

# Status of the trigger system

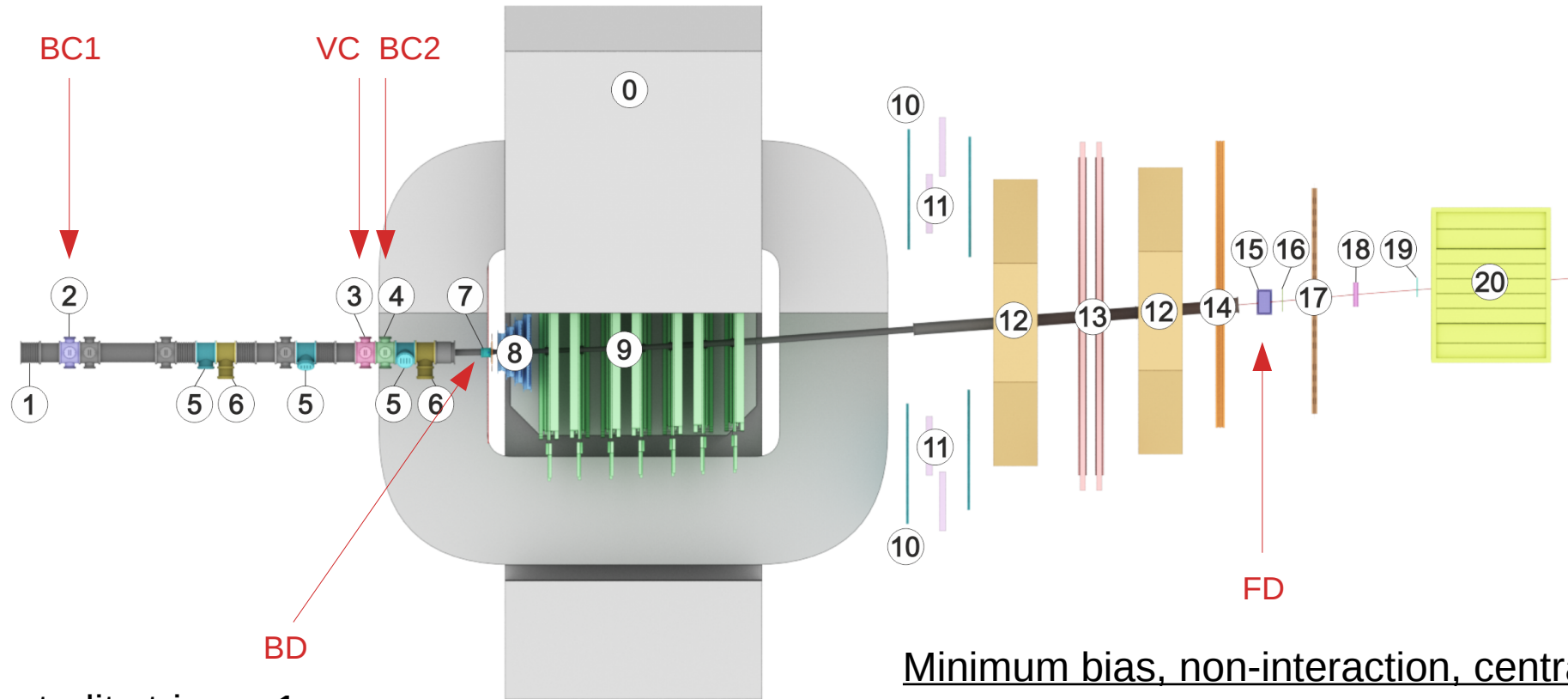
Sergey Sedykh  
for the BM@N trigger group

*Analysis and Detector Meeting of the BM@N experiment  
March 04, 2025*

# Trigger detectors and trigger logic in the 2023 Xe run

## Beam trigger

$$BT = BC1 \cdot \overline{VC} \cdot BC2$$



## Centrality trigger 1

$$CCT1 = BT \cdot BD \quad (n \geq 4)$$

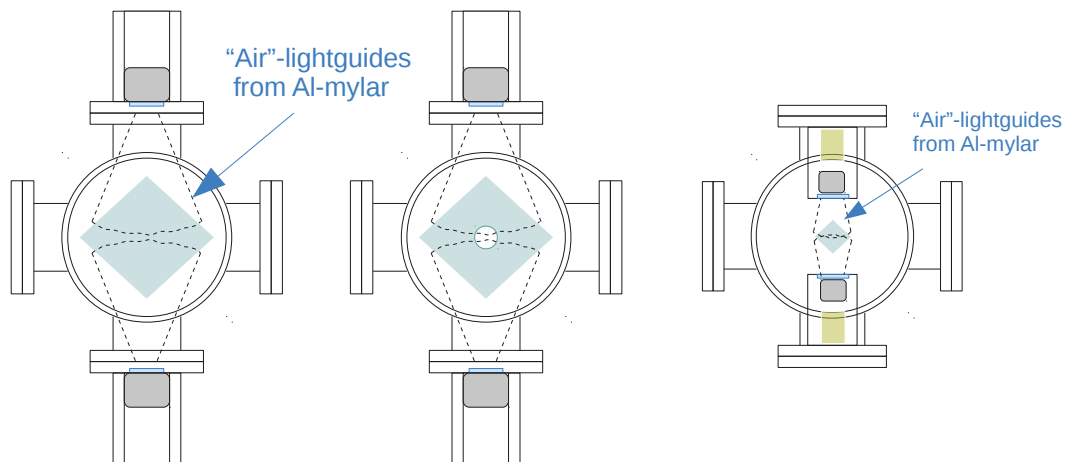
## Minimum bias, non-interaction, centrality trigger 2

$$MBT = BT \cdot \overline{FD}$$

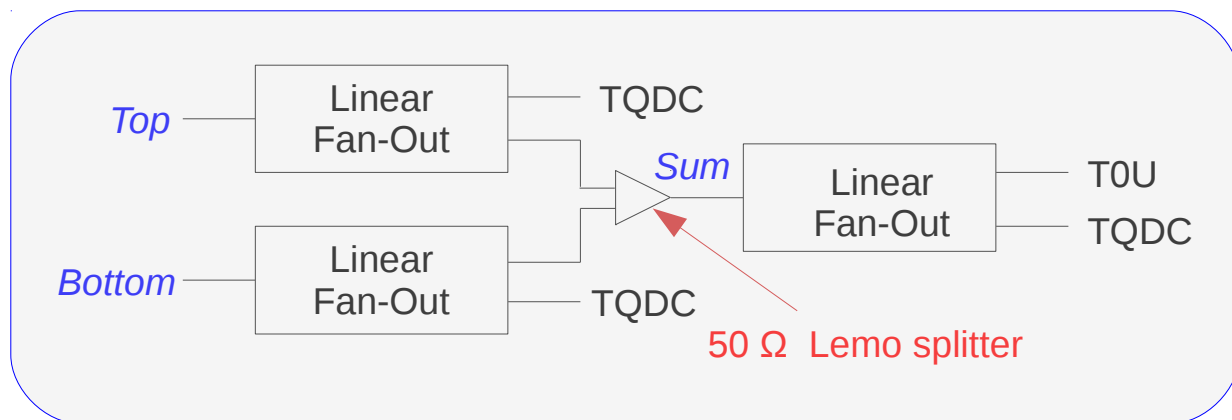
$$NIT = BT \cdot \overline{FD}$$

$$CCT2 = BT \cdot \overline{FD} \cdot BD \quad (n \geq 4)$$

## TQDC, TDC read-out and trigger T0U inputs



Schematic view of BC1, VC and BC2 counters



BC1, VC and BC2 TQDC read-out and T0U input

### T0U inputs:

- accept summed pulses from top and bottom PMTs of BC1, BC2, VC and future BC0
- "poor man solution" of Fan-In built from 50Ω LEMO connectors will be replaced by custom made NIM Fan-In/Fan-Out module (*V.Rogov*)

### TQDC read-out:

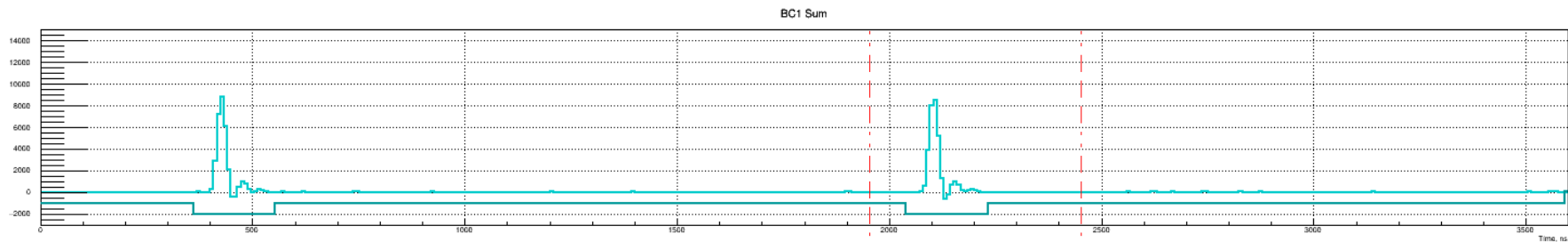
- BC1T, BC1B, BC1S, BC2T, BC2B, BC2S, VCT, VCB, VCS, FD, FDx10
- will be added: BC0T, BC0B, BC0S (active only during beam tuning)

### TDC read-out:

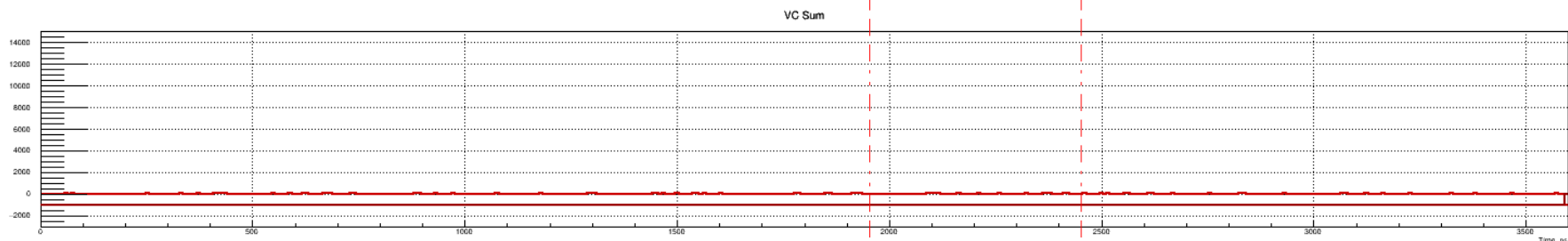
- BD (40 channels)
- BC2AT, BC2AB, BC2MT, BC2MB will be prepared as in the last run, but not available with new PMTs
- will be added: BC1S, BC2S, VCS, BC0S, FD
- BC2S TDC signal can be used as T0 for quick TOF400, TOF700 calibration

# 3.6 $\mu$ s TQDC read-out without Zero-Suppression

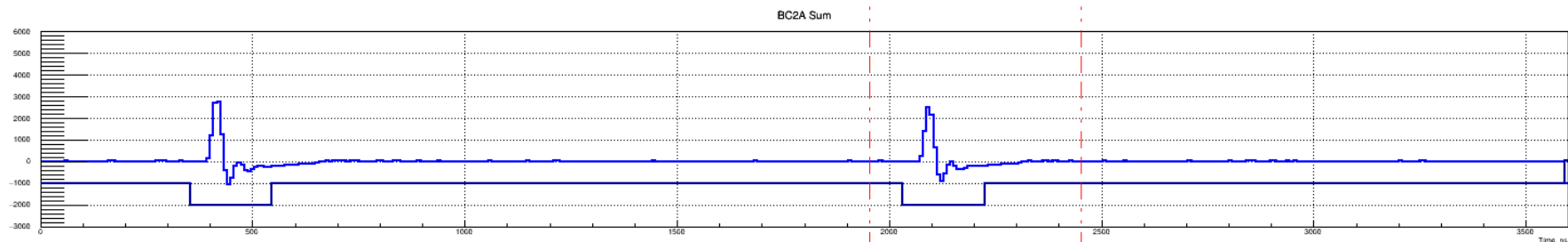
BC1S



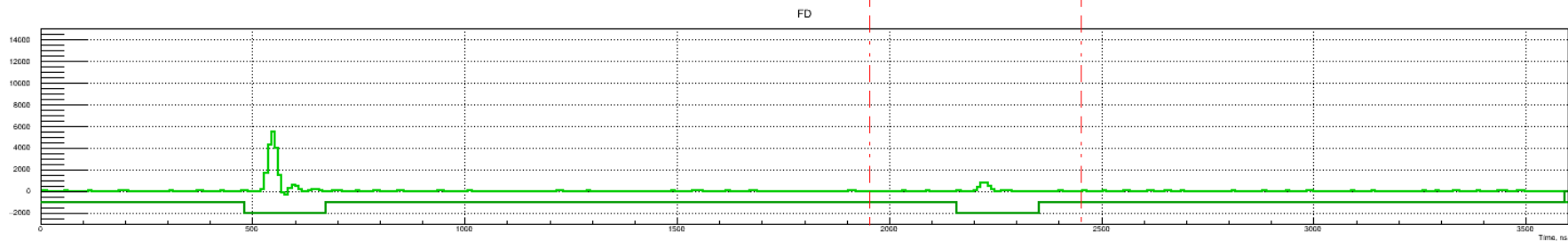
VCS



BC2S



FD



1000

2000

3000

Trigger time window

Time, ns

**TQDC16VS-E**

Main tool to study trigger features

waveform sampling  
by 125 MS/s ADC (8ns bins)

25 ps bin TDC

wide time window is used  
for offline Before/After  
protection analysis

Long negative tail in BC2  
pulses complicates  
analysis of pile-up events.  
Reason for PMT change  
to R2490-07 (BC1 type).

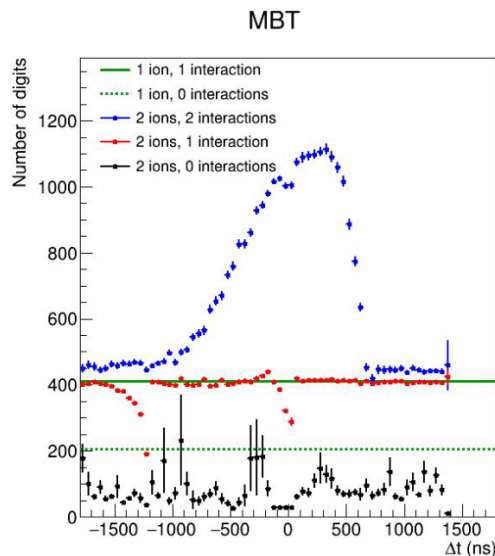
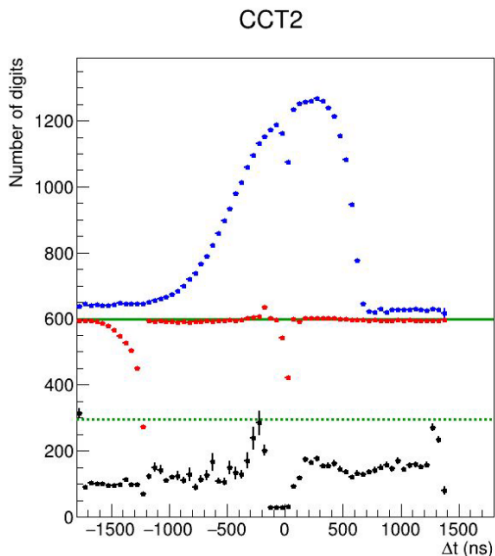
“Close pile-up”:  $\pm 60$  ns  
with respect to trigger time

“Distant pile-up”:  
(- 2000, -60 ns)  
(+60, +1600 ns)

# Should we extend TQDC time window to cover more “Before” time?

Additional hits in tracking detectors if there is a second interaction

FSD

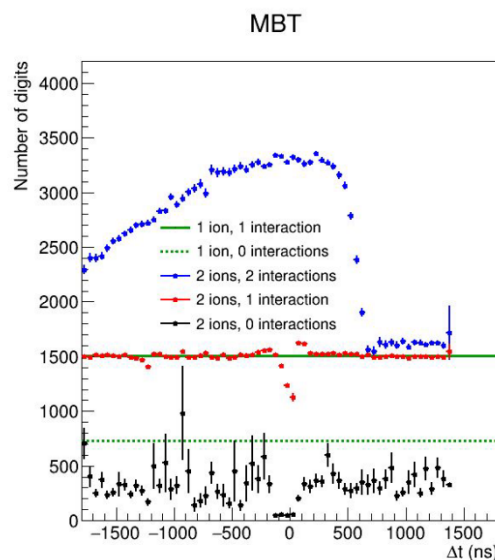
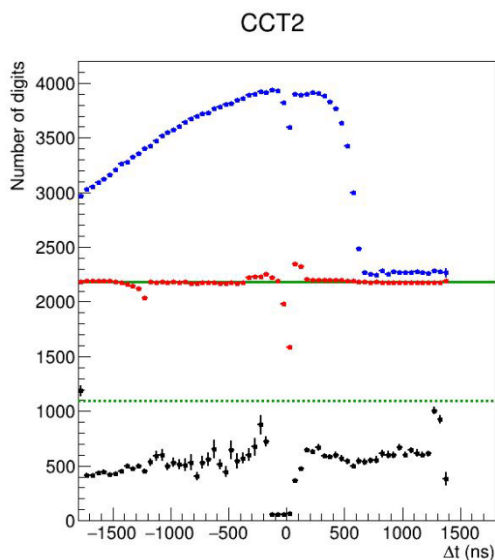


Based on extra hits in GEM it might be good to add about 1.5  $\mu\text{s}$  “before” time

Windows of TOF400, TOF700

and of forward detectors:  
SciWall, FHCaI, QHD

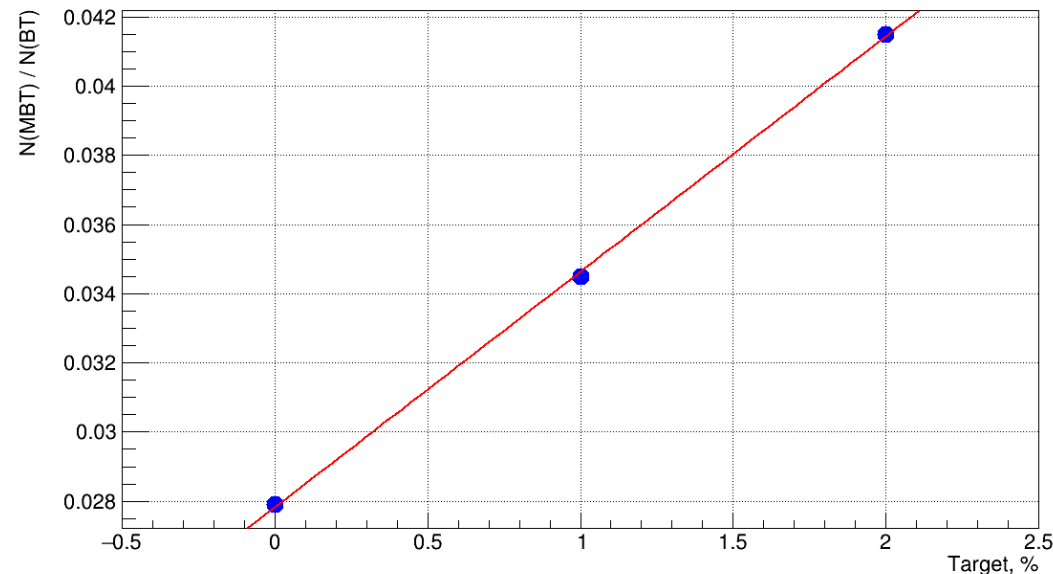
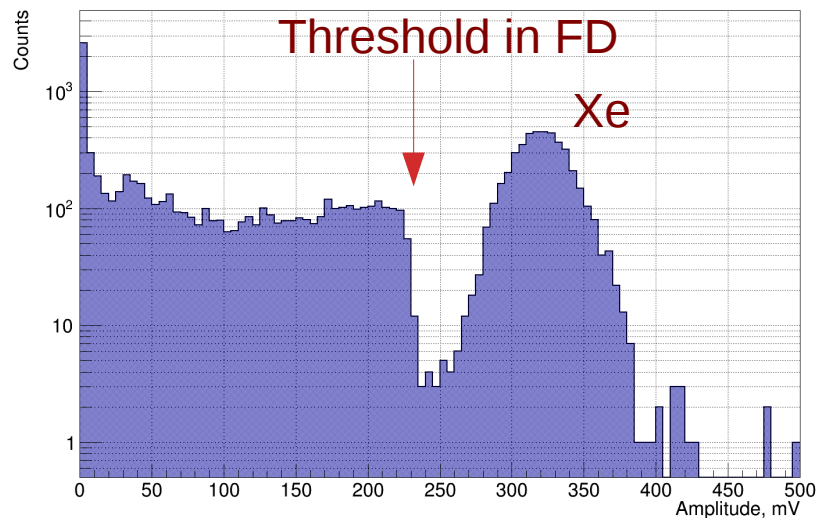
GEM



are also good to extend to match the trigger TQDC time window

Oleg Golosov  
Coll. Meeting May 2024

# Minimum Bias Trigger ( $MBT = BT \cdot FD_{\text{veto}}$ )



## Two main sources of background in the MBT:

- 1) additional material between BC2 and FD adds  $\sim 1.9\%$
- 2) close pile-up withing  $\pm 50$  ns, adds  $\sim 0.8\%$  (presumably due to dead time in the TOU elements)

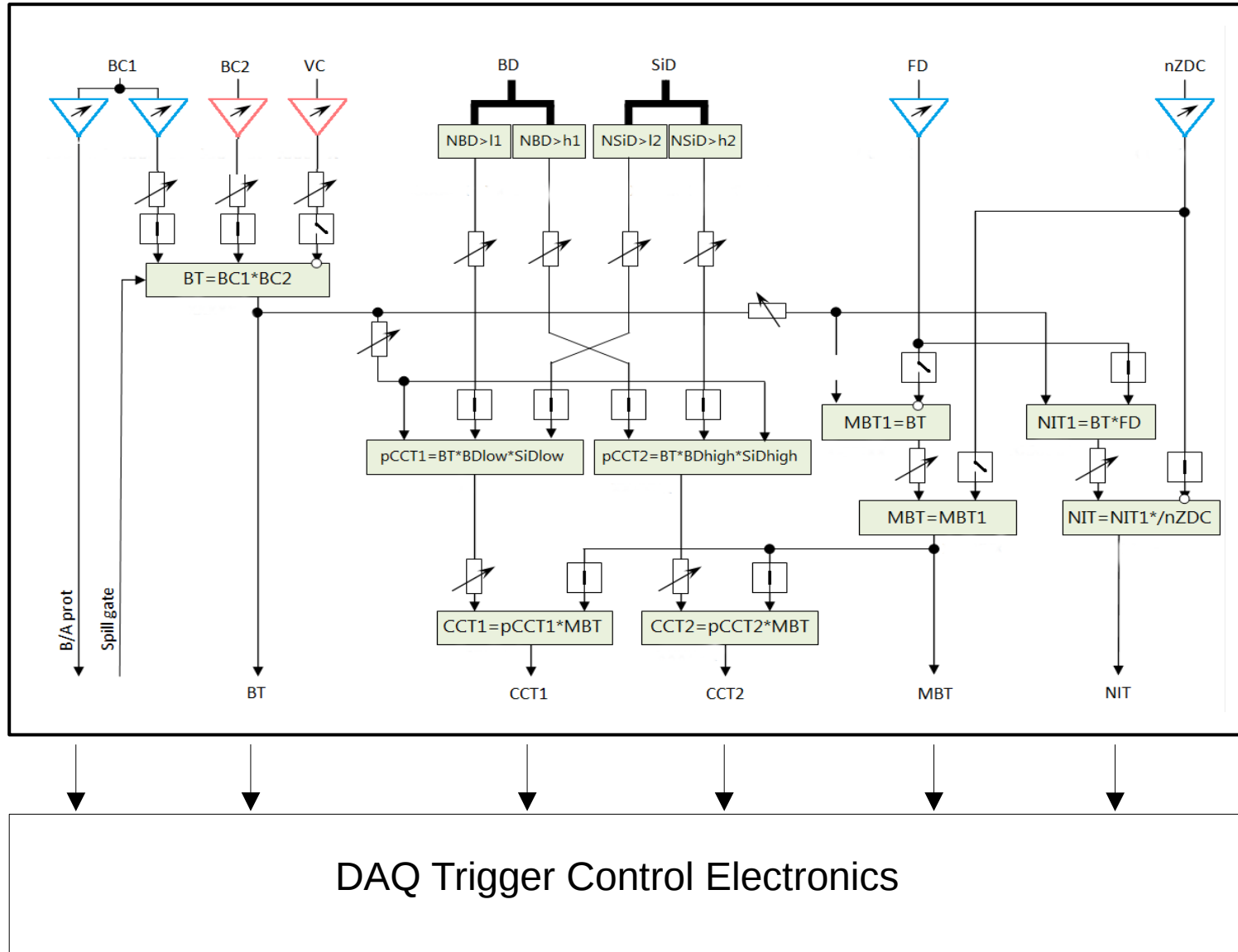
By suppressing events with close pile-up, and by placing FD radiator in vacuum and swapping BC2 with SiBT3, one might expect reduction in MBT background from 2.7% to 0.3%,

i.e. for 2% target and 70% centrality selected by MBT:

2023, actual: 1.4% signal + 2.8% background  
 2025, expected: 1.4% signal + 0.3% background

Material	Thickness, mm	Interaction probability %
Si BeamTracker	0.175	0.30
Ti vacuum window	0.08	0.17
FD, black tape, etc.	0.5	0.94
Air	150	0.21
FD, scint.	$\sim 0.1$	$\sim 0.2$
BC2, scint.+Mylar	$\sim 0.04$	$\sim 0.1$
		<b>Total <math>\sim 1.9</math></b>

# Changes in T0U trigger logic



## For existing triggers:

- change delays type (“no dead time”)
- add rejection of events with overlapped or two close BC1 pulses
- fix not-working B/A protection by BC1 trigger in DAQ Trigger Control (either missing signal, or out of allowed time window)

## Remove no longer needed parts:

- remove SiMD trigger branch;
- take CCT1 trigger from CCT2 branch ( $CCT1 = pCCT2$ ); this is cleaner and frees the CCT1 branch;

## Additional triggers:

- BC0 (no coincidence, “stand-alone”)
- add second FD threshold (“soft”)
  - “soft” for  $MBT = BT * FD_{veto}$
  - “hard” for  $CCT2 = BT * BD * FD_{veto}$
- $CCT3 = BT * FHCal * BD (\geq n)$

# FHCal Signal in CAEN data



Input to T0U was out of expected trigger time window  
TQDC output was never properly read-out  
only CAEN data in pile-up events can provide some info

## FHCal signal parameters:

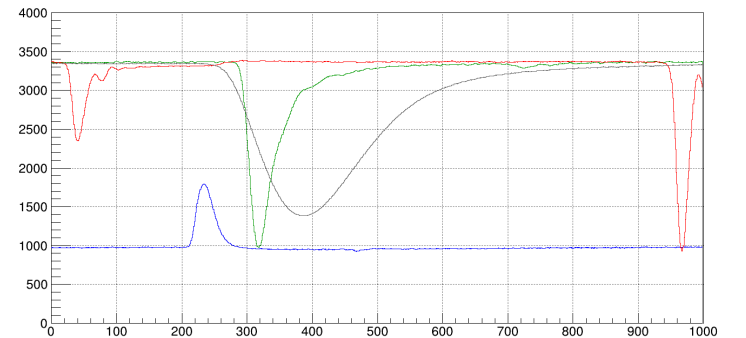
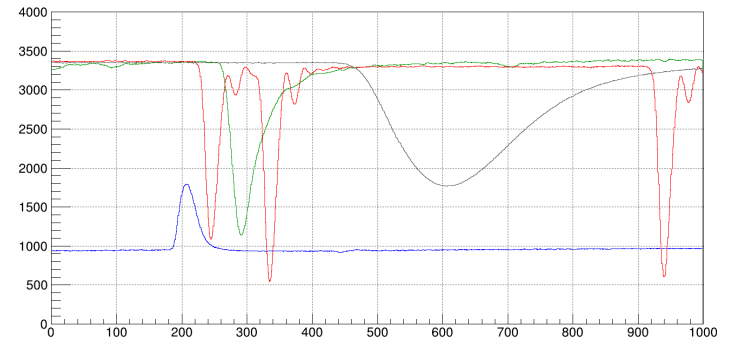
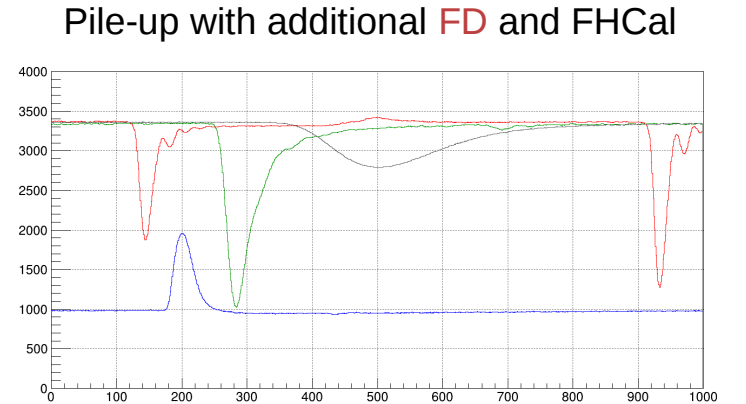
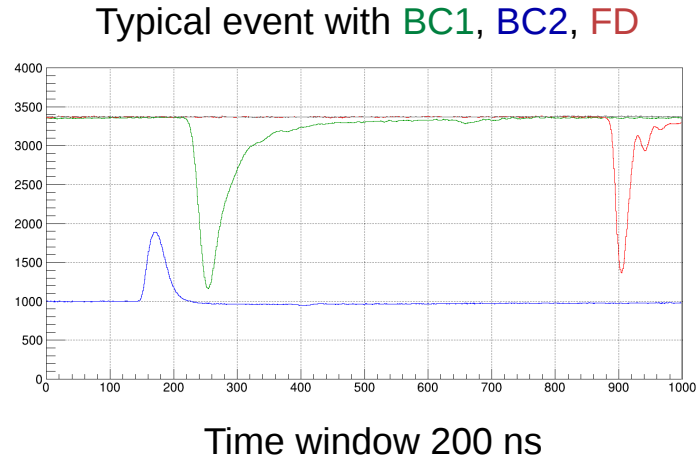
Delay with respect to FD was  $\sim 70$  ns;

BC2  $\sim 220$  ns (will be shorter with new cables)

Front duration  $\sim 25$  ns

at low fixed threshold this will be the signal “time walk”

Pulse duration  $\sim 80$  ns





## T0U work division and timeline

Finalize T0U trigger logic scheme by 10<sup>th</sup> of March  
(*Sergey Sedykh, Vladimir Yurevich, Mikhail Kapishin*)

FPGA programming (*Pavel Grigoriev*)

Changes in the T0U interface (*Sergey Sergeev*)

Testing with FPGA generator signals (*Pavel Grigoriev, Sergey Sergeev*)

Tests with the laser system and/or external generator  
(*Sergey Sedykh, Nikita Lashmanov*)

Tests of Before/After protection in T0U and TRC  
(*trigger group and DAQ team*),  
starting April 10<sup>th</sup> ?

Two T0U modules will be used

*Thank you for your attention!*