The New Triggers Settings

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Abstract

The TOTd and MoPS triggers have been running now in the local stations since August 2013. However, their final implementation, specifically the value of all of the trigger parameters, have never been fully disclosed in a GAP note. This GAP describes the current settings of the TOTd, MoPS, and Th triggers. These settings have been identified via a technical document written by Dave Nitz [1] along with the actual UB code. Note that where applicable, this paper will use the same notation. Some of the parameters have also been checked directly from a station by Ricardo Sato [2].

1 Introduction

In the middle of 2013, two new T2 trigger types were implemented into the local stations. These triggers, Time Over Threshold Deconvoluted (TOTd), and Multiplicity of Positive Steps (MoPS) were designed to be less sensitive to the ambient flux of background muons. Thus, they are able to measure lower energy components of the shower and lower energy showers in general. Due to their specific requirements, their implementation is a bit more complicated than the original Time Over Threshold (TOT) and Threshold (Th) triggers. The new trigger original designs were detailed in [3] for TOTd and [4] for MoPS. These GAP note describe in a theoretical sense the way that the triggers work, however, they do not give the final values of the control parameters.

Due to the usefulness of the TOTd and MoPS triggers in the lowering of the infill energy range as well as various studies into primary photon and neutrino identification, this GAP aims to describe the implemented algorithms and settings for both of these triggers.

2 TOTd

The TOTd trigger philosophy is to find signals which look like the traditional TOT shape (described approximately by a log-normal distribution), but are too small in amplitude to pass the TOT criteria. This algorithm works by running the traditional TOT algorithm on a deconvoluted trace. This is done using the average decay time of light in the tanks, τ. The deconvoluted trace is calculated using:

$$d_i = (a_i - e^{-\Delta t/\tau}\ a_{i-1})/(1 - e^{-\Delta t/\tau}). \tag{1}$$

Here d_i is the i-th bin of the deconvoluted trace and a_i is the i-th bin of the original FADC trace. Δt is the FADC bin width, 25 ns. So the relevant parameter for this algorithm is the scaling parameter τ which has been set to 67 ns.

The motivation for the TOTd trigger is that a typical trace which is due to electromagnetic particles will be a sharp increase followed by a quasi-exponential decrease with time constant, τ. Looking only at the decreasing part of the signal and ignoring the baseline, the deconvolution would make an ideal signal totally flat. A real signal will look something like the ideal signal but with each bin having some statistical fluctuations which are proportional to the square-root of the signal amplitude. So the deconvoluted trace will be a series of pulses where each bin has a random sign but will decrease like $\sqrt{\exp(-\Delta t/\tau)} = \exp(-\Delta t/2\tau)$.

Once the deconvoluted trace $\{d_i\}$ has been created, the TOT algorithm is applied to it. This requires that there are at least two PMTs which each find more than 12 bins with an amplitude of 0.2 VEM over the baseline within a sliding window of 120 bins. Where as the normal TOT algorithm applies this directly to the FADC trace $\{s_i\}$, the TOTd algorithm applies this instead to the deconvoluted trace, $\{d_i\}$.

Note that due to the limitations of the onboard computer, the decay value is stored as a fixed point number. So the deconvolution factor is actually stored in the local stations as bit-shifted values. The deconvolution factor ($e^{-\Delta t/\tau}$) of equation 1 is

$$FD = (\text{int})(64 * exp(-\Delta t/\tau) + 0.5) = 44$$

and the normalization (the denominator) is stored as

$$FN = (\text{int})(1024/(64 - FD) + 0.5) = 51.$$

Again, both of these bit-shifted values correspond to a time constant of 67 ns.

3 MoPS

Generally, MoPS trigger looks for consecutive bins for which the FADC trace increased. By finding clusters of these increases, a trigger is identified. To reduce the contamination from the background, extra constraints are added. Note that this is the only trigger type that is totally divorced from the concept of the VEM and is solely calculated on bin counts.

The algorithm begins by finding a sequence of (≥ 2) consecutive bins for which the FADC trace always increased with time. For this cluster of bins, the total vertical increase, Δy, is calculated. This total is required to be $y_{min} < \Delta y \leq y_{max}$. The minimum cut avoids most statistical fluctuations and the upper cut removes muon-like signals. Each cluster which passes this maximum and minimum cut is added to the cluster-multiplicity, m. This multiplicity will be repeatedly checked against a minimum occupancy requirement: OCC $< m$.

After each identified cluster (regardless of its ability to pass $y_{min} < \Delta y \leq y_{max}$), the search for the next cluster is put on hold for a number of veto bins. The length of the veto is related to the magnitude of the previously found Δy.

$$\text{Veto} = (\text{int})(\log_2(\Delta y) + 1 - \text{OFS})$$

Here OFS is one of the MoPS parameters (see table below).

One final check is made regarding the total signal integration. A simple cut requires this integration to be above some value INT $< \sum y_i$ (in units of bins). Note that the sum is over the previous 250 bins. Since some of these bins will not be sent to the Central Data Acquisition System, the MoPS trigger cannot be completely reproduced offline. Further, there is one extra consideration regarding the actual integration by the online computers. As described in [1]:

> The signal integration operates by keeping a running sum of the pulse height in the current ADC time bin minus that in the bin 250 time slots earlier. However, there is a period after a trigger, when no triggers are possible due to finishing the ADC trace or if no buffers are available, in which the earlier time bin is not available in the PLD. While this does not affect any triggered events, it could cause the integrated signal to diverge from zero. In order to mitigate this effect, the integrated signal is exponentially decayed with a time constant of 2048 time bins. The actual integral decays faster than that due to the undershoot following a signal. Note that in any case, the integral depends upon the history of signals not only in the trace, but before the trace, so **an exact offline reconstruction of the trigger is not possible**. The integral remains valid for ~ 250 time bins after the primary trigger.

To make a MoPS trigger both the integration signal constraint as well as the multiplicity constraint must be satisfied in a sliding window of 120 bins for two out of the three PMTs.

Parameter	**Value**
y_{min}	3
y_{max}	31
INT	75
OCC	4
OFS	3

4 Th

As detailed in the current local station code, the current settings for the threshold triggers are:

# Working PMTs	Th-T2	Th-T1
3	3.20	1.75
2	3.60	2.00
1	5.00	2.85

This table includes the settings for the T1 and T2 trigger thresholds based on the number of working PMTs in the station. Less PMTs require a more strict cut on threshold. Note that these values have changed over the years and thus will not be the same as those written in earlier Auger Publications [5] (specifically for the 1 and 2 working PMT cases).

5 Acknowledgements

I would like to thank Ricardo Sato and Dave Nitz for helping me track down these values as well as Pierre Billoir for giving me his original TOTd/MoPS code.

References

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