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BM@N
Baryonic Matter at Nuclotron

Upgrade of the trigger electronics

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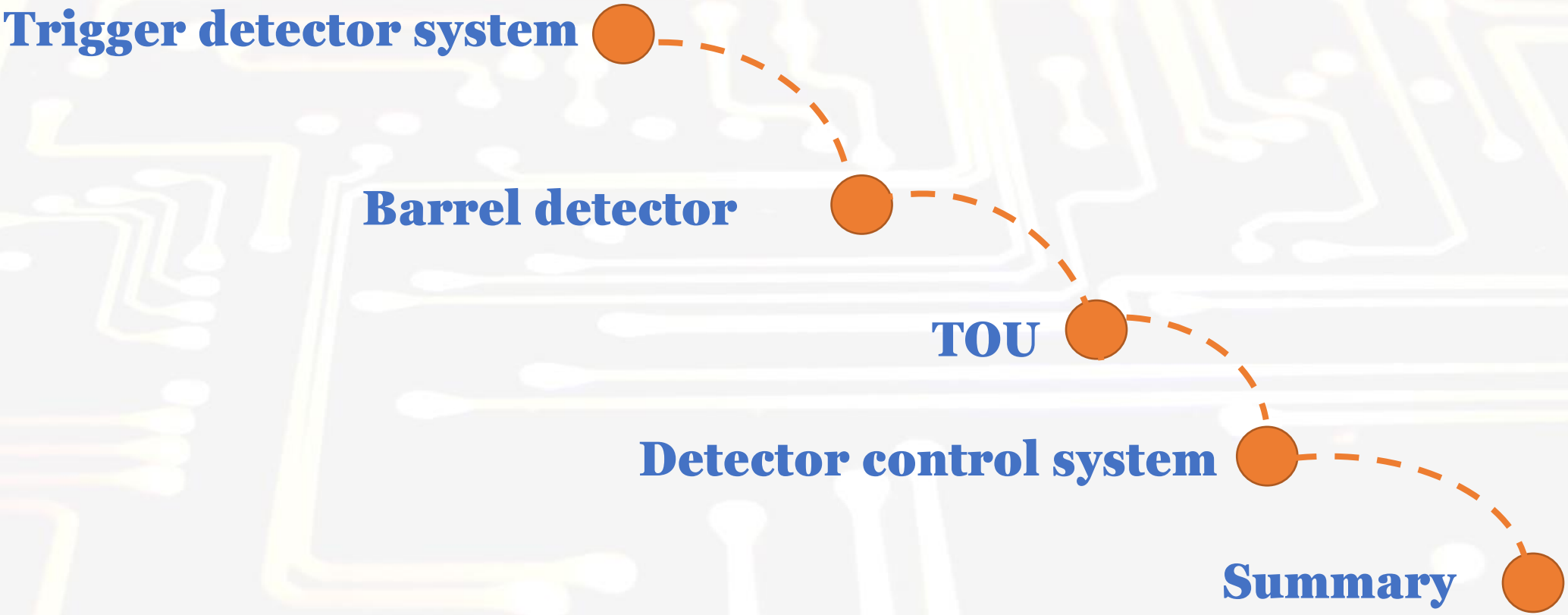
on behalf of BM@N L0 trigger group

Content

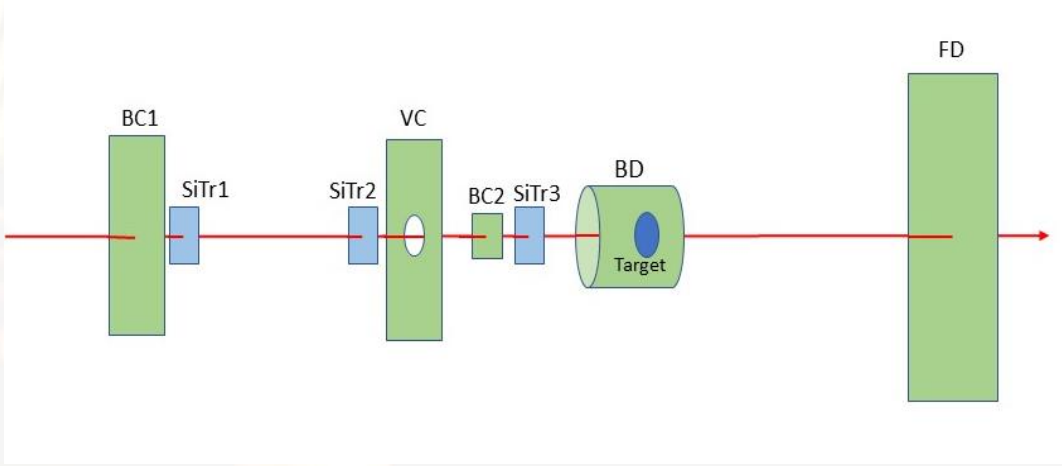

Trigger detector system
Barrel detector
TOU
Detector control system
Summary

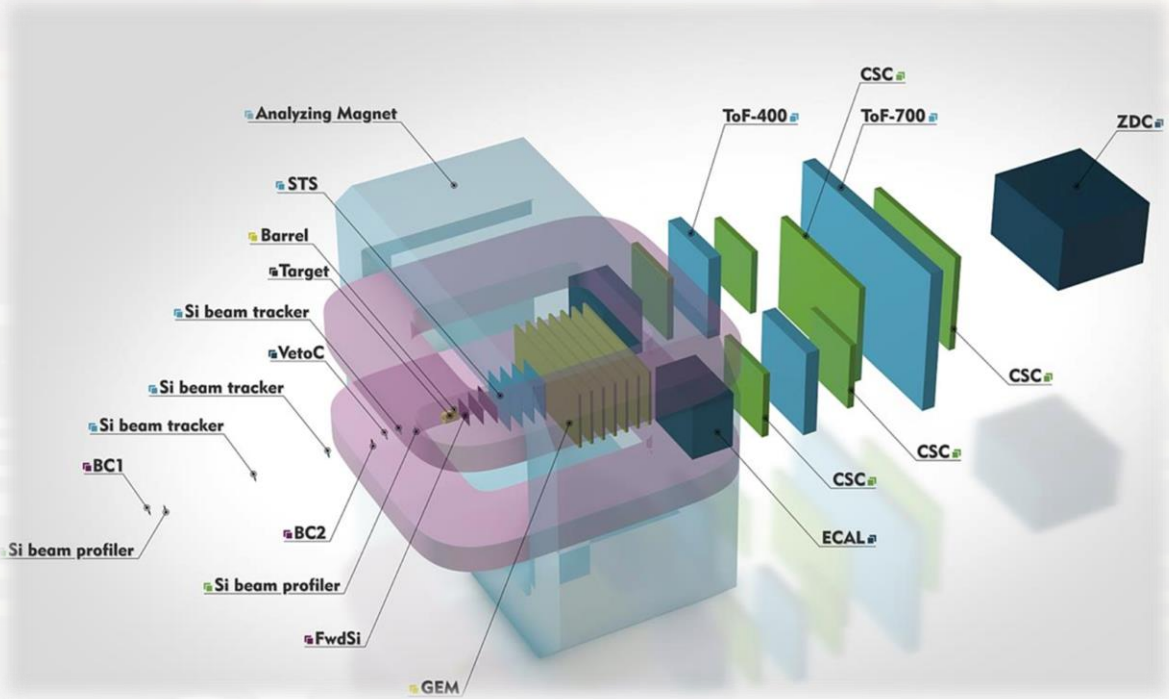
Requirements for trigger system

- ✓ **Minimum materials**
- ✓ **Minimum background**
- ✓ **Minimum delay and jitter**
- ✓ **Trigger processing time <100ns**
- ✓ **High efficiency for selection of nucleus-nucleus interactions in the 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

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





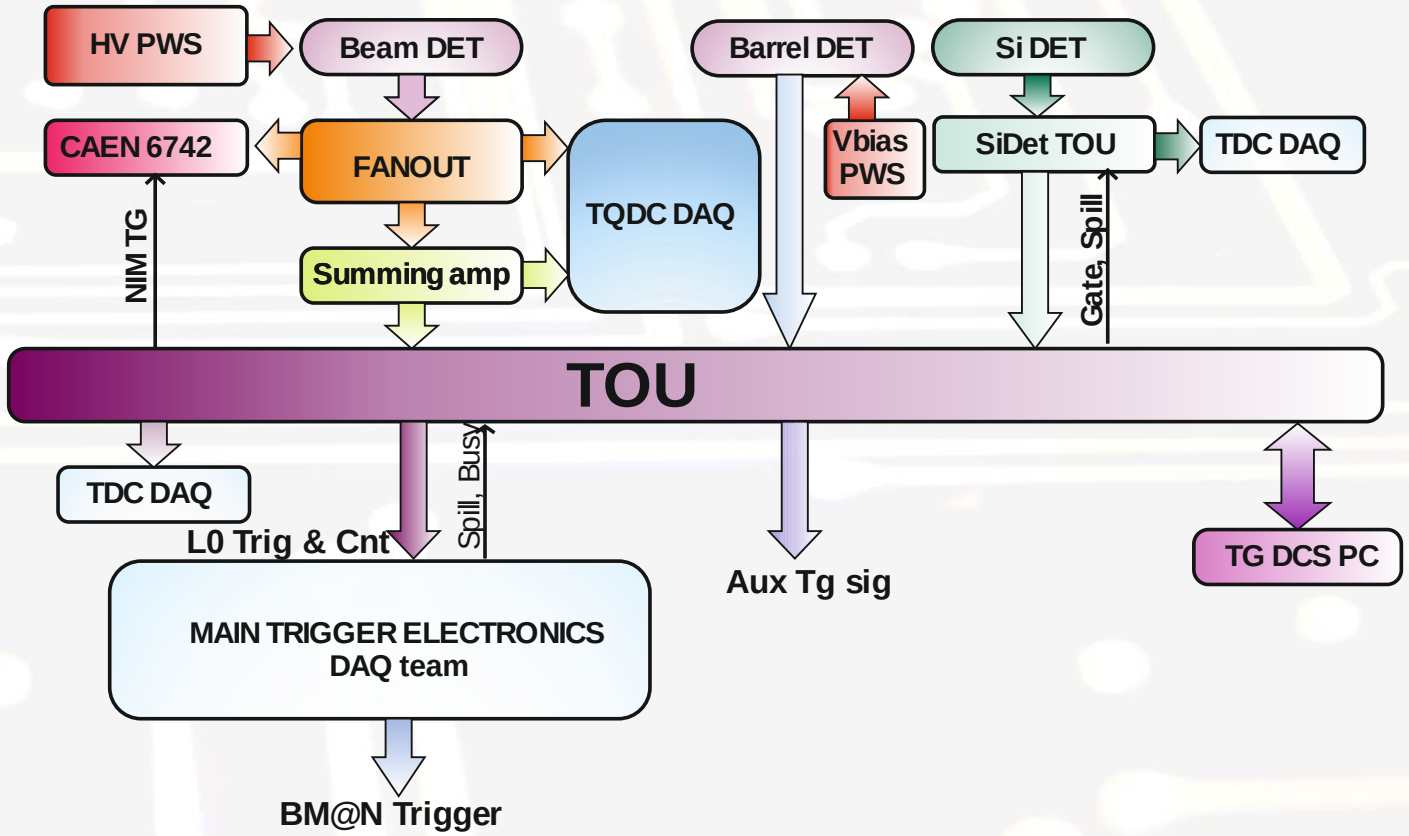
Trigger system at BM@N

Beam Trigger (BT) = BC1*BC2*$\overline{VC}$

MBT = BT* $\overline{FD}$

CCT1 = BT*BD(>*N*)

CCT2 = MBT*BD(>*N*)



Upgrade motivation

- ✓ New BD has more channels -> linear dependence of BD response on collision centrality
- ✓ It detects only energetic charged particles with shorter scintillators -> smaller background contribution
- ✓ It consists of two parts with 32 channels each -> easier installation around the vacuum beam pipe
- ✓ It has new improved FEE and readout scheme
- ✓ Differences in T0U and TDC counts -> adding one shot multivibrator strobed by BC2
- ✓ Effective threshold setting for input comparators -> adding analog MUX and ADC to monitor analog signal shapes and amplitude
- ✓ Suppression of multiple beam ion events in T0U
- ✓ Now the dead time of T0U delay lines is ~200ns -> in the new design it is ~10ns
- ✓ Connection with PC – 100 MB UDP/IP
- ✓ More trigger outputs

Old Barrel Detector

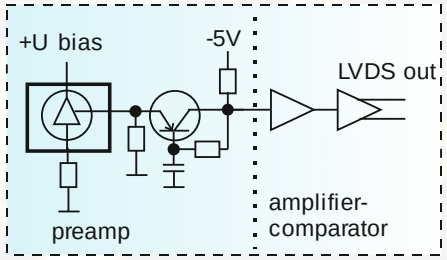
The BD active area has 45 mm radius and 150 mm length. It consists of 40 150×7×7 mm^3 strips made of polished BC-418 scintillator wrapped by Al Mylar.

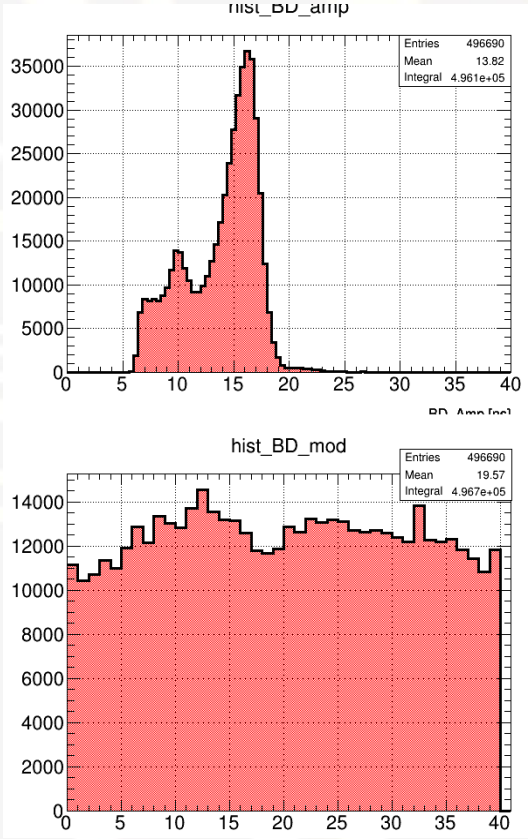
The scintillation light produced by charged particles is detected at one side of the strips by SiPMs.

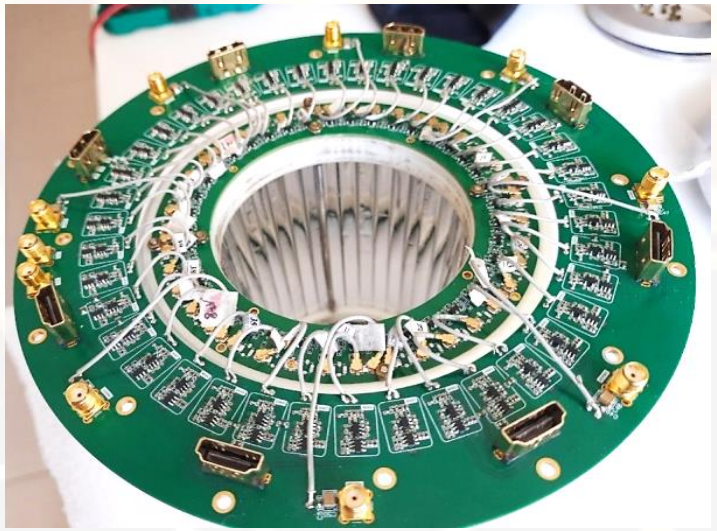
The signals from the SiPMs are fed to the first stage low noise amplifiers and then to the FEE board, which performs amplification and discrimination functions with fixed threshold. A time-over-threshold comparator produces LVDS pulses for the trigger logic unit and TDC.

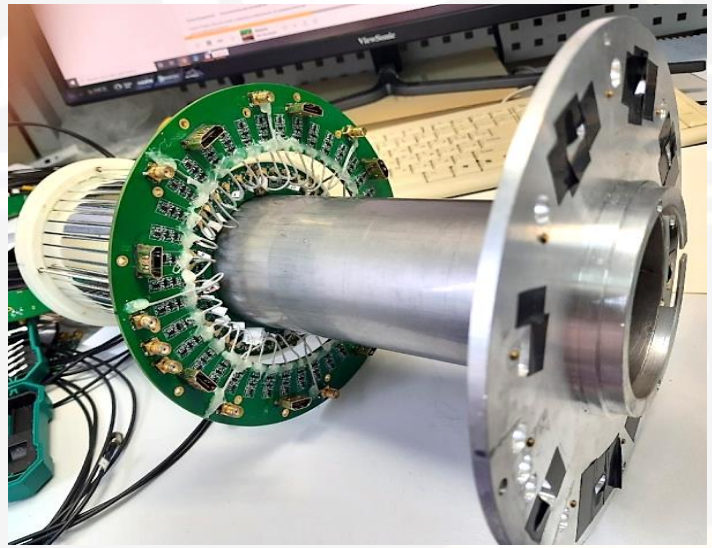
Problems occurred – we observe different counts in TDC and TOU

Upgrade – increase threshold on FEE comparators









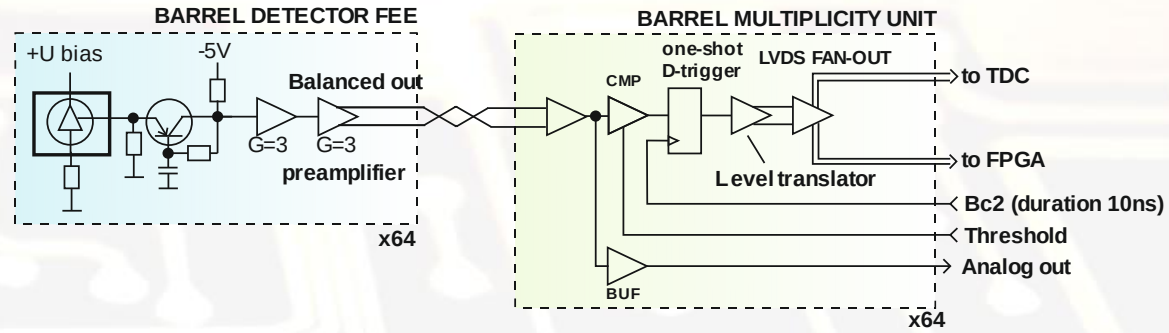
New Barrel Detector electronics

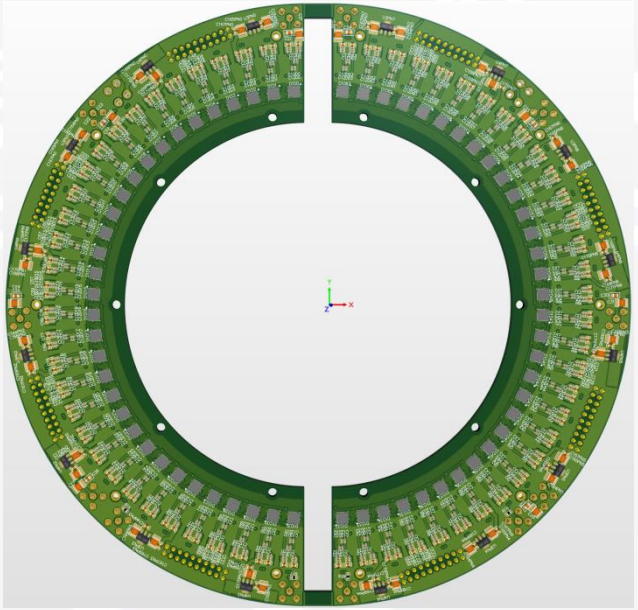
New barrel is divided in 2 pieces for easer installation around the beam pipe. The new BD active area has a 65.5 mm radius and 57 mm length and it consists of 64 57×7×5 mm^3 scintillation strips wrapped by Al-mylar. The scintillation light produced by charged particles is detected at one side of the each strip by SiPM 3×3 mm^2 , SensL, J-ser.

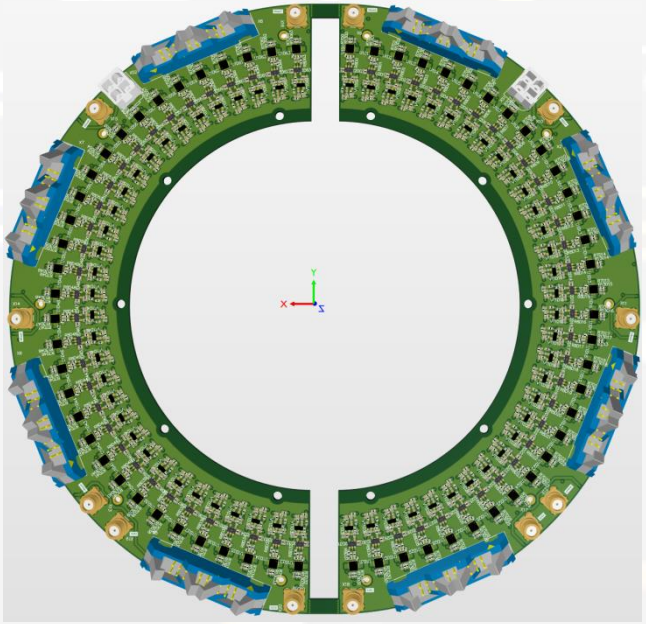
The signals from the SiPMs are fed to the first stage low noise amplifiers and then to the FEE board, which performs amplification and conversion to balanced analog signal.

The balanced signals go to the Barrel multiplicity module (BMM) in the T0U. The BMM calculates multiplicity of signals and compares with adjustable threshold, and then the resulting signal is sent to one-shot multivibrator (20 ns width, strobed by BC2) to produce fixed-width signals to meet the TDC width requirements and to prevent discrepancies in DAQ count and T0U manager count of hit.

The PCB's of Barrel detector FEE is in production
BMM prototype is tested and now it is in PCB tracing stage



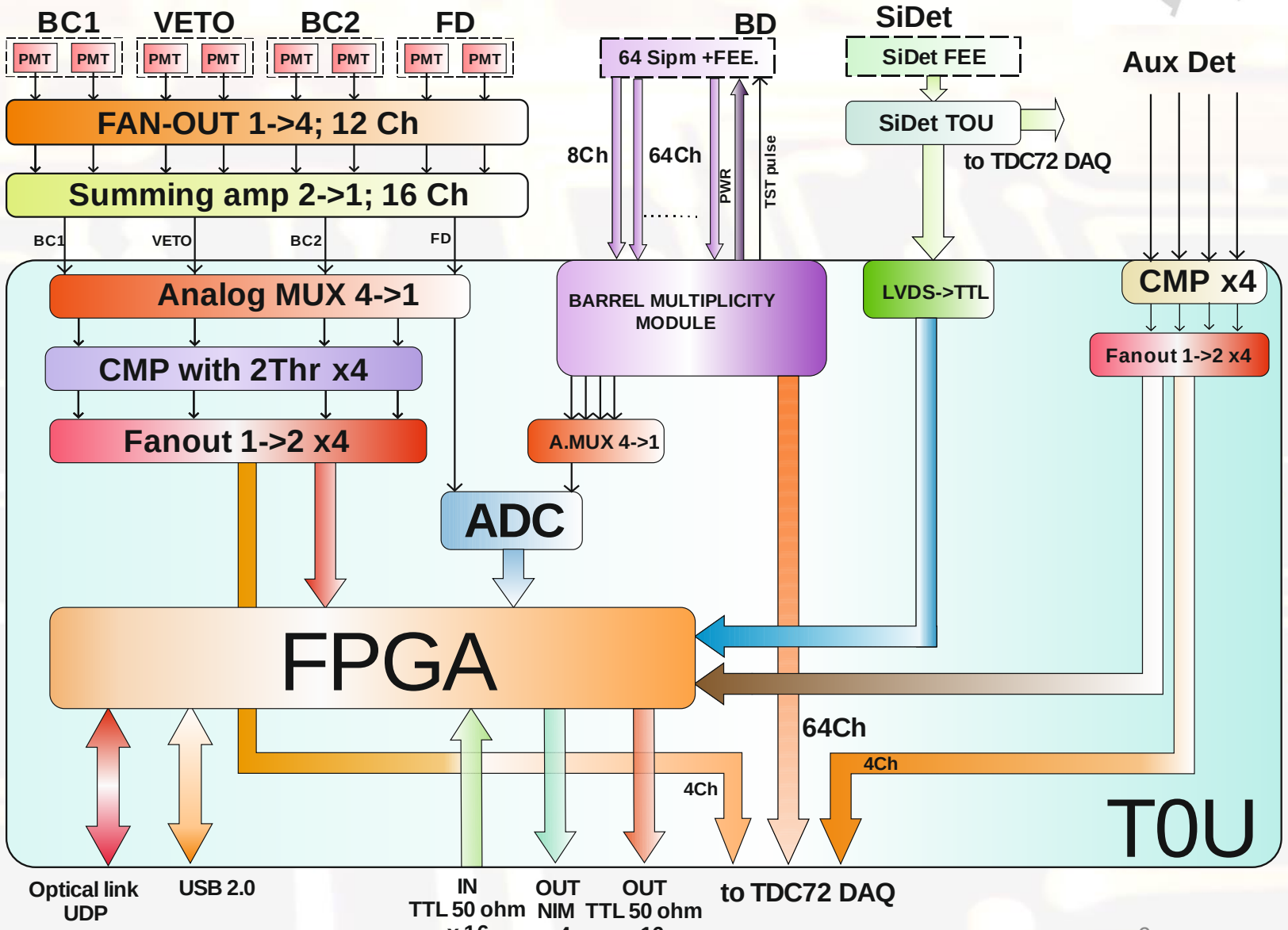




TOU

TOU V2.0 module

The TOU 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.



T0U

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.

Ver 1.2

- The T0U has a modular structure..
- The motherboard performs the following jobs:

- distribution of input signals to external readout electronics (TDC72VL) 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.

Ver 2.0

- The T0U has a modular structure.
- The motherboard performs the following jobs:

- distribution of input signals to external readout electronics (TDC72VL) and L0 trigger processor
- More input and output signals
- L0 trigger generation by the trigger processor built on Altera Cyclone 10 GX FPGA,
- New input channel for the Barrel detector
- Comparators with 2 threshold
- New FPGA firmware
- Interface with PC – Optical link + USB 2.0
- accumulation of the trigger monitoring information.

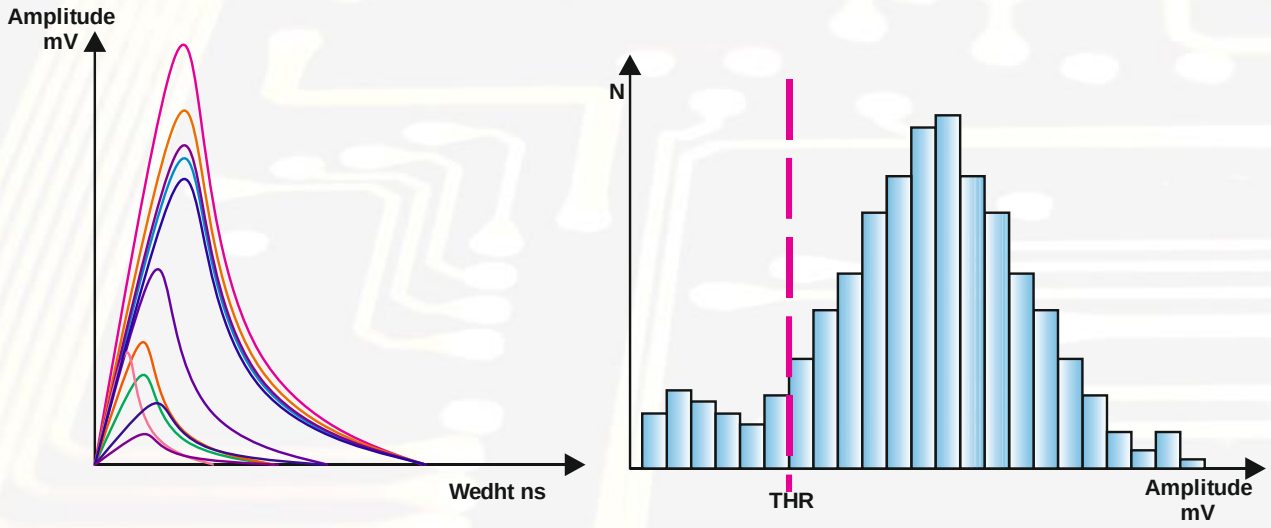
T0U

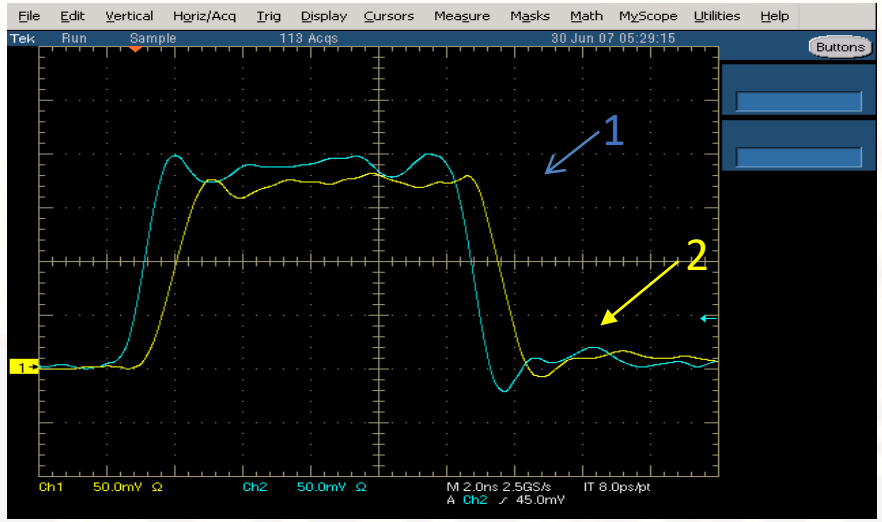
All analog signals can be viewed in T0U manager for monitoring.

We add one RF analog multiplexor 4 ->1 (ADG904) for beam counters and the same for barrel detector signals with jitter < 10ps.

Purpose – monitoring the shape of signals, making more effective adjustment of threshold for beam counters pulses.

We plan to collect data for analysis of the amplitude distribution per spill.





Test waveform of the ADG904 multiplexer chip:the 1st channel – the original signal. the 2st channel – the signal after passing through the multiplexer

TOU

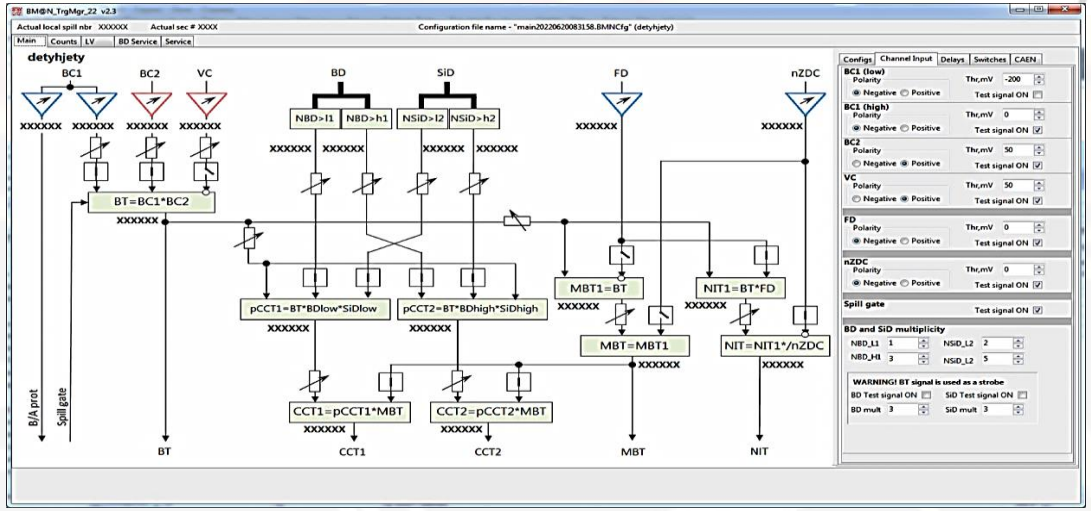
Firmware upgrade

- ✓ **Pipeline type delay (No deadtime delay lines)**
- ✓ **New Multiplicity calculation scheme**
- ✓ **Analog signal readout**
- ✓ **Connection with PC using UDP/IP**
- ✓ **More outputs**

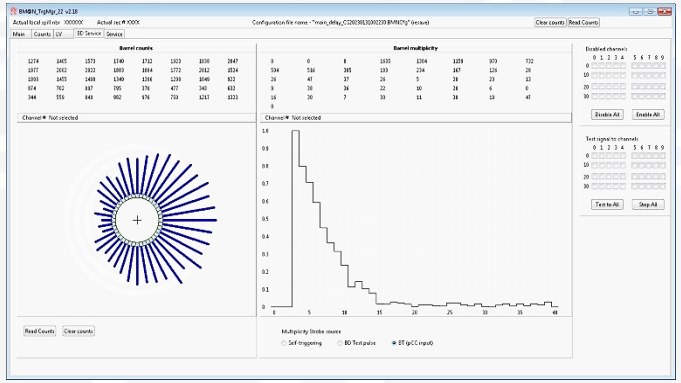
Detector control system

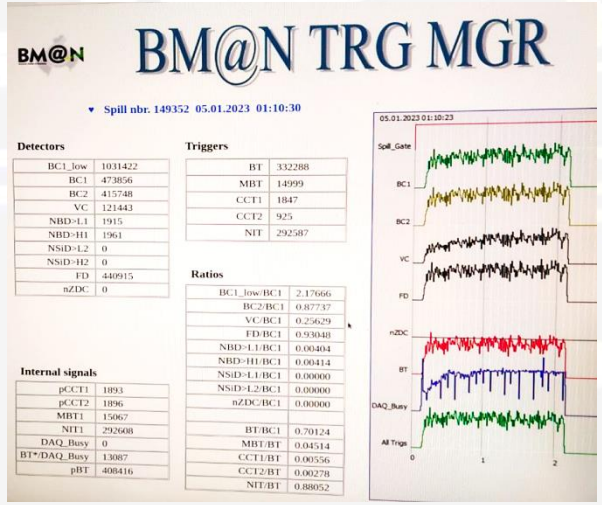
The Trigger System DCS performs following

- 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 are 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 persons



Trigger GUI





Summary

- The trigger system developed for BM@N experiment was successfully operated during the BM@N run 2022-2023.
- At the same time, the experience gained in the run is used to further development and improvement of the trigger characteristics, which includes the development of a new BD detector and electronics.
- Also, the T0U old version with modifications and the current BD can be used if the new version wont be ready in time for a new BM@N run.
- New T0U is under development, almost all components are available, some modules are in the production stage (BT). We plan to test the new T0U and BD by the end of 2024.

Thank you for your attention