Indentification of Charged Kaons

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May 2017

Abstract

In this short document, the details of charged kaon identification used for E1-F analysis are described.

1 Introduction

The charged K mesons, or kaons are light mesons containing strange (anti-strange) and up (anti-up) valence quarks. Several properties are summarized in the table below, one important property (for identification) is the lifetime. The charged kaons have a long enough lifetime to be directly detected in CLAS (for the observed momenta that is detected).

Parameter	Value (K^+/K^-)
mass	$493.667 \pm 0.002\ MeV/c^2$
lifetime	$(1.238 \pm 0.002) \times 10^{-8}\ s$
J^{PC}	0^-
quark composition	$(u\bar{s}/s\bar{u})$

The biggest challenge in identifying charged kaons is separating them from charged pions at higher momenta. This is evident from figure 2.

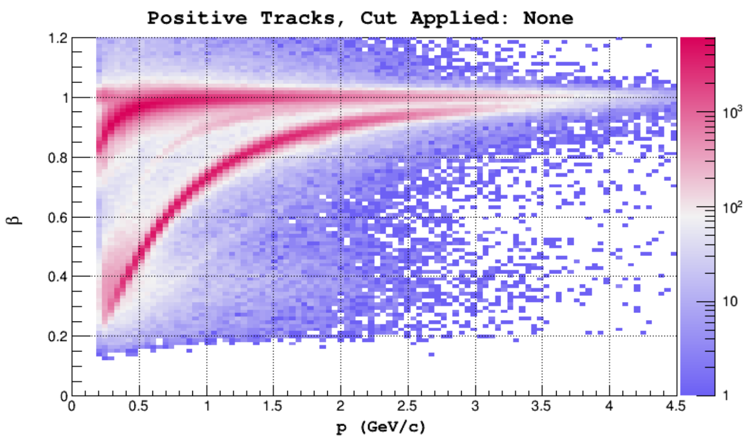

Figure 1: $\beta(p)$ for positive tracks in sector 1.

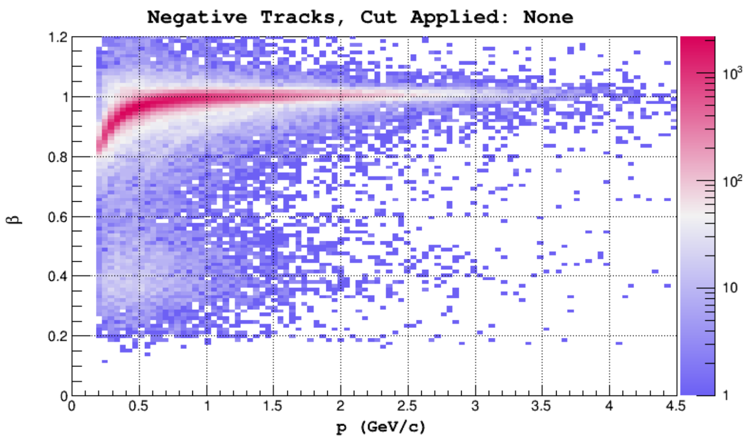

Figure 2: $\beta(p)$ for negative tracks in sector 1.

2 Preliminary Cuts

To identify possible candidates several cuts are applied.

- An electron must be detected in the event.
- The difference between the candidate vertex and the electron vertex must be less than 4 cm. This removes many low momentum tracks that don't come directly from the interaction in the target.
- For positive tracks, a fiducial cut is placed on the drift chamber region 1.

The fiducial cut on positive (which bend toward the beamline in the magnetic field used for this experiment) tracks prevents events near the boundaries of the detector (poorly understood effects) from entering our sample. The cut boundaries intersect 10 cm radially away from the beamline, and open at 60 degrees.

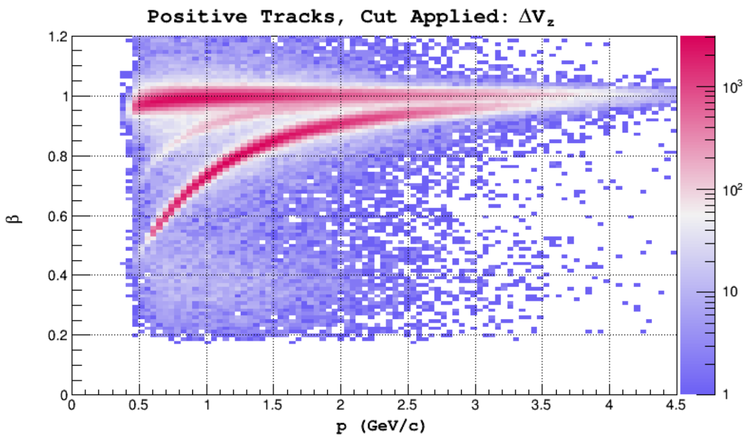

Figure 3: $\beta(p)$ for positive tracks passing the ΔV_z cut shown.

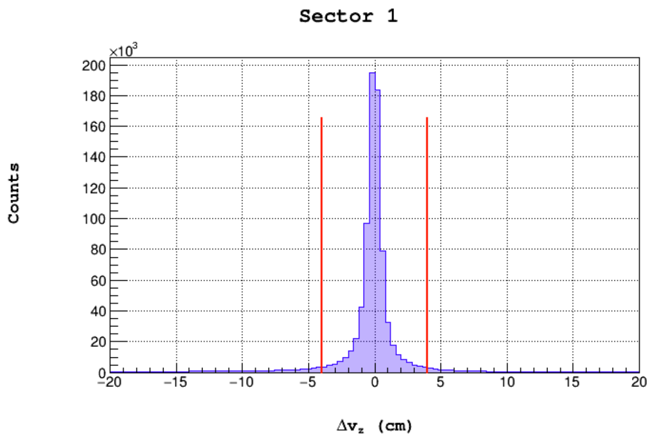

Figure 4: The distribution of ΔV_z for positive tracks.

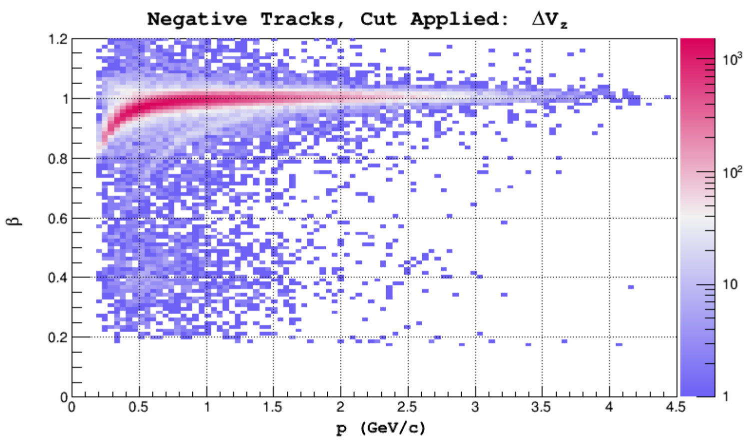

Figure 5: $\beta(p)$ for negative tracks passing the ΔV_z cut shown.

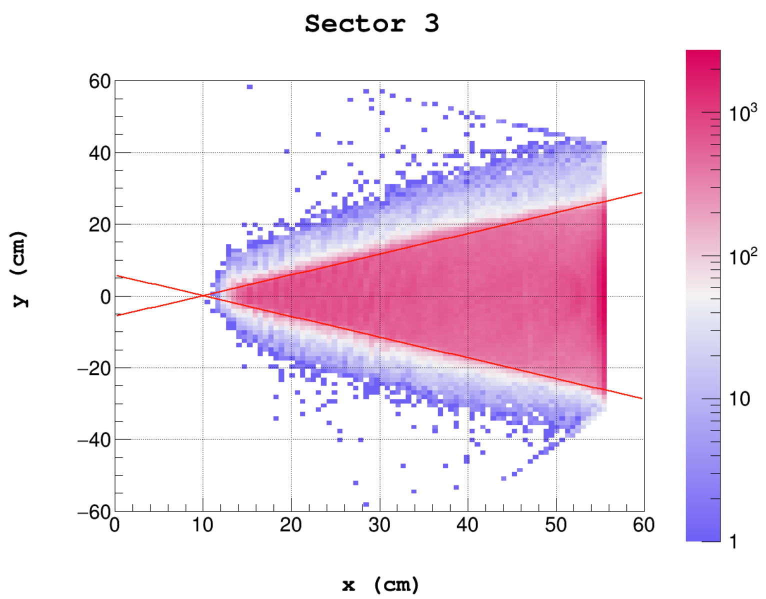

Figure 6: Positive tracks at the region 1 drift chambers. The red lines illustrate the cut boundary for good tracks (inside).

3 Timing Cuts

There are several approaches used historically to identify hadrons in CLAS, all of them rely on time-of-flight information. Before applying timing cuts, timing information is corrected following the method of Nathan Harrison (cite here). This method involves (details here).

3.1 Time of Flight Mass Cut

The mass of a particle can be calculated using the time of flight information and the start time of the event,

$$M_{ToF} = p \, \frac{1-\beta^2}{\beta^2} \tag{1}$$

Where $\beta = \frac{d}{(t_{hit}-t_{start})c}$ and $t_{start} = t_e - d/v_e$. All timing information used in these calculations is corrected as described above. Linear boundaries can be used to cut around the mass of a particle of interest, in our case the kaon mass. As with other timing cuts, separation of pions and kaons becomes difficult at higher momentum. Time of flight mass cuts have the advantage that for weak signals the boundaries are easy to draw, where fitting the $\beta(p)$ distribution might be difficult. This cut has a disadvantage as compared with the $\beta(p)$ cut (below) that M_{ToF} not only contains detector information from time of flight but also from drift chambers in the momentum term. In this analysis, a time of flight mass cut is considered. The upper boundary $M_{ToF} < 0.75 \ GeV/c^2$ is not difficult to place, because for the negative case there is not a heavier background, and for the positive case protons lie far enough away. The lower boundary is the critical boundary in order to maximally separate kaons from the lighter pions.

In order to choose the lower boundary, the time of flight mass is sliced into different momentum bins. Each slice is then fit with a double Gaussian over the neighboring pion-kaon mass peaks. If the fit quality is good, the individual Gaussian fits are interpreted as the mass distribution of each particle in the sample. Using this information, the kaon efficiency is defined.

$$\epsilon_{K^\pm} = \frac{\int_{M_{cut}}^{M_{upper}} f_{K^\pm}(M) dM}{\int_{M=0.0}^{M_{upper}} f_{K^\pm}(M) dM} \tag{2}$$

Where $f_{K\pm}$ is the fit to the kaon mass peak for positive/negative charge. The efficiency represents the fraction of kaons that we identify with a given value of M_{cut}. The pion contamination is defined as,

$$C_{\pi^\pm} = \frac{\int_{M_{cut}}^{M_{upper}} f_{\pi^\pm}(M) dM}{\int_{M_{cut}}^{M_{upper}} f_{K^\pm}(M) + f_{\pi^\pm}(M) dM} \tag{3}$$

and represents the fraction of the total sample that is pion background.

3.2 β Cut (Momentum Dependent)

The calculation of the quantity β was described above, using only time of flight information for the electron and hadron candidate. Particles of mass m show up in lines of constant mass from the equation below. This can also be observed from figure 2.

$$\frac{p}{E} = \beta = \frac{p}{\sqrt{p^2+m^2}} \tag{4}$$

While the signal particle is more difficult to extract from these lines, the distribution is not skewed by information from the drift chambers momentum.

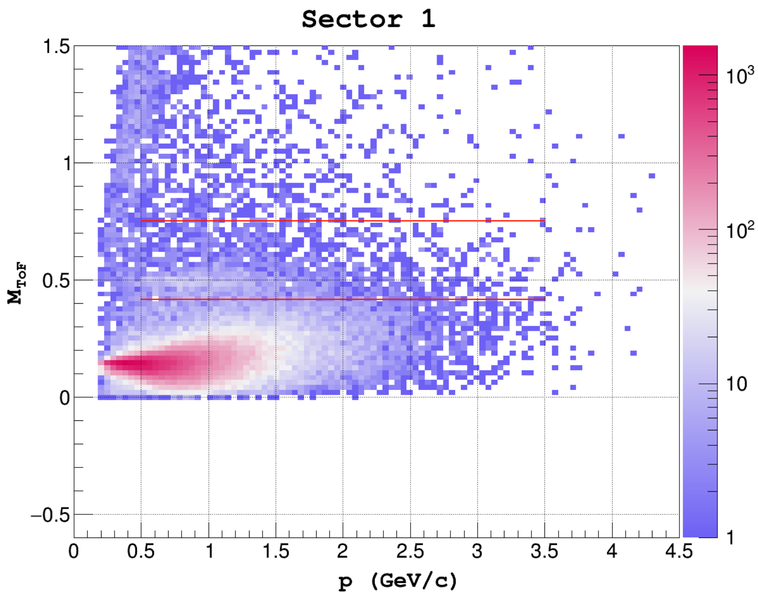

Figure 7: Time of flight mass shown for positive tracks in sector 1.