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

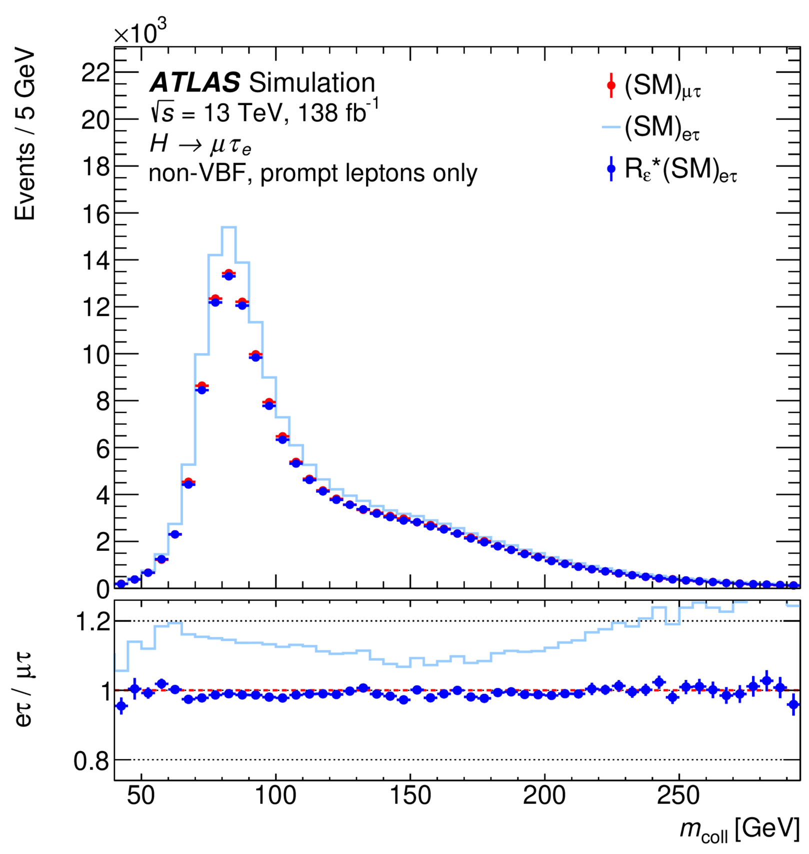
General Strategy

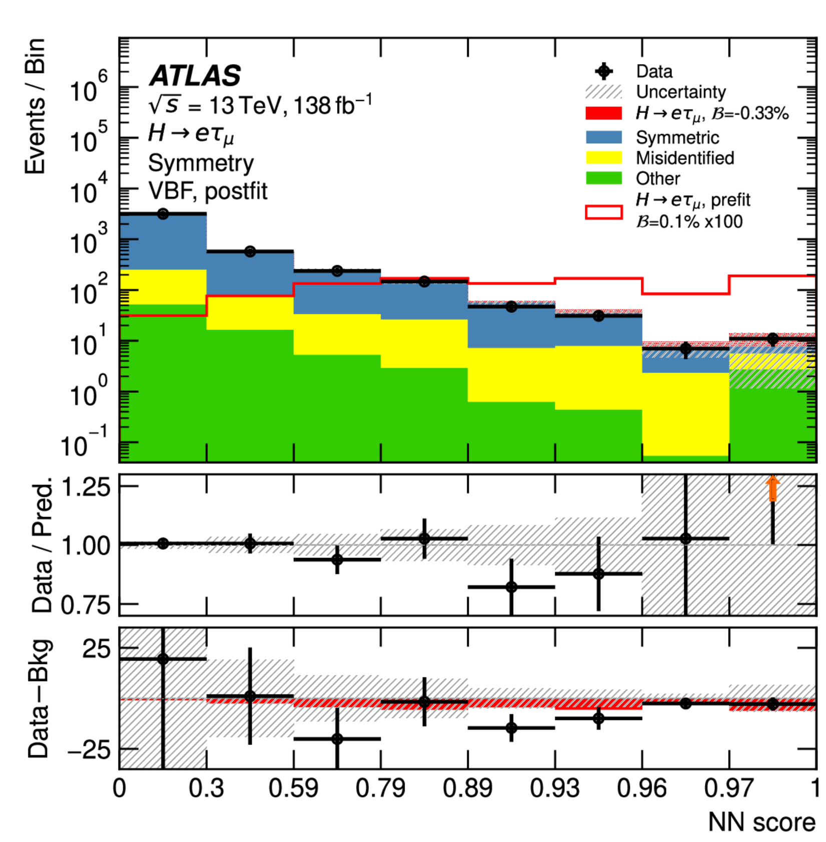
- Searching for **two independent signals**, $\boldsymbol{H \to e\tau}$ and $\boldsymbol{H \to \mu\tau}$. Considering **hadronic** and **leptonic** τ decays.
- Two background estimation methods: **MC-template** method ($\ell\tau_{\ell'}$ and $\ell\tau_{had}$) and **Symmetry** method ($\ell\tau_{\ell'}$ only).
- Categorized into **VBF** and **non-VBF** signal regions.
- Utilized **MVA** (BDT and NN) to enhance sensitivity.

Background Estimation

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

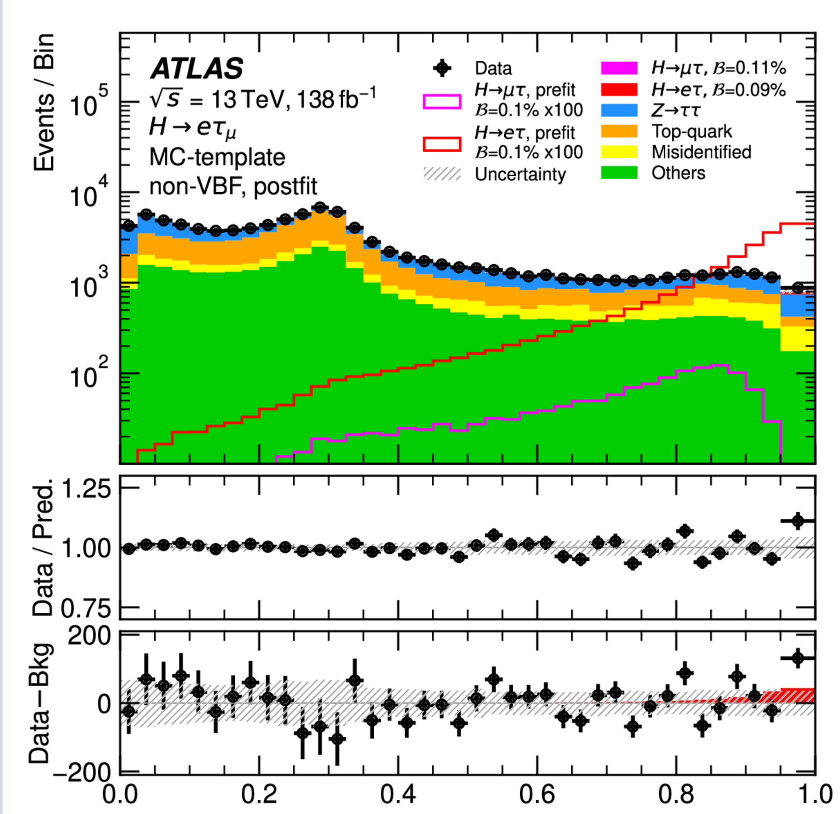
- **SM processes** are **symmetric** w.r.t. prompt e ↔ μ exchange.
- **Symmetry** is **broken** when $\mathcal{B}(H \to e\tau) \neq \mathcal{B}(H \to \mu\tau)$.
- Prompt lepton background in **one channel** is estimated from the data in the **other channel**.
  - ➢ After **corrections** for asymmetric experimental effects.
- **Fakes** estimated by a **data-driven method**.
- The **branching ratio difference** is estimated.





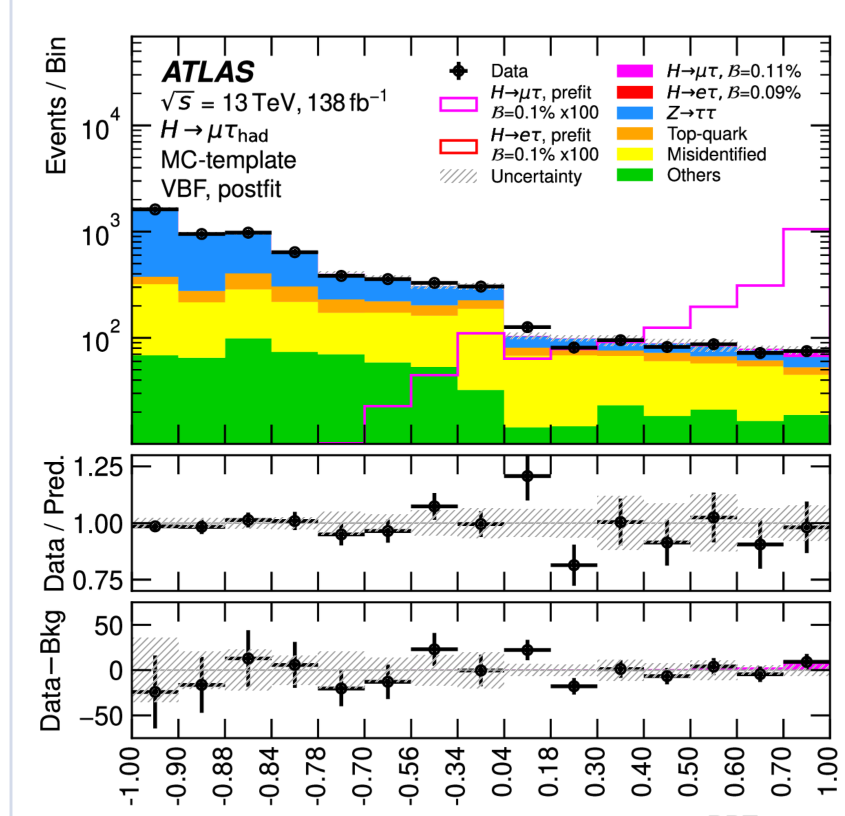
MC-template $\ell\tau_{\ell'}$

- 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.
- Fakes estimated by a data-driven method.



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

- Backgrounds estimated with **MC-templates**.
- **Normalization** of $\boldsymbol{Z \to \tau\tau}$ and **top-quark** backgrounds. extracted from **CRs** for each VBF/non-VBF category.
- Fakes estimated by a data-driven method.



MVA and Statistical Analysis

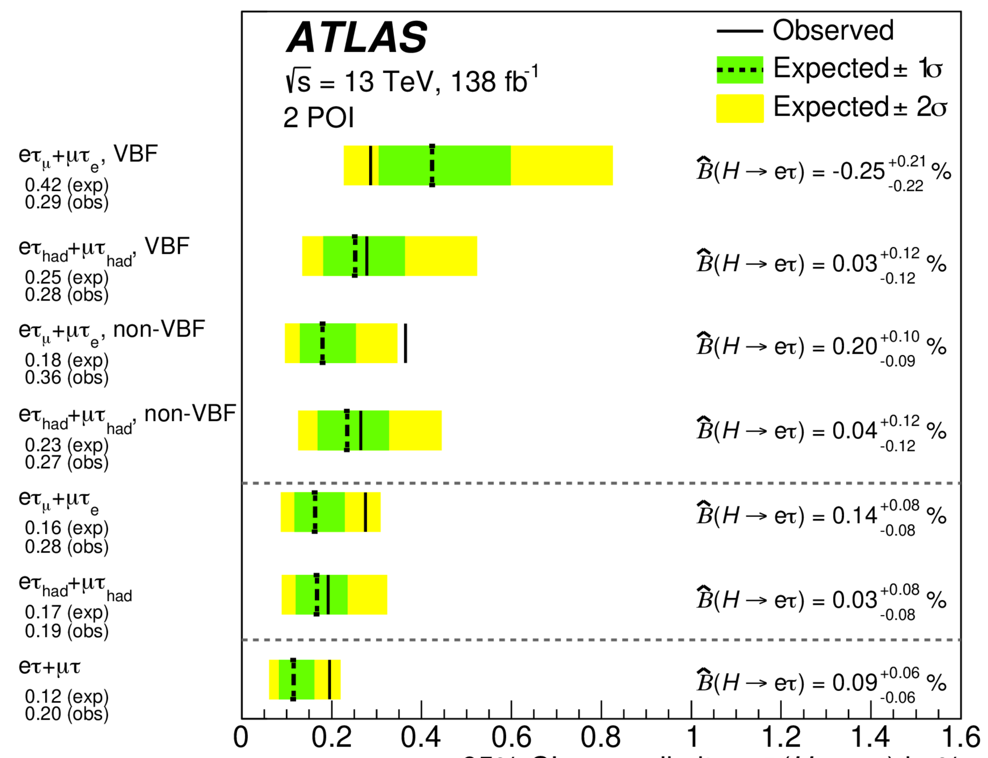
- **MVA outputs** used as **final discriminant** to extract signal strength and upper limits.
- For **MC-template**, a final score is obtained from the **combination** of individual BDTs trained with signal against various backgrounds. Non-VBF and VBF categories are treated separately.
- For **Symmetry** method, combination of three NNs is used for VBF. **Multiclassifier NNs** used for non-VBF. Signal node used in the fit.

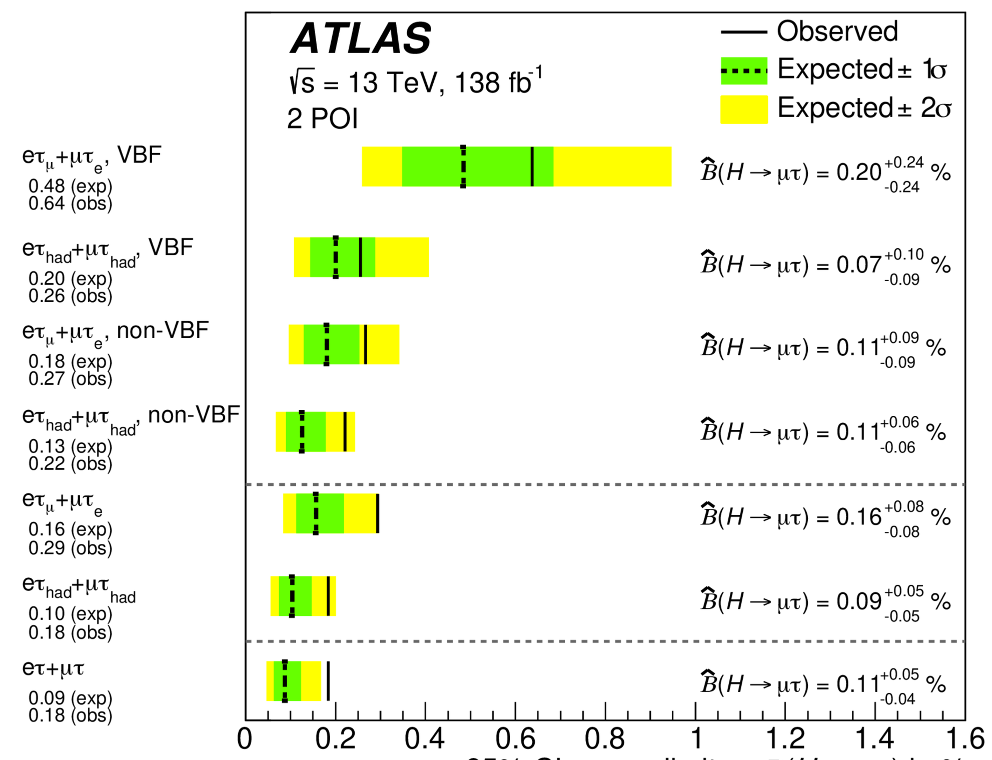
Three fit setups:

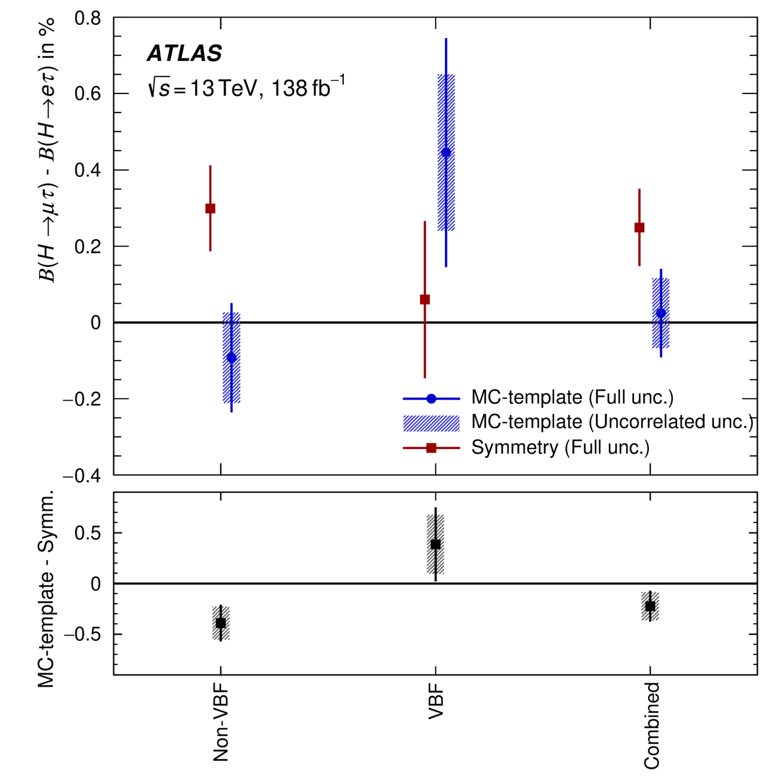
- **1 POI fit**: Independent fit of $\mathcal{B}(H \to e\tau)$ or $\mathcal{B}(H \to \mu\tau)$. One is assumed to be zero when fitting the others. Combination of Symmetry and MC-template method.
- **2 POI fit**: Simultaneous fit of $\mathcal{B}(H \to e\tau)$ and $\mathcal{B}(H \to \mu\tau)$. Utilized MC-template method only.
- **Branching ratio difference**: fit $\mathcal{B}(H \to \mu\tau) - \mathcal{B}(H \to e\tau)$. Utilized Symmetry method in $\ell\tau_{\ell'}$ only.

Results and Conclusions

- The **2 POI fit** gives the observed (expected) limits of **0.20% (0.12%)** for $\boldsymbol{H \to e\tau}$ and **0.18% (0.09%)** for $\boldsymbol{H \to \mu\tau}$, **compatible with SM** within **2.1σ**.
- **Branching ratio difference** is found to be $\mathcal{B}(H \to \mu\tau) - \mathcal{B}(H \to e\tau) = \mathbf{0.25 \pm 10}\%$, compatible with zero within **2.5σ**.
- **Small**, but **not significant excess** observed.
- Observed (expected) limits improved by a factor of 2.5 (3.1) for $H \to e\tau$ and 1.6 (4.1) for $H \to \mu\tau$ with respect to the previous ATLAS result.
- Check all the results in JHEP 07 (2023) 166.







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Michael Kwok Lam Chu (Weizmann Institute of Science)