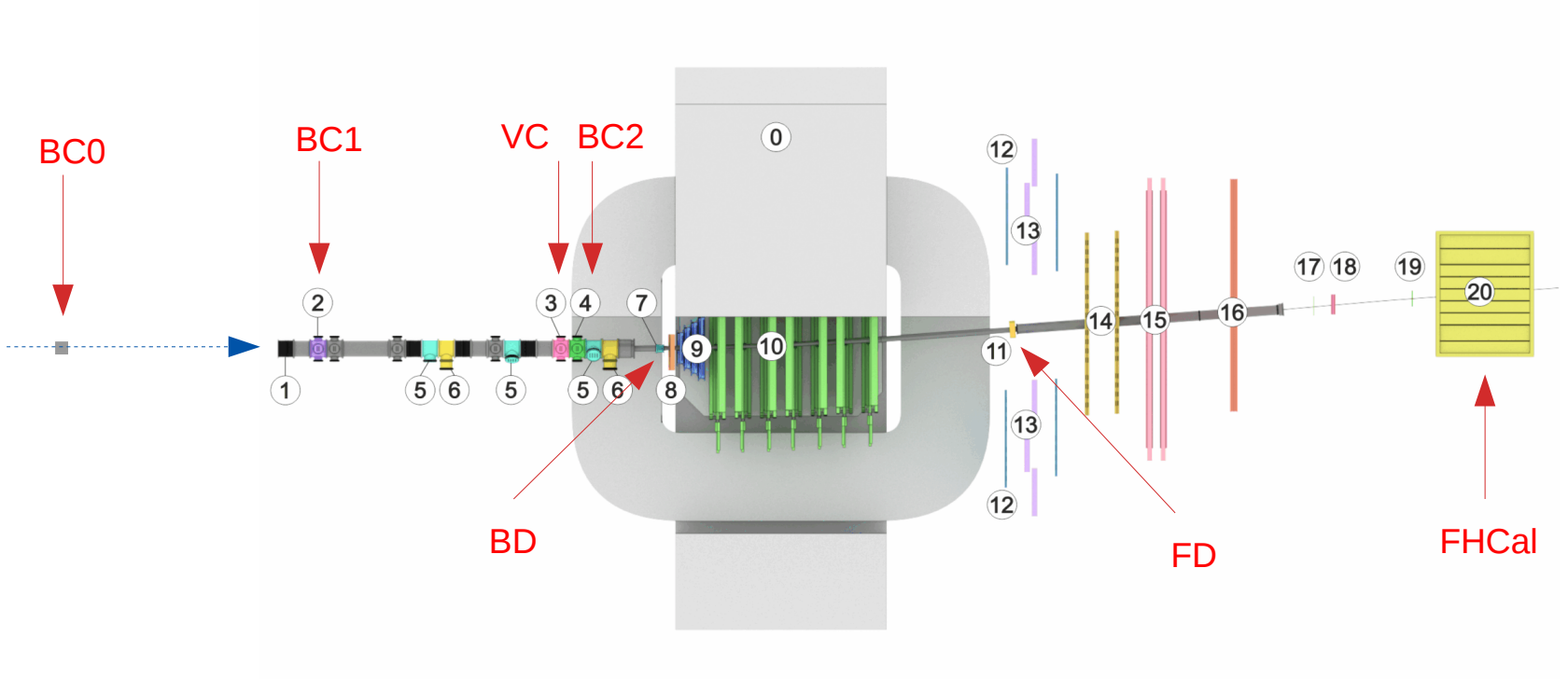
Status of the trigger system

Sergey Sedykh
for the BM@N trigger group

16th Collaboration Meeting of the BM@N experiment
May 13, 2026

Trigger detectors in the 2026 Xe run



Physics triggers

Beam trigger:

BT = BC1 x $\overline{\text{VC}}$ x BC2

No interaction trigger:

NIT = BT x $\overline{\text{FD}}$

Minimum and low bias triggers:

MBT = BT x $\overline{\text{FD}}$ (amp>high)

LBT = BT x $\overline{\text{FD}}$ (amp>low)

Centrality triggers:

CCT1 = BT x BD(n>th)

CCT2 = BT x BD(n>th) x $\overline{\text{FD}}$

CCT3 = BT x BD(n>th) x FHCal

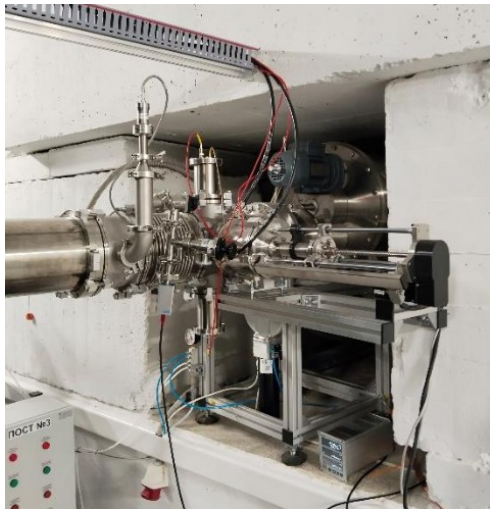
Main changes after 2023 Xe run:

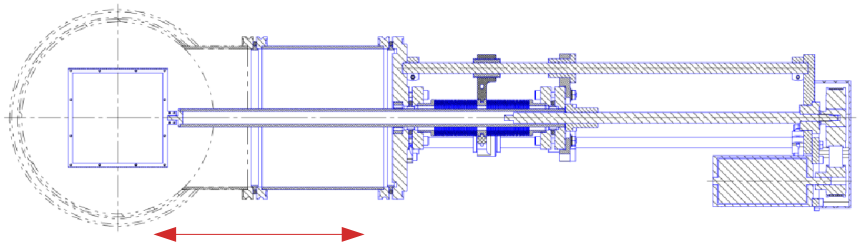
- added stand-alone BC0 trigger for beam tuning
- added close BC1 pile-up rejection in the Beam Trigger
- moved FD upstream and placed the scintillator in vacuum
- added second threshold in FD
- prepared and tested FHCal trigger

Upgrade of the beam counters

S.Novozhilov, S.Piyadin
V.Velichkov, V.Azorskiy, N.Lashmanov
Belgorod group

BC0 photo



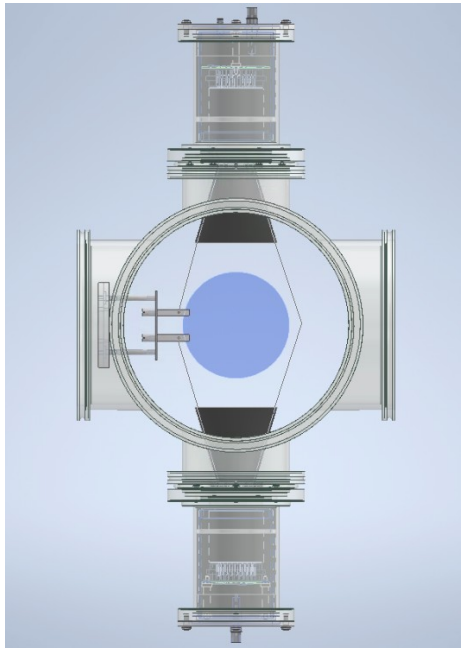


BC0

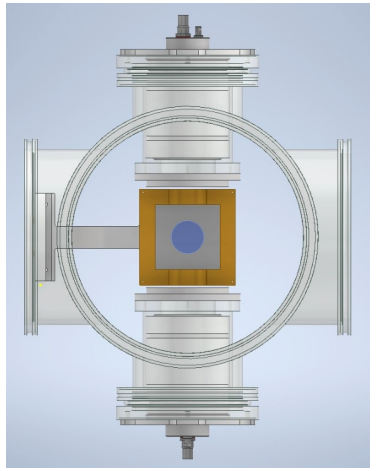
New detector at the entrance of the BM@N.
Scintillator can be moved in and out of the beam.
Used for beam tuning and time resolution of BC

Worked fine, one PMT was replaced.
In the next run BC0 will be used as is,
but the plan is to move it downstream, closer to BC1.

BC1 schematic view



BC2 schematic view



Time resolution:

BC1 ≈ 38 ps (43 ps in 2023)
BC2 ≈ 44 ps (38 ps in 2023)

BC1, VC and BC2

New vacuum boxes
with wider side openings.

New mount,
easy scintillator replacement.

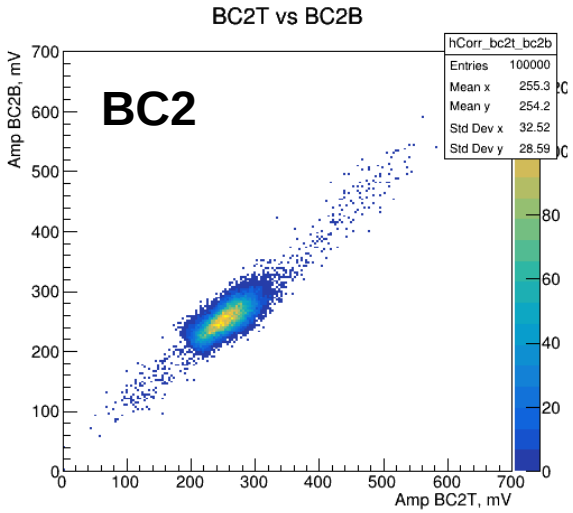
Different type of PMTs in BC2
(fine-mesh instead of MCP).

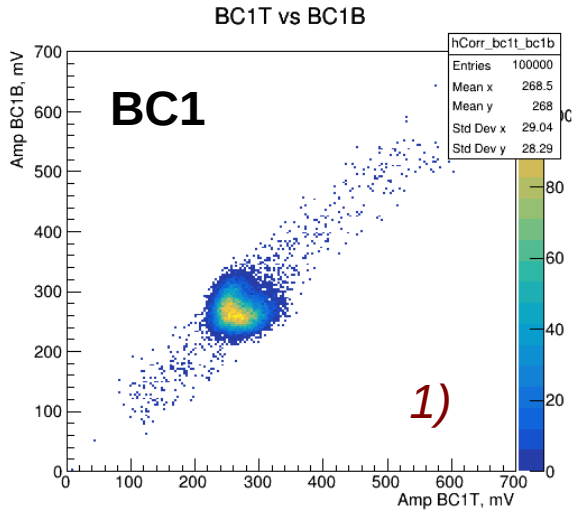
Run	Detector	σ/A (%)
2023	BC1	4.8
	BC2	7.1
2026	BC0	5.7
	BC1	5.1 → 11.3
	BC2	6.3 → 12.6

Replacement of scintillators in BC1, BC2, FD
takes about 1hr, but requires opening vacuum pipe.

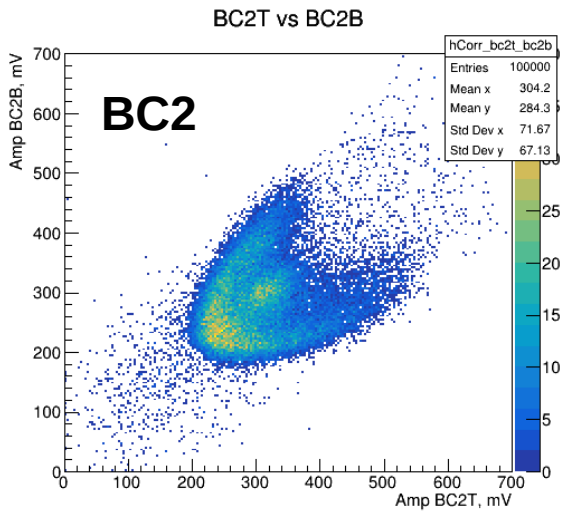
Keep as is, but, perhaps, go back to square BC2 scintillator
(40x40 or 40x60 mm^2) for easy alignment.

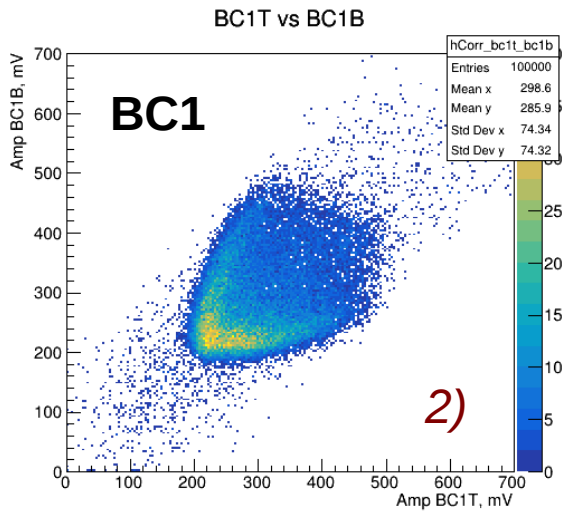
14.02.2026 Start of 2.2 AGeV





28.02.2026 End of 2.2 AGeV

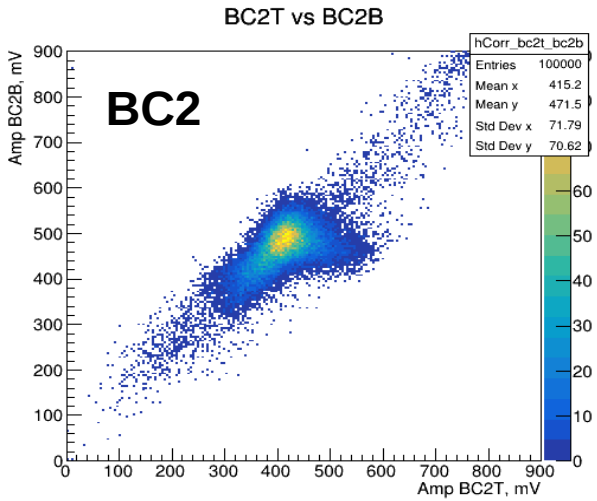


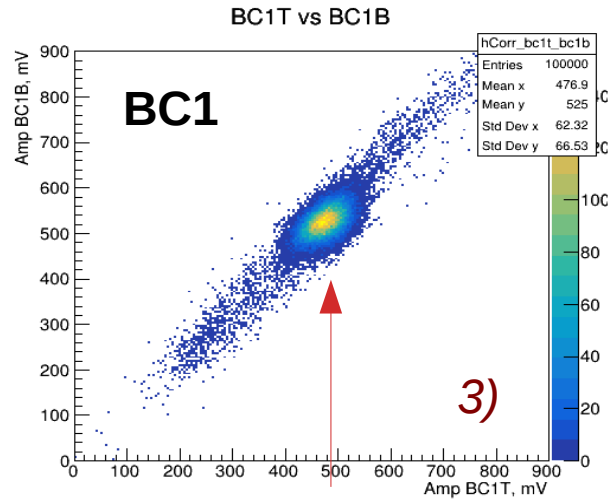


BC2S(RMS): 8.9→16 %

BC1S(RMS): 5.5→19 %

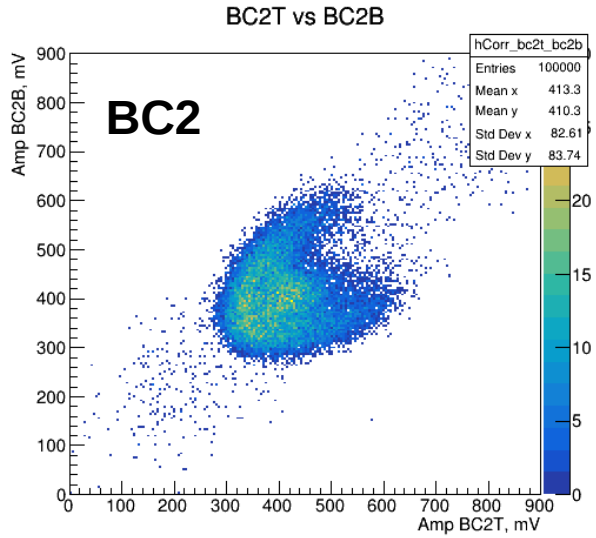
21.03.2026 Start of 3.0 AGeV

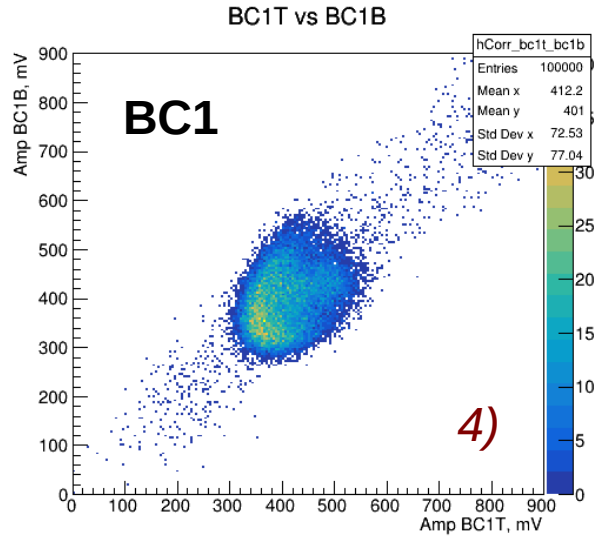




The same BC1 scintillator as in 2.2AGeV.
Recovered after being 1 month exposed to air.

01.04.2026 End of 3.0 AGeV



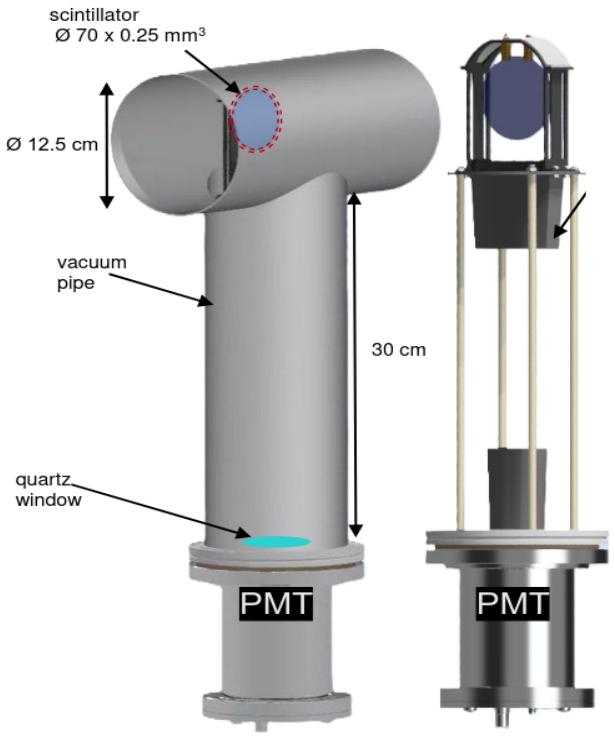


BC2S(RMS): 8.7→13 %

BC1S(RMS): 5.1→12 %

Upgrade of the fragment detector

S.Novozhilov, S.Piyadin
V.Velichkov, V.Azorskiy, N.Lashmanov
Belgorod group



FD schematic view



Photo of FD installed in the beamline

Run	Radiator	σ/A (%)
2023	Scint. 0.50 mm	5.3
2026 (26.01)	Scint. 0.25 mm	6.9
2.2 AGeV		7.2 → 9.8
1.6 AGeV		5.5 → 7.5
3.0 AGeV		5.9 → 12

Points for improvement in 2026 Xe run:

Reduced material between BC2 and FD radiators
- place FD radiator in vacuum
- exchange positions of BC2 and SiBT3

New location and shorter cable resulted in faster trigger signal from FD:

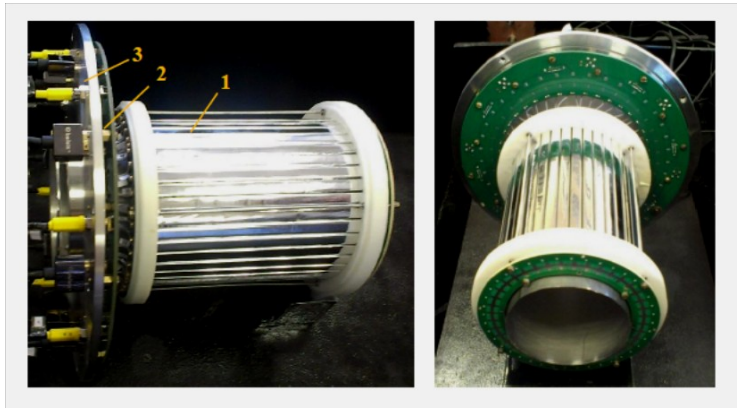
Δt (FD - BC1) = 67 ns
compared to 120 ns in 2023

Replacement of of FD scintillator is more tricky compared to BC1, BC2 and subject of potential displacement.

For 2027 run plan to keep as is.
Perhaps, we will put 0.50 mm scintillator for Kr beam.

Barrel detector

Target is located inside the BD



Barrel Detector (BD):
1 – 40 scintillation strips, 150 x 7 x 7 mm, BC418
2 – the board with SiPMs, Sensl C-series, 6 x 6 mm
3 – the board of front-end electronics.

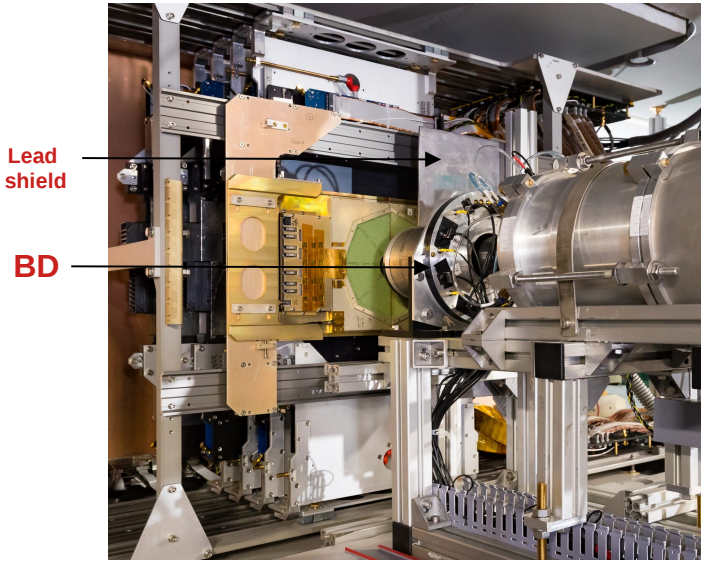
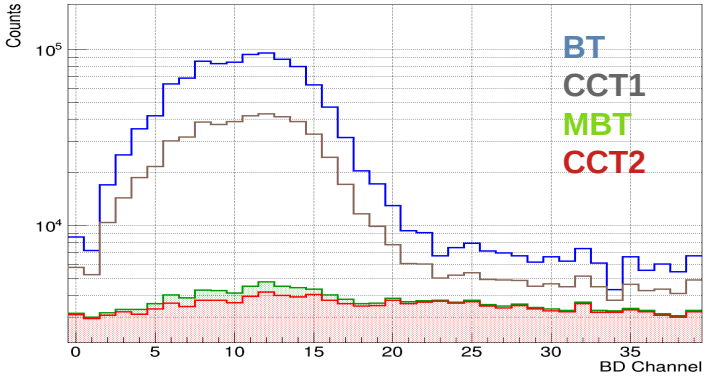
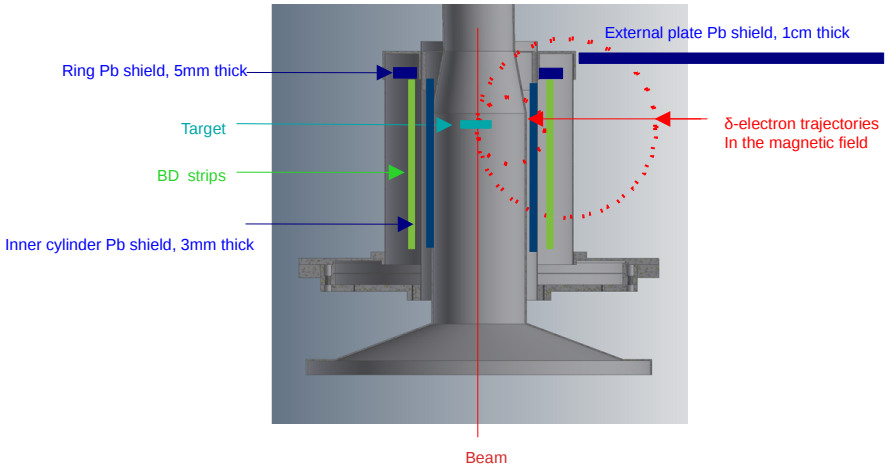


Photo of BD installed
in the 2023 setup

Strong background hits from δ – electrons, curved in the magnetic field and hitting right side of the BD.



Distribution of hits in BD strips
for different triggers in 2023 run



Target section of carbon
vacuum pipe and BD

For BD>3 in 2023 Xe run:

N(CCT1) / N(BT) ≈ 0.22 at 3.8 AGeV
N(CCT1) / N(BT) ≈ 0.11 at 3.0 AGeV

For BD>3 in 2026 Xe run:

N(CCT4) / N(BT') ≈ 0.07 at 3.0 AGeV

Potential improvement in 2026 Xe run:

Suppressed counts of short pulses (< *6 ns*) in T0U (P.Grigoriev).

Keep as is for the next run.

Choice of LBT as the main trigger

MBT and CCT2 in 2023 Xe run:

for 2% target and 70% centrality

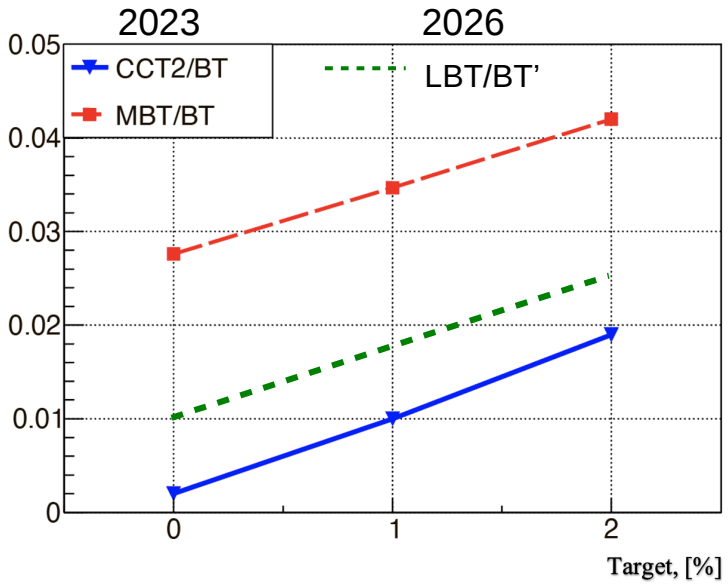
$$N(MBT) / N(BT) \approx 0.042 = \underset{\text{(signal)}}{0.014} + \underset{\text{(background)}}{0.028}$$

$$N(CCT2) / N(BT) \approx 0.018 = \underset{\text{(signal)}}{0.014} + \underset{\text{(background)}}{0.004}$$

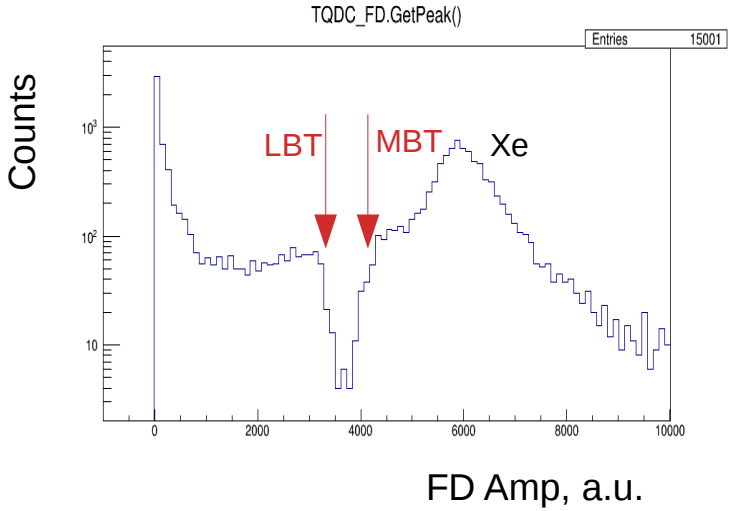
LBT in 2026 Xe run:

$$N(LBT) / N(BT') \approx 0.025 = \underset{\text{(signal)}}{0.015} + \underset{\text{(background)}}{0.010}$$

$$N(MBT) / N(BT') \approx 0.06\text{-}0.10$$

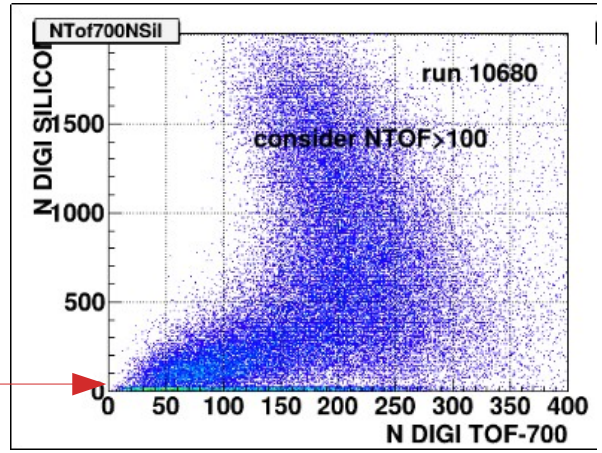


Compared to 2023 MBT backgroud in 2026 LBT was reduced by a factor of 3, while 10 was expected



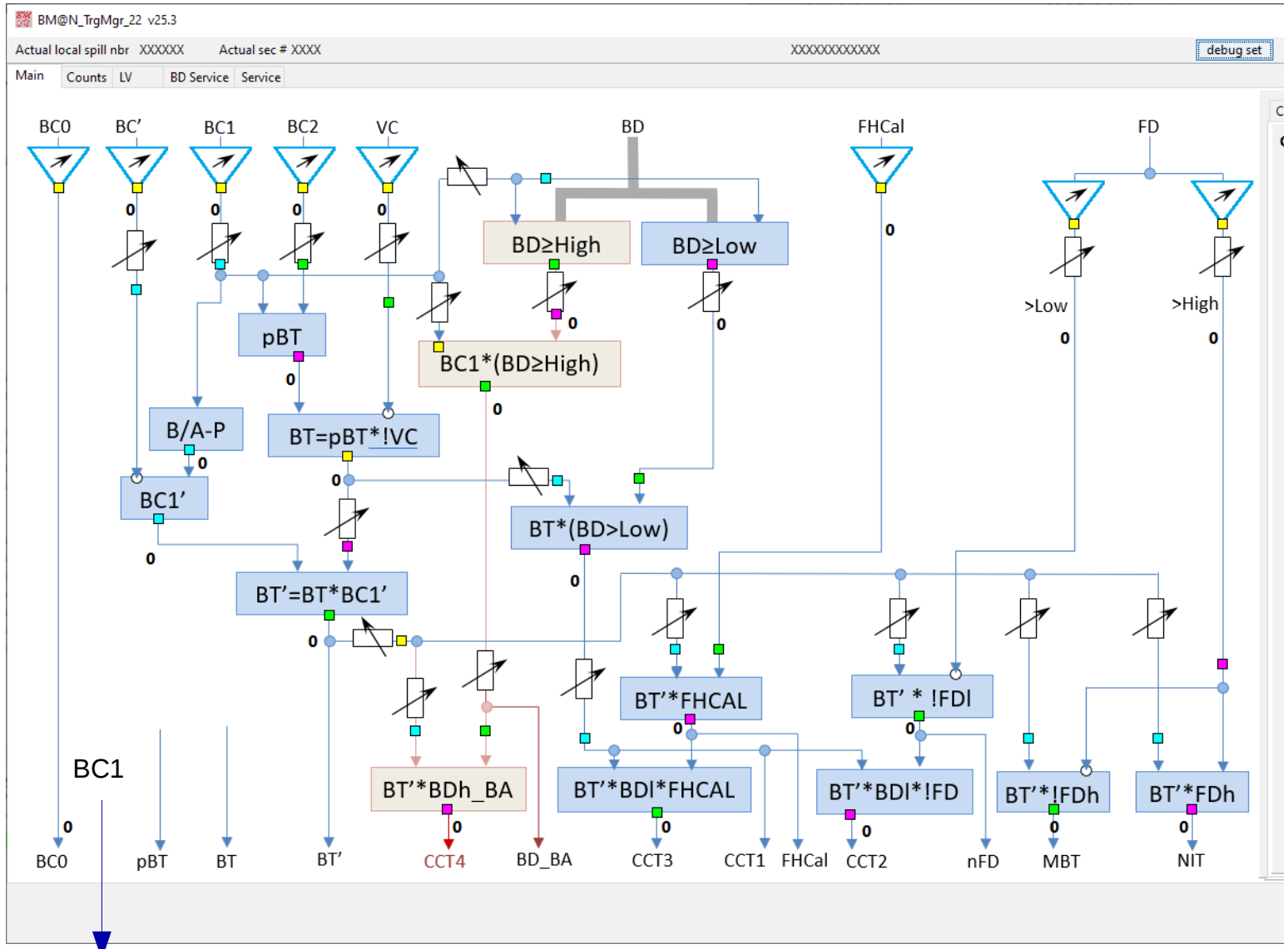
Trigger	Downscaling	Fraction, %
LBT	1	>90
MBT	250	~1
CCT1 (BD>2)	150	~3
BT'	2000	~1

Additional background from beam ions missing FD



Implementation of trigger logic in T0U

S.Sergeev,
P.Grigoriev



0 10 10 58 63 63 62 65 65 ← Relative delays, ns

Changes in T0U for 2026 Xe run:

Added B/A protection for close pulses in BC1 (± 40 ns)

BC1, BT without protection
BT' with protection

FPGA delays without dead time

Two thresholds for FD (LBT and MBT)

CCT3 with FHCal

Plans for 2027 Kr run:

Remove triggers which were tested and no longer needed:
FHCal, CCT3, BD_BA, CCT4, but keep FHCal_Sum in TQDC

Trigger monitoring

1) Spill by spill monitoring of trigger counts

BM@N TRG MGR Beam Feb.2026

Spill nbr. 0000125334 23.02.2026 00:15:08

Detectors

BC1	1673542
BC2	1624052
VC	39977
BC' (BC1 high)	79933
NBD≥Low	159406
NBD≥High	165800
FD Low	1571515
FD High	1497137
FHCAL	289362
BC0	0

Triggers

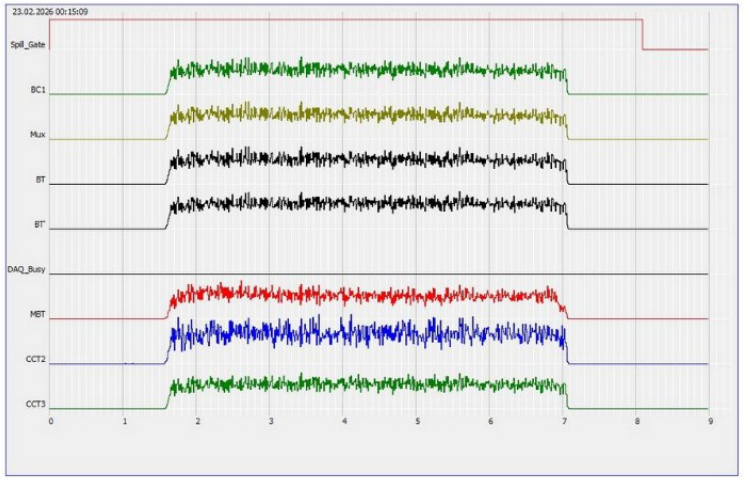
BT	1618102
BT'	1395001
MBT	100527
NIT	1294740
LBT	33224
CCT2	21904
CCT3	186416
CCT4	118865

Internal signals

CCT1	137972
BD_BA	1501013
DAQ_Busy	0
PBT	1627859

Ratios

BC2/BC1	0.97043
VC/BC1	0.02389
BC'/BC1	0.04776
NBD≥Low/BC1	0.09525
NBD≥High/BC1	0.09907
FD_Low/BC1	0.93904
FD_High/BC1	0.89459
FHCAL/BC1	0.17290
BT/BC1	0.96687
BT'/BT	0.86212
MBT/BT'	0.07206
NIT/BT'	0.92813
LBT/BT'	0.02382
CCT1/BT	0.08527

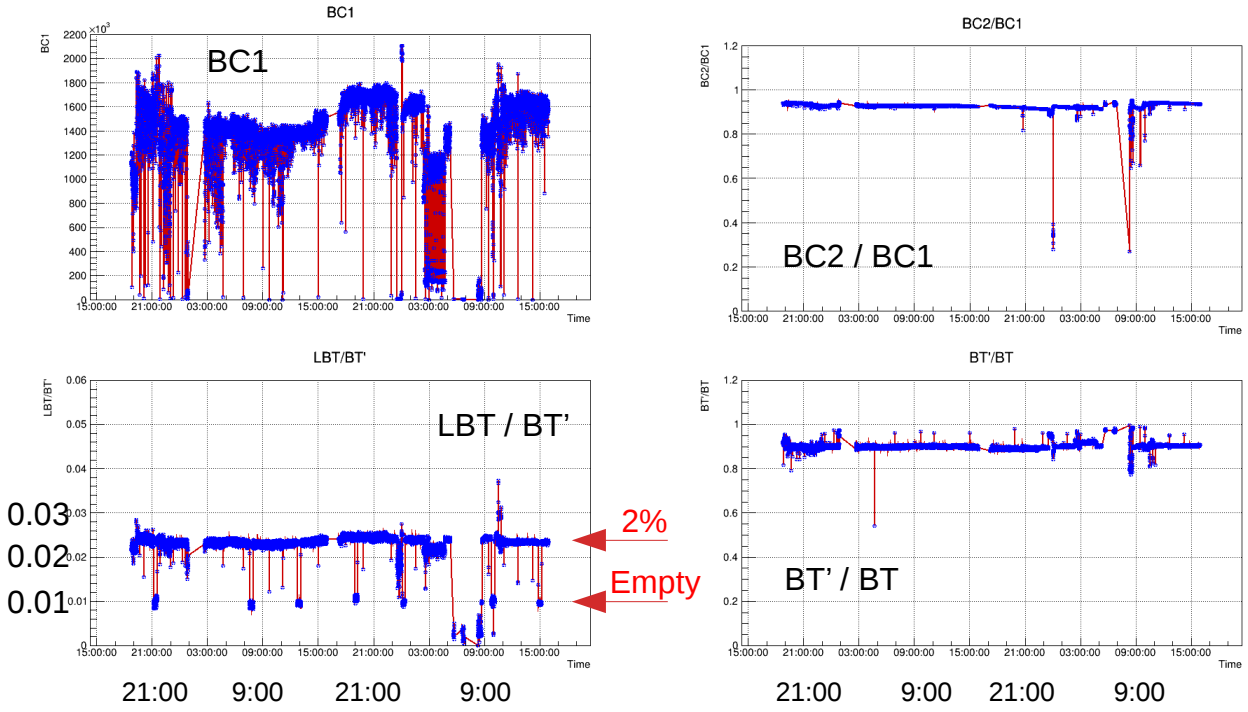


T0U counts in spill (by Sergey Sergeev)

2) Regular run by run monitoring of counter amplitudes in trigger mix

In bmn-mon histograms added
selection of BC, FD, BD pulses
in a narrow trigger window (by Ilnur)

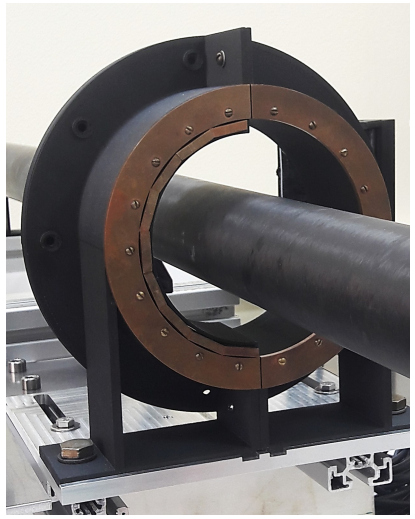
3) Long-term monitoring of important ratios



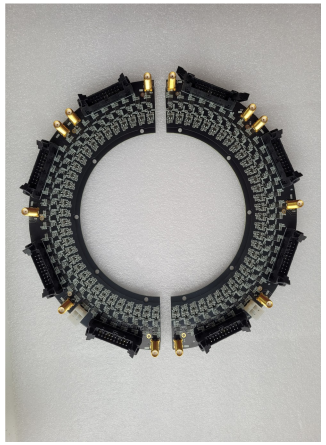
Long-term changes in trigger counts and ratios
(added in 2026 by N.Lashmanov and S.Sergeev)

Good to add for the next run:
fast analysis of background in LBT
(interactions, pile-up, missing FD)

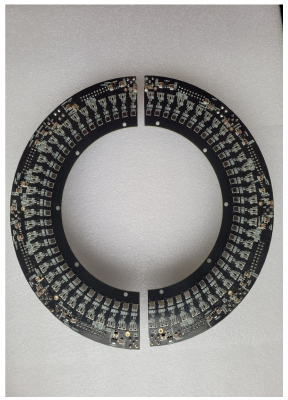
New Barrel Detector



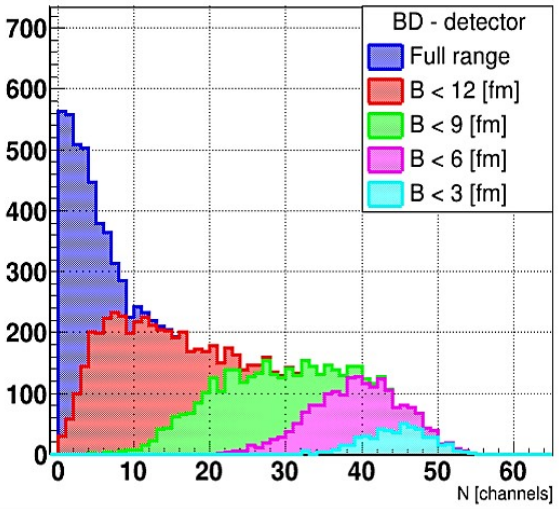
Mechanical parts
made and assembled



FEE PCB
connectors side



FEE PCB
SiPM side



Au+Au, 3.8 AGeV, 2%

Mechanics *(V.Azorskiy):*
completed, assembled

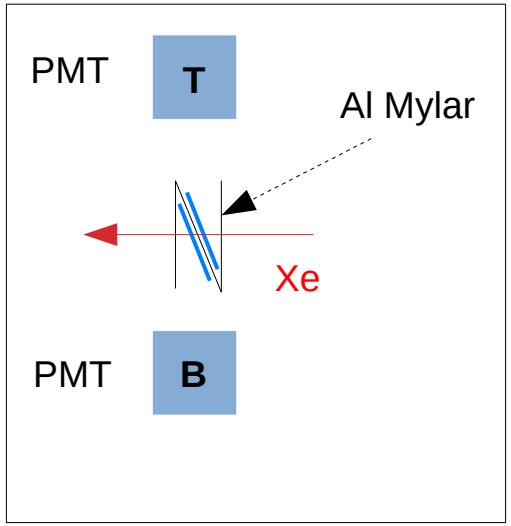
FEE (*V.Rogov*):
completed, tested

Scintillators, SiPMs:
available, assembly
(*V.Velichkov*, July – August, 2026)

Multiplicity logic module
(*S.Sergeev, V.Rogov*):
components available,
design, production – half a year

Simulation *(N.Lashmanov)*:
done for Au+Au

Test of a prototype counter with quartz radiators (FD1)

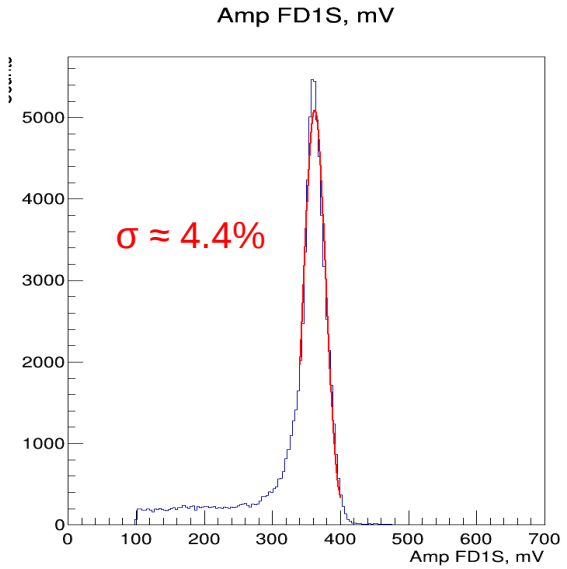


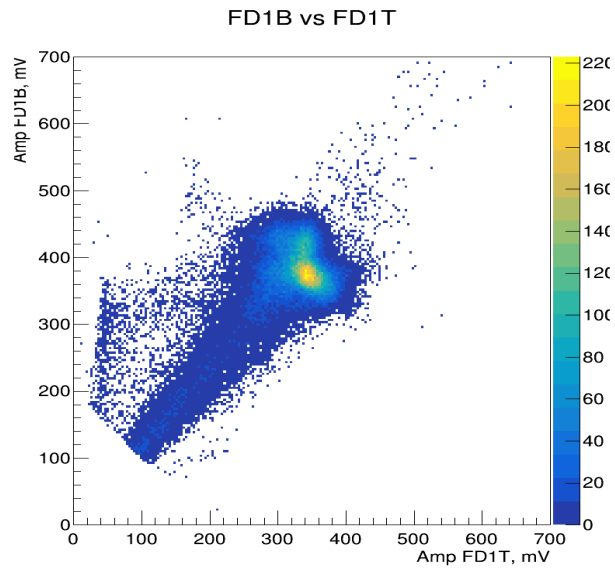
Tested: 2 quartz plates
40 x 40 x 1 mm³
inclined by ~11°

Available quartz 40 x 40 x 0.2 mm³
40 x 40 x 0.4 mm³

Promising option for BC2, similar scheme can be tried for BC1, FD

Plans: order larger quartz plates,
prepare prototypes





Thank you for your attention