I UPDATE ON ELECTRONICS DEADTIME

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This is an update on electronics deadtime (EDT) measurements which was first reported on in the Year 2000 Annual Report. Some experiments run with rates of several hundred kilohertz in the scintillators, and therefore one should expect deadtimes of a few percent. In the past year the two goals have been: 1) To reduce the EDT by reconfiguration of the trigger hardware; and 2) To improve the accuracy and reliability of the EDT measurement.

To reduce the EDT, we tried two things: 1) To avoid using the Memory Lookup Unit (MLU) which may introduce a bottleneck when strobed. The results are discussed below. 2) We tried to reduce the width of the discriminator outputs, but this latter attempt did not work well because reducing the discriminator widths from 100 nsec to 40 nsec causes too much "after-pulsing", which are secondary pulses at the trigger supervisor that result from the PMT signals ringing and crossing threshold multiple times. After-pulsing is dangerous if not corrected, since it distorts the DAQ deadtime computed from scalers. With standard thresholds and high voltages, the probability of after-pulsing is $\approx 8\%$ for a singles trigger if one uses a 40 nsec discriminator output width and this reduces to $\approx 0.1\%$ with 100 nsec pulses since most ringing occurs before 100 nsec. (Note, these numbers are not known precisely.) One can eliminate after-pulses by increasing the threshold or lowering HV, but this is considered an undesirable reduction in efficiency. Instead our approach is to leave the widths 100 nsec and to put the trigger into a multihit TDC to try to measure the probability of after-pulsing.

In Jan 2001 we started running our main trigger without the MLU. Instead the trigger is formed from an overlap of the scintillator planes S1 and S2 after first requiring 2 PMTs on either end of a paddle in each plane to fire above a discriminator level. Thus, the trigger requires 4 PMTs and no particular angle through the detector stack. One may suffer more background, depending on running conditions, but there is some evidence that this has also reduced the EDT. Comparing to the EDT measurements from Mark Jones' Oct 2000 report (see www.jlab.org/~jones/e97111/report_on_deadtime.ps.gz), Lingyan Zhu's analysis of data from Spring 2001 shows a reduction in the EDT when parameterized as the MLU strobe rate in order to compare to running with an MLU. The MLU strobe rate should not be a relevant parameter anymore, and comparisons between different running periods is fraught with difficulties, but nevertheless there did appear to be a reduction in EDT by at least a factor of two. The preliminary analysis of E00102 data from Oct 2001 suggests that the EDT is $\approx 100\text{nsec} \times R_{\text{trig}}$ where R_{trig} is the trigger rate, which is now the relevant parameter. Since the trigger rate is usually less than the strobe rate (typically by a factor of 2), we believe we have reduced the EDT by this factor. If the backgrounds are also not bad, then avoiding the MLU is worthwhile. During E00102, a high rate experiment with the new trigger setup, the pattern of scintillator paddle hits looks like the old "S-Ray" pattern of the mlu trigger; therefore, the background is similar.

The new EDT measurements (EDTM) system was engineered and constructed by James Proffitt of the Jefferson Lab Electronics Group. It was installed on the spectrometers by Bodo Reitz in April 2001. The principle behind the measurement is as follows: we send a well-defined, recognizable pulse into the frontend of the trigger and see if it makes it through to the trigger supervisor, which is the point at which the DAQ is triggered. Also, if the DAQ is alive, the trigger supervisor will accept this pulser trigger and it will show up in the datastream as a tagged event. The fraction of such events that get lost is the deadtime correction. Note, one can measure both the electronics and the DAQ deadtime separately this way.

The EDTM system sends a pulser signal which looks like a scintillator pulse through the path of four PMTs required to make a trigger (left and right on one paddle in S1 and S2). The two spectrometers are simultaneously pulsed, when run in coincidence mode, and this also provides a check of the timing of the trigger. The pulser signals are added to the PMTs signals using an active circuit which preserves the time resolution and low-noise of the apparatus. Each paddle has its deadtime measured in turn, i.e. we first pulse paddle 1, then paddle 2, etc up to 6. The pulser is sent to a TDC as a flag, and also the "and" of the pulser and trigger is sent to scalers to measure losses up to this point. The main difference to last year's one-paddle pulser setup is that now the deadtime can be measured differentially across the focal plane. The rate of pulsing an individual paddle is ≈ 1 Hz and can be made proportional to beam current, though at present we only use fixed rates.

To obtain the total deadtime of the system (TDT), which to first order is the sum of the computer DAQ deadtime (CDT) and the EDT, one observes how many pulses are in the TDC. This is essentially Mark's and Lingyan's analysis, see Mark's report for definitions. In the data, in addition to a loss we see a tail and secondary narrow peaks in TDCs (e.g. the EDT flag) which is presumably caused by pileup in the gate retiming circuit and in the stops. One can extract the EDT by subtracting the CDT calculated in the usual way from the TDT, with some small corrections to avoid double counting and to correct for the fact that the EDTM pulser is not random. One curious result is that at present the scaler measurement of EDT is zero. Probably this is because the nature of the EDT is a pileup condition, not a loss. However, the EDT measured from event analysis using the TDCs is not zero. A code to analyze these data will be made publicly available.