Search for heavy resonance decaying to *WH* in *lvbb* final state in 139 fb^{-1} of *pp* collisions at $\sqrt{s}$ = 13 TeV with ATLAS

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1. Introduction

- A search for resonance W' decaying into a W boson and a SM Higgs boson in the $l\nu bb$ final state ($l = e$ or μ) is performed, using the full Run 2 dataset collected by ATLAS.
- This analysis is conducted by examining the reconstructed invariant mass distributions of $W' \to WH$ candidates in the mass range from 400 GeV to 5 TeV.
- $H \to bb$ for enlarging the statistics. $W \to l\nu$ for triggering and selecting signal events efficiently.

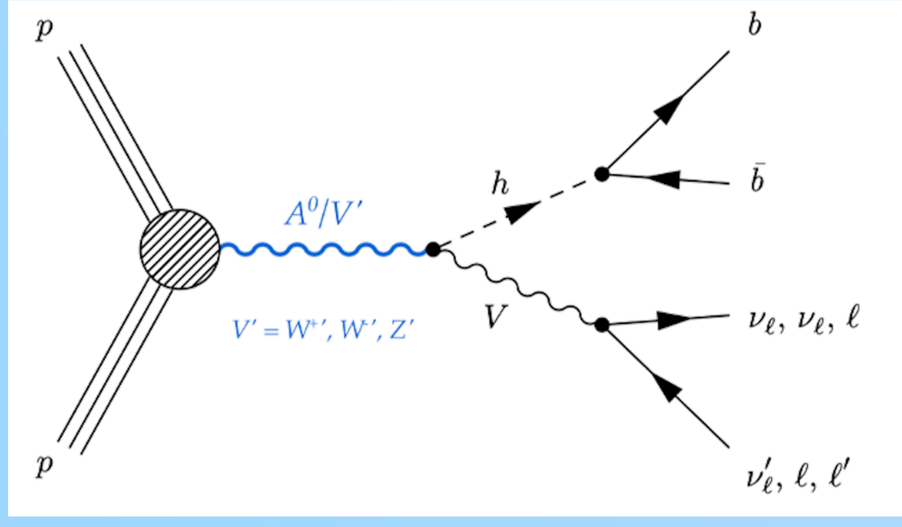

Fig 1: An illustrative diagram

2. Event categorization and selection

Two regimes for event categorization:

- resolved (two small-R jets);
- merged (one large-R jet), for high Higgs momentum.

"Priority Resolved signal region (PRSR)" scheme used.

Variable	Resolved	Merged
Number of jets	≥2 central small-R jets	≥1 large-R jet ≥ 2 VR track jets (matched to leading large-R jet)
Leading jet p_T [GeV]	> 45	> 250
m_{jj}/m_J [GeV]	110–140	75–145
Leading lepton p_T [GeV]	> 27	> 27
E_T^{miss} [GeV]	> 80 (40†)	> 100
$p_{T,W}$ [GeV]	$> \max\left[150,\ 710 - (3.3\times10^5\ \text{GeV})/m_{WH}\right]$	$> \max\left[150,\ 394\cdot\ln(m_{WH}/(1\ \text{GeV})) - 2350\right]$
$m_{T,W}$ [GeV]	< 300	

Tab 1: Event selection

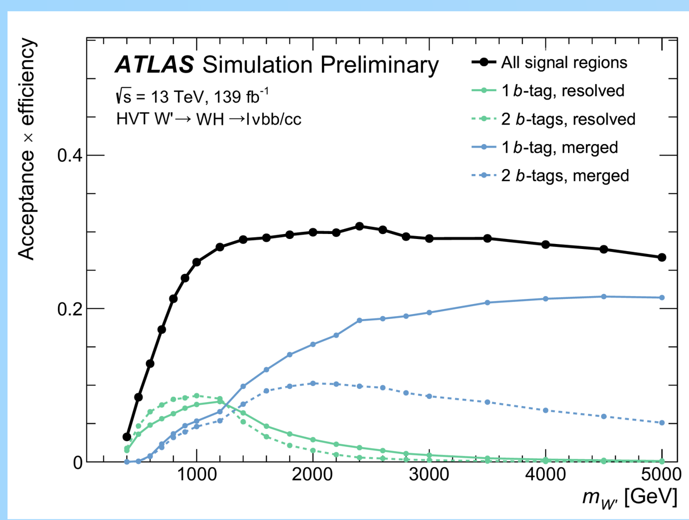

Fig 2: Signal selection efficiencies

3. Background estimation

- The background processes are estimated by Monte Carlo (MC) simulation except the multi-jet (MJ).
- MJ estimation is performed with data-driven method because MC suffered from limited statistics and difficult modeling. This method exploits the isolation of leptons to select a data sample enriched in MJ.

	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

Tab 2: Isolated and non-isolated region

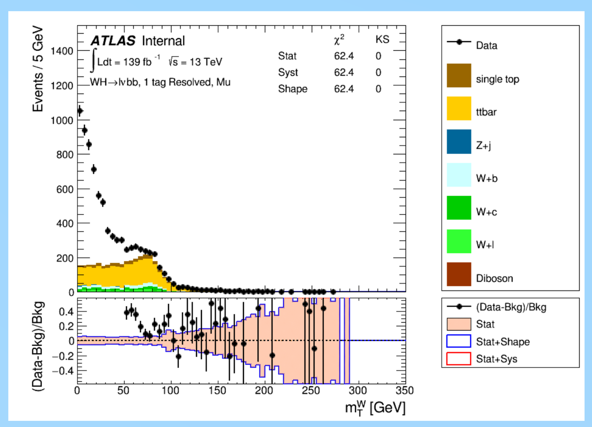

Fig 3: MJ control region

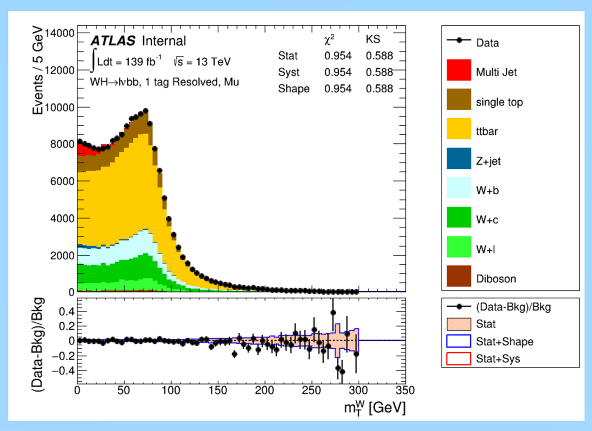

Fig 4: Post-fit distributions, the red histogram indicates the MJ contribution

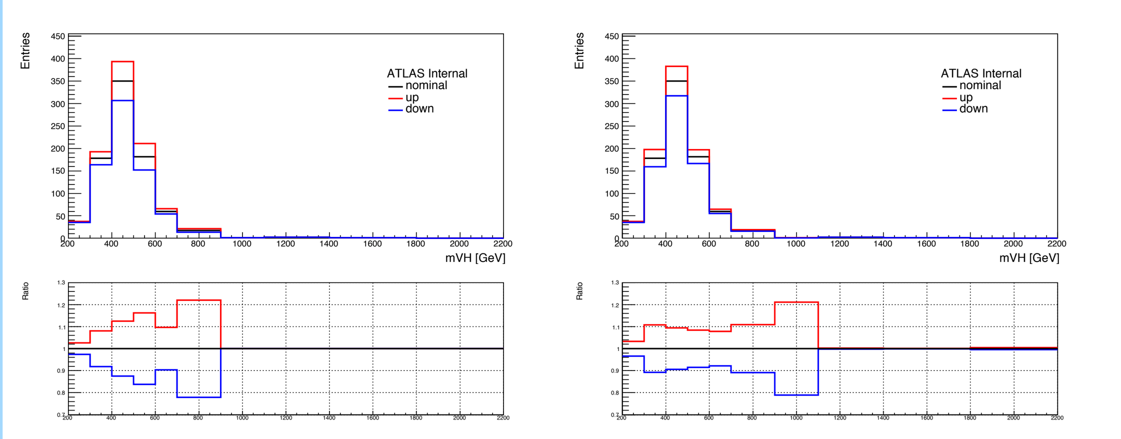

Fig 5 and 6: Shape systematic uncertainties for MJ estimation

4. Statistical analysis

To test the resonance, the templates m_{WH} from the signal and background samples are fit to data using a binned maximum-likelihood approach, where the binning is optimized to maximize the sensitivity while minimizing the impact of statistical fluctuations.

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

	Resolved		Merged	
	1 b-tag SR	2 b-tag SR	1 b-tag SR	2 b-tag SR
Top	86911 ±753	18272±111	26215±217	1100±29
Z+hf	80±19	58±12	22±4.5	11±2
Z+hl	561±110	6±1	107±17	1±0
Z+l	117±28	1±0	38±15	0
W+hf	2674±168	1344±76	1120±56	547±28
W+hl	21439±816	126±9	5275±214	29±3
W+l	2706±443	2±1	1240±142	3±1
Diboson	235±30	24±3	370±38	49±5
SM VH	143±16	182±19	31±3	25±2
Multijet	324±81	-	-	-
Total	115190±282	20015±86	34418±123	1765±27
Data	115145	20017	34403	1771

Tab 3 and 4: Regions and the post-fit yields

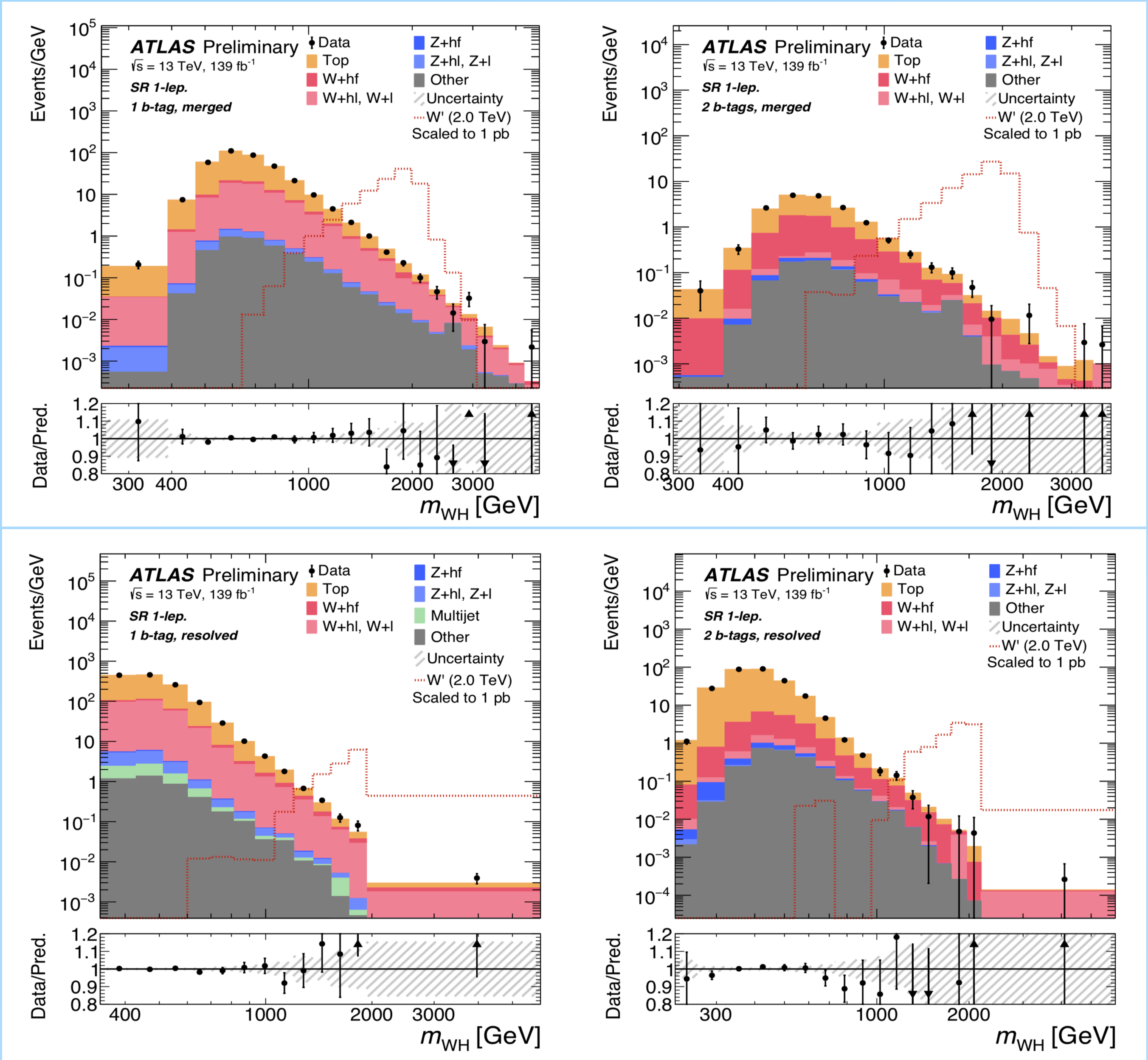

Fig 7: Post-fit distributions in merged (top) and resolved (bottom) regions

5. Conclusion

- ✓ No significant excess is observed above the SM prediction, and upper limits are set on the production cross-section for $pp \to W'$ times the branching fraction for $W' \to WH$.
- ✓ W' masses below 2.95 TeV are excluded for the HVT benchmark Model A [1]; for Model B [1] W' masses below 3.15 TeV are excluded.
- ✓ The cross-section limits improve on the results from the last publication with Run 2 dataset of 36.1 fb^{-1} in ATLAS [2]. The improvements range from about 200% for resonance mass 400 GeV to about 350% for a mass of 5 TeV.
- ✓ The paper is in preparation.

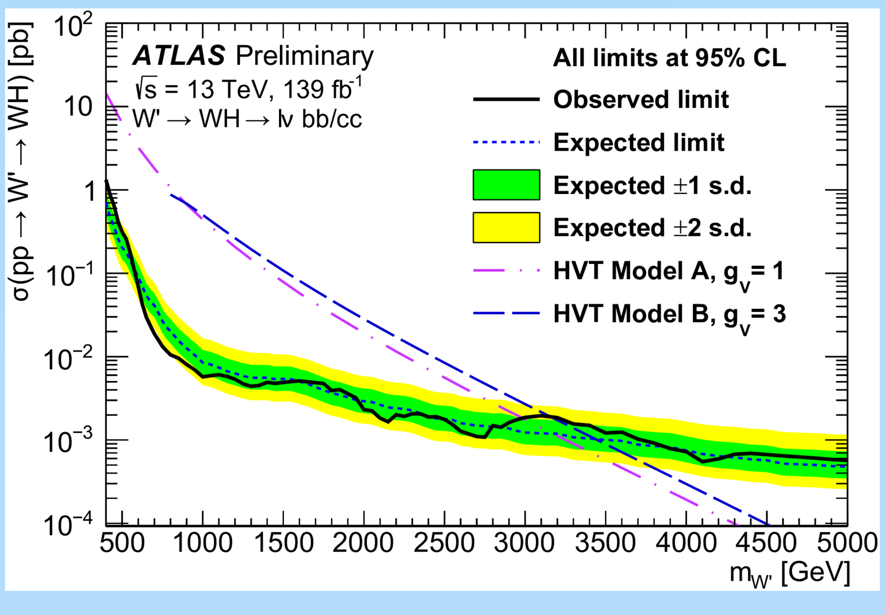

Fig 8: Expected and observed upper limits at 95% CL on the production cross-section for $pp \to W' \to WH$

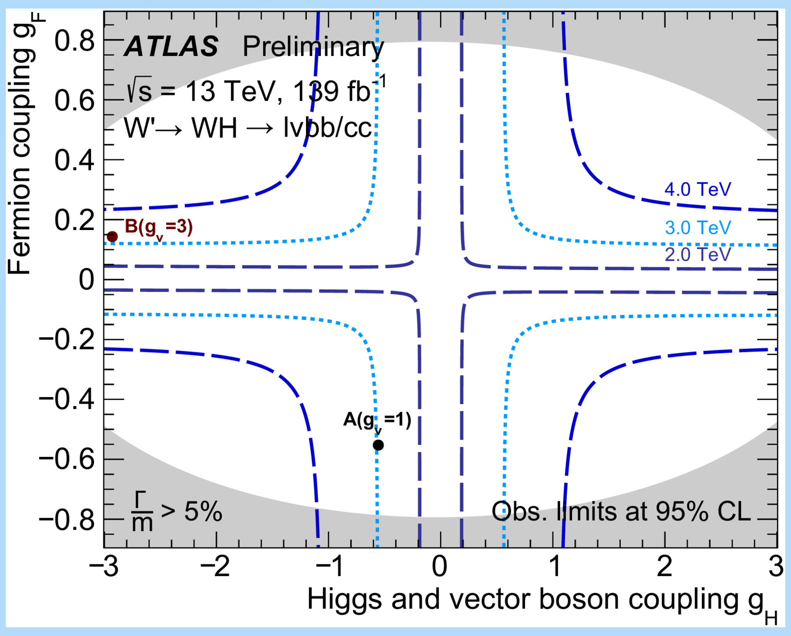

Fig 9: Observed limits on HVT Model at 95% CL in the g_F vs. g_H plane for W' masses of 2, 3 and 4 TeV

6. References

[1] arXiv: 1402.4431 [hep-ph].
[2] arXiv: 1607.05621 [hep-ex].

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