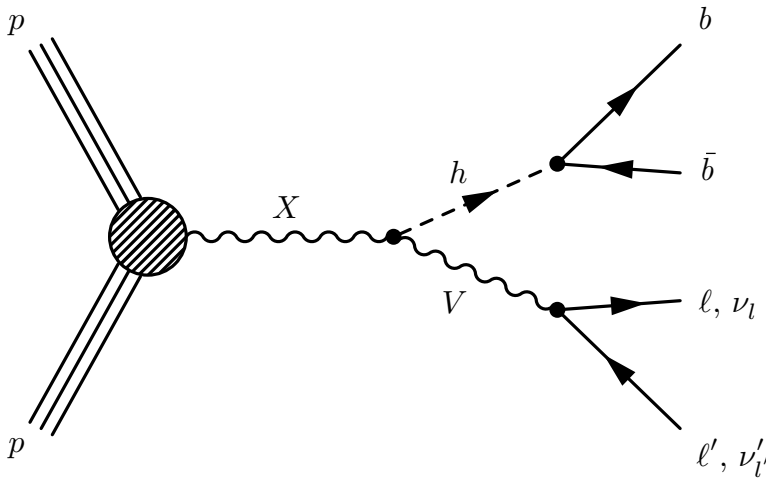
A data-driven QCD background estimation for heavy *Wh* searches in the $\ell\nu b\bar{b}$ final state in ATLAS



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supverised by Felix Müller

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(Werner-Heisenberg-Institut)

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Bundesministerium für Bildung und Forschung

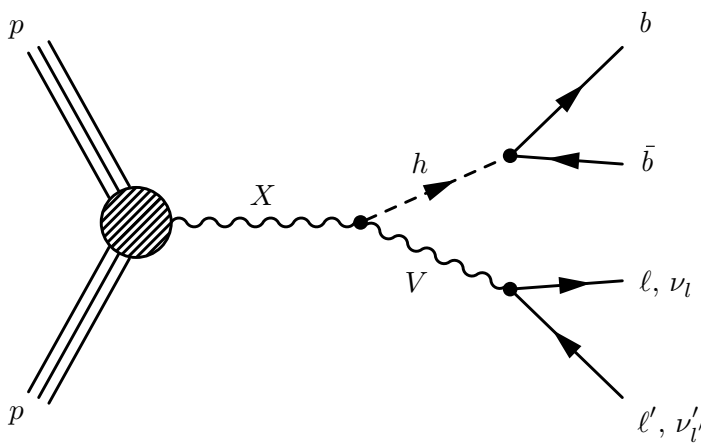
ATLAS EXPERIMENT

FSP 103 ATLAS

MAX-PLANCK-GESELLSCHAFT

What is this search about?

- Heavy **diboson resonance**
- Physics beyond the Standard Model
- Test **benchmark models**:
  - **spin-0**: **heavy H** in extended Higgs sector
  - **spin-1**: W'/Z' in **HVT**, A^0 in **2HDM**
  - **spin-2**: **Randall-Sundrum** KK Graviton



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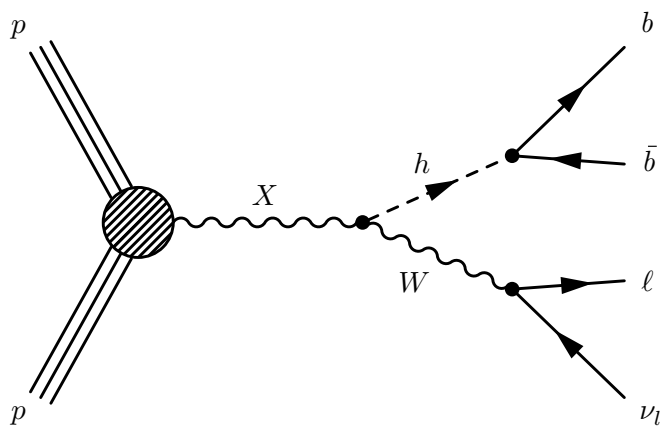
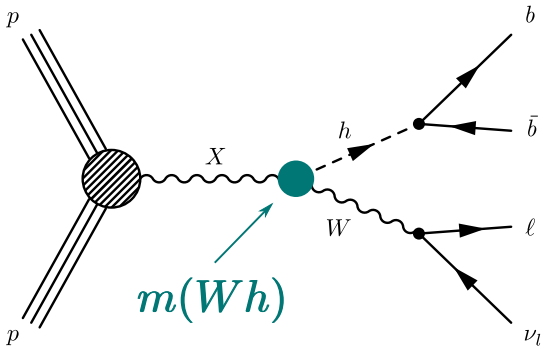


Characteristics

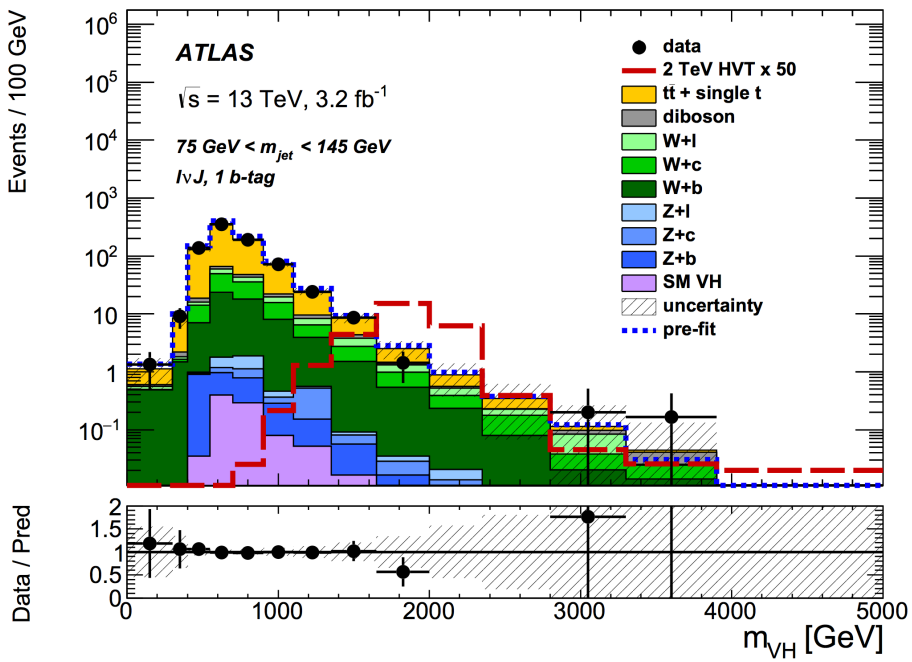


Discriminating variable:

- Mass of the diboson system
- labelled m_{VH} or $m(Wh)$

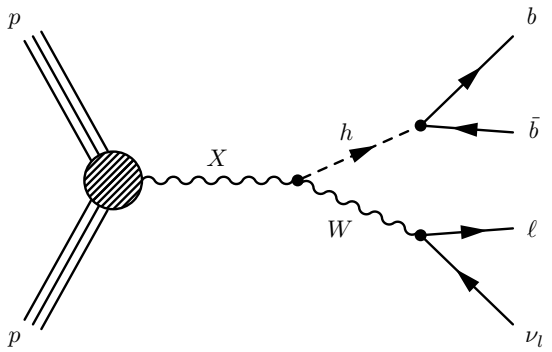
Event selection:

- Exactly 1 lepton
  - well reconstructed (identified)
  - well-isolated
- Neutrino $\Rightarrow E_T^{miss}$
- Heavy resonance $\Rightarrow$ high p_T^V
- Jets
  - 2 small-R (resolved)
  - 1+ large-R (merged)
  - find 1 or 2 b tags
  - define SR for $m_{jet(s)} \approx m_h$



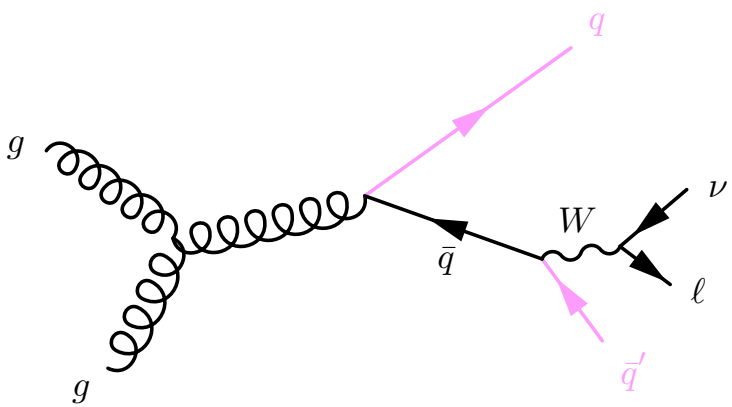
[arxiv:1606.04833]

Multijet background (representative diagrams)

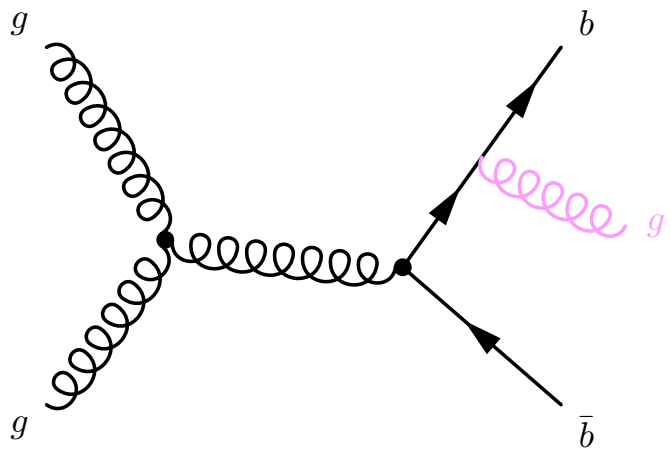


- Multijet (MJ) source: QCD processes
- Most prominent events in pp collisions
- Cannot be simulated in this analysis

Weak decay in jet



Light jet fakes e

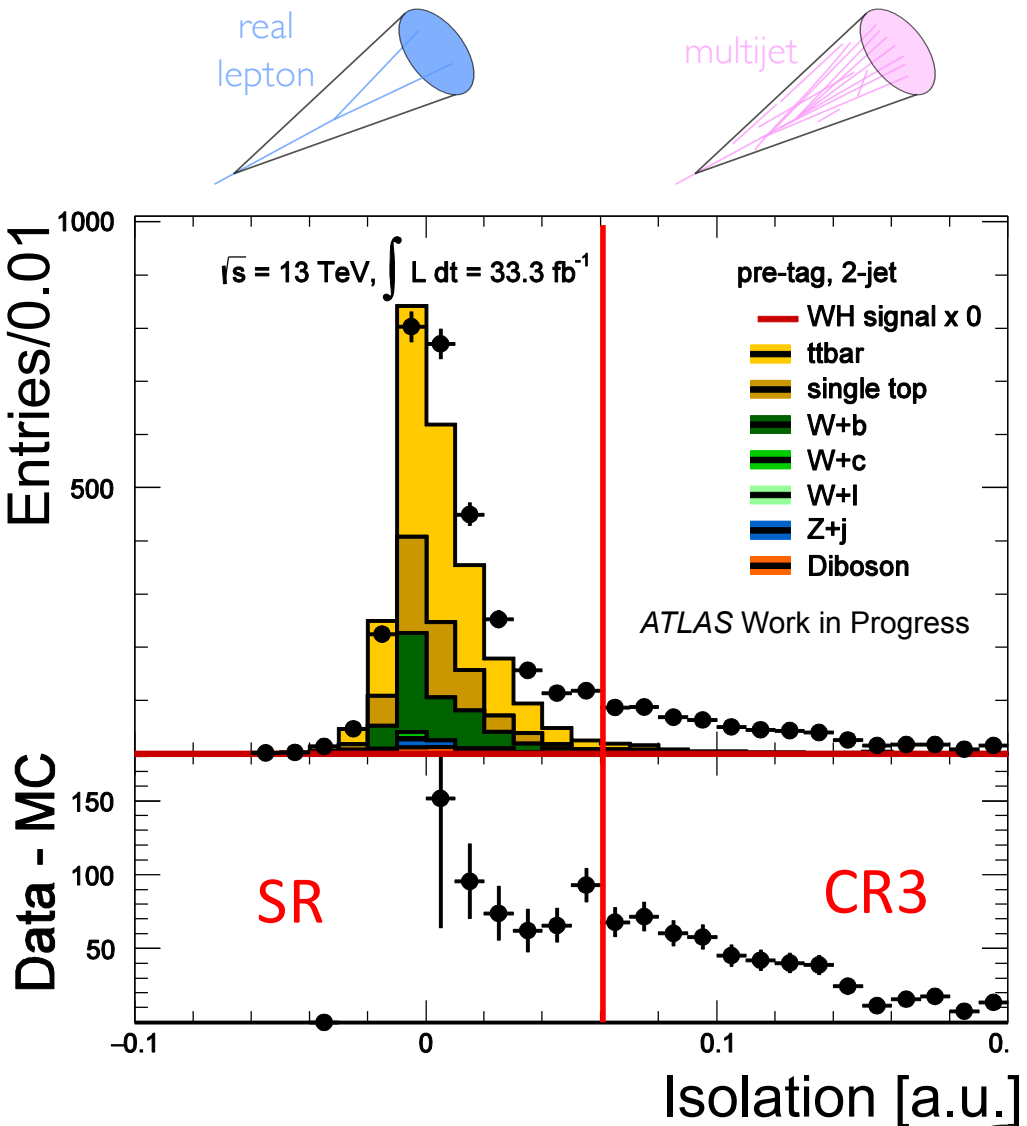


How to find the right control region

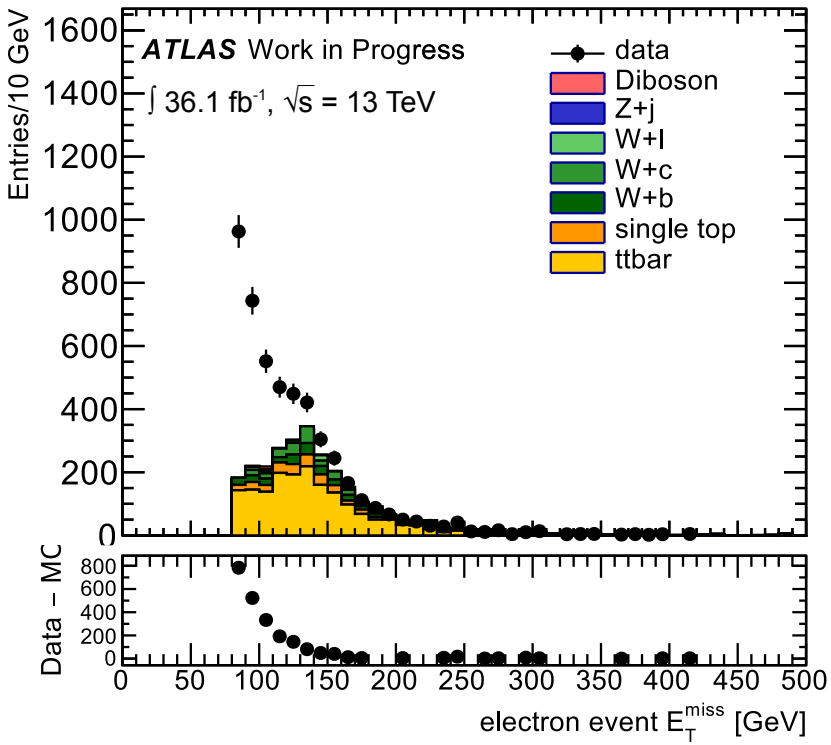
A good control region is

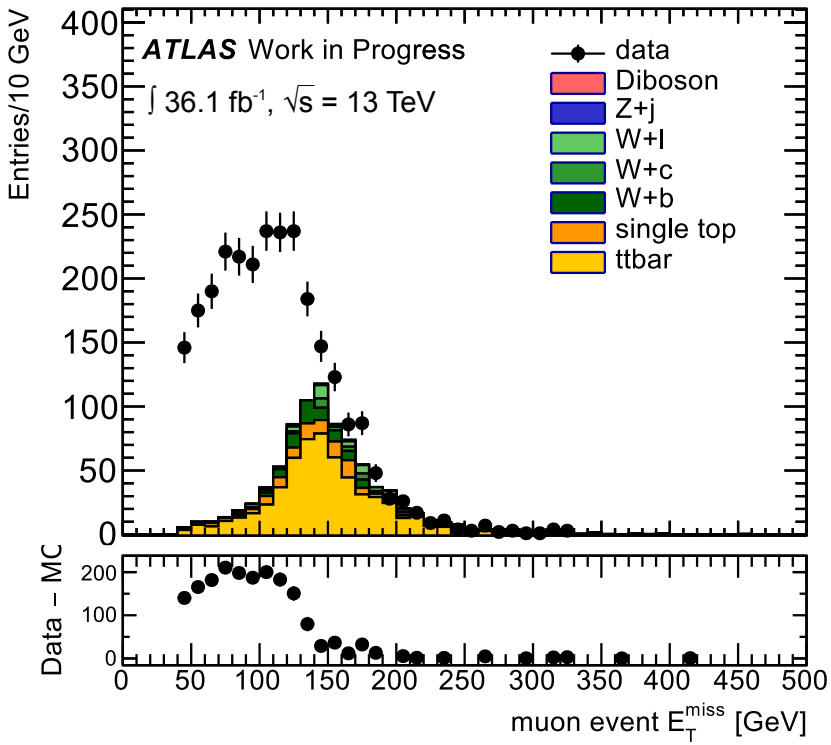
- ▷ similar to signal region
- ▷ free of signal
- ▷ multijet-enriched

→ invert lepton isolation requirement



Shape estimate in the CR

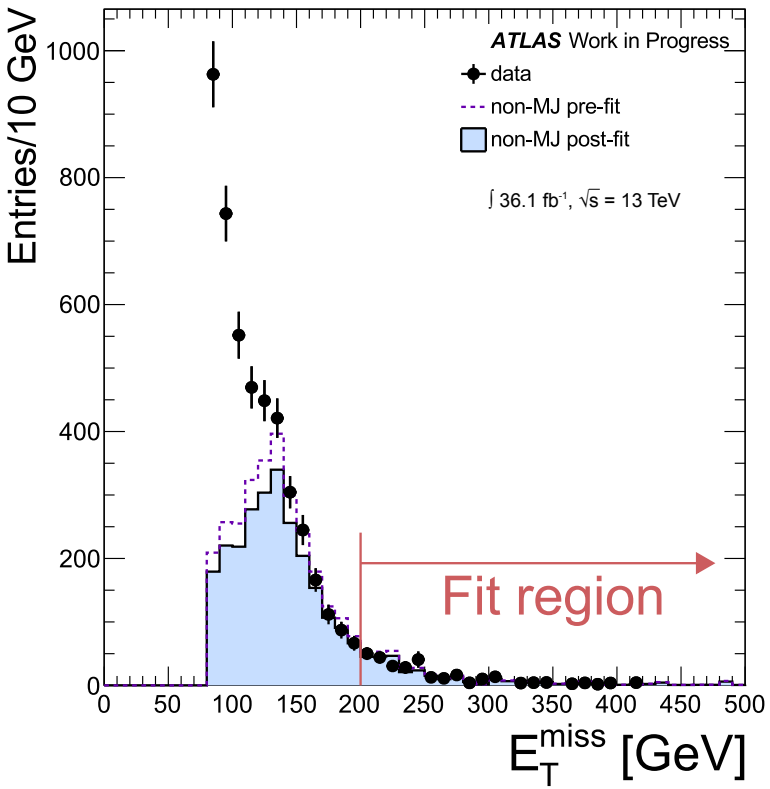




Shape ≡ Data − MC

(Plot shows all events with 1 b tag and **50 GeV** $< m_{\mathrm{bb}} <$ **200 GeV**.)

Correct non-MJ mismodellings



Okay…one caveat:

- ▷ Imperfect modelling in non-isolated region
  - In particular: **Normalisation**
- ▷ No multijet for high E_T^{miss} motivated

→ Fit E_T^{miss} tail

The best way to normalise

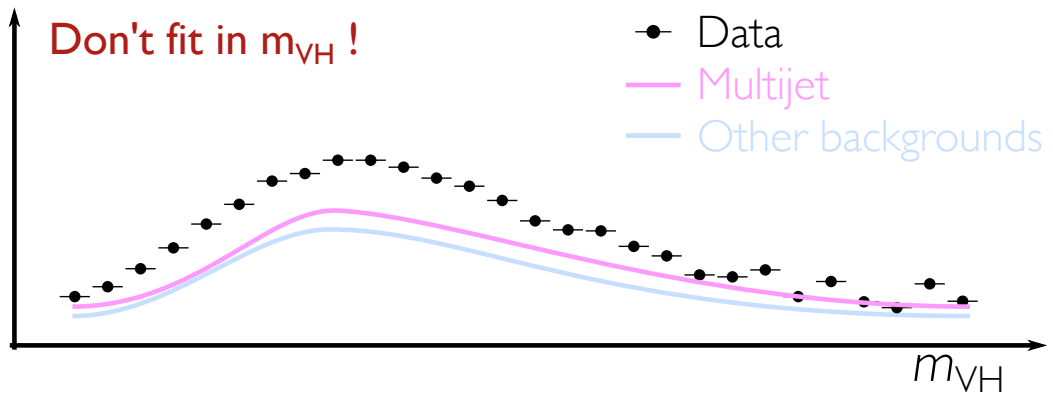
MJ SHAPE

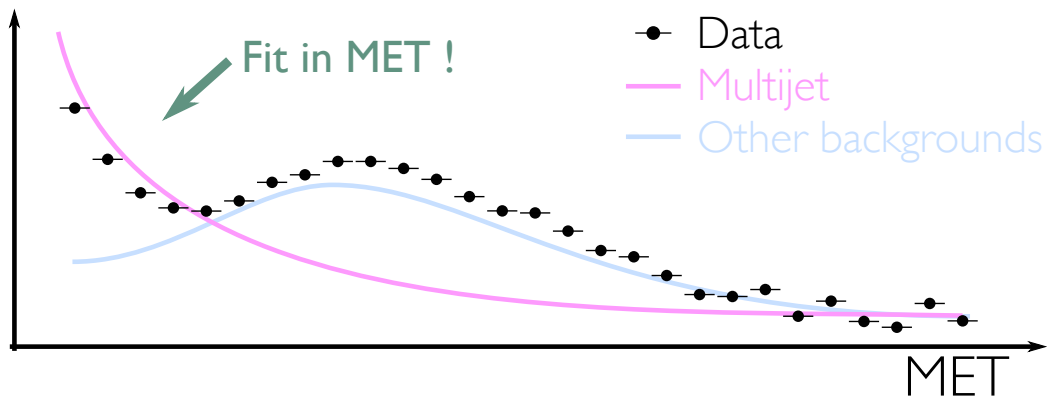
FROM CR

NORMALISATION FROM FIT

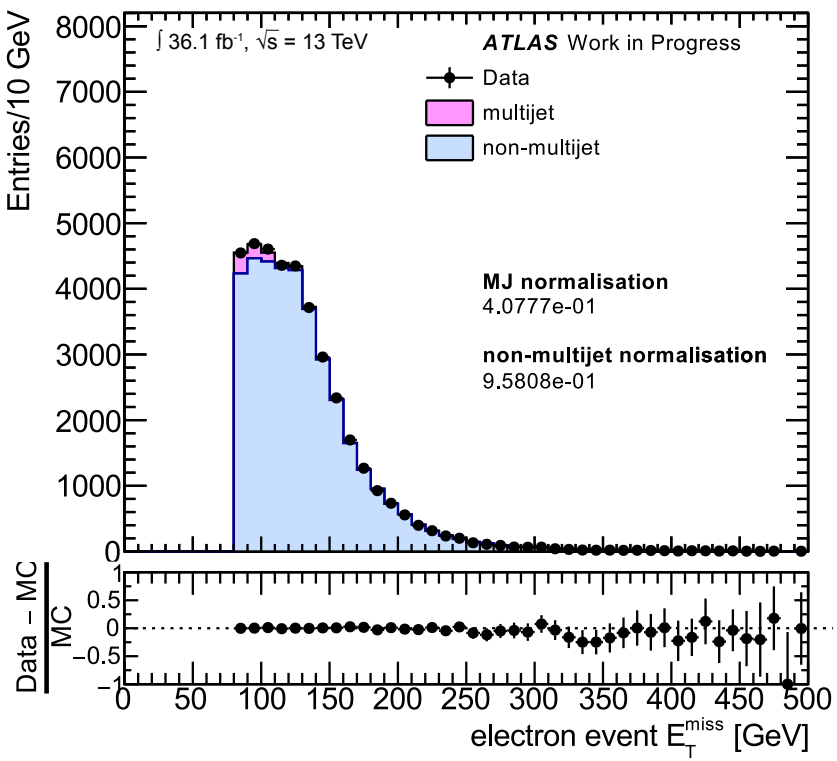
MJ ESTIMATE

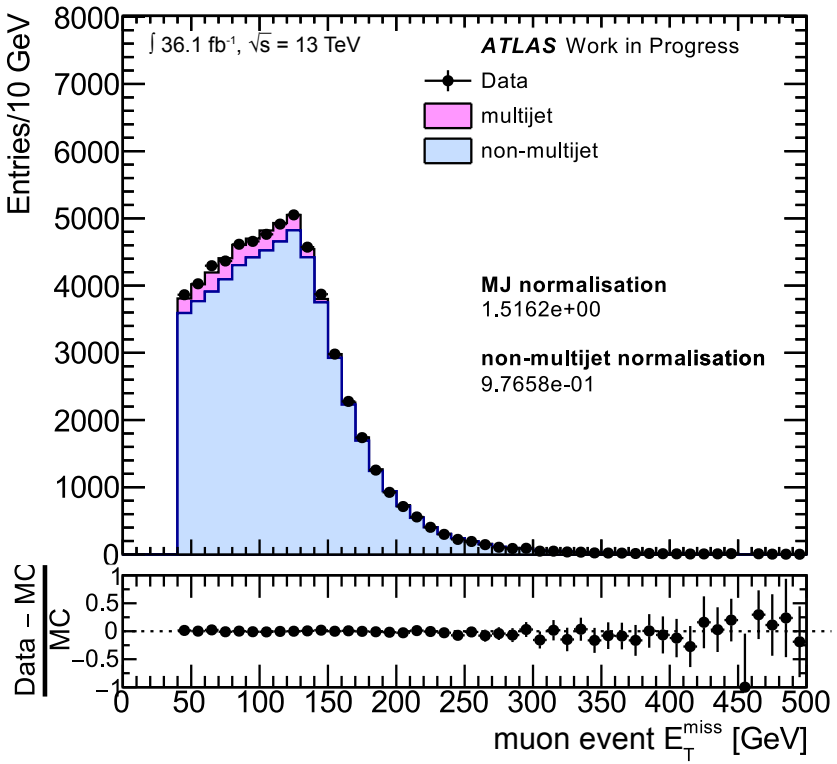
IN SR



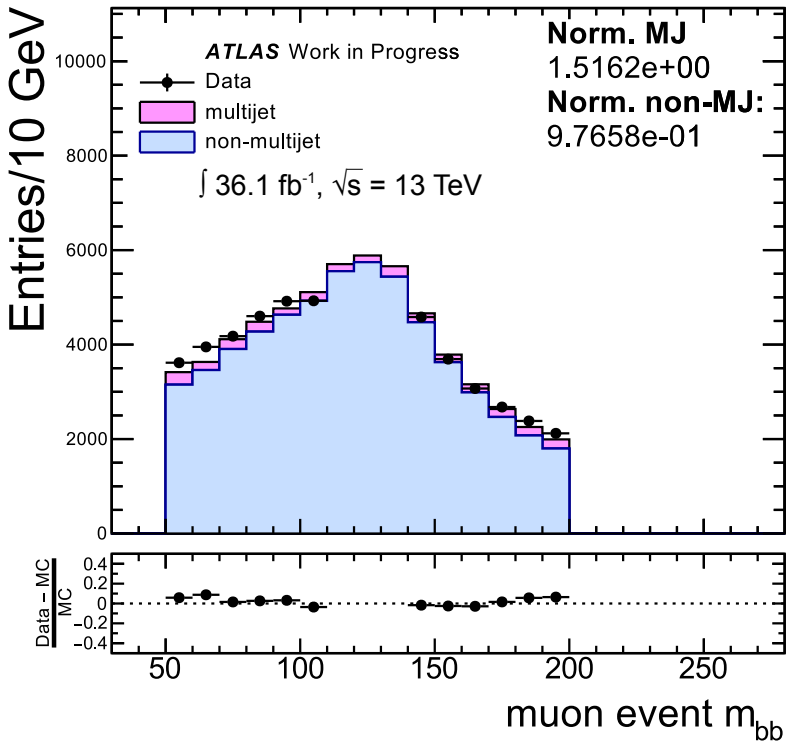


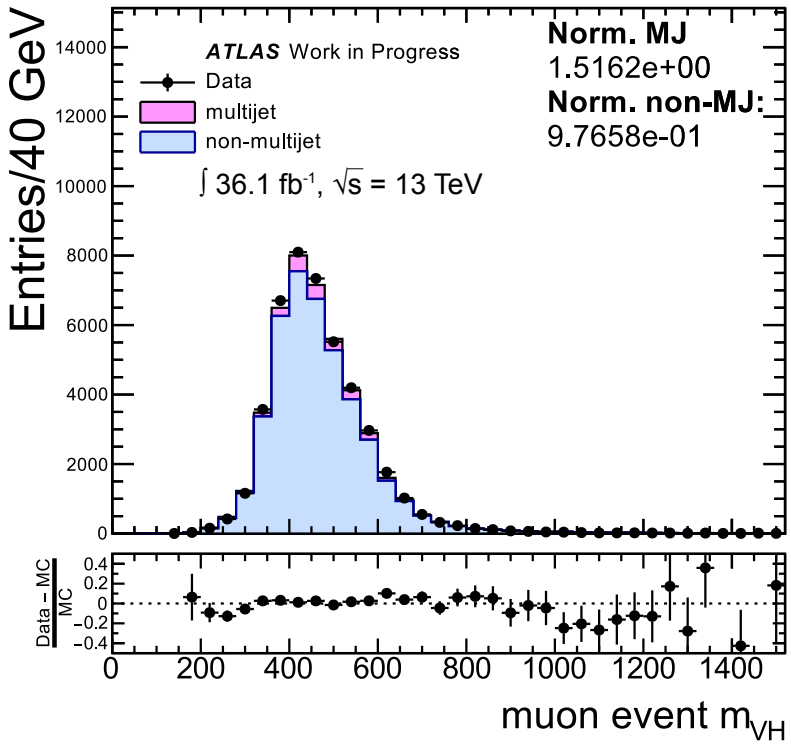
Template Fit





Result



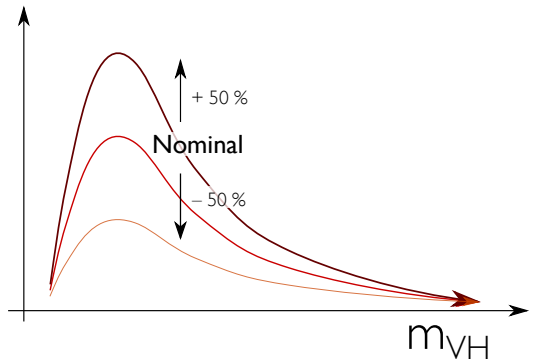


		1 *b* tag		2 *b* tags	
		Electrons	Muons	Electrons	Muons
Multijet	Resolved	(2.4 ± 0.7) %	(4.6 ± 1.0) %	(0.0 ± 2.3) %	(0.0 ± 0.7) %
	Merged	(0.5 ± 0.6) %	(0.0 ± 0.2) %	(1.0 ± 6.1) %	—

Uncertainties

Normalisation uncertainty:

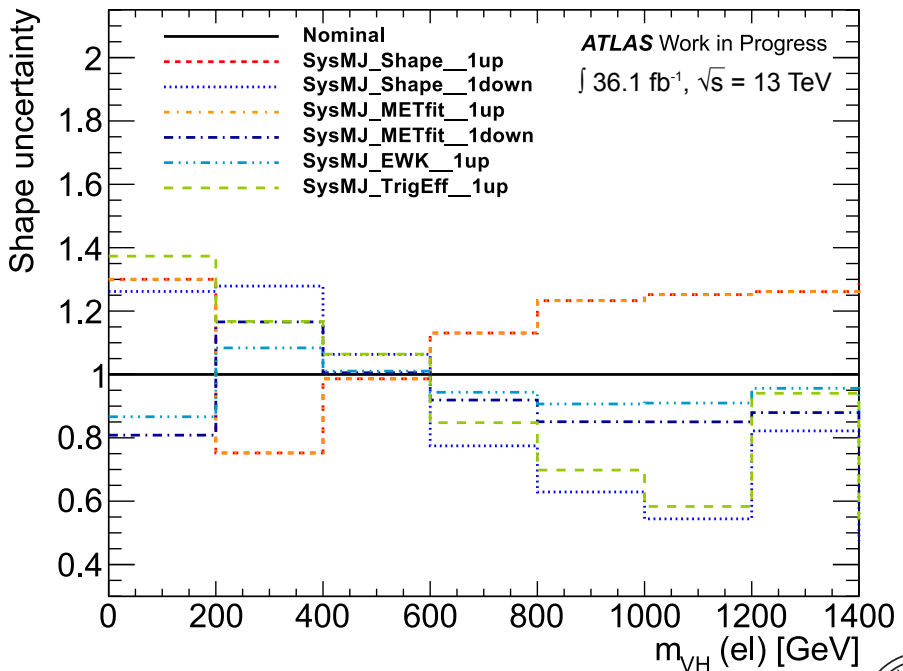
- Estimated from fit of E_T^{miss} tail
- Conservative estimate: $\pm 50\,\%$



Shape uncertainty:

- trigger bias
- normalisation of MC backgrounds

→ **combine** into single shape uncertainty



Summary

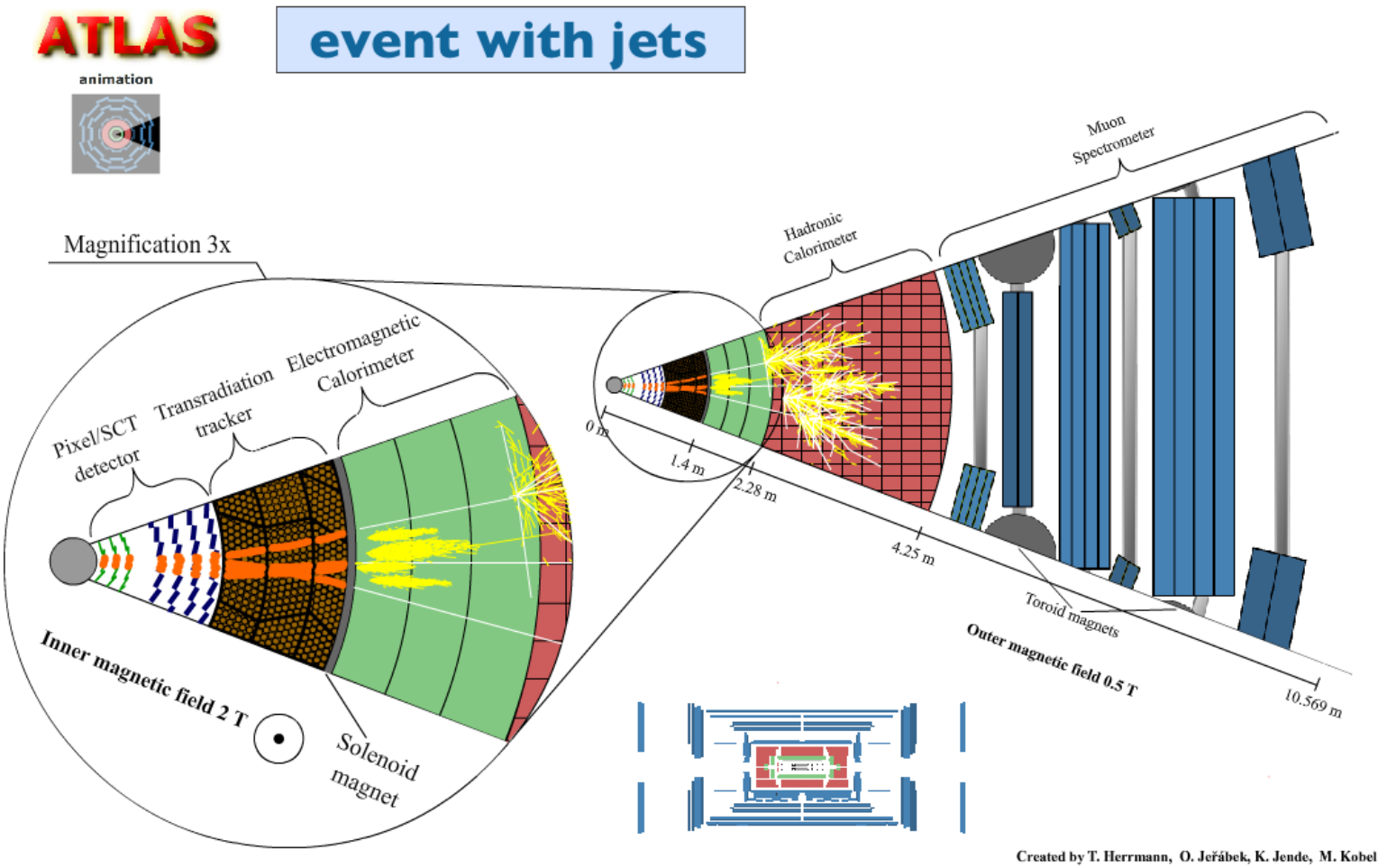
- **Data-driven multijet estimate** for searches for new diboson resonances in the final state $\ell\nu\mathrm{b}\bar{\mathrm{b}}$
- **Template Method** works **robustly**
- We show
  - **small** $(2-5\,\%)$ contribution in 1-tag resolved
  - **negligible** in other categories
- Results used for the **statistical interpretation** of the full 2015+2016 dataset $(36.1\,\mathrm{fb}^{-1})$

BACKUP

1-Lepton Event Selection

Selection	1-lepton resolved	1-lepton merged
Trigger	electron trigger and $E_{\mathrm{T}}^{\mathrm{miss}}$ trigger	
1 lepton	exactly 1 WHLoose electron/muon which should also pass the WHSignal criteria	
$E_{\mathrm{T}}^{\mathrm{miss}}$	$E_{\mathrm{T}}^{\mathrm{miss}}$> 80 GeV in electron events $E_{\mathrm{T}}^{\mathrm{miss}}$> 40 GeV in muon events	$E_{\mathrm{T}}^{\mathrm{miss}}$>100 GeV
$p_T(W)$	$p_T(W) > (-3.26 \times 10^5) \cdot \frac{1}{m_{Vh}[GeV]} + 709.60$ lower cap of $p_T(W) > 150$ GeV	$p_T(W) > 394 \cdot \ln(m_{Vh}[\mathrm{GeV}]) - 2350$
m_h	50 GeV < m_h < 200 GeV	
Jets	2 or 3 signal jets ≥ 0 forward jets	≥ 1 fat jet ≥ 1 track-jet associated to leading fat jet
Leading jet p_{T}	> 45 GeV	-
	Veto on events with 3 or more b-jets	-

Why the electron/jet mix-up?



[http://kjende.web.cern.ch/kjende/en/]

Trigger issues

We're using several electron triggers with different electron p_T thresholds.

Problem: Some are inefficient in the non-isolated region & the logical **OR** results in a distribution with kinks.

Solution: Use only single trigger (the one with lowest electron p_T threshold).

Correct for the electron-p_T dependent inefficiency with linear fit.