JOINT INSTITUTE
FOR NUCLEAR RESEARCH

BM@N
Baryonic Matter at Nuclotron

# Development of BM@N trigger system, status and upgrade plan

**Victor Rogov**
**on behalf of BM@N Lo trigger group**

10th Collaboration Meeting of the BM@N Experiment at the NICA Facility

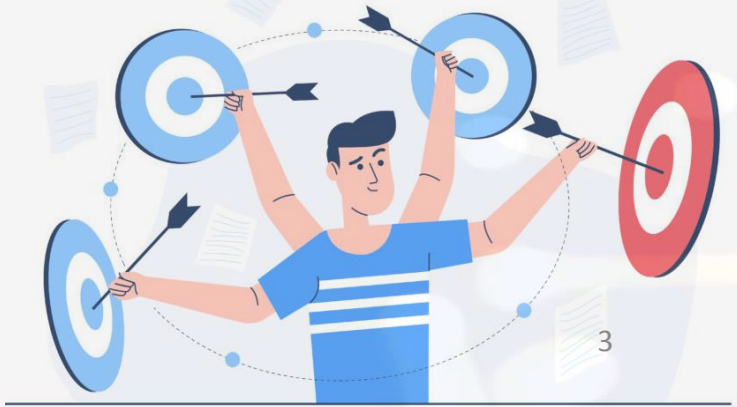
# Content

## Discuss BM@N run 2022-2023

- Trigger detector system
- Electronic modules
- Detector control system
- Upgrade plan
- Summary

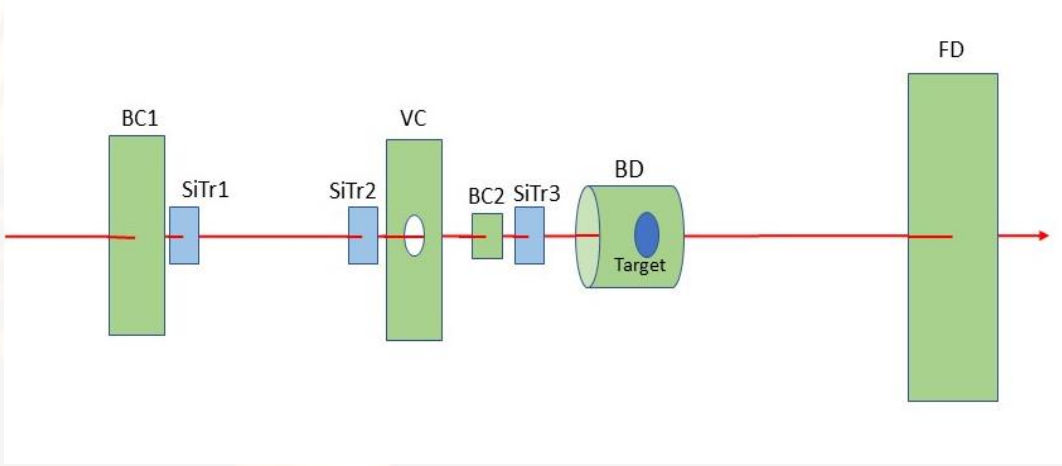
# Requirements for trigger system

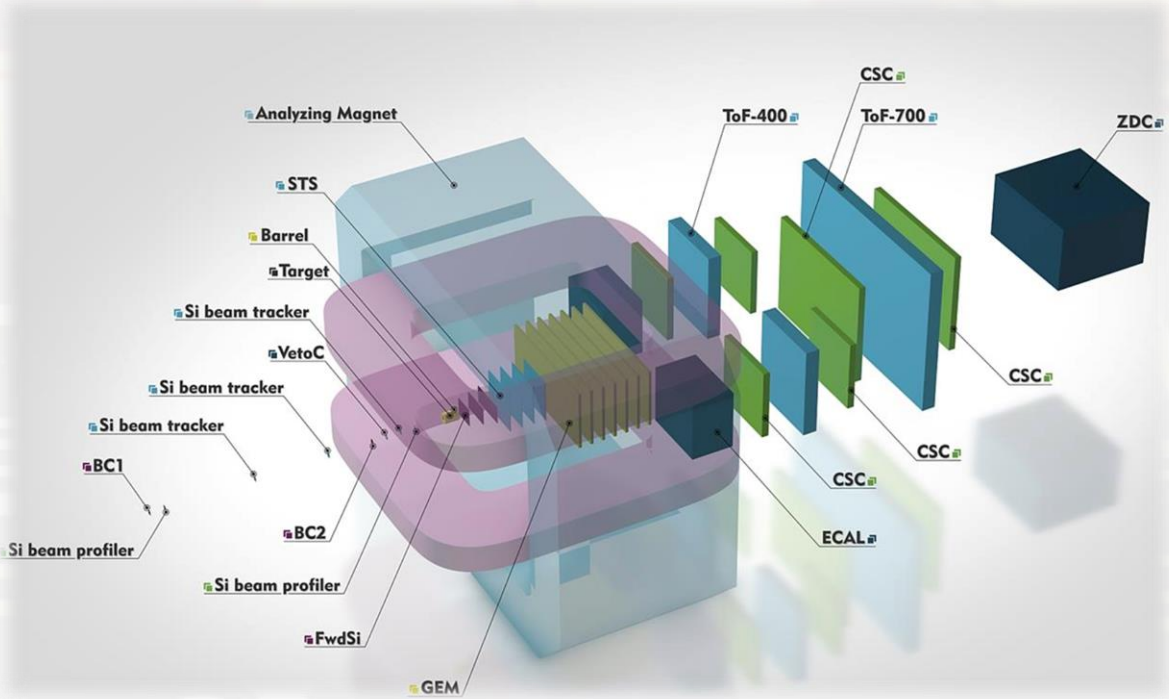
- ✓ **Minimum materials**
- ✓ **Minimum background**
- ✓ **Minimum delay and jitter**
- ✓ **Trigger processing time <100ns**
- ✓ **High efficiency for selection of nucleus-nucleus collisions in target**
- ✓ **Monitoring of beam conditions**
- ✓ **GUI for control of the trigger and detector parameters**
- ✓ **Compatibility with the DAQ system**



# Trigger detector system at BM@N 2022-2023 run

- **Beam line detectors**
  - BC1, BC2
  - VC (Veto-counter)
  - FD (Fragment detector)
- **Target area detector**
  - BD (Barrel detector)



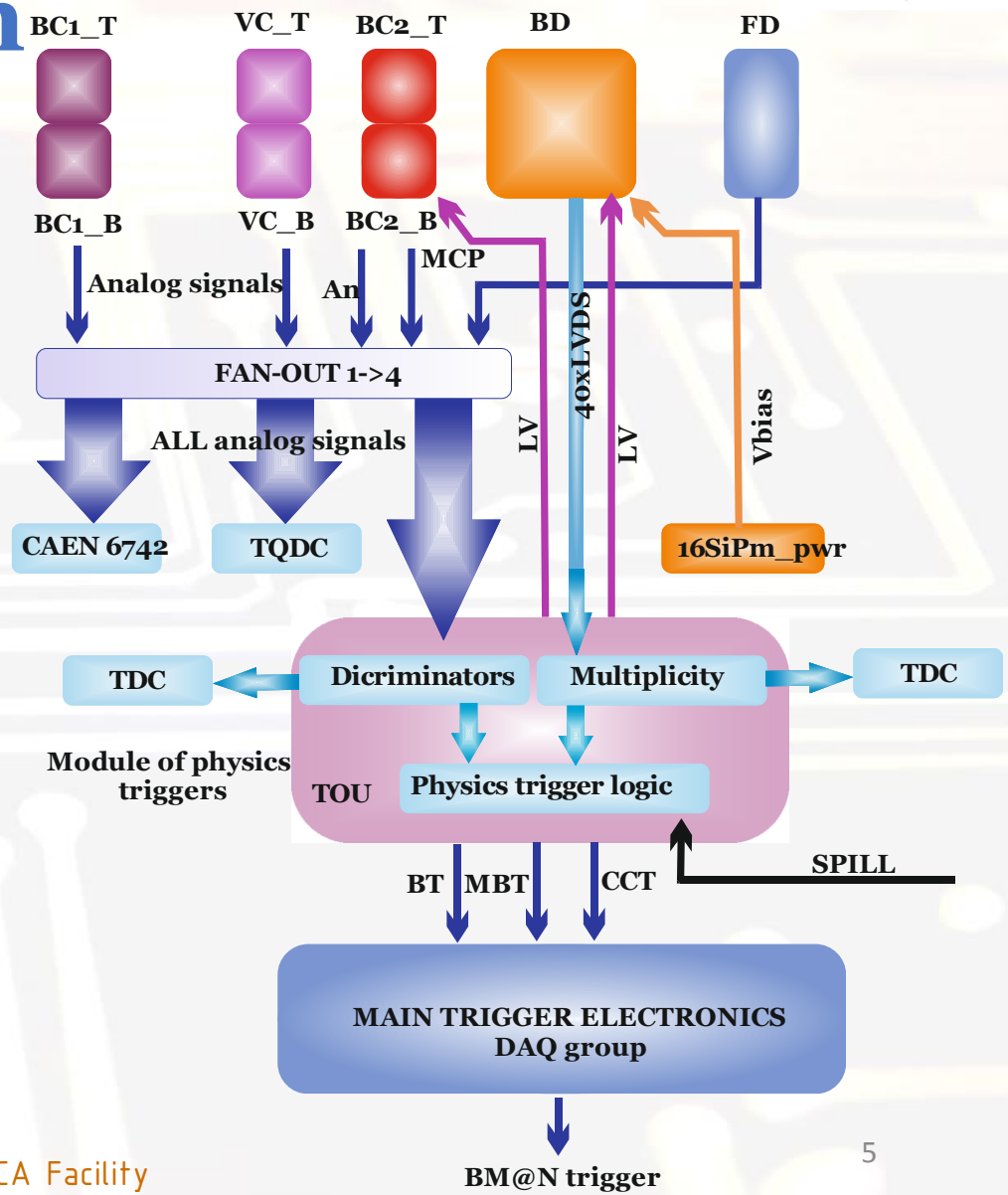
# Trigger detector system at BM@N 2022-2023 run

**Beam Trigger (BT) = BC1*BC2*VC(veto)**

**MBT = BT* FD(veto)**

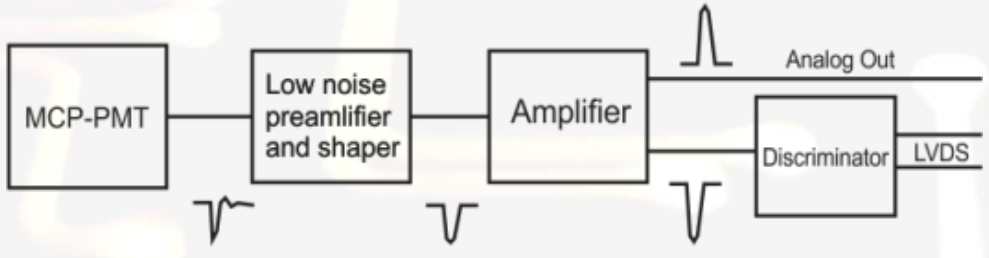
**CCT1 = BT*BD(>*N*)**

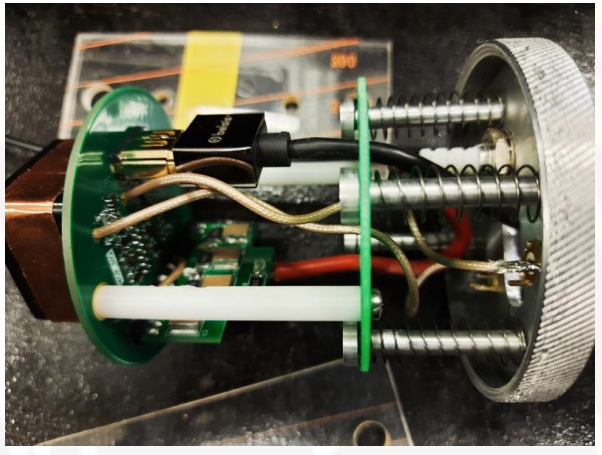
**CCT2 = MBT*BD(>*N*)**



# To detector

The functional scheme of T0 and BC2 detectors FEE is given in Fig. below. It consist of a low-noise input amplifier with BFR93 transistor, a pulse shaper minimizing signal to noise ratio, a RC chain filtering signal frequency, a fast amplifier and discriminator based on LMH 7220. Analog output pulses with ~ 2-ns rise time are transmitted to the readout electronics through a coaxial cable and the discriminator provides LVDS-level logic signals. The LVDS signal goes to the T0U via an HDMI cable. This cable is also used for FEE power supply lines.

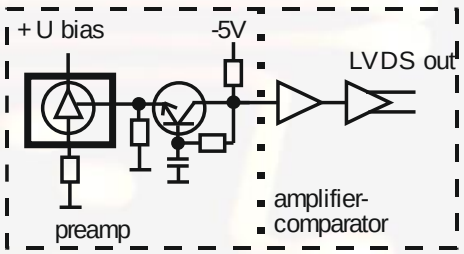


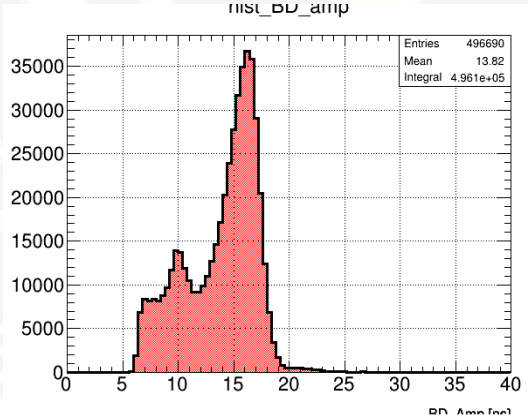



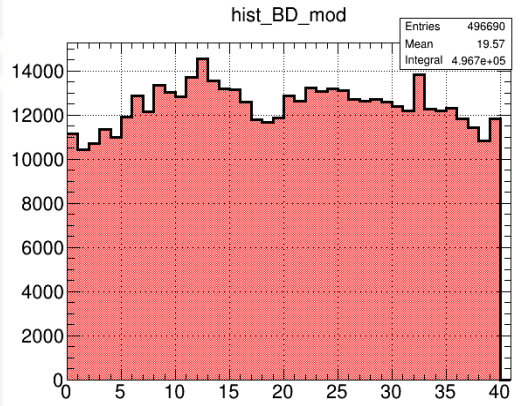
# Barrel detector

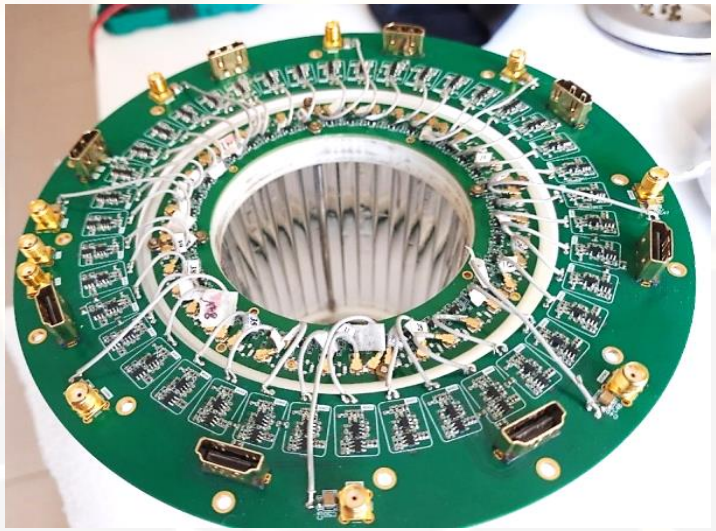
## Target area detector

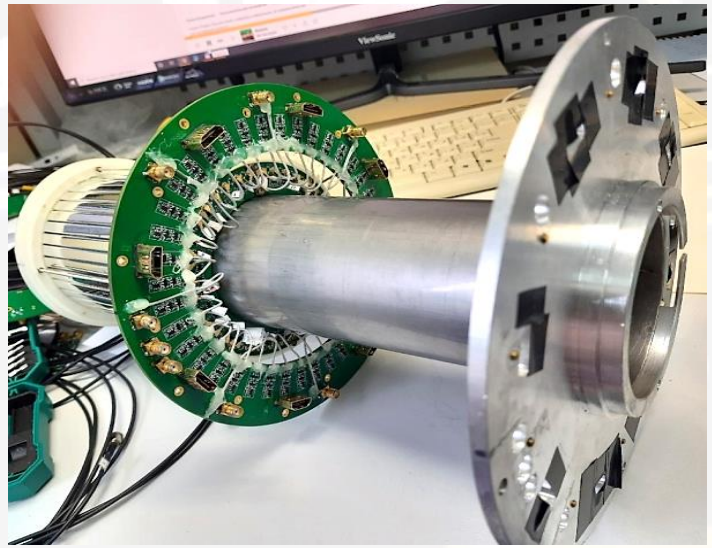
The active area of the BD has a 45 mm radius and 150 mm length, and it consists of 40 150×7×7 $mm^3$ strips made of polished BC-418 scintillator wrapped by Al Mylar. The scintillation light produced by charged particles is detected on single ends of the strips by SiPMs. The signals from the SiPMs are fed to the first stage low noise amplifiers and then to the FEE board, which performs amplification, and discrimination functions. A time over threshold comparator produces LVDS pulses for a trigger logic unit and TDC.





# Electronic modules

## TOU module

The T0U generates a trigger signal which is the 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 100 input signals in total, 60 of them arrive from T0 FEE and up to 40 signals could be taken from other detectors or units

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.

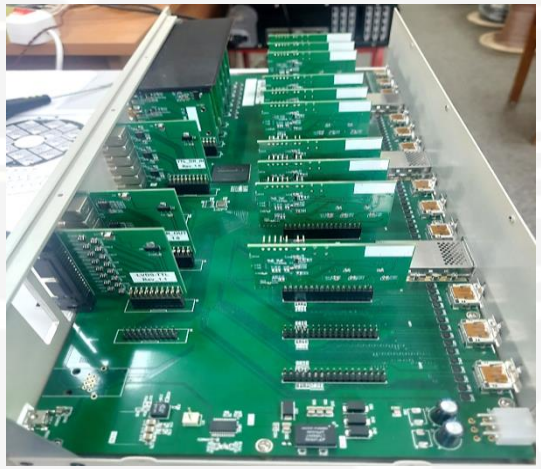
The T0U output connectors for DAQ for TOF are Molex 76105-0585.

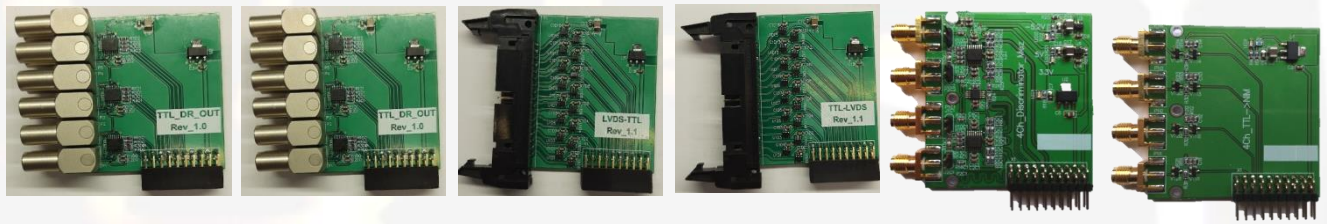
# Electronic modules

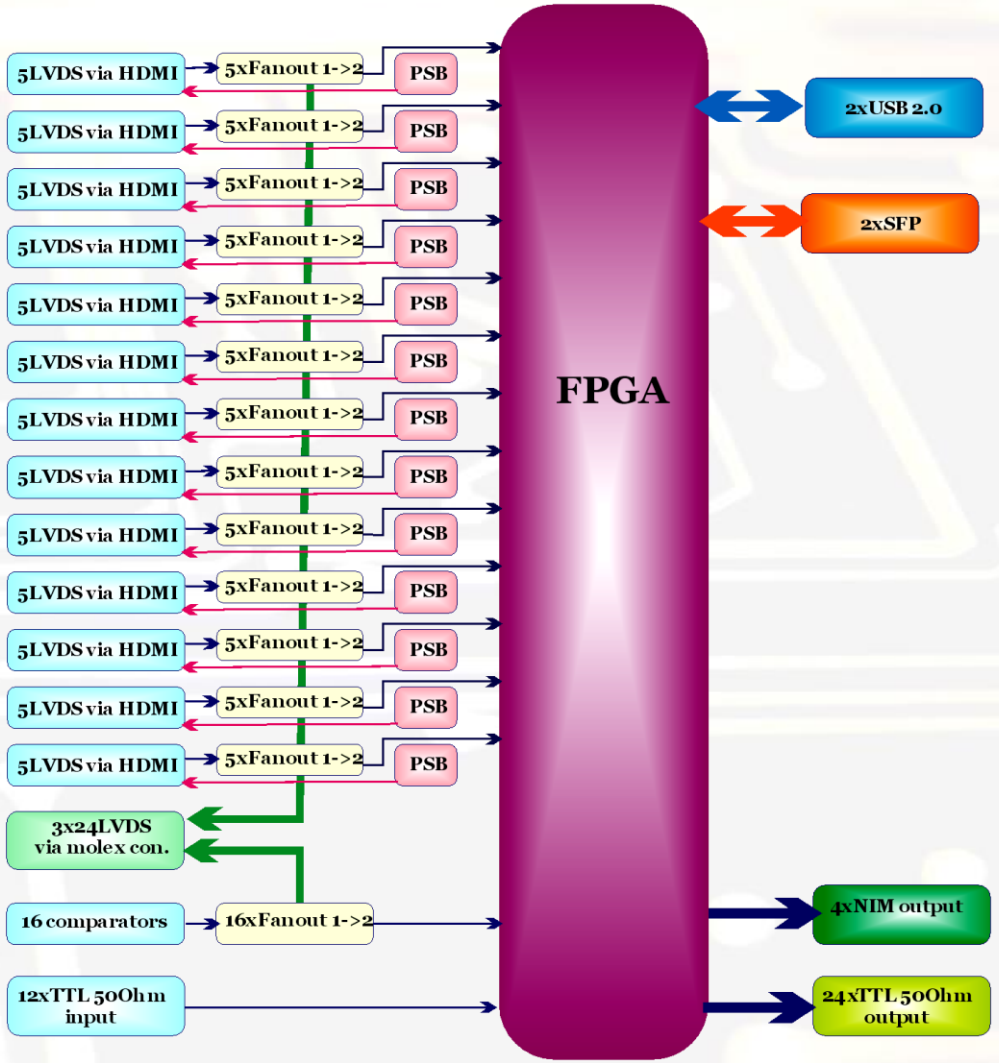
## TOU module




IO mez.brd





# Electronic modules


## Power supplies

The Power Supply Board (PSB) provides three independent voltages to supply detector FEE, those supplies are monitored and controlled with high precision. Each channel could be switched on/off independently.

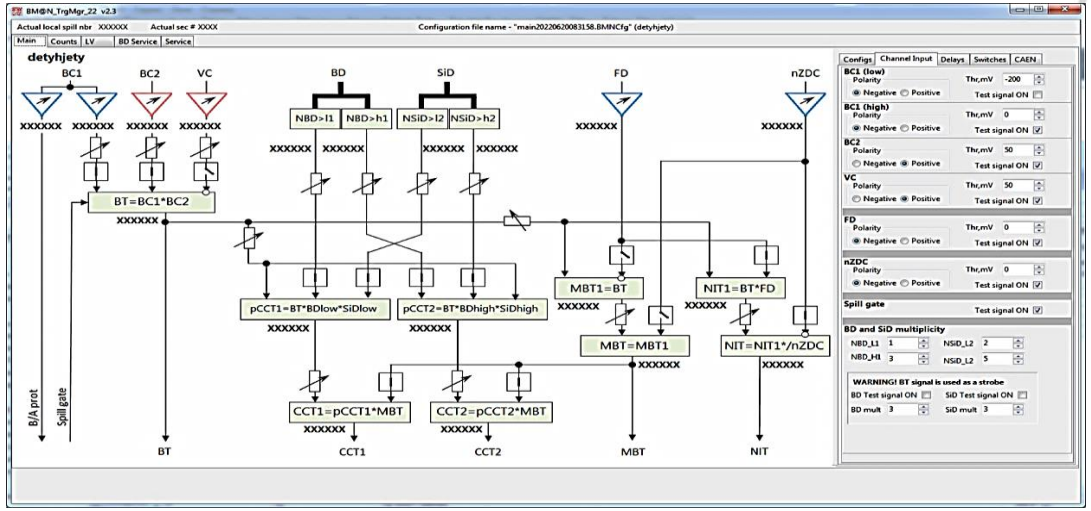
- The Negative voltage channel provides current up to 100 mA at -7.3V.
- The Positive channels provide current up to 800 mA in a voltage range from 4.0V to 8.0V and could be adjusted with 1mV step.
- 12 bit DAC is used to adjust the voltage
- The channel output voltages and currents are read back by 12-bit ADC.

The SiPMs power supply module provides bias voltage for the barrel detector photosensors and neutrons detector of the BM@N setup. Each of the 16 channels could be switched «On» or «Off» independently, the channel voltage range is 24 to 28 V with 1 mA current per channel and the output voltage could be adjusted with about 1 mV step.
The communication to the detector control system is done via USB 2.0, Ehternet or RS serial link.

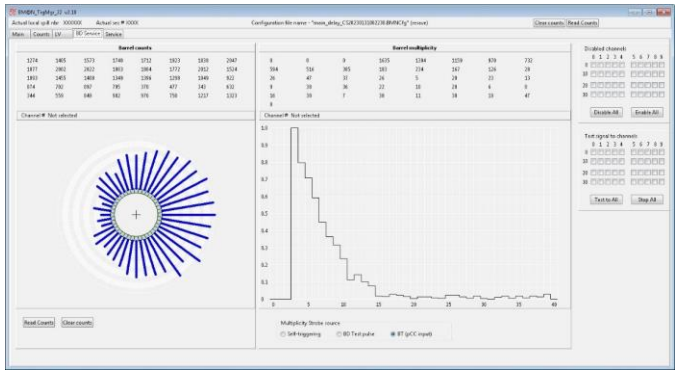
# Detector control system

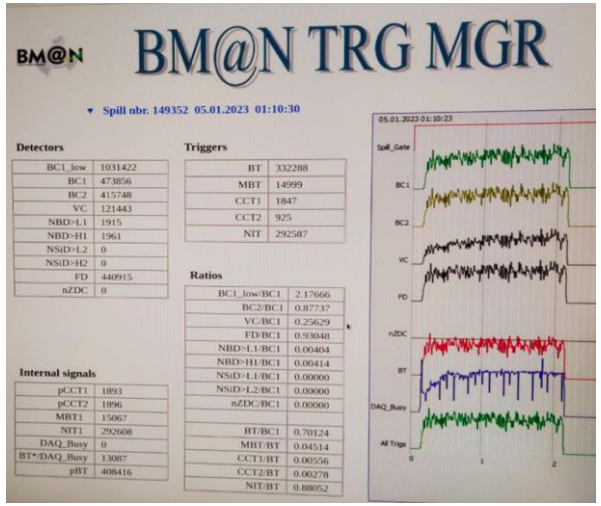
The Trigger System DCS performs following

- Setting tens of parameters of the Trigger System to T0U using interactive GUI.
- Control and monitoring of the Trigger system with data recording to local and remote log-files. The remote file data were put to the BM@N data stream
- Control and monitoring of
  - HV for PMTs
  - Bias voltage for SiPM
  - LV for FEE
- Data publishing to Web with web-server providing access to the run state to all interested




Trigger GUI





# Upgrade plan

**Detector electronics**

- Rise up the threshold of FEE comparators of BD
- Add shaper to BD FEE to provide stable TDC readout (weight more then 10ns)
- FETURE upgrade – Increase BD channels to 64, minimize scintillators dimension and new mechanics – divide BD to 2 pieces for easy installation around the vacuum pipe

**TOU electronics**

- Develop a 2 threshold fast comparator mezzanine card for beam profile detectors

**Detector control system**

- Modify BT input in CCT1, CCT2, MBT -> use switch instead of fixed
- Multiplexed NIM output trigger for local DAQ via CAEN
- Suppression of multiple beam ion events in TOU

# Summary

**The trigger system developed for BM@N experiment was successfully tested during the BM@N run 2022-2023. The time resolution of 40 ps was obtained for start pulse provided by BC2 detector. The obtained experience will be used in father development and upgrade of the trigger detectors, the electronics, and the control system.**

JOINT INSTITUTE
FOR NUCLEAR RESEARCH

BM@N
Baryonic Matter at Nuclotron

# Thank you for your attention