RD27 note 23
02 March 1994

An Analysis of the RD27 Level-1 Prototype Calorimeter Trigger Processor Test Beam Data — April/May 1993

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Abstract

An analysis of data from a beam test of RD27's prototype, first-level calorimeter trigger processor is presented. The data were taken in collaboration with the RD3 liquid Argon "Accordion" electromagnetic calorimeter group at CERN from 20 April to 08 May 1993.

The fluctuations in the pedestals are investigated, from run to run, from event to event within a selected run, and within single events in that run. The major features can often be explained by the hardware configuration, especially changes to it.

A significant cross-talk is found in the run which is analysed event-by-event. It affects all trigger channels connected to the calorimeter.

Additionally, the trigger output is briefly studied.

The present analysis was done as part of the CERN Summer Student Programme 1993. It was supervised by Nick Ellis.

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1 Introduction

The following subsection gives a brief review of the test beam setup, intended to cover what is needed to understand the rest of this note. More detailed descriptions of the trigger system and general analyses of the data can be found in the references [1, 2]. An overview of the calorimeter design and some RD3 test beam results are included in the ATLAS Letter of Intent [3]. The physics motivation for the choice of trigger algorithm is described in all three places.

Concisely, the purpose of the tested part of the first-level trigger system is to enable a reduction of the data rate from 40 MHz (the LHC bunch crossing frequency, with typically 20 proton-proton events per bunch) down to 10–100 kHz by delivering — for each trigger cell —

- two hit flags (hit bits): set when isolated, high energy electron/photon candidates are found; one bit for each of two sets of trigger thresholds
- an energy sum of surrounding cells: intended for the jet trigger, which is a future part of the first level system

Data flow during a run

In each run a beam of electrons or pions with a fixed energy was targeted on a single calorimeter cell. Each calorimeter cell covered a solid angle of $\Delta\eta \times \Delta\phi = 0.025 \times 0.025$, where η is pseudo-rapidity and ϕ is azimuthal angle. Calorimeter cells were added by RD3 and RD27 analog electronics (in the shaper modules and fan-ins shown on Fig. 1) to form trigger cells of granularity 0.1×0.1 in $\eta\times\phi$, summed over either the first two or all three depth samplings (18 or 27 radiation lengths). The signals from a square of 6×6 adjacent non-overlapping trigger cells were fed into three 12-channel, 8-bit Flash ADC cards made by RD27. These continually sampled the signals, usually with a clock period of 25ns (i.e. at 40Mhz), but in some runs down to 12ns. The digitized signals were then fed to the RD27 electromagnetic Cluster-Finding Module (CFM) containing 9 ASICs (Application Specific Integrated Circuits). Each ASIC read 4×4 ADC values (Fig. 2) each clock cycle, and was expected to deliver the corresponding energy sum and 2 hit bits to the read-out buffer respectively 6 and 7 clock cycles later. The energy sum was simply the sum of the 16 ADC values. The hit bits were calculated by adding certain ADC values and comparing the sums with one 9-bit cluster threshold and one 12-bit isolation threshold for each hit bit, roughly as indicated in Fig. 2. For ASIC number n ($n = 1,\ldots, 9$), the cell labeled "Trigger cell" on Fig. 2 corresponds to the cell with number n on Fig. 1.

The tested system differed from the proposed scheme of Fig. 2 in two ways. First of all, there was no hadronic calorimeter (HCAL). Secondly, the ASICs were exposed to a trivial wiring error in the manufacturing process, so that the horizontal cluster sum was replaced by a diagonal one [1].

When the RD3 scintillation triggers registered a particle entering the calorimeter, the scrolling read-out buffers were frozen after a suitable delay. Then the data from between 20 and 256 clock cycles (time slices) containing the peak signal were saved. These data together constitute a single *event* in RD27 terminology. For each time slice of each event, the following raw data were saved to the RD27 tapes: the 6×6 ADC values, the 3×3×2 ASIC hits and the 3×3 ASIC energy sums. In addition, for each event, 10 CAMAC words were saved, containing information of e.g. the clock phase at the time of the RD3 trigger. They also tell whether the "event" comes from such a *physics trigger* or whether it was a *calibration trigger* (pedestal run, test pulse, etc.). Only the latter bit of CAMAC information has been used in this analysis.