# Improved analysis strategy to determine R($D^*$) at Belle II

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In the Standard Model (SM) of particle physics, the W boson couples identically to the three lepton flavors. This concept is known as Lepton Flavour Universality (LFU). An observation of LFU violating processes would be a direct hint for physics beyond the standard model and provide insight into the workings of our universe which the SM currently fails to explain. Various previous analysis have probed these parameters to provide ever more precise understanding of LFU and have largely been in agreement with the SM predictions. However, some deviations have been noted in the past decade at B factories such as Belle, Belle II, BaBar and LHCb in the semileptonic decays of B mesons. The ratios of theses semileptonic decays are great probes due to their clean signature at B factories since many of the theoretical and experimental uncertainties cancel out. The ratios studied in this work are of the form $\mathrm{R}(D^*) = \mathcal{B}(B \to D^{(*)}\tau\bar{\nu}_\tau)/\mathcal{B}(B \to D^{(*)}\ell\bar{\nu}_\ell)$, where the additional particles in the extensions of the SM, which couple to the $b - c - \tau - \nu_\tau$ vertex, are able to modify the coupling to the three lepton flavors. The current measurements of these ratios have shown a deviation of $3\sigma$ from the SM as depicted in the fig. 1.

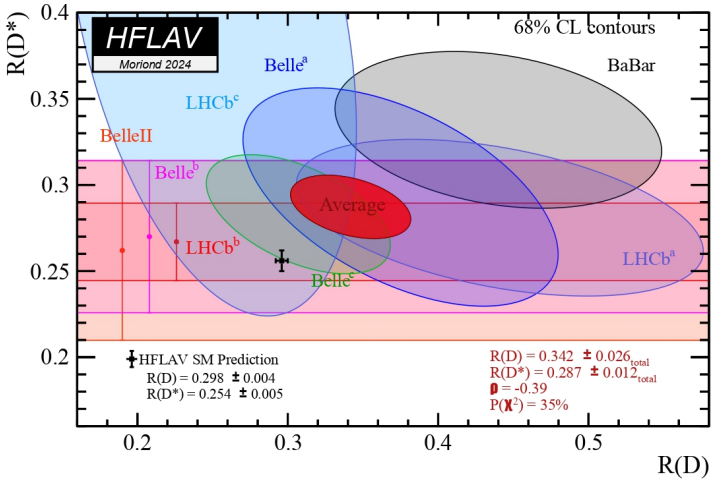


Figure 1: Overview of the measurements of R($D^*$) conducted at various B factories.

The Belle II experiment at the SuperKEKB asymmetric-energy collider, where electrons and positrons are collided at the $\Upsilon(4S)$ resonance, is able to collect a large number of events with $B\overline{B}$ pairs. A technique known as tagging is employed to reconstruct one of the B mesons exclusively in hadronic channels and using the precisely known

kinematic information from the initial collision, the missing energy due to the presence of the neutrino can be attributed to the other B meson and the entire decay can be reconstructed. We consider the leptonic decay of the $\tau$ lepton which decays into the same final state as the light leptons but with two additional neutrinos. This extra invisible energy is used as one of the signatures to measure the ratios of interest.

In this work, we present the current status of an improved analysis strategy to determine $\mathrm{R}(D^*)$ using 364 $\mathrm{fb}^{-1}$ of integrated luminosity of Run 1 collision data of the Belle II experiment.