

# Searching for lepton-flavour-violating decays of the Higgs boson with the ATLAS detector

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# Motivation | Channels | Backgrounds

- Lepton flavour violation (LFV) is **not allowed** in the Standard Model. However, the observation of neutrino oscillations indicates that LFV occurs in nature
- In the charged sector one possibility are LFV Higgs boson decays:  
$$\mathbf{H \rightarrow \tau e, H \rightarrow \tau \mu, H \rightarrow e \mu^*}$$
- There are many BSM models predicting them: supersymmetry, composite Higgs models, more than one Higgs doublet models, Randall–Sundrum models, and more
- In our paper, we search for  $\mathbf{H \rightarrow \tau e}$  and  $\mathbf{H \rightarrow \tau \mu}$  (separately) using data collected by ATLAS in 2015-2016  $\Rightarrow \mathcal{L} = 36 \text{ fb}^{-1}$
- Each search has two **channels**:
  - tau decaying leptonically ( $\ell^{\tau_{\text{lep}}}$ :  $e\tau_{\mu}, \mu\tau_e$ )
  - tau decaying hadronically ( $\ell^{\tau_{\text{had}}}$ :  $e\tau_{\text{had}}, \mu\tau_{\text{had}}$ )
- **Backgrounds**:
  - From simulation:  $Z \rightarrow \tau\tau$  (Sherpa) (**main in both channels**), Top (**2nd for  $\ell^{\tau_{\text{lep}}}$** ), Diboson,  $H \rightarrow \tau\tau$  and  $Z \rightarrow \ell\ell$
  - From data: Fake bkg, jets mis-id as  $\tau_{\text{had}}$  or  $\ell$  (**2nd for  $\ell^{\tau_{\text{had}}}$** ), calculated using transfer factors derived in control regions

\* not covered in this poster, for more info see [Phys. Lett. B 801 \(2020\) 135148](#)

# Event selection | Multivariate Analysis

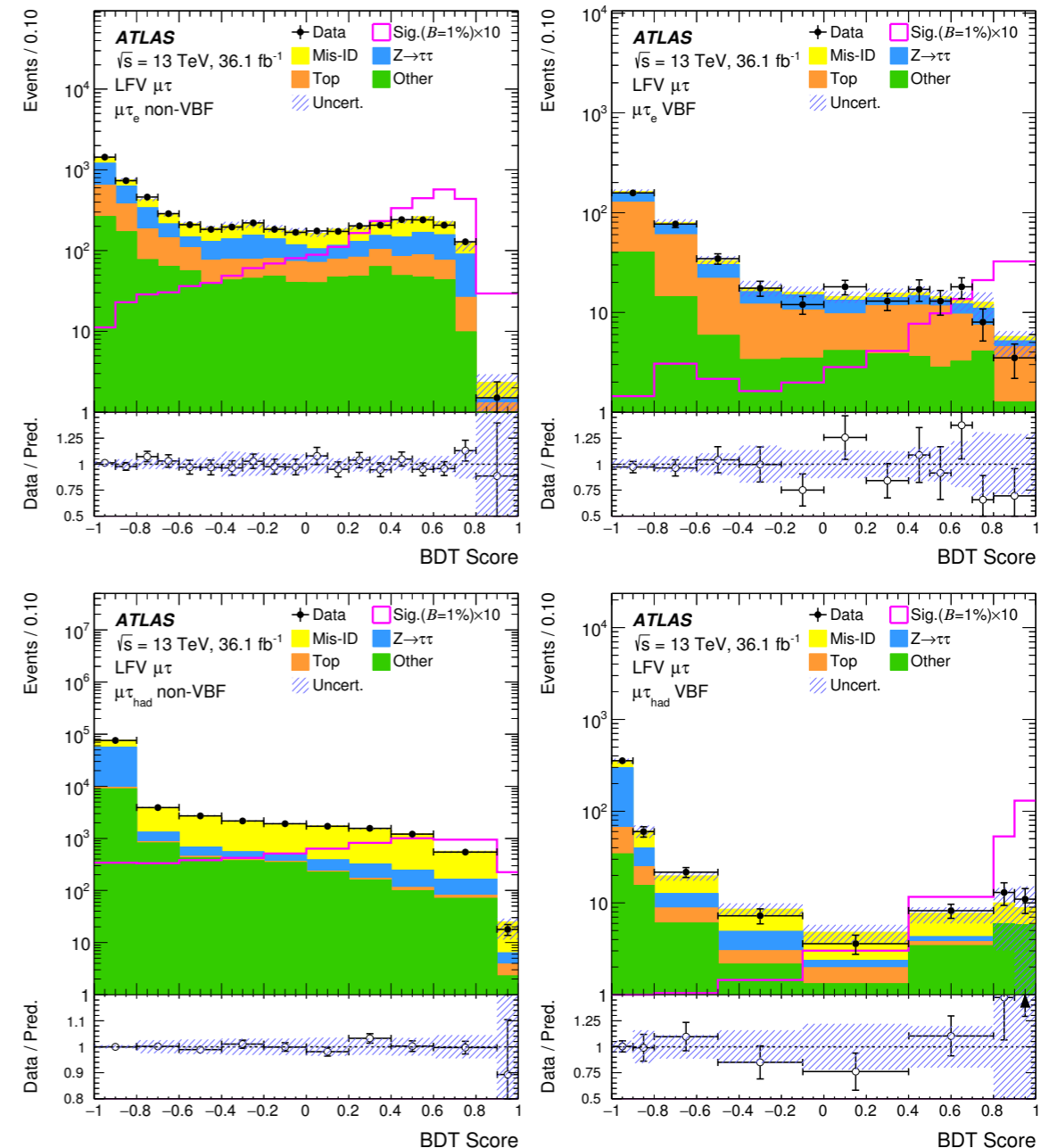
- **Event selection:**

- $\ell_{\tau_{lep}}$ : exactly 2 light-leptons of different flavour and opposite charge
- $\ell_{\tau_{had}}$ : exactly 1  $\tau_{had}$  and 1 light-lepton, with opposite charge
- $n_{b-jets} = 0$  (suppress Top bkg)

- **Signal regions:**

- **VBF region:**  $n_{jets}(p_T > 30 \text{ GeV}) \geq 2$ ,  $p_{Tj^0} > 40 \text{ GeV}$ ,  $m_{jj} > 400 \text{ GeV}$  and  $|\Delta\eta_{jj}| > 3$
- **nonVBF region:** fails VBF selection + additional criteria

- **MVA:** A BDT is trained in each channel and signal region to separate signal from bkg using kinematic variables



BDT score distributions for  $H \rightarrow \tau\mu$  search, after signal+bkg fit. LFV signal (BR=1%)x10 is overlaid for visibility.

# Results

- A statistical analysis was performed using a binned likelihood function. The BDT scores of all signal regions are analysed, plus control regions to constrain the  $Z \rightarrow \tau\tau$  and Top bkg
- The main systematic uncertainties impacting the fit are: jet kinematics, fake bkg related (and muon related in  $H \rightarrow \tau\mu$  search)
- **No significant excess over the SM bkg is found.** Observed (expected) upper limits at 95% CL are set:
  - $BR(H \rightarrow \tau e) < 0.47\%$  ( $0.34^{+0.13}_{-0.10}$  %)
  - $BR(H \rightarrow \tau\mu) < 0.28\%$  ( $0.37^{+0.14}_{-0.10}$  %)
- Good improvement from ATLAS Run1 results (2x and 5x, respectively)
- These limits can be converted to limits on off-diagonal Yukawa coupling matrix elements  $|Y_{\tau\ell}|$  and  $|Y_{\ell\tau}|$ , to be shown together with the limits from the ATLAS Run 1 analysis and from  $\tau \rightarrow \ell\gamma$  searches:

