TRIGGER AND BEAM MONITORING SYSTEM OF BM@N AND SRC EXPERIMENTS

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The report describes a Trigger unit control and monitoring system used at experiments BM@N and SRC held in JINR. These both experiments require very good trigger time resolution therefore the trigger equipment must be located in the beam area to provide small cable length. This applies restrictions to the access to the trigger equipment during the experiment and the trigger control and adjustments should be done remotely.
The trigger processor is built using FPGA and all trigger logics and delay lines are located inside this FPGA. The control of the system is performed with a set of programs with graphical user interfaces. This set includes HV power supply server, the trigger unit manager also providing front-end electronics LV power supplies, a web-server publishing the spill summary information and the beam data server providing publishing in real time mode the experiment-relevant curves like an actual beam intensity and counts. The system was successively used during more than three years.

Keywords: BM@N, Trigger system, Heavy ion experiment, Monitoring system

1. Introduction

A concept of the trigger system of heavy ion experiments BM@N [1] and SRC [2] with external beam of Nuclotron [3] is mainly defined by requirement of fast and efficient detection of nucleus – nucleus collisions in targets. Sets of trigger detectors in these two experiments are different but universal programmable module of trigger electronics, a Trigger Zero Unit (T0U), is applied in both experiments for the detector pulses preprocessing, the trigger pulse generation, and for control and monitoring purpose. For operation with beam intensity up to 10^6ion/s, the trigger pulse appears with delay less than 50 ps.The trigger detectors and electronics are located in the experimental zone with restricted access. This requires remote access to the trigger system for adjustment and monitoring.

2. Trigger Zero Unit

The heart of the trigger system is a Trigger Zero Unit (or T0U) module which consists of a motherboard and a set of daughter boars installed to the motherboard depending on experiment requirements.

The motherboard contains Cyclone V FPGA implementing the trigger logics. The T0U has two serial RS232 lines. As an interface to a computer the USB virtual com-ports are used. The board contains twelve HDMI connectors to connect to the beam-line detectors and a Barrel detector. The digital signals have LVDS levels. The powering of the FE electronics is dove via free lines in these cables.

The T0U could have set of daughter boards installed as follow:

- Up to twelve LV power supply boards providing power for the front-end electronics. Each board contains two controllable positive LV channels and one fixed negative LV channel. All currents and actual values of voltages are read back with 12-bit ADCs.

- Up to four Input signal boards with four input channels each. The channel contains an adjustable discriminator controlled by 10-bit DAC.

- Up to four output signal boards of two types with four channels each. The board output signals depending on a type could have NIM or 50 Ohm TTL levels.

All delays and shapers are built inside the FPGA and could be adjusted via serial link. No mechanical switches are used in the trigger system.

To check trigger performance and to set proper counter signal timing the T0U contains multiplexers which allow to select signals from the key points of trigger logics and to send them to an oscilloscope located out of the beam area.

In addition to the generation of physical trigger signal the experiment trigger system also provides synchronization with the accelerator, generates logical gates for physical events and calibration events, it also generates a series of LED flash pulses outside the beam spill for the ECAL LED calibration system and generates GEM heating control signal.

3. The BM@N hardware configuration

Since the BM@N experiment requires triggering according to the secondary particle multiplicity values in both Barrel detector (BD) [4] and a Silicon detector (SiD) the BM@N trigger system uses two trigger modules having different firmware, see fig. 1.

The SiDU calculates multiplicity in the silicon detector and generates SiD trigger pulse if the multiplicity has defined value. This value and the timing pulse are send to the main trigger unit - T0U. The multiplicity threshold value for SiDU could be set from the control PC "in the flight" via a serial link.

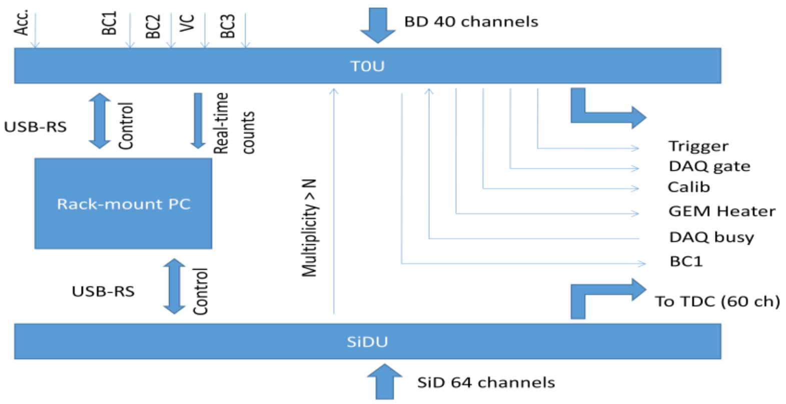

Figure 1. Configuration of trigger units for the BM@N experiment

The T0U is used to generate beam-line trigger and a physical reaction trigger based on the BD and SiD multiplicity. SiDU and T0U are connected with the twisted pair cable.

4.The BM@N software configuration

The trigger system hardware is controlled by a set of servers and hardware managers, see fig.2.

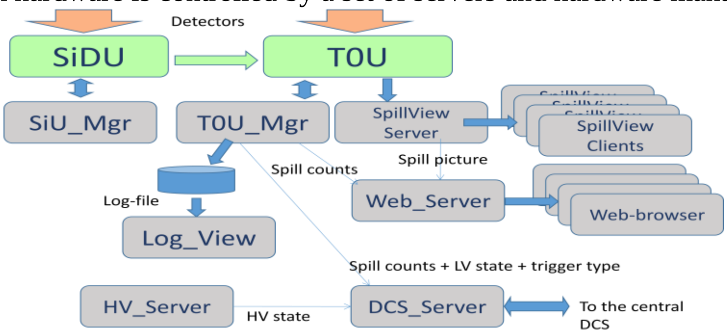

Figure 2. Software architecture for the BM@N experiment trigger system

The SiDU manager is used to set up SiD com-port, to enable/disable selected channels and to monitor performance of the SiD. This manager presents hit count in SiD strips and a multiplicity of events. These histograms are interactive and cursor positioning over a histogram bin allows to get information about bin number and a count in a bin. The pictures are refreshed after each spill. The main window and a channel masking window are shown in fig. 3.

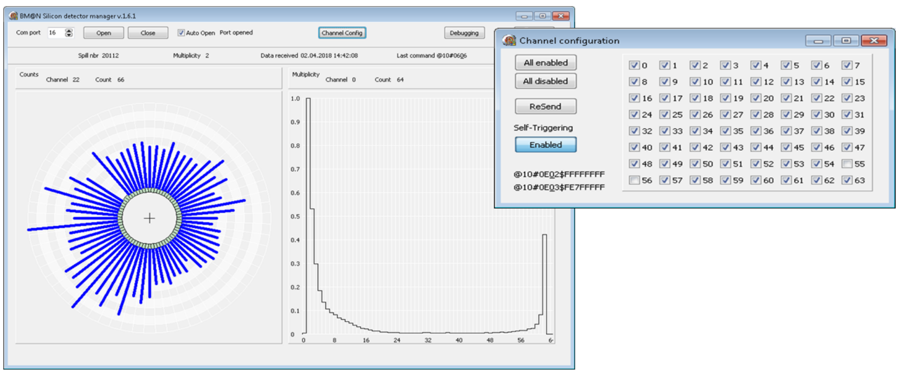

Figure 3. The SiDU manager main windows

The T0U_Mgr application is used to control FE LV power supplies, to set proper trigger setting like delays lines and shapers in scintillator counter chains, to set trigger parameters and to monitor trigger system performance. The application has extended GUI with hundreds of controls. The main window also shows counts in key points of the trigger logics.

The T0U_Mgr also publishes spill-relevant information like counts in beam counters, BD etc. in a shared memory in JASON format. This information also is recorded to the local archive file. It could be browsed by the Log_View application.

The main window of the T0U_Mgr is shown in fig. 4.

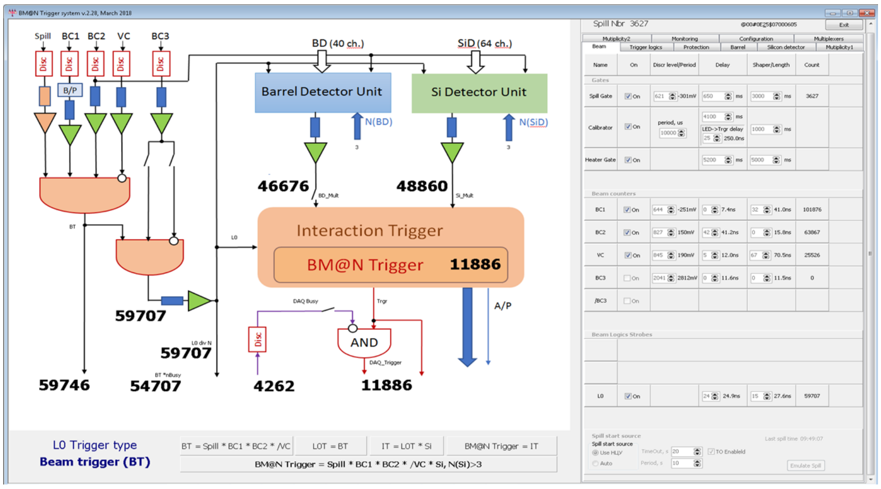

Figure 4. The T0U manager main window

To provide observing of the beam intensity in the real-time mode the Spill_View application has been developed. This is a TCP/IP server which reads out 10 counters located in the T0U FPGA with 100 Hz frequency and publishes this data set to all connected clients. This system works under Windows OS. During the beam-run we had typically had 3-5 clients connected and running at different PCs.

In addition to the live picture publishing, the Spill_View builds a static picture of counters for the first 5 seconds of a spill. This picture together with the spill summary information provided by the T0U_Mgr is used by the TMGR_Web_Server application being a web server publishing this information to connected http clients (web browsers). By using of AJAX scripts the web-page is refreshed with frequency about 1 Hz. The view of the Spill_View_Client picture and a web-page of trigger system are shown in fig.5.

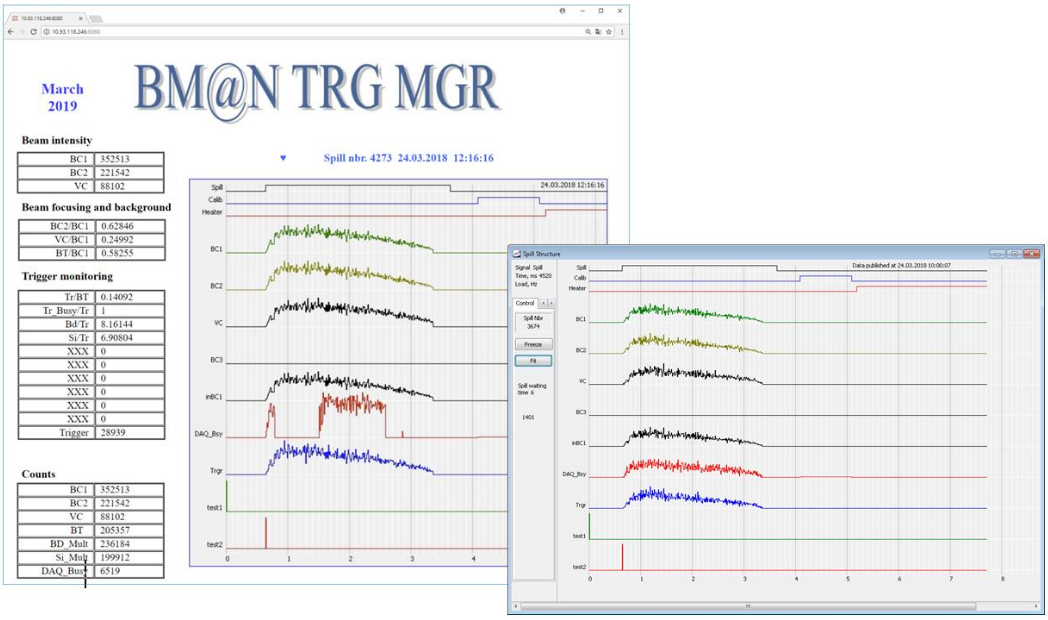

Figure 5. The trigger system web-page and the real-time beam intensity picture

The HV power supply server provides a communication to the HVSys HV power supply. The server provides full control on the power supply hardware and allows to create a library of HV setting configurations. With dedicated windows the user could browse configuration settings and download the chosen configuration to the power supply hardware. This server also publishes information about actual values of voltages and currents in HV channels in shared memory.

All information from LV and HV power supply channels together with the trigger system state information is published for the Detector control system (DCS) with the DCS_Server program being a TCP/IP server. According to the request from a connected clients it sends a data block containing all trigger system relevant information in JASON format. This information was used by the DCS to fill a condition database.

4. The SRC experiment

The T0U hardware also was used for the SRC experiment [2]. The architecture of the software stays similar to BM@N experiment. The difference between BM@N and SRC is in amount of scintillation counters, in absence of BD and SiD and in the trigger logics. Due to this the SRC FPGA firmware reuses main modules of BM@N firmware like delays and shapers, synchronization timers and a command parser.

The SRC trigger control and monitoring software includes SRC_Mgr to control T0U and it does not have SiD manager since SiD is not used. The rest of the system uses the same applications with some cosmetics modifications. The main window of the SRC_Mgr is shown in fig. 6.

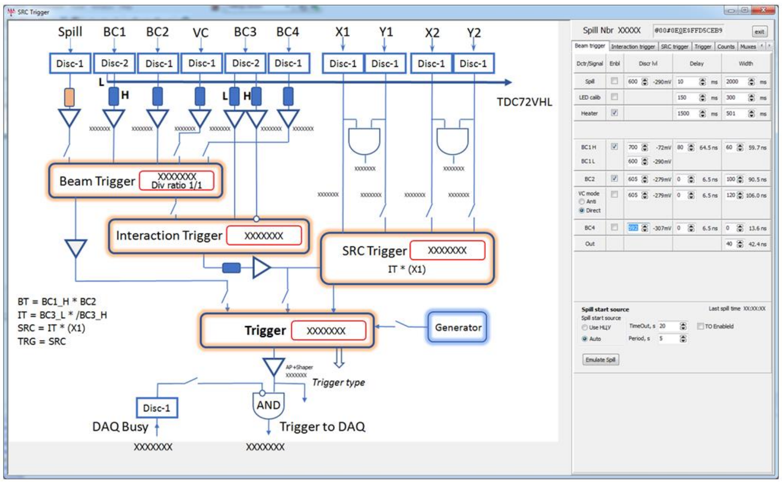

Figure 6. The SRC_Mgr manager main window

5. Conclusion

The developed trigger system fulfills requirements of heavy ion experiments BM@N and SRC to provide fast and efficient trigger of nucleus – nucleus interactions. All delay lines, shapers and discriminator thresholds are built inside the FPGA. Therefore, the trigger system does not contain mechanical switches. As the result the system is controlled remotely and the system hardware is located in the restricted access area of the experimental zones. All settings, control and monitoring are carried out by operator in a control room. The system is controlled by GUI-based applications what simplify trigger system adjustment and debugging.

References

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[4] http://ceur-ws.org/Vol-2023/252-258-paper-40.pdf