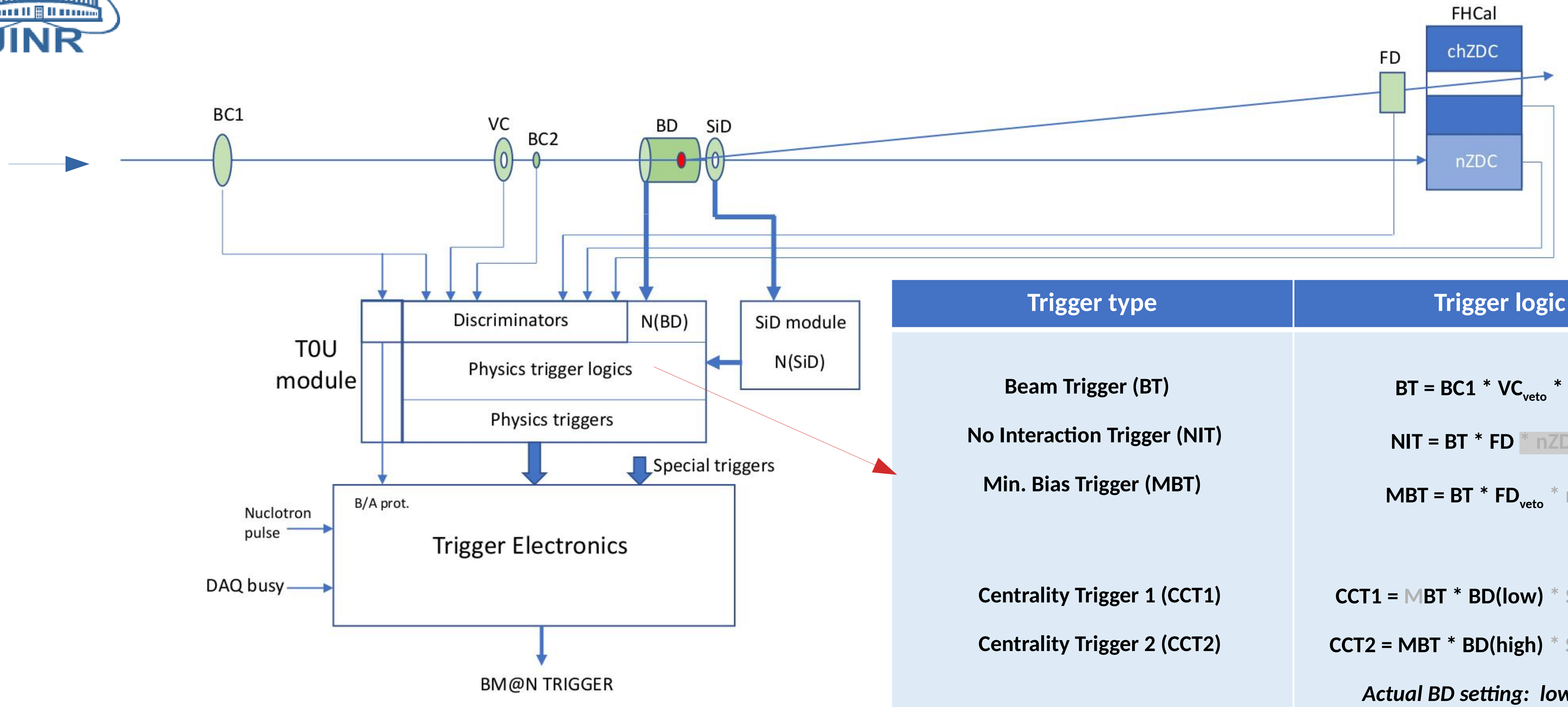
Preparation of the trigger system to the next run

BM@N detector council meeting
October 3, 2023

Overview of the trigger scheme

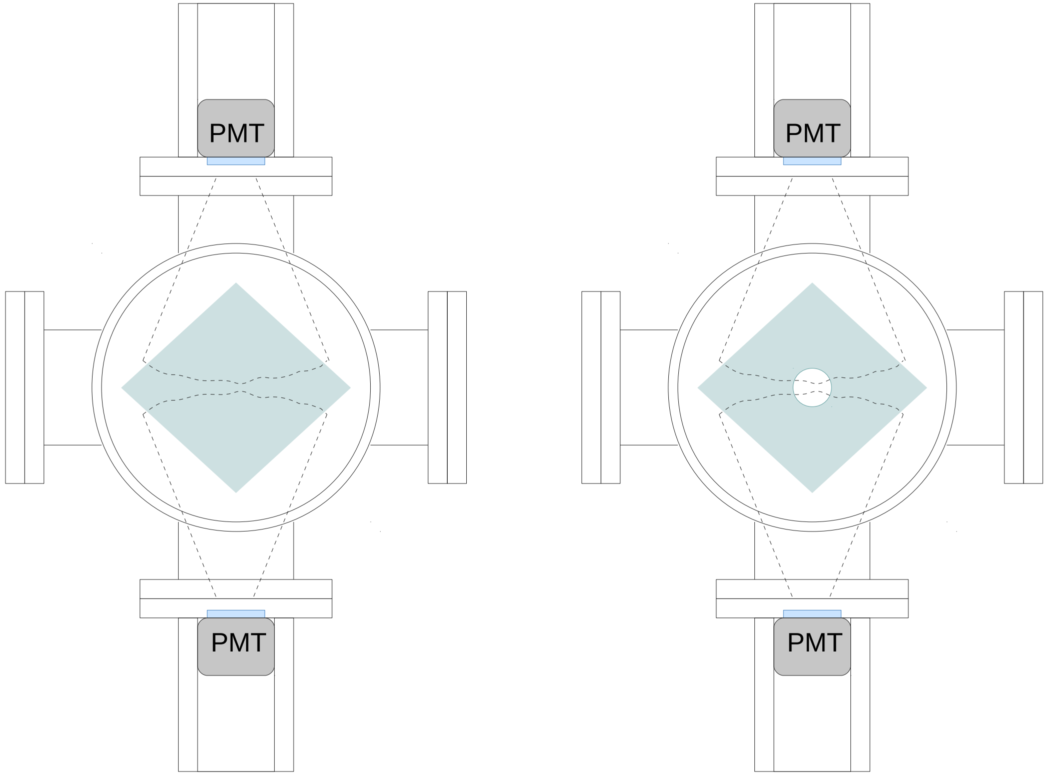
BM@N trigger system 2021



Trigger type	Trigger logic
Beam Trigger (BT)	BT = BC1 * VC_{veto} * BC2
No Interaction Trigger (NIT)	NIT = BT * FD * $nZDC_{veto}$
Min. Bias Trigger (MBT)	MBT = BT * FD_{veto} * nZDC
Centrality Trigger 1 (CCT1)	CCT1 = MBT * BD(low) * SiMD(low)
Centrality Trigger 2 (CCT2)	CCT2 = MBT * BD(high) * SiMD(high)
	Actual BD setting: low = high

No major changes. Three physics triggers: BT, CCT2, MBT

Beam trigger. BC1, VC



Detector	PMT	Radiator
BC1	Hamamatsu R2490-07	Scint. BC400B 100 x 100 x 0.25 mm^3
VC	Hamamatsu R2490-07	Scint. 113 x 113 x 4 mm^3 Ø 25 mm

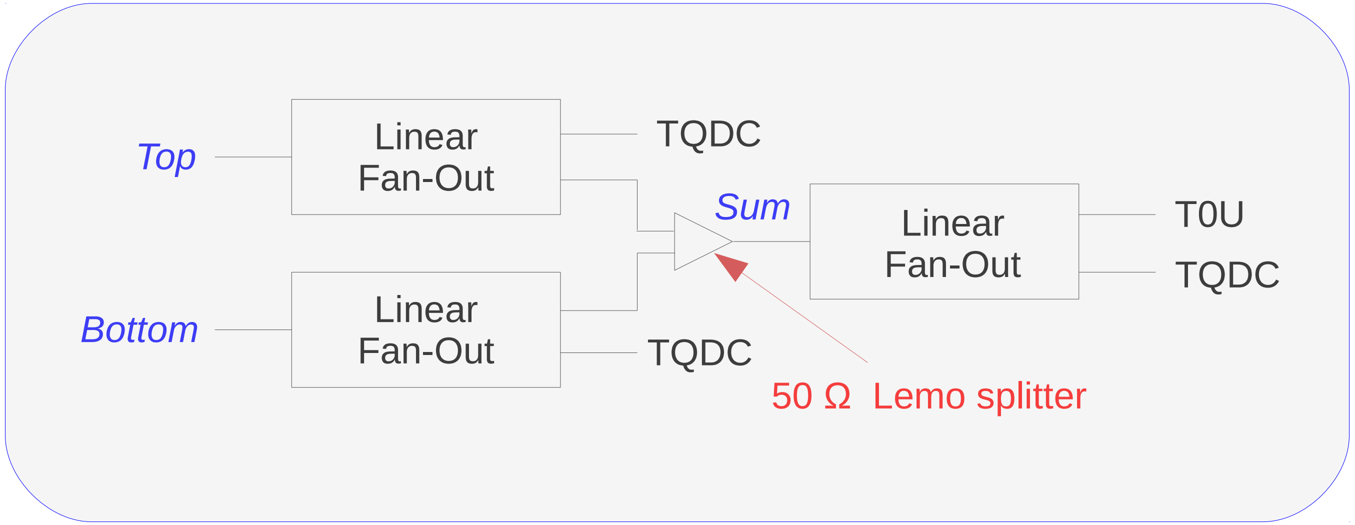
“Air”-lightguides from Al-mylar

No major changes. Will replace scintillator in BC1.

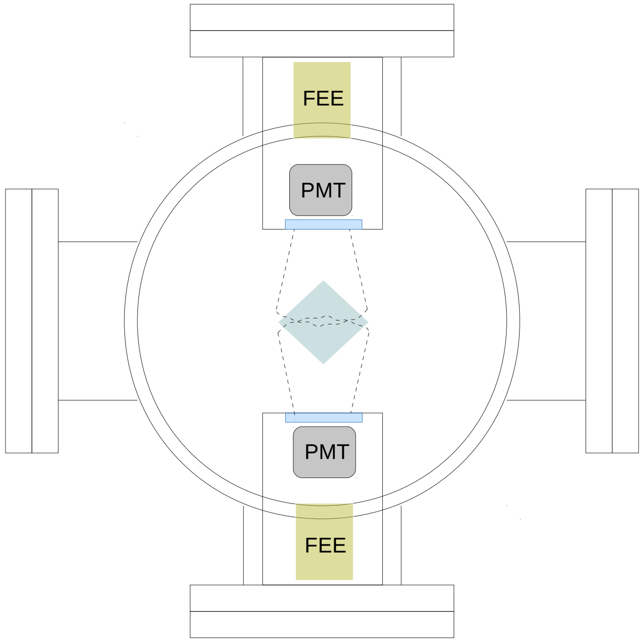
Rotate the scintillators?

If BC0 is made it will be added to the BT logic and read-out.

New fan-in electronic module?



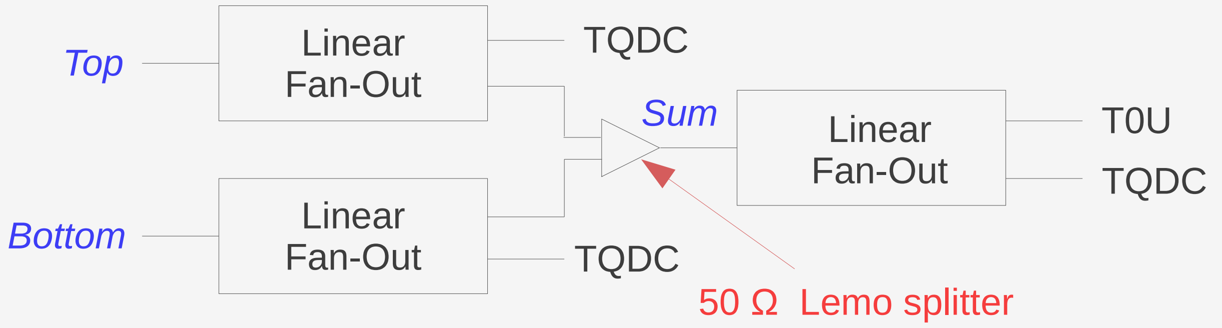
Design and read-out of BC2



Detector	PMT	Radiator
BC2	Photonis XPM85112/A1 Q400 25x25 mm^2	Scint. BC400B 34 x 34 x 0.15 mm^3

"Air"-lightguides from Al-mylar

Two signals from each PMT: Anode and MCP



Change PMT to Hamamatsu R2490-07,
No TDC read-out.

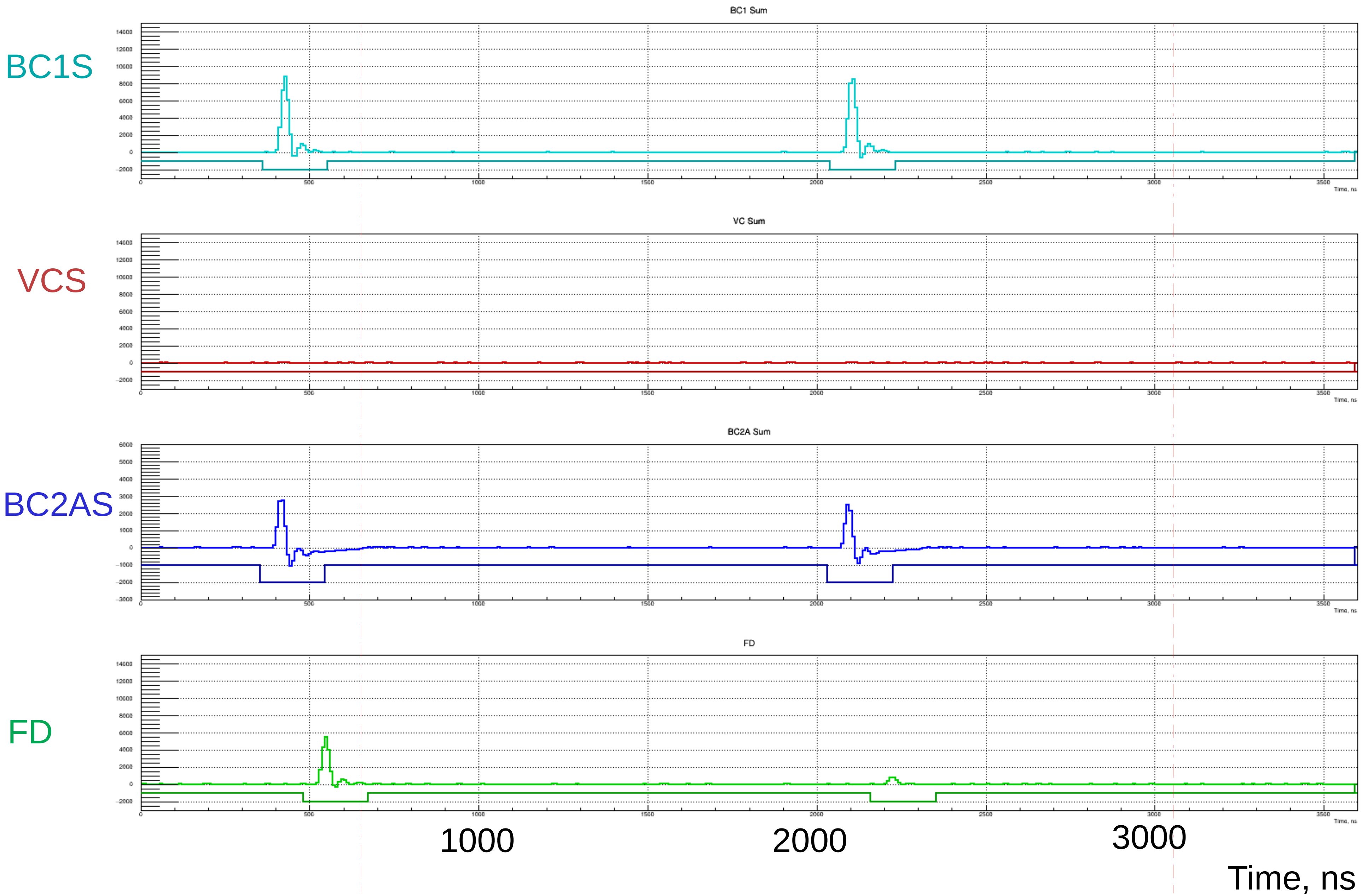
Will fit into existing vacuum station,
but new housings will be needed.

Keep old BC2 PMT ready.

Put fresh scintillator.

Additional read-out of LVDS signals from FEE into TDC72VHL.
Both, TQDC and TDC provide high resolution timing.

3.6 µs TQDC read-out without Zero-Suppression



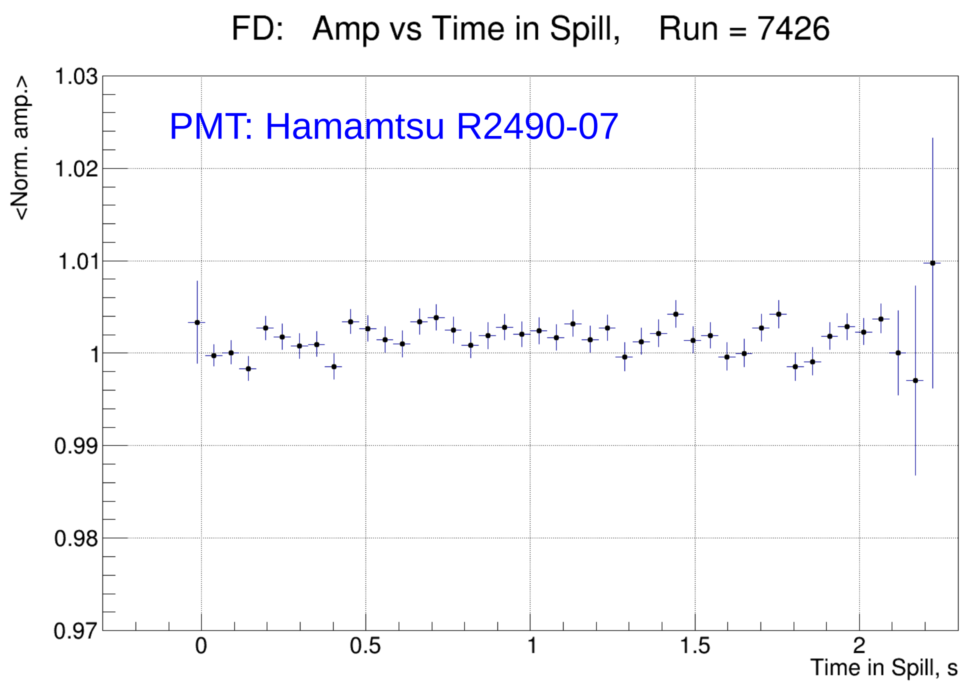
Keep as is.
Extend time window for HODO.

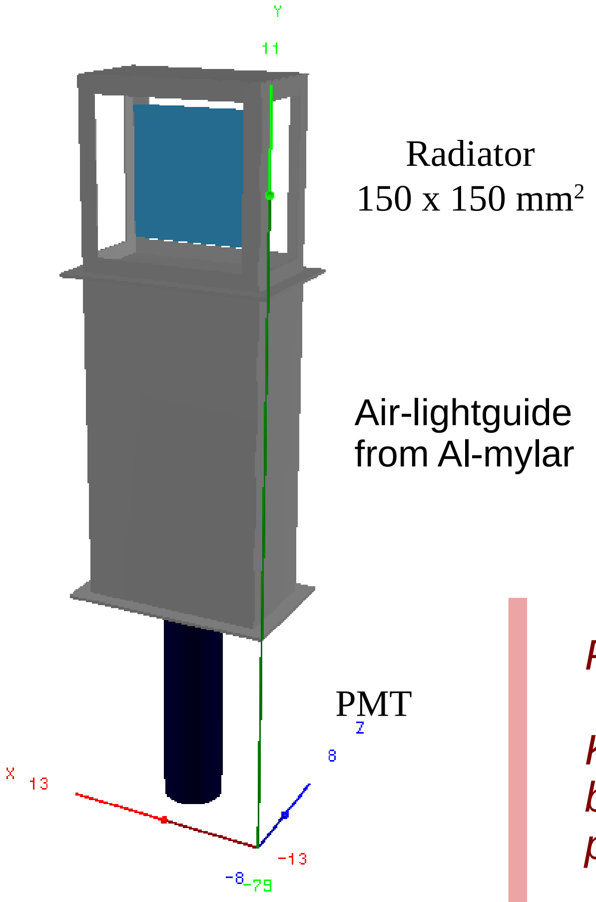
Efficient detection of small pulses

Extra info outside of Before/After time window (useful for beam composition and beam counter response studies)

Fragment Detector

PMT	Radiator	σ/A (%)
XP2020	Scint. 0.5 mm	6.0
XP2020	Quartz 1 mm	17.0
XP2020/Q	Quartz 1 mm	11.7
R2490-07	Scint. 0.5 mm	9.1 → 6.7 → 5.3





Prepare stable base for XP2020

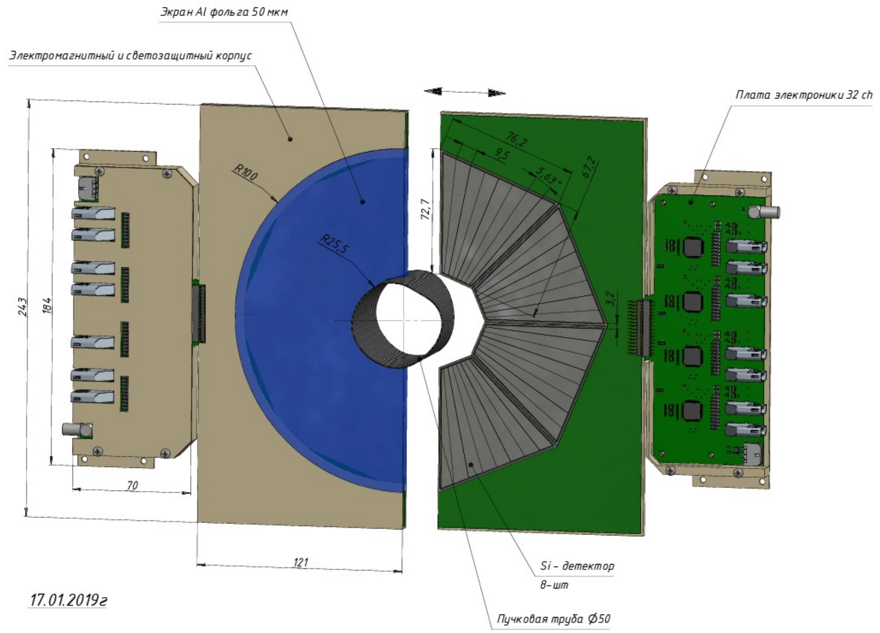
Keep scintillator radiator, but continue tests with quartz prototypes

No work yet on a vacuum version of FD

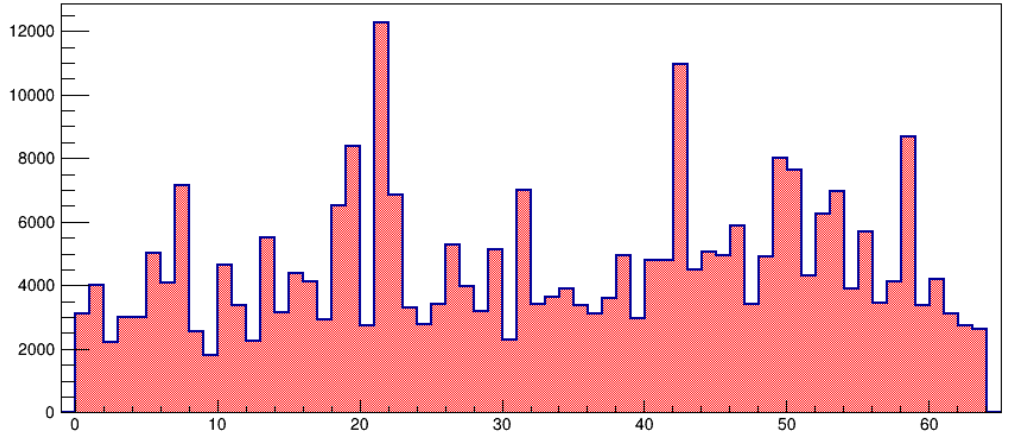
Response of Si Multiplicity Detector

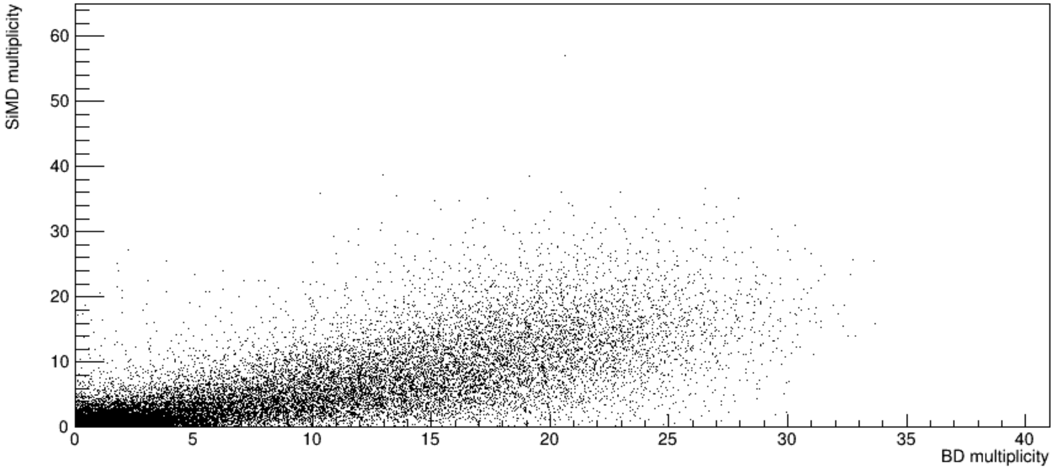
Group of N.Zamjatin

Beam 3 GeV/n, trigger MBT



- all 64 channels are working
- clear correlation of hits multiplicity in SiMD and BD





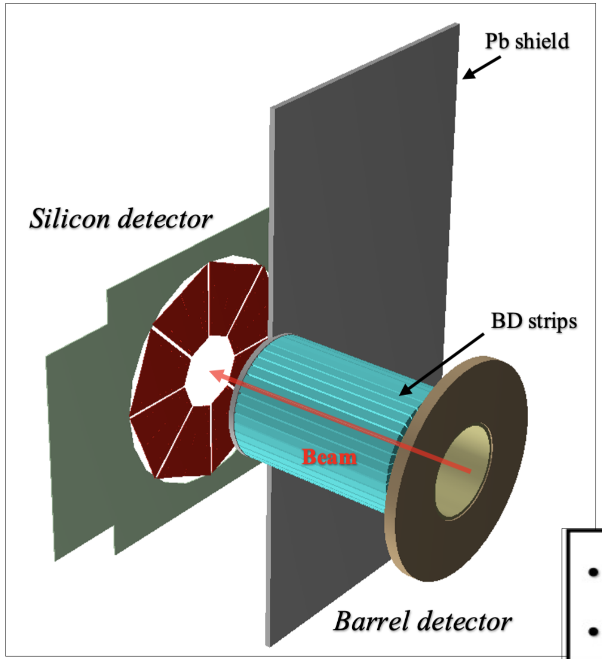
Detector parameters:

– opening for the beam. Dia. 50 mm
– 8 trapeziodal detectors
– 64 strips in total
– 525 µm thick

Seems fine
but not needed

If not installed,
can be taken out
of the trigger logic

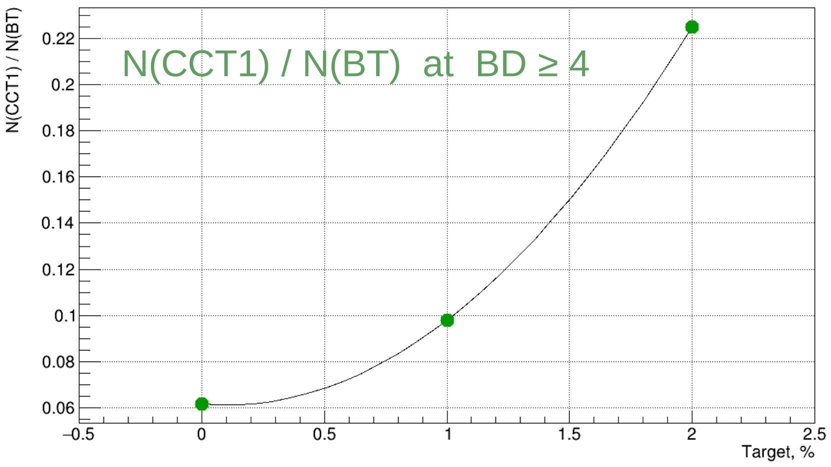
Barrel Detector and trigger CCT1 = BT • (BD≥n)



Even with added Pb-shielding,
the background from δ-electrons is significant
and larger, than predicted by Geant4 simulations

At BD ≥ 4 and 2% target,
N(CCT1) / N(BT) is 0.22,
while 0.02-0.04 was expected.

In addition, CCT1 rate is very non-linear
with 1% and 2% targets, indication of
high sensitivity to pile-up of beam ions



- *Inner shield*: Pb - cylinder 0.3 cm thick;
- *Outer shield*: 25 x 50 cm², L = 0.5 cm.

Keep BD as is.

Remove second BD threshold in trigger logic

Work on new BD
(started but not likely be ready for the next run)

Detector:

Two left and right halves as in SiMD.

Shorter strips: 150 → 50 mm (less Pb for shielding)

Increased number of strips: 40 → 64

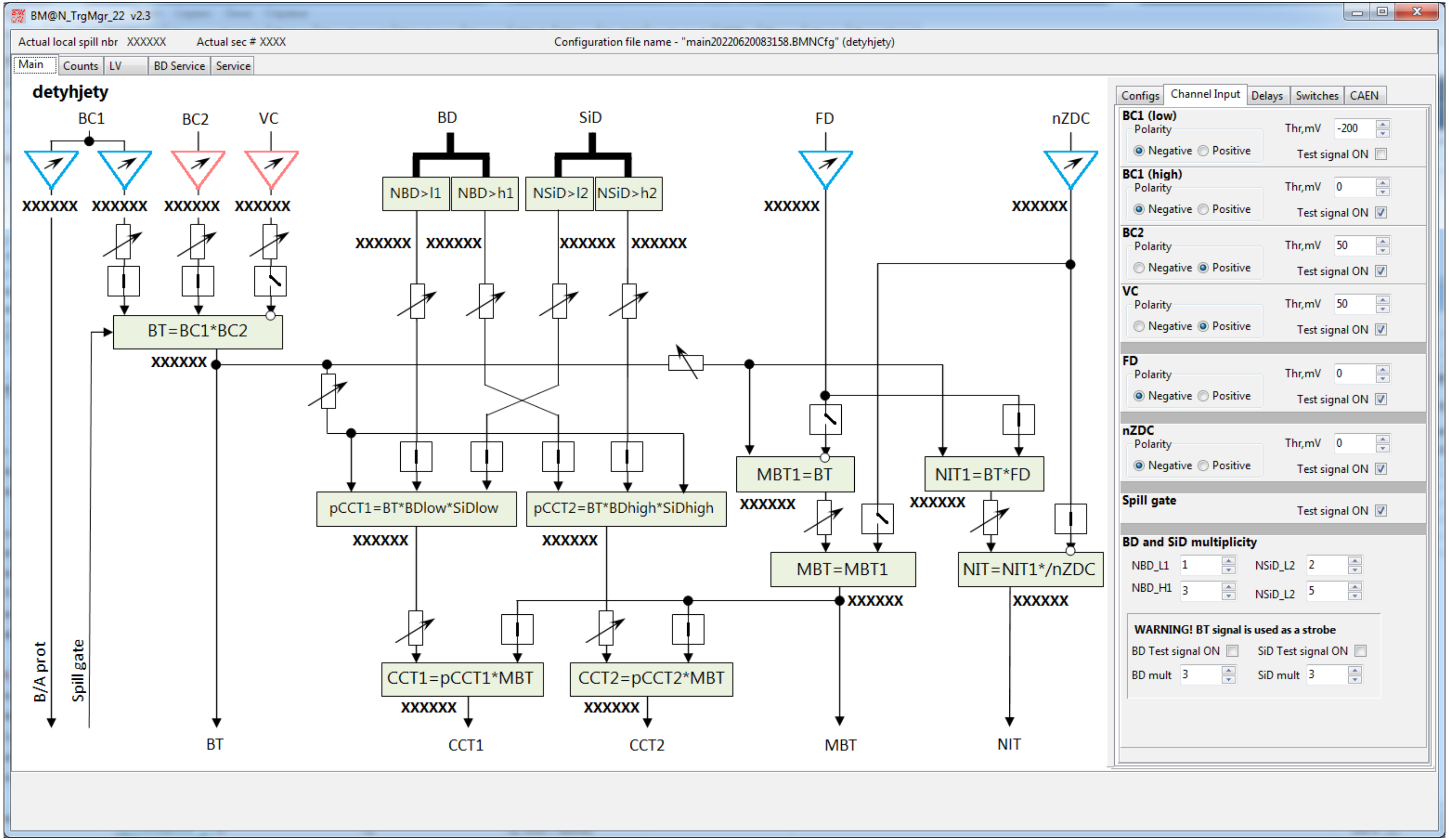
Optimized Z position (simulation will be needed)

Electronics:

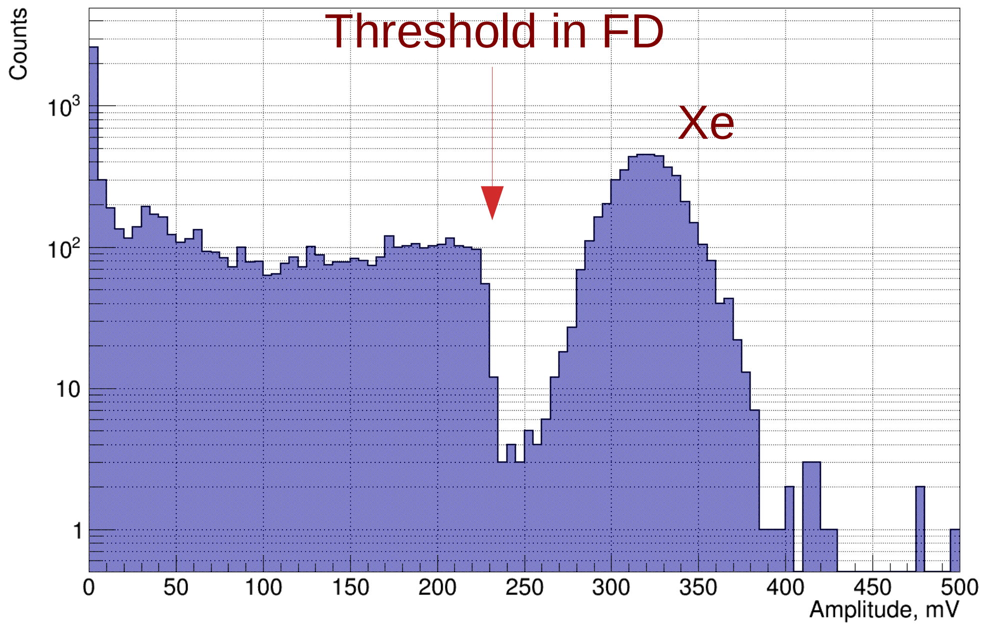
New FEE: higher threshold and fixed 12 ns pulses.

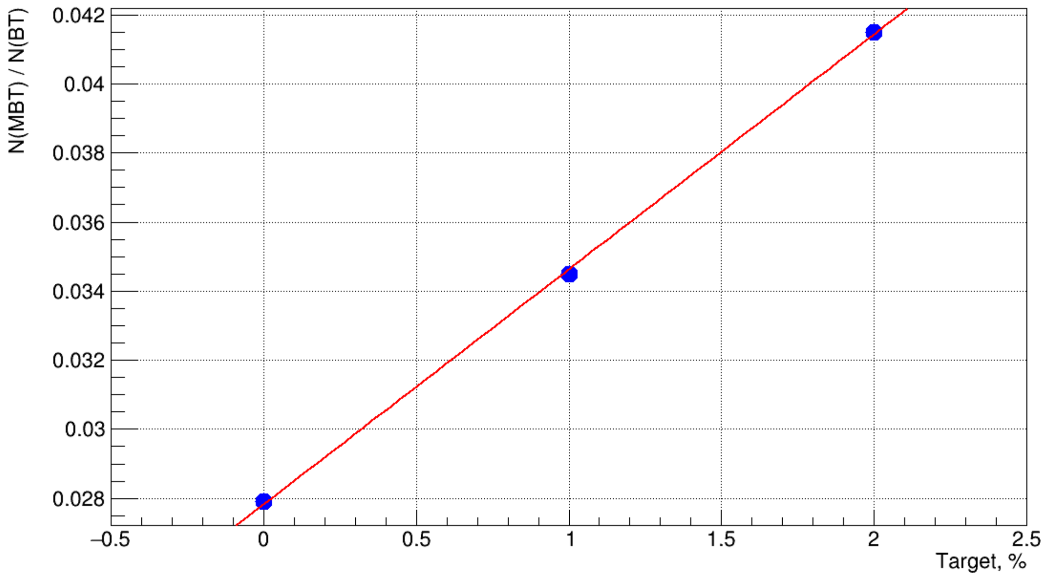
New T0U: added to the main T0U similar to SiMD.

T0U trigger logic scheme



Minimum Bias Trigger (MBT = BT • FD_{veto})





Good linearity with Empty, 1%, 2% targets;
N(MBT) / N(BT) for "empty target" ~0.028

Confirm that two close pulses in FD can cause false MBT.

Reproduce with laser system or generator. If confirmed, make modifications in T0U.

Introduce two thresholds in FD:
"soft" for MBT;
"hard" for CCT2

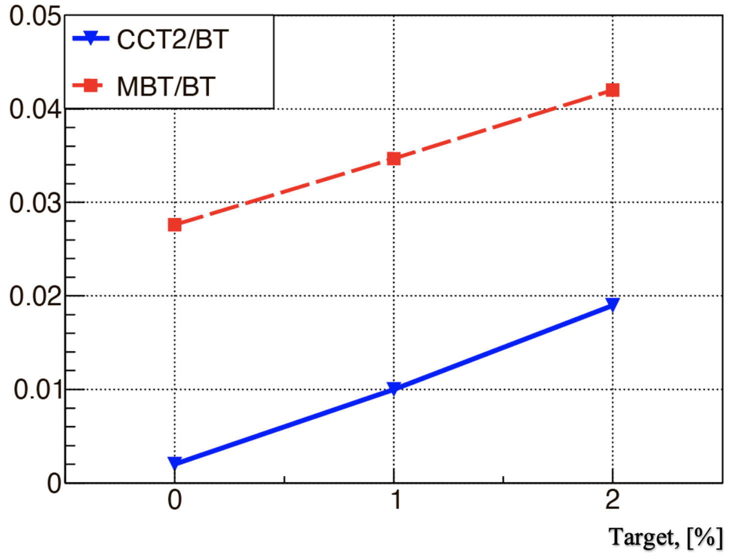
Material	Thickness, mm	Interaction probability %
Si BeamTracker	0.175	0.30
Ti vacuum window	0.08	0.17
FD, black tape, etc.	0.5	0.94
Air	150	0.21
FD, scint.	~0.1	~0.2
BC2, scint.+Mylar	~0.04	~0.1
		Total ~1.9

Central collisions trigger CCT2 = MBT • (BD≥n)

The backgrounds in triggers MBT and CCT1 are suppressed when MBT and CCT1 are combined in CCT2

Some non-linearity with 1% and 2% targets remains in CCT2, but becomes much smaller

N(CCT2) / N(BT) at BD ≥ 4



“Regular” mix of triggers used in data taking

Trigger	Downscaling factor	Fraction, %
BT	2000	3
MBT	35	7
CCT1	230	5
CCT2	1	85

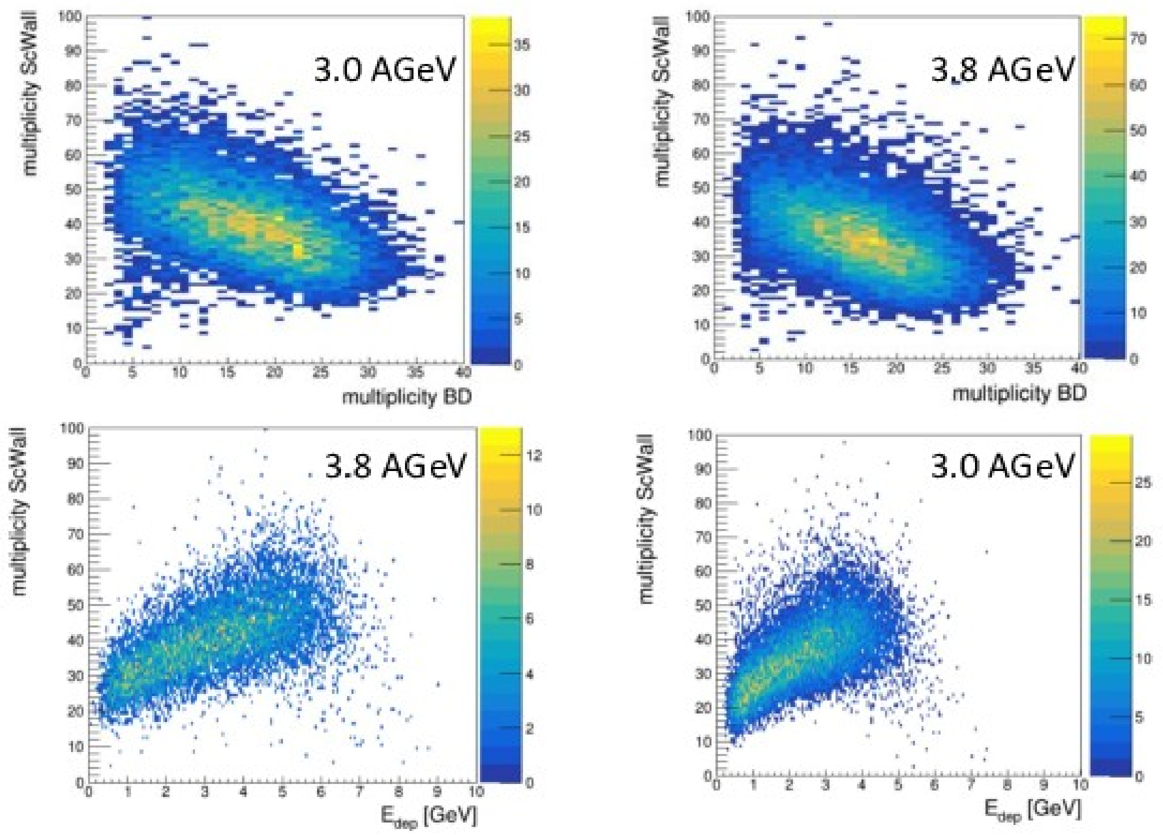
No major changes
If second amplitude threshold is added in FD, “hard” threshold will be used in CCT2.

Vadim Volkov. Recent talk on Baldin conference

Check if multiplicity in ScWall can provide additional trigger signal

All changes in the trigger logic should be fixed ”two month” before the run

Multiplicity in ScWall / multiplicity in BD



Multiplicity correlates with energy deposition in the calorimeter, and anticorrelates with multiplicity in BD.

Cuts:
BC1S
Z^2 (ScWall) > 0.4
vertex Z (-1.5 < Z <1.5)
Z^2 (FQH) < 100

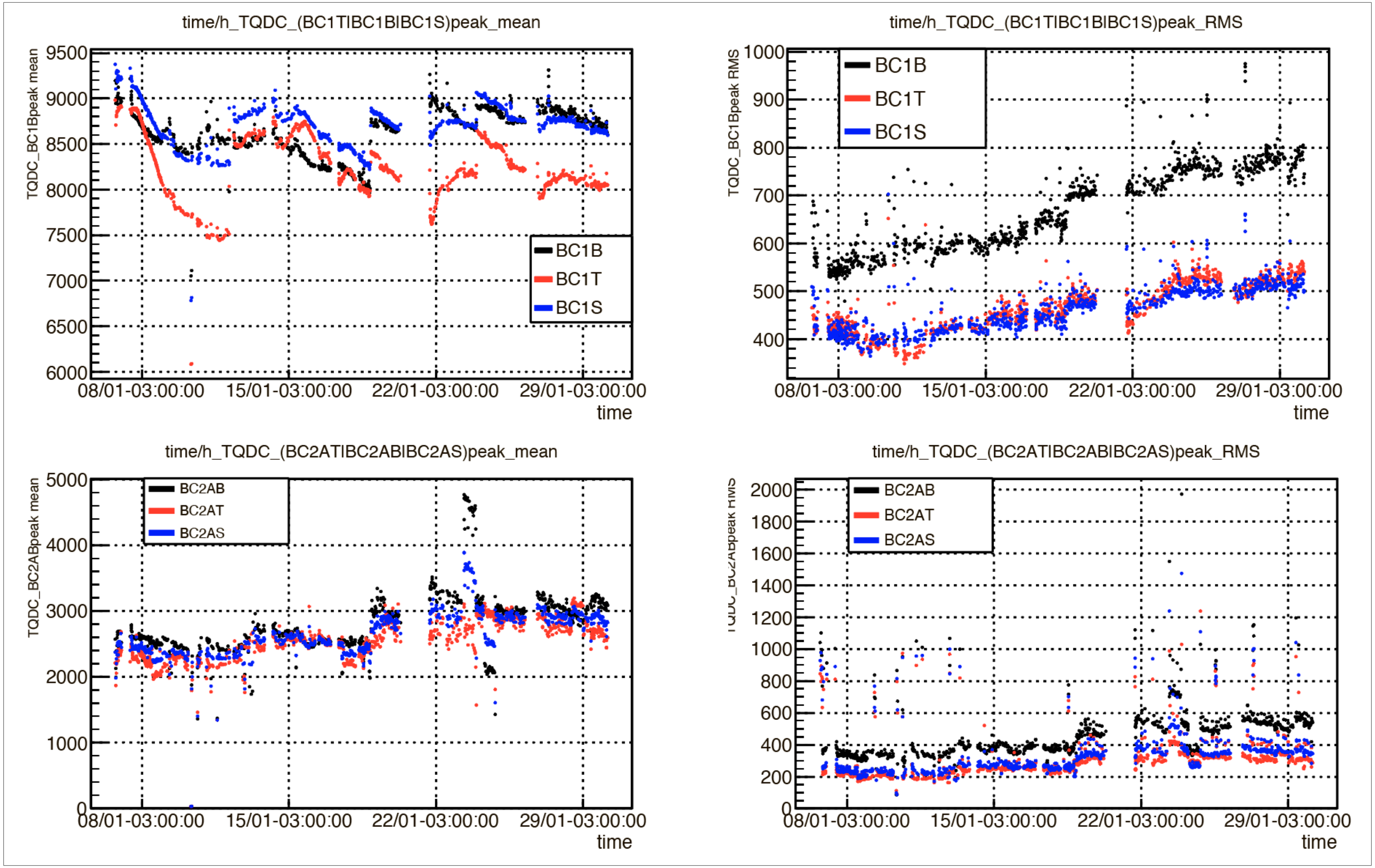
CCT2

9

Improvements in trigger setup and control tools can be addressed next time:

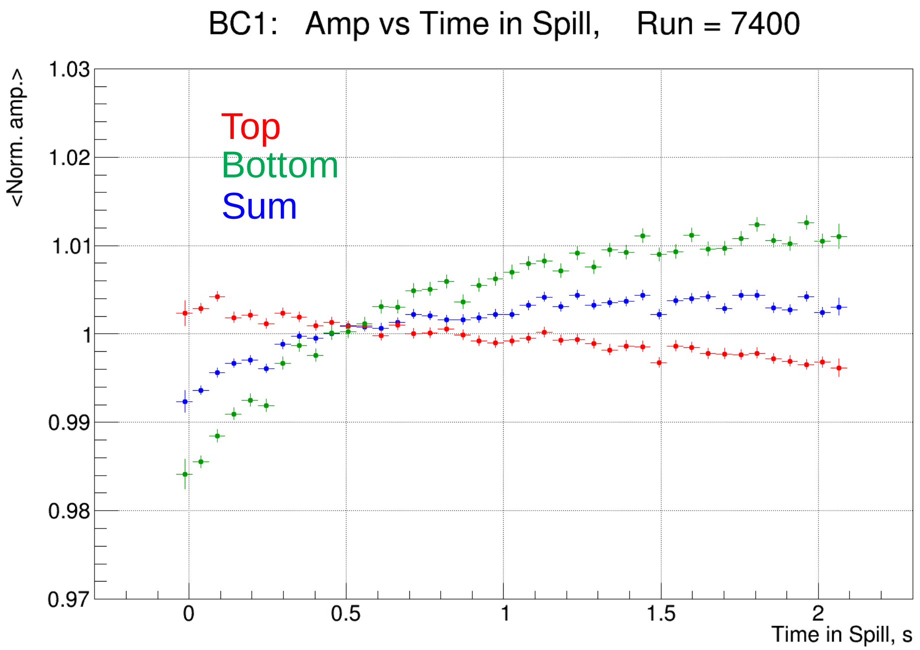
- *monitoring*
- *scalers*
- *multiple CAEN read-out*
- *read-out of logical trigger signals in CAEN and TQDC*
- *B/A related issues*

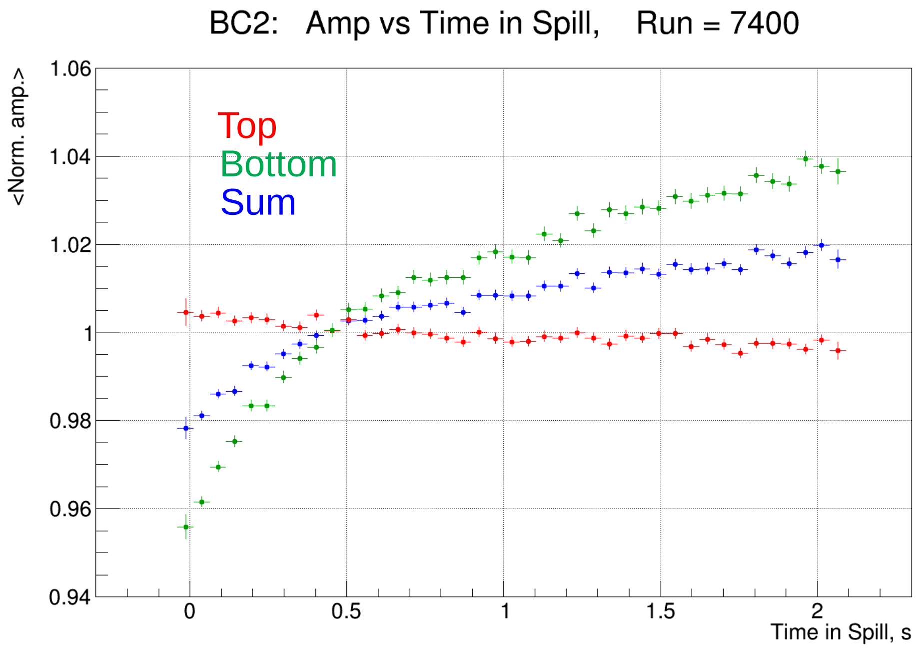
Monitoring of BC stability during the run



Oleg Golosov
MEPhI-group

BC1 and BC2: Amplitude stability in spill





- stable at 2-4 % level
- can be sensitive to (X,Y) beam movement during spill
- next step is to add Beam Tracker into analysis

Time resolution of BC1 and BC2

$$\Delta t_{ij} = t_i - t_j$$

$$\sigma_{ij}^2 = \sigma_i^2 + \sigma_j^2$$

i,j: *BC1, BC2, FD1*

Measured with additional FD1 counter, placed behind the FHCal hole.

FD1 is similar to BC1 in design, PMTs and scintillator (prepared by V.Velichkov).

Each of BC1 and BC2 have ≤ 45 ps resolution. Combined, they can provide ≤ 30 ps resolution.

Detectors	σ_{ij}, ps
BC1 - BC2	57
BC1 - FD1	61
BC2 - FD1	58
(BC1&BC2) - FD1	52

Detectors	σ_i, ps
BC1	43
BC2	38
FD1	44
(BC1&BC2)	28.2
	28.5