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Particle identification with the Belle II calorimeter using machine learning

The Belle II experiment is located at the asymmetric SuperKEKB e^+e^- collider in Tsukuba, Japan. The Belle II electromagnetic calorimeter (ECL) is designed to measure the energy deposited by charged and neutral particles. It also provides important contributions to the particle identification system. Identification of low-momenta muons and pions in the ECL is crucial if they do not reach the outer muon detector.

This talk presents an application of a convolutional neural network (CNN) to separate muons and pions in the ECL. Since track-seeded cluster energy images provide the best possible information, the shape of the energy depositions for muons and pions in the crystals around an extrapolated track at the entering point of the ECL is used together with crystal positions and transverse momentum of the track to train a CNN. The CNN is exploiting the difference between the dispersed energy depositions from pion hadronic interactions and the more localized muon electromagnetic interactions.

The performance of the CNN is investigated with a subset of 2020 and 2021 data with almost pure muon and pion samples from different physics channels. Finally, comparisons of the CNN approach with a standard likelihood-based particle identification and a boosted decision tree using shower-shapes are presented.

References

Speaker time zone

Compatible with Europe

Significance

The standard Belle II PID algorithm in the ECL defines a univariate likelihood as a function of the ratio of energy measured in the ECL over the momentum measured by the trackers. The standard method has its shortcomings when it comes to low-momenta muons and pions. Recently, there has been development in the PID with boosted decision trees (BDT) using shower shape variables in the ECL as inputs. However, if there is no shower shape information, the BDT method fails. In this talk, I will introduce a new method (CNN) based on extrapolated tracks which uses more low level information regarding the energy patterns in the pixel images around the track which feed to a CNN as inputs. The advantage of the CNN method is that there is no need to rely on the information coming from shower shape variables or likelihoods.

Primary author: NARIMANI CHARAN, Abtin (Deutsches Elektronen-Synchrotron (DESY))

Presenter: NARIMANI CHARAN, Abtin (Deutsches Elektronen-Synchrotron (DESY))

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