学位申請論文公開講演会

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申請者：AVERSANO　MICHELE（N 研）

場所：物理会議室（C207）　およびオンライン

接続先の問い合わせ先：飯嶋徹 iijima_@_hepl.phys.nagoya-u.ac.jp (_@_は@に置き換える)

題目：Search for $B\to\tau\nu$ decays with a hadronic tagging method at the Belle II Experiment
（Belle II 実験におけるハドロニックタグ手法を用いた$B\to\tau\nu$崩壊の探索）

主論文の要旨

The Standard Model (SM) of particle physics describes the fundamental particles and their interactions. It has been successful in explaining experimental results obtained by now but phenomena such as the baryon asymmetry of the universe and dark matter cannot be explained within this framework. Rare processes, such as the $B \to \tau\nu$ decays, are sensitive to potential contributions from New Physics (NP) beyond the SM. These decays offer a unique testing ground for the validity of the SM and the exploration of extensions to it.

In the SM, the decay $B \to \tau\nu$ proceeds through a charged current mediated by the W boson. The branching ratio for this process is proportional to the square of the CKM matrix element $|V_{ub}|$, the B meson decay constant f_B, and the B meson lifetime τ_B. The SM predicts a suppression of this decay due to helicity constraints. However, extensions to the SM, such as the Two Higgs Doublet Model (2HDM), introduce a charged Higgs boson that can interfere with the W-mediated decay, altering the branching ratio. Such deviations provide evidence of NP or constraints on NP parameters.

In this thesis work, we measure the branching ratio of $B \to \tau\nu$ using the e^+e^- collision data collected by the Belle II experiment at the SuperKEKB collider. We also study its consistency with SM predictions and previous experimental results and set constraints on NP parameters. To reconstruct candidate events, first a multivariate analysis-based hadronic tagging method is applied, maximizing signal purity while minimizing background noise. Signal events are searched through τ decays in one charged track, electron, muon, pion and ρ, and then selected based on stringent criteria, including machine learning classifiers. Finally, the branching ratio is extracted using a multi-dimensional binned maximum likelihood fit, to isolate the decay signal from other processes. Advanced modeling techniques were used to calibrate simulation inputs to match experimental data and to account for systematic uncertainties. The analysis revealed a branching fraction consistent with the SM predictions. Additionally, the results were compared to previous measurements and used to place constraints on NP parameters, such as the mass of the charged Higgs boson and the ratio of the vacuum expectation values $(m_{H^\pm}, \tan\beta)$ in the 2HDM type II.

In conclusion, this thesis work presents a study of the decay $B \to \tau\nu$ using data from the Belle II experiment. The branching ratio of this process was measured and compared with predictions from the SM and previous experimental results. The analysis also places constraints on potential contributions from NP, such as those predicted by models with a charged Higgs boson.