BigBite T2 Trigger

Matthew Posik

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Abstract

The following is an overview of the BigBite Čerenkov group + Shower group overlap trigger (T2 trigger), used during the E06014 d_2^n experiment. Which was used as the main electron trigger.

Contents

1 T2 Trigger

1.1 Forming the T2 Trigger

The T2 trigger is used as the main electron trigger in the d_2^n experiment. In a typical situation, the signals from photomultiplier tubes (PMTs) are split into two copies; one goes to ADCs and the other goes into a discriminator. The discriminator signal is then duplicated. One goes into TDC inputs and the other copy is sent through OR and AND logic to form a trigger. The newly formed trigger then sent to the trigger supervisor (TS) which subjects the trigger to a prescale decision. This prescale factor allows us to adjust how frequently a particular trigger type is taken. This is done to prevent multiple hits and reduce electronic dead time. If the trigger satisfies the prescale condition, then the trigger will generate a level 1 accept (L1A). The L1A will form a common stop for all TDCs and form a gate for the ADCs as well.

In the d_2^n experiment the electronics logic is a little more sophisticated, but the basic principles above still apply. Instead of forming just one trigger, we form multiple triggers from various sub-detectors. The T2 trigger is one of these more complicated triggers. The T2 trigger is formed when an geometric overlap between the BigBite sub-detectors, the Čerenkov counter and Shower calorimeter are made. The electronics diagrams for the Čerenkov and Shower are shown in Figures [1,2]. The Čerenkov is segmented into nine clusters, and the shower is split into a number clusters as well. When an event triggers a signal in the Čerenkov and corresponding geometrically overlapped Shower cluster, a T2 trigger is formed (see Figure3). The other triggers used for the BigBite in the d_2^n experiment was a low threshold shower calorimeter trigger (T1), a high threshold shower calorimeter trigger (T6), a Čerenkov trigger (T7) and a 1024Hz pulser trigger (T8). The T3, T4 and T5 triggers were not used in BigBite during single arm running. They are exclusive to the LHRS and BigBite and LHRS coincidence running. The electronics for the various triggers to the trigger supervisor are shown in Figure 4.

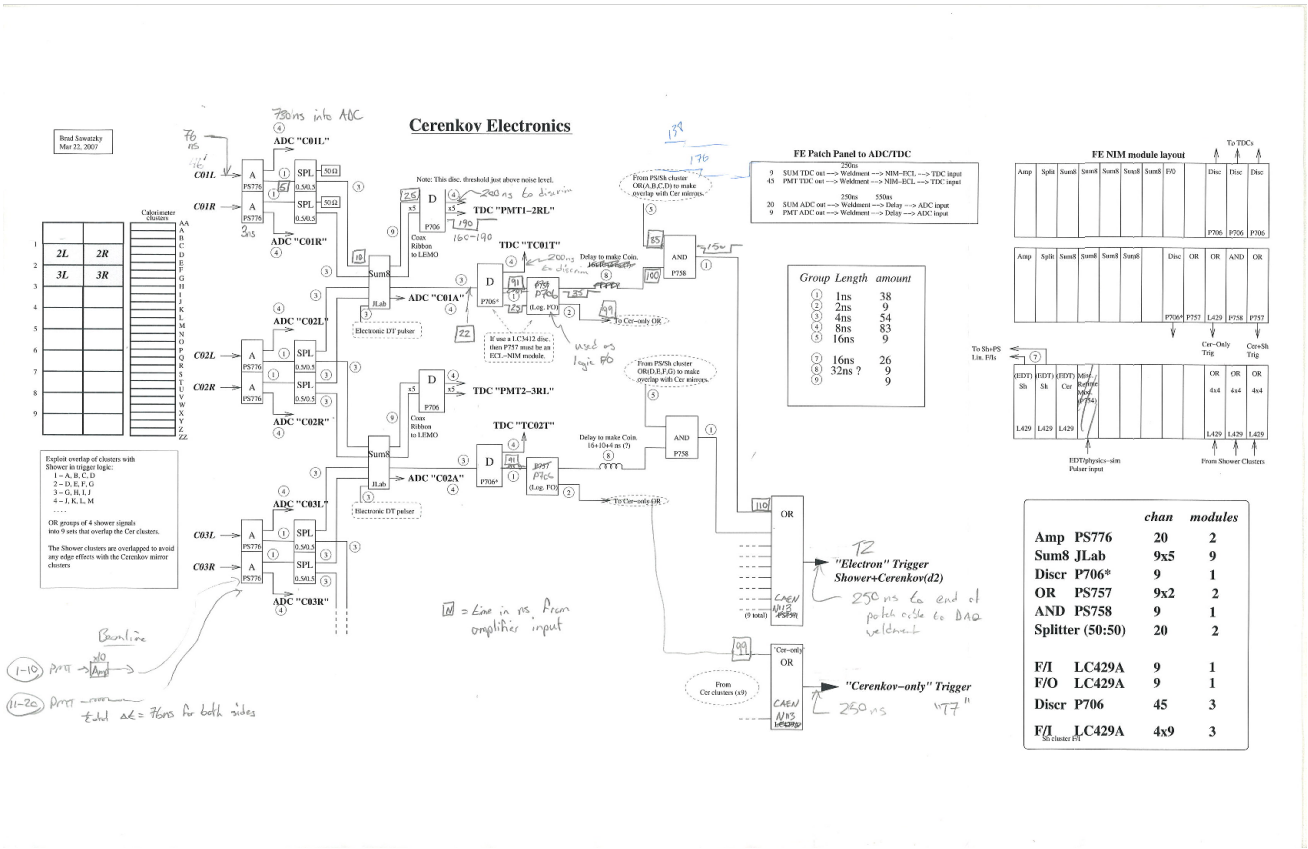

Figure 1: BigBite Čerenkov electronics summing logic.

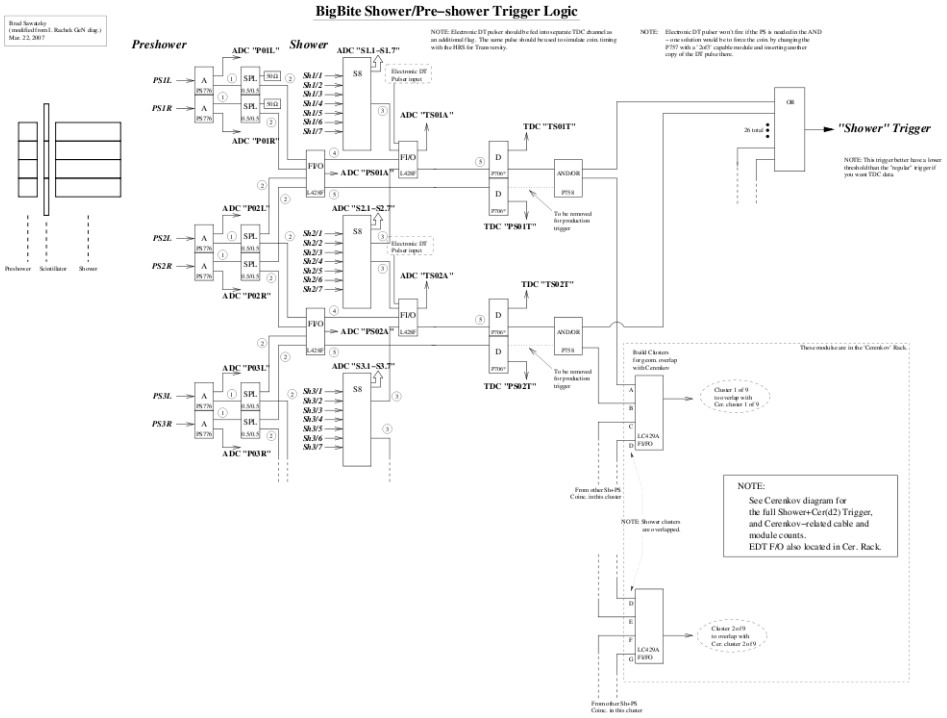

Figure 2: BigBite Shower and PreShower electronics summing logic.

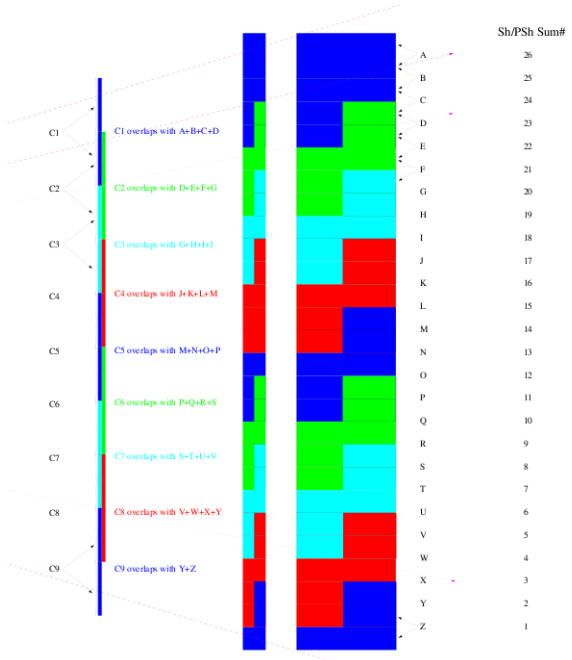

Figure 3: Graphical representation of the BigBite Čerenkov and Shower geometrical overlaps, which forms the T2 trigger.

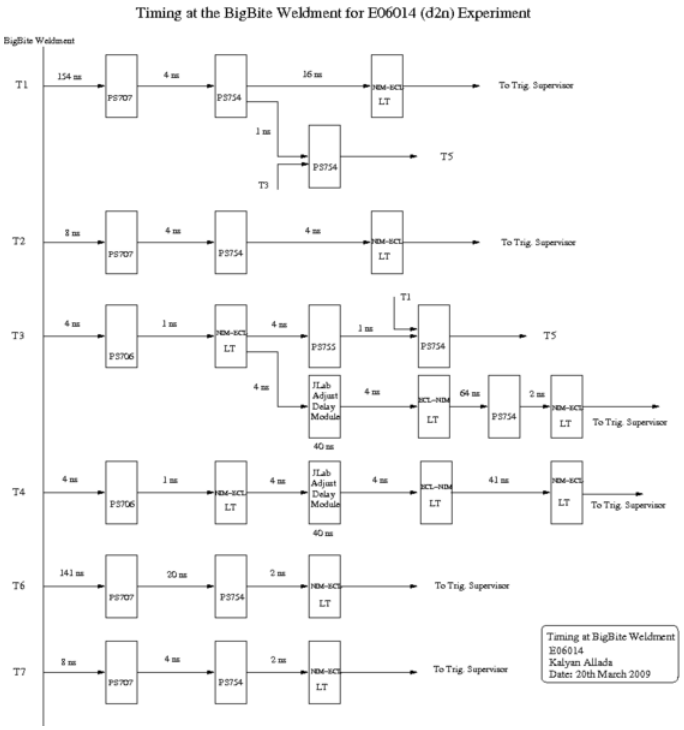

Figure 4: The Trigger paths to TS electronics.

1.2 Re-Timing of the T6 Trigger

We want all of the TDC common stops and ADC gates to be timed off of a single trigger. In the case of the d_2^n experiment, the T6 trigger was used. In order to accomplish this, we retime all T2-generated L1As with the T6 trigger after the TS. This electronic diagram can be seen in Figure 5.

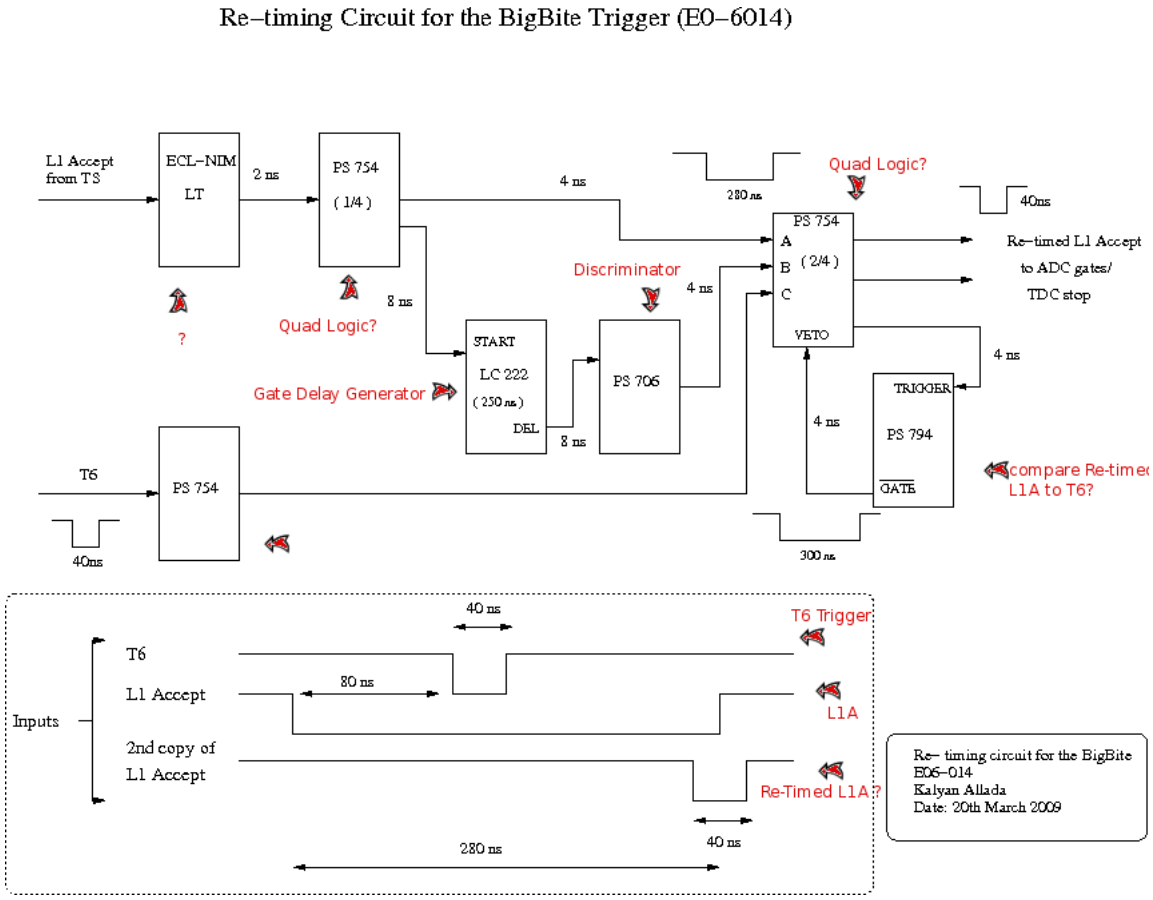

Figure 5: L1A and T6-L1A retiming electronics diagram

1.3 T2 Trigger Structure

In a simple case where one trigger for one particular sub-detector forms a L1A, it forms a TDC signal at a fixed time difference. So looking at the TDC signal of a trigger that formed a L1A for several events, one would expect to see a sharp peak, this is known as the trigger's self-timing peak. During the d_2^n experiment, the T1 trigger had a simple self-timing peak, see Figure 6.

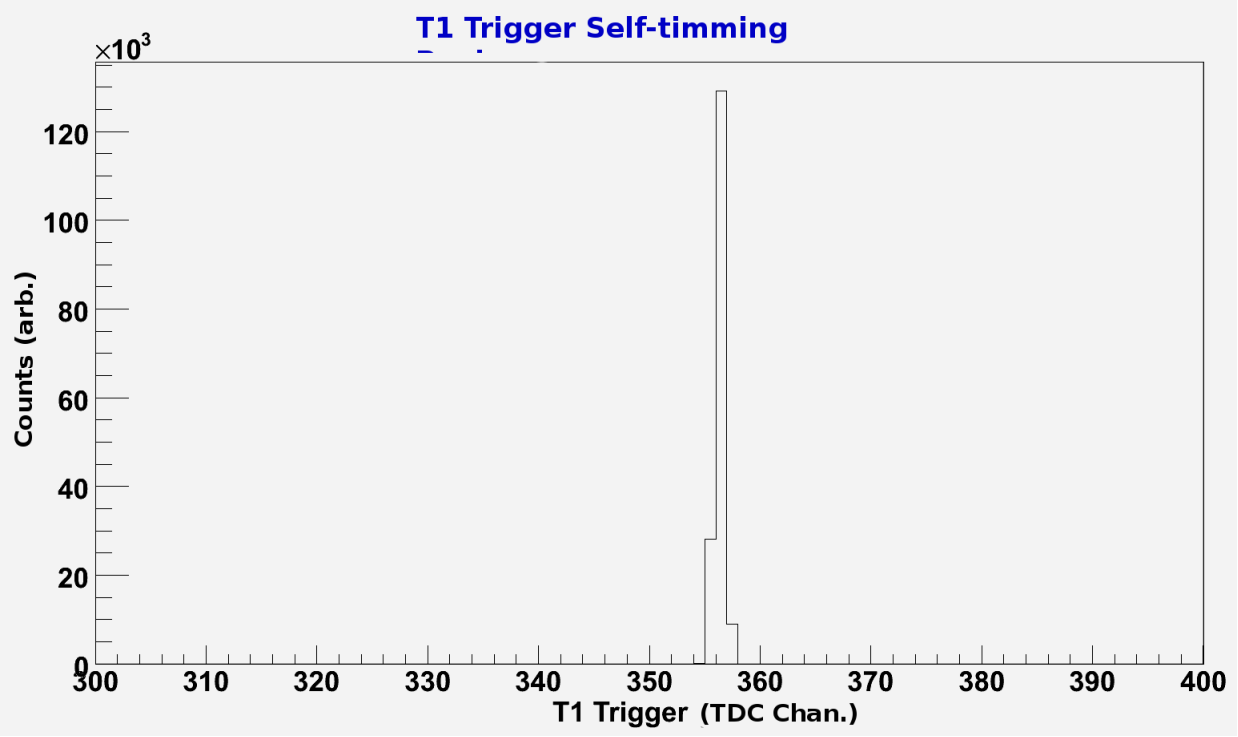

Figure 6: Shows the T1 trigger self-timing peak

As described above, depending on the electronics, more complicated triggers can be formed from multiple sub-detectors. This is the case with the T2 trigger, which is formed from the geometrical overlap of the BigBite Shower calorimeter and the BigBite Čerenkov Counter. This means that a T2 must have a T7 and a T6, but since a T6 is a copy of T1 but with a higher threshold, every T6 should also have a T1. Not only does the T2 depend on multiple triggers, but T2 generated L1As are also retimed with the T6 trigger. This causes the T2 trigger to have a more complicated structure as seen in Figure 7.

The fact that the T2 generated L1As are retimed with the T6 trigger can be seen in the data. We can plot the T2 trigger vs. the TDC signals for a BigBite Čerenkov PMT, see Figure 8. The correlated walk seen here shows that the T2 and TDC signal are moving together vs the retimed L1A, which means that the TDC signal is generating the T2 for those events. Another thing to notice about this structure is the dark horizontal band near the T2 TDC channel

560. In this region, events are coming in with a fixed T2 time relative to the retimed L1A. This suggests that the T2 is being timed off of the T6 part of the Shower and Čerenkov overlap. To get a clearer picture of what this structure is, we now look at the TDC signal for PMT 6 in Figure 9. There are two features to this TDC signal that stand out from the background. There is the electron timing peak centered on TDC channel 210, and a shoulder region to the right of the electron timing peak that runs from approximately channel 230-300. This is a difference of 70 TDC channels. The TDCs used in the Čerenkov are 1877 TDCs and have a timing resolution of 0.5 ns, so the shoulder region stretches about 35 ns. From this TDC signal it looks as though the shoulder region are random background events in the TDC that happen to arrive early in the Shower and Čerenkov overlap. If this is the case, then the timing of the overlap is carried by the T6 and the width of the shoulder should be equal to the width of the Čerenkov logic pulse at that overlap. Using the electronics in Figure 1 we see that the width was 35 ns or in 1877 TDC channels 70. This is the width of the shoulder, which means these are just random events that are firing the TDC.

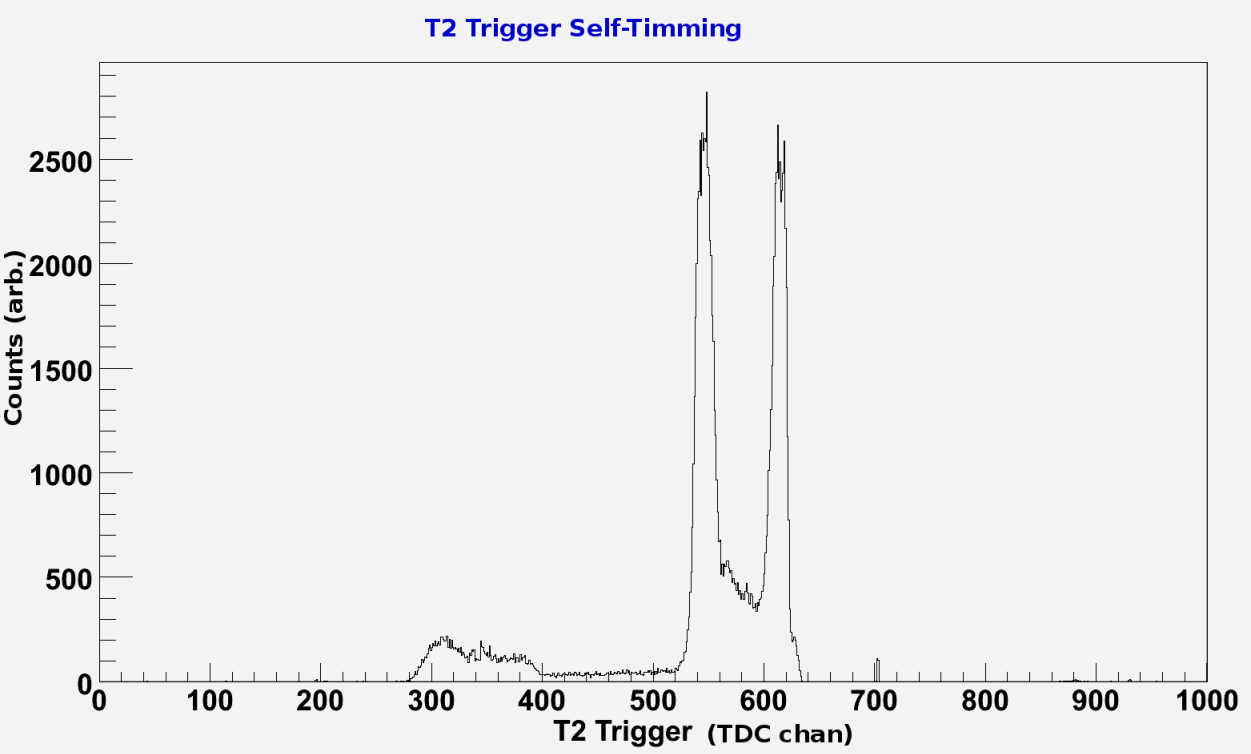

Figure 7: Shows the T2 trigger self-timing peak. This has a more complicated structure than the T1 trigger

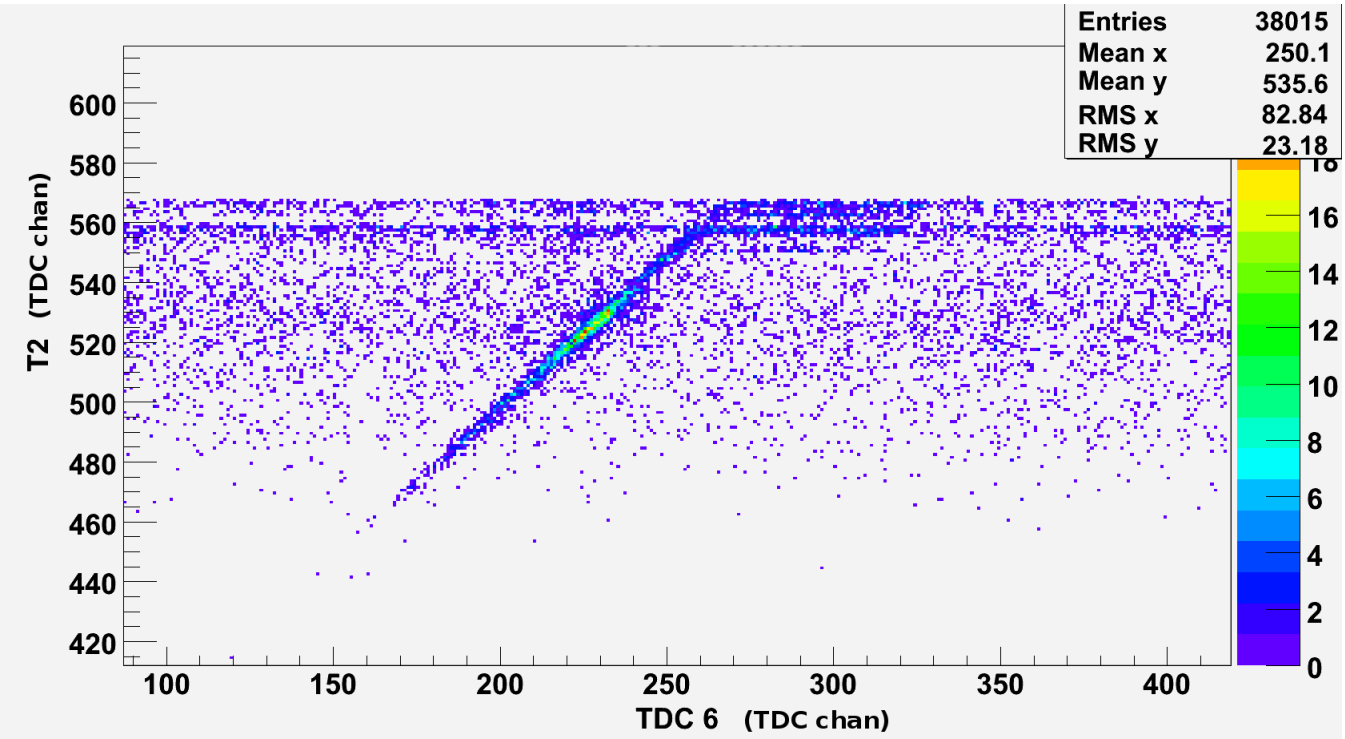

Figure 8: Shows the T2 vs. Čerenkov TDC of PMT 6

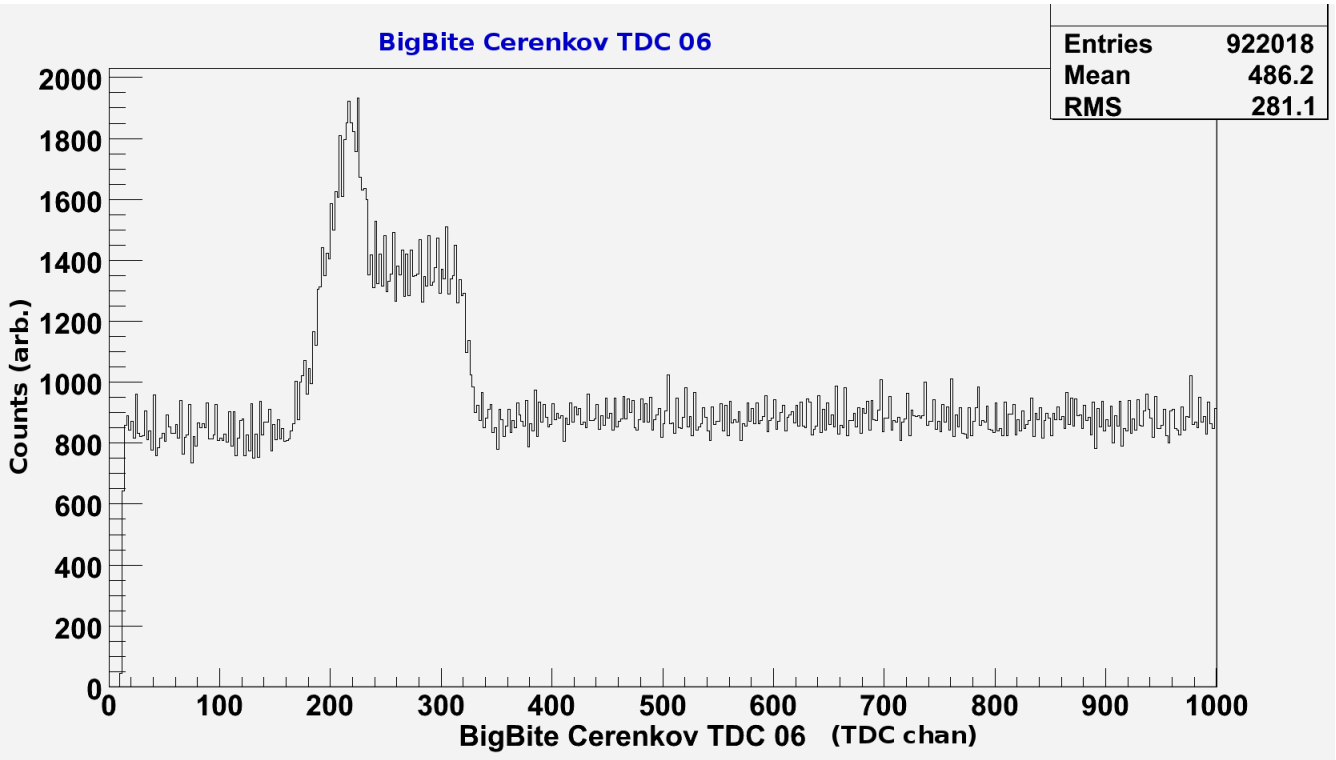

Figure 9: Shows BigBite Čerenkov TDC signal for PMT 6