Study the particle identification performance for $K_s^0 \longrightarrow \pi^+\pi^-$ decays using sPlot method

Sanjeeda Bharati Das[1*]

(on behalf of the Belle II Collaboration)

[1]Malaviya National Institute of Technology Jaipur, India

[*]Address correspondence to: 2018rpy9055@mnit.ac.in

Abstract

The $K_s^0 \longrightarrow \pi^+\pi^-$ sample gives access to low momentum pions, which are useful for studying the particle identification performance. In this work, we have validated the sPlot technique using Belle II simulated sample for $K_s^0 \longrightarrow \pi^+\pi^-$ at integrated luminosity of 10fb^{-1}. The Belle II is the upgraded experimental facility at SuperKEKB, KEK, Japan. In this work, we study the relative difference between true efficiencies and that obtained from the sPlot technique for different pion-identification criteria in bins of momentum and cosine of the polar angle. This study is now included as part of the Belle II Systematic Correction Framework.

1 Introduction

An inclusive sample of $K_s^0 \longrightarrow \pi^+\pi^-$ decays provides access to a large sample of charged pions with momentum below 1 GeV/c. Such pions can be used to study the performance of the particle-identification (PID) algorithms at low momentum. The aim of this work is to develop an analysis method based on the sPlot technique [1], in simulation and to study the PID performance in the context of the Belle II Systematic Correction Framework [2]. The Belle II [3] is an experimental facility at SuperKEKB [4], located in Tsukuba, Japan.

2 Reconstruction of $K_s^0 \longrightarrow \pi^+\pi^-$

Using 10 fb^{-1} of centrally produced Monte Carlo events, pairs of oppositely charged pion tracks are combined to reconstruct the mass of K_s^0, denoted by $m(\pi^+\pi^-)$. The K_s^0 decay time is required to exceed 0.007 ns, to suppress the combinatorial background. The transverse distance of the K_s^0 decay vertex from the origin is required to be less than 3.5 cm, corresponding to the distance of the first layer of the Belle II Silicon Vertex Detector(SVD) [3].

3 Results

The $m(\pi^+\pi^-)$ peak is modelled using the sum of a Gaussian and a Johnson's S_U [5] function and the background is modelled using a 1^{st} order Chebychev polynomial. A binned least squares fit is performed over the entire momentum range as shown in Figure 1 (left). The sWeights thus computed from this fit are used to compute *mc systematic error*, defined as: $mc\_syst\_error = (\epsilon_{sw} - \epsilon_{tm})/\epsilon_{tm}$, where ϵ_{sw} is the sWeighted efficiency (from splot technique) and ϵ_{tm} is the efficiency from truth matching. It is observed that mc_syst_error increases in the momentum range [0.5, 3.5] GeV/c with the maximum difference being about 7.5% as shown in Figure 1 (right). This dependence of mc_syst_error in pion momenta may be due to the presence of correlations between $m(\pi^+\pi^-)$ and momentum of the pions. The impact of these correlations are evaluated by computing sWeights based on independent fits to $m(\pi^+\pi^-)$ in disjoint bins of momenta: [0.5, 1.5] GeV/c and [1.5, 3.5] GeV/c as shown in Figure 2. No dependence of mc_syst_error on pion momenta is observed, which implies that pion identification efficiencies obtained from sWeights are in agreement with that obtained from truth matching.

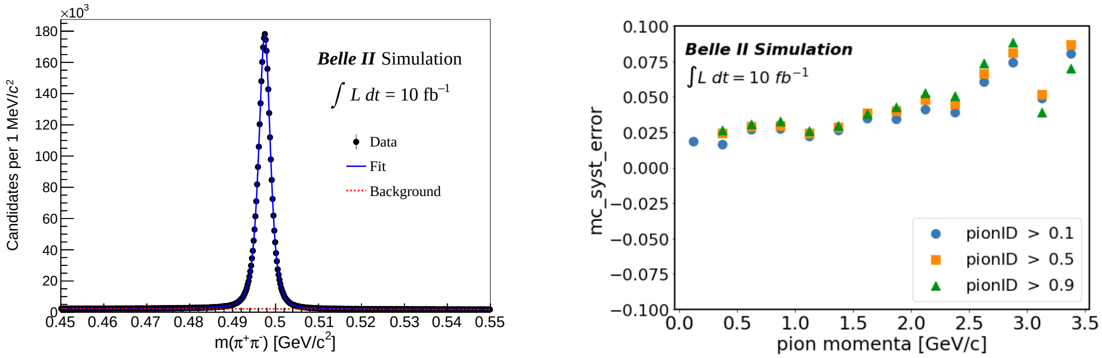

Figure 1: Distribution of $m(\pi^+\pi^-)$ (left), with fit projections overlaid distributions of *mc_syst_error* in bins of pion momenta (right).

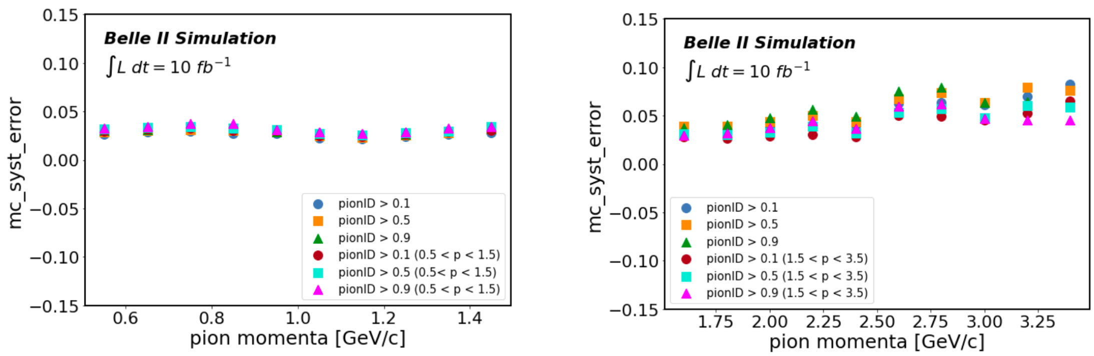

Figure 2: *mc_syst_error* in bins of pion momenta: [0.5, 1.5] GeV/c (left) and [1.5, 3.5] GeV/c (right).

4 Summary

The sPlot technique has been validated using an inclusive sample for $K_s^0 \longrightarrow \pi^+\pi^-$. The truth-matching procedure and the sPlot technique are consistent.

References

1. Pivk M and Le Diberder FR. SPlot: A Statistical tool to unfold data distributions. Nucl. Instrum. Meth. A 2005;555:356–69.
2. Belle II Systematic Corrections Framework.
3. Abe T et al. Belle II Technical Design Report. 2010.
4. Akai et al. SuperKEKB collider. Nucl. Instrum. Meth. 2018;907:188–99.
5. Johnson NL. Systems of frequency curves generated by methods of translation. Biometrika 1949;36:149–76.