Zero deadtime event readout of the neutron ball for NIMROD experiments at the cyclotron institute

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We reported [1] an upgrade to our data acquisition where we exploited the dual bank nature and multievent capability of the Struck 3316 digitizers [2] to significantly enhance our data taking rate capabilities in experiments performed at the Cyclotron Institute. The software was optimized for large multi-parameter experiments in NIMROD [3], FAUST[4] and DAPPER[5], but has been used to enhance data rate capabilities in smaller scale experiments as well.

While the multievent capability works well for the charged particle array in NIMROD [4], experiments requiring information from the Neutron Ball [6] presented a readout issue with the heretofore method used for the neutron ball. Readout from the neutron ball to date has involved taking the signals from the PMTs, amplifying them, inserting the amplified signals into discriminators, and counting the logic outputs of any signal above threshold in a two 100us gates, the first starting with the trigger from the event and the other following at the end of the first, using VME scalers with the first window used to count neutrons associated with the reaction and the second used to estimate the background. Various configurations of this method involved either simply counting the signals from the discriminators or requiring signals from at least two PMTs in the same neutron ball segment within a short period of time to discriminate against random noise and counting those coincidences.

Such an approach does not lend itself easily to the multievent readout of NIMROD that we now routinely employ in most of our current experiments. In order to address this issue and exploit current technology, we have extended our software to exploit the multievent capability of the Struck Digitizers to acquire multievents from the neutron ball within the multievents being used for the charged particle array. In order to utilize the digitizers, the PMT signals were connected directly to the digitizers and thresholds were set. The clocks of the digitizers were synchronized with the clocks of the other digitizers in the rest of the experiment. In order to acquire neutron ball signals associated the reactions of interest, the NIMROD trigger (min bias in the test run) was used to open a 200us gate that was used as an external gate to the digitizers for the neutron ball. All signals within the 200us gate were thus multievents that contained all of the neutron ball information for the particular event, but were embedded inside each event in the multievents from NIMROD.

In addition to allowing readout of the neutron ball in the multievent mode, the information from the digitizer in the "events" (neutron ball hits) in 200us external gate is significantly enhanced compared to the information available from the previous single event readout of NIMROD with neutron ball scalers. The neutron multiplicity comparable to the previous method is simply the number of "events" in the first 100us and the background is simply the number of "events" in the second 100us. In addition to that information, we now have access to the time of each hit as well as the amplitude of each hit. This gives a measure of the capture time distribution on an event-by-event basis. In addition, the time of each hit allows to easily construct coincidences between the various PMTs in a single sector and since all data is written, different combinations can be tried with different gate widths in order to ascertain the most dependable results. Also, the amplitude of the signals may allow to discriminate noise in the "true" (1st

100us) gate. For example, if a large signal is observed in coincidence with another sector, it is quite possible that such a signal results from a cosmic muon traversing the detector and it would be eliminated from the counting of the neutron ball multiplicity.

As a proof of concept, we present in Fig. 1 the time difference between each PMT hit in the neutron ball from the trigger time of the event given by a minimum bias trigger from NIMROD. We note a strong peak near just after the trigger, near zero in the plot, followed by a more gradually varying distribution having peak near but below 10μs. The strong peak at small times relative to the trigger time shows the gamma flash that originates from γ-rays from the reaction and recoil protons from the scattering of neutrons in the scintillator [7]. The distribution at later times indicates the capture time distribution of neutrons which are captured on Gd nuclei from the dopant and, hence, the sum of all hits after the gamma flash provides the total number of neutrons detected from the reaction [7]. We note a similar capture time distribution to what was reported in [7] hence indicating that the technique works.

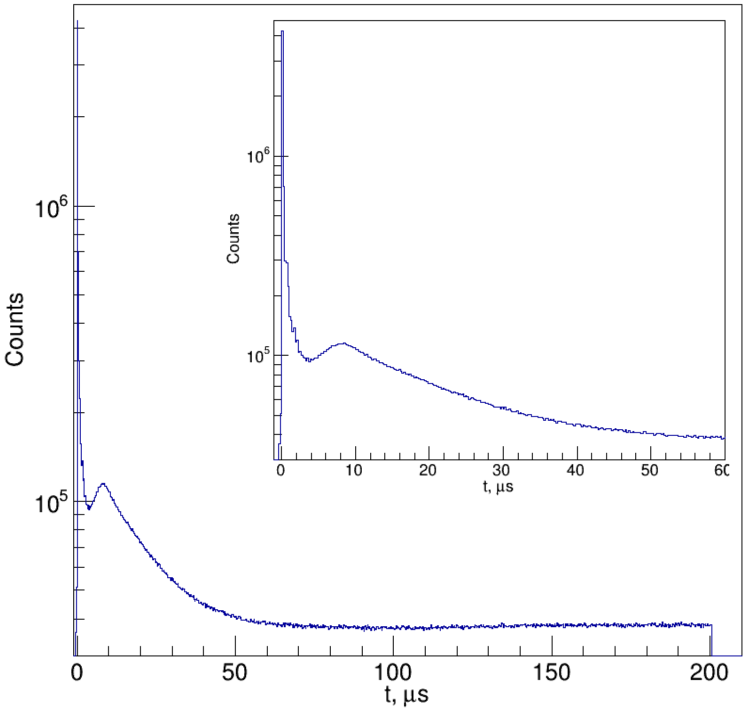

Fig. 1. Neutron Ball Capture time distribution. The inset shows the same, but with a range to 60 μs.

The data are on disk and are currently being analyzed in order to understand how well the extra information provided by the multievent readout of the neutron ball can be utilized to enhance the measure of the neutron multiplicity from the neutron ball. Initial indications are that technique works well.

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