A TRIGGER SYSTEM USING WIRE CHAMBER INFORMATION

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ABSTRACT

A second-level trigger system using conventional wire chamber readout systems and NIM modules is described. The events to be processed by the on-line computer are selected in a time interval of one microsecond on the basis of the number and the distribution of hits in the wire chambers. Some applications of the system and their performance are described.

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1. PRINCIPLE

In several experiments performed with the Omicron Spectrometer [1] it has been found useful to supplement the fast trigger derived from scintillators with a secondary level of selection based on wire chamber signals in order to decide whether to record a given event.

This secondary trigger selects events with prescribed hit-patterns and eliminates others which have an insufficient number of hits to permit track reconstruction. In experiments with low-energy secondaries, in which the number of chamber planes has to be kept to a minimum, such a secondary trigger provides a safeguard against chamber inefficiencies and against certain backgrounds. The simple systems described here are made from standard NIM modules. They act within about 1 μ s and significantly reduce the trigger rate.

The principle of the secondary trigger logic (STL) is illustrated by fig. 1. The fast trigger activates decoder units whose "Busy" outputs show if a hit has been registered. "Busy 1" and "Busy 2" outputs indicate the occurrence of one or two hits per unit, respectively. With standard NIM coincidence and fan-in units, the "Busy" outputs are first combined into signals indicating the number of hits in each plane. From these the desired patterns are formed and fanned-in to OR STL together with a sample of fast triggers not subject to the STL (bypass).

Finally, a normal and a veto output from OR STL are matched separately with the delayed fast trigger. If the STL decision is positive, a LAM signal is generated to initiate the CAMAC readout. As a consequence, the data acquisition program reads, resets, and enables the whole readout system. In the case of a negative STL decision no LAM signal is formed. Therefore additional hardware reset and enable signals have to be generated.

2. MWPC AND DRIFT CHAMBER READOUT

In the applications described here, STLs were applied to signals from multi-wire proportional chambers (MWPCs) and adjustable-field drift chambers (AFDCs),

which were used respectively to detect primary beam particles and secondaries produced in hydrogen targets.

For the readout of the MWPCs the CERN receiver/memory hybrid (RMH) system is used, a detailed description of which is given in ref. [2]. The chamber signals are sent via preamplifiers and 100 m long 32-twisted-pair cables to the RMH modules. Here they are amplified and stored in memory if a strobe pulse has been generated by the fast trigger. Each RMH module has 32 channels with a strobe input and a common monitor output giving real-time signals. These are used for the MWPC logic described below.

The readout used for the drift chambers is the CERN drift-time digitizer (DTD) system [3,4]. The pulses from the sense wire of a drift chamber are led via a CERN N4190-type preamplifier/discriminator to the DTDs, type 215. Each of these modules has four time-measuring channels for a maximum of 16 inputs, with a time bin of 2 ns and a range set to 768 ns in our experiments. Signals from the chambers are taken as the start of time measurements; the stop is the fast trigger, suitably delayed. Each time-measuring channel provides a "Busy" signal. These signals are fanned-in for "Busy 1". To generate "Busy 2", use is made of the fact that the channels are activated cyclically. Two consecutive start signals therefore appear in adjacent channels, and one obtains "Busy 2" signals from a decoder unit by combining the "Busy" signals of the four pairs of adjacent channels in four twofold coincidences and by fanning-in the coincidence outputs.

3. APPLICATIONS AND RESULTS

3.1 Layout of the detectors

In both the experiments described, primary and secondary trajectories were momentum-analysed by the field of the Omicron Spectrometer. Figure 2 shows the layout of one of these experiments. A pion beam of momentum spread $\Delta p/p \sim 5\%$ FWHM enters from the left and is defined by counters GC, S1, S2, and a guard counter S3 before striking a hydrogen target. Hodoscope counters to the right and left of

the beam detect secondaries, and fast triggers are formed from beam coincidences $B_m = S1 \cdot S2 \cdot \overline{S3} \cdot \overline{GC}$ with various combinations of hodoscope signals R and L.

Trajectories of the incident pions are recorded by the MWPCs C1 to C4, and those of the secondaries by three AFDCs, RD and LD on the right and left side of the beam. The chambers are described elsewhere [5].

Both experiments were designed to observe very rare processes, and the suppression of unwanted backgrounds was therefore a matter of great importance.

3.2 STL for drift chambers (DCL)

3.2.1 Function

The drift chamber logic (DCL) is intended to reduce the trigger rate by applying selection criteria to the secondary particle tracks. It is particularly efficient in rejecting unanalysable events and some kinds of background.

A particle track is recognizable if three wires in separate vertical planes and two wires in horizontal planes are hit, permitting position and momentum determination. In fact, since an interesting event is composed of one incoming and two outgoing tracks and since a vertex is required in the target, the above recognition requirement can be relaxed for one of the secondary particle tracks by stipulating just two hits in the vertical wire planes and one hit in a horizontal one. An event is analysable if the set of tracks forming it can be recognized.

The requirement of analysability rejects most of the background of electromagnetic origin. Gamma rays which may trigger hodoscopes are unlikely to produce a signal in the drift chambers. An additional source of background triggers is the low-momentum tail of the pion beam, which is of the order of 10% of the total beam intensity, i.e. 10^5 to 10^6 s⁻¹. Some of these particles are deflected into chamber frames, where they may interact and produce a trigger. However, they usually do not have hits in the drift chamber planes nearest to the target; hence they do not produce analysable events.

3.2.2 DCL in the search for the decay $\pi^0 \rightarrow e^+e^-$

An experiment intended to study the decay of the neutral pion into an electron-positron pair, whose branching ratio is predicted to be at least 5×10^{-8} , was performed in the Omicron Spectrometer [6]. The experimental layout was similar to that of fig. 2. Neutral pions were produced by letting 300 MeV/c negative pions strike a 100 mm long liquid-hydrogen target placed in the centre of the pole gap. Large-angle pairs of oppositely charged, fast secondaries triggered the detection system.

Precautions were taken to reduce triggers due to common events, e.g. electromagnetic interactions of beam electrons, π^-p elastic scatters, or single Dalitz pairs from π^0 decay. Nevertheless, about half the recorded events were not analysable because of insufficient hits. In many of these there was no evidence of a charged secondary in the RD chambers.

"Busy 1" signals from the DTD units were therefore used to ensure that the recorded events were analysable. A simplified block diagram is shown in fig. 3, where the elements M are majority logic units. Their outputs are labelled according to the number of input signals required to generate an output. Figure 3 shows that triggers were accepted when there were hits in two of the six wire planes of the LD chambers and in two of three vertical wire planes and in one horizontal wire plane of the RDs. Whilst these conditions fall short of the "analysability criterion" defined in subsection 3.2.1, they were sufficient to ensure that only analysable tracks were recorded.

The DCL reduced the trigger rate by 49%. A gas Cherenkov counter vetoing electrons produced a reduction of 44%, but this was partly due to the spread of the beam spot caused by the Cherenkov counter. The remaining 56% were reduced to 33% of the original trigger rate by applying the DCL.

3.2.3 DCL for $\pi p \rightarrow \pi\pi N$

In this experiment the production of pions in pion-proton collisions near threshold [7] is studied by allowing beams of positive or negative pions and of

various momenta to traverse an 800 mm long, 150 mm diameter cylindrical target filled with gaseous hydrogen at 12 bar pressure [8]. The layout of the detection system is that shown in fig. 2.

Secondary particles are again detected in spectrometer arms on the left-hand (L) and right-hand (R) sides of the central beam trajectory. Each arm consists of three drift chambers, a hodoscope of scintillation counters, and now includes veto counters.

Counters S1, S2, S3, and $\check{G}\check{C}$ determine the fast beam trigger, $B_m = S1 \cdot S2 \cdot \overline{S3} \cdot \overline{G}\check{C}$. Since events with double tracks in one of the secondary arms or with single tracks in both arms are expected, three types of triggers have to be considered. The BmLL and BmRR triggers require a fast beam trigger and two hits in different strips of the left- or right-arm hodoscope, respectively. Correspondingly, the BmRL trigger demands a hit in each arm.

The resulting trigger rate ($B_{mLL} + B_{mRR} + B_{mRL}$) was 500 s^{-1} , which is too high for our system, but it was reduced to an acceptable value by the use of the DCL shown in fig. 4. The "Busy 1" and "Busy 2" output signals generated in the DTD modules are fed via TTL/NIM converters into various coincidences to provide DCL signals matching the three different triggers (B_{mLR} , B_{mLL} , B_{mRR}). The signals are first combined to give the number of hits per plane. Whilst the one-hit-per-plane signals are formed for all chamber planes, the two-hits-per-plane signals are provided for the vertical-wire (VW) planes only. For the triggers B_{mLL} and B_{mRR} , which require two secondary particles in one arm, the DCL pattern is two hits in each of the VW planes and one hit in each of the horizontal-wire (HW) planes of the corresponding spectrometer arm. In the case of B_{mLR} trigger, three hits in the VW planes of one spectrometer arm and two hits in the VW planes of the other are required as well as hits in two of the three HW planes of each arm. In addition, a hit is always demanded in each of the VW planes nearest to the target.

This DCL system was tested and successfully used in measuring $\pi p \rightarrow \pi\pi N$ reactions in the momentum range from 300 MeV/c to 480 MeV/c. Since the origin and

proportion of background vary from trigger to trigger, the effect of the DCL was studied for each of them separately.

The reduction factor for the BmRL trigger was 3.5 for the full target (12 bar) and 5 for the target at atmospheric pressure. This indicates that the DCL is more efficient in eliminating the background originating from materials outside the target. For BmLL and BmRR triggers, the reduction factor was about 20. The rejected events are believed either to be electromagnetic or to originate from the low-momentum tail of the beam.

During data-taking an over-all reduction factor of approximately 6 was obtained, thus reducing the trigger rate from about 500 s^{-1} to 80 s^{-1} . The resulting computer dead-time was 20%.

3.3 STL for multiwire proportional chambers (MCL)

The aim of the multiwire chamber logic (MCL) system is to reduce the number of events with unanalysable beam trajectories. Since the number of events with less than three hits in four VW planes does not exceed 5% of all beam tracks (at 90% MWPC efficiencies), it seems unnecessary to impose extra restrictions similar to those of the DCL. However, it is reasonable to introduce conditions for the beam momenta near threshold, where the determination of the energy dependence of the cross-section relies critically on the momentum resolution. Since L , the distance between the first and the last MWPC, is small compared to the radius of beam tracks, the momentum resolution goes as L^2 . Therefore, it becomes necessary to require hits in the vertical planes of the first and the last MWPC.

The signals for the MCL are taken from the monitor outputs of the CERN RMH modules and then fed into different OR and AND gates, as is seen from fig. 5. The final MCL signal is combined separately with the DCL signal, the DCL bypass signal, and the signal indicating a beam sample. As a consequence, the number of beam triggers and of accepted events can be deduced. These numbers are used later on for the normalization in the evaluation of the cross-section.

4. CONCLUSIONS

The secondary trigger logic applied to multiwire and drift chamber signals in low cross-section measurements with the Omicron Spectrometer proved easy to implement with standard NIM units and was effective in eliminating events having an insufficient number of hits to permit an analysis. Trigger rates were reduced by factors of between two and six, with a corresponding reduction in computer dead-time and in the consumption of magnetic tapes.

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Figure captions

- Fig. 1 : A simplified scheme of secondary trigger logic.
- Fig. 2 : Layout of detectors in the Omicron Spectrometer for the experiment " $\pi p \rightarrow \pi\pi N$ reactions near threshold".
- Fig. 3 : Drift chamber logic for $\pi^0 \rightarrow e^+e^-$, using majority logic units.
- Fig. 4 : Drift chamber logic in the $\pi p \rightarrow \pi\pi N$ experiment.
- Fig. 5 : MWPC logic circuitry.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5