

STUDY OF K_L^0 CLUSTER RECONSTRUCTION EFFICIENCY IN THE BELLE II CALORIMETERS USING THE RECOIL MOMENTUM TECHNIQUE

D. Kulakov¹, V. Aushev¹, S. Glazov², S. Raiz², E. Ganiev³

¹Taras Shevchenko National University of Kyiv, Kyiv, Ukraine

²Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

³Jozef Stefan Institute, Ljubljana, Slovenia

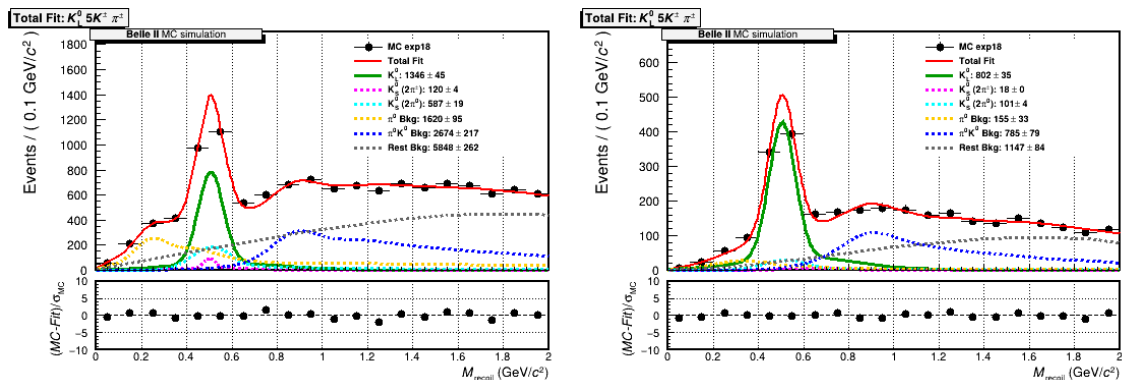
In this The Belle II experiment, a next-generation B-factory, aims to search for rare B-meson decays with neutrinos in the final state, such as $B^0 \rightarrow K^{*0} \nu \bar{\nu}$. Similar decay modes are considered to find a processes beyond Standard Model. A significant challenge in these searches arises from background modes containing neutral particles, like long-lived kaons (K_L^0), which carry away energy and mimic the neutrino signature.

This work presents a method for identifying K_L^0 clusters in the Electromagnetic Calorimeter (ECL) and the K_L^0 and Muon detector (KLM) using a technique primarily based on the detector's tracking system. The method reconstructs the recoil momentum to predict the K_L^0 trajectory and subsequently searches for clusters within a 0.3-radian cone that pass basic selection criteria. This approach is particularly effective for events where the hadronic shower originates in the ECL and extends into the KLM. To further improve signal purity in the ECL, we utilize a cleaning method described in Ref. [2].

Our work utilizes the "recoil method". The K_L^0 four-momentum is reconstructed as the missing momentum relative to the beam energy-momentum of collider after reconstructing all other charged particles in the $e^- + e^+ \rightarrow \text{Charged hadrons} + K_L^0$ process.

Our results show that for events satisfying the cluster selection, the efficiency of the method reaches up to 95% depending on the decay channel. The recoil mass spectra demonstrate a significantly enhanced K_L^0 peak after selection, confirming the method's effectiveness in background suppression for calculating efficiency and Data/Monte-Carlo correction of K_L^0 reconstruction at the Belle II experiment.

The signal extraction and performance evaluation were performed using the RooFit framework in Ref. [1]. We employed an unbinned maximum likelihood fit to the recoil mass distribution to construct the probability density functions (PDFs). This approach allowed for a precise determination of the K_L^0 yield and the evaluation of different backgrounds.



Recoil mass spectrum fits before cluster selection (left) and after the selection (right). Black points represent the MC sample, and the red line indicates the total fit. Colored components: signal K_L^0 (green), $K_S^0 \rightarrow \pi^+ \pi^-$ (magenta), $K_S^0 \rightarrow \pi^0 \pi^0$ (azure), π^0 background (yellow), $\pi^0 + K^0$ background (blue), and other backgrounds (grey).

1. W. Verkerke and D. Kirkby, "The RooFit toolkit for data modeling", Statistical Problems in Particle Physics, Astrophysics and Cosmology, Oxford (2006), pp. 186-189.
2. S. Longo et al. CsI(Tl) pulse shape discrimination with the Belle II electromagnetic calorimeter as a novel method to improve particle identification at electron-positron colliders. Nucl. Instrum. Meth. A, 982:164562, 2020.