Chapter 1
Introduction

Physics deals with the development of quantitative models that describe nature. The most fundamental and precise models at present are: general relativity, which describes gravity as an interaction between the curvature of space-time and matter; and the Standard Model of particle physics (SM), which describes matter and the remaining electromagnetic, weak and strong interaction in the form of relativistic quantum fields.

The current high-energy physics (HEP) research focuses on the precise determination of the 19 free parameters of the SM and the search for new physics phenomena beyond the SM.

The Belle II experiment is part of this effort. It is located at the SuperKEKB electron-positron collider in Tsukuba, Japan. It is designed to perform a wide range of high-precision measurements in all fields of heavy flavour physics, including: B meson decays; B_s^0 meson decays; charm physics; τ lepton physics; hadron spectroscopy; and pure electroweak measurements. These measurements will constrain the parameter space of the SM as well as some of its extensions.

This work focuses on the development of software, in particular machine learning algorithms, to advance scientific progress, and to enable and improve a wide range of physics measurements at Belle II. This thesis summarizes my contributions to the Belle experiment and its successor the Belle II experiment.

Four major topics are covered. The conversion of the data recorded by the Belle experiment into the new data-format used by Belle II in Chap. 2. The integration of state-of-the-art machine learning algorithms and novel data analysis techniques into the Belle II Software Framework (BASF2) in Chap. 3. The development of the `Full Event Interpretation` exclusive tagging algorithm, which is unique to the Belle II experiment in Chap. 4. And the validation of the entire analysis software stack using the benchmark measurement of the branching fraction of the rare decay $B \rightarrow \tau\nu_\tau$ in Chap. 5.