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L0 TRIGGER UNIT PROTOTYPE FOR BM@N SETUP

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The BM@N facility is a fixed target experiment based on heavy-ion beams of the Nuclotron-M accelerator. The aim of the BM@N is to study nucleus–nucleus collisions at energies up to 4.5 GeV/nucleon. A level-0 trigger processor unit (Trigger L0 unit, T0U) for the BM@N deuterons and carbon ions at Run 2015 has been developed. The T0U is used to generate a BM@N zero-level trigger and a TOF detector precise start. T0U generates trigger signal based on beam line and target area detector signals. This module also provides both control and monitoring of the detector front-end electronics power supplies. This article presents a concept, characteristics and test results of the T0U module during Run 2015.

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INTRODUCTION

The BM@N facility is a fixed target experiment based on heavy-ion beams of the Nuclotron-M accelerator. The aim of the BM@N experiment is to study nucleus–nucleus collisions at energies up to 4.5 GeV/nucleon [1, 2].

Beam line and target area detectors are an important part of the BM@N setup, and this detector system is used for the following purposes: active transportation of beam ions to a target, beam monitoring, start pulse generation with picosecond precision for TOF detector, effective triggering of the collisions in a target by generation of L0 trigger signal.

The BM@N test-beam Run 2015 has been performed with beams of deuterons and carbon ions with an energy of 3.5 GeV/nucleon. The detector system used in Run 2015 is based on scintillation counters BC1–BC3 with 5-mm plastic scintillators, a Cherenkov beam counter CD with 8-mm quartz plate installed with an angle of 47° to the beam axis, and a T0 detector with $32 + 8$ individual channels which is a modular Cherenkov detector with 15-mm quartz bars. The CD detector pulse was chosen as a start signal for TOF system.

The T0 detector modules were placed around a target detecting high-energy photons and charged particles produced in the collisions. The T0 detector is developed for start pulse and trigger signal generation in study of $\mathrm{Au} + \mathrm{Au}$ collisions.

During Run 2015, T0 detector has been tested in a field of 0.5 T of the BM@N magnet and its characteristics have been measured. More information about design and characteristics

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of the Cherenkov detector modules with picosecond time resolution is given in [3, 4]. The BC3 was located at a distance of 25 cm behind a target and it was used as the veto detector for the fast selection of nuclear interactions in the target in L0 trigger logic. The main collision L0 trigger in the target was provided by the coincidence of the beam counter pulses BC1*CD*BC2*BC3 veto.

The microchannel plate PMTs XP85012/A1 from Photonis were used in CD, BC2, BC3, and T0 modules operated in a strong magnetic field of BM@N magnet. The beam tests of Cherenkov detectors based on MCP-PMT XP85012/A1 also showed an excellent time resolution of 20–40 ps (sigma) required for the start detector [3–5].

A special electronic module L0 trigger unit (T0U) was developed for the BM@N Run 2015 with beams of deuterons and carbon ions. The concept and characteristics of the T0U module and experience obtained in Run 2015 are discussed in this paper.

T0U MODULE

The main tasks of the T0U module are: beam line and target area detector signals processing, monitoring of beam conditions and operation of the detectors, L0 trigger logic with a convenient and flexible interface, a stable low-voltage power supply for the T0 detector channels.

A scheme of T0U connection with the detectors and BM@N electronics in Run 2015 is shown in Fig. 1, *a*. It consists of the beam and T0 detectors providing incoming signals, T0U, CAEN-Digitizer for monitoring of detector operation and for local runs, HV module, and control PC. The FEE power distribution and signal transmission is done via standard HDMI connector and cables.

The T0U generates a trigger pulse which is output signal of a programmable logic based on FPGA with a suitable trigger interface. This module also provides control and monitoring of the front-end electronics power supplies. The T0U can process 76 input signals in total, 60 of them arrive from T0 FEE and up to 16 signals could be taken from other detectors or units.

A block diagram of the T0U module is shown in Fig. 1, *b*. The T0U has a modular structure. It has a motherboard and 4 different type mezzanine boards.

The motherboard performs the following jobs:

• distribution of input signals to external readout electronics (TDC32VL) and L0 trigger processor;

• L0 trigger generation by the trigger processor built on Altera Cyclone V GX FPGA, powering, monitoring, and control of mezzanine cards including: power supply board (PSB) for FEE of the detectors, four discriminator cards (DIB), four TTL-NIM convertor cards (TNB), one Ethernet interface card (ETB);

• accumulation of the trigger monitoring information.

The control and L0 trigger monitoring are made using special PCs connecting with T0U module via optical link, Ethernet, or USB 2.0.

A Micrel chip SY58608U is used as a fanout 1:2. It provides propagation delay < 300 ps, rise/fall time < 100 ps and it processes signals as fast as 2 GHz. The T0U output connectors for DAQ for TOF are Molex 76105-0585.

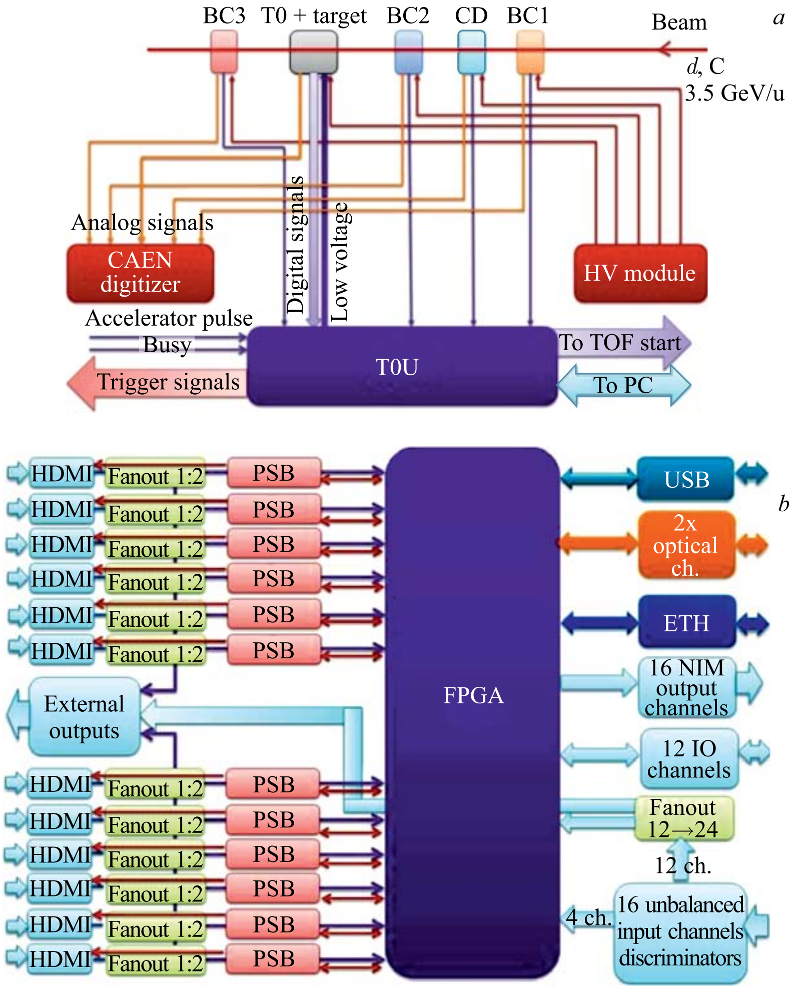

Fig. 1. *a*) A scheme of T0U connection with the detectors and BM@N electronics. *b*) A block diagram of T0U

The T0U was assembled in 2U height rack-mount module. It has a 8-layer PCB, all input channels traces are equalized to each group both individual and common. Figure 2, *a* shows a view of T0U.

The Power Supply Board (PSB) provides three independent voltages to supply T0 detector FEE being controlled and monitored with high precision. Every channel could be switched on or off independently. The Negative voltage channel provides current up to 100 mA at –7.3 V. The Positive channels provide current up to 150 mA in the voltage range from 4.0 to 8.0 V and could be adjusted with a 1 mV step. The channel output voltage and current are read back by 12-bit ADC. The communication to the slow control system is done via RS serial link.

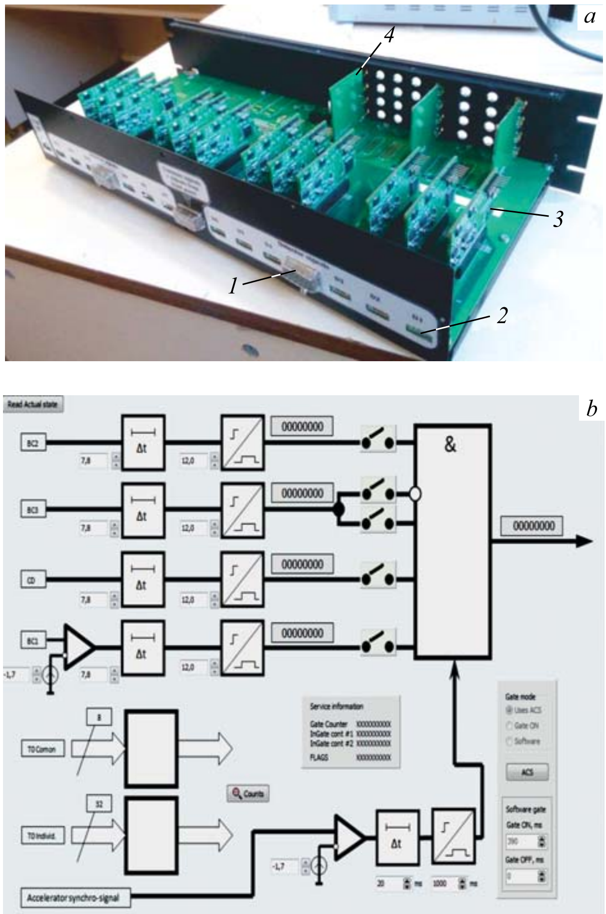

Fig. 2. *a*) A view of the T0U: *1* — output connector; *2*— input connector; *3* — power supply board; *4* — IO module. *b*) A panel of the GUI

The Discriminator Board (DIB) consists of 4 input channels having fast discriminators with 1.5 GHz equivalent input rise time bandwidth and 700 ps propagation delay. The threshold could be set in the range from -2 to $+3$ V with a step around 5 mV.

The TTL–NIM Convertor Board (TNB) is used to convert trigger processor output TTL signals to NIM signals which could be sent to external subsystems. The board contains four converters TTL to NIM.

Ethernet Board (ETB) is used to control T0U and to access slow control data via Ethernet. It provides control of PSBs and reading/writing of trigger processor registers and data. The module supports TCP/IP protocol.

The T0U Slow Control is built using client/server architecture on Windows platform and it provides connection to TANGO system. T0U expert client software with an extended GUI allows a total access to the T0U hardware. The TANGO system has access only to subset of T0U controls excluding some internal T0U registers which could damage T0U hardware in a case of improper usage.

The expert client runs only on the T0U Slow Control PC. GUI users can: monitor counting rates of detectors and selected trigger, adjust the duration and delay of signals, modify the trigger logic scheme, monitor and control power to FEE.

OPERATION IN RUN 2015

The T0U operation has been tested during the first BM@N run in February–March 2015 with beams of deuteron and carbon ions with an energy of 3.5 GeV/u. The T0U was the main element of the trigger system and it provided effective and suitable monitoring of the beam and trigger. Detector signals were transported to T0U module by 5-m cables. The T0U was mounted in a special rack located at a distance of ~ 1 m from the BM@N magnet.

The LVDS signals of the detectors were fed to TDC32VL modules placed in VME crate of TOF detector. These data together with data from other BM@N detectors were read out and stored during a global run. The data were collected with carbon and copper targets and without target.

In parallel with global runs, local runs were carried out with beam and T0 detectors. Here the signals were fed to 5-G/s digitizer CAEN mod. N6742. The time resolution of the CD detector measured with CAEN digitizer was 85 ps for deuteron beam and 27 ps for carbon beam. The typical plot of pulse heights of the BC2 and BC3 counters obtained in a run with carbon ions, copper target, and trigger on incident C ion (BC1*BC2*CD) is shown in Fig. 3. A large fraction of C ions passed through the beam line and the target without interactions and gave high-amplitude responses in the counters. The events with lower pulse height of BC3 and high response in BC2 correspond to nuclear interactions in the target and partly in the BC2 scintillator and air. The events with lower responses in both counters correspond to interactions occurring in beam line materials in front of the BC2.

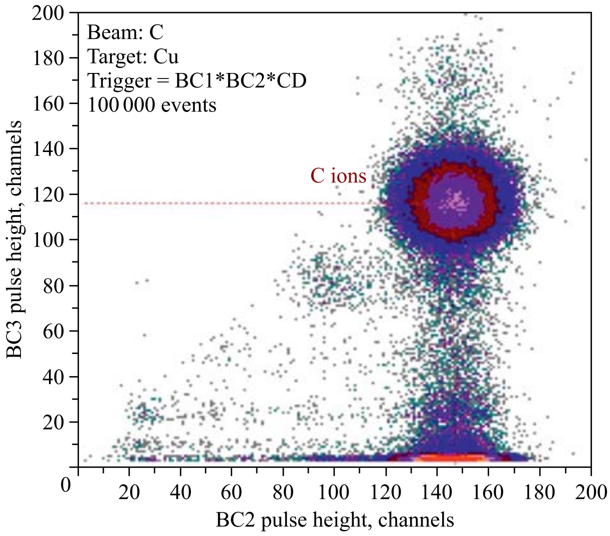

Fig. 3. Plot of BC2–BC3 responses obtained with a beam of 3.5-GeV/u C ions and Cu target

CONCLUSIONS

The T0U and trigger system were successfully tested during the first BM@N run in February–March 2015 with beams of deuteron and carbon ions with an energy of 3.5 GeV/u.

The next version of the module, with enhanced trigger logic and interface for planned deuteron beam BM@N Run 2016 is under development. This module in addition to old functions will process signals from 40-channel scintillation barrel detector based on SiPMs which will be used for triggering interactions in a target.

REFERENCES

1. *Kapishin M. N. et al.* Study of Baryonic Matter with the BM@N Experiment at the Nuclotron // JINR News. 2014. No. 3.
2. BM@N Conceptual Design Report. http://nica.jinr.ru/files/BM@N/BMN_CDR.pdf.
3. *Yurevich V. I. et al.* Fast Forward Detector for MPD/NICA Project: Concept, Simulation, and Prototyping // Phys. Part. Nucl. Lett. 2013. V. 10, No. 3. P. 258–268.
4. *Yurevich V. I.* Development and Study of Picosecond Start and Trigger Detector for High-Energy Heavy Ion Experiments // 7th Intern. Conf. on New Developments in Photodetection, Tours, June 30–July 4, 2014; Nucl. Instr. Meth. A. 2015.
5. *Yurevich V. I. et al.* Beam Tests of Cherenkov Detector Modules with Picosecond Time Resolution for Start and L0 Trigger Detectors of MPD and BM@N Experiments // Phys. Part. Nucl. Lett. 2015. V. 12, No. 6. P. 778–785.