Measurement of $R(D^0)$ and $R(D^{*0})$ with 3-prong hadronic tau decays at LHCb

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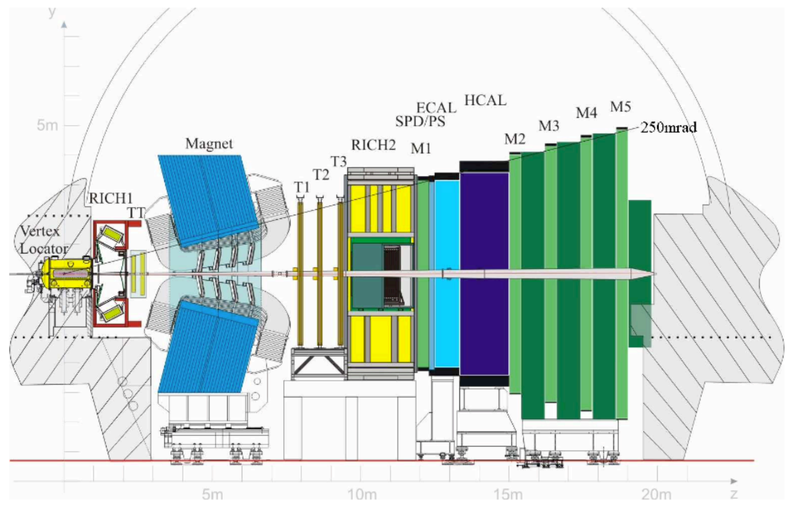
1. What is Lepton Flavour Universality (LFU)?

- In the Standard Model (SM), the only difference between the three lepton families are their masses.
- LFU violation could hint at New Physics beyond SM!
- Experimental results and SM predictions on LFU show a significant tension.

2. Why is LHCb good for LFU probes?

- Single-arm forward spectrometer, designed to study beauty and charmed hadrons.
- Excellent particle identification.
- Good momentum and spatial resolution.



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3. How is LFU tested in this analysis?

- Ratio observables are powerful LFU tests - accurate theoretical predictions and reduced systematic uncertainties.
- The goal of this analysis is the simultaneous measurement of these ratios:

$$R(D^{(*)0}) = \frac{\mathcal{B}(B^+ \to \bar{D}^{(*)0}\tau^+\nu_\tau)}{\mathcal{B}(B^+ \to \bar{D}^{(*)0}\ell^+\nu_\ell)},$$

where $D^{(*)0}$ is either D^0 or D^{*0} and ℓ^+ is e^+ or μ^+.

4. What is the analysis strategy?

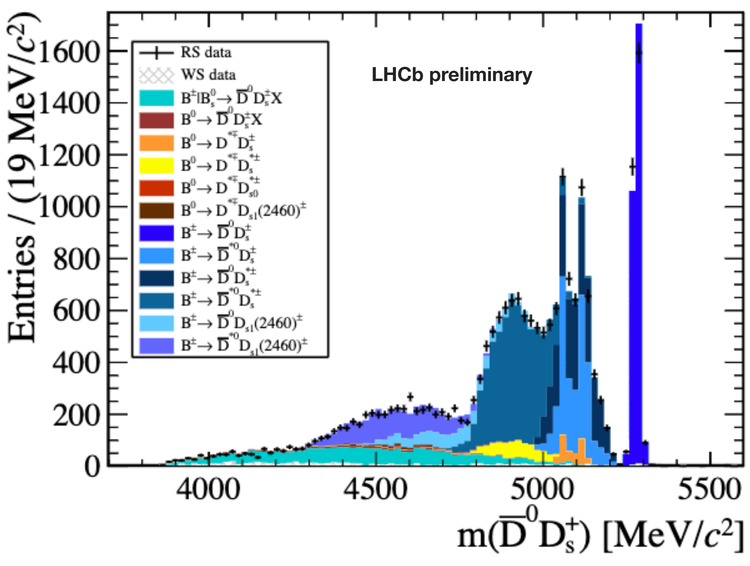
- 3-prong tau reconstruction: $\tau \to 3\pi^\pm(\pi^0)\nu_\tau$ (allows for higher background suppression).
- *D* meson reconstruction: $D^0 \to K^-\pi^+$ and D^{*0} to either $D^0\pi^0$ or $D^0\gamma$ (neutral pions and photons are not reconstructed).
- Optimised candidate selection, including boosted decision trees (BDT).
- Detailed study of control samples to describe different background contributions - bottom left picture: example of subsample for the main component $B \to D^0 D_s(X)$.

5. How is this ratio computed?

- The normalisation channel $B^- \to D^0 D_s^-(\to 3\pi^\pm)$ is introduced so the ratio may be arranged as:

$$R(D^{(*)0}) = \frac{N_s}{N_n} \cdot \frac{\varepsilon_n}{\varepsilon_s} \cdot \left(\frac{\mathcal{B}(B^- \to D^0 D_s^-(\to 3\pi^\pm))}{\mathcal{B}(B^+ \to \bar{D}^{(*)0}\ell^+\nu_\ell)} \right)_{ext}$$

- The second fraction requires external inputs.
- Signal and normalisation efficiencies are extracted from Monte Carlo (MC) samples.
- The normalisation yield is obtained from a fit to the $m(D^0 D_s^-)$ invariant mass.
- Signal yields are estimated by using a 3D fit on the tau decay time, the BDT output and $q^2 = (p_B - p_D)^2$.



6. What is the outlook for $R(D^{(*)})$?

- In this analysis, the signal yield is blinded.
- Current disagreement is significant (combined tension at $\sim 3\,\sigma$).
- More LFU precision tests needed in order to reduce systematic uncertainties.