

A Novel Approach to Precision Determination of V_{ub} Using Strange-Quark Fragmentation in Semileptonic B_s Decays

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The precise measurement of the Cabibbo–Kobayashi–Maskawa (CKM) matrix element V_{ub} is an ongoing gap in our understanding of quark flavor physics and provides an important test of the Standard Model. Traditional approaches to measuring V_{ub} are limited by theoretical and experimental uncertainties. The aim of this study is to develop a novel machine-learning approach that exploits strange fragmentation to improve the identification of signal events relevant for V_{ub} measurements. A gradient-boosted decision trees classifier was developed. The classification was performed in two stages. First, a track-level classifier was trained to identify kaons originating from strange fragmentation and distinguish them from other tracks in the event. In the second stage, an event-level classifier was applied. This classifier combines information from multiple tracks together with global event variables to determine whether the tracks in the event are consistent with a B_s signal decay. At the track level, the model achieved a 25% increase in ROC AUC compared to traditional selection methods. In addition, event level showed improved separation between signal and background, with improvement consistent with the track-level results. This suggests that the fragmentation approach can improve the efficiency of signal selection. This method is designed to be generalizable with analyses performed at CERN in the LHCb experiment and could improve sensitivity in measurements of V_{ub} . More precise measurements of V_{ub} would help test CKM matrix unitarity and resolve discrepancies between inclusive and exclusive determinations. Improving the precision of these measurements strengthens the ability of flavor physics experiments to test the consistency of the Standard Model.

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