Coincidence Time Measurements

Robert Michaels, Nov, 2001

The purpose of this note is to explain how the coincidence time is measured during the E00102 experiment and to try to explain the many odd features of the raw TDC spectra (so-called "TC", not to be confused with "TC-corr"). These notes may be relevant to other experiments, though things have evolved over time.

Figure 1 shows how we measure the coincidence time redundantly on each spectrometer using a TDC model 1875 (single hit, common start, 100 psec resolution). The start comes from the result of a retiming circuit explained later. The stop comes from the other arm's trigger. The "TC" variable from ESPACE usually looks at is the TDC on one spectrometer (the left ? not sure).

It is important to realize how the retiming circuit works. There are two inputs: The level-1 accept (L1A) from the trigger supervisor, and a local scintillator. The output of the retiming is a logical "AND" with a timing tied to the scintillator leading edge. The L1A has a precise time relation to the accepted trigger, so if the trigger is TN (N=1,2,3..) the L1A has the timing of TN. The local scintillator comes typically 80 nsec after the L1A, and this timing is used to open the fastbus gates (e.g. the start of the TDCs). There are two main benefits of this retiming: 1) The gates have less jitter than the L1A since the L1A is the result of many modules, and 2) The fastbus gate timings are independent of the trigger type, in normal circumstances (but see below).

In order to guarantee that there is always a fastbus gate, so we do not lose synchronization in our DAQ, there are three logical conditions anticipated for the retiming: 1) The normal condition that there is a scintillator pulse within the expected time window, at either the exact time or it may a bit earlier due to pileup. The fastbus gate is tied to this scintillator. 2) At the time the L1A arrives the scintillator signal may be logical true. This may happen if there is pileup whose leading edge is earlier than the L1A. In this case, the retiming circuit makes a pulse whose timing is tied to th L1A. 3) During a finite window (about 200 nsec) after the L1A there might not be any scintillator pulse (it got lost somehow). In that case there is a fastbus gate tied to the L1A but delayed about 200 nsec.

One of the consequences of this scheme is that there could be a hit in the TC TDCs for singles events. But this is easy to clean up by requiring tracks, etc. Incidentally, real coincidences in singles triggers are a measure of trigger inefficiency; but this is another topic. A second and deleterious consequence is that for extremely high rates on the scintillators, the TC spectra will get smeared, as explained below.

The trigger supervisor is programmed to make event types from the pattern of trigger inputs. The relationship is one-to-one (event type N is trigger input N) except for overlaps. If *any* two triggers overlap within the 10 nsec hardware "coincidence window" defined by the trigger supervisor, we define this as an event type 5. Again, analysis must decide if it is worth keeping. In some previous running, I had programmed all overlaps to be "event type 14", but this seemed to be even more confusing and was often ignored. Under normal circumstances, the trigger 5 is timed to arrive much earlier at the trigger supervisor than triggers 1 and 3, so trigger 5 will make event type 5. In any case, these triggers are plugged into different channels of a multihit TDC (so-called trigger latch pattern) which is not described here; therefore, one can sort out what the triggers existed for that event.

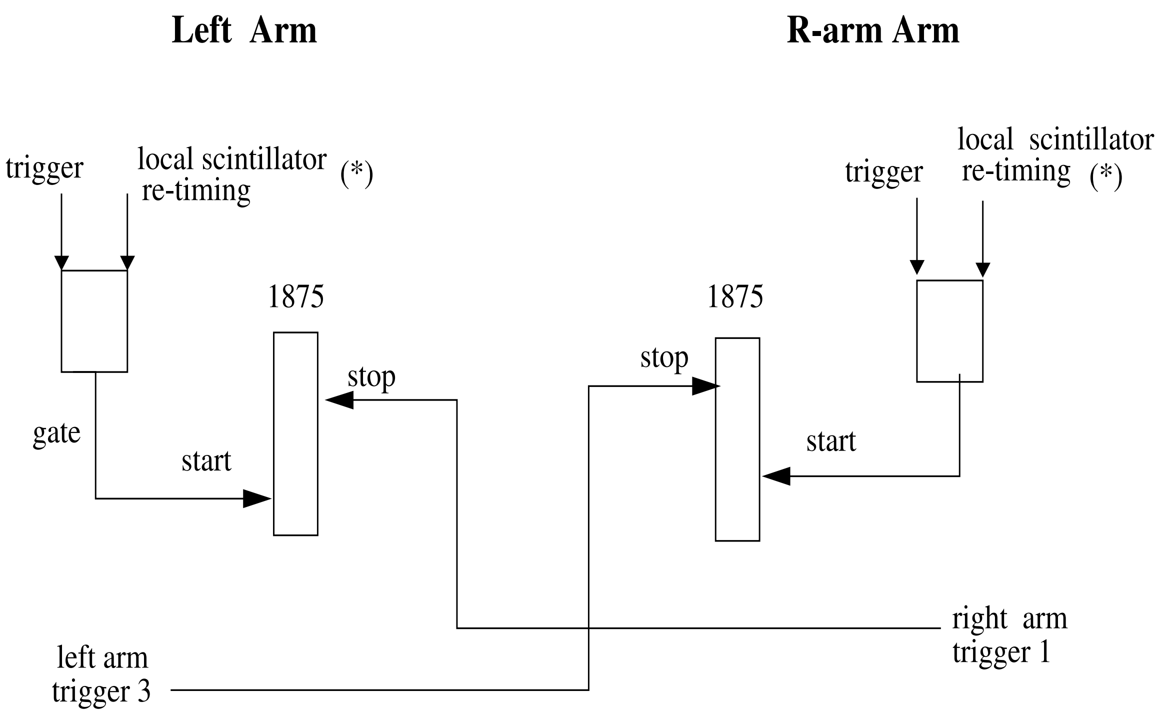
Using the above information, I believe we can explain most features of the TC picture, see figure 2, which was for run 1614 in E00102. If someone doing a careful analysis decides I'm wrong about any of this, or has useful additional insight, please let me know so I can update this note. It would be a good idea to take some lower rate data to verify that most of these features are rate dependent.

- There is a normal region where the TC's measured on the two arms are anticorrelated.
- Region A is probably the case in which the L-arm retiming circuit does not see a scintillator pulse. It gets lost somehow. As a result, the retiming circuit output is tied to the L1A and shifted about 40 nsec later than normal. For one part of the randoms window the L1A is tied to the L-arm and for another it is tied to the R-arm. This explains the change in

direction of the line. There does not seem to be a corresponding case in which the R-arm retiming gets lost.

- Region B and the smeared data that occurs between B and the normal line is due to pileup at the retiming circuit. There is an approximately 80 nsec window for this to happen. If a scintillator pulse arrives earlier than normal, it shifts the retiming output earlier, causing TC to be bigger. If the scintillator arrives earlier than the L1A but still overlaps with L1A, one gets a forced retiming pulse which is tied to the L1A. Since the scintillator pulses are 100 nsec wide, there is a 100 nsec window of opportunity for this latter case, hence the darkened region of B. Also the shape of B being two lines that join at an angle is explained similarly to the previous item.
- Both spectrometers are affected by pileup, hence one has a second band of smeared data perpendicular to the band that goes to B.
- Region C is probably caused by random overlaps of T1 and T3 at the trigger supervisor. I have not proven this. However, we know that these overlaps within 10 nsec are programmed to be an event type 5. The amount that shows up depends on the rates of T1 and T3, and on the prescale factors, since the overlap is only considered on prescaled triggers. These are random T5.
- There is a box all around bordered by approximately 50 nsec and 409.6 nsec. I believe these are underflows and overflows in the TDC. They are probably caused by pileup of the stops. For example if the signal is too wide and overlaps the end of the 12 bit range overflows may occur in that case.
- Not shown, there is a tiny fraction of event 5 which have no data in one or both of the TC TDCs.

Coincidence Time Measurements -- Hall A



(*) local scintillator re-timing is the "or" of 6 PMTs from right sides of scintillator plane S2, "or"ed with the delayed right sides of S1.

TDC: Single hit, high resolution (100 psec), common start LeCroy model 1875.

FIGURE 1. The measurement scheme for TC on the two spectrometers during E00102 and some other experiments.

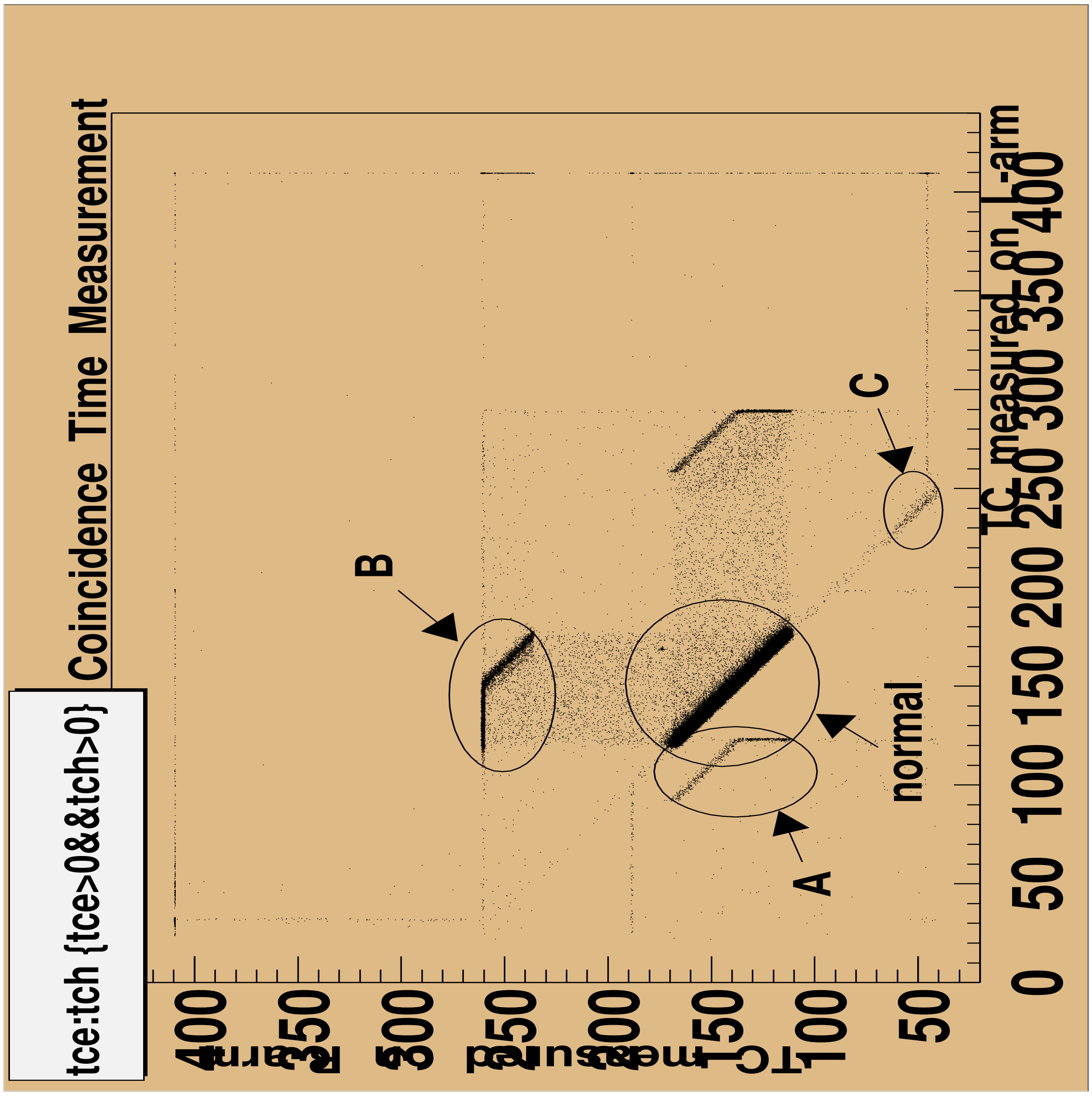


FIGURE 2. Data from run 1614 of E00102 showing the coincidence time measured on each spectrometer. It is important to understand all the effects (see text for an attempt). The stuff that is not "normal" represents a few percent, most of which is a correction to apply to the cross section.