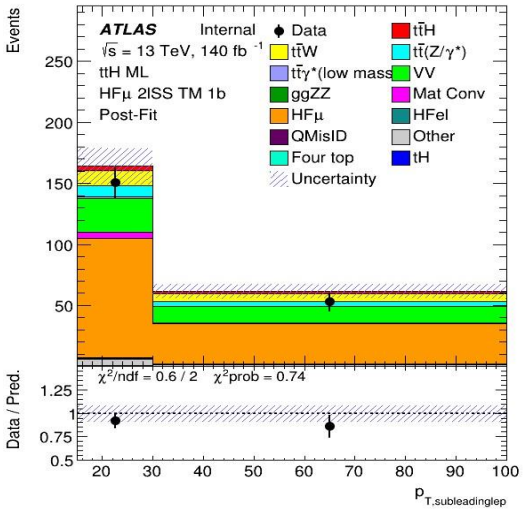






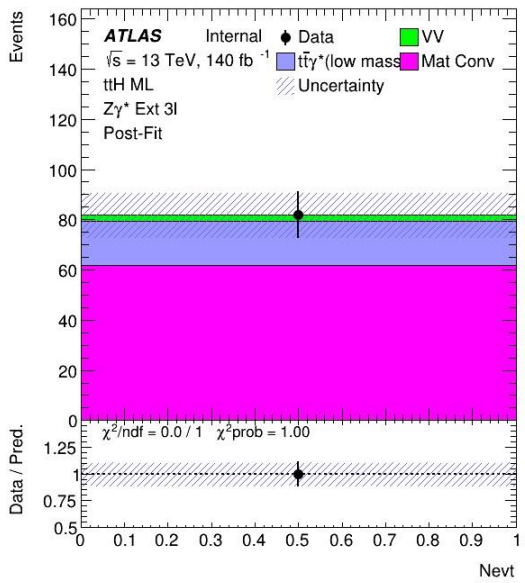


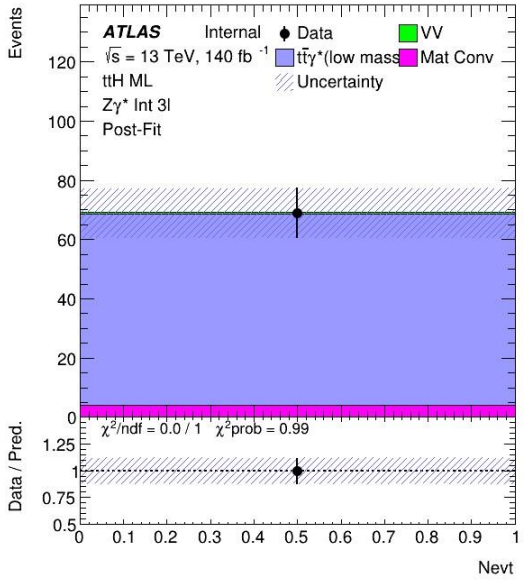


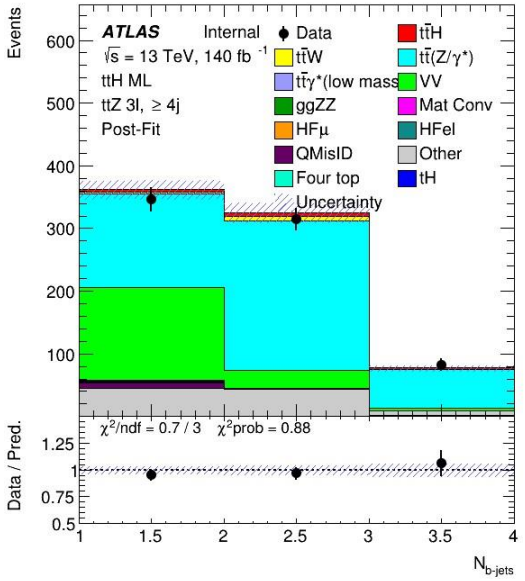


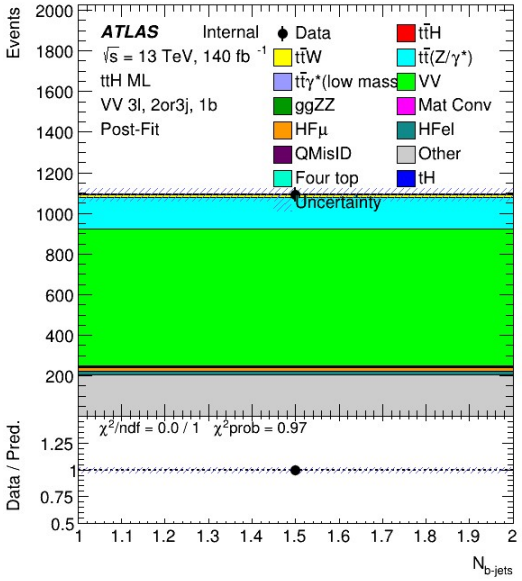
Conversion, $t\bar{t}Z$ and VV CRs

Post-fit



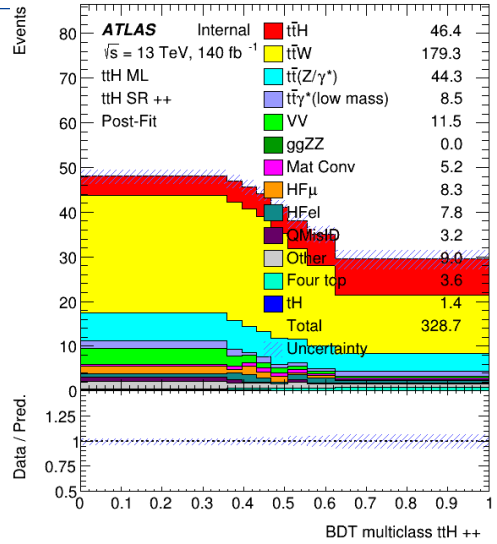


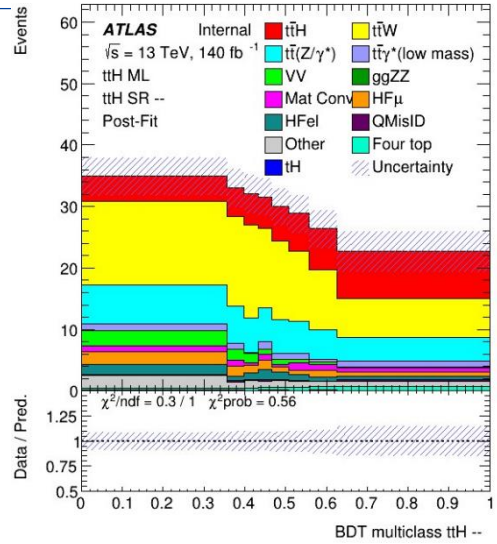




MVA-based SRs and CRs

Post-fit





	$ttHSR++$	$ttHSR--$
ttH	46.3 ±5.1	46.6 ±5.1
$t\bar{t}W$	133.4 ±27.0	75.0 ±14.5
$t\bar{t}(Z/\gamma*)$	39.2 ±3.4	37.8 ±3.2
$rareTop$	8.0 ±0.5	8.1 ±0.6
$IntConv$	8.1 ±4.2	6.5 ±3.3
VV	10.7 ±1.5	8.0 ±1.1
$ggZZ$	0 ±0	0 ±0
$MatConv$	5.2 ±2.8	5.5 ±1.2
$HF\{mu(lead)$	1.6±1.2	1.4±0.7
$HF\{mu(sub-lead)$	6.6 ±4.6	8.1 ±2.7
$HF_{el}(lead)$	0.8 ±0.5	0.7 ±0.3
$HF_{el}(sub-lead)$	5.6 ±2.3	6.2 ±3.6
$QMisID$	3.2 ±0.8	1.5 ±0.4
$Threetop$	0.5 ±0.2	0.5 ±0.2
$Fourtop$	3.6 ±1.5	3.7 ±1.6
$t\bar{t}WW$	3.9 ±2.0	3.8 ±2.0
tZ	1.8 ±0.2	1.1±0.1
WtZ	2.7 ±1.4	2.4 ±1.2
VVV	0.1 ±0	0.1±0
VH	0.1 ±0	0.9 ±1
$tHjb$	0.5 ±0.1	0.3 ±0.1
tWH	0.9 ±0.1	0.8 ±0.1