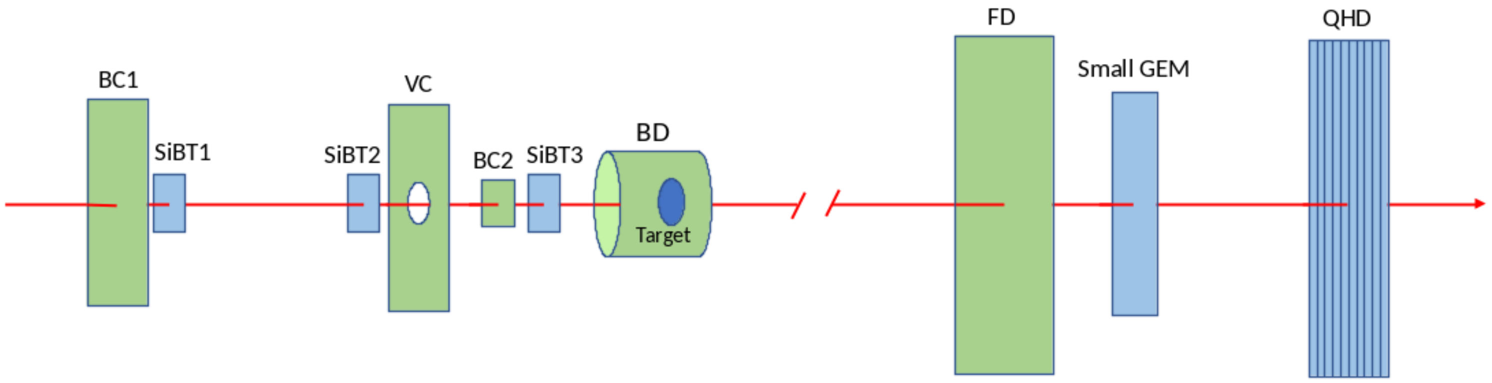
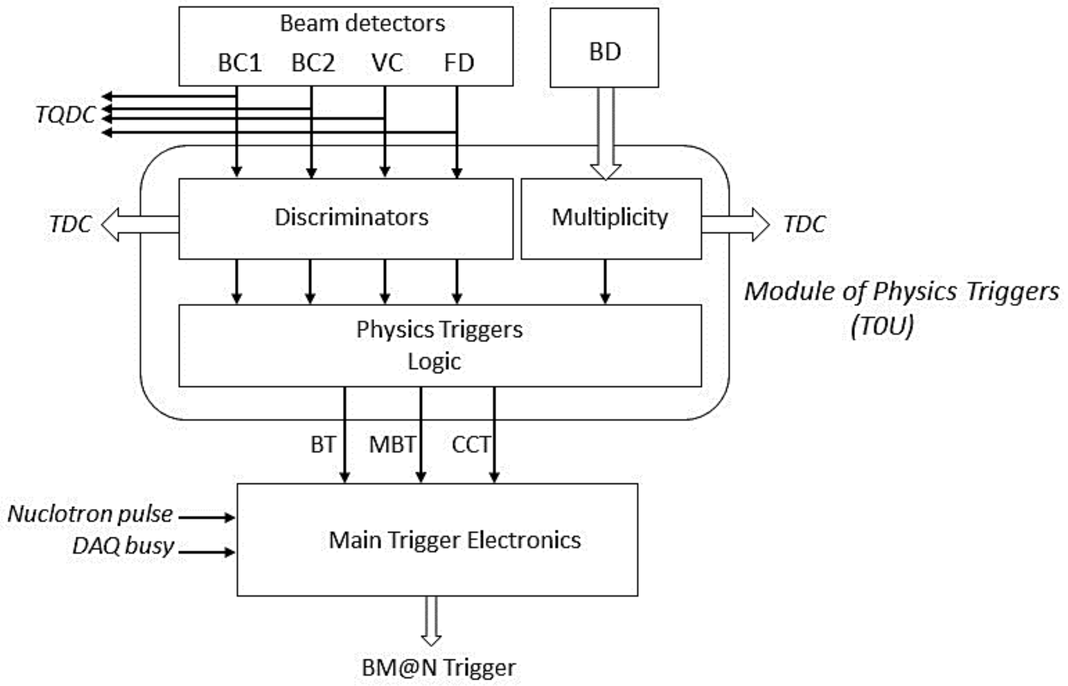
Status of the trigger system

Sergey Sedykh for the BM@N

11th Collaboration meeting of the BM@N experiment
November 29, 2023

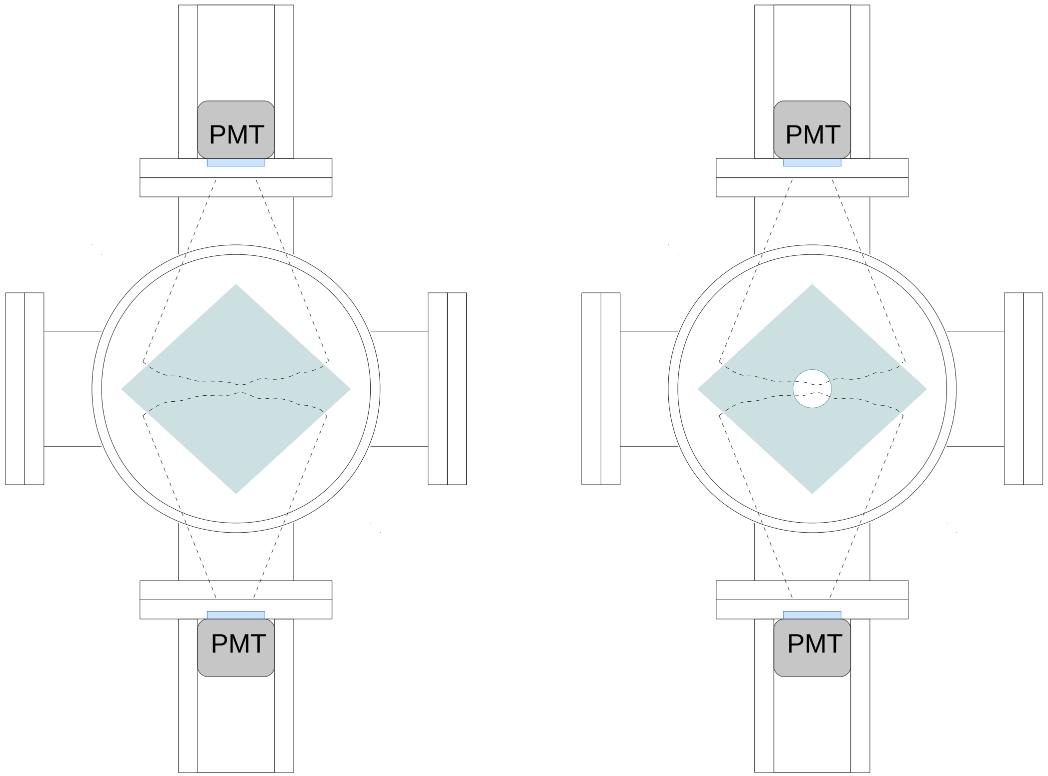
Overview of the trigger scheme in 2023 Xe run





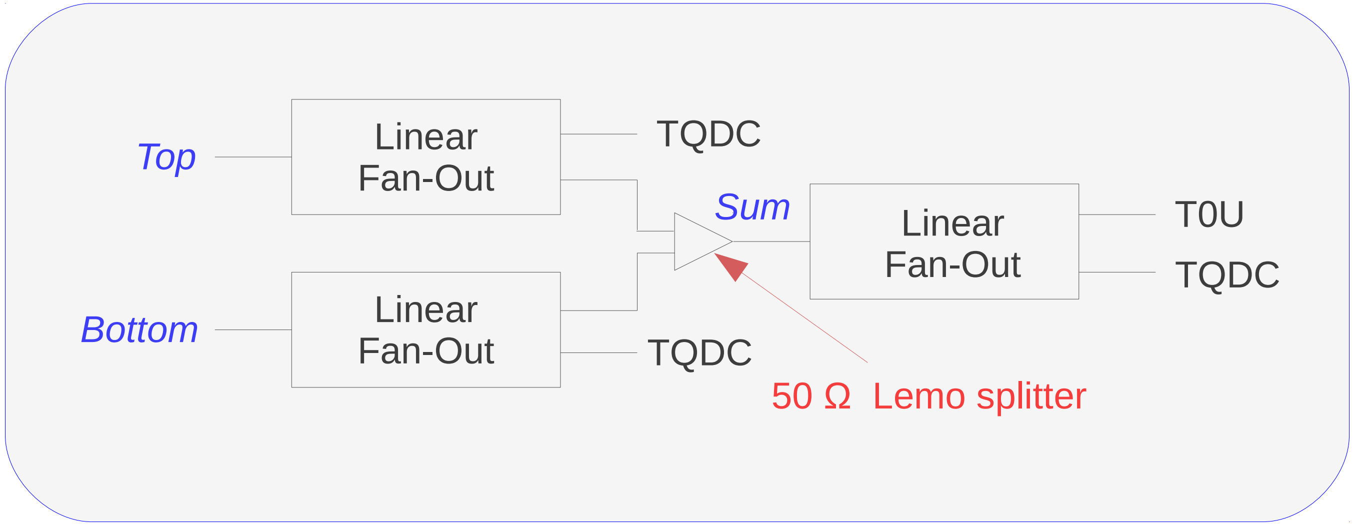
Trigger type	Trigger logic
Beam trigger	BT = BC1 * BC2 * VC_{veto}
Min. bias trigger	MBT = BT * FD_{veto}
Central trigger	CCT2 = MBT * BD (≥n)
BC1 (beam tuning)	BC1 = $BC1_{low}$
Beam trigger without VC	pBT = BC1 * BC2
Central trigger without FD	CCT1 = BT * BD (≥n)
Non-interaction trigger	NIT = BT * FD

Design and read-out of 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

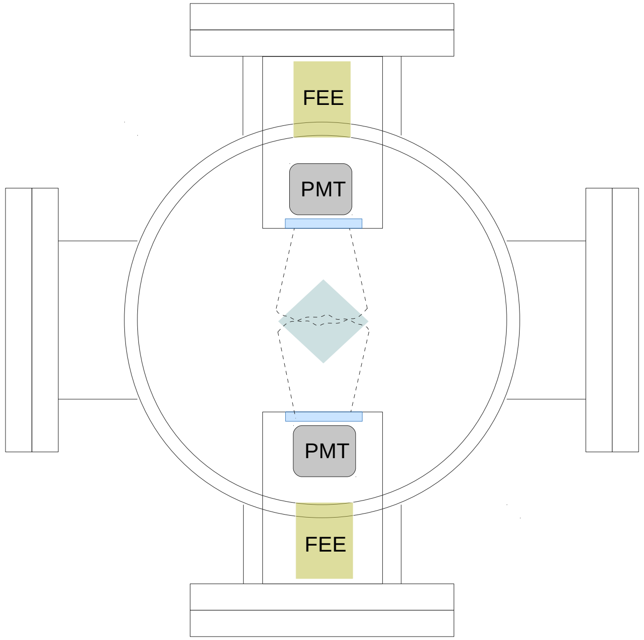
"Air"-lightguides from Al-mylar

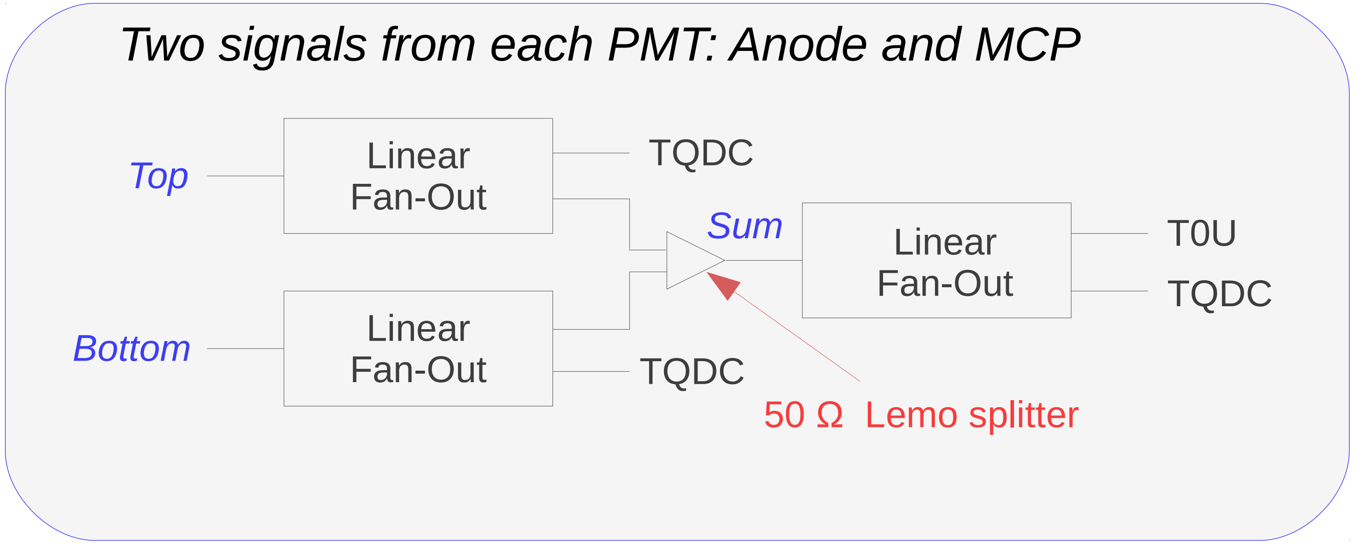


Design and read-out of BC2

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

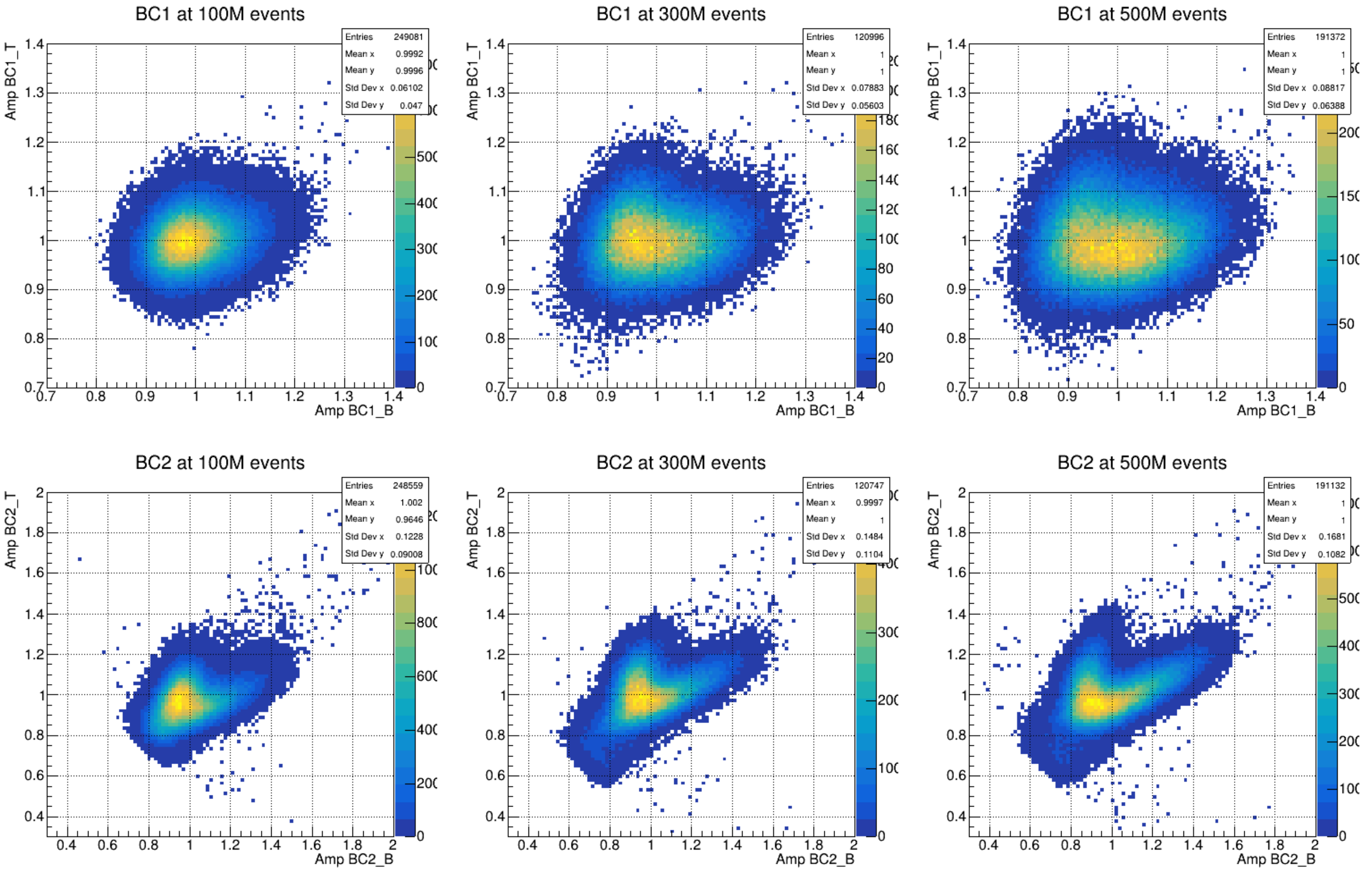
“Air”-lightguides from Al-mylar



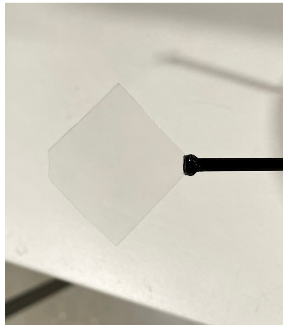


Additional read-out of LVDS signals from FEE into TDC72VHL.
Both, TQDC and TDC provide high resolution timing.

Indication of radiation damage in BC1 and BC2



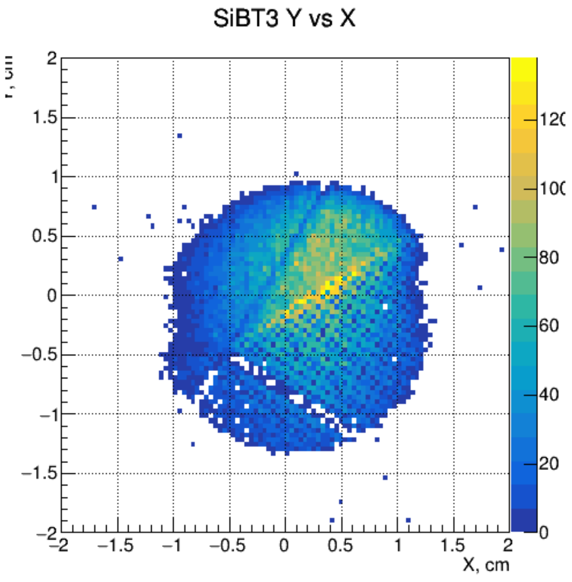
More pronounced in BC2

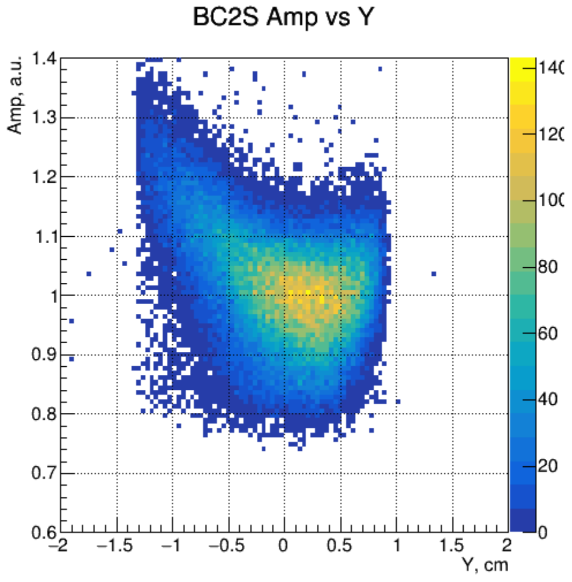


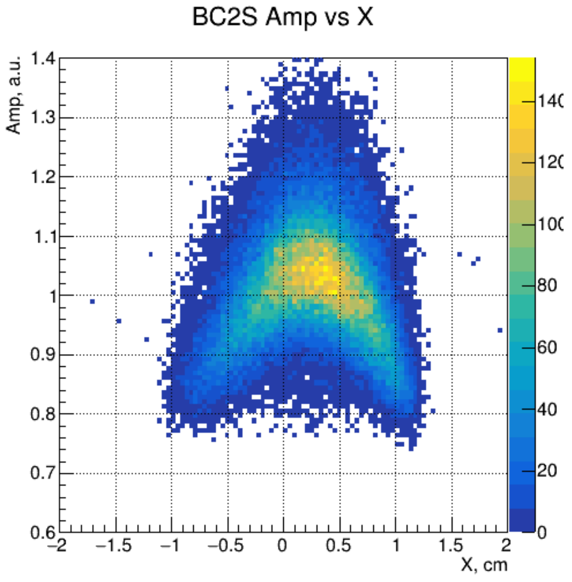
No visible effect in transparancy of the BC2 scintillator.

Study performed by the LPI RAS group didn't show any difference in transparancy of the middle part compared to outside

First look at BC2 with SiBT3







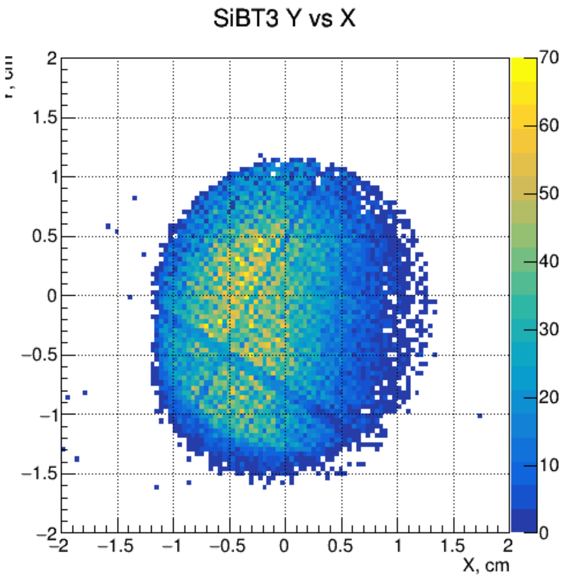
Runs 7361-67
(100M)

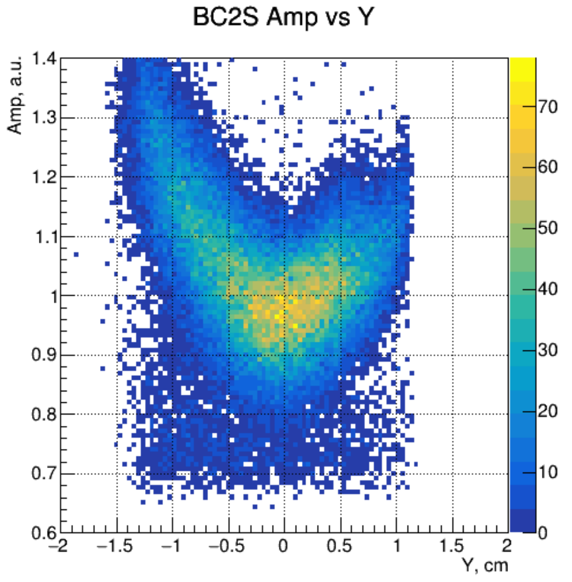
X and Y are taken directly from SiBT3, 20 cm in Z from BC2.

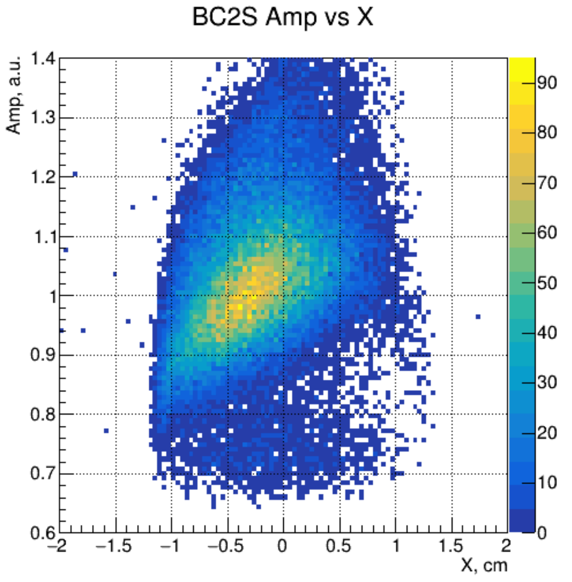
Unexpected X dependence (light collection non-uniformity?)

Analysis will be continued with the next production, once improved digitization of the SiBT is added.

Similar analysis will be done for BC1.





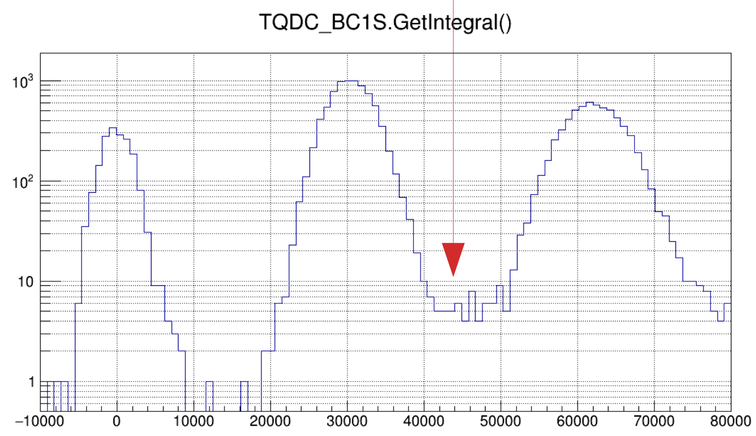


Runs 8421-26
(500M)

BC1 and BC2 RMS (%) at the start and at the end of the run

	BC1 S	BC1T	BC1B		BC2S	BC2T	BC2B
Initial	4.6	4.6	5.9		9.9	8.9	12.8
Final	5.6	6.8	8.8		11.6	11.6	15.7

No low Z additional pulses



BC1 Integral in 3.6 μs, a.u.

Continue to use BC1S and BC2S in the trigger.

Replace the scintillator for BC2 (it's out anyway), 9 spare scintillators are available.

In order to replace the scintillator of the BC1 one would need to take out the vacuum section, 7 spare scintillators are available.

Offline amplitude resolution

Detector	σ (%)
BC1	4.8
BC2	7.1
SiBT3 (expected)	3-4

Time resolution of BC1 and BC2

Measured with additional FD1 counter, placed behind the FHCal hole.
FD1 is similar to BC1 in design, PMTs and scintillator (*prepared by V.Velichkov*).
FD1 is saved ready for the next run.

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

BC2 signals have long negative tail, and for two close pulses (~100 ns) showed considerable decrease of the second pulse amplitude.
Therefore, replacement of the PMTs to Hamamatsu R2490-07 is planned.
(PMTs are available, the housing will be designed and made by V.Velichkov, V.Azorskiy). The current MCP PMTs will be also ready, if needed.

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

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

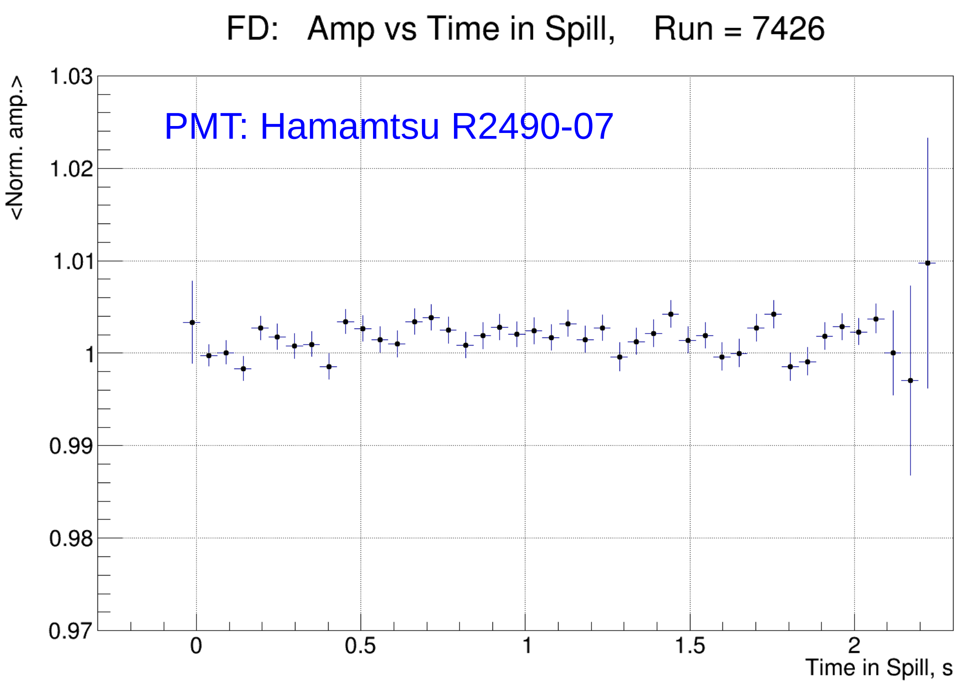
i,j: BC1, BC2, FD1

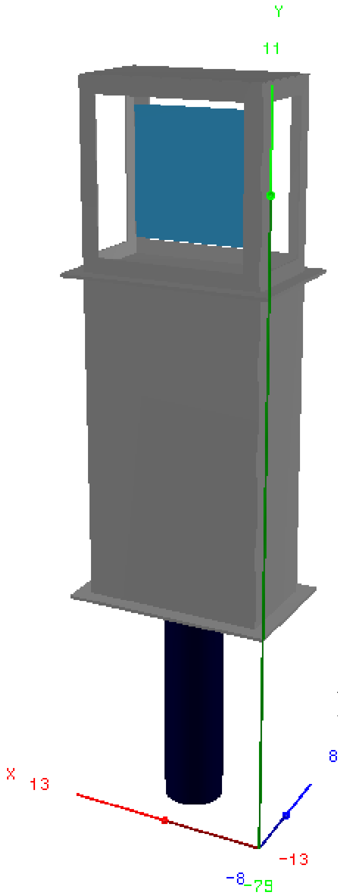
Detectors	σ_{ij}, ps
BC1 - BC2	57
BC1 - FD1	61
BC2 - FD1	58
(BC1&BC2) - FD1	52

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

FD design and response

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





Significantly better resolution with scintillator radiator.

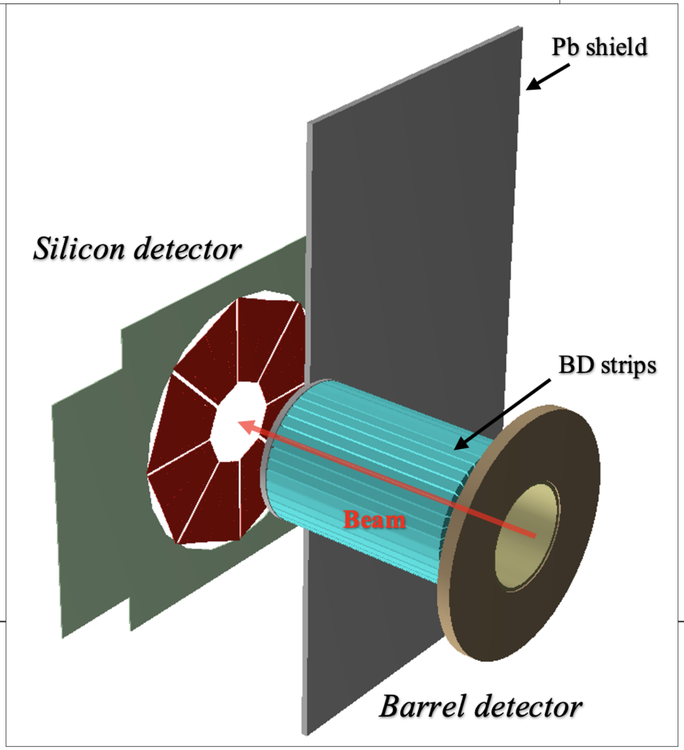
Quartz hodoscope has 2% resolution (FHCal group) and will be used in offline analysis.

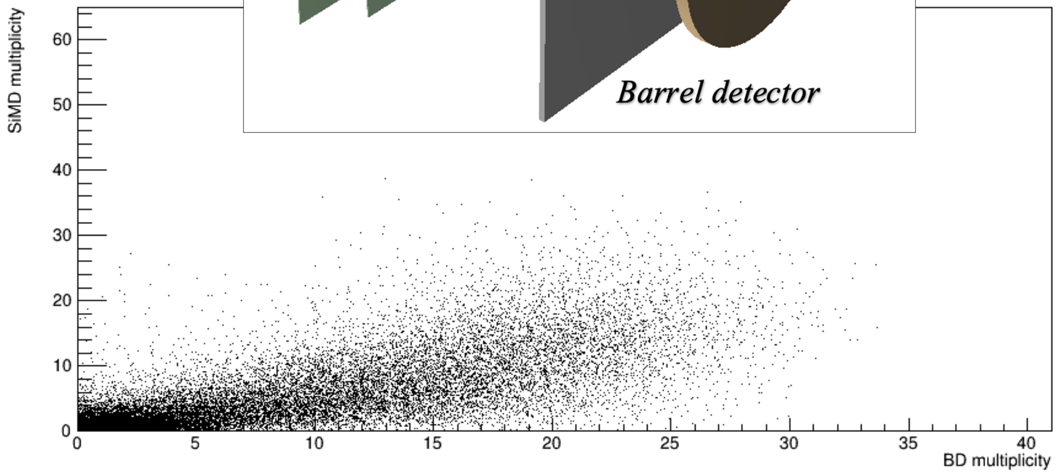
Current FD is ready for the next run.

Vacuum version is under consideration, but not yet designed.

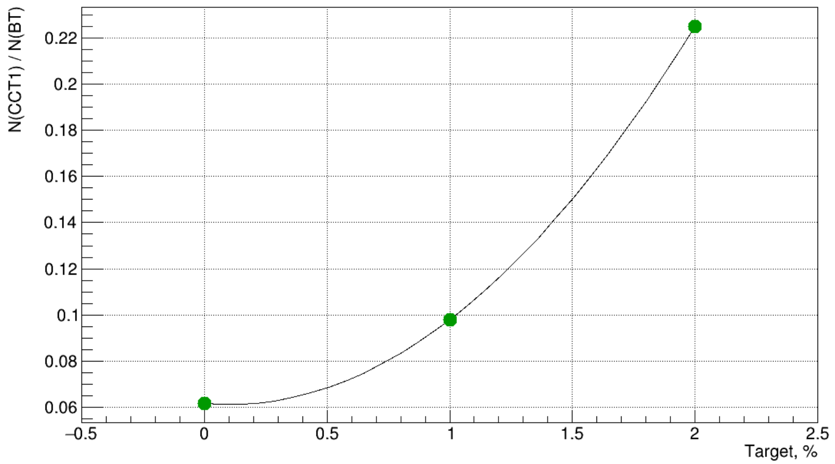
Multiplicity Detectors

- *Inner shield*: Pb - cylinder 0.3 cm thick;
- *Outer shield*: 25 x 50 cm^2, L = 0.5 cm.





N(CCT1) / N(BT) at BD ≥ 4



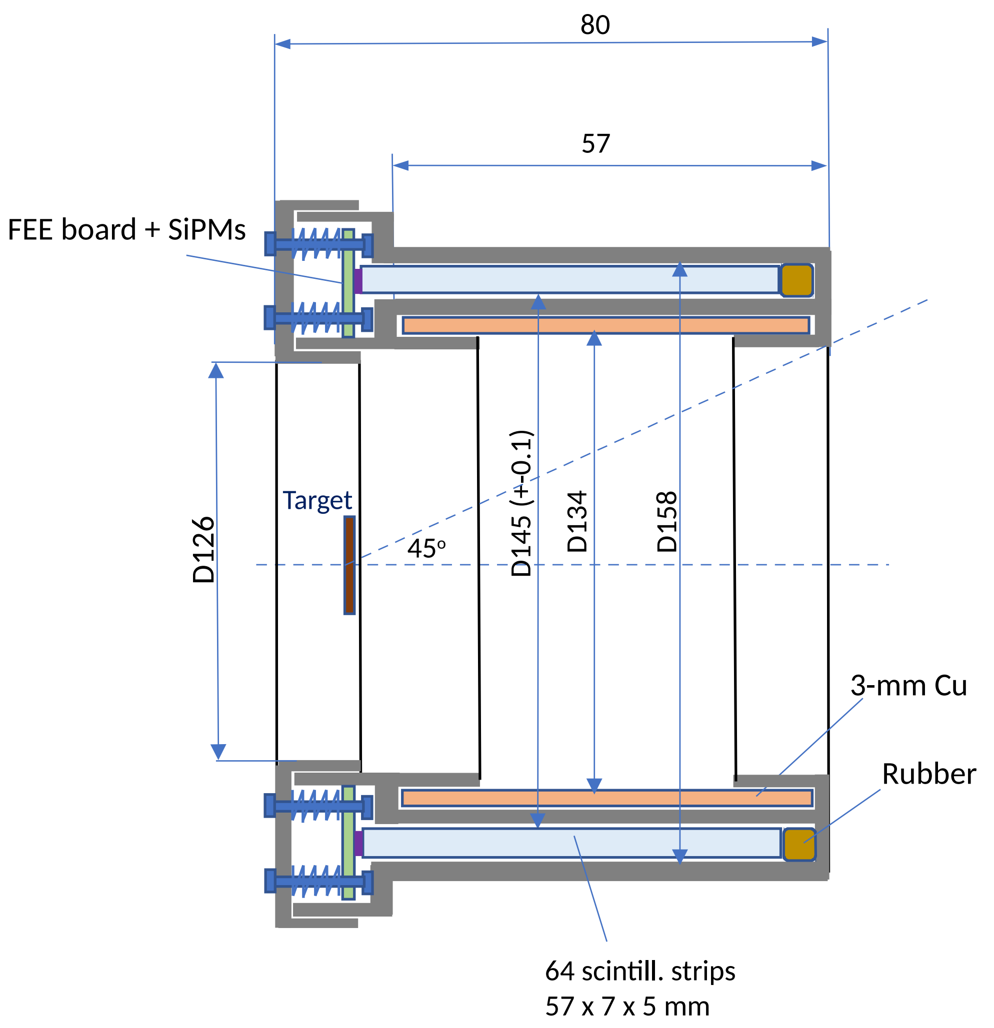
BD was sufficient in the last run, SiMD might be useful for the light ion beams. *(Should the SiMD be prepared for the next Xe run?)*

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. CCT1 rate is very non-linear with 1% and 2% targets (high sensitivity to pile-up of beam ions?).

Planned change in the handling of the BD pulses:
1) higher FEE threshold *(V.Rogov)*,
2) short pulses will be ignored in the T0U *(S.Sergeev)* ,
3) the multiplicity count will be not dynamical, as currently,
but locked at fixed time after BT *(S.Sergeev)*.

New Barrel Detector with 64 scintillation strips



BD granularity is increased from 40 to 64 channels for more efficient selection of central collisions.

57×7×5 mm scintill. strips and 3×3 mm SiPMs (J-ser. SensL) have been purchased in 2023

BD consists of two parts (right and left) with 23 channels each and simple installation around the vacuum beam pipe

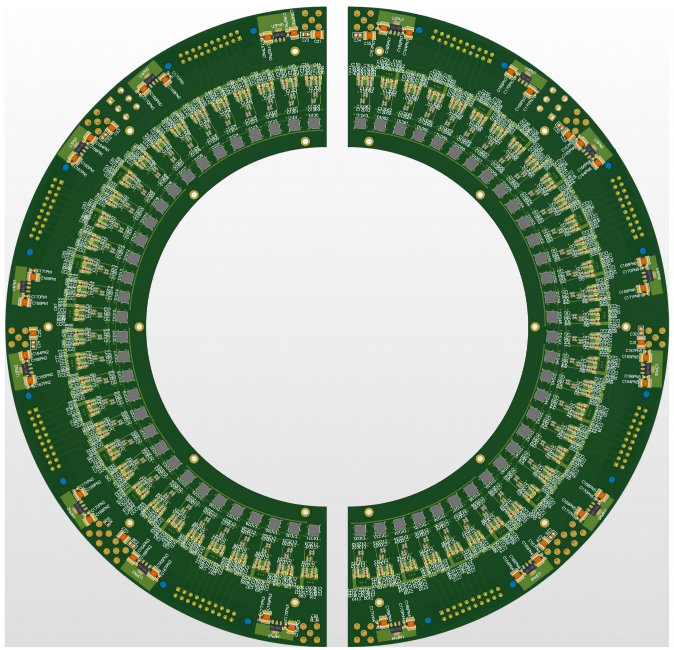
3-mm Cu layer instead of Pb one is used for the delta-electron protection to decrease the nuclear interactions of hadrons produced in the target

Purchased parts: SiPMs, scintillator strips, cupper.

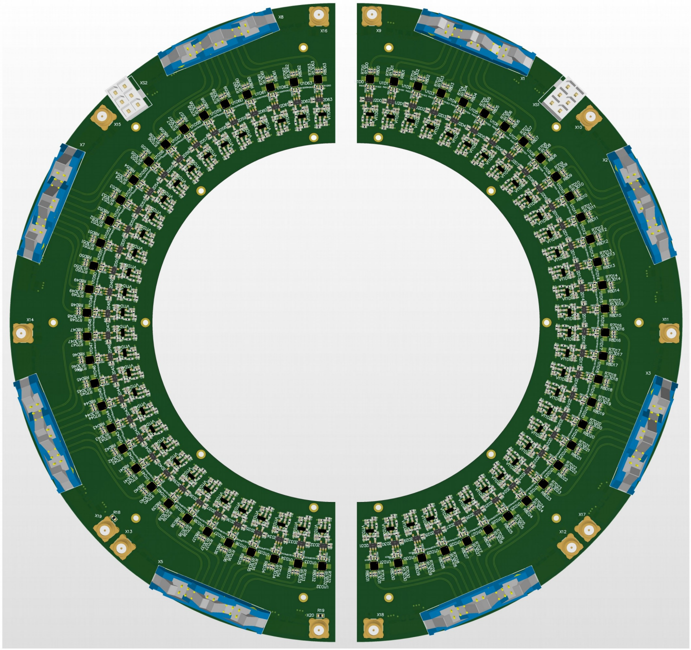
The new BD is planned not for the next run, but is ready, It might be used.

New shield simulation will be performed (*N.Lashmanov*).

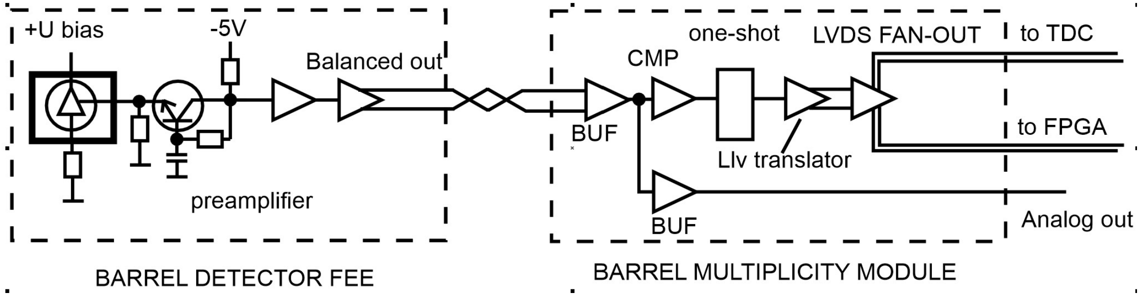
Electronics for the New Barrel Detector



FEE PCB SiPM side
(design)



FEE PCB connectors side
(design)

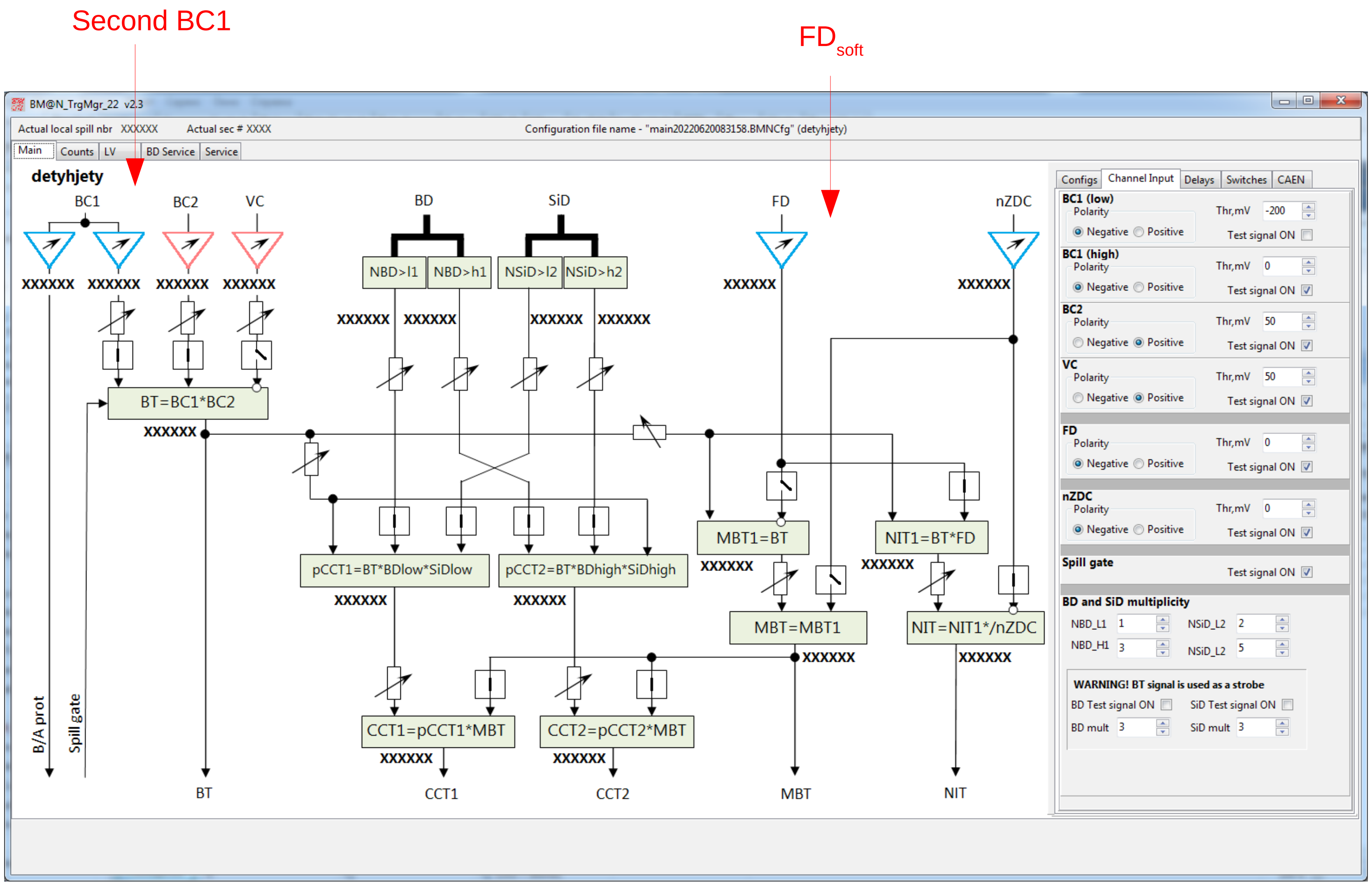


FEE design is in progerss (*V.Rogov*).

New T0U will be needed to implement new functionality (*V.Rogov, S.Sergeev).*

Main components for the T0U are available.

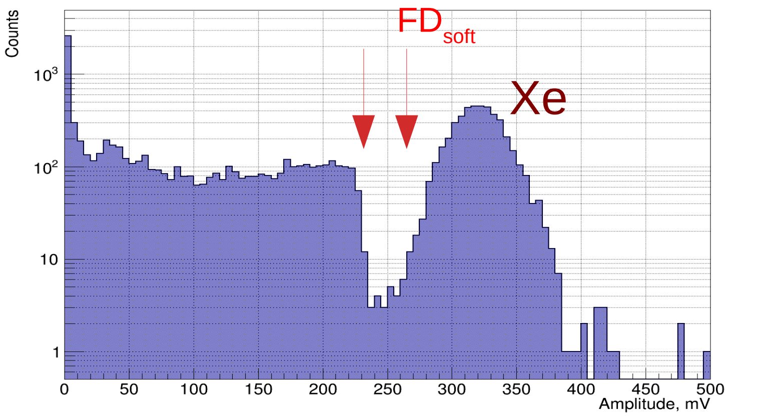
Planned modifications to the T0U trigger logic



1) Second threshold for FD signal

MBT_{hard} for CCT2 as now (i.e. 65-70%)

MBT_{soft} (~90%) with downscaling

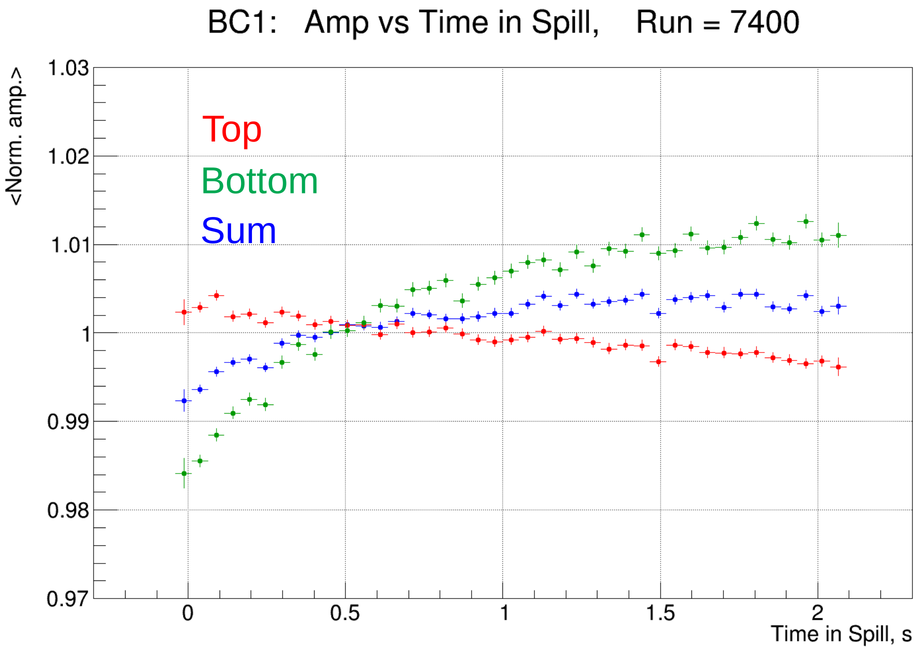


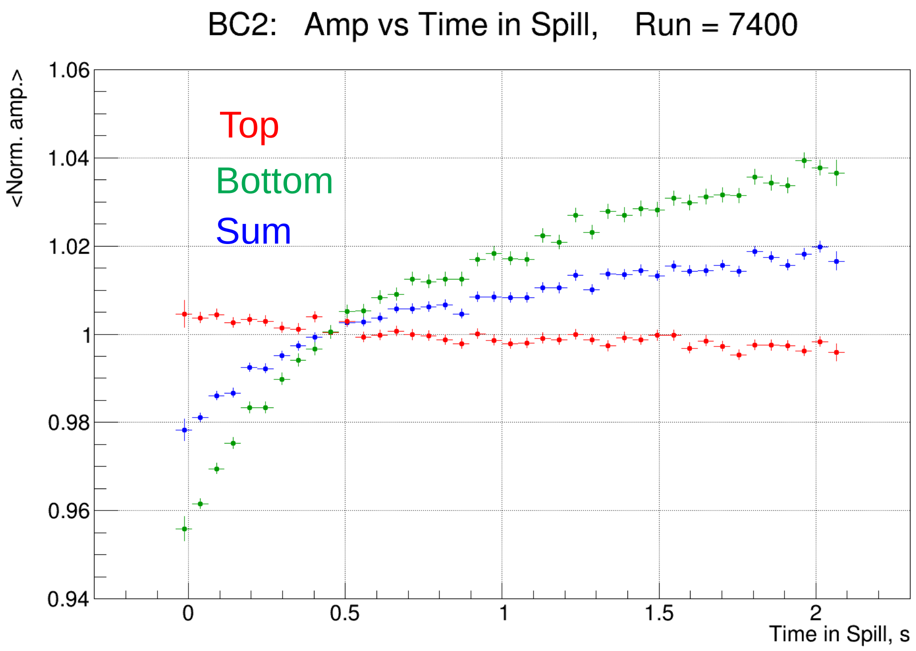
2) Second BC1 input signal
In order to reject close pile ups
at the T0U level.

3) Multiplexor output not only
to the scope (as now),
but also to CAEN digitizer.

Thank you for your attention

BC1 and BC2: Amplitude stability in spill. Offline resolution





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

Offline amplitude resolution

Detector	σ (%)
BC1	4.8
BC2	7.1

Good resolution of BTr3 is very important for offline rejection of upstream interactions