Searches for lepton-flavour-violating decays of the Higgs boson into $e\tau$ and $\mu\tau$ in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector

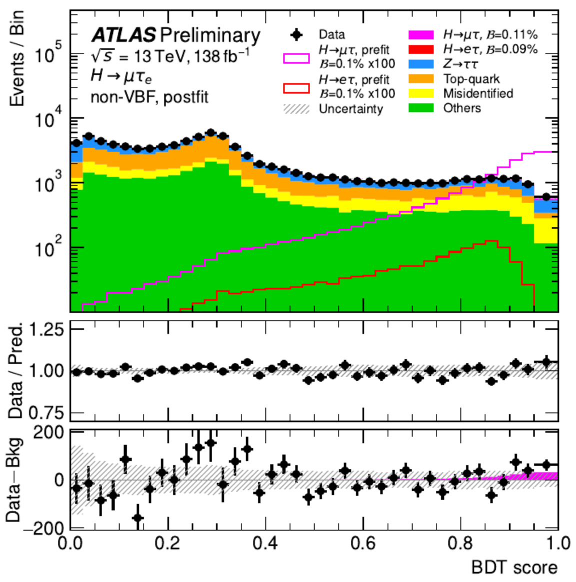
General strategy

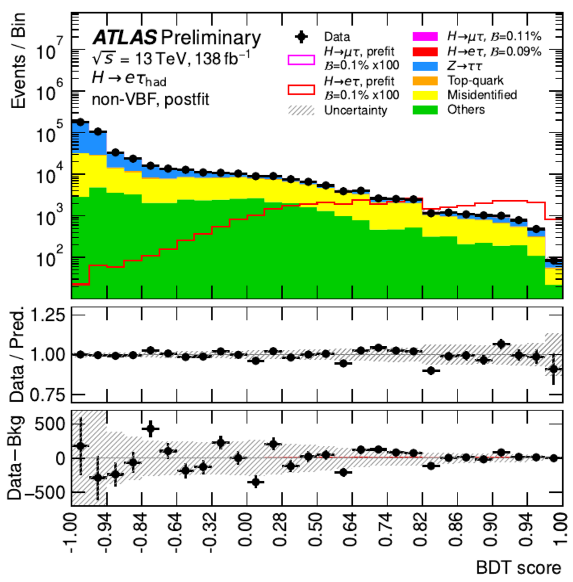
- Searching for **two independent signals**, $\boldsymbol{H \to e\tau}$ and $\boldsymbol{H \to \mu\tau}$. Considering **hadronic** and **leptonic** τ decays.
- Two background estimation methods: MC-template method ($\ell\tau_{\ell'}$ and $\ell\tau_{\text{had}}$) or Symmetry method (only $\ell\tau_{\ell'}$).
- Loose preselection and further categorization into **VBF** and **non-VBF** signal regions.
- Fit over **MVA** output to enhance sensitivity.

Background estimation

MC-template $\ell\tau_{\text{had}}$

- Backgrounds estimated with **MC templates**.
- $\boldsymbol{Z \to \tau\tau}$ with **floating** normalization factors. **Top-quark** backgrounds extracted from **CRs** for each VBF/non-VBF category.
- Misidentified background estimated using data-driven techniques.



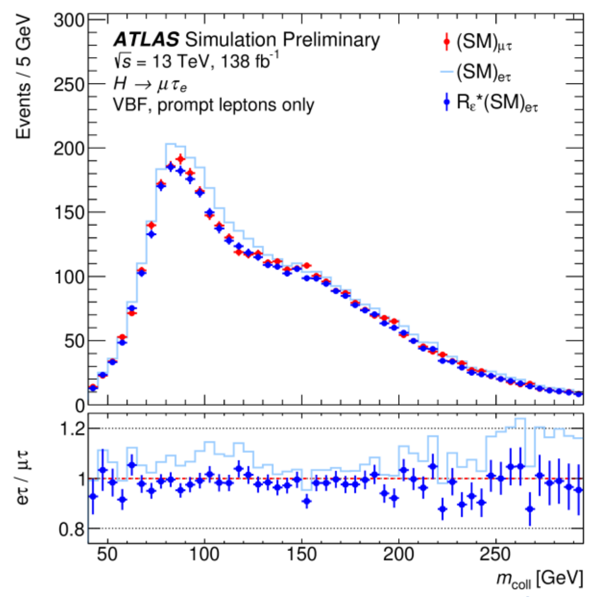


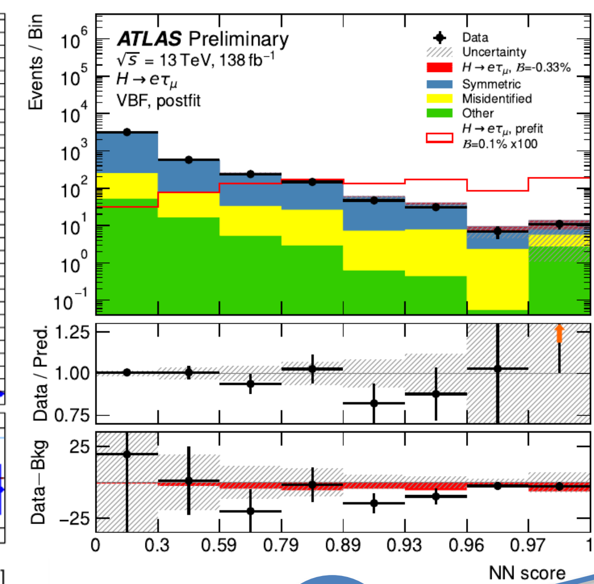
MC-template $\ell\tau_{\ell'}$

- Backgrounds estimated with **MC templates**.
- **Normalisation** of $\boldsymbol{Z \to \tau\tau}$ and **top-quark** backgrounds extracted from **CRs** for each VBF/non-VBF category.
- Misidentified background estimated in a data-driven way.

Symmetry $\ell\tau_{\ell'}$

- **SM processes** are **symmetric** under $e \leftrightarrow \mu$.
- $\mathcal{B}(H \to e\tau) \neq \mathcal{B}(H \to \mu\tau)$ would **break** the **symmetry**.
- Data from **one channel** can be used for the **background estimation** of **the other** channel (after corrections for asymmetric experimental effects). The symmetric background contains processes as $Z \to \tau\tau$, top-quark backgrounds and di-boson production, as well as other minor contributions.
- Fakes estimated in a data-driven way.
- Sensitive to **branching ratio difference**.



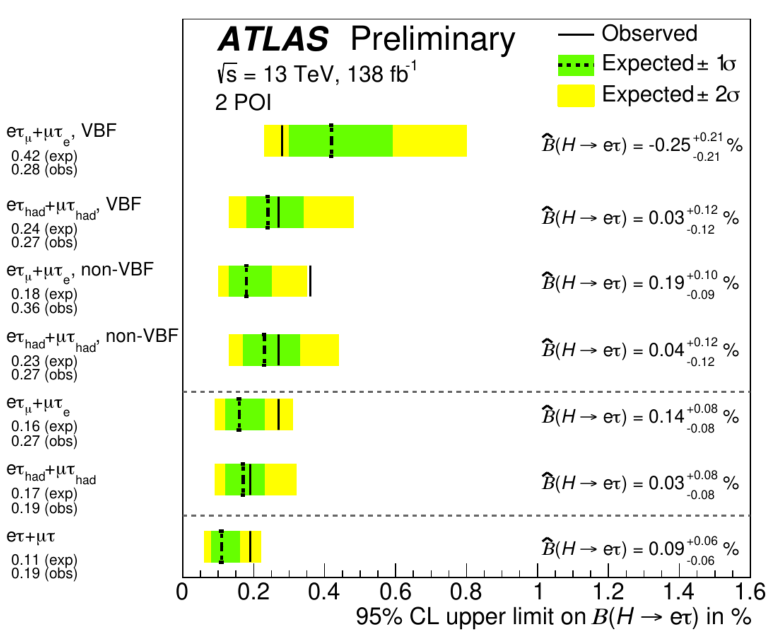


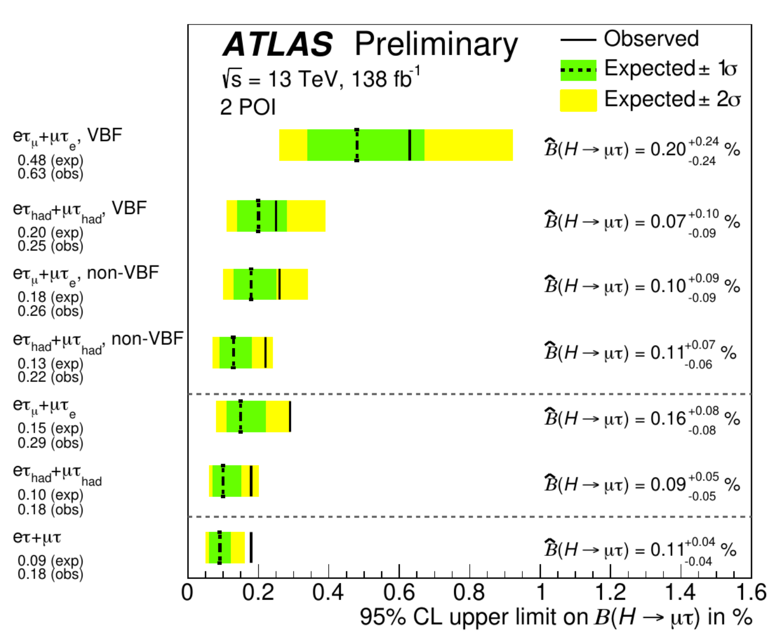
MVA and fit strategy

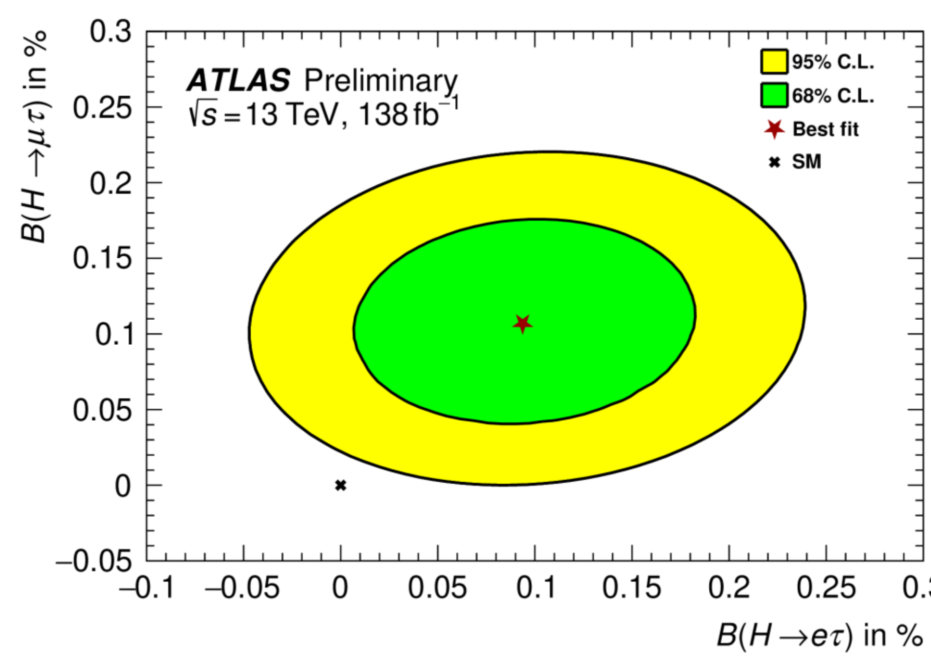
- **MVA outputs** used as final **discriminant** to extract signal strength and upper limits.
- For **MC-template**, final output obtained as **combination** of individual **BDTs** trained to discriminate LFV signal against various backgrounds. Non-VBF and VBF categories treated separately.
- For **Symmetry** method, **combination** of three **NNs** used for VBF. **Multiclassifier NNs** used for non-VBF. Signal node used in the fit.
- Three fit results:
  - **1 POI fit.** Independent fit of $\mathcal{B}(H \to e\tau)$ and $\mathcal{B}(H \to \mu\tau)$. One is assumed to be zero when fitting the other. Combination of Symmetry and MC-based method.
  - **Branching ratio difference.** No assumption of one branching ratio while fitting the other.
  - **2 POI fit.** Simultaneous fit of $\mathcal{B}(H \to e\tau)$ and $\mathcal{B}(H \to \mu\tau)$ with MC-template inputs.

Results

- From **2 POI fit**, the observed (expected) limits are 0.19% (0.11%) for $H \to e\tau$ and 0.18% (0.09%) for $H \to \mu\tau$. Compatibility with SM within 2.2σ.
- **Branching ratio difference** measured with the symmetry method in $\ell\tau_{\ell'}$, found to be $\mathcal{B}(H \to \mu\tau) - \mathcal{B}(H \to e\tau) = 0.25 \pm 10$ %.







Conclusions

- **Small,** but **not significant excess** observed.
- Observed (expected) limits improved by a factor 2.4 (3.1) for $H \to e\tau$ and 1.5 (4.1) for $H \to \mu\tau$ with respect to the previous ATLAS result.
- Check all the results in ATLAS-CONF-2022-060.

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