Particle Identification with Neural Networks and Partial-Wave Analysis of $\bar{B}^0 \to J/\psi K^-\pi^+$ at Belle II

Martin Bartl

Max-Planck-Institute for Physics

1 The Belle II Experiment

The Belle II experiment at the SuperKEKB collider in Tsukuba, Japan, is at the forefront of flavor physics, focusing on precision measurements to search for potential new physics beyond the Standard Model. This experiment records electron-positron (e^-e^+) collisions at a center-of-mass energy of 10.58 GeV, corresponding to the resonance peak of the $\Upsilon(4S)$ particle. The $\Upsilon(4S)$ predominantly decays into B meson pairs, making Belle II an ideal platform for studying B-physics.
Belle II currently holds the world record for achieved instantaneous luminosity of $4.7 \times 10^{34}\text{cm}^{-2}\text{s}^{-1}$. In addition to the resulting large dataset, the experiment benefits from highly controlled initial collision conditions, featuring a single collision per event with a low track and cluster multiplicity in the detector. These characteristics enable the precise reconstruction of missing energy and improve the detection and reconstruction of neutral final state particles, which are critical for conducting precise measurements of the standard model.

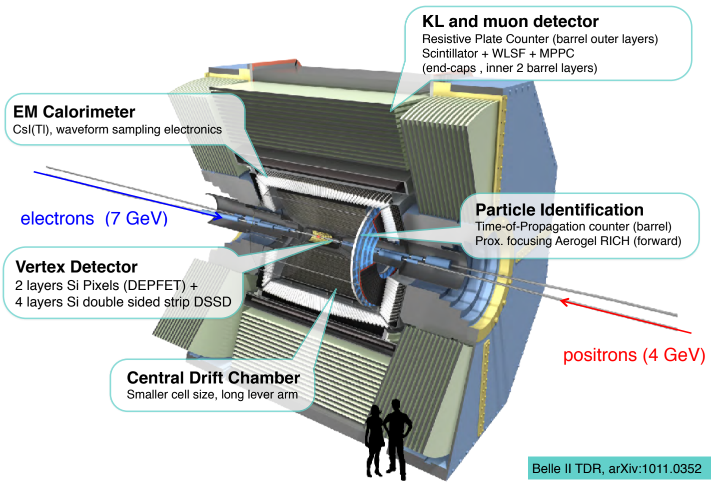

Figure 1: 3D Sketch of the Belle II experiment.

2 Particle Identification with Neural Networks at Belle II

An integral part of the physics performance of Belle II is the correct identification of final state particle species. For charged particles such as electrons, muons, pions, kaons, protons, and deuterons, Belle II uses a standard particle identification (PID) approach, which involves multiplying likelihood values for each species from six subdetectors (see 1).

To improve PID performance, the next logical step is to include additional information, such as tracking information like charge and momentum, and to employ more sophisticated analysis techniques like boosted decision trees (BDTs). Although BDTs enhance selection performance, they are relatively simple models. So, to further improve PID performance, we implement a neural network approach. This method leverages potential correlations in the data in a model-independent manner. After training on generic Monte Carlo data, we demonstrate that this approach improves classification performance in real data, thereby enhancing the purity and number of signal events in future event selections.