A NEW VME TRIGGER PROCESSOR FOR THE NA57 EXPERIMENT

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Abstract

The ALICE experiment will use a trigger concept requiring independent dead times for each sub-detector system, and with detector-specific past-future protection. These features are implemented in a new VME-based trigger processor for the NA57 experiment. Monitoring and diagnostic features of the new trigger processor are also described.

1 INTRODUCTION

The triggering requirements for heavy ion experiments are in general different from those in hard scattering experiments. In heavy ion physics one is looking for evidence for a phase transition, which should in general be produced in all or a significant proportion of the events, and therefore the required cross sections are large. A consequence of this is that the triggering signatures are global, based on multiplicity or global energy deposition. For this, signals from a single sub-detector should in principle be sufficient to identify a collision of interest. Useful checks of efficiencies and systematics are added by using more than one detector. In addition, certain rarer signatures, such as high mass dilepton pairs and isolated single photons, are of great interest. The trigger system should be able to select signals of this kind with high priority, scaling down more common triggers if required in order to stay within the bandwidth for the data flow.

In this paper we give an overview of the ALICE central trigger system. The new trigger system for the NA57 experiment is described, and the monitoring facilities envisaged are listed. The parallels in the triggering requirements for ALICE and NA57 are pointed out.

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2 OVERVIEW OF THE ALICE CENTRAL TRIGGER.

The Alice trigger system has been described in more detail elsewhere [1, 2, 3]. It uses three trigger detectors:-

1. *Forward Multiplicity Detectors* (FMD) based on *Micro channel Plates* (MCP). The FMD system consists of segmented half-ring detectors surrounding the beam pipe and relatively close to the interaction point. There are four planes on one side of the interaction point and three on the other, because of space restrictions imposed by the absorber for the ALICE dimuon arm [4, 5].

   The signals from the MCP system are short pulses with precise leading edges, and the pulse height is proportional to the number of particles going through the plate segment. The signals can be used to select interactions in the bunch crossing region, reject beam gas interactions and select on overall multiplicity. The trigger electronics is described in another contribution to this workshop [6].

2. A *Zero Degree Calorimeter* (ZDC) system consisting of two calorimeter assemblies placed 115 metres from the interaction point. Separate neutron and proton "spaghetti" calorimeters measure neutral and charged forward hadronic energy, allowing a more precise centrality cut [4].

3. The *dimuon* trigger system is provided by two stations (4 planes) of Resistive Plate Chambers (RPCs) placed at the end of the dimuon arm where almost all hadrons have been absorbed. A level 1 trigger uses correlation matrices to look for hits consistent with two tracks coming from the interaction point with p_t greater than a predetermined cut-off. The computation takes 600 ns. A level 2 dimuon trigger computes the effective mass of the dimuon pair and applies a mass cut inside 100 μs [7].

Further level 2 trigger algorithms, for example to find isolated photons in the PHOS electromagnetic calorimeter, are under study.

In the ALICE experiment, the trigger system processes each bunch crossing, irrespective of the busy status of the detectors, and classifies the results into trigger classes, each with a list of required sub-detectors. Owing to the considerable differences in the arrival times of the signals from the different detectors, this is split into two steps. A *level 0* (L0) trigger sets a strobe to sub-detectors that require it within 1.2 μs, while at $\sim 2.4\ \mu$s, when all the information from the sub-detectors has arrived, a full classification is made and a *level 1* (L1) signal sent to the DAQ to initialise read-out from the selected sub-detectors. This is done using *trigger distribution cards*, one for each sub-detector system, which provide the correct sequence of signals for a given sub-detector. An additional problem for the ALICE detector is the comparatively long drift time (100 μs) of the principal detector, a TPC. In heavy ion collisions, where the multiplicities are very high, it is not possible to disentangle multiple events in the TPC. For this reason, a *past-future protection* unit checks for a second event less than 100 μs before or after a given triggering event. Note that the second event may or not itself trigger, so events which do not themselves give rise to an L0 trigger must be recorded by the trigger system, at least for the duration of the past-future protection interval.

Figure 1 illustrates the principal features of the proposed approach. Inputs from the MCP detector and the dimuon system are used at level 0 to strobe the front end of the detectors. When the information from the Zero Degree Calorimeter arrives, the level 1 decision is taken and the trigger type is determined. At this point the past-future protection unit assesses the busy status of the detectors and the previous history of the trigger to determine whether a trigger can be issued. The trigger decision is translated into signals for each sub-detector in an array of independent trigger distribution units. A provision is made for an early clear of the trigger system through a level 2 trigger, which may arrive at any time up to the end of the TPC drift time, 100 μs after the event.

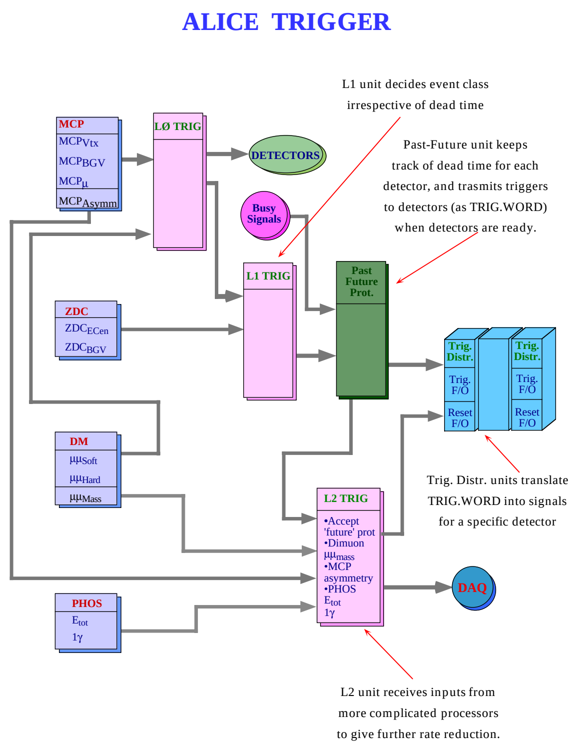

Figure 1: ALICE trigger logic diagram.

3 THE NA57 EXPERIMENT.

The NA57[8] experiment is being set up in the CERN North Area to fulfil two requirements: to perform an experiment using silicon detectors similar to the WA97 experiment at the Omega Spectrometer,and to provide a test facility for ALICE detectors. The input triggers come from a collection of scintillators, some in the beam, some around the target or along the principal detector, a silicon telescope, and some close to the ALICE test detectors. The data acquisition rates and requirements of the test detectors and of those used for the experiment may differ widely, and in general they could trigger under different signatures. Because of their differing read-out speeds, it is more efficient to treat their dead times independently, and allow a trigger to be issued to an appropriate class of detectors even if other detectors are busy, provided none of the busy detectors is required for the new trigger. In all these respects the NA57 requirements for a central trigger processor are similar to those of ALICE. What is different in NA57 is that, as a fixed target experiment, the trigger start times are random, whereas in ALICE they only occur at the bunch crossings.

The arrangement of trigger detectors for NA57 (main experiment) is shown in figure 2. S2, S3 and V3 are beam counters upstream of the target. They define an incoming beam. Arrays of counters from the PETAL detector (Pb beam) or the telescope (p beam) provide the basic definition of an interaction, which can be confirmed by the absence of a signal in the downstream beam counter V0. In addition there may be inputs from ALICE test detectors, some of which may be on the beam line and therefore trigger very often, while others may pick up secondary particles at quite large angles, and therefore will trigger infrequently. The counters produce analogue signals with a width of about 20 ns. These are discriminated before being presented to the central trigger system, so the inputs to the trigger system are logical pulses of width 20 ns. Fast logic protects against two signals closer together than 40 ns. A good beam signal then acts as a strobe for the other signals.

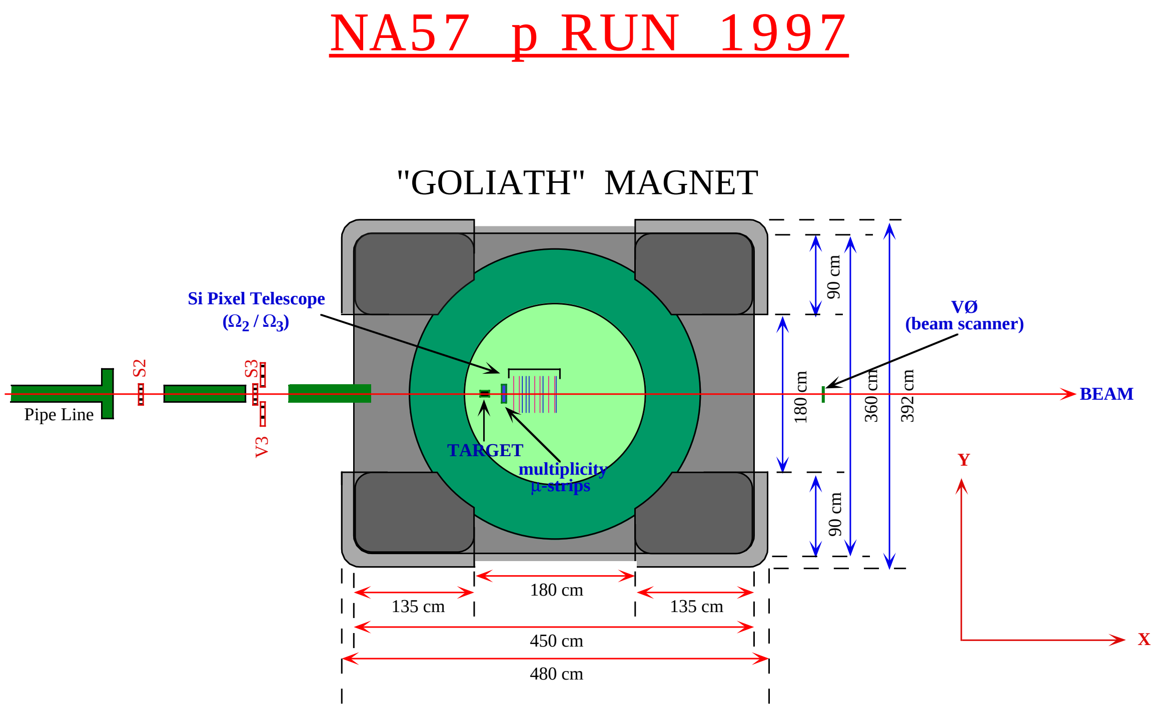

Figure 2: Layout of the NA57 experiment.

The solution which is being implemented for NA57 is shown in figure 3. It uses three VME boards. The divisions between the three trigger boards, labelled BPL (Beam and Petal Logic), TMX (Trigger Matrix) and TOP (Trigger Output) are shown with dotted lines. Signals from the upstream beam counters are used to select one of a number of predefined beam trigger signals. The unit rejects cases where a second beam particle arrives less than 40 ns before or after the triggering beam. The beam logic provides a strobe to an input register, which gives a snapshot of the status of the trigger input signals, and of the busy status of the detectors. The experiment additionally uses signals from a scintillator array (*petal* or *telescope*). The hit patterns in these arrays are checked using a small look-up table (256 words) which is fast enough not to require an input register. Valid hit patterns from this table are flagged and passed to the input register described above.

The contents of the the input register are in turn checked in a trigger matrix (16K words). This does not use the busy status of the detectors, but classifies trigger patterns into up to six trigger classes irrespective of busy status. Busy *qualifiers*, which flag when the buffer memory for a given detector is approaching saturation, are checked in order to give greater priority to rare events.

Up to six different trigger classes can be selected. The input register strobes the busy status of up to eight detectors, which are used (*via* another fast random access memory) to determine whether the trigger class assigned in the trigger matrix is matched by a suitable ready pattern in the detectors. If it is, the trigger is transmitted to the appropriate detectors *via* the output register. The OR of the trigger signals is used as an event counter, which is sent to all detectors. Local trigger units, one in each subdetector, count all the event counter pulses so as to identify events. In general, not all sub-detectors will receive the accompanying trigger pulse. Those that do receive it set their BUSYs, and maintain them until the end of the read-out cycle, thus blocking further triggers to them. In order to allow for delays in receiving the BUSY signals from the sub-detectors, the trigger system imposes 500 ns of dead time every time a trigger is issued. The dead time is then extended up to the end of the last BUSY input for the given event.

The trigger matrices are implemented using fast random access memories, CYPRESS CY7C123-7VC (256

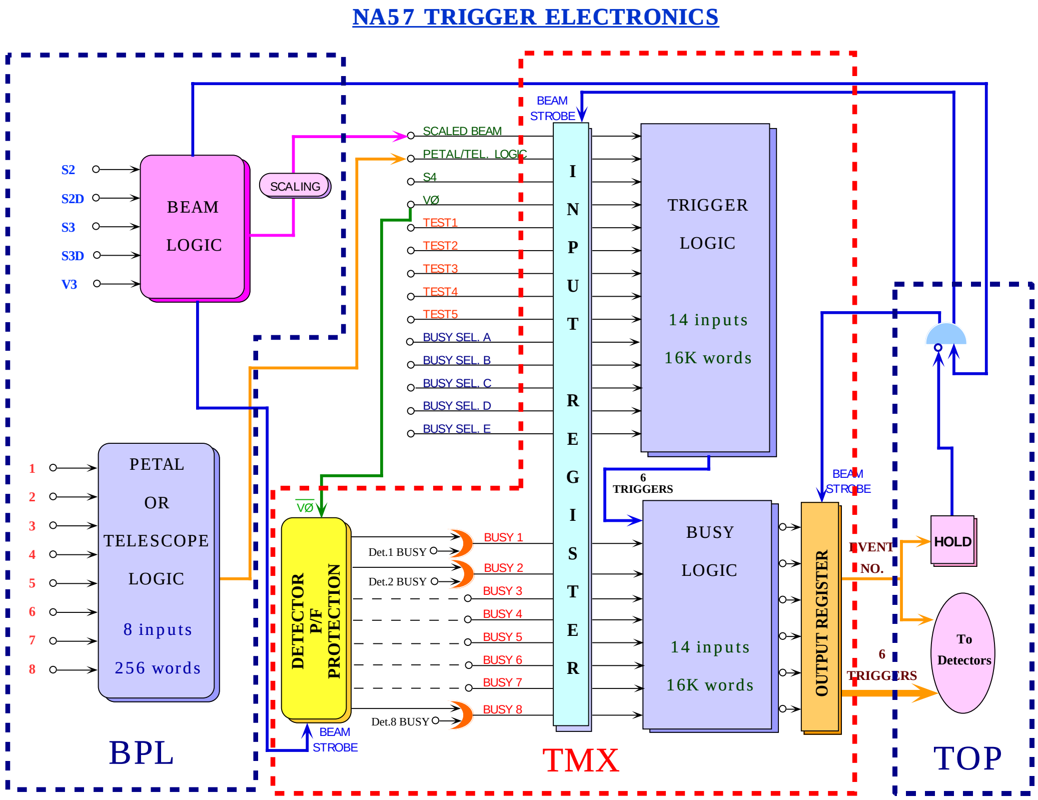

Figure 3: Schematic layout of NA57 VME central trigger processor.

word) and CY7C199-10VC (32K word) for petal and trigger matrix logic respectively. Most of the other logic functions required are performed using ALTERA EPM 7128 ELC 84-7 and EPM160 ELC 84-10 programmable logic chips, and the alignment of input signals uses programmable delays (mostly 6 bit with 1 ns steps) from Data Delay Devices.

4 MONITORING

Monitoring functions form an important part of the new design. In order to check timing, input signals to either the BPL or TMX boards can be selected and monitored on two outputs on the BPL board, which can then be connected to an oscilloscope. The signals are passed between the two boards using the backplane. In addition, all the inputs to the trigger system are counted in scalers. The contents of the input and output registers are stored in buffers which are read out between bursts.

The trigger matrices can be overwritten in a few milliseconds, as can the values of the delays on the inputs. This opens the possibility for a number of new tests. For example, the rate for a coincidence, normalised to one of the inputs, can be rapidly scanned as a function of the delay, thus allowing optimisation of delays. In addition, the trigger matrix has two further outputs which can be used to study any arbitrary trigger conditions without disturbing the operation of the trigger outputs. In this way, trigger diagnostics or new trigger conditions can be investigated conveniently while data-taking is in progress.

5 TRIGGER MATRIX LANGUAGE

From the discussion above, it is clear that the operation of the trigger system depends crucially on the ability to generate trigger matrices quickly and conveniently. For this purpose a *trigger matrix language* has been developed. The inputs, outputs and logical operations are defined in a script. A compiler, written in C, parses the script and runs through all input combinations in order to generate the matrix. The Boolean operations NOT, AND, and OR are supported, and functions can be written to perform more complicated operations, such as majority logic.

An example is given in figure 4. Four inputs are defined. Two trigger conditions are defined in terms of the inputs and these are assigned to two trigger outputs. A ".", "+" and "*" denote AND, OR and NOT respectively. At present, a 16K word matrix takes ~ 0.5 s to generate on a Motorola MVME 2600 processor.

6 CONCLUSIONS

It has been decided to operate the ALICE trigger system in pipelined mode, as a versatile way to cope with the widely differing trigger rates in different modes of operation. The system keeps track of dead time in each sub-detector separately in order to use fast sub-detectors more efficiently, and must provide past-future protection over a long interval. The NA57 central trigger system has been designed to exploit as many of these features as possible, in order to test them in the environment of a working experiment. The NA57 trigger system will be used in conjunction with a prototype ALICE DAQ system, and as such will provide a valuable test of both concepts. The trigger is implemented on three VME boards, using standard components. Monitoring is an important feature of the design, and new software has been written to generate the trigger matrices efficiently.

The design of the trigger boards has been complete, and production is starting now. The sytem will be available for testing before the end of this year, and we intend to use it in the 1998 NA57 experiment run.

```
; matrix TRIGGER
        beam = Input_0
        telescope = Input_1
        v_0 = Input_3
        test_1 = Input_4
        final = beam . telescope . v_0* ; final trigger
;
        test_trig = beam . test_1
        Output_0 = final
        Output_1= test_1
```

Figure 4: Example of a trigger definition script.

7 REFERENCES

[1] ALICE experiment proposal CERN/LHCC 95-71 LHCC/P3, ch. 9

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[3] H. Beker et al., Proc. 2nd Workshop on Electronics for LHC Experiments, Balatonfüred, Hungary, 1996, CERN/LHCC/96-39, p. 170.

[4] ALICE experiment proposal, ch. 7.

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[7] Addendum to ALICE proposal, ch. 5.

[8] NA57 Proposal, CERN/SPSLC/96-40 SPSLC/P300, 1996.