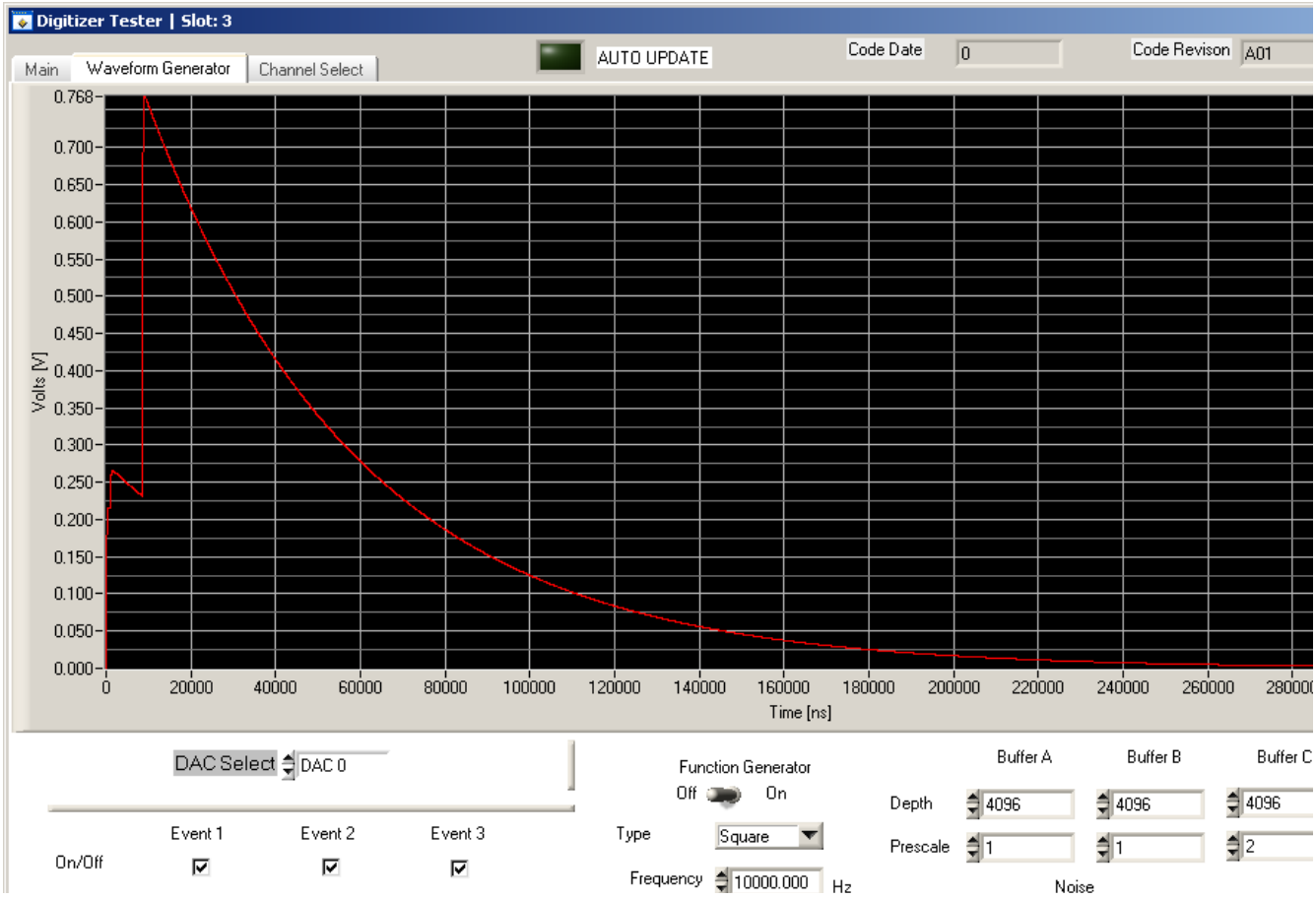
⅄Analysis of different readout modes of digitizer using implant signals

The digitizer tester was set up to generate an implant-electron-fission sequence found in DSSD.



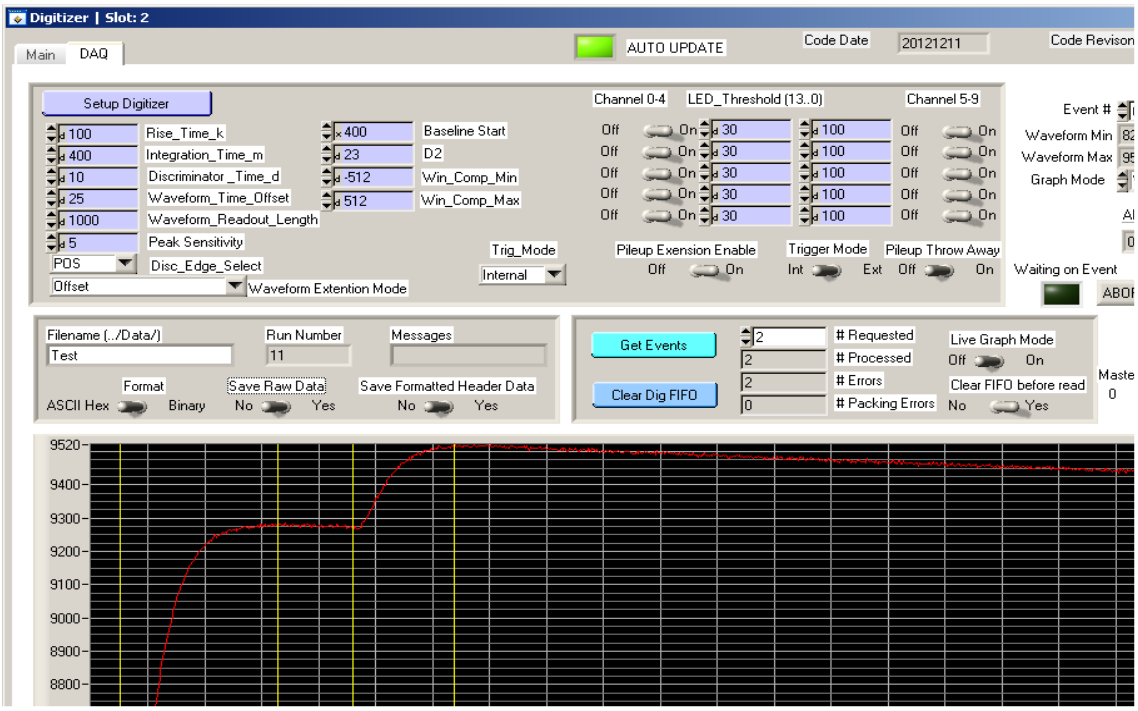
The mode of the tester was set to use timestamps such that an event was generated at about 0.6Hz rates. The DFMA Master was decoupled from the DGS Master and the trigger system re-synchronized to use local timing. The tester was locked to the timestamp of the DFMA Master.

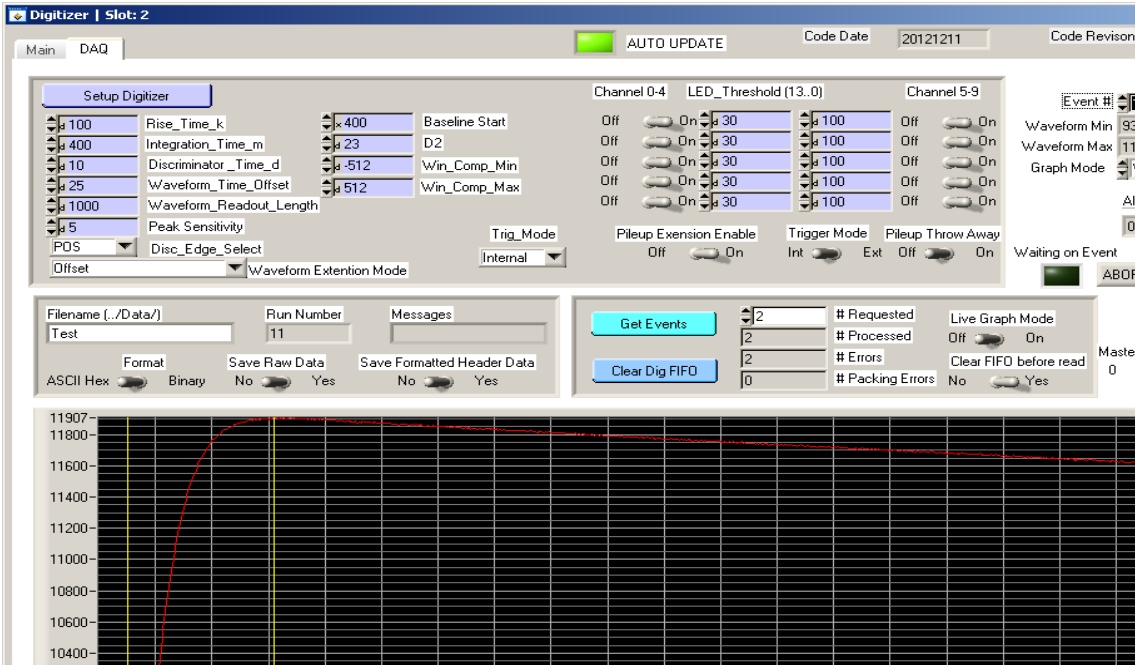
●*Digitizer setup*

Digitizer was set with 'm'=400, waveform readout=1000, waveform offset=25, pileup reject off, pileup extension on, offset readout. In this mode, since the readout length is longer than the pileup time, we expect to see pairs of events stored within the digitizer. The first waveform of each pair should be the piled-up pulses, and the second waveform should be the late pulse.

Because the readout length is longer than the time between the first two pulses, it is expected that we

will see dropped events in the counters, and we do. For each three discriminator firings captured in the digitizer event counters, we see ***two*** accepted hits (the 2nd pulse is piled up and is an ***extended*** hit), ***two*** accepted events, and ***one dropped event.*** This is correct because ***the second pulse can't be read out as it occurred during the readout of the first one***. Thus, the 2nd one is 'dropped' *because it has already passed.*





The first event

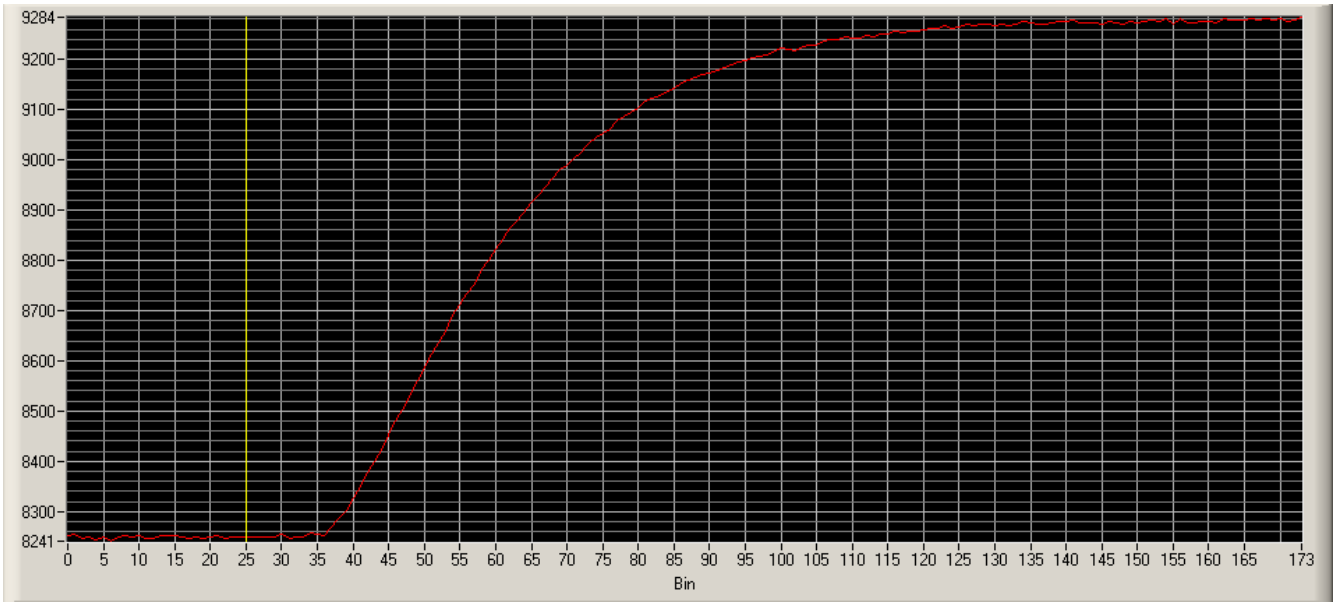
The second event

In the raw data there will be two headers associated with the 1st and 3rd discriminator firings. Because the 2nd event was dropped, the header data for that event is lost.

●*Effect of Changing the Readout Length*

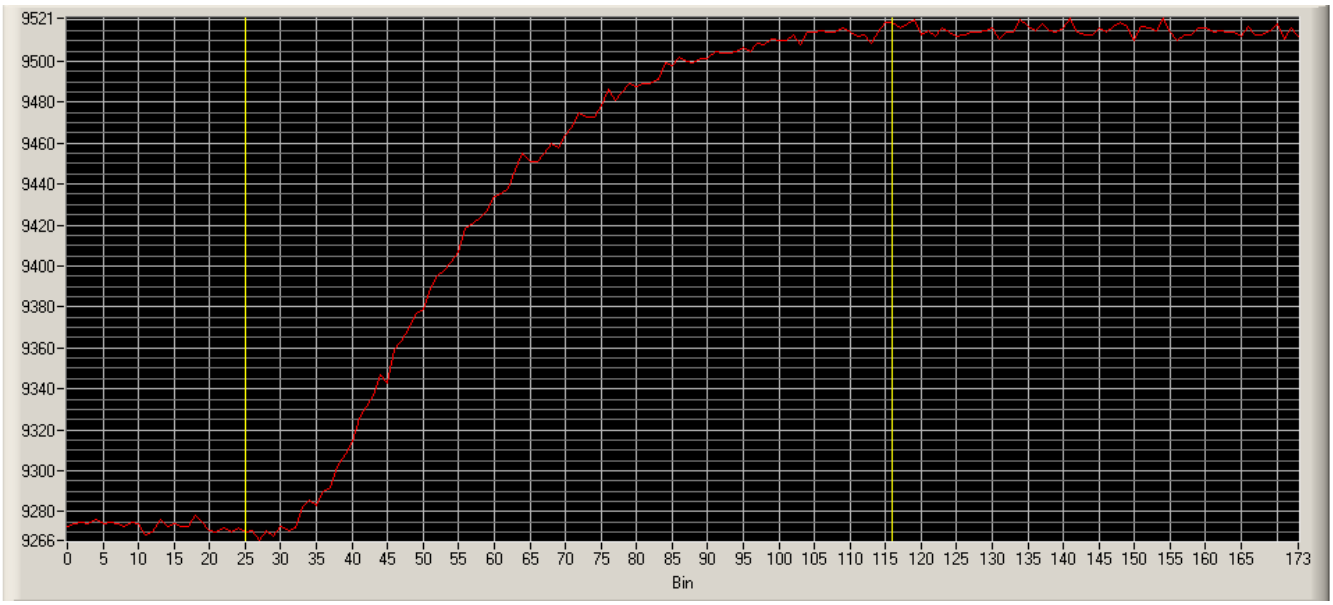
Setting the readout length shorter will allow the middle discriminator firing to be independently recognized by the readout machine. Let's set the readout length to 200 and see what happens.

- Now events come in triples and there are no dropped events.
- There are three headers and three waveforms stored per event.
- Each waveform readout has a discriminator flag mark in it but not every event has a peak flag mark. This is because the readout length is too short; the peak flag occurs after the readout window has

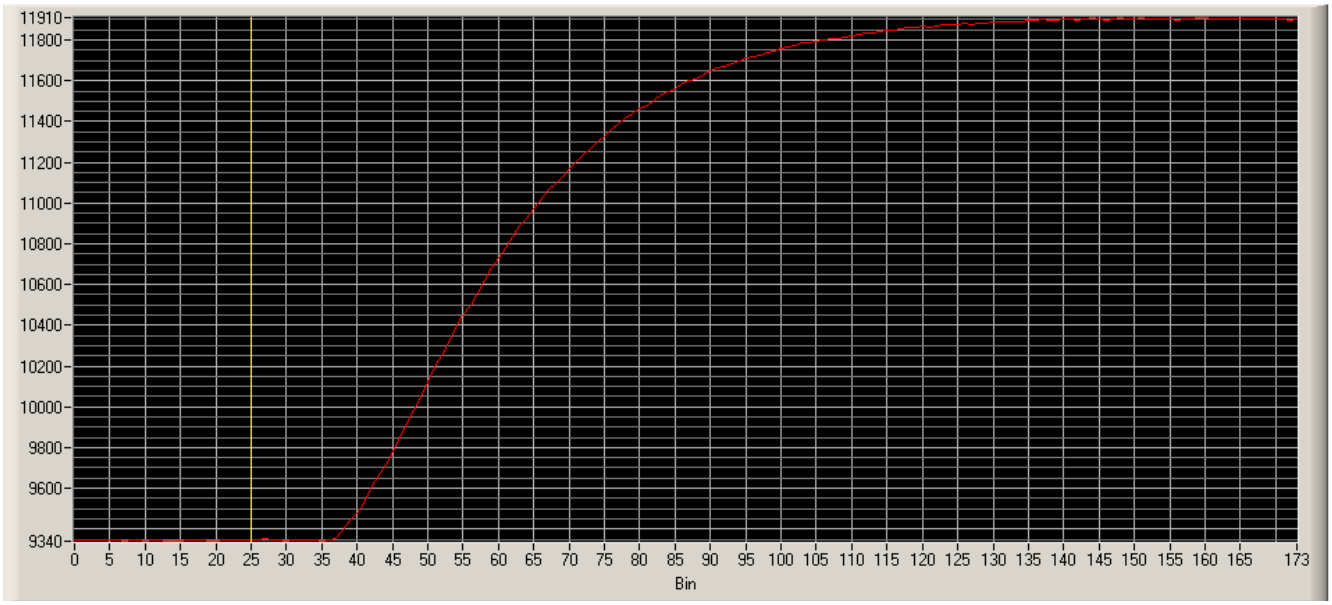


elapsed.

First discriminator firing



Second discriminator firing



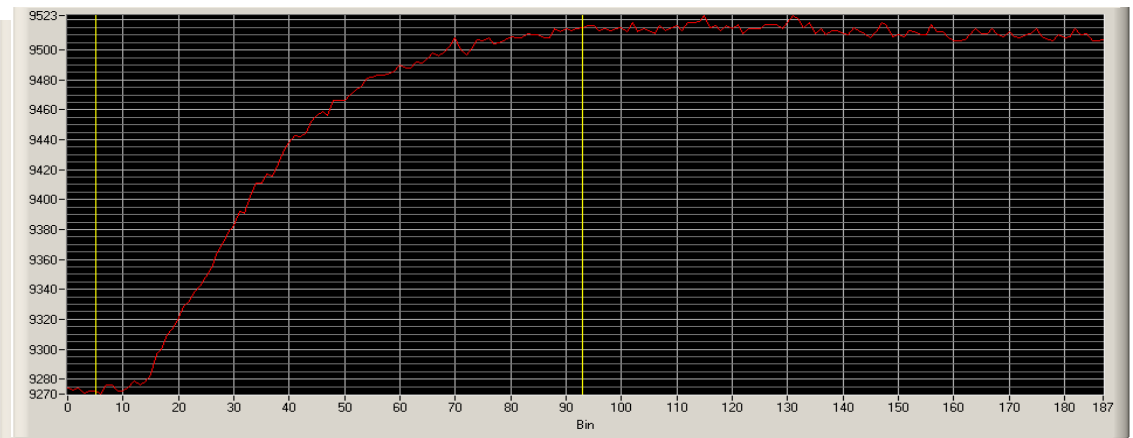
Third firing

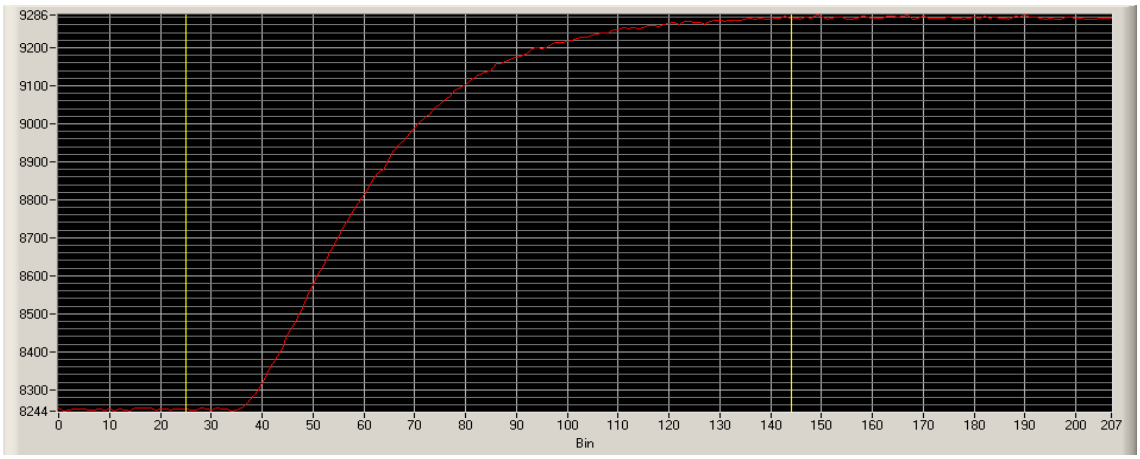
In the above setup I chose 200 as the readout length intentionally as it insures that the discriminator edge of the 2nd pulse occurs clearly after the end of the readout of the 1st pulse; a setting of 200 actually reads out only 173 samples due to the length of the header. Add another 25 samples for the pre-trigger and the readout of the first pulse ends well before the 2nd pulse that occurs 2us after the 1st one.

Things change if the readout length is just a little bit longer, at 236. At that readout length the 2nd pulse discriminator firing is now just a bit too soon after the 1st one. There are still three events read out, ***but the waveform offset setting can't be applied to the 2nd pulse.*** In this case the readout control settings

become critically important.

- If the Waveform Extension Mode is set to ***disabled*** the 2nd pulse does not show up in the readout at all. Because the selected waveform offset cannot be applied, the 2nd pulse is ***dropped.*** The first waveform reads out 210 samples (requested length of 236, minus the 26 byte length of the header). There is no header or any waveform data for the second pulse, and a 210 sample readout for the third pulse.
- If the Waveform Extension Mode is set to ***offset*** the 2nd pulse *does* appear in the readout and three pulses are recorded; *but* the starting point of the waveform is not where you expect it to be as some of the pre-edge waveform *was already recorded in the waveform for the first pulse.*
- The first pulse reads out as expected with 210 samples.
- The second pulse reads out 210 samples as well, but the discriminator mark is at the 3rd or 4th sample, not the expected 25th. This is because the time it takes to stuff in the header for the 2nd sample causes some of the offset to be lost and the readout machine can only start grabbing data after the header is loaded.
- The 3rd pulse reads out as expected with 210 samples.
- If the Waveform Extension Mode is set to ***offset with truncation*** the readout of the ***1st*** pulse is truncated to 208 samples (as opposed to the normal 210) so that the stuffing of the header for the 2nd event can occur a bit earlier.
- The first pulse is offset 25 samples as expected but the readout stops after 208 samples.
- The second pulse is still not offset the expected 25 samples, but has moved a little closer, with the discriminator mark at thr 5th or 6th sample. Readout of the second event stops at 188 samples because *that is the actual time at which the full length readout of the 2nd event would have stopped*, had it not been offset.
- The third pulse reads out as normal.





If the Waveform Extension Mode is set to ***headers only***, of course only the headers of events are read out and no waveform data is saved.

●Insuring readout of the 2nd waveform no matter where it lies

From the above, it is clear that either ***offset*** or ***offset with truncation*** is the best mode. Let's sweep the readout time around the critical area in these modes to understand what happens.

Readout LengthOffsetOffset with Truncation2203 events, 2nd disc mark at 19, lengths of 194, 194, 194.3 events, 2nd disc mark at 21, lengths of 192, 188,1922303 events, 2nd disc mark at 8, peak flag at 119, lengths of 204, 204, 204.3 events, 2nd disc mark at 11, lengths of 202, 188,2022403 events, 2nd disc mark not found, lengths of 214, 214, 214.3 events, 2nd disc mark at 1, lengths of 212, 188,2122503 events, 2nd disc mark not found, peak flag at 87, lengths of 224, 224, 224.3 events, 2nd disc mark off screen, peak flag at 95, lengths of 222, 188,2222603 events, 2nd disc mark not found, peak flag at 69, beginning of rise of signal now moved off screen to the left, lengths of 234, 234, 234.3 events, 2nd disc mark off screen, peak flag at 72, lengths of 232, 188,2322703 events, 2nd disc mark not found, peak flag at 76, beginning of rise of signal now moved off screen to the left, lengths of 244, 244, 244. ***Initial rise of 2nd waveform now becoming visible in 1st waveform but disc flag not yet visible. Clearly a few samples between 1st and 2nd waveform are missing. Last sample of 1st waveform is 9308; first sample of 2nd waveform is 9420.***

Estimating from other waveforms, the non-recorded section is about 20 samples.3 events, 2nd disc mark not found, peak flag at 76, beginning of rise of signal now moved off screen to the left, lengths of 244, 244, 244. ***Initial rise of 2nd waveform now just becoming visible in 1st waveform but disc flag not yet visible. Clearly a few samples between 1st and 2nd waveform are missing. Last sample of 1st waveform is 9293; first sample of 2nd waveform is 9405.***

2843 events, 2nd disc mark is consistently visible ***in the first waveform.*** 258 samples in first waveform, last sample is 9397 counts. Second waveform is clearly peak area of 2nd pulse, but first sample of second waveform is at 9468 counts. Peak of 2nd pulse now at 38th sample in 2nd waveform.