Determining NCD Events z Positions

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An ionization signal generated along the 40 proportional counters deployed in the D_2O of the SNO detector travels in both directions. These proportional counters are also referred to as Neutral Current Detectors or (NCDs). The signal traveling downward is reflected when it reaches the end of the delay line. The signal is delayed 86 ns in the delay line and travels at a speed of $0.86c$ in the NCD. This results in a delay, Δt, between the direct signal traveling upward and the reflected signal which depends on the original z of the signal given by

$$\Delta t = \frac{2(z + L_i/2)}{v} + t_{delay}, \tag{1}$$

where z is relative to the center of the NCD, L_i is the length of NCD i, $v = 0.86c$ is the velocity of the signal in the NCD, and t_{delay} is the time delay of the delay line.

This document describes a method developed to determine z based on the peaks in the waveform. It also describes results obtained with deployed sources and background events. Because this method only works on $\sim$30 % of neutron events, it is unlikely that this z position information could be used in a fit to obtain the neutron numbers, but it could be used to better understand the backgrounds. The reflected pulse could be deconvolved from the observed waveform to simplify the fitting of the ionization tracks however.

In order to better resolve the peaks in the waveform the effect of the electronics response and ion mobility are first deconvolved from the waveform. Then the derivative of the waveform was calculated so that the leading edge of both the direct and reflected pulse shows up as a separate peak which allows for better separation than possible with the undifferentiated waveform. Then a number of cuts are applied to remove peaks caused by noise.

Figure 1 shows the time between the direct and reflected pulses versus the deployed z position. There is clearly very good agreement with the nominal speed in the NCD and the delay time. The data points move away from the straight line at high and low z positions because the neutron distribution is distorted by the fact that it can not be capture beyond the end of the NCD. This method appears to have a resolution of approximately 180 cm and results in a fit for approximately 30 % of the neutrons.

This method for determining NCD event z position is then applied to the neutrino dataset. For alphas in the neutron energy region it results in a good z position fit for less than 20 % of the events. This increases to greater than 80 % of events with a good z position fit for high energy alphas. For these higher energy events Figure 2 shows that there appears to be an excess of alpha events near the boundaries between the different sections of the NCDs. We are now working to determine if these alpha events near a boundary could have a different shape, due to the electric field shape, which could affect neutron and alpha event separation. Based on PMT data it appears there is a background at -300 cm on NCD 31 and -100 to 0 cm on NCD 18. If this caused photo-disintegration there should also be a low energy peak due to neutrons on these NCDs. The statistics for the low energy events is very poor; however there does not appear to be any excess at this position in neutron capture energy region.

In conclusion a method for determining the z positions of NCD events has been developed. This is providing useful information on the background distribution.

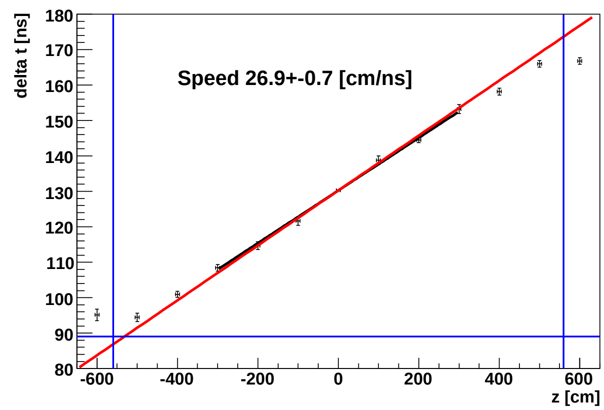

FIG. 1: The data points show the time between direct and reflected pulse versus the deployed source z position. The vertical lines represent the ends of the NCD and the horizontal line represents the 89 ns delay from the delay line. The black line is a linear fit to the data, with the resulting speed shown. The red line represents the nominal speed of $0.86c$, with the same intercept as the black line fit.

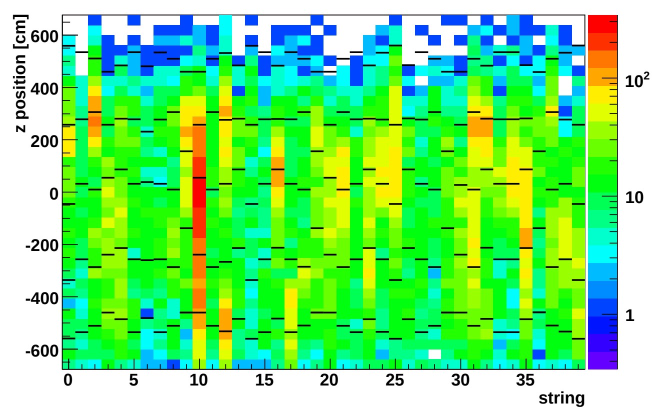

FIG. 2: Reconstructed z position for events with energy greater than 2 MeV and less than 6 MeV in the blind dataset. The short horizontal lines correspond to the boundaries of the different segments.