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USE SIGNALS FROM SLOW DRIFT DETECTORS FOR GENERATION OF LEVEL 1 MUON TRIGGER

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Introduction

The paper investigates a version of the muon trigger system which uses signals from drift tubes.

The use of a large number of drift detectors usually requires external trigger systems. As drift detector systems in SSC and LHC experiments become increasingly large, creation of an inexpensive precise external trigger system using the vast number of signal channels becomes an increasing challenge.

Thus, an intriguing opportunity may lie in the exploitation of the actual drift detector signals for triggering. We suggest some methods pertaining to this problem. These methods feature, firstly, the symmetry of the time signals registered in the drift detectors and, secondary, involve a transformation of the coordinate system from individual drift times to differential time coordinates. The geometrical arrangement assumes that even and odd detector layers are offset by one half-cell, and that the projective distance between adjacent layers is constant.

One idea for generating fast trigger signals from two triplets of drift detector cells is posed in Refs. [1,2]. This method allows calculation of the arrival time of the track and generation of a precise trigger signal. The coincidence matrix for selecting true signals from among candidate solutions is investigated, and a possible muon trigger system for drift cell superlayers is proposed. However, a specific study for one detector system shows that the volume of the electronics necessary for evaluating the coincidence matrix elements increases significantly for multi-track events, as noted in Ref. [3].

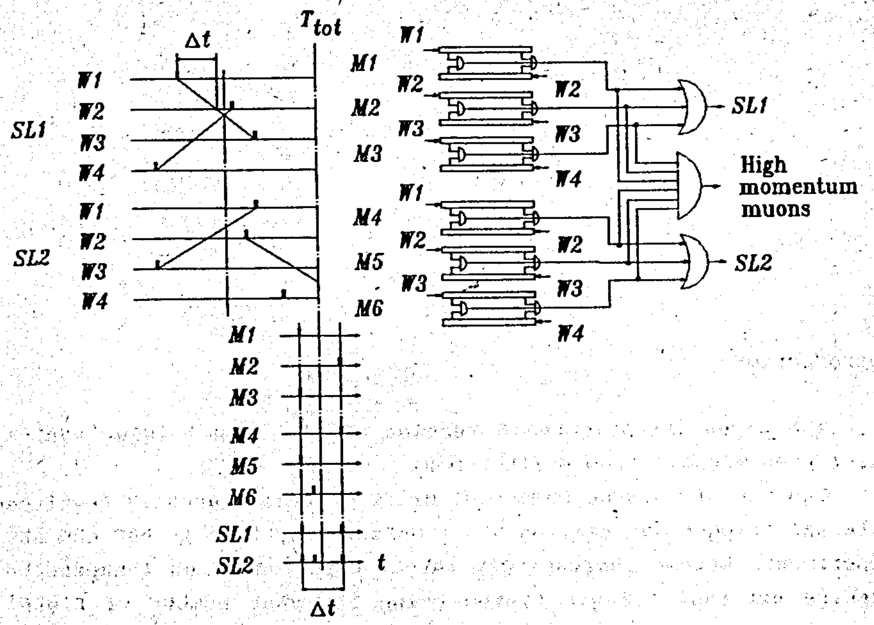

Fig.1. The first stage of analysis of signals from drift tubes superlayers.

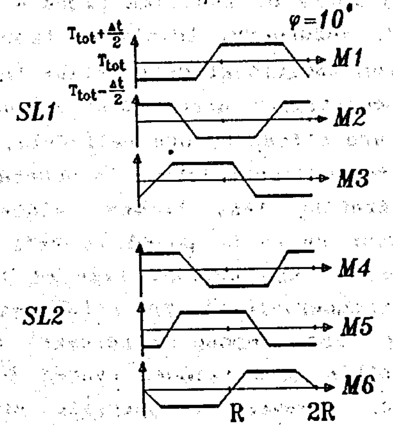

Fig.2. Dependence of behavior of mean timer decisions from the coordinate of tracks in the first detector layer with slope equal to 10 degrees.

A second idea is discussed in Ref. [4]. This method proposes the use of mean timers for the generation of the trigger signals. The present investigation studies a hybrid version of the two methods with a restricted detector geometry, and results are described below.

2. Principles of trigger signal generation.

The first stage of analysis of drift tube signals is shown in Figure 1. The drift time signals from a straight track registering in SL1 and SL2 superlayers are shown. A time reflection symmetry about T_{tot} is seen in SL1 between pairs (W1,W3) and (W2,W4). This symmetry is characteristic of particle tracks that lie within an imaginary corridor of four sequentially alternating half-cells. However, in SL2, the track has passed outside the corridor boundaries at layer 4, and the W4 signal registered in the neighboring tube breaks the time reflection symmetry.

Signals from each adjacent pair of drift tubes layers come to the inputs of mean timers M1-M6. The resulting output signal realizes the arithmetical process:

$$t = T_{tot} \pm \frac{\Delta t}{2} = \frac{T_1 + T_2}{2} + \frac{T_m}{2} \qquad (1)$$

where t is the time of signal from the output of mean timer, T_1 and T_2 are times of the input pulses, and T_m is the total delay of the mean timer. Tm must be greater than or equal to T_{tot}, the total drift time of electrons in the drift tubes, by an amount dependent on the propagation delay of the electronics. Figure 1 shows the time position of output mean timer pulses for the case when $T_m = T_{tot}$.

The time symmetry of pulses coming from the wires to the mean timer inputs is violated in the presence of tracks with slopes relative to the detector plane. Thus the output mean timer signals are shifted relative to T_{tot} time and the value of the shifts is $\pm\Delta t/2$ for true decisions. For wrong decisions which originate in cases when a track crosses a boundary of cells, the shift is smaller than $\Delta t/2$.

The behavior of the output mean timer decisions for two 4-layer superlayers SL1 and SL2 is illustrated in figure 2 for a corridor of width 2R. The output signals M1-M6 were calculated for tracks with a fixed slope of 10 degrees. As seen from the figure, we have at least two true decisions for each superlayer. Such a picture is observed up to 12° for distance between the detector layers equal to $R\sqrt{3}$. Beyond this angle the range of tracks where only one true decision is found increases.

Thus, the main purpose of M1-M6 mean timers is a symmetrization of the time picture relative to time T_{tot}. The pulses from M1-M3 and M4-M6 mean timer outputs are joined by using the OR circuits. Each track is presented by two pulses symmetrical about T_{tot}. Wrong decisions are randomly distributed in the time interval between the pair of true pulses. In a result, we form a condition for subsequent separation of tracks: this is the symmetrical time picture of pulses near T_{tot}.

The 6-fold coincidence circuit can be used for generation of a trigger pulse for cases, when the slope of the track and the associated Δt are small. These events will correspond to high momentum muons if the drift tubes are oriented to project back to the interaction point, as in the SDC muon system.

The second stage of analysis is shown in figure 3. The second stage mean timer has a shorter delay depth defined by the angular range of registered muons. In particular, muons with momentum equal to 5 Gev/c will have a slope of 9° in SDC muon system so the delay of the second short mean timer has to be of order 350 ns.

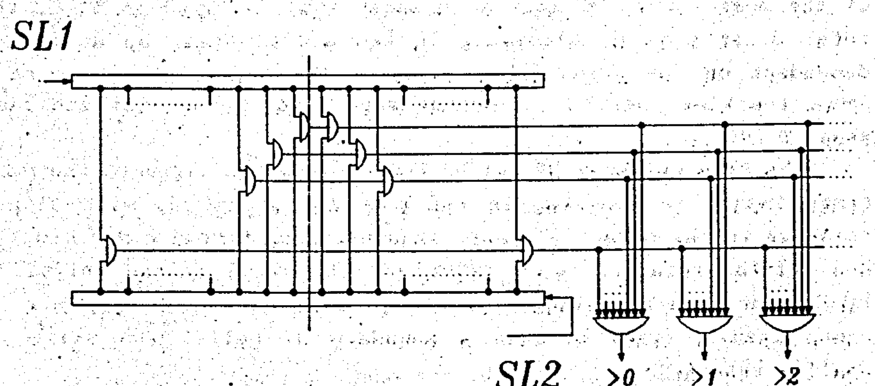

Fig.3. A scheme of a "short" position mean timer.

The symmetrization feature of the mean timer can be of further advantage in rejecting ghost pulses. Since true time coincidences are marked by symmetrical patterns of time pulses about T_{tot}, the outputs of M1-M3 and M4-M6 can be ORed and then fed into the inputs of the second position sensitive mean timer. True time coincidences are then accepted by a coincidence gate centered on the middle of the short mean timer. 4-fold position coincidences can be constructed to reduce the rate of random and combinatorial ghost pulses.

Coincidence positions can be calculated by formula:

$$P = \frac{T_2 - T_1}{2} \qquad (2)$$

where T_1 and T_2 are the times of pulses on the inputs of short mean timer (see fig.3; SL1, SL2 inputs) and position is calculated near the middle of short mean timer. Another version of a second stage of analysis is shown in figure 4.

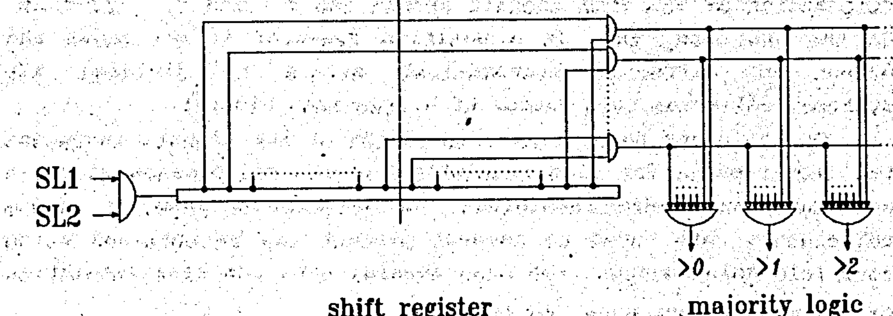

Fig.4. A version of a "short" position mean timer.

A position coordinate can be used for estimation of track slope and, for example, in SDC muon system, for estimation of the muon momentum. A P_t selectivity will determine the number of mean timer stages and the corresponding time resolution.

As we posed above, any track generates paired pulses on the OR outputs. For events with n tracks each M_i mean timer gives n^2 decisions and we obtain approximately $3n^2$ decisions from each OR circuit. This set includes n pairs which represent the true decisions, all others are combinatorial in origin. Since only one decision has n-fold amplitude, combinatorial ghost pulses can be rejected by the use of majority coincidence circuits. However, this criterion is true only for the multi-track events. If we have a multi-track event overlapping in time with a single-track event, the situation is more complex. A blind application of the majority coincidence circuits can lead to a loss of the single-track event. In such cases, the output information from the majority coincidence circuits must be recorded for use in subsequent analysis. The first majority circuit can be used for generation of the trigger signal only, and the subsequent rejection of combinatorial signals must to be done using coincidence with second coordinate superlayers and other superlayers which registered other muons.

The second significant feature of the mean timers is the compression of the time signals around the T_{tot} and $T_{sh.m}$ /2 time. On the one hand, this is a positive feature: it decreases the effect of different systematical errors by dividing any systematical error by a factor of 4 (two mean timers).

On the other hand, time compression of the signals increases the requirements for time resolution of the coincidence circuits and the mean timers themselves. As estimations show, a random coincidence rate equal to several percent can be obtained using four-fold coincidences (two muon events) when the time resolution of all mean timers equal to 4-5 ns.

In conclusion, we would like to emphasize that the application of mean timers to muon triggering has many advantages and difficulties and more detailed simulations are required to this end.

We discussed in this paper a method of using mean timer circuits for generating a muon trigger without any other systems of detectors. Including other systems such as planes of scintillation counters in the trigger can significantly decrease the requirements to the described scheme.

References

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