Upgrade of the CMD-3 trigger system.

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I. CMD-3 detector.

A Cryogenic Magnetic Detector (CMD-3) is an electrophysical installation designed for accurate measurements of charged particles and photons. Since 2010, CMD-3 has successfully participated in the collection of statistics as part of the VEPP-2000 collider. The detector is a modified analog of the detector CMD-2 of the VEPP-2M collider. Schematic images of the cross-sections of the detector are shown in Figure 1, left.[1]

The Data Acquisition system (DAQ) is an integral part of the CMD-3 detector electronics (Figure 1, right). Its task is to collect and deliver data for primary trigger systems, provide synchronization signals for time meters, start measurements, collect digitized data, and interact with accelerator systems. CMD-3 DAQ work can be conditionally divided into separate functional subsystems, the purpose of which in the general system is strictly defined. The CMD-3 DAQ includes blocks of recording front-end electronics, L-1 trigger, Module for synchronization of system (MChS), General Interface Board for Data Delivery (GIBDD), and an Event Builder.[2]

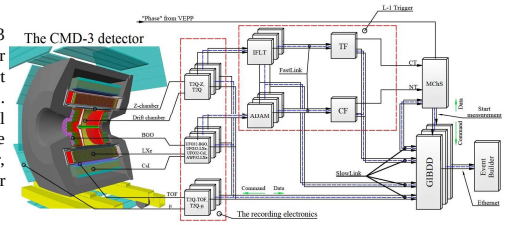


Figure 1. CMD-3 and DAQ.

II. L-1 trigger.

The L-1 trigger includes blocks: IFLT, ADAM (Figure 2), Trackfinder (TF) and Clusterfinder (CF) (Figure 3). The IFLT and ADAM units prepare data from the recording electronics and send them to the TF and CF, respectively. Based on the received data, the blocks form logical arguments and, comparing them with masks, issue a decision on the registration of the current event. A final decision is a logical signal that subsequently starts the digitization cycle of all detector systems. At the moment, there are two trigger signals (solutions): “Charged Trigger” (TF) and “Neutral Trigger” (CF).

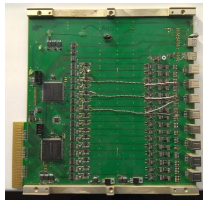


Figure 2. ADAM board.

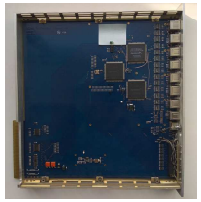


Figure 3. TF and CF board.

III. Final Decision Block.

When designing the trigger system of the CMD-3 detector, it was planned that the start of the event digitization cycle would be carried out by a device called the “Final Decision Block” (FDB). The following signals should act as input: “Charged trigger” and signs of tracks, “Neutral trigger” and signs of clusters, which are formed in TF and CF respectively. Based on the arguments received, the FDB was obliged to make a final decision on the registration of the current event and, in the case of a positive decision, to generate the “L-1 trigger” signal. According to the initial requirements, the trigger decision should have been ready 1.2 μs from the moment the event started. And since during the implementation of recording electronics and L-1 trigger blocks the total decision time from the moment of the event was about 1.6 μs, it was decided to abandon the FDB. To start the digitization cycle on the basis of the “Charged Trigger” and “Neutral Trigger” signals, as a result of which, certain restrictions are imposed on the physical conditions when searching for events. Due to this, the FDB was not forgotten. Its development was postponed for some time.

IV. Block development.

In 2017, the luminosity was increased at the VEPP-2000 collider, in connection with which it was decided to upgrade the trigger system of the CMD-3 detector. Upgrade will be carried out in two stages. The first stage consists in the implementation of the FDB directly, and the second - in its refinement, which will combine the TF, CF and FDB (Figure 4).

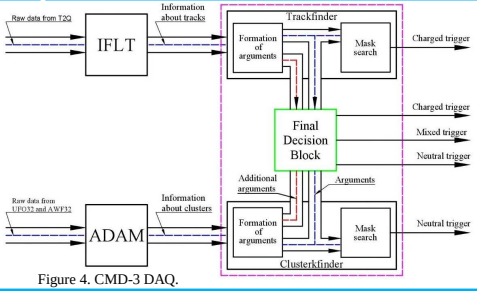


Figure 4. CMD-3 DAQ.

V. Results of Stage-1 of development.

At the end of 2017, the development of the FDB began. The main unit of the device was the INTEL FPGA - Cyclone IV, which is responsible for performing all logical operations. For interaction with the user the CAMAC interface is provided. Data is transmitted to the CMD-3 DAQ via the C-Link interface. The general block diagram of the device is shown in Figure 5.

In 2019-2020 experimental season, testing of the FDB version 1 on the test-bench and detector has been done (Figure 6). The first stage of testing was aimed at checking all the functions of the block.

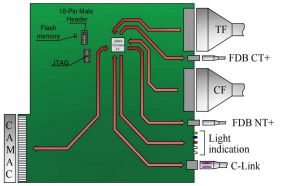


Figure 5. FDB block diagram.

Figure 6. FBD.

The purpose of the second stage of testing is to verify the health of the unit in the CMD-3 DAQ and verify the decisions made. The FDB recorded similar masks that are used in the CF. Comparing the decision of the two blocks (Figure 7), we can conclude that the FDB is operational. For more details on the test results of the first stage, see [3].

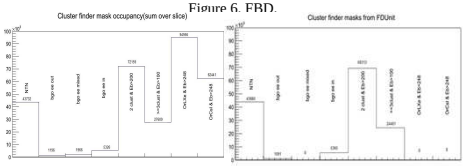
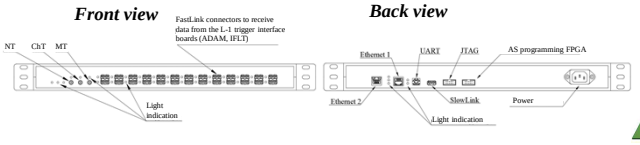


Figure 7. FBD test results in the CMD-3 DAQ.

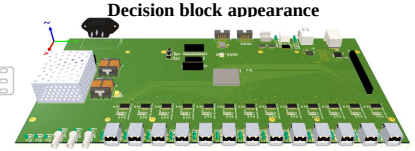
VI. Stage-2.

Functionality of the new decisive block

- ❑ Event registration will be carried out similarly to CF and TF.
- ❑ Data transmission to the DAQ will be carried out via the Ethernet interface (via the TCP/IP protocol , SoC FPGA).
- ❑ A test mode will be added, which will allow, based on the raw data received from an external device, to make a decision on registering an event (checking various combinations of arguments and masks).



Decision block appearance



- ➢ 26 FastLink connectors (double USB-A) for receiving data from L-1 trigger interface blocks
- ➢ 1 USB connector for data transfer between FDB processor and computer
- ➢ 1 SlowLink connector for receiving DAQ commands and programming Trigger masks
- ➢ 1 Ethernet connector for data transmission to the DAQ or for connection to external devices
- ➢ 3 LEMO connectors (NT, ChT, MT) for transmitting NIM signals to the MChS
- ➢ Light indication (quantity not yet determined)

At the moment, preparations are underway to launch the second version of the Final Decision Block on the CMD-3 detector in the experimental season 2021-2022.

References:

[1] Kozyrev A.N. et al., “The CMD-3 TOMA DAQ infrastructure”, Journ. Instrument, 2014, 9, C10016.
[2] A.A. Ruban et al., “The CMD-3 data acquisition and control system”, Nucl. Instrum. Meth. A 598 (2009) 317.
[3] A. Gorkovenko et al., “The CMD-3 detector's Final Decision Block”, JINST, 2020, Volume 15, C10005.

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