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First level trigger for DIRAC

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The updated version of the 1-st level trigger is presented. A new dedicated module for complanarity selection has been included. Some modifications of the scheme have been done and the number of detector channels has been changed.

1 Introduction

A multilevel trigger of the DIRAC experiment [1] is aimed to suppress a high rate of background events below the level acceptable for the data acquisition system. According to the Proposal [1] there will be four trigger stages. The first level trigger $T1$ deals with data from the detectors downstream of the spectrometric magnet: horizontal and vertical scintillation hodoscopes (H and V), gas Cherenkov counters (Ch) and muon scintillation counters (Mu). The second level trigger signal $T2$ arises if $T1$ is accompanied by the positive decisions of the scintillating fiber detector ($SciFi$) logic and of the ionization hodoscope (dE/dx) logic, that is, of the detectors upstream of the magnet. The signals $T3$ and $T4$ are worked out by, respectively, hodoscope processor (HP) and drift chamber processor (DCP) which impose the kinematic criteria specific for the pionic atom events.

The data streams used for $T1$ and $T2$ are parallel and $T2$ signal may be produced simultaneously with $T1$. So the separation into two stages ($T1$ and $T2$) is only mnemonic one, helping to understand the role of in-beam and the spectrometer arms detectors. Really just $T2$ signal triggers all TDC, ADC, fast processors and the whole DAQ.

In this note a scheme for the first and second level trigger is presented. The scheme includes the front-end electronics of the detectors involved in trigger and is detalized for the first level trigger part, whereas for the second level trigger the $SciFi$ and dE/dx logics are considered as "dark boxes" and only their outputs are implemented into the scheme.

2 First level trigger tasks

The first level trigger has to fulfill the following tasks:

- to select coincidences of different detector signals in each arm separately, specifying the particle type by the detectors AND-NO combinations;

- to arrange coincidences between two arms, including detection of accidentals within pre-defined time interval;

- to select coincidences between two arms with imposing of complanarity criterium which is a specific characteristic of the pionic atom breakup.

A particle type is identified in each arm by the following combinations of signals:

pion: $\pi = H \cdot V \cdot \overline{Ch} \cdot \overline{Mu}$

electron: $e = H \cdot V \cdot Ch \cdot \overline{Mu}$

muon: $\mu = H \cdot V \cdot \overline{Ch} \cdot Mu$

Other hadrons (p and K) will also be detected under the "pion" formulae as they cannot be identified in the present setup in real time.

The shower detectors aimed for an additional suppression of electrons (which could be a dangerous source of background) are proposed to be used at off-line data handling, without their implementing to trigger.

The positive and negative pions from the atom breakup have close vertical coordinates after passing the magnet. This is due to a small relative momentum of pions in the breakup process. If the width of the scintillator element in the horizontal hodoscopes is 25 mm then the ordinal numbers of the hit elements may differ by no more than 2: to any hit element #i in the first arm there may correspond one of the elements #i, #i-1, #i+1, #i-2 or #i+2 in the second arm. Such selection is foreseen in the presented trigger scheme.

3 Front-end electronics

Front-end electronics of the horizontal $H1, H2$ and vertical $V1, V2$ hodoscopes includes constant fraction discriminators CFD and meantimers MT (Fig.1). Meantimers are used to exclude dependence of the signal arrival time on hit coordinate in a long scintillator.

One of two MT outputs is used in a trigger scheme, another one is directed to TDC for precise timing in off-line analysis[1].

The front-end electronics of Cherenkov counters is composed of linear fan-in Σ, amplifier $\gg$ and CFD (Fig.2). The linear fan-in unit sums the signals of all 10 photomultipliers of each counter. The second output of the amplifier is used for sending the signals to ADC, that of CFD is for time measurement.

Each of two muon detectors consists of 35 scintillation counters, the scintillators being looked by PMs from one side. The front-end electronics includes CFD with subsequent logic fan-in in the OR scheme (Fig.2) arranged with the LeCroy 4516 module. This module consists of 16 sections, each one receiving up to 3 signals. The signals of 35 counters are distributed between 16 sections by 2 (sections #1–#13) or 3 (sections #14–#16). There are individual ORi of each section and their total OR. The total OR goes to a trigger scheme, the individual ORi are sent to register for readout and off-line analysis[2].

The modules proposed for the front-end electronics are:

[1] In the previous note [2] we supposed to measure the time not only from MT but also from CFD. Here we refuse of it as we have tested experimentally that the time resolution obtained with MT or with a half-sum of two CFD signals is exactly the same (the measurements have been done with a scintillation hodoscope in Juelich).

[2] If the counting rate of the muon counters is high due to background of the catcher, then their accidental signals may produce a lot of veto's and thus suppress detection of useful events. To avoid this one can exclude the muon counters from trigger and record in registers the muon counters pattern. Then in off-line analysis it is possible to accept as veto not any muon counter signal but only from the counters in the vicinity of extrapolated track measured by the drift chambers. The losses will be essentially decreased in this case.

Function	Notation in Figs.	Type	Number
Constant fraction discriminator	CFD	LeCroy 3420	15
Meantimer	MT	CAEN C561	5
Logic fan-in	OR	LeCroy 4516	2
Linear fan-in	Σ	LeCroy 428F	2
Amplifier	$\gg$	LeCroy 612A	1

4 Trigger scheme

For the trigger scheme we propose to use ECL programmable modules of LeCroy. The scheme is presented in Figs.1 and 3.

From meantimer outputs the signals of all H and V hodoscope elements come to a dedicated trigger module K424. The signals of $V1, V2$ preliminarily are fan-out'ed in 4518 Delay/Fan-out modules to be sent to the HP – hodoscope processor of the 3-d level trigger.

The dedicated trigger module K424 (to be developed in JINR) selects the events by the complanarity criterium. It receives the signals of $H1$ and $H2$ hodoscopes and compares the ordinal numbers $n1$ and $n2$ of hit elements. If there is a coincidence of signals and $|n1 - n2| \leq 1$ or $|n1 - n2| \leq 2$ (selected by the user) then the module works out a pulse which is a complanarity mark M. There are also the outputs OR H1 and OR H2 (total OR of the hodoscopes) available in the module as well as their coincidence without a test for complanarity.

The OR signals of $V1$ and $V2$ hodoscopes (OR V1 and OR V2 in the figures) are produced by 4516 module, each hodoscope occupying 1/2 of it.

After preparing of OR signals from all the detectors the trigger is arranged using two 2365 logic modules (Fig.3). The Octal Logic Matrix 2365 is able to receive up to 16 signals and to produce of them 8 logical combinations AND-NO or OR with fan-out of 2 for the output signals. The first Octal Logic Matrix 2365 checks combinations of signals to recognize the type of particles (π, μ, e) detected in both arms in accordance with definitions given in Sect.2 and shown in the bottom of Fig.3. The output signals are the signatures of detection of pions, electrons and muons in each spectrometer arm.

In the second OLM 2365 the signals of the two arms are combined each other as well as with a complanarity mark M and with signals from the dE/dx and $SciFi$ detector logic. At the outputs there are the following combinations:

$T1$ is a first level trigger signal for pionic atom detection (two pions with a complanarity mark);
$\pi\pi$ is a coincidence of two pions without the complanarity condition;
ee means an electron-positron pair;
$T2_\pi$ is a second level trigger which is a coincidence of $T1$ with the signals of the $SciFi$ and dE/dx logic.
T_e is an electron-positron trigger of variable rate.

A necessity of the latter is clear from the following. During data taking we need, for calibration purposes, to accumulate in parallel with the pionic statistics also the e^+e^--pair events and to have possibility to tune the level of this admixture. For this reason there is arranged at the 2365 output the electron trigger T_e which is electron-positron coincidences with a variable dead time inserted by a veto signal of ajustable duration. A veto signal is produced with a gate generator GG triggered by ee signal (LeCroy 222 or LeCroy 4222 Gate and Delay Generator may be used as GG, for example). The logical combinations in OLM 2365 are programmed so that Veto is applied only to electron events.

The signals from accidental coincidences may be rather short at the output of the second OLM 2365 (there is no output shaper in this module). To restore their normal duration, the 2365 module is followed by a shaper 4415A. To obtain the final $T2$ signal which includes both pionic and electron events, the outputs $T2_\pi$ and T_e are OR'ed in the 4516 scheme.

For control of counting rates the signals from the available second outputs of the first OLM and of the shaper may be sent to scalers.

The number of modules for the 1-st and 2-nd level trigger scheme is:

Function	Notation in Figs.	Type	Number
Logic fan-out	F/O	LeCroy 4518	3
OR/AND unit	OR,AND	LeCroy 4516	2
Logic matrix	OLM	LeCroy 2365	2
Shaper	Sh	LeCroy 4415A	1
Level converter	–	LeCroy 4616	1
Gate generator	GG	LeCroy 222	1

A level converter LeCroy 4616, not shown in the figures, has been added to transform the ECL trigger signals to NIM.

5 Delay of trigger

The delay of $T1$ and $T2$ trigger signals is seen from Fig.4. On the time scale used a zero corresponds to the moment of coming of the H and V hodoscope signals to the inputs of CFD. There are taken into account the transit times of electronic modules, short interconnections between the modules, location of the detectors along the beam axis (i.e. time of flight). The transit times of photomultipliers and their possible difference in different detectors were not included. A significant delay inserted by the cables from detectors to electronics is not taken into account in Fig.4 and the value of delay in the figure corresponds to zero cable length for all the detectors.

At these conditions the total delay is around 140 ns. It is seen from the figure that there is near 100 ns for $SciFi$ and dE/dx logic for making decision before coming to a trigger module.

6 Conclusions

The updated version of trigger for DIRAC experiment has been presented. More flexibility is provided by inclusion of a new dedicated trigger module. Other units are commercially available ECL programmable modules.

REFERENCES

[1] B.Adeva et al. Proposal to the SPSLC, CERN/SPSLC 95-1, SPSLC/P 284, Geneva, 1994. Lifetime measurement of $\pi^+\pi^-$ atoms to test low energy QCD predictions.

[2] A.Kulikov. First level trigger for DIRAC. DIRAC note 96-26, 1996.

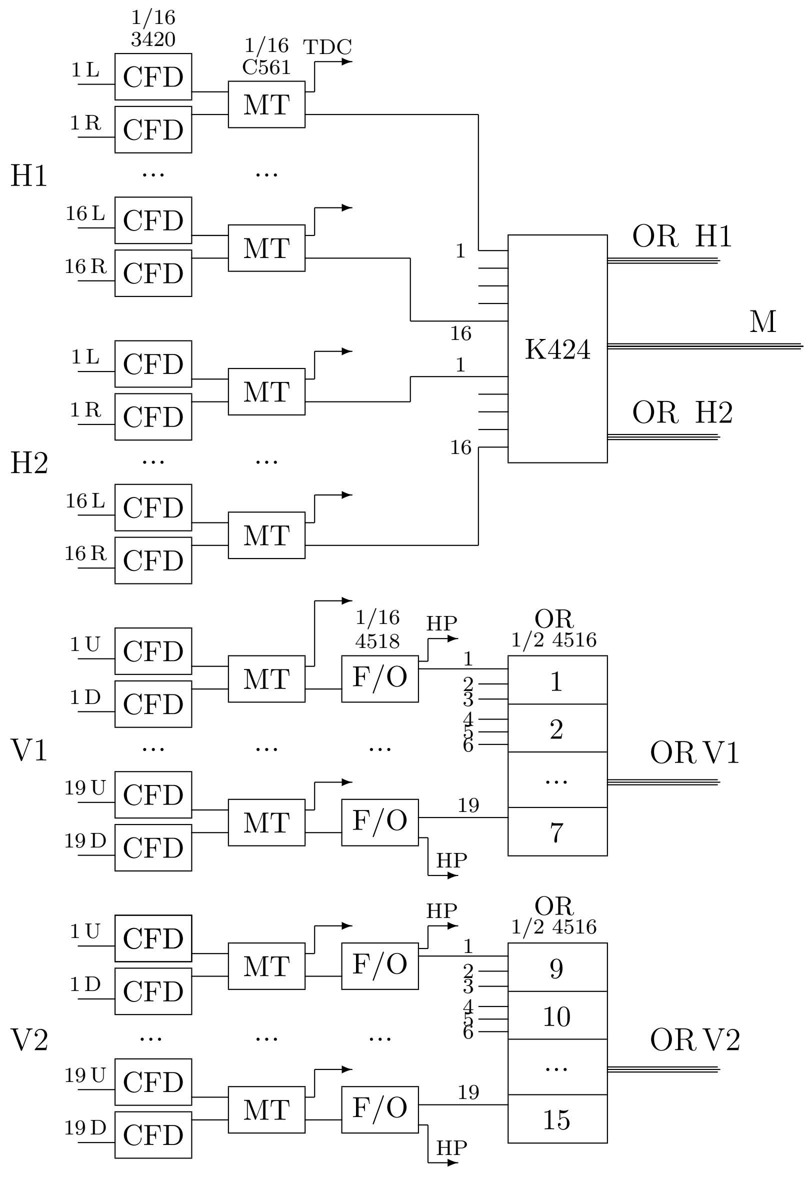


Figure 1: Front-end electronics and initial part of the trigger scheme for H and V scintillation hodoscopes.

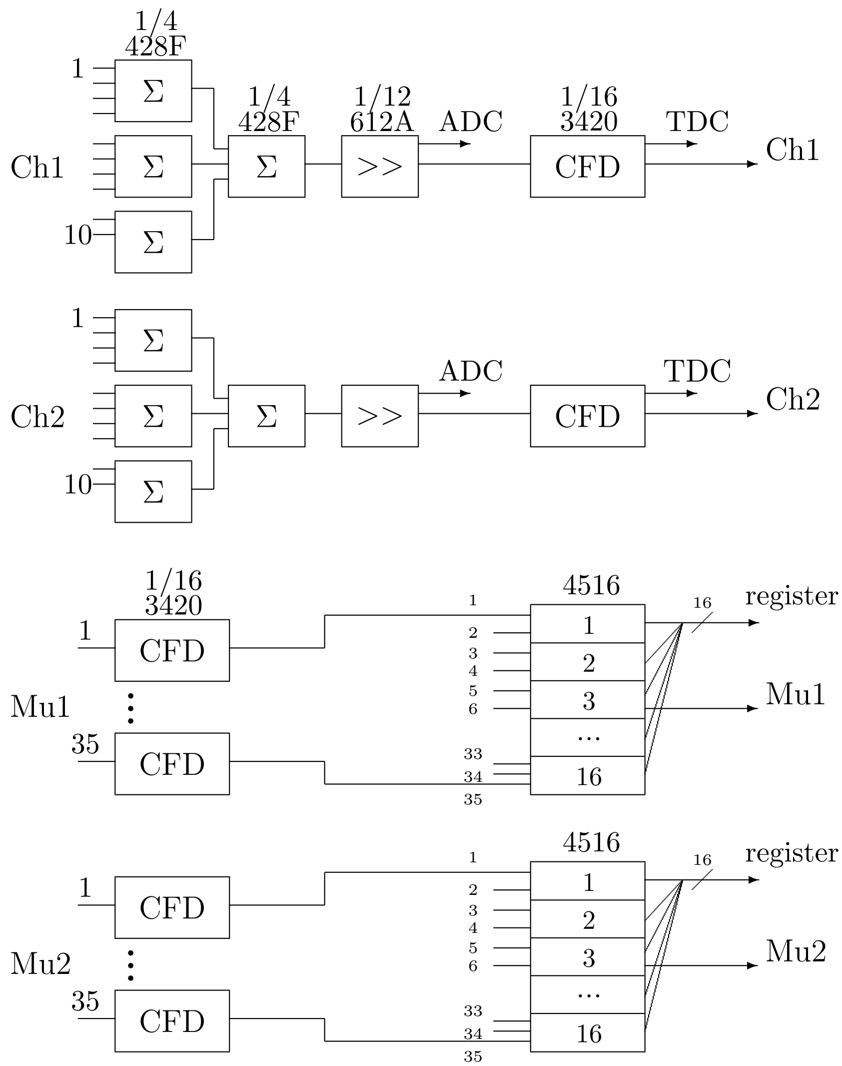
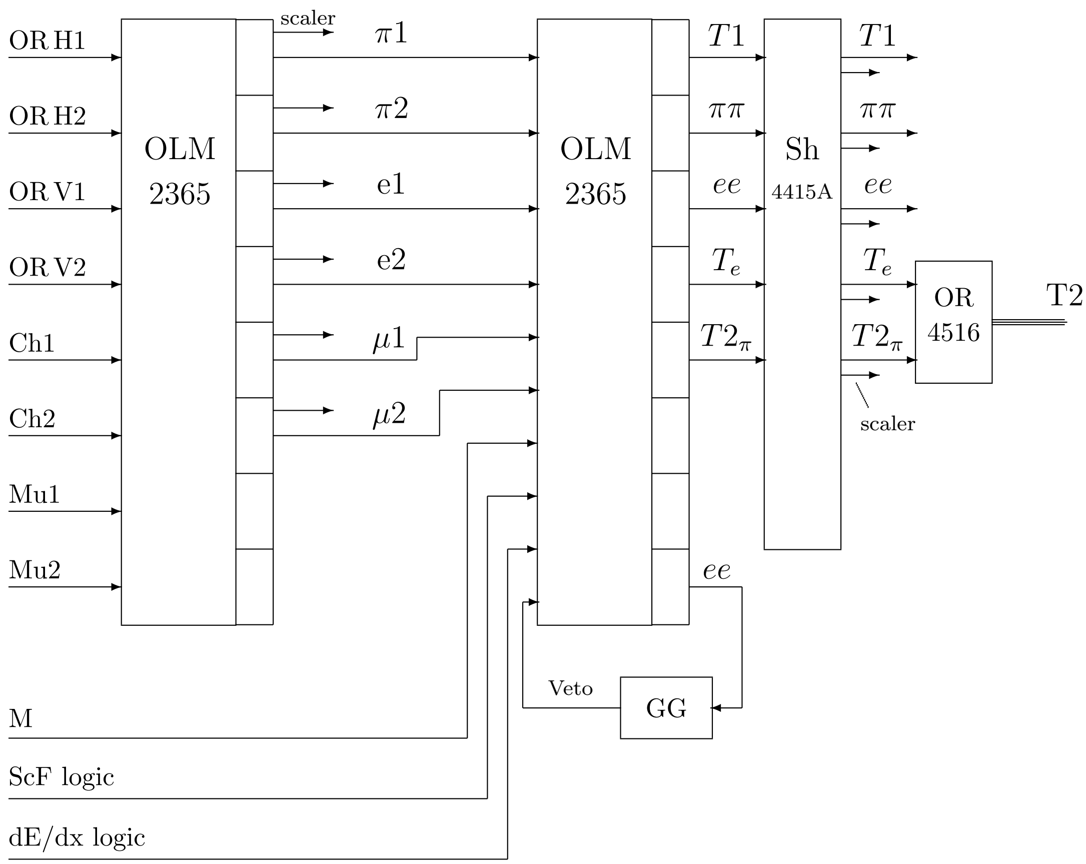


Figure 2: Front-end electronics of Cherenkov and muon counters.



$$\begin{aligned}
\pi 1 &= H1 \cdot V1 \cdot \overline{Ch1} \cdot \overline{Mu1} \\
e1 &= H1 \cdot V1 \cdot Ch1 \cdot \overline{Mu1} \\
\mu 1 &= H1 \cdot V1 \cdot \overline{Ch1} \cdot Mu1
\end{aligned}$$

$$\begin{aligned}
\pi 2 &= H2 \cdot V2 \cdot \overline{Ch2} \cdot \overline{Mu2} \\
e2 &= H2 \cdot V2 \cdot Ch2 \cdot \overline{Mu2} \\
\mu 2 &= H2 \cdot V2 \cdot \overline{Ch2} \cdot Mu2
\end{aligned}$$

$$\begin{aligned}
T1 &= M \cdot \pi 1 \cdot \pi 2 \\
\pi\pi &= \pi 1 \cdot \pi 2 \\
ee &= e1 \cdot e2
\end{aligned}$$

$$\begin{aligned}
T_e &= e1 \cdot e2 \cdot \overline{Veto} \\
T2_\pi &= T1 \cdot ScF \cdot dE/dx \\
T2 &= T2_\pi + T_e
\end{aligned}$$

Figure 3: The 1-st and 2-nd level trigger logic.

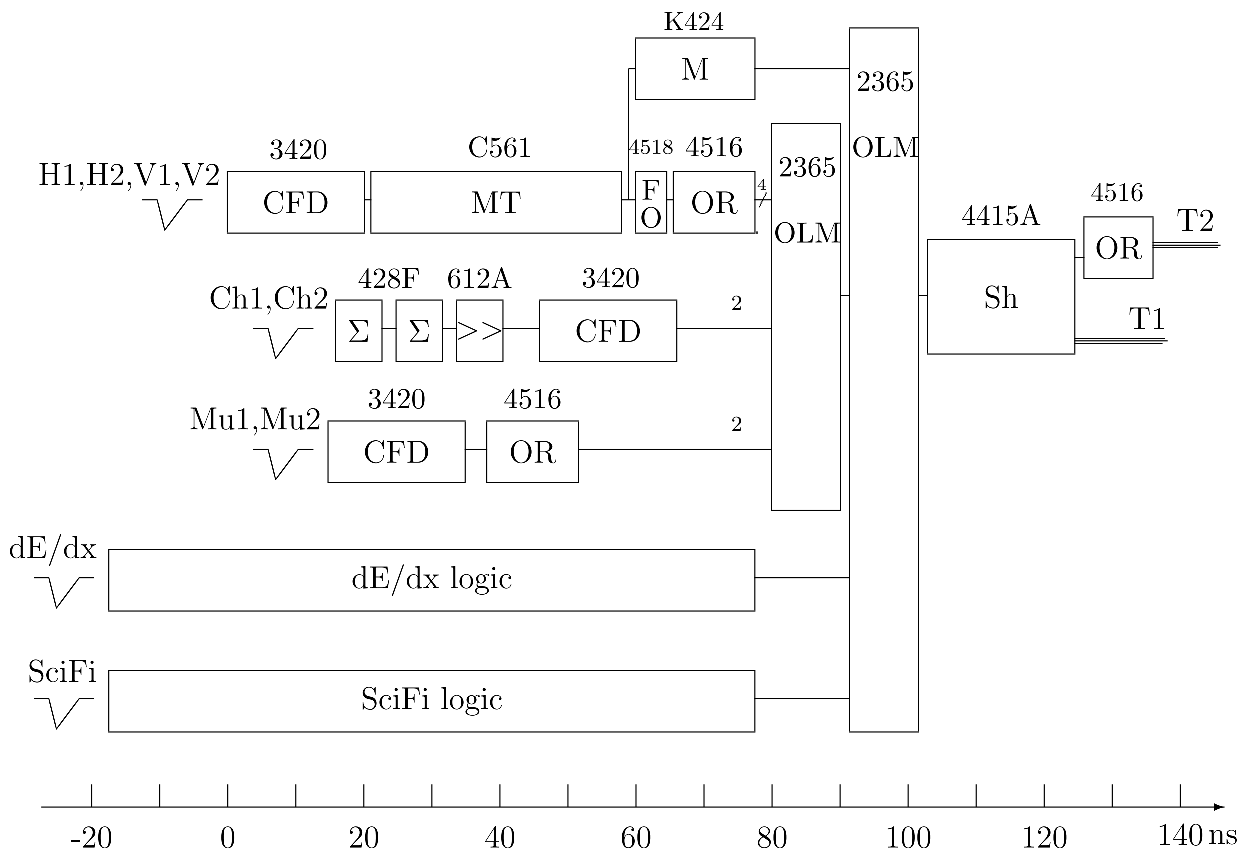


Figure 4: Time diagram of the trigger logic.