Determination of Timing Alignment of TDC Channels of Fission Fragment Chamber

Sharmalee D. Randeniya

Version 2

The Fission Fragment Chamber(FFC) consists of 4 Multi Wire Proportional Chamber modules and each module has a timing TDC channel to read out the time of flight of fission fragments formed. This document describes how calculate delays of these TDC channels.

In the following formulation the index "1" refers to the trigger module and the rest of the modules are indexed as 2, 3 ,4. "a" refers to actual values and "m" refers to measured values. Average values of TDC readouts are denoted by "<T>" and average value of delay of each TDC cahnnel is denoted by D. Average delay of the i^{th} TDC channel with respect to the trigger TDC channel is denoted by d_{1i} and "i" runs from 2 to 4.

The readout time of any channel is equal to the actual value plus a delay. Hence for the 1st and 2nd. channels,

$$<T_{1a}>+D_1 = <T_{1m}> \tag{1}$$

$$<T_{2a}>+D_2 = <T_{2m}> \tag{2}$$

Average Time of Flight (TOF) of fragments between the first and second planes is

$$<TOF_{12}> = <T_{1a}>-<T_{2a}> = <T_{1m}>-<T_{2m}>-(D_1-D_2) \tag{3}$$

$$<TOF_{12}> = <T_{1m}>-<T_{2m}>-d_{12} \tag{4}$$

Similarly, for the modules 3 and 4,

$$<TOF_{13}> \ = \ <T_{1m}>-<T_{3m}>-d_{13} \tag{5}$$

$$<TOF_{14}> \ = \ <T_{1m}>-<T_{4m}>-d_{14} \tag{6}$$

For calibration purposes of the FFD ^{252}Cf fission source is used. This source emits fission fragments of asymmetric masses and fragments' mass distribution is concentrated in two regions.

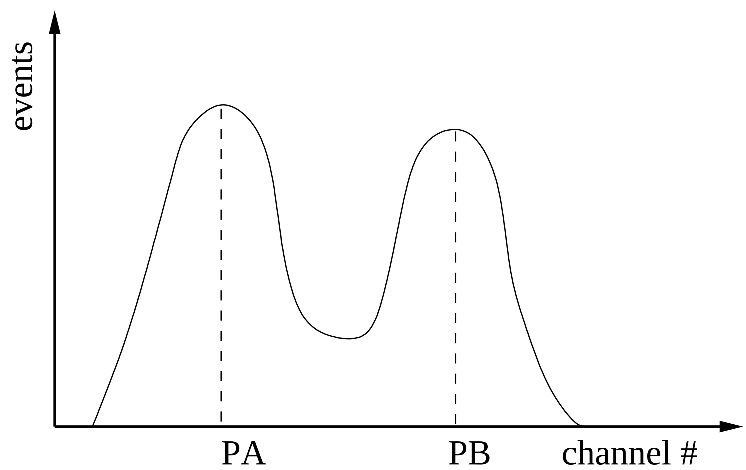

Figure 1 : TDC spectrum of a channel

A sketch of a TDC spectrum obtained using a ^{252}Cf source is shown in figure 1. The two peaks correspond to fragments of two different of masses. Let's denote them as type A and B. To calculate the delays, obtain the values “PA”, “PB” from TDC spectrum for each channel. These are the mean values of T measured for both types, for each channel. For example to calculate d_{12} , one needs $<S_{12}^{A}> \ = \ <S_{12}^{B}>$ from the TDC spectrum of channel 1 and from the TDC spectrum of channel 2. Then consider $<TOF_{12}>$ for type A and B. By taking the ratio of Time of Flights of types A and B,

$$\frac{<TOF_{12}^{A}>}{<TOF_{12}^{B}>} = \frac{(<T_{1m}^{A}>-<T_{2m}^{A}>-d_{12})}{(<T_{1m}^{B}>-<T_{2m}^{B}>-d_{12})} \tag{7}$$

The velocities of fragments A and B are known. $V_A = 1.04 \quad cm/ns$ and $V_B = 1.372 \quad cm/ns$. Then,

$$<TOF_{12}^{A}> = \frac{<S_{12}^{A}>}{V_A} \quad \text{and} \quad <TOF_{12}^{B}> = \frac{<S_{12}^{B}>}{V_B}$$

where $<S_{12}^{A}>$ and $<S_{12}^{B}>$ are average path lengths for types A and B between module 1 and 2. Since the direction of the emitted fission fragments are independent of their type(charge, mass etc.) , $<S_{12}^{A}> = <S_{12}^{B}>$. Then

$$\frac{<TOF_{12}^{A}>}{<TOF_{12}^{B}>} = \frac{V_B}{V_A} \qquad (8)$$

From equations (7), (8) the delay d_{12} is given by

$$d_{12} = \frac{<T_{1m}^{B}> - <T_{2m}^{B}> - V_A/V_B(<T_{1m}^{A}> - <T_{2m}^{A}>)}{(1 - V_A/V_B)} \qquad (9)$$

Similarly d_{13}, d_{14} can be calculated.