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Trigger scheme of the ionization hodoscope

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The electronics and the trigger scheme of the ionization hodoscope have been considered in [1,2]. Nevertheless, for the trigger electronics only a basic logic was schematically shown. In this note there are suggested the versions of practical realization of the ionization detector trigger following [2] and going further.

The ionization hodoscope (IH) consists of two planes each of 16 vertically oriented strips. The planes are shifted by a half-width of the strip to remove an inefficiency due to gaps between the strips. The logic should select the events with a double ionization in any single or two adjacent strips from the background of single-ionizing particles and pairs crossing non-adjacent strips. As far as in this experiment the equal conditions for detection both of real and accidental pairs have to be ensured, the accidental "false" double ionization events (when two uncorrelated particles hit the same or adjacent strips within the resolution time and their integrated charge overcomes the double ionization threshold) should also be accepted.

A positive decision of the IH logic is a subtrigger 2. A total trigger 2 includes also the decision from the SciFi detector logic. For short, in this note the IH subtrigger 2 is named T2. The IH electronics should provide also the subsequent Trigger 3 scheme with a bit-pattern where non-zero bit(s) correspond the number(s) of strip(s) which detected the double ionization.

In the logic suggested in [2] the events are analyzed for double ionization in single and adjacent strips separately. For this aim the signals from every strip are split in a linear fan-out unit to two branches. For single strips the modified LeCroy FERA ADC 4300B with a fast output of the integrated signal [1] is used. For adjacent strips usual discriminators followed by coincidences of pairs of all adjacent strips fulfill the needed selection.

The IH logic is triggered by Trigger 0 (T0) signal arranged using the vertical hodoscopes and preshower signals [3]. At the expected high rate of T0 (over 100 kHz) there will be essential dead time inserted by ADC. To avoid this V.Karpukhin suggested to use two ADC per plane instead of one supplemented with a dedicated commutator unit which distributes gate signals among the ADC. Normally only the first ADC is in operation but if the interval between the adjacent triggers is less some guard time (defined by the ADC dead time), then the gate is directed to the second ADC thus sharply decreasing a dead time. V.Karpukhin developed and produced the prototype of this commutator unit (K426 module).

In Fig.1 there is shown the scheme which follows the logic of [2]. All modules are standard LeCroy products except the commutator unit and the mentioned upgrade of FERA ADC 4300B. After linear fan-in/fan-out 428F the single strip branch splits into two integrating ADC (4300B), only one of them is gated in each event by T0 signal via the commutator unit. The integrated signal from the fast output comes to the discriminator D_2 (3412) with a threshold set at the double ionization level. The outputs of two discriminators are summed in 4516 module configurated as OR unit (16 pairs of signals in one module).

The adjacent strips branch from linear fan-in/fan-out is connected to the discriminator D_1 with a threshold corresponding to single-ionizing particles. The discriminator is also gated by T0 (with $\overline{T0}$ applied to the Veto input) to have the same timing like in the single strip branch. Then the outputs of OR in the n-th channel of the single strip branch and of two D_1 of the channels n and $n-1$ are connected to the logic module AND/OR (4516) where there is made AND of two adjacent strips signals followed by OR with a single strip double ionization signal. The output of 4516 after fan-out in 4518 module is directed to three points: 1) to OR of 16 channels of the probable double ionization decisions of the plane (in 4564 module); 2) to FERA register for readout (FERA register is programmed on the base of LeCroy 2366 universal logic module); 3) to bit-to-bit OR (in 4516) with another IH plane to prepare the input pattern for the Trigger 3 logic.

The electronics of the second IH plane has the same structure. The OR of the first as well of the second plane and OR of both planes are made in a single 4564 module. This final OR of two planes is the T2 signal which indicates that somewhere in the first or the second plane there is recognized the double ionization in a single or two adjacent strips.

Readout data in this scheme are: 1) the double ionization patterns of the first and second planes (from FERA registers); 2) the charges measured by integrating ADC. The counting rate of the double ionization decisions can be measured for every plane and for their sum from 4564 outputs. The counting rate of the separate strips can be taken from the second available outputs of D_1 and D_2 for single and double ionization threshold levels, respectively. (Double ionization counting rate can be measured at standard data taking only for single strips, to measure it for adjacent strips the parameters of AND/OR 4516 should be changed.)

The total number of modules in this scheme is:

Linear fan-in/fan-out 428F	8	NIM, 4 ch.
Fast integrating FERA ADC 4300B	4	CAMAC, 16 ch.
Discriminator 3412	6	CAMAC, 16 ch.
Logic OR and AND/OR units 4516	5	CAMAC, 16 ch.
Logic fan-out 4518	2	CAMAC, 16 ch.
OR unit 4564	1	CAMAC, 64 ch.
Register 2366	2	CAMAC, 16 bit

Starting from the above scheme we came to another version which seems to have more advantages than drawbacks compared to the previous one. It is presented in Fig.2. The main idea is that the double ionization for adjacent strips is analysed in the same integrating ADC that for single strips.

The number of linear fan-in/fan-out units is doubled here. The first row of these modules makes fan-out of every scintillator strip signal. The second row makes fan-in of pairs of adjacent strips signals. The outputs of this fan-in come to two integrating ADC and then to the discriminators D_2 with a double ionization threshold followed by 4516 OR scheme. Thus at the output of the n-th discriminator (and of the n-th OR) there will appear a signal if the double ionization is detected in the single $(n-1)$-th or single n-th strip or in the sum of adjacent strips $(n-1)$ and n. Then after fan-out in 4518 module the signals go, like in the previous scheme, to OR schemes and registers.

The total number of modules in the scheme of Fig.2 is:

Linear fan-in/fan-out 428F	16	NIM, 4 ch.
Fast integrating FERA ADC 4300B	4	CAMAC, 16 ch.
Discriminator 3412	4	CAMAC, 16 ch.
Logic AND/OR unit 4516	3	CAMAC, 16 ch.
Logic fan-out 4518	2	CAMAC, 16 ch.
OR unit 4564	1	CAMAC, 64 ch.
Register 2366	2	CAMAC, 16 bit

Let us consider what is different in perfomance of this scheme from that of the first one and mark by signs +/- the advantages and drawbacks of the scheme of Fig.2.

1. (++) The complete identity in detection of double ionization in single strips and in adjacent strips. This is the main and really essential advantage of the scheme 2. The single or adjacent strip signals in this scheme go through the same logic path and the same modules thus removing any probable difference in thresholds and time windows for accidentals. This helps to exclude sistematic errors in handling of these two types of events.

2. (+) The scheme 2 is logically more simple.

3. (+) The events corresponding to double ionization in a single or in adjacent strips can be separated at data handling, if needed (it can be useful for the analysis of the detector and trigger perfomance, especially at the first stage of the experiment): when the trigger is initiated by a double ionization in a single strip n then in the register there are always "1" in two adjacent bits n and $(n+1)$; otherwise, if the trigger is caused by adjacent strips n and $(n+1)$ then "1" is found only in the $(n+1)$-th bit of the register. In the scheme 1 such separation could be realized only with doubling of the number of registers.

4. (+/-) The scheme 2 takes 8 NIM modules more (428F) but 4 CAMAC modules less (3412 and 4516).

5. (-) Somewhat less rejection factor in the subsequent T3 trigger stage: around 5% decrease of the rejection factor is expected according to calculations of 1996 by Yazkov. This occurs due to two (instead of one) valid adjacent bits sent to the T3 scheme per a single strip with double ionization. It is approximately equivalent to twice more coarse sampling of the ionization hodoscope as seen by the T3 scheme.

In conclusion let us make two remarks which do not depend on the choice between the versions.

The integrating ADC of IH is gated by T0 signal, but for the useful events the conditions of Trigger 1 should be fulfilled. Hence, one has to select from the T2 signals of IH only those accompanied by T1. For this purpose a coincidence module is needed with inputs T1 and T2. The T1 signal should be delayed a little with the aim just T1 defines the timing of coincidences. This excludes the jitter of the final T2 which could be observed if IH would define this timing. (The jitter of the IH electronics output in respect to T1 is due to T0 jitter caused by absence of meantimers in T0 scheme.)

Another remark concerns the signal delays of the IH counters. Development of T0 signal takes around 50 ns [3]. The gate signal to the ADC should come 20 ns before the analog signals [4]. If the Trigger 0 was produced by accidental coincidence then its timing (and of ADC gate) is defined by the last of two coinciding signals and hence, not to loose acidentals in the charge integration process, the integration should begin 10-20 ns earlier than if we would be interested in the real coincidence only. In addition, the flight time of 28 ns along 8.5 m distance between the ionization and vertical hodoscopes has to be taken into account. Fig.3 illustrates this consideration. As a result, the delay in the signal cables of IH should be around 120 ns more than in VH cables (neglecting the difference in transit times of IH and VH photomultipliers).

REFERENCIES

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2. C.Brickman et al. Ionisation hodoscope: a trigger scheme. DIRAC note 97-01.
3. A.Kulikov. Fast zero level trigger. DIRAC note 98-01.
4. LeCroy Research Systems, 1997 Catalog. Model 4300B ADC.

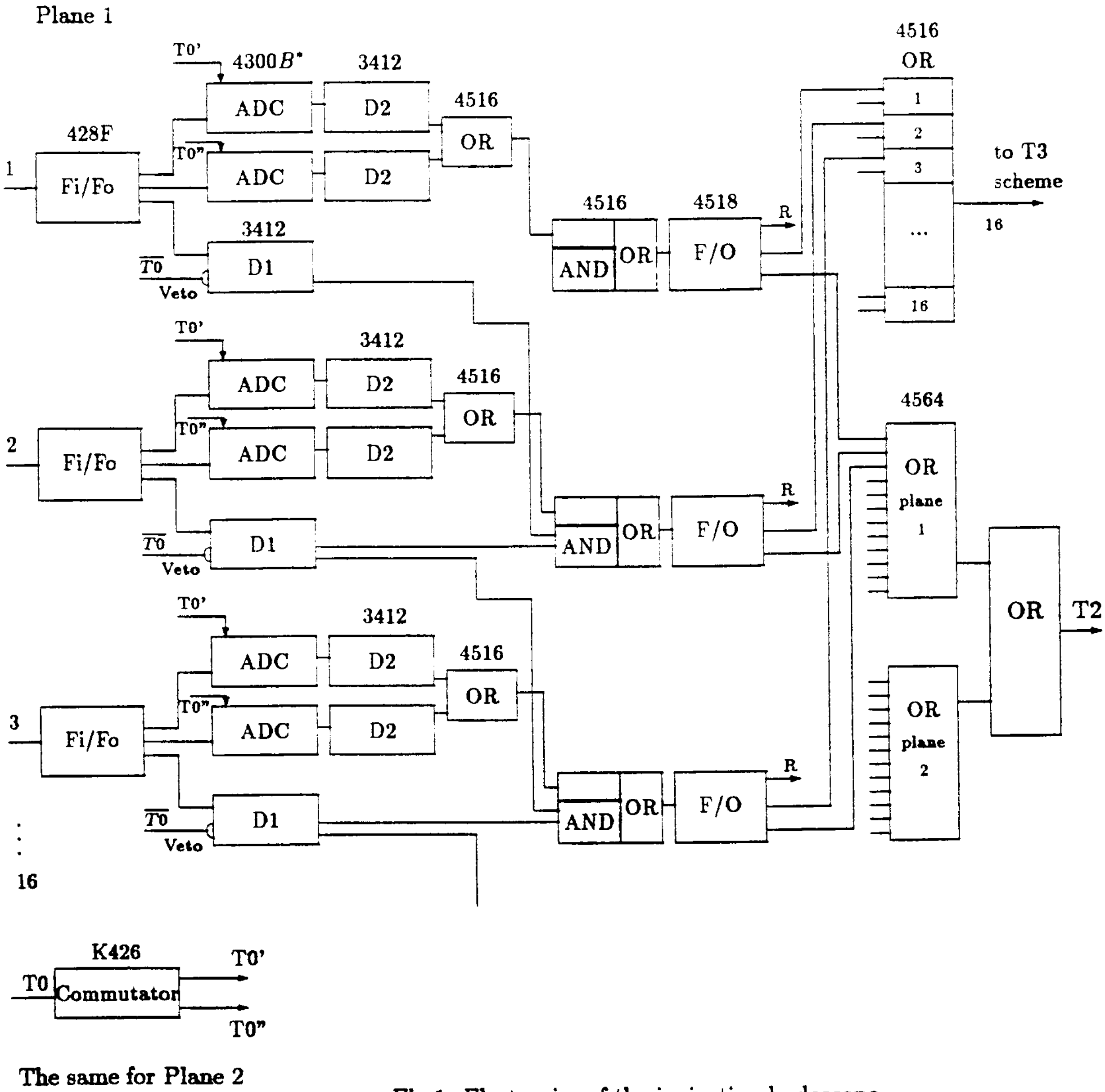

Fig.1. Electronics of the ionization hodoscope.

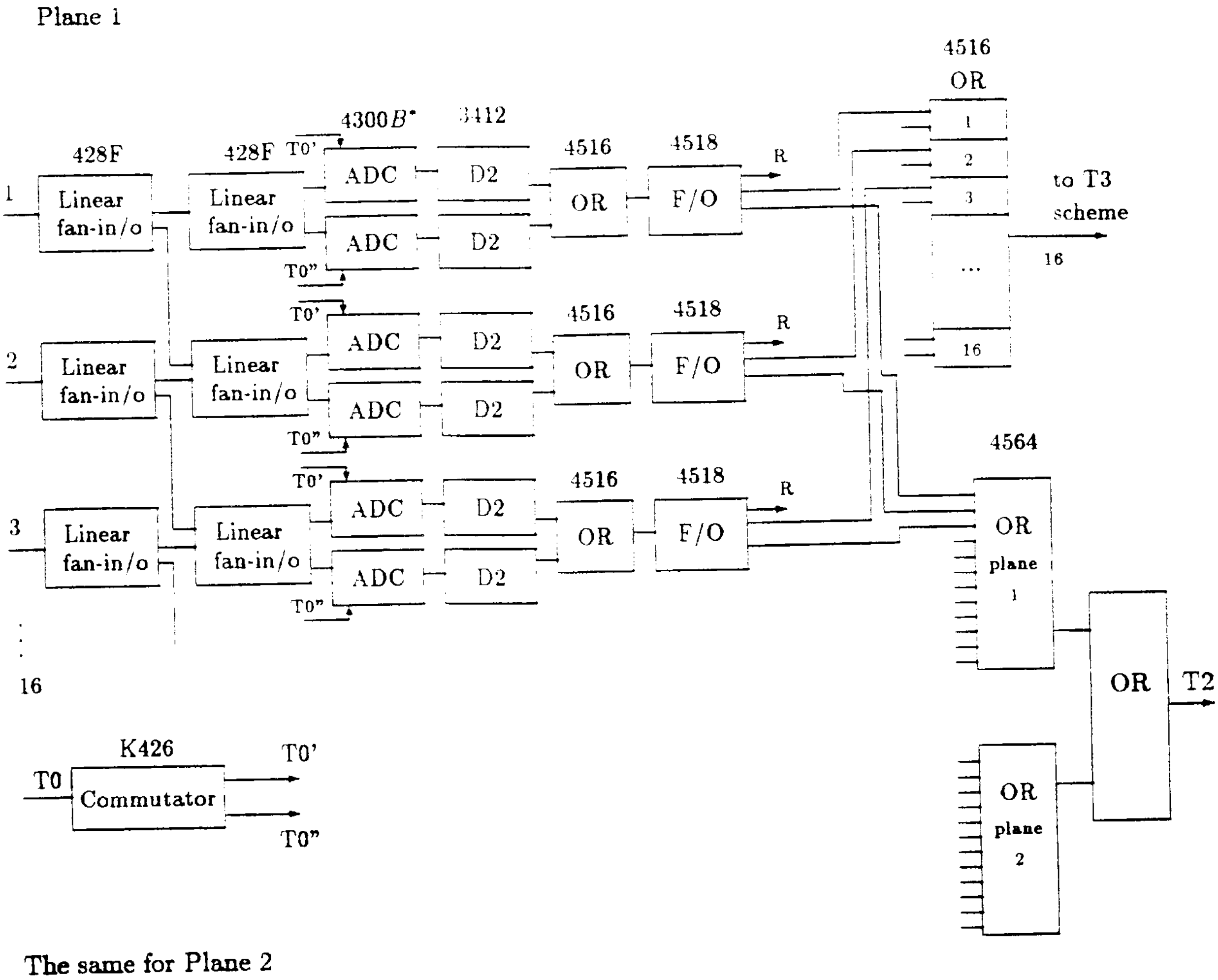

Fig.2. Second version of the IH electronics. Double ionization in single and adjacent strips is analyzed in the same channels.

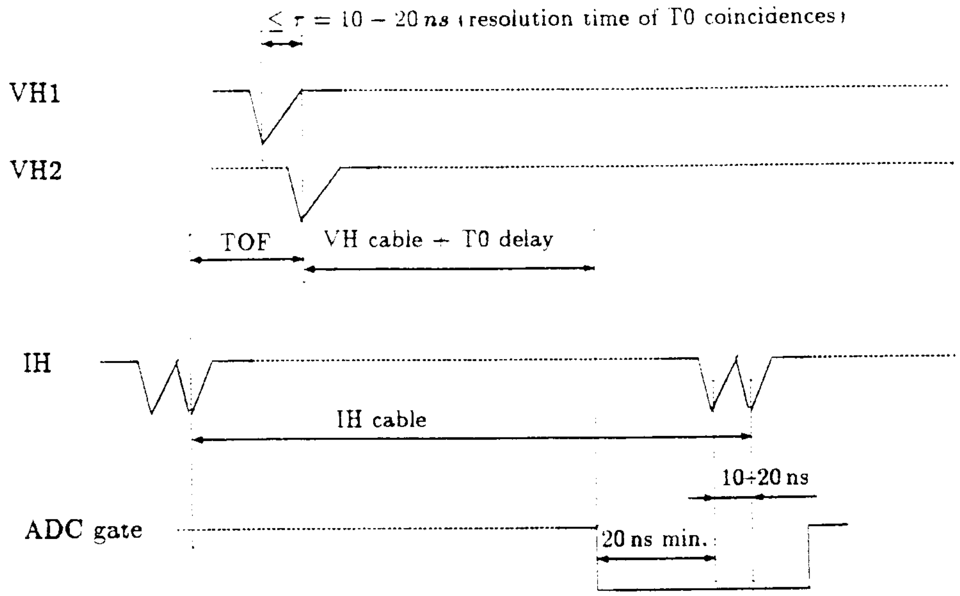

Fig.3. Time diagram for the delays of IH signals.
The case of accidental coincidence is shown.