Disclaimer

D0 Note 691

Trigger Sensitivity to Calorimeter Discharges

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Introduction

This note summarizes the results of our investigation of the effects of calorimeter discharges on the Level One Trigger.

Data

Two different kinds of data were recorded for this investigation:

1) The Data Acquisition (DAQ) system was randomly triggered to simulate the situation that will exist in the real experimental environment. This study was limited by statistics as we could realistically record only a few tens of thousands of events and of these only a few were of interest in that they exhibited discharge noise.

2) The DAQ was triggered on the discharges themselves at the trigger pick-off at a variety of thresholds.

Data Analysis

During our data taking we were intermittently plagued by electronic noise[1]. Care had to be taken to ensure that this noise did not influence our measurement of the discharge rate. Our method was to fit a Gaussian to the pedestal distribution and plot, as a function of threshold, this Gaussian along with the data. In extracting noise rates we carefully avoided the tail of the Gaussian by going 3 - 4 standard deviations out.

A. The HV-Off data:

These data were taken after the high voltage to the module had been off for about three hours. The discharges were unmeasurable but we did have a high level of electronic noise. We collected about 5000 events and the following figure summarizes our results.

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[1]The noise appeared as a 3-5 MHz signal with amplitude of about 15 mV peak-to-peak. By comparison the "no-noise" situation was characterized by signals of 1-3 mV.

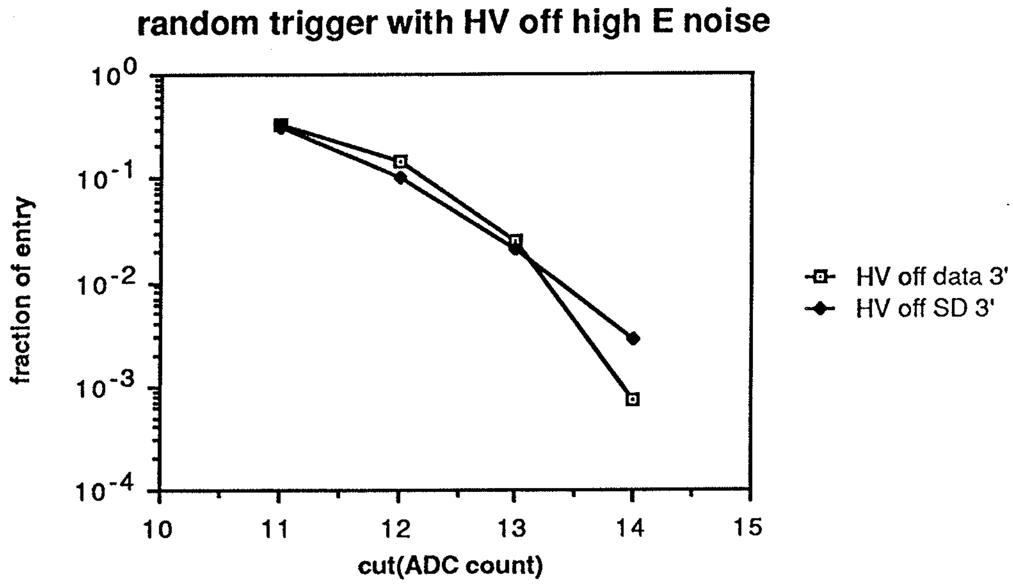

Figure 1

In this Figure, as well as the next two, each ADC count corresponds to about 1 GeV of energy and the pedestal is at channel 10. The open squares represent the data and the closed symbols the values from the tail of a Gaussian curve generated with the same average and standard deviation as the data. We plot the probability of finding a signal equal to the cut or greater vs. the value of the cut. As can be seen, the data is in good agreement with the Gaussian.

B. Random Trigger with High Electronics Noise and High Discharge Rate[2]

We took a total of 11,000 events under these conditions.

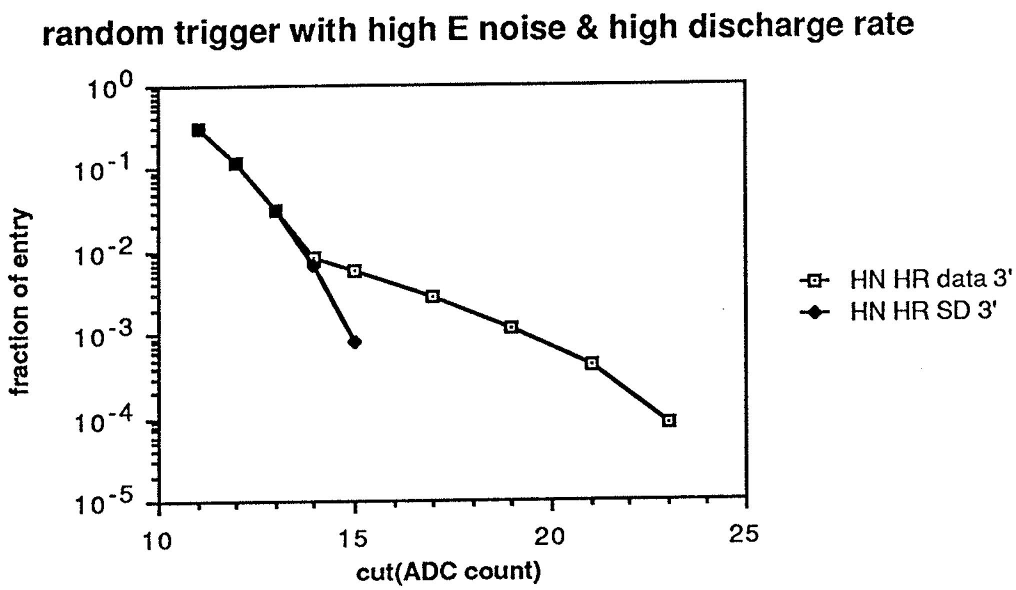

Figure 2

We can see from Figure 2 that the data follows the Gaussian curve well until about 15 ADC counts (which is about 3-4 standard deviations) when it departs due to the dominance of discharges.

2 When the high voltage was first turned on (2.5 kV), the discharge rate was measured to be about 50 Hz with a 1 Volt threshold at the BLS input. We will call this the low discharge condition. During our data taking, the discharge rate kept increasing until it reached about 500 Hz which we will call the high discharge condition.

C. Random trigger with high electronics noise and low discharge rate

About 19,000 triggers were taken under these conditions.

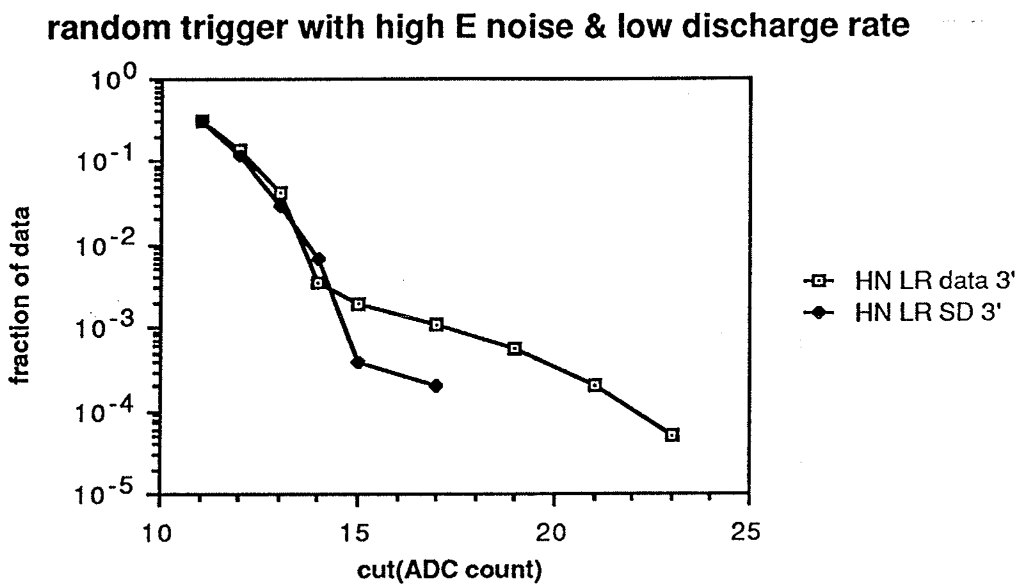

Figure 3

From the figure we can see that the distribution is comparable to the one with high discharge rates with the difference being that this rate is a factor of 2- 5 smaller. As we shall see below, even this rate is intolerable.

D. Random trigger with low electronics noise and low discharge rate.

We carefully verified that the electronics noise was indeed low (1 - 3 mV peak-to-peak) and managed to record 8,000 events under these conditions.

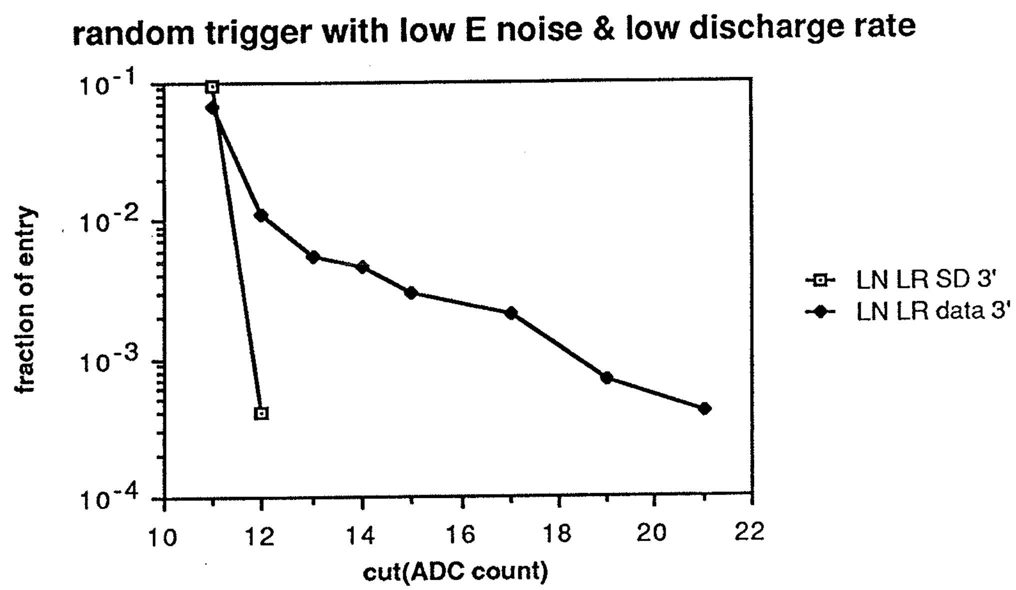

Figure 4

From the sharply falling Gaussian distribution in the plot we verify the low noise condition but also note the presence of considerable discharge from the elevated value of the data at high cuts.

2) Trigger on a Discharge Signal:

Our procedure here, was to attach the oscilloscope to trigger pick-off no. 3, set for a given threshold and then use the "trigger-out" from the oscilloscope to trigger the DAQ. We tried thresholds of 75 mV, 100 mV, 150 mV and 175 mV. A counter in the trigger framework kept track of the number of triggers and we measured the elapsed time in order to be able to calculate an absolute trigger rate.

Figure 5, below, shows the trigger rate vs threshold.

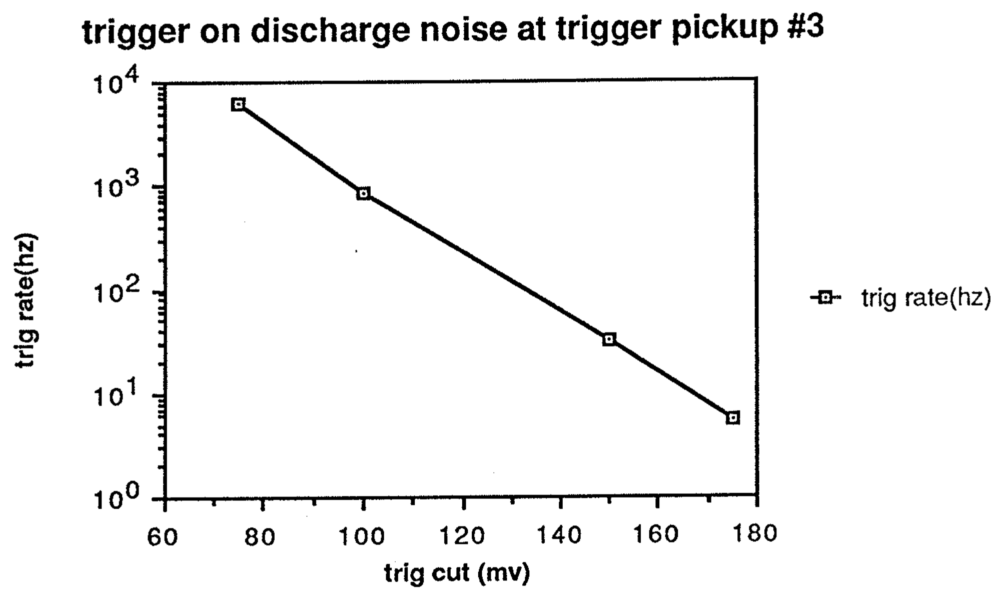

Figure 5

In Figure 5 above, 10 mV corresponds to about 1 GeV in energy and it can readily be seen that the data is represented well by an exponential fall-off with threshold setting.

Figure 6 below, shows the signals from trigger pick-off no. 3 along with those from the full read-out contributing to that pickoff plotted as a function of the discriminator setting. Not unexpectedly, the two curves are parallel and rise linearly with the discriminator setting.

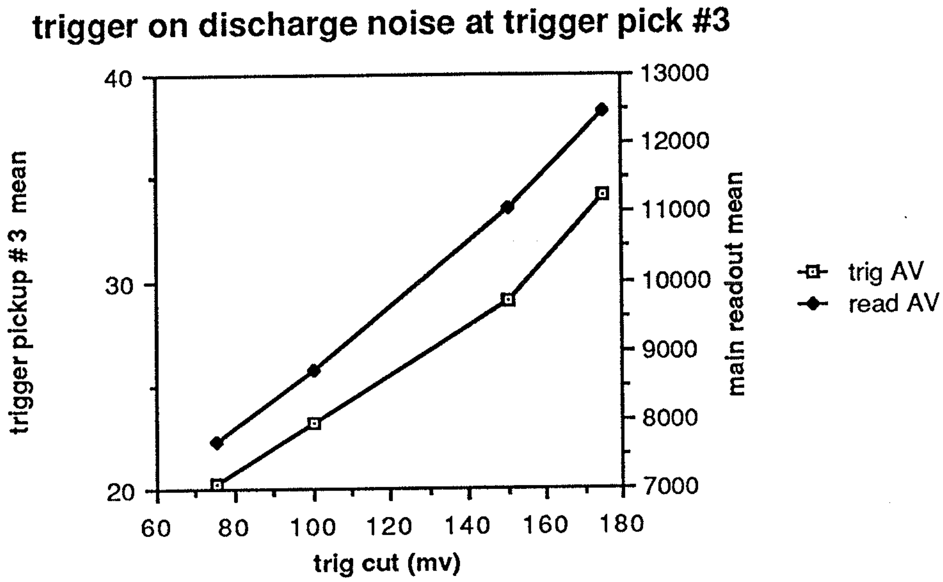

Figure 6

Summary

From the curves above we can estimate the trigger rate from the hadronic part of the full detector for a given setting of the Et (transverse energy) threshold, for example 10 GeV.

First, from the random trigger data of Figure 2 we deduce that 19 ADC counts corresponds to 10 GeV. (The pedestal is at 10 ADC counts and each count is equal to about 1 GeV). At this value the ordinate is about 10^{-3} i.e. there is a 0.1% probability of getting a signal at least this large. In one second at the collider there will be about 300,000 crossings (3.5 μsec between crossings) and thus we will have 300 discharges per tower per second that will exceed this threshold.

If we consider the data from triggering on the discharge noise we can see from Figure 5 that at a threshold of 100 mV (about 10 GeV) we have a trigger rate of about 2 kHz. If we assume that the discharge pulse, as seen by the trigger, has a width of 1 μsec[3], then the rate in the real experiment will be about 200 Hz, which is consistent with our previous estimate of 300 Hz.

Using the numbers above we can readily estimate the trigger rate from the hadronic part of the full detector for hadronic localized energy deposits exceeding 10 GeV in transverse energy.

We assume that the discharge rate is proportional to the surface area of a tower or, equivalently, to the capacitance of the tower ℓ, which we labe C_ℓ. The variable ℓ goes from 1 to 21 for trigger tower rapidities from 0.1 to 4.1. The particular tower that we have studied is one for which the rapidity is 0.7 and thus $\ell = 4$. Thus the trigger rate for the full detector is:

$$\mathrm{RATE} = \sum_{i=1}^{32} \left(2 \sum_{\ell=1}^{21} \left(\frac{A}{C_4}\right)\left(C_\ell \, e^{-\frac{BE_t}{\sin\Theta_\ell}}\right)\right)$$

where the first sum, from 1 to 32, goes over the 32, identical, azimuthal towers and the second sums over the rapidities for one half of the detector. The values of the capacitances, C_ℓ, are the actual values for the detector and C_4 is used as the normalization point.

From Figure 5, above, we derive the values for A and B:

$$A = e^{13.82} = 10^{6} \quad \text{and} \quad B = 0.693/\mathrm{GeV}$$

Using these numbers and our measured discharge rate of 300 Hz for a single tower, we conclude that the hadronic part of the full detector will give a discharge rate of 120 kHz at a threshold of 10 GeV in transverse energy. An additional part will come from the EM part. This is to be compared to a rate of 1 kHz, expected from real two-jet events at the same threshold. Instituting more stringent trigger requirements, such as demanding two hadronic jets, does not help matters because even though the trigger rate due to discharges

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[3] This is in agreement with typical pulse widths observed with an oscilloscope at the trigger pick-off.

drops by a factor of 1,000, the real trigger rate also drops by about 1,000.

We conclude that the discharge rate must be reduced by more than two orders of magnitude before data taking with this detector becomes feasible.