Search for heavy resonances decaying into a W boson and a Higgs boson in final states with leptons and b-jets in 139 fb^{-1} of *pp* collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector

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Introduction

- Several new physics models predict **heavy W' resonances**. The search is performed in the **"semi-leptonic" final state**, where the Higgs boson is required to decay hadronically and the W boson leptonically. The analysis requires the presence of exactly one reconstructed electron, muon, or leptonically decaying tau lepton and missing transverse energy. The analysis is split into one **merged** (one large-R jet H->J) and one **resolved** (two small-R jets H->jj) regime, each additionally split into **one and two b-tag** regions. The search is conducted by examining the reconstructed invariant mass distributions of **W' → WH candidates** for a localized excess in the mass range from 400 GeV to 5 TeV.

- This poster presents a **new result**[1] searching for a **W' resonance** with data collected by the ATLAS experiment at the LHC from 2015-2018, corresponding to an integrated luminosity of 139 fb^{-1} in the *pp* collisions at $\sqrt{s}$ = 13 TeV.

1 CONF-HDBS-2021-06

Analysis Update

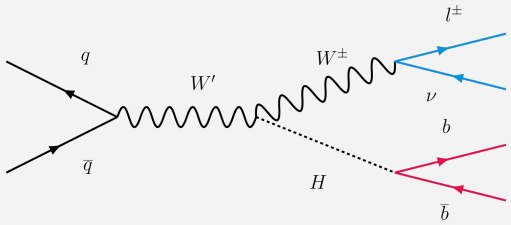
Compared to the previous publication with 36.1 fb^{-1} *(JHEP03(2018)174)*, several improvements are implemented in this analysis:

- **Track-CaloCluster**[1] (TCC) jets introduced for large-R jets.
- **Variable-Radius**[2] (VR) track jets introduced for flavor tagging in merged regime.
- **New** lepton isolation requirements.
- Full **Run II** 139 fb^{-1} dataset.

1 ATL-PHYS-PUB-2017-015
2 ATL-PHYS-PUB-2017-010

Theory

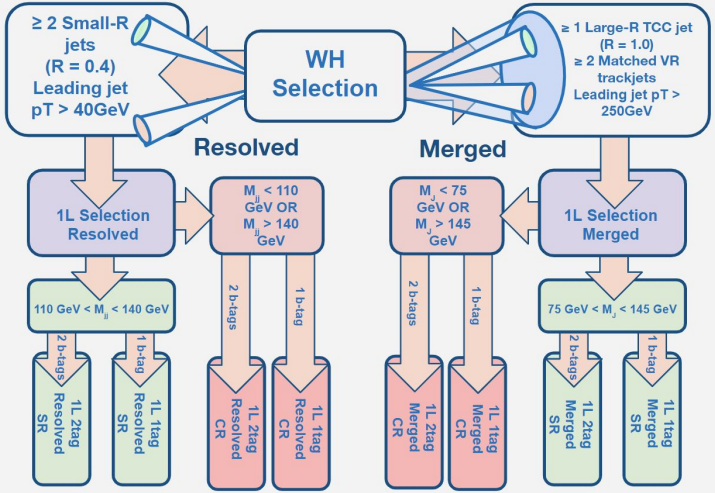
- Open questions remain related to EW symmetry breaking, particularly the **naturalness problem.**
- Various models of dynamical EW symmetry breaking attempt to solve the naturalness problem by assuming **new interactions at a high energy scale.**
- Generically predict **new vector resonances** that **decay into a Higgs boson and a vector boson.**
- Resonance searches not sensitive to all underlying parameters of a model -- use simplified models such as **Heavy Vector Triplet (HVT)** models that add an additional SU(2) field to the SM and provide a **restricted number of new couplings.**



Analysis Strategy

Event Selection

- Exactly one isolated **Muon** or **Electron**
- Lepton p_T threshold -- matched to single lepton trigger for **electrons**
- E_T^{miss} threshold -- **reduce multijet**
- M_{WH} dependent p_T^W cut
- $M_{T,W}$ threshold -- **improve W candidate quality**



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]	> 40 (80†)	> 100
$p_{T,W}$ [GeV]	$> \max\left[150,\ 710 - (3.3 \times 10^5\ \text{GeV})/m_{WH}\right]$	$> \max\left[150,\ 394 \cdot \ln(m_{WH}/(1\ \text{GeV})) - 2350\right]$
$m_{T,W}$ [GeV]	< 300	

(†) indicates the electron channel, the non-indexed value the muon

Fitting

Fitting Procedure: Fit M_{WH} distributions to measure signal strength with varying HVT W' mass points using binned maximum likelihood fit

- Four signal regions (SR) and four control regions (CR)

Background Model:

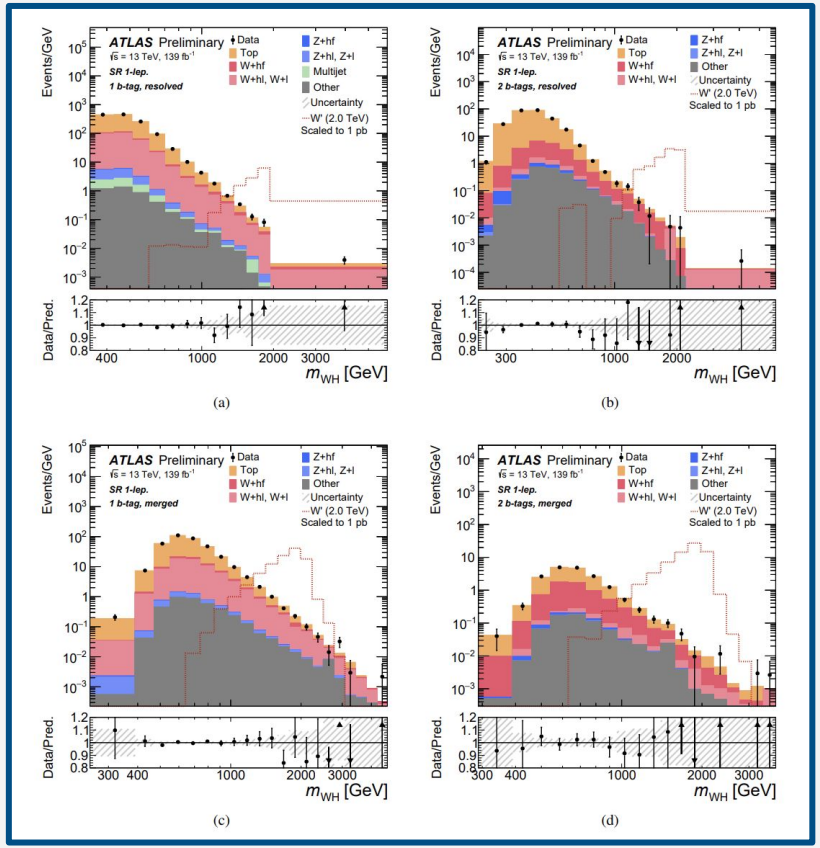
- Top-quarks, W/Z+jets (MC)
- SM Diboson (MC)
- Multijet (data-driven, template method)

Dominant Systematics:

- **Theory uncertainties** relating to parton shower matching as well as **p_T^W modeling uncertainties** dominant at low to intermediate W' masses
- **Large-R jet p_T modeling uncertainties** and **data statistics** dominant at high W' masses

Signal Morphing:

- HVT masses between simulated points are interpolated using a Moment Morphing procedure[1]



1 arxiv.org/abs/1410.7388

Results

HVT Model A: Branching fractions to fermions and gauge bosons are comparable, as in some models with an extended gauge symmetry

HVT Model B: Fermionic couplings are suppressed, as in strong dynamical models such as the minimal composite Higgs model

Couplings[1]: Higgs and SM vector boson $g_H = g_V c_H$ **Fermion** $g_F = g^2 c_F / g_V$

No significant excess is observed. 95% CL Upper Limits on σ(pp->W'->WH):

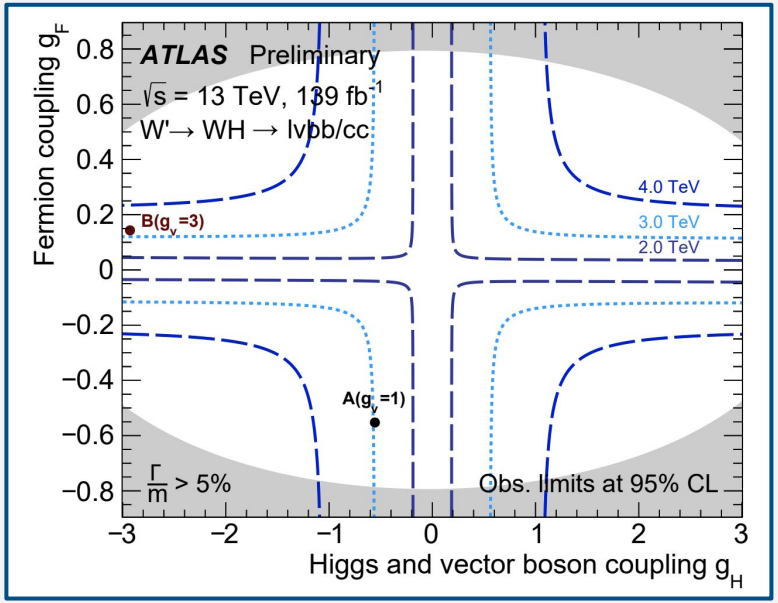
$M_{W'}$= 400 GeV: 1.3 pb

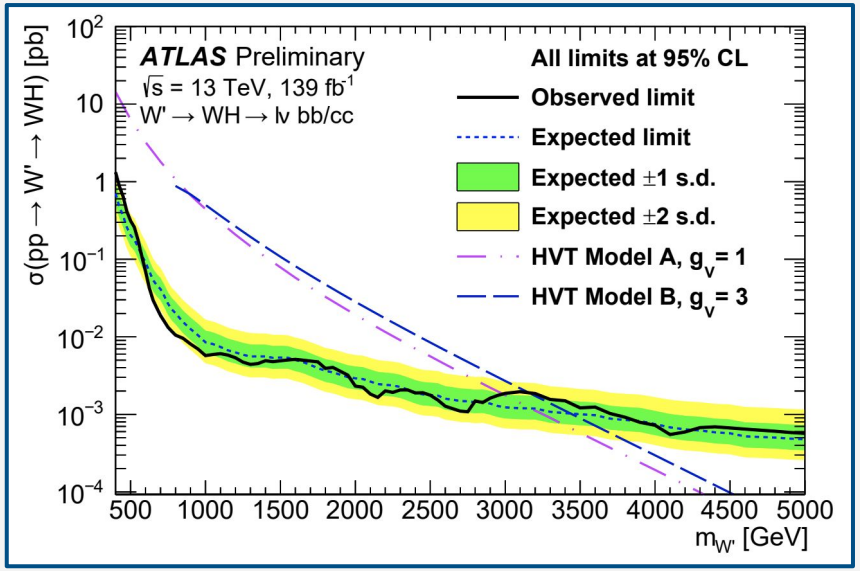
$M_{W'}$= 5 TeV: 0.56 fb

Exclusions:

Model A: W' < 2.95 TeV Previous Publication Model A: W' < 2.67 TeV

Model B: W' < 3.15 TeV Previous Publication Model B: W' < 2.82 TeV





1 Defined in terms of the couplings in https://arxiv.org/abs/1402.4431