Search for heavy resonance via *WH → lvbb* with ATLAS

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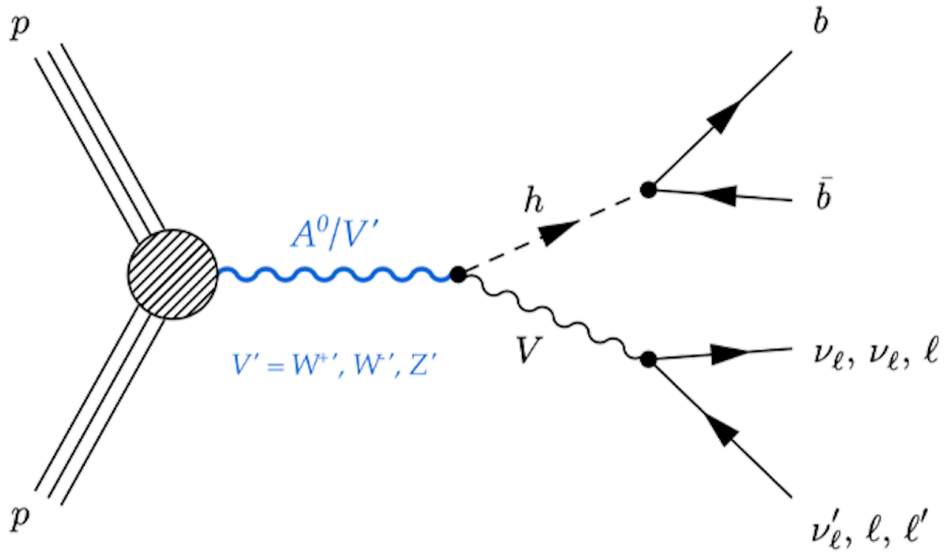
Introduction

Search for heavy resonance decaying into *W(lν)H(bb)*

- Predicted by several BSM theories
- *H* identified with the SM Higgs (m_h=125 GeV)
- $H \rightarrow bb$ for enlarging the statistics
- $W \rightarrow l\nu$ for triggering and selecting events efficiently
- ATLAS full Run 2 dataset used



Heavy Vector Triplet (HVT)

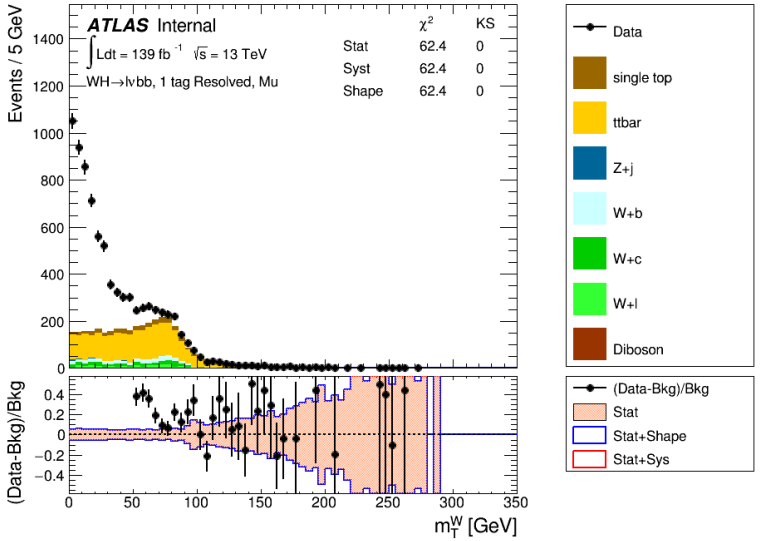
- Heavy vector bosons *W'*
- Interpret of two benchmark models: Model A / Model B

1L CONF Note

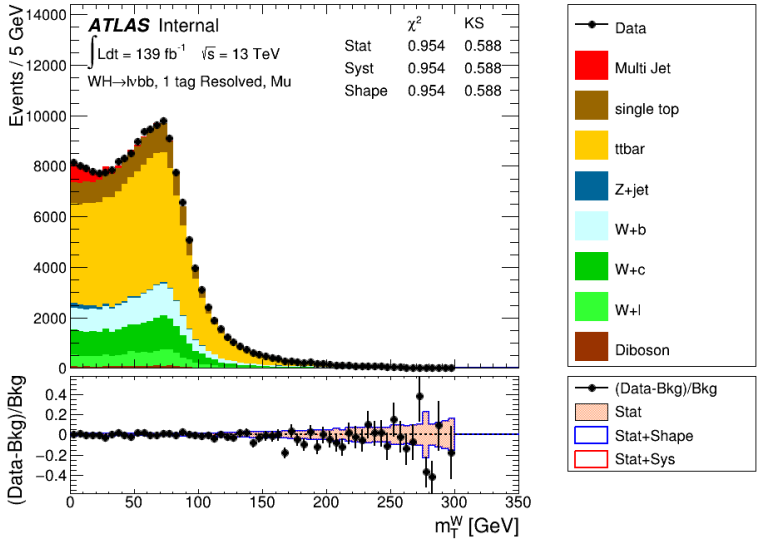
Multi-jet (MJ) background estimation

	Criterion	isolated region	non-isolated region
Electron	ID	TightLH	TightLH
	Trk Isolation	ptvarcone20/pT < 0.06	ptvarcone20/pT < 0.06
	Calo Isolation	topoetcone20/pT < 0.06	topoetcone20/pT > 0.06
Muon	ID	TightLH	TightLH
	Trk Isolation	ptvarcone30/pT < 0.06	0.06 < ptvarcone30/pT < 0.15

Definition of isolated and non-isolated region



mTW distributions in MJ CR

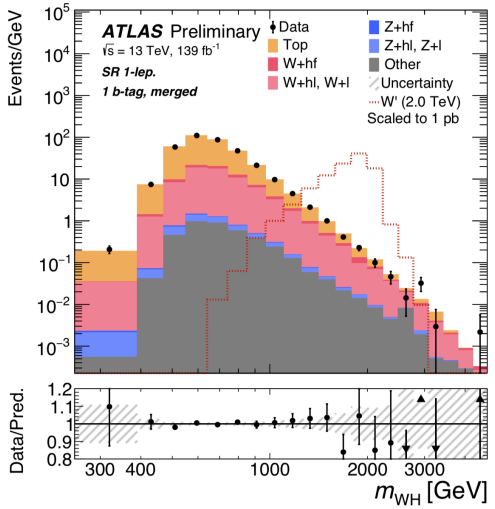


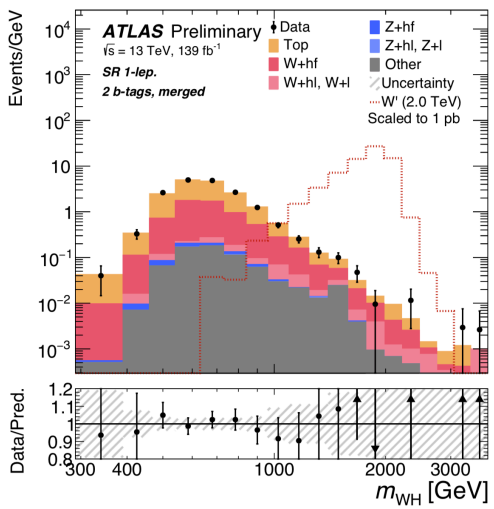
Post-fit distributions in SR

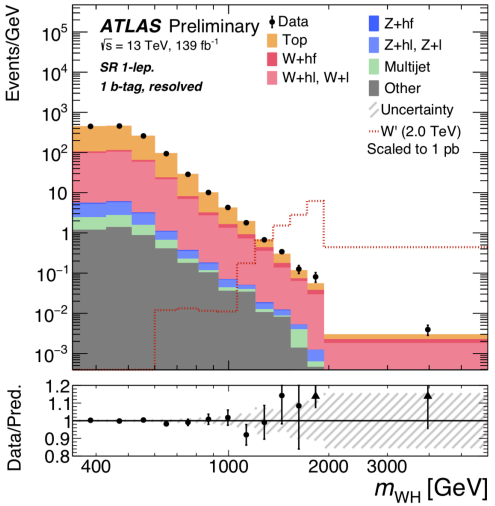
Statistical analysis

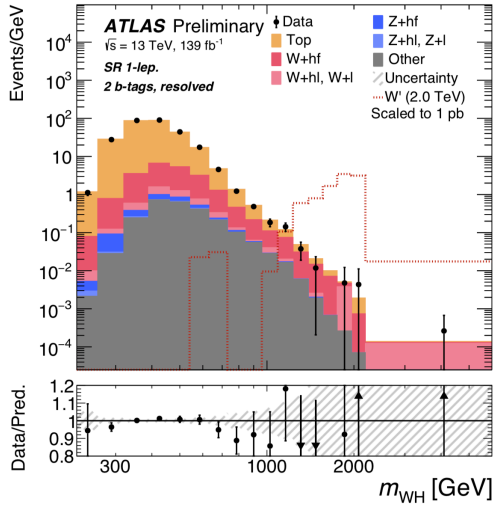
Region	signal regions	control regions
	Resolved	
b-tags	1, 2 b-tag	1, 2 b-tag
Mass window	$110 < m_{jj} < 140$ GeV	$50 < m_{jj} < 110$ GeV $\|\|$ $140 < m_{jj} < 200$ GeV
	Merged	
b-tags	1, 2 b-tag	1, 2 b-tag
Mass window	$75 < m_J < 145$ GeV	$50 < m_J < 75$ GeV $\|\|$ $145 < m_J < 200$ GeV

- Regions considered in the fit
- Post-fit distributions in signal regions
- The signal with mass 2 TeV is shown as a dashed red line

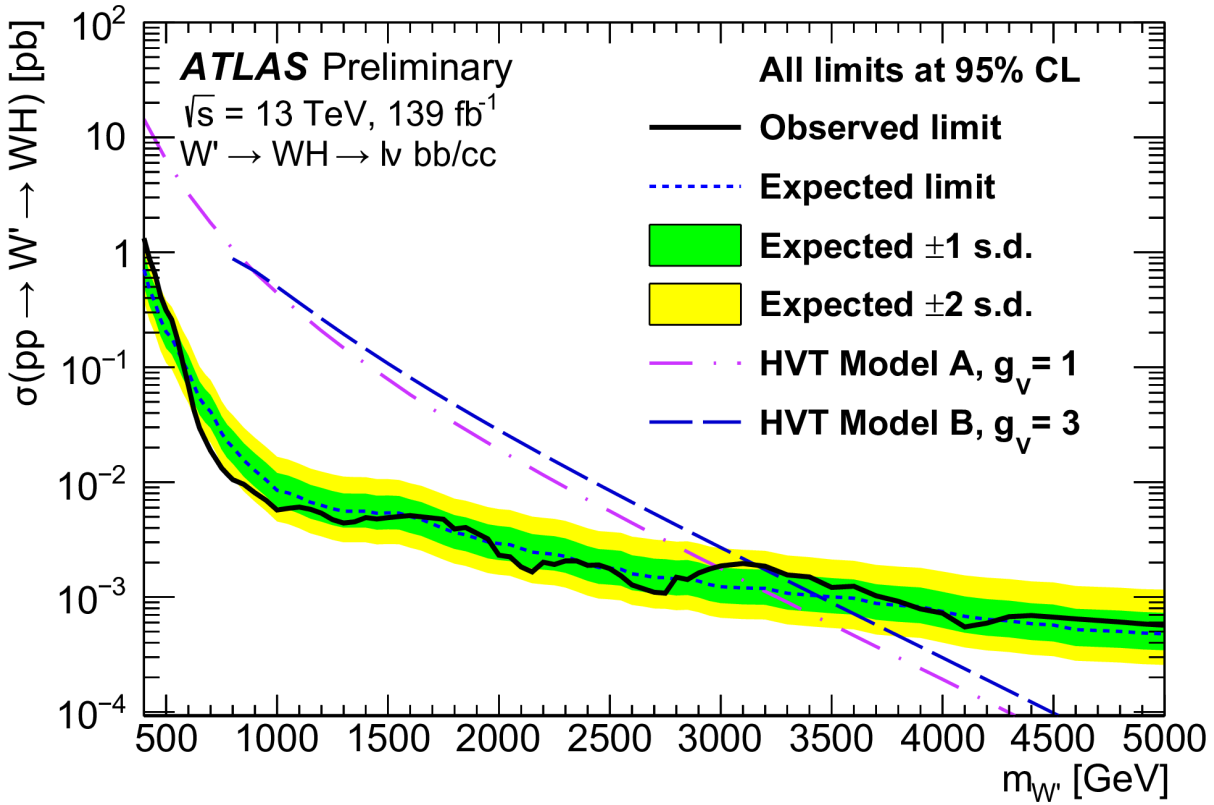








Conclusions



No significant excess observed above SM predictions. Upper limits set on the cross section

- *W'* masses below 2.95 TeV excluded for HVT Model A and 3.15 TeV excluded for Model B
- The improvements on limits range from ~200% for a resonance mass of 400 GeV to ~350% for a mass of 5 TeV, compared with last publication with partial (36.1/fb) Run2 dataset

Back Up

Data and MC samples

Full Run2 dataset used

Process	Generator	Prediction order of σ_{prod}
$W \to \ell\nu, Z \to \ell\ell, Z \to \nu\nu$	Sherpa 2.2.1	NNLO
$t\bar{t}$	Powheg + Pythia8	NNLO+NNLL
single top ($s/t/Wt$-channel)	Powheg + Pythia8	NLO
$t\bar{t} + h$	MG5_aMC@NLO + Pythia8	NLO (QCD) and NLO (EW)
$t\bar{t} + V$	MG5_aMC@NLO + Pythia8	NLO
$qg/q\bar{q} \to VV \to \ell\ell/\ell\nu/\nu\nu + q\bar{q}$	Sherpa 2.2.1	NLO
$gg \to VV \to \ell\ell/\ell\nu/\nu\nu + q\bar{q}$	Sherpa 2.2.2	NLO
$qg/q\bar{q} \to \ell\ell\nu\nu$	Sherpa 2.2.2	NLO
$qq \to Wh \to \ell\nu + b\bar{b}$	Powheg + Pythia8	NNLO (QCD) and NLO (EW)
$qq \to Zh \to \ell\ell/\nu\nu + b\bar{b}$	Powheg + Pythia8	NNLO (QCD) and NLO (EW)
$gg \to Zh \to \ell\ell/\nu\nu + b\bar{b}$	Powheg + Pythia8	NLO+NLL

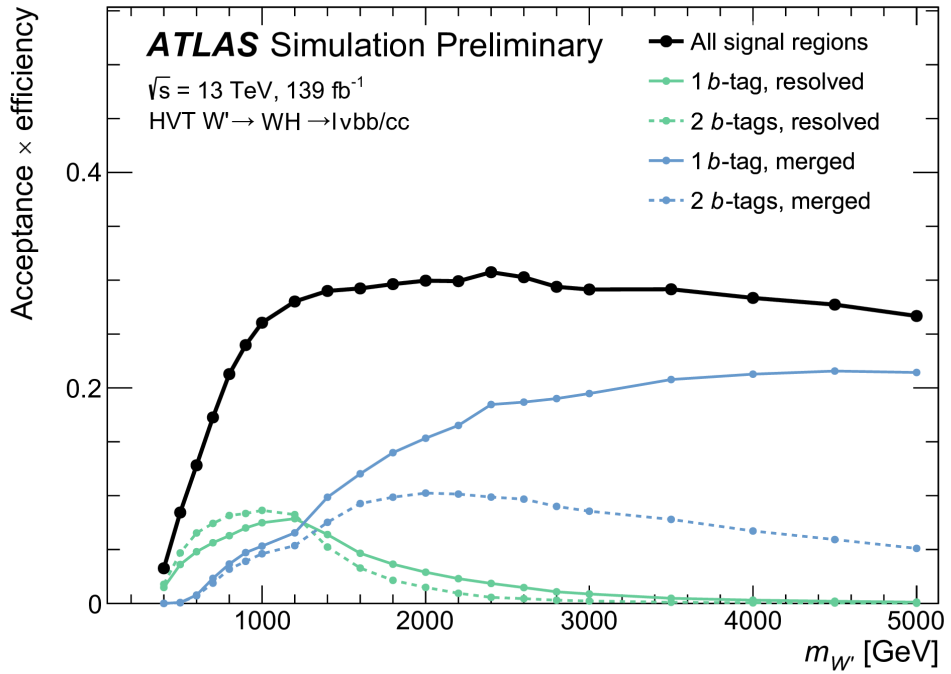
Event selection

Variable	Resolved	Merged
Common selection		
Number of jets	≥2 small-R jets (0, 2-lep.) 2 or 3 $R = 0.4$ jets (1-lep.)	≥1 large-R jet
Leading jet p_{T} [GeV]	> 45	> 250
m_H [GeV]	110–140 (0,1-lep.), 100–145 (2-lep.)	75–145
0-lepton selection		
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 150	> 200
H_T [GeV]	> 150 (120^{*})	–
$\Delta\phi_{bb}$	$< 7\pi/9$	–
$p_{\mathrm{T}}^{\mathrm{mis}}$ [GeV]	$> 30^{\ddagger}$	
$\Delta\phi(\vec{E}_{\mathrm{T}}^{\mathrm{mis}}, \vec{p}_{\mathrm{T}}^{\mathrm{mis}})$	$< \pi/2$	
$\Delta\phi(\vec{E}_{\mathrm{T}}^{\mathrm{mis}}, H)$	$> 2\pi/3$	
$\min\left[\Delta\phi(E_{\mathrm{T}}^{\mathrm{miss}}, R = 0.4\text{jet})\right]$	$> \pi/9$ (2 or 3 jets), $> \pi/6$ (≥ 4 jets)	
$N_{\tau_{\mathrm{had}}}$	0^{**}	
1-lepton selection		
Leading lepton p_{T} [GeV]	> 27	> 27
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 40 ($80^{\dagger}$)	> 100
$p_{\mathrm{T},W}$ [GeV]	$> \max\left[150,\ 710 - (3.3 \times 10^5\ \mathrm{GeV})/m_{Vh}\right]$	$> \max\left[150,\ 394 \cdot \ln(m_{Vh}/(1\ \mathrm{GeV})) - 2350\right]$
$m_{\mathrm{T},W}$ [GeV]	< 300	
2-lepton selection		
Leading lepton p_{T} [GeV]	> 27	> 27
Sub-leading lepton p_{T} [GeV]	> 20	> 25
$E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$ [$\sqrt{\mathrm{GeV}}$]	$< 1.15 + 8 \times 10^{-3} \cdot m_{Vh}/(1\ \mathrm{GeV})$	
$p_{\mathrm{T},\ell\ell}$ [GeV]	$> 20 + 9 \cdot \sqrt{m_{Vh}/(1\ \mathrm{GeV}) - 320}^{\dagger\dagger}$	
$m_{\ell\ell}$ [GeV]	$[\max[40\ \mathrm{GeV},\ 87 - 0.030 \cdot m_{Vh}/(1\ \mathrm{GeV})],\ 97 + 0.013 \cdot m_{Vh}/(1\ \mathrm{GeV})]$	

Event selections in 3 channels

Event selection

For 1- lepton, the final discriminant is the invariant mass of the *VH* system



Selection performance of signal in 1L (top) and 2L (bottom) channel

Fit results and post-fit distributions

	Electron	Muon
MJ events	397.03 ± 476.44	3677.48 ± 435.72
MJ fraction	0.35% ± 0.42%	2.11% ± 0.25%

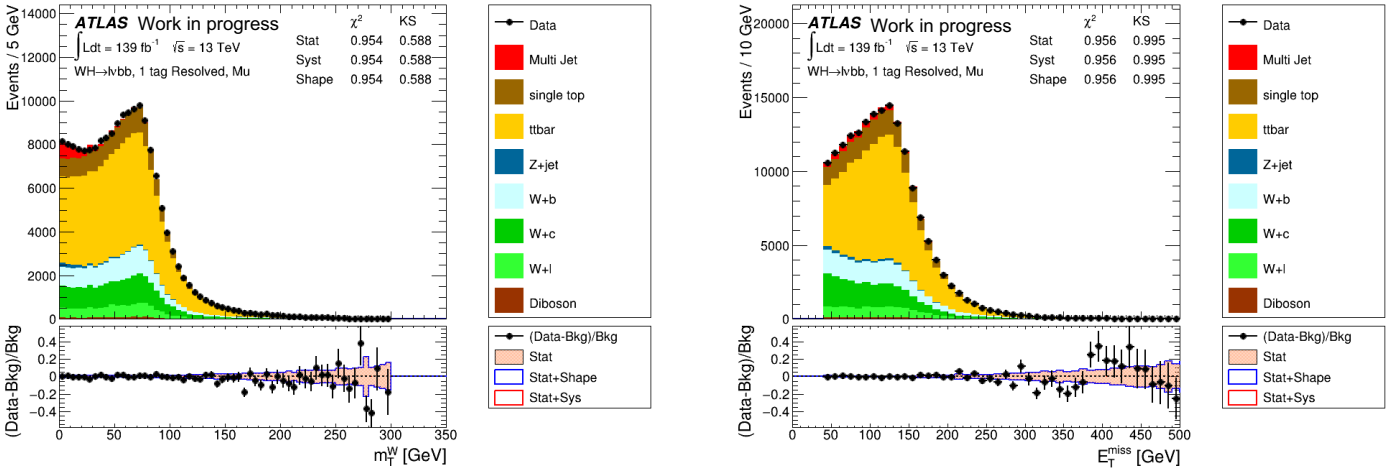
Fit 2 components to data:

- MJ and sum of EW bkg
- both floating

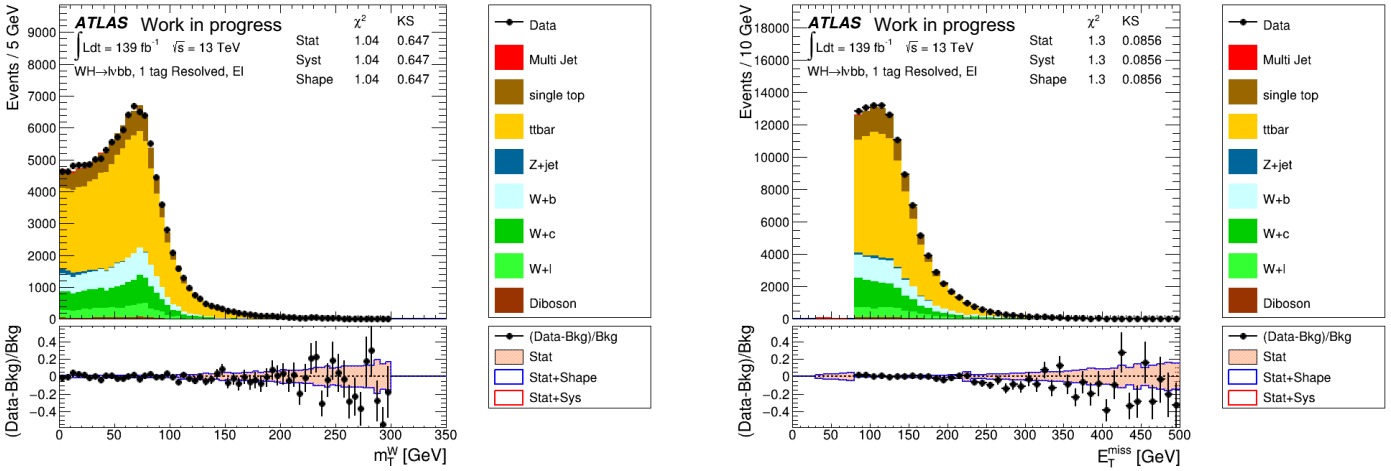
Binning: 40 GeV / bin

Fit range: 0 – 300 GeV

Stable fit has been gotten

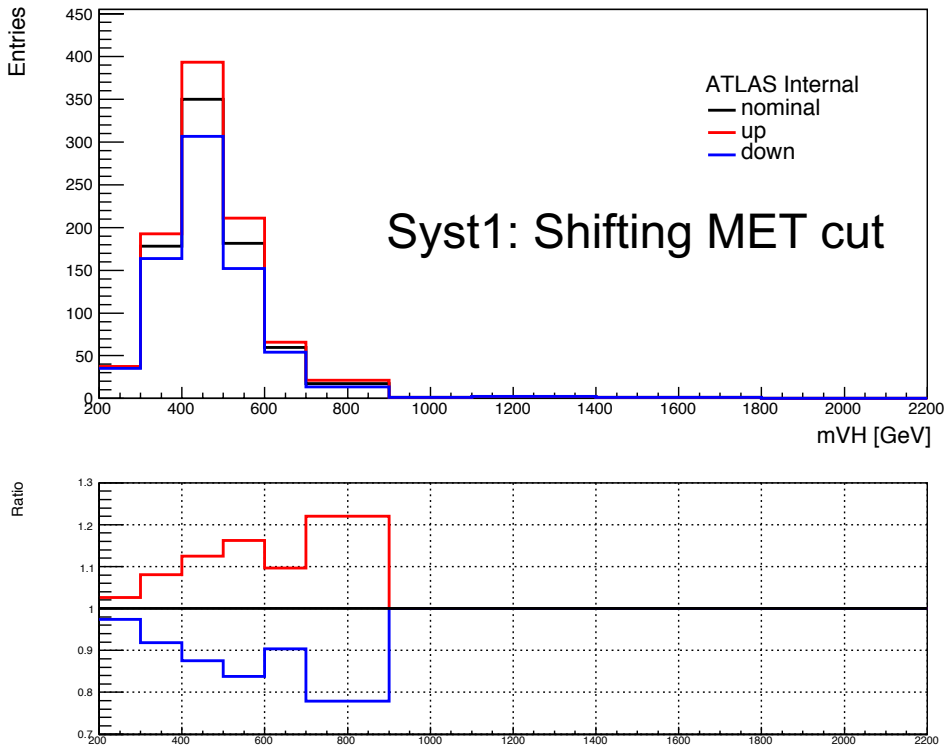


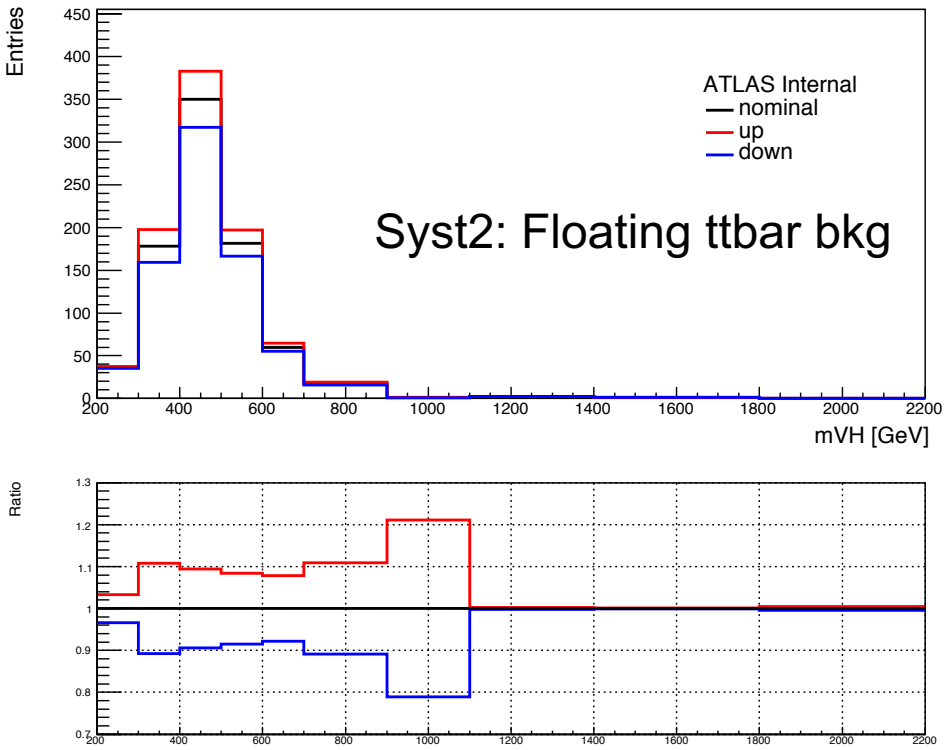
Muon channel



Electron channel

Systematic uncertainties in MJ estimation





- 2 kinds of systematics were derived:

1> Shifting MET cut by 25% up and down;

2> Floating ttbar background by 10% up and down.