0.1 V0 Selection

Λ ($\bar{\Lambda}$) and K^0_S are neutral particles which cannot be directly detected, but must instead be reconstructed through detection of their decay products, or daughters. This process is illustrated in Figure 1. In general, particles which are topologically reconstructed in this fashion are called V0 particles. The class AliFemtoV0TrackCutNSigmaFilter (which is an extension of AliFemtoV0TrackCut) is used to reconstruct the V0s.

In order to obtain a true and reliable signal, one must ensure good purity of the V0 collection. The purity of the collection is calculated as:

$$Purity = \frac{Signal}{Signal + Background} \tag{1}$$

To obtain both the signal and background, the invariant mass distribution (m_{inv}) of all V0 candidates must be constructed immediately before the final invariant mass cut. Examples of such distribtions can be found in Figures **??** and 8. It is vital that this distribution be constructed immediately before the final m_{inv} cut, otherwise it would be impossible to estimate the background. As shown in Figures **??** and 8, the background is fit (with a polynomial) outside of the peak region of interest to obtain an estimate for the backfround within the region. Within the m_{inv} cut limits, the background is the region below the fit while the signal is the region above the fit.
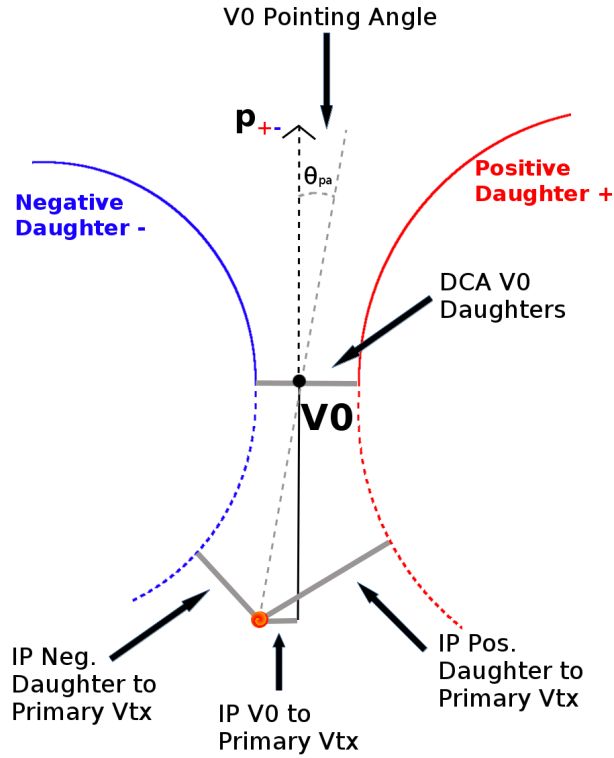

Fig. 1: V0 Reconstruction

0.1.1 Λ Reconstruction

The following cuts were used to select good Λ ($\bar{\Lambda}$) candidates:

1. Daughter Particle Cuts

- (a) Cuts Common to Both Daughters
    - i. $|\eta| < 0.8$
    - ii. SetTPCnclsDaughters(80)
    - iii. SetStatusDaughters(AliESDtrack::kTPCrefic)
    - iv. SetMaxDcaV0Daughters(0.4)
- (b) Pion Specific Daughter Cuts
    - i. $p_T > 0.16$
    - ii. DCA to prim vertex > 0.3
- (c) Proton Specific Daughter Cuts
    - i. $p_T > 0.5(p)$ $[0.3(\bar{p})]$ GeV/c
    - ii. DCA to prim vertex > 0.1

2. V0 Cuts

- (a) $|\eta| < 0.8$
- (b) $p_T > 0.4$
- (c) $|m_{inv} - m_{PDG}| < 3.8$ MeV
- (d) Cosine of pointing angle > 0.9993
- (e) OnFlyStatus = false
- (f) Decay Length < 60 cm

3. Shared Daughter Cut for V0 Collection

- – Iterate through V0 collection to ensure that no daughter is used in more than one V0 candidate
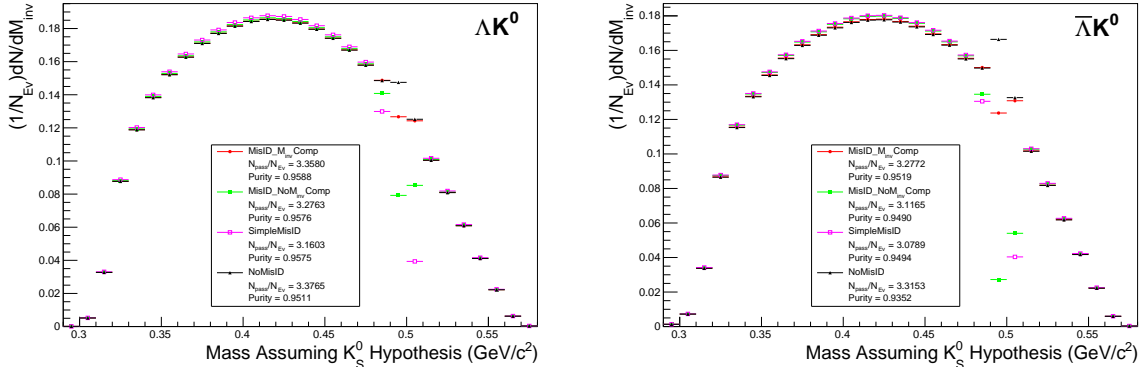
(a) Mass assuming K_S^0-hypothesis for Λ collection, i.e. assume the daughters are $\pi^+\pi^-$ instead of $p^+\pi^-$.

(b) Mass assuming K_S^0-hypothesis for $\bar{\Lambda}$ collection, i.e. assume the daughters are $\pi^+\pi^-$ instead of $\pi^+\bar{p}^-$.

Fig. 2: Mass assuming K_S^0-hypothesis for V0 candidates passing all Λ (**??**) and $\bar{\Lambda}$ (**??**) cuts. The "NoMisID" distribution (black triangles) uses the V0 finder without any attempt to remove misidentified K_S^0. The slight peak in the "NoMisID" distribution around $m_{inv} = 0.5$ GeV/c^2 contains misidentified K_S^0 particles in our $\Lambda(\bar{\Lambda})$ collection. "SimpleMisID" (pink squares) simply cuts out the entire peak, which throws away some good Λ and $\bar{\Lambda}$ particles. "MisID_NoM$_{inv}$Comp" (green squares) uses the misidentification cut outlined in the text, but does not utilize the invariant mass comparison method. "MisID_M$_{inv}$Comp" (red circles) utilizes the full misidentification methods, and is currently used for this analysis. "N$_{pass}$/N$_{ev}$" is the total number of $\Lambda(\bar{\Lambda})$ particles found, normalized by the total number of events. The purity of the collection is also listed.

Figure **??** shows the mass assuming K_S^0 hypothesis for the Λ collection, i.e. assume the daughters are $\pi^+\pi^-$ instead of $\pi^+\bar{p}^-$. Figure **??** is a similar plot, but is for the $\bar{\Lambda}$ collection, i.e. assume the daughters are $\pi^+\pi^-$ instead of $\pi^+\bar{p}^-$. The K_S^0 contamination is visible, although not profound, in both in the slight peaks around $m_{inv} = 0.497$ GeV/c^2. If one simply cuts out the entire peak, good Λ particles will be lost. Ideally, the Λ selection and K_S^0 misidentification cuts are selected such that the peak is removed from this plot while leaving the distribution continuous. To attempt to remove these K_S^0 contaminations without throwing away good Λ and $\bar{\Lambda}$ particles, the following misidentification cuts are imposed; a $\Lambda(\bar{\Lambda})$ candidate is rejected if all of the following criteria are satisfied:

- $\left| m_{inv,\ K_S^0\ Hypothesis} - m_{PDG,\ K_S^0} \right| < 9.0$ MeV/c^2

- Positive and negative daughters pass π daughter cut implemented for K_S^0 reconstruction

- $\left| m_{inv,\ K_S^0\ Hypothesis} - m_{PDG,\ K_S^0} \right| < \left| m_{inv,\ \Lambda(\bar{\Lambda})\ Hypothesis} - m_{PDG,\ \Lambda(\bar{\Lambda})} \right|$

Figure **??** shows the invariant mass (M_{inv}) distribution of all $\Lambda(\bar{\Lambda})$ candidates immediately before the final invariant mass cut. These distributions are used to calculate the collection purities. The Λ and $\bar{\Lambda}$ purities are found to be: Purity(Λ) $\approx$ Purity($\bar{\Lambda}$) $\approx 95\%$.

(a) Λ Purity

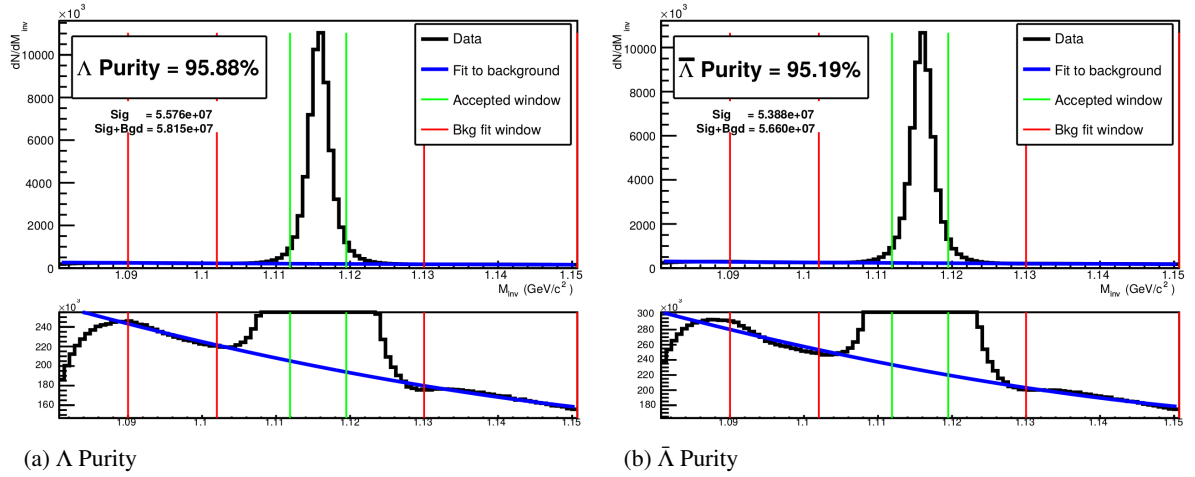(b) $\bar{\Lambda}$ Purity

Fig. 3: Invariant mass (M_{inv}) distribution of all Λ (a) and $\bar{\Lambda}$ (b) candidates immediately before the final invariant mass cut. The bottom figures are zoomed to show the background with fit. The vertical green lines represent the M_{inv} cuts used in the analyses, the red vertical lines delineate the region over which the background was fit, and the blue line shows the background fit. These distributions are used to calculate the collection purities, Purity(Λ) $\approx$ Purity($\bar{\Lambda}$) $\approx 95\%$.

0.1.2 K_S^0 Reconstruction

The following cuts were used to select good K_S^0 candidates:

1. Pion Daughter Cuts

    (a) $|\eta| < 0.8$

    (b) SetTPCnclsDaughters(80)

    (c) SetStatusDaughters(AliESDtrack::kTPCrefic)

    (d) SetMaxDcaV0Daughters(0.3)

    (e) $p_T > 0.15$

    (f) DCA to prim vertex > 0.3

2. K^0_S Cuts

    (a) $|\eta| < 0.8$

    (b) $p_T > 0.2$

    (c) $m_{PDG} - 13.677$ MeV $< m_{inv} < m_{PDG} + 2.0323$ MeV

    (d) Cosine of pointing angle > 0.9993

    (e) OnFlyStatus = false

   (f) Decay Length < 30 cm

3. Shared Daughter Cut for V0 Collection

    – Iterate through V0 collection to ensure that no daughter is used in more than one V0 candidate

As can be seen in Figure **??**, some misidentified Λ and $\bar{\Lambda}$ particles contaminate our K^0_S sample. Figure **??** shows the mass assuming Λ-hypothesis for the K^0_S collection, i.e. assume the daughters are $p^+\pi^-$ instead of $\pi^+\pi^-$. Figure **??** is similar, but shows the mass assuming $\bar{\Lambda}$ hypothesis for the collection, i.e. assume the daughters are $\pi^+\bar{p}^-$ instead of $\pi^+\pi^-$. The Λ contamination can be seen in **??**, and the $\bar{\Lambda}$ contamination in **??**, in the peaks around $m_{inv} = 1.115$ GeV/c^2. Additionally, the $\bar{\Lambda}$ contamination is visible in Figure **??**, and the Λ contamination visible in Figure **??**, in the region of excess around $1.65 < m_{inv} < 2.1$ GeV/c^2. This is confirmed as the number of misidentified Λ particles in the sharp peak of Figure **??** (misidentified $\bar{\Lambda}$ particles in the sharp peak of Figure **??**) approximately equals the excess found in the $1.65 < m_{inv} < 2.1$ GeV/c^2 region of Figure **??** (Figure **??**).

The peaks around $m_{inv} = 1.115$ GeV/c^2 in Figure **??** contain both misidentified Λ ($\bar{\Lambda}$) particles and good K^0_S. If one simply cuts out the entire peak, some good K^0_S particles will be lost. Ideally, the K^0_S selection and $\Lambda(\bar{\Lambda})$ misidentification cuts can be selected such that the peak is removed from this plot while leaving the distribution continuous. To attempt to remove these Λ and $\bar{\Lambda}$ contaminations without throwing away good K^0_S particles, the following misidentification cuts are imposed; a K^0_S candidate is rejected if all of the following criteria are satisfied (for either Λ or $\bar{\Lambda}$ hypothesis):

– $\left| m_{inv,\ \Lambda(\bar{\Lambda})\ Hypothesis} - m_{PDG,\ \Lambda(\bar{\Lambda})} \right| < 9.0$ MeV/c^2

– Positive daughter passes $p^+(\pi^+)$ daughter cut implemented for $\Lambda(\bar{\Lambda})$ reconstruction

– Negative daughter passes $\pi^-(\bar{p}^-)$ daughter cut implemented by $\Lambda(\bar{\Lambda})$ reconstruction

– $\left| m_{inv,\ \Lambda(\bar{\Lambda})\ Hypothesis} - m_{PDG,\ \Lambda(\bar{\Lambda})} \right| < \left| m_{inv,\ K^0_S\ Hypothesis} - m_{PDG,\ K^0_S} \right|$
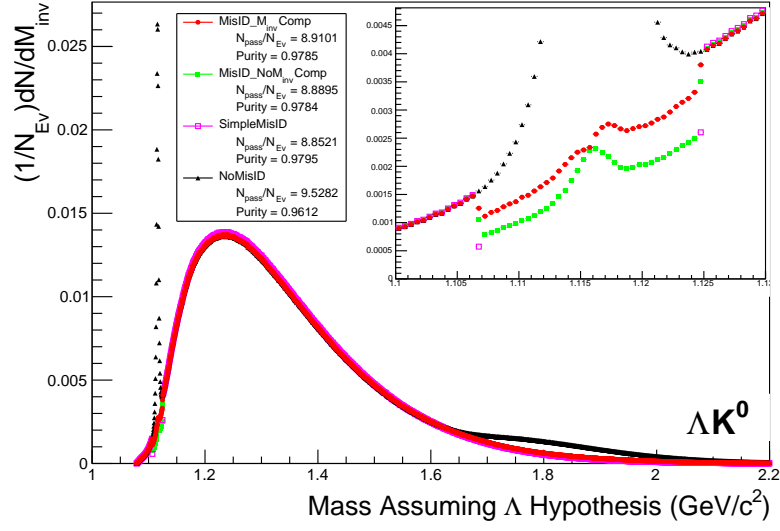
(a) Mass assuming Λ-hypothesis for K_S^0 collection, i.e. assume the daughters are $p^+\pi^-$ instead of $\pi^+\pi^-$.
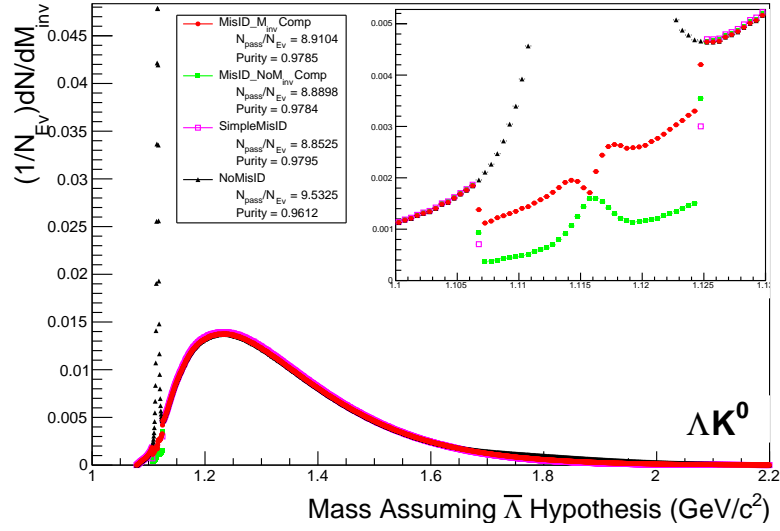
(b) Mass assuming $\bar{\Lambda}$-hypothesis for K_S^0 collection, i.e. assume the daughters are $\pi^+\bar{p}^-$ instead of $\pi^+\pi^-$.

Fig. 4: Mass assuming Λ-hypothesis (**??**) and $\bar{\Lambda}$-hypothesis (**??**) for K_S^0 collection. The "NoMisID" distribution (black triangles) uses the V0 finder without any attempt to remove misidentified Λ and $\bar{\Lambda}$. The peak in the "NoMisID" distribution around $m_{inv} = 1.115$ GeV/c^2 contains misidentified Λ (**??**) and $\bar{\Lambda}$ (**??**) particles in our K_S^0 collection. "SimpleMisID" (pink squares) simply cuts out the entire peak, which throws away some good K_S^0 particles. "MisID_NoM$_{inv}$Comp" (green squares) uses the misidentification cut outlined in the text, but does not utilize the invariant mass comparison method. "MisID_M$_{inv}$Comp" (red circles) utilizes the full misidentification methods, and is currently used for this analysis. "N$_{pass}$/N$_{ev}$" is the total number of K_S^0 particles found, normalized by the total number of events. The purity of the collection is also listed. Also note, the relative excess of the "NoMisID" distribution around $1.65 < m_{inv} < 2.1$ GeV/c^2 shows misidified $\bar{\Lambda}$ (**??**) and Λ (**??**) particles in our K_S^0 collection.
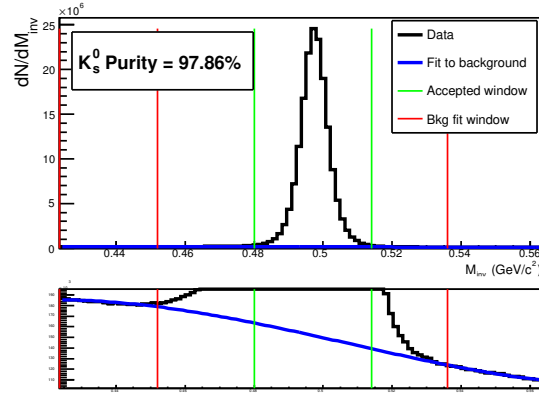
Fig. 5: Invariant mass (M_{inv}) distribution of all K_S^0 candidates immediately before the final invariant mass cut. The bottom figure is zoomed to show the background with fit. The vertical green lines represent the M_{inv} cut used in the analyses, the red vertical lines delineate the region over which the background was fit, and the blue line shows the background fit. This distribution is used to calculate the collection purity, Purity(K_S^0) $\approx 98\%$.