## TDCs offset calibration

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Events are triggered in both HRSs by two scintillator planes located, as shown in figure 1, 2m apart in the detector stack.



Figure 1: Left and Right HRS detector stack

Each plane is constructed out of scintillator paddles. On the Left HRS, The Front (S1) and Rear (S2) planes has 6 paddles each, On the Right HRS, S1 has 6 paddles and S2 has 16 paddles.

TDCs are connected to both photomultipliers on each paddle. The time reading of the paddle is taken as the average of the time reading of the TDCs on both its ends. In order to use the time measurements of the TDCs, one needs to determine the time offset value for each TDC, the different offsets are due to different cable lengths. The procedure has been done in two steps:

1. Calibration of the relative offset between the paddles

For each spectrometer, we first cut on events that fired from two neighbouring paddles simultaneously. For those events we know that the difference of the reading from those TDCs should be 0, so we calibrated the relative offset accordingly.

For fine tuning, we looked at the time spectrum generated for each paddle, where we identified the three peaks for protons, deuteron and 3He (See Figure 5), and aligned their relative time readings to match for each



Figure 2: Distrib. of the firing paddles S1 vs S2 on the Right HRS  $\,$ 

paddle. For further certainty in regard to the identification of the proton peak, we cut on events that had an event in coincidence in the other spectrometer - this suppressed the Deuteron and 3He peaks.

2. Absolute time reading calibration

By looking at the time spectrum and identifying the Proton, Deuteron and 3He peaks. We calibrated the absolute value of the TDCs reading to match the calculated time of flights for the given momentum.



Figure 3: Beta over P at  $1.1 {\rm GeV}$  from the Left HRS before TDC offset calibration



Figure 4: Beta over P at 1.1GeV from the Left HRS after TDC offset calibration



Figure 5: TOF for HRS-R, HRS-L for particles that passed in the central paddle of each plane.  $1\sigma\!=\!0.3ns$  for HRS-R and  $1\sigma\!=\!0.6ns$  for HRS-L



Figure 6: Beta spectrum at 1.1GeV from the Left and Right HRS after TDC offset calibration.  $1\sigma$ =0.03 for RHRS and  $1\sigma$ =0.06 for LHRS