Particle identification using $K_s^0 \longrightarrow \pi^+\pi^-$ decay

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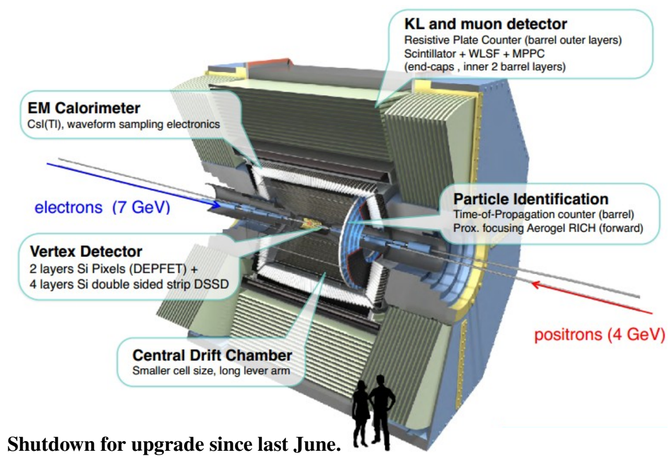
XXV DAE-BRNS HIGH ENERGY PHYSICS SYMPOSIUM, December 12-16, 2022 @ IISER Mohali

Introduction

- Inclusive sample of $K_s^0 \longrightarrow \pi^+\pi^-$ decays provides access to large samples 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 (Nucl. Instrum. Meth. A555 (2005) 356–369), in simulation.
  - Study the PID performance in the context of the **Belle II Systematic Correction Framework**.

Belle II Detector



Shutdown for upgrade since last June.

Collected 428 fb^{-1} data. Target: 50ab^{-1}

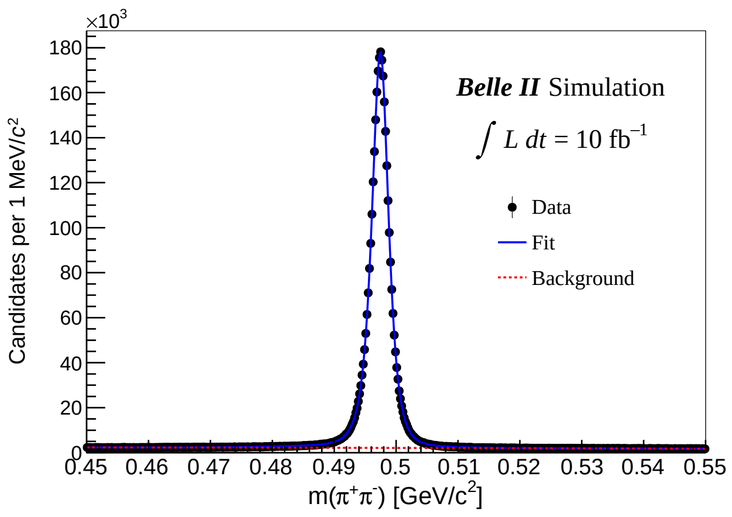
Reconstruction

Pairs of oppositely charged pion tracks are combined to reconstruct the invariant mass of K_s^0, which is denoted by $m(\pi^+\pi^-)$.

Data Sample & Selection Criteria:

- 10 fb^{-1} of centrally produced hadronic skims of simulated events are used.
- The K_s^0 decay time > 0.007 ns is used to suppress the combinatorial background.
- A veto on the invariant mass, computed by swapping the pion and proton hypothesis, K_s^0 mass $m(p\pi^-)$ is applied to eliminate candidates arising from $\Lambda^0 \longrightarrow p\pi^-$.
- 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). This restricts the analysis to charged pions that have traversed the tracking detectors that provide measurements of the dE/dx.

Fit model for $m(\pi^+\pi^-)$



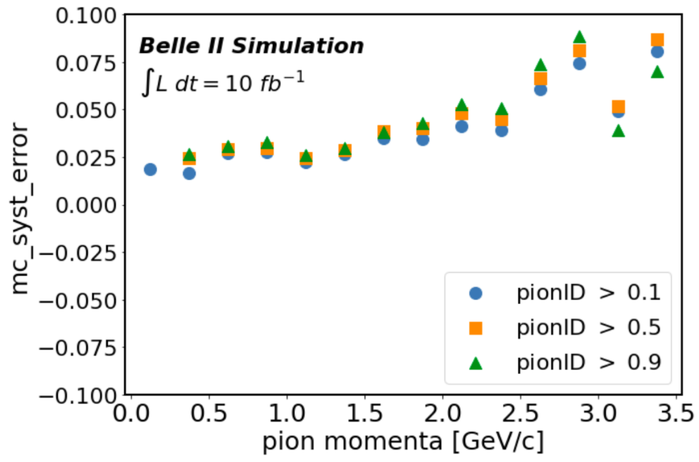
- The signal is modelled using the sum of a Gaussian and a Johnson S_U function. While the background is modelled using 2^{nd} order Chebyshev Polynomial.
- Binned least squares fit is performed over the entire momentum range and all parameters are left free to float.
- The sWeights thus computed are used to compute *mc_syst_error* (mc systematic error) for different pion-identification criteria.

mc_syst_error

The relative difference between measured and true efficiencies of different pion-identification criteria:

$$mc\_syst\_error = \frac{(\epsilon_{sw} - \epsilon_{tm})}{\epsilon_{tm}},$$

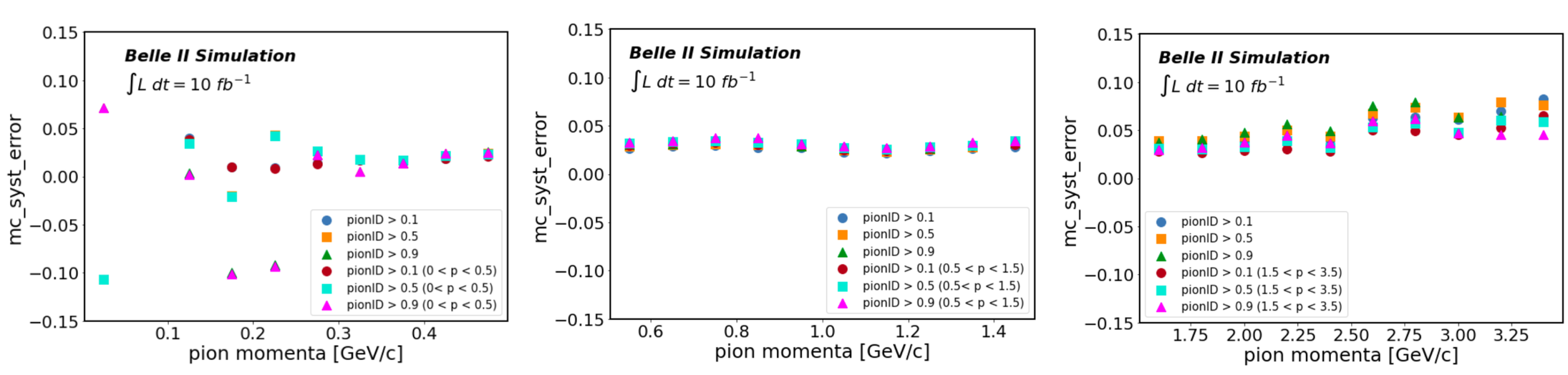
where ϵ_{sw} is the sWeighted efficiency and ϵ_{tm} is the efficiency from truth matching.



mc_syst_error is observed to increase in bins of momenta with the maximum difference being about 7.5%.

mc_syst_error in Bins of Pion Momenta

- The kinematic dependence of *mc_syst_error* may be due to the presence of correlations between $m(\pi^+\pi^-)$ and momentum of the pions, which invalidates one of the underlying assumptions of the sPlot method.
- The impact of these correlations are evaluated by computing sWeights based on three independent fits to $m(\pi^+\pi^-)$ in disjoint bins of momenta the ranges areas follows In the range [0, 0.5] GeV/c (left), there is a downward trend of *mc_syst_error* , [0.5, 1.5] GeV/c (middle), where the distribution of *mc_syst_error* is flat (right), and [1.5, 3.5] GeV/c, where an increasing trend is observed.



Summary

- $m(\pi^+\pi^-)$ fit model is now included in the **Belle II Systematic Correction Framework**.
- Developed and validated and analysis procedure based on the sPlot method.
- Pion identification efficiencies obtained from sWeights are in agreement with that obtained from truth matching.
- This procedure can now be used to study PID performance at low momentum (below 1 GeV/c).