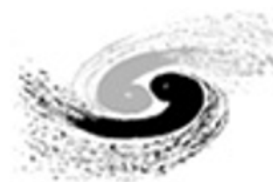




HHML Combination status

Fangyi



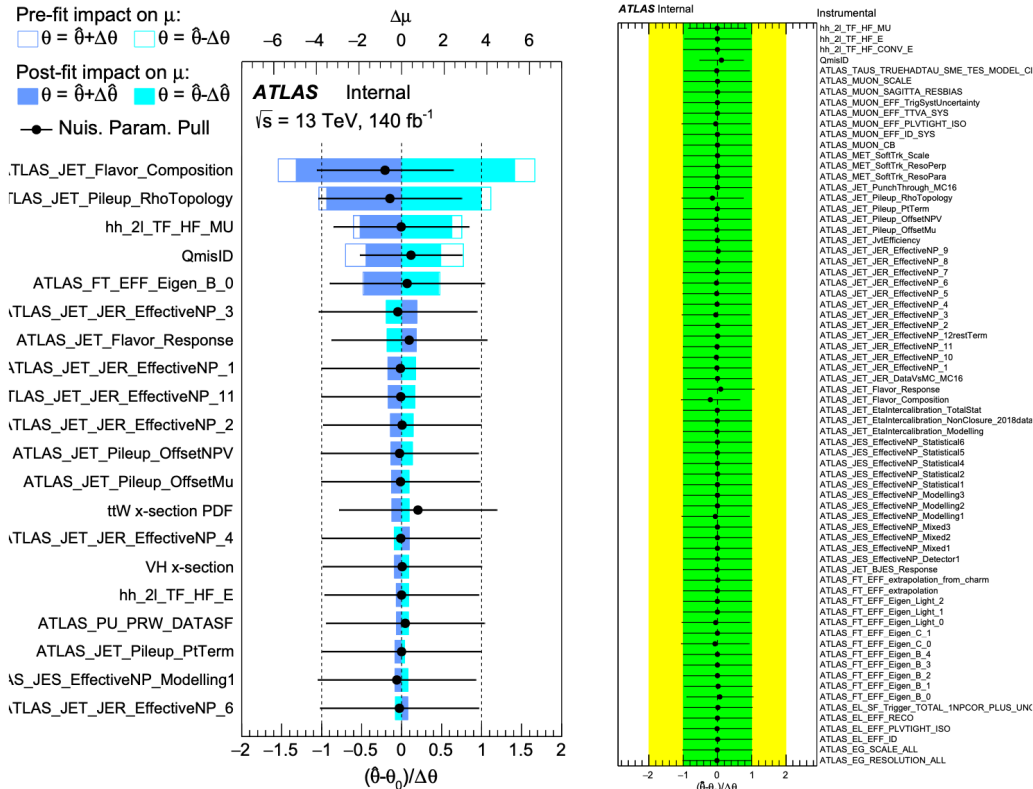
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Institute of High Energy Physics Chinese Academy of Sciences

2LSS channel

• Results in approval

	-2σ	-1σ	Expected	$+1\sigma$	$+2\sigma$	Observed
$\sigma_{HH}/\sigma_{HH}^{SM}$ Stats.	16.47	22.12	30.70	43.47	59.82	blinded
$\sigma_{HH}/\sigma_{HH}^{SM}$ Sys.	18.68	25.08	34.81	49.61	69.10	blinded



• My results

```

exp_upperlimit = 34.8109
exp_upperlimit_plus1 = 49.6074
exp_upperlimit_plus2 = 69.1038
exp_upperlimit_minus1 = 25.0832
exp_upperlimit_minus2 = 18.6839
  
```

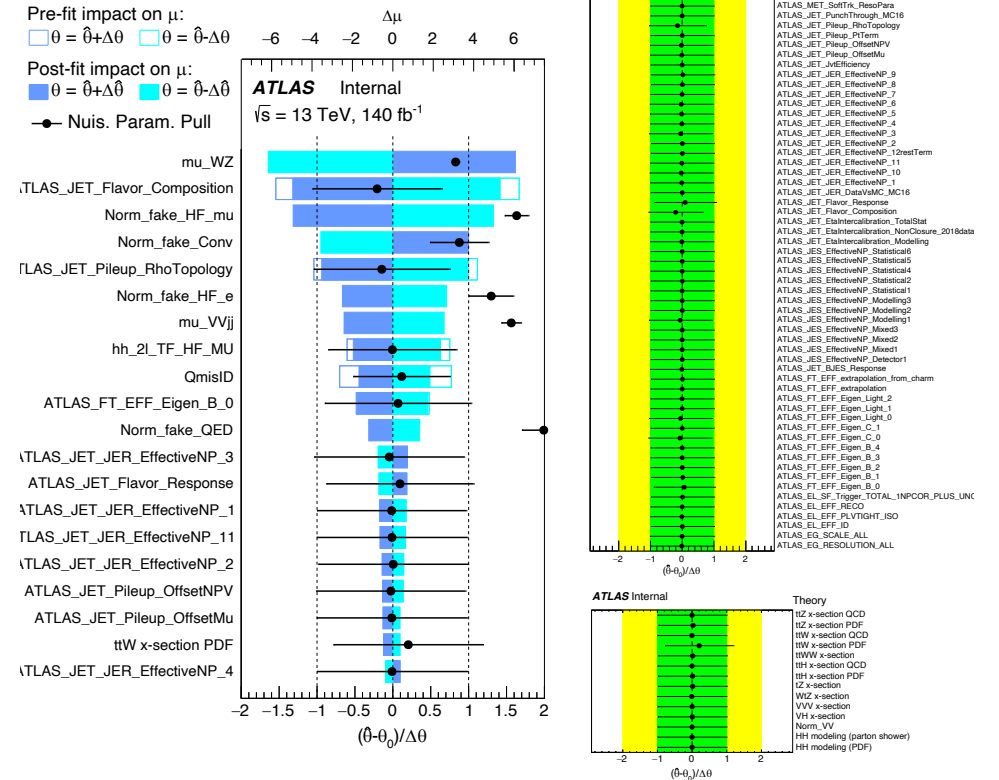


Figure 111: The ranking of top 20 nuisance parameters in 2LSS channel.

SS+1tau channel

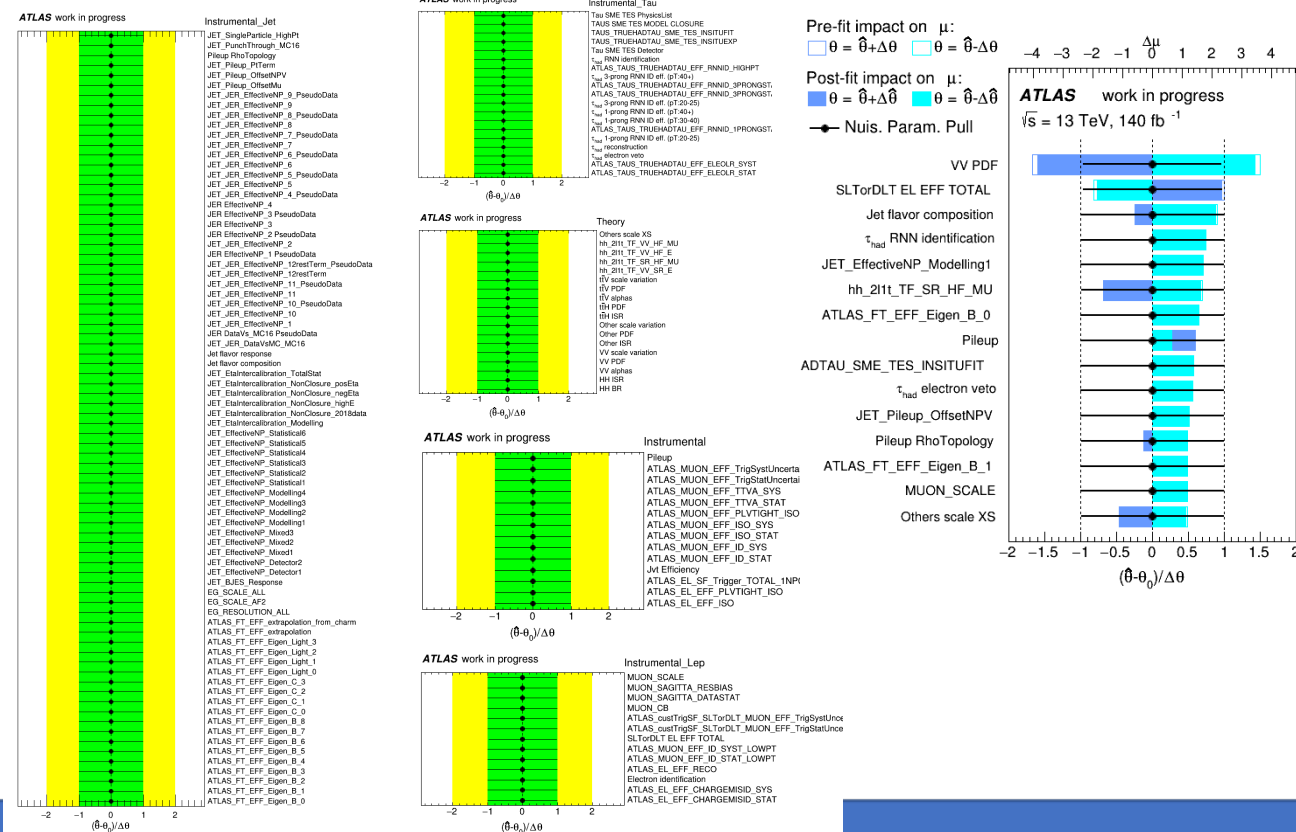
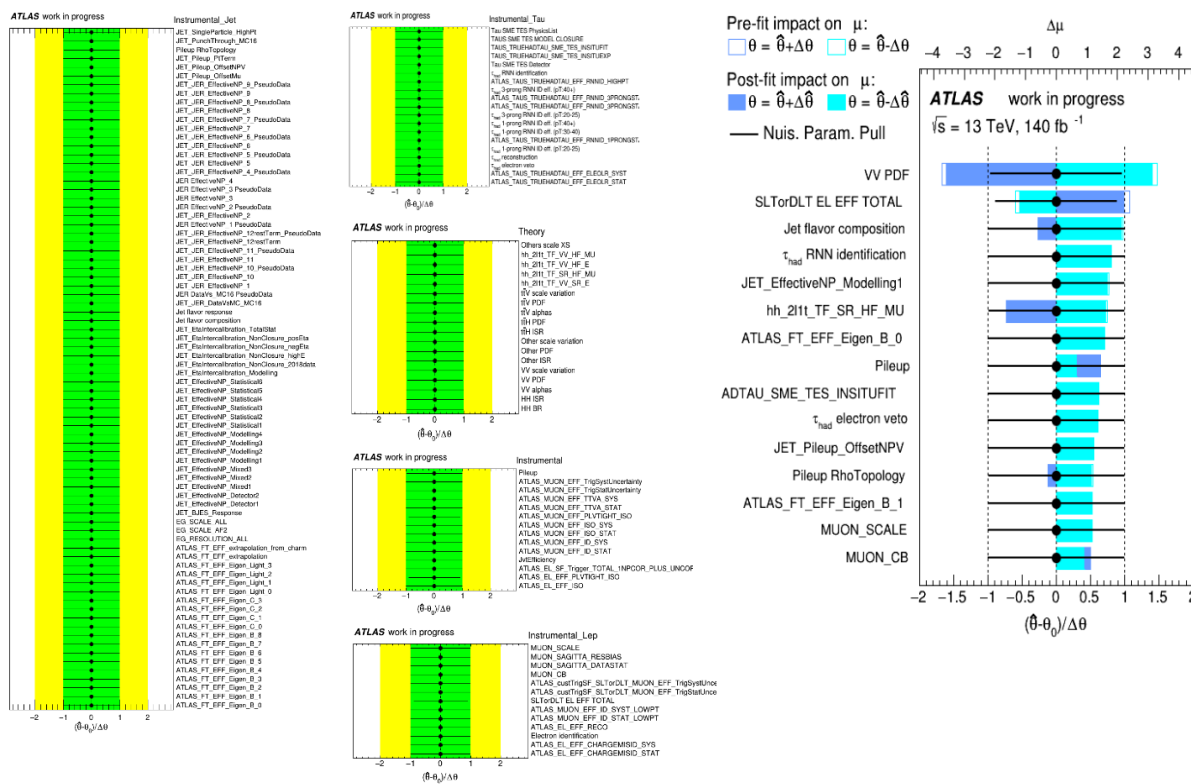
Results in approval

	-2σ	-1σ	$+1\sigma$	$+2\sigma$
Stats.	27.1762	36.4841	50.63	70.467
Syst.	28.86	38.745	53.77	78.8405

My results

```

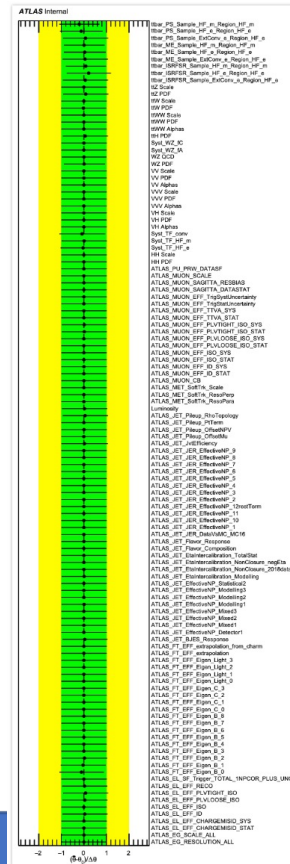
exp_upperlimit = 53.3565
exp_upperlimit_plus1 = 78.6396
exp_upperlimit_plus2 = 115.287
exp_upperlimit_minus1 = 38.4463
exp_upperlimit_minus2 = 28.6378
    
```



3 channel

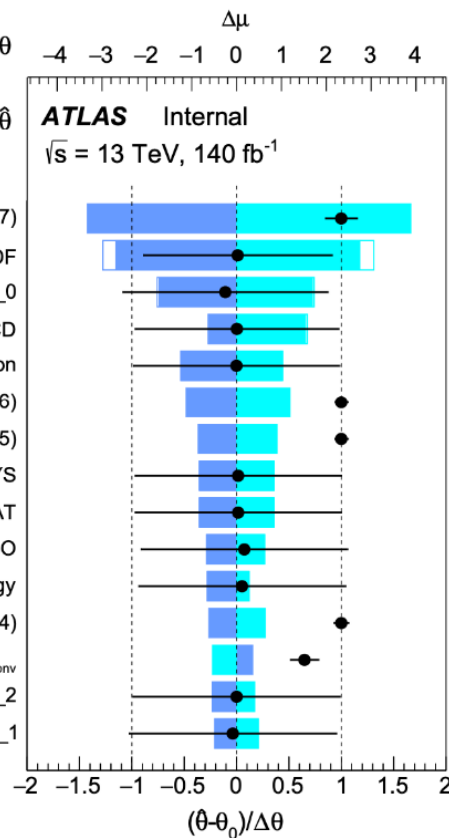
Results in approval

	-2σ	-1σ	Expected	$+1\sigma$	$+2\sigma$
$\sigma_{HH}/\sigma_{HH}^{SM}$ Stats.	12.79	17.16	23.82	34.03	47.68
$\sigma_{HH}/\sigma_{HH}^{SM}$ Sys.	15.10	20.27	28.13	40.94	58.70



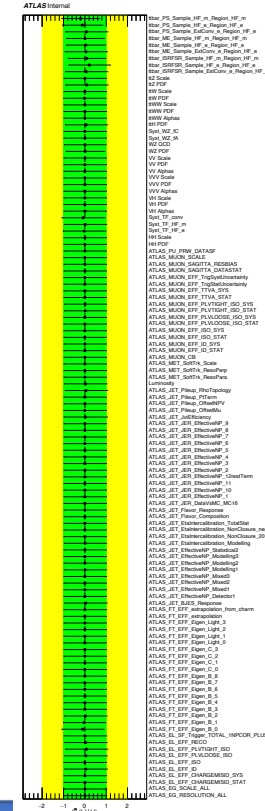
Pre-fit impact on μ :
 $\square \theta = \hat{\theta} + \Delta\theta$ $\square \theta = \hat{\theta} - \Delta\theta$
 Post-fit impact on μ :
 $\blacksquare \theta = \hat{\theta} + \Delta\hat{\theta}$ $\blacksquare \theta = \hat{\theta} - \Delta\hat{\theta}$
 —●— Nuis. Param. Pull

γ (hh3IBDT bin 7)
 WZ PDF
 ATLAS_FT_EFF_Eigen_B_0
 WZ QCD
 ATLAS_JET_Flavor_Composition
 γ (hh3IBDT bin 6)
 γ (hh3IBDT bin 5)
 ION_EFF_PLVTIGHT_ISO_SYS
 ION_EFF_PLVTIGHT_ISO_STAT
 ATLAS_EL_EFF_PLVTIGHT_ISO
 ATLAS_JET_Pileup_RhoTopology
 γ (hh3IBDT bin 4)
 μ^e ExtConv
 ATLAS_JET_JER_EffectiveNP_2
 ATLAS_FT_EFF_Eigen_B_1



My results

```
exp_upperlimit = 28.1348
exp_upperlimit_plus1 = 40.9434
exp_upperlimit_plus2 = 58.6955
exp_upperlimit_minus1 = 20.2726
exp_upperlimit_minus2 = 15.1006
```



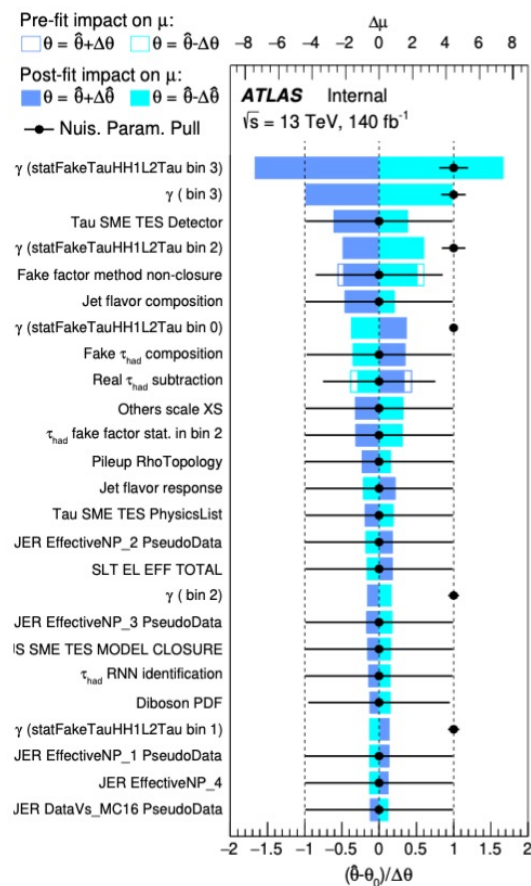
Ranking is running.

- **Results in approval**

ATLAS Internal

Others scale XS
Tau SME TES PhysicsList
TAUS SME TES MODEL CLOSURE
TAUS_TRUEHADTAU_SME_TES_INSUITUEP
TAUS_TRUEHADTAU_SME_TES_INSUITUEP
Tau SME TES Detector
MUCON_SAGITTA_REBBIAS
MET_SoftTrk_ResoPerp
tV PDF
tH PDF
tH ISR
Diboson scale variation
Diboson alphas
HH PDF
HH ISR
Pileup Rho Topology
JET_Pileup_OffsetNPV
JET_JER_EffectiveNP_9
JET_JER_EffectiveNP_8_PseudoData
JET_JER_EffectiveNP_8
JET_JER_EffectiveNP_7
JET_JER_EffectiveNP_6_PseudoData
JET_JER_EffectiveNP_6
JET_JER_EffectiveNP_5_PseudoData
JET_JER_EffectiveNP_5
JET_JER_EffectiveNP_4_PseudoData
JET_JER_EffectiveNP_4
JET_JER_EffectiveNP_3_PseudoData
JET_JER_EffectiveNP_3
JET_JER_EffectiveNP_2_PseudoData
JET_JER_EffectiveNP_2
JET_JER_EffectiveNP_1_PseudoData
JET_JER_EffectiveNP_1resTerm
JET_JER_EffectiveNP_11_PseudoData
JET_JER_EffectiveNP_11
JET_JER_EffectiveNP_10_PseudoData
JET_JER_EffectiveNP_10
JET_JER_EffectiveNP_1
JER DataVs_MC16 PseudoData
JET_JER_DataVsMC_MC16
Jet flavor response
Jet flavor composition
JET_EtaIncalibration_Modeling
JET_EffectiveNP_Modeling1
JET_DJES_Response
HH BR
 τ_{had} fake factor stat. in bin 8
 τ_{had} fake factor stat. in bin 6
 τ_{had} fake factor stat. in bin 5
 τ_{had} fake factor stat. in bin 2
 τ_{had} fake factor stat. in bin 1
 τ_{had} fake factor stat. in bin 11
Real τ_{ee} subtraction
Fake τ_{ee} composition
Fake factor method non-closure
EG_SCALE_ALL
EG_RESOLUTION_ALL
SLT_EL EFF TOTAL
RNN identification
 τ_{had} 1-prong RNN ID eff. (pT-40+)
 τ_{had} reconstruction
 τ_{had} electron veto
Pileup
ATLAS_FT_EFF_Eigen_B_2
ATLAS_FT_EFF_Eigen_B_1
ATLAS_FT_EFF_Eigen_B_0

($\theta=0$)/ $\Delta\theta$



- **My results**

Pre-fit impact on μ :
 $\square \theta = \hat{\theta} + \Delta\theta$ $\square \theta = \hat{\theta} - \Delta\theta$

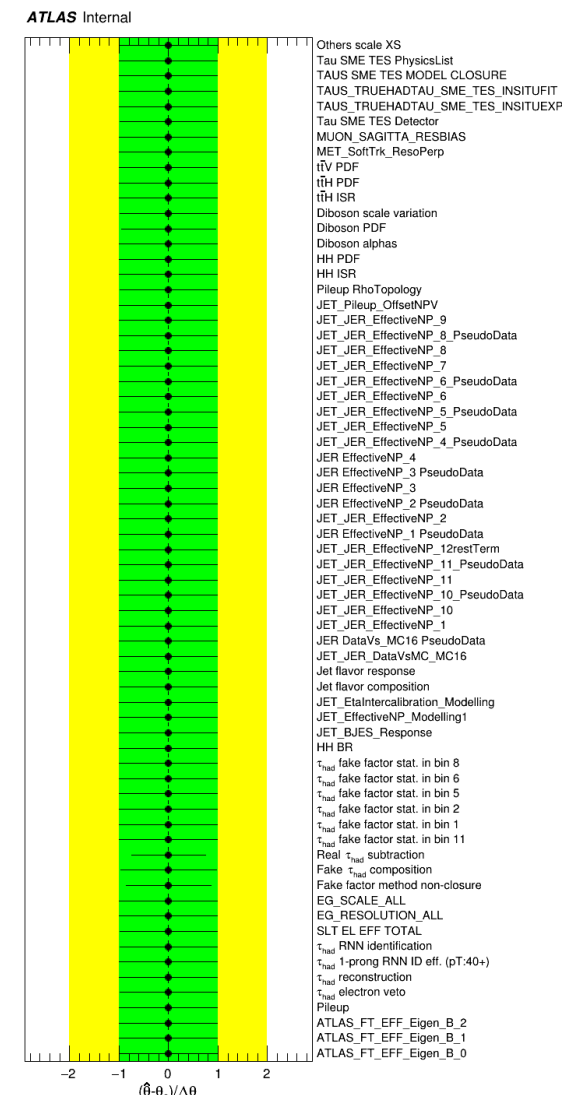
Post-fit impact on μ :
 $\square \theta = \hat{\theta} + \Delta\hat{\theta}$ $\square \theta = \hat{\theta} - \Delta\hat{\theta}$

—● Nuis. Param. Pull

γ (statFakeTauHH1L2Tau bin 3)
 γ (bin 3)
 Tau SME TES Detector
 γ (statFakeTauHH1L2Tau bin 2)
 Fake factor method non-closure
 Jet flavor composition
 γ (statFakeTauHH1L2Tau bin 0)
 Fake τ_{had} composition
 Real τ_{had} subtraction
 Others scale XS
 τ_{had} fake factor stat. in bin 2
 Pileup RhoTopology
 Jet flavor response
 Tau SME TES PhysicsList
 JER EffectiveNP_2 PseudoData
 SLT EL EFF TOTAL
 γ (bin 2)
 JER EffectiveNP_3 PseudoData
 S SME TES MODEL CLOSURE
 τ_{had} RNN identification
 Diboson PDF
 γ (statFakeTauHH1L2Tau bin 1)
 JER EffectiveNP_1 PseudoData
 JER EffectiveNP_4
 JER DataVs_MC16 PseudoData

ATLAS Internal
 $\sqrt{s} = 13 \text{ TeV}, 140 \text{ fb}^{-1}$

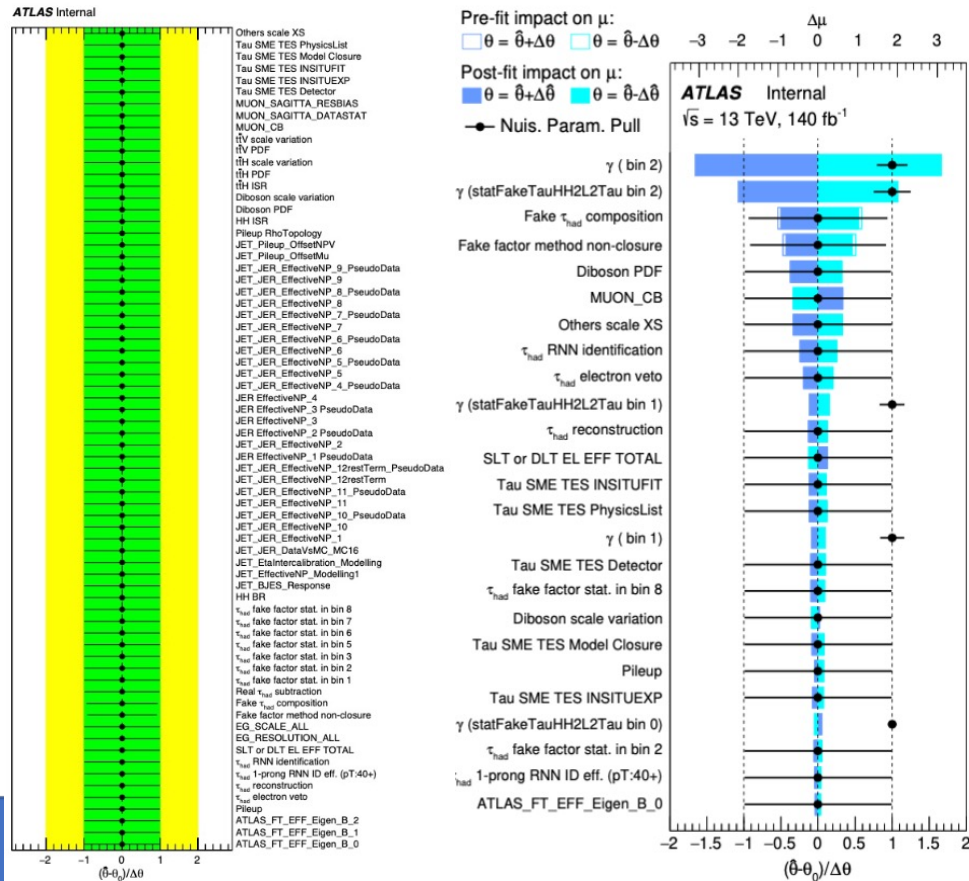
$(\hat{\theta} - \theta) / \Delta\theta$



2l2tau channel

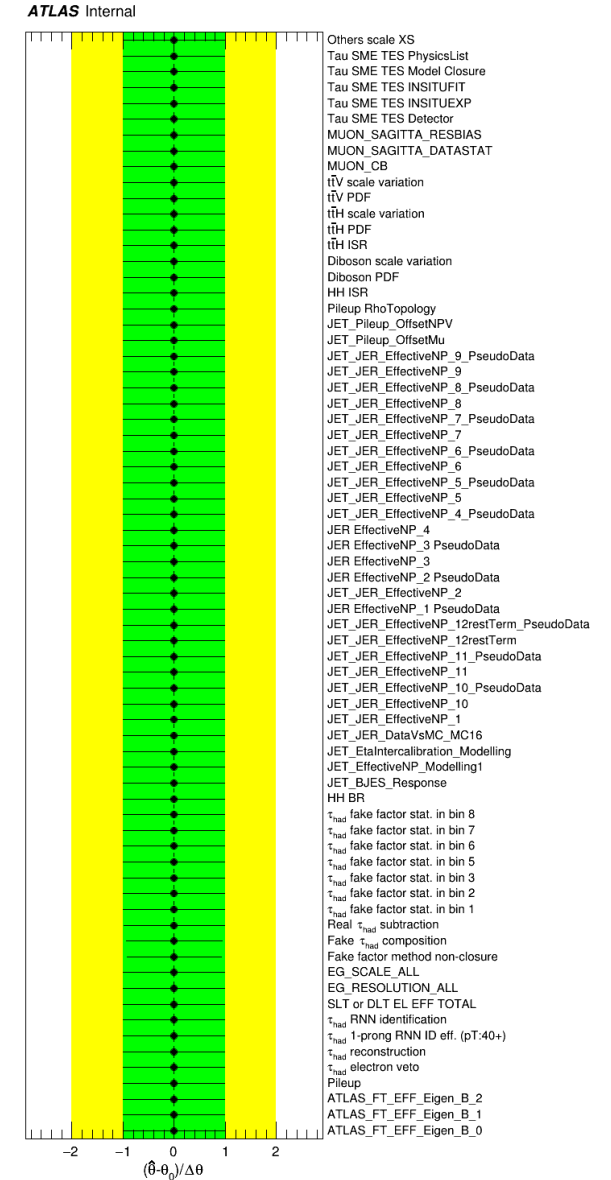
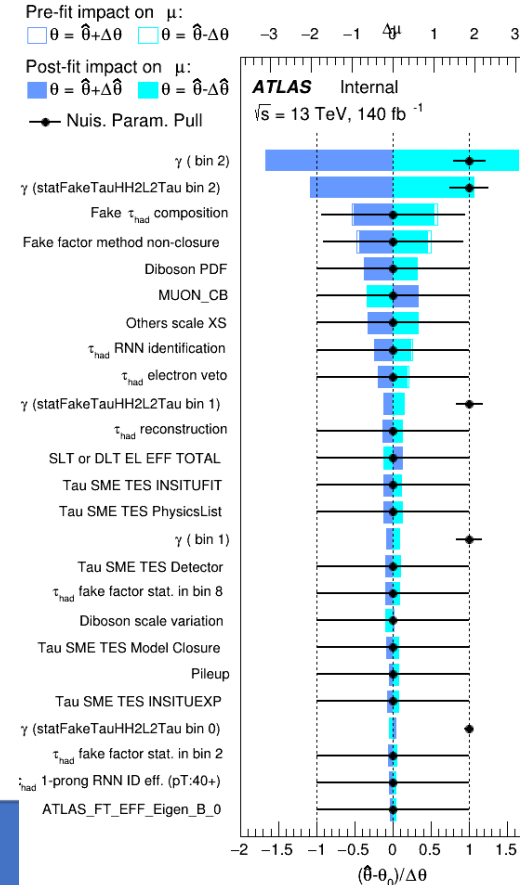
Results in approval

	Expected limit on signal strength				
	+2 σ	+1 σ	Median	-1 σ	-2 σ
1 l +2 τ_{had}	83.24	58.92	41.21 (34.64)	29.70	22.12
2 l +2 τ_{had}	74.05	50.09	33.99 (32.82)	24.49	18.24



My results

```
exp_upperlimit = 33.9928
exp_upperlimit_plus1 = 50.0906
exp_upperlimit_plus2 = 74.0483
exp_upperlimit_minus1 = 24.4937
exp_upperlimit_minus2 = 18.2448
```



Combination



- **Norm factors:**

Channel	Norm factor list
2LSS	mu_WZ, mu_VVjj, Norm_fake_QED, Norm_fake_Conv, Norm_fake_HF_e, Norm_fake_HF_mu
2LSS+1tau	-
3l	NF_HF_e, NF_HF_m, NF_ExtConv_e
1l2tau	-
2l2tau	-
bb4l	mu_ttXsec, mu_ttVXsec, mu_VVXsec, mu_HiggsXsec, mu_ZjetsXsec,

- Fully correlation for the same syst.
- NFs: check and combine.
- No fixed NFs in the individual channel.

- **Results:**

- $\mu_{HH} = 1.00^{+6.306}_{-5.767} (stat.)^{+7.324}_{-6.618} (stat.+syst.)$
- Upper limit: 14.8706. $\pm 1\sigma$: (10.7151, 21.1493). $\pm 2\sigma$: (7.98144, 29.3641).

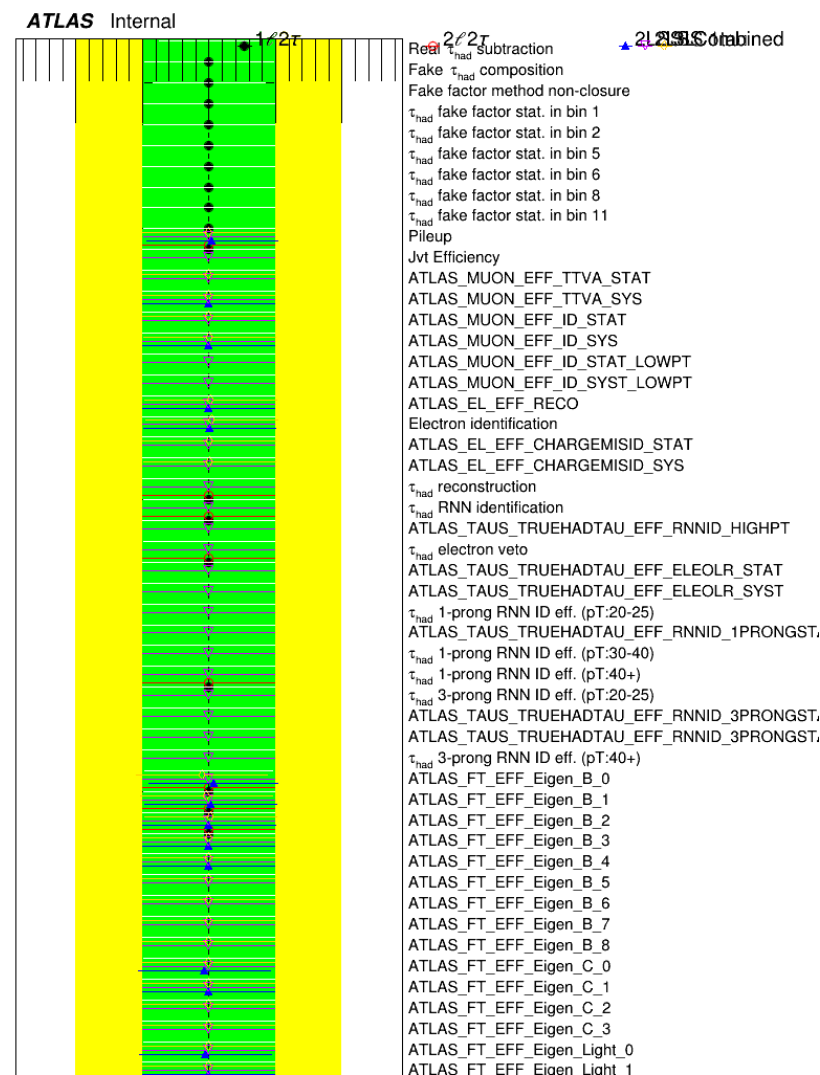
Combination



• Summary and next step:

- WIP channel: $bb4l, \gamma\gamma + ML$.
- Finish the combination asap.
- Try the toy study.

- HHComb group is asking for the progress and workspace.





Backup

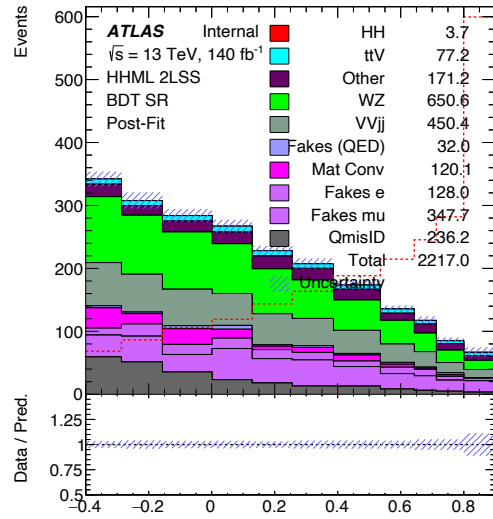


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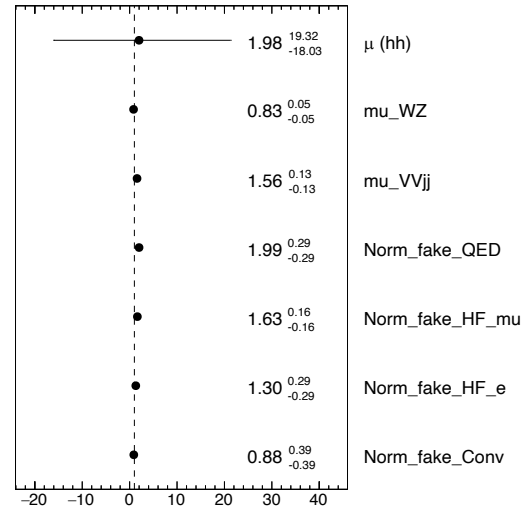
bb4l channel



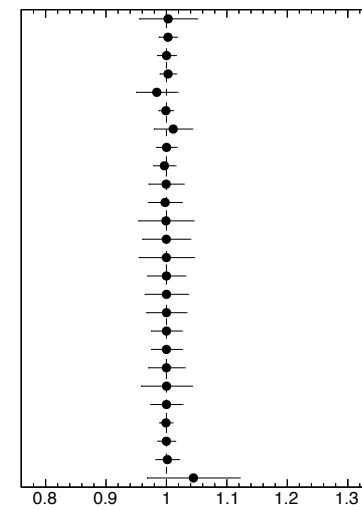
2LSS



ATLAS Internal



ATLAS Internal



γ hh 2l QED bin 0000

γ hh 2l HT lep emmm bin 0003

γ hh 2l HT lep emmm bin 0002

γ hh 2l HT lep emmm bin 0001

γ hh 2l HT lep emmm bin 0000

γ hh 2l HT lep 2b meee bin 0000

γ hh 2l DRll01 1b meee bin 0003

γ hh 2l DRll01 1b meee bin 0002

γ hh 2l DRll01 1b meee bin 0001

γ hh 2l DRll01 1b meee bin 0000

γ hh 2l Conv bin 0000

γ hh 2l BDT bin 0010

γ hh 2l BDT bin 0009

γ hh 2l BDT bin 0008

γ hh 2l BDT bin 0007

γ hh 2l BDT bin 0006

γ hh 2l BDT bin 0005

γ hh 2l BDT bin 0004

γ hh 2l BDT bin 0003

γ hh 2l BDT bin 0002

γ hh 2l BDT bin 0001

γ hh 2l BDT bin 0000

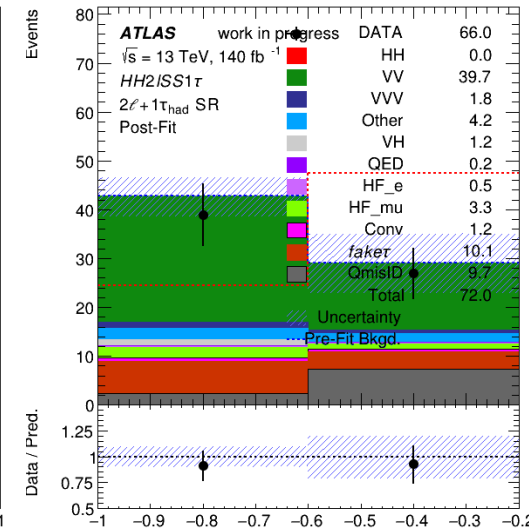
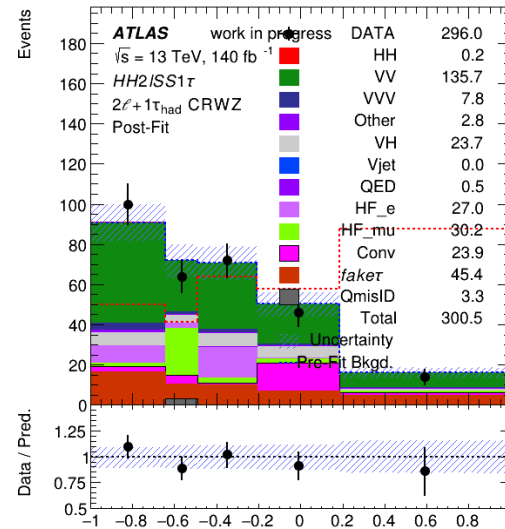
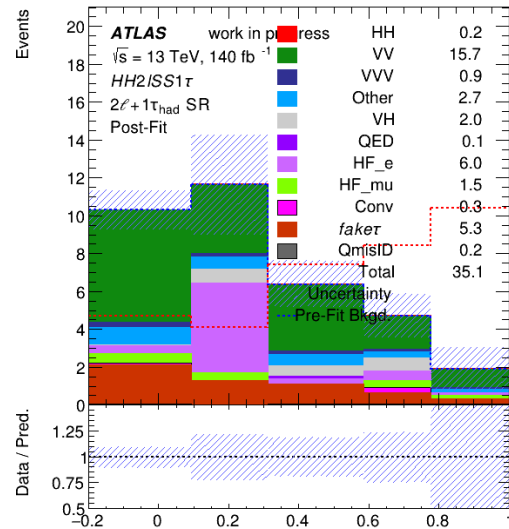
γ HH l20tau 2lSSVVCR bin 0003

γ HH l20tau 2lSSVVCR bin 0002

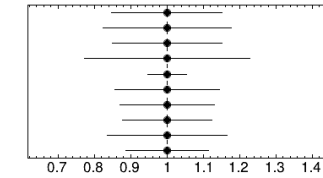
γ HH l20tau 2lSSVVCR bin 0001

γ HH l20tau 2lSSVVCR bin 0000

2LSS+1tau

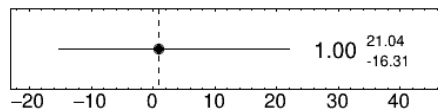


ATLAS work in progress



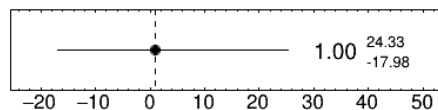
γ hh 2l1tau SR BDTG bin 0004
 γ hh 2l1tau SR BDTG bin 0003
 γ hh 2l1tau SR BDTG bin 0002
 γ hh 2l1tau SR BDTG bin 0001
 γ hh 2l1tau SR BDTG bin 0000
 γ hh 2l1tau CRWZ BDTG bin 0004
 γ hh 2l1tau CRWZ BDTG bin 0003
 γ hh 2l1tau CRWZ BDTG bin 0002
 γ hh 2l1tau CRWZ BDTG bin 0001
 γ hh 2l1tau CRWZ BDTG bin 0000

ATLAS work in progress



μ (hh) Stat only

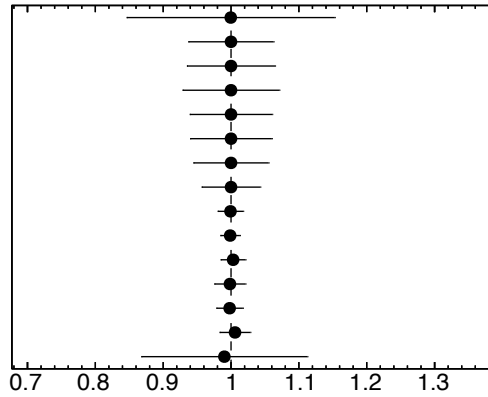
ATLAS work in progress



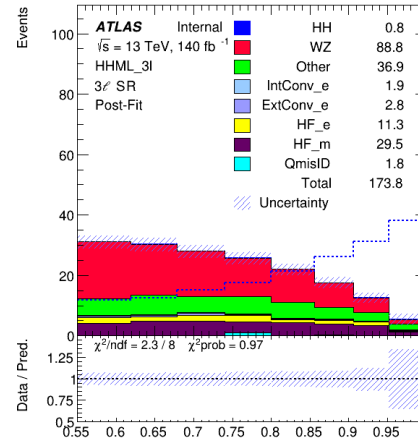
μ (hh) Stat+syst



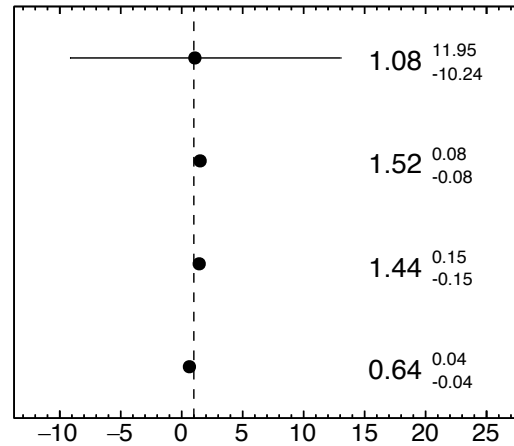
ATLAS Internal



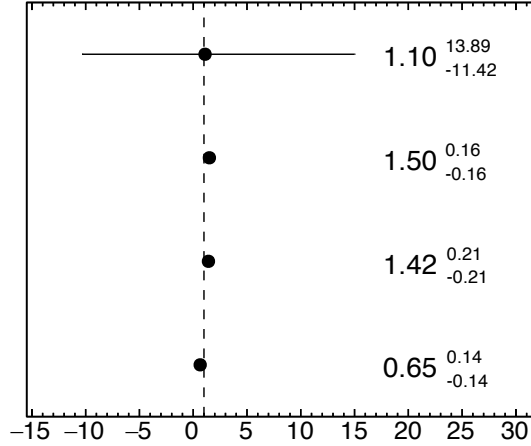
γ hh 3l BDT bin 0007
 γ hh 3l BDT bin 0006
 γ hh 3l BDT bin 0005
 γ hh 3l BDT bin 0004
 γ hh 3l BDT bin 0003
 γ hh 3l BDT bin 0002
 γ hh 3l BDT bin 0001
 γ hh 3l BDT bin 0000
 γ HF m bin 0002
 γ HF m bin 0001
 γ HF m bin 0000
 γ HF e bin 0002
 γ HF e bin 0001
 γ HF e bin 0000
 γ ExtConv e bin 0000



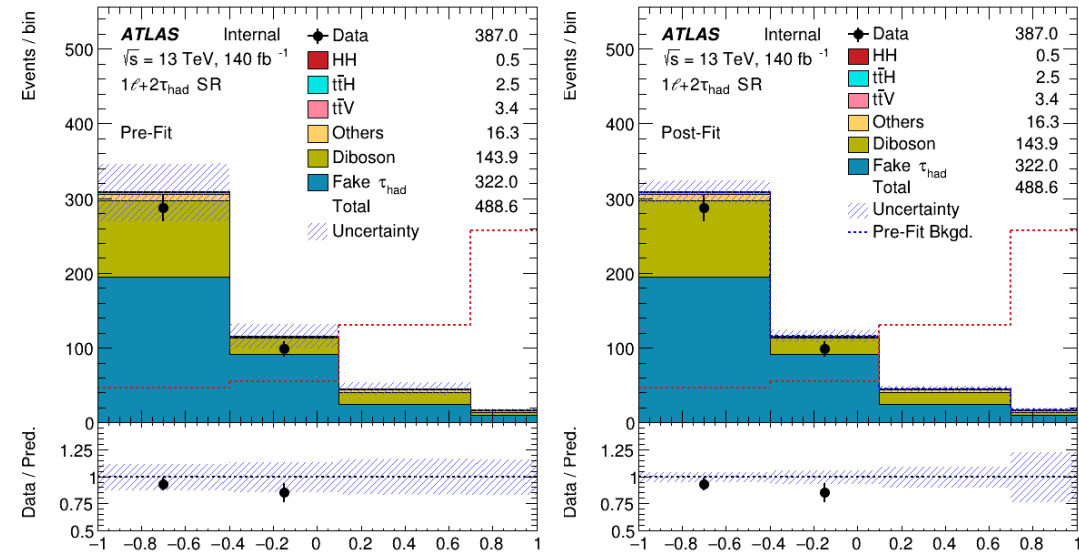
ATLAS Internal Stat only

 μ (hh) μ_{HF}^{μ} μ_{HF}^e μ_{ExtConv}^e

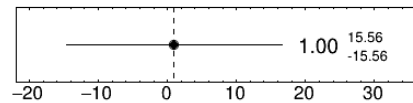
ATLAS Internal Stat + syst

 μ (hh) μ_{HF}^{μ} μ_{HF}^e μ_{ExtConv}^e

1l2tau

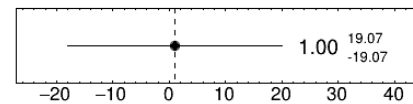


ATLAS Internal



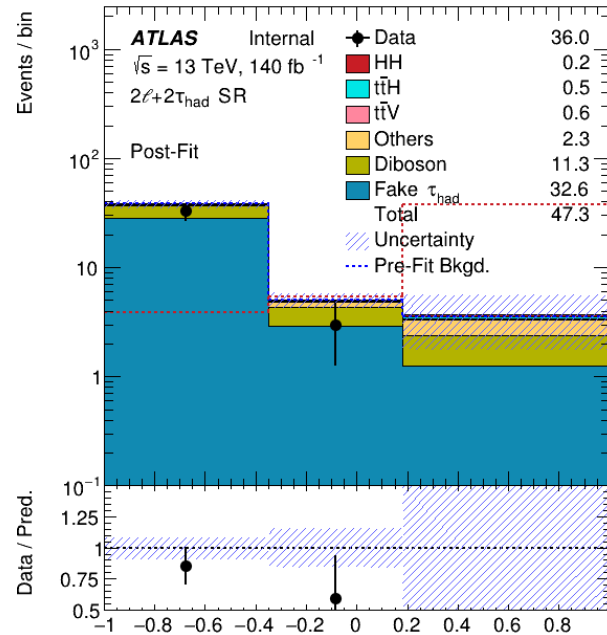
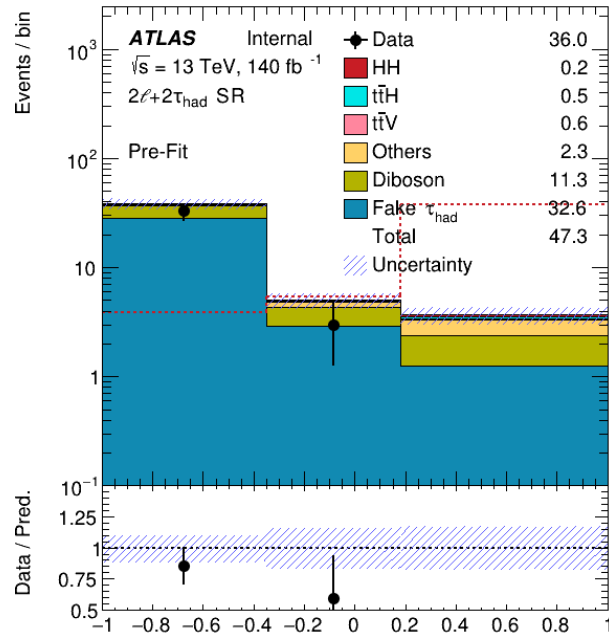
Stat only

ATLAS Internal

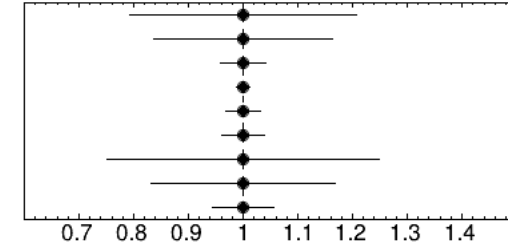


Stat+syst

2l2tau

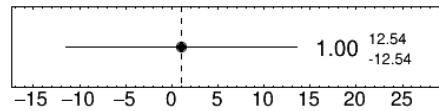


ATLAS Internal



γ HH2L2Tau bin 0002
 γ HH2L2Tau bin 0001
 γ HH2L2Tau bin 0000
 γ HH HH2L2Tau bin 0002
 γ HH HH2L2Tau bin 0001
 γ HH HH2L2Tau bin 0000
 γ FakeTau HH2L2Tau bin 0002
 γ FakeTau HH2L2Tau bin 0001
 γ FakeTau HH2L2Tau bin 0000

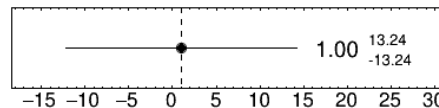
ATLAS Internal



mu_XS_hh

Stat only

ATLAS Internal



mu_XS_HH

Stat+syst