K_L^0 Identification Efficiency of the KLM detector using sPlot

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A Brief Introduction to sPlots

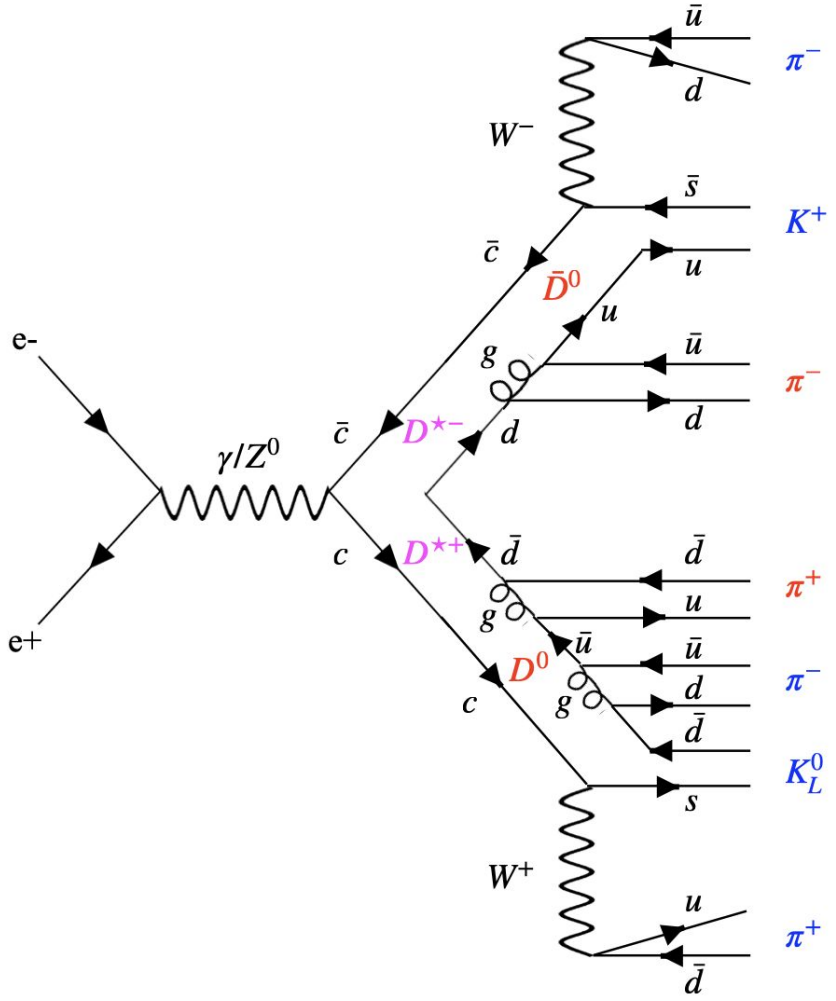
The main feature of sPlot is that it allows us to take a variable with a known signal and background PDF to act as a discriminating variable to calculate sWeights in order to reconstruct and classify a control variable with a poorly understood distribution and classification. Importantly, the control and discriminating variable should be statistically independent within classes[1][2]

Monte Carlo Sample

This study started as a mentored undergraduate research for a poster presentation at the UofL showcase fare, mentored by D. Biswas and Sw. Banerjee [3].

A sample of MC events were generated in release 05-02-18.

The decay mode to the right was chosen since it has a good branching fraction, and importantly, produces only 1 K^0_L, constrained by energy-momentum conservation.

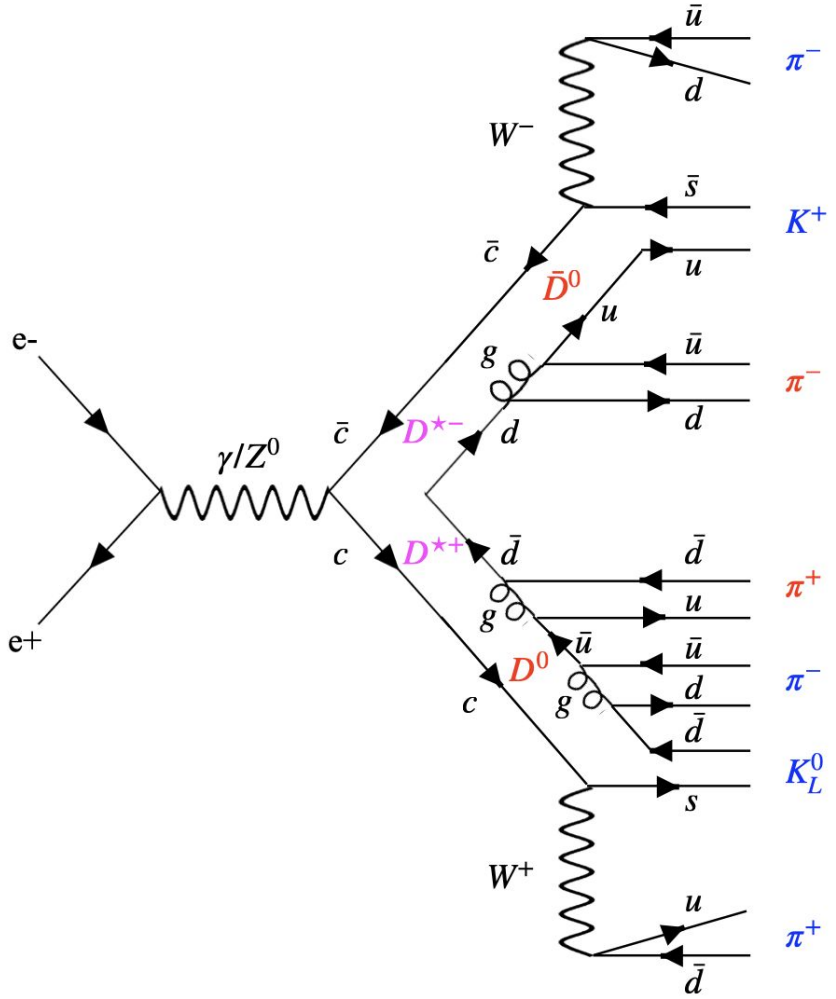


Selection Criteria

In the steering file cuts were made on the charged kaon and pions
|dz| < 2.0, dr < 0.5, nCDCHits > 20'
Take the track with highest “kaonID” to be the charged kaon

For the tag D0, a cut on the mass requiring to fit into 1.7<M<2.1 GeV

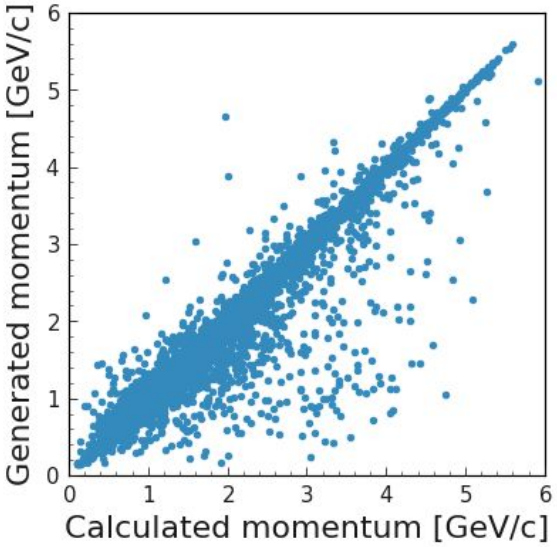
And the tag D^* was required to have a cms p > 2.5 GeV and mass difference with its 1st daughter less than 0.2 GeV



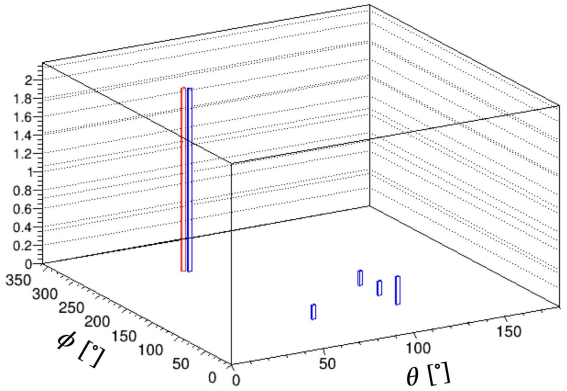
Analysis

We can use conservation of momentum to compute the K^0_L's momentum from reconstruction level quantities

For this analysis only reconstructed KLM cluster candidates within a 10° cone in the theta vs phi plane of the calculated direction, and momentum within 25% of the calculated momentum are considered signal.



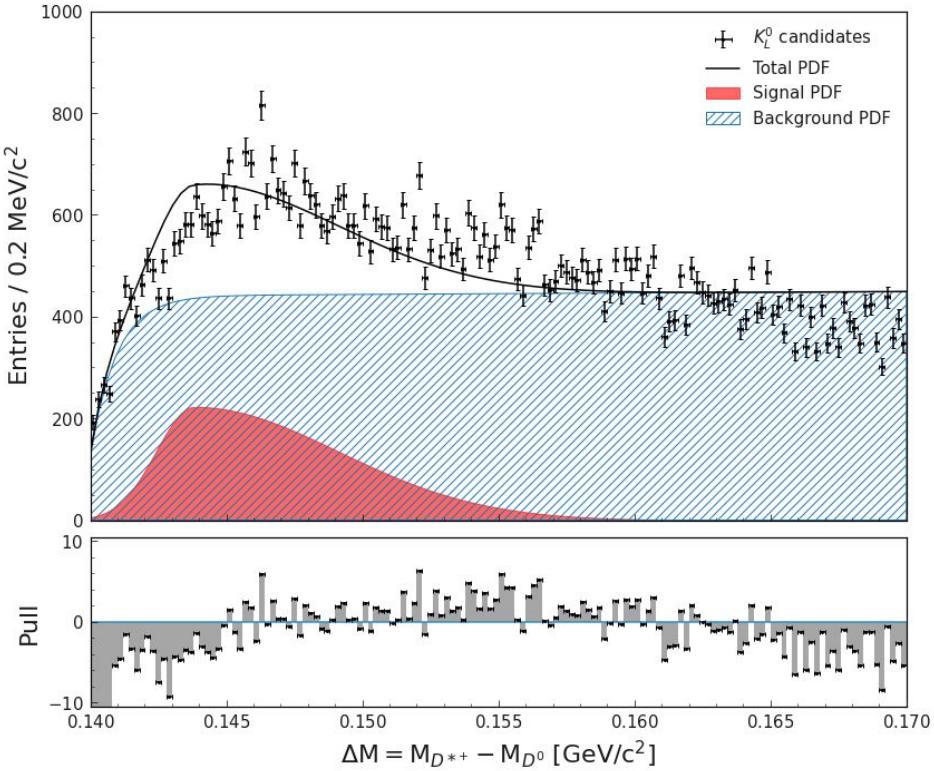
Generate dK^0_L momentum vs calculated



Calculated K^0_L candidate momenta (red) vs reconstructed (blue) in the theta vs phi plane

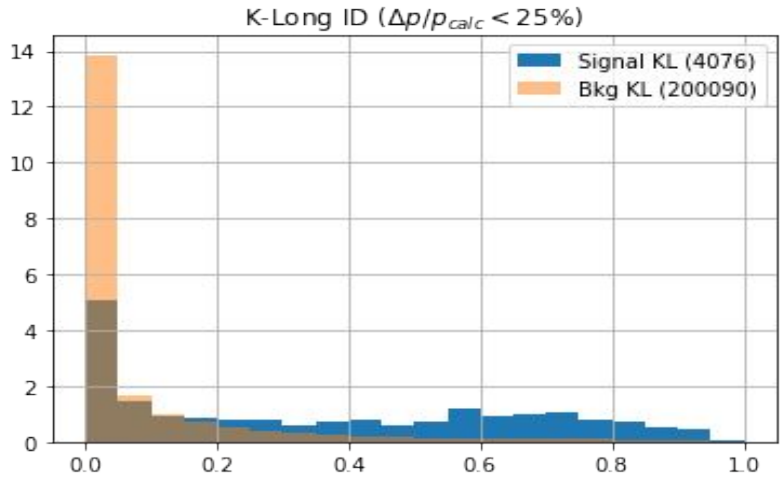
Discriminating Variable Fit

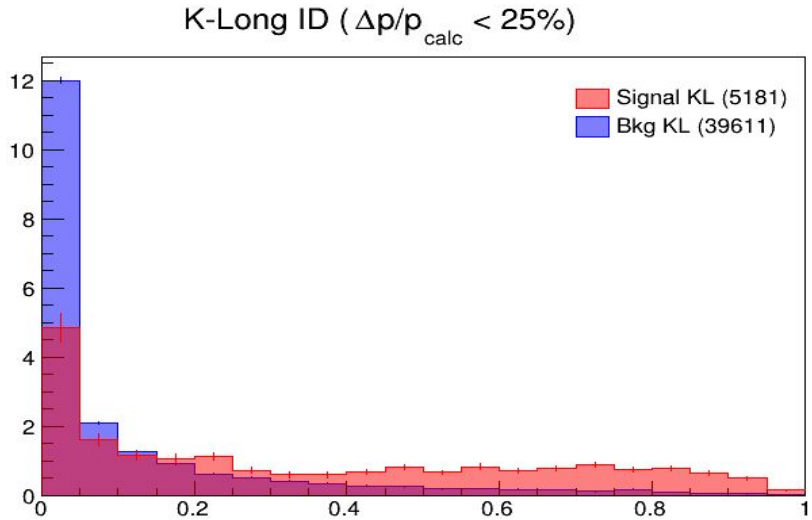
The discriminating variable was chosen to be the mass difference between the D^{*+} and D^0. The distribution is obtained by using the reconstructed K^0_L momentum and fitted to the sum of signal and background PDFs. The signal structure is a double Gaussian and the background is a polynomial with exponential damping



Standard Techniques vs. sPlot

Based on the previous cuts we can see signal and background K^0_L ID distribution (top)
On the bottom we can see the result of the sPlot technique, and that it yields higher statistics, especially for K-Long ID > 0.2.
The major advantage of this technique is the ability to study ID efficiency without relying on generator level quantities

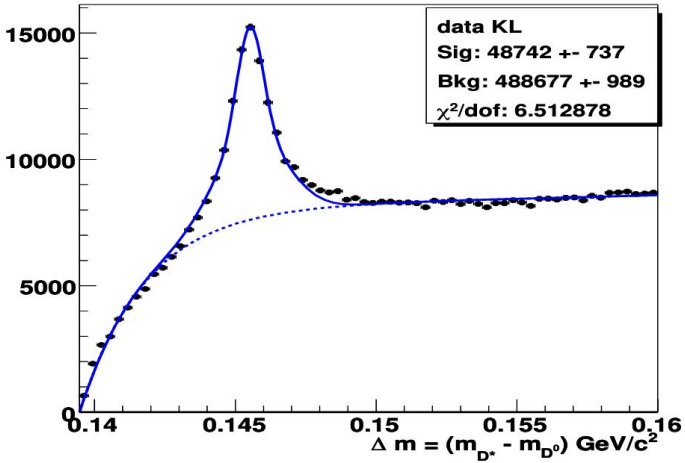




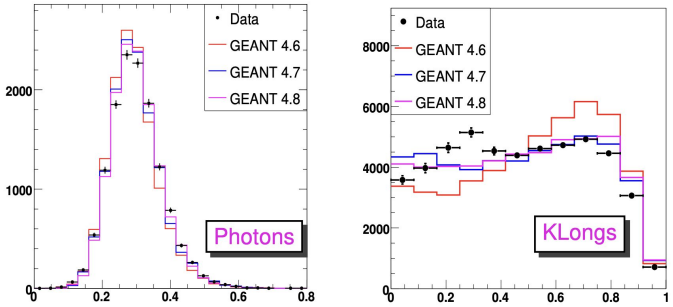
Plans for Continuation

- Here the sPlot method was used on MC.
- It can be further applied to real reconstruction level data as in the BaBar experiment [4], where the EMC shower shapes were classified as coming from Photons vs KLongs by fitting DeltaM.

  [CHEP 2007 presentation and conference note by Sw. Banerjee, et. al].



- Lateral Moment:



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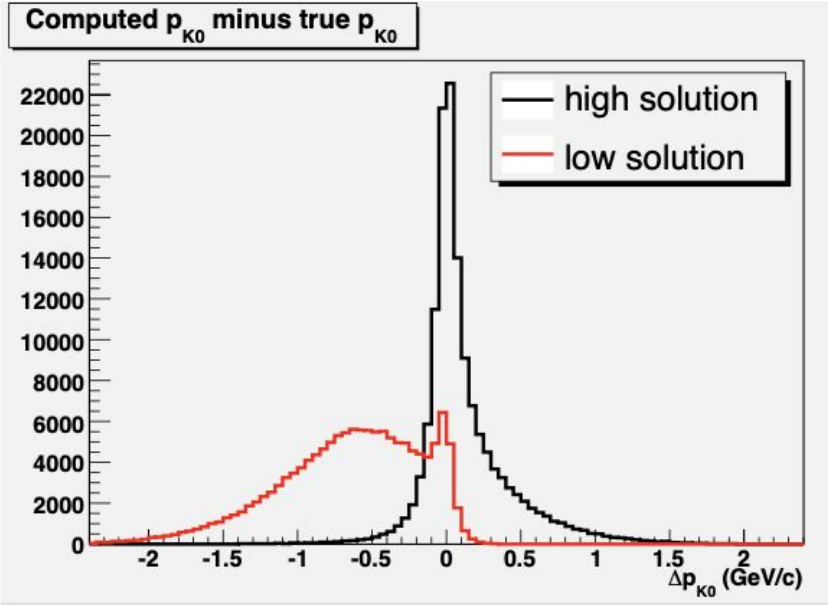
Plans for Continuation

- The exploration of the inclusive tagging of $D^{*+} \to [D^0 \to K^0_L \pi^+ \pi^-] \pi^+$ decay mode is expected to significantly increase the event statistics.
- The idea is to use mass constraints from signal-side reconstruction to calculate the Klong energy upto 2-fold ambiguity, assuming Klong direction is measured. But high solution is right “mostly”.
- This method not depending on tag-side is based on an internal BaBar note #1191.



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References

1. “sPlot: A Statistical tool to unfold data distributions,” M. Pivk and F. R. Le Diberder, Nucl. Instrum. Meth. A 555, 356-369 (2005).
2. Rogozhnikov, A. (2015, October 7). *sPlot: a technique to reconstruct components of a mixture*. Splot: A technique to reconstruct components of a mixture. https://arogozhnikov.github.io/2015/10/07/splot.html
3. D. Biswas, BELLE2-POSTER-DRAFT-2020-004
   J. Davis, UofL undergraduate research showcase fare
4. Validating Geant4 versions 7.1 and 8.3 against 6.1 for BABAR ”, S Banerjee, et al., J. Phys. Conf. Ser. 119, 032007 (2008).
5. Internal BaBar analysis document #1191.