Upgrade of the beam pipe, beam detectors and trigger system

Sergey Sedykh for the BM@N

6th Collaboration meeting of the BM@N experiment
October 26, 2020

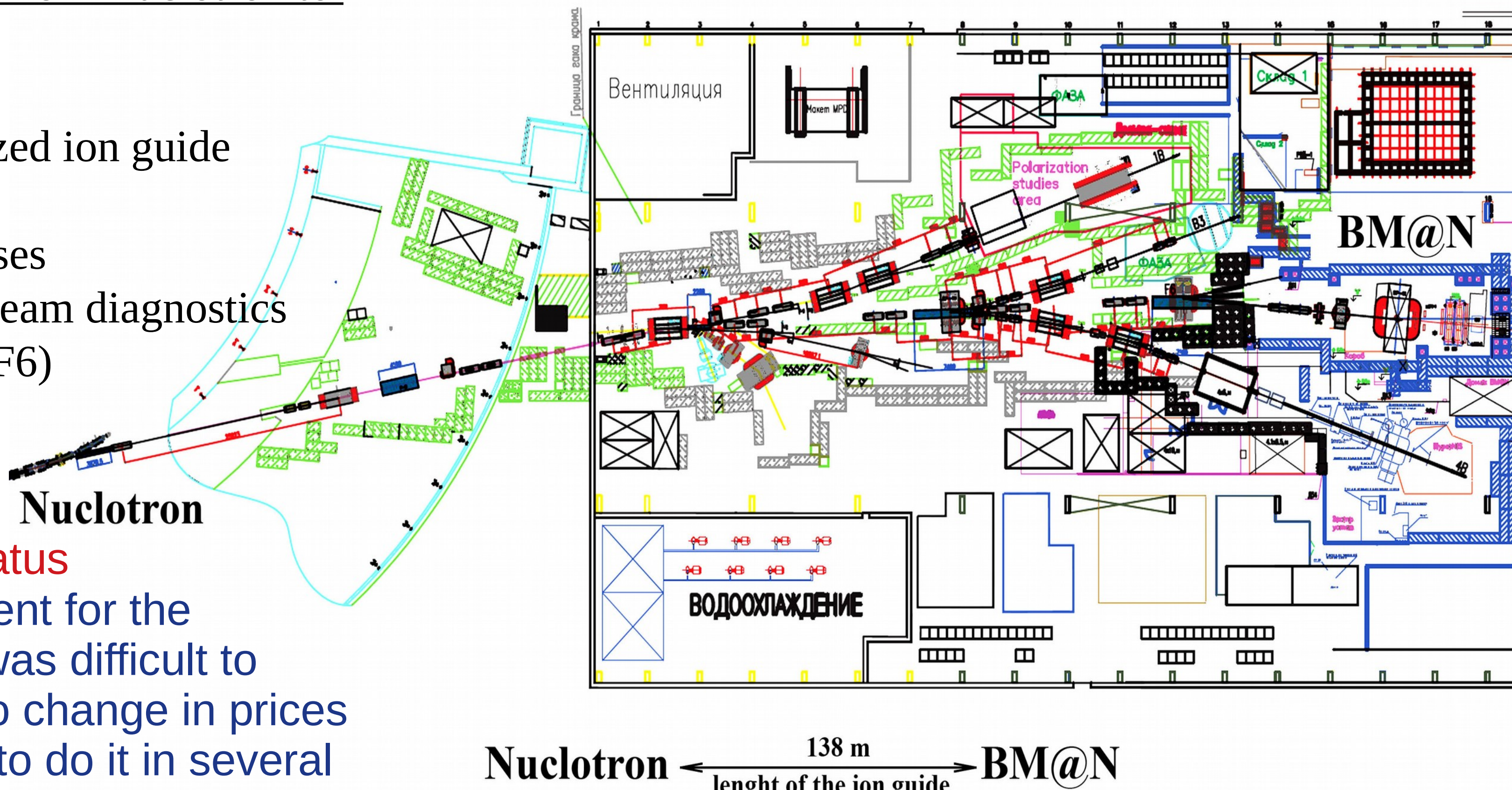
Outline

– *Beam transport line from Nuclotron to BM@N*
– *Target station*
– *Beam counters (BC1, BC2, VC)*
– *Trigger multiplicity detectors (BD, Si)*
– *Options for downstream trigger detectors*

Vacuum ion transport line from Nuclotron to BM@N

Continuous vacuum from Nuclotron to BM@N

– 110 m of modernized ion guide
– 6 magnets
– 17 quadrupole lenses
– 14 points for ion beam diagnostics
– 4 focus areas (F3-F6)

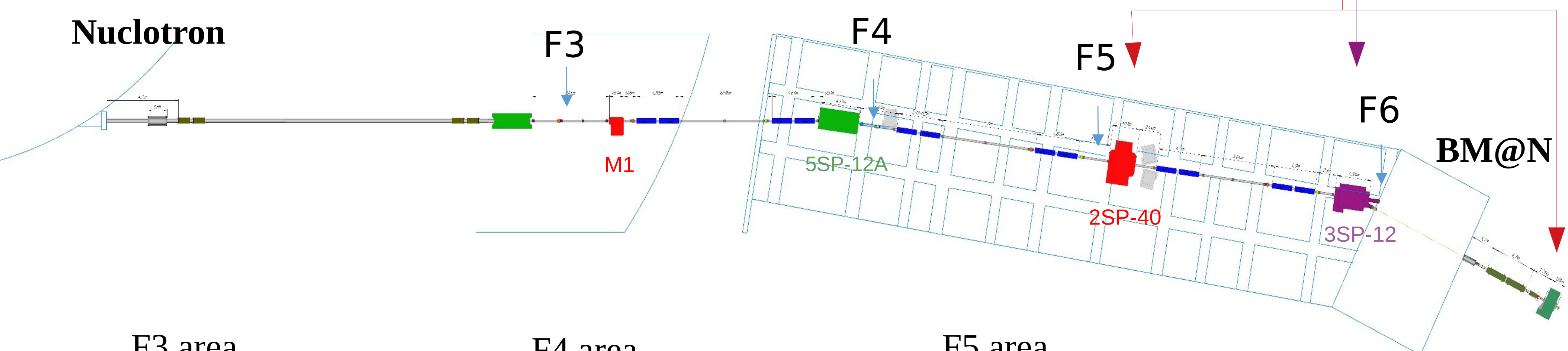


Current status

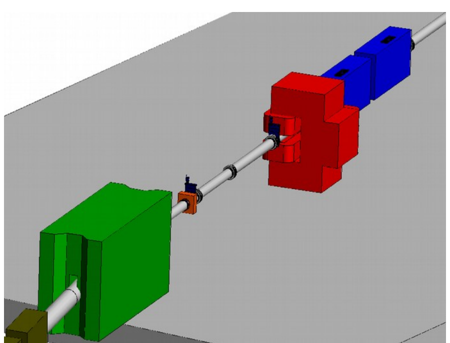
– formal agreement for the whole project was difficult to organize due to change in prices
– new approach to do it in several stages; separation of standard and non-standard components for faster paper-work

Vacuum ion transport line from Nuclotron to BM@N

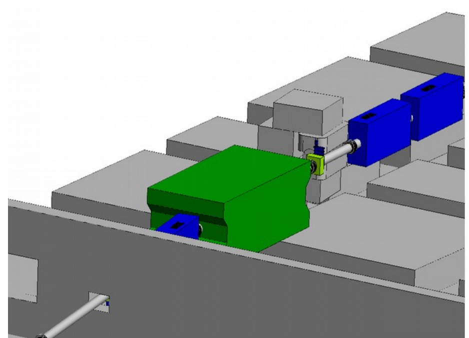
– detailed 3D model of the ion guide done in Feb-Mar 2019
– in March 2020 vacuum chamber was installed in SP-12 in F6
– region currently worked on



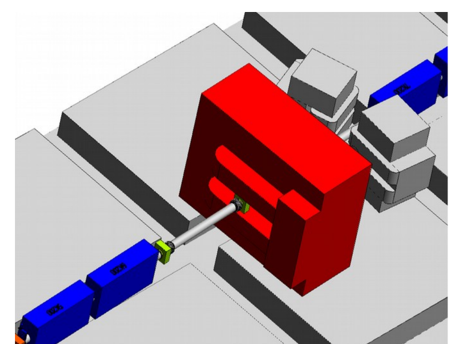
F3 area



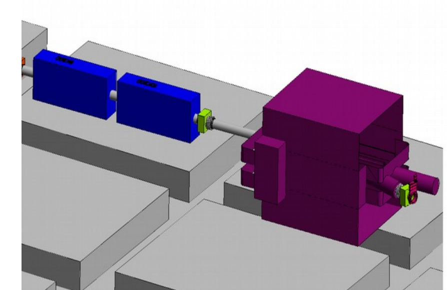
F4 area



F5 area



F6 area



Installation of vacuum chamber for SP12 in F6

A.Kubankin ea (BSU Group), S.Anisimov ea (LHEP),
P.Rukoyatkin (Beam Transport), S.Piyadin (BM@N)

Requirements and parameters

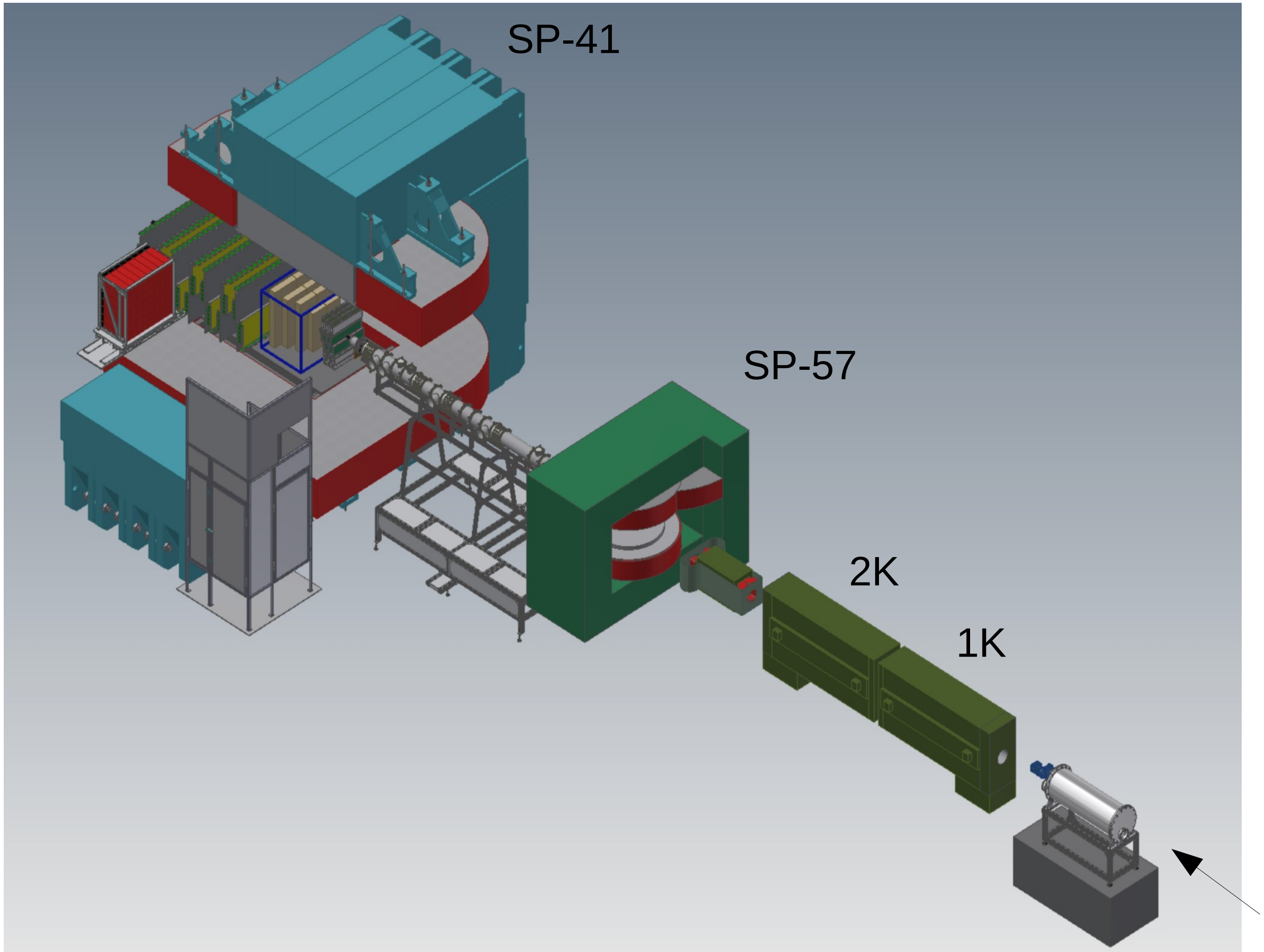
– inner part from the steel same to the poles, no welding
– vacuum $<10^{-2}$ Torr
– length ~4m; weight ~1.5t

<u>Installation involved</u>

– removal of RP concrete blocks
– lifting of the upper part of the magnet (32 t)

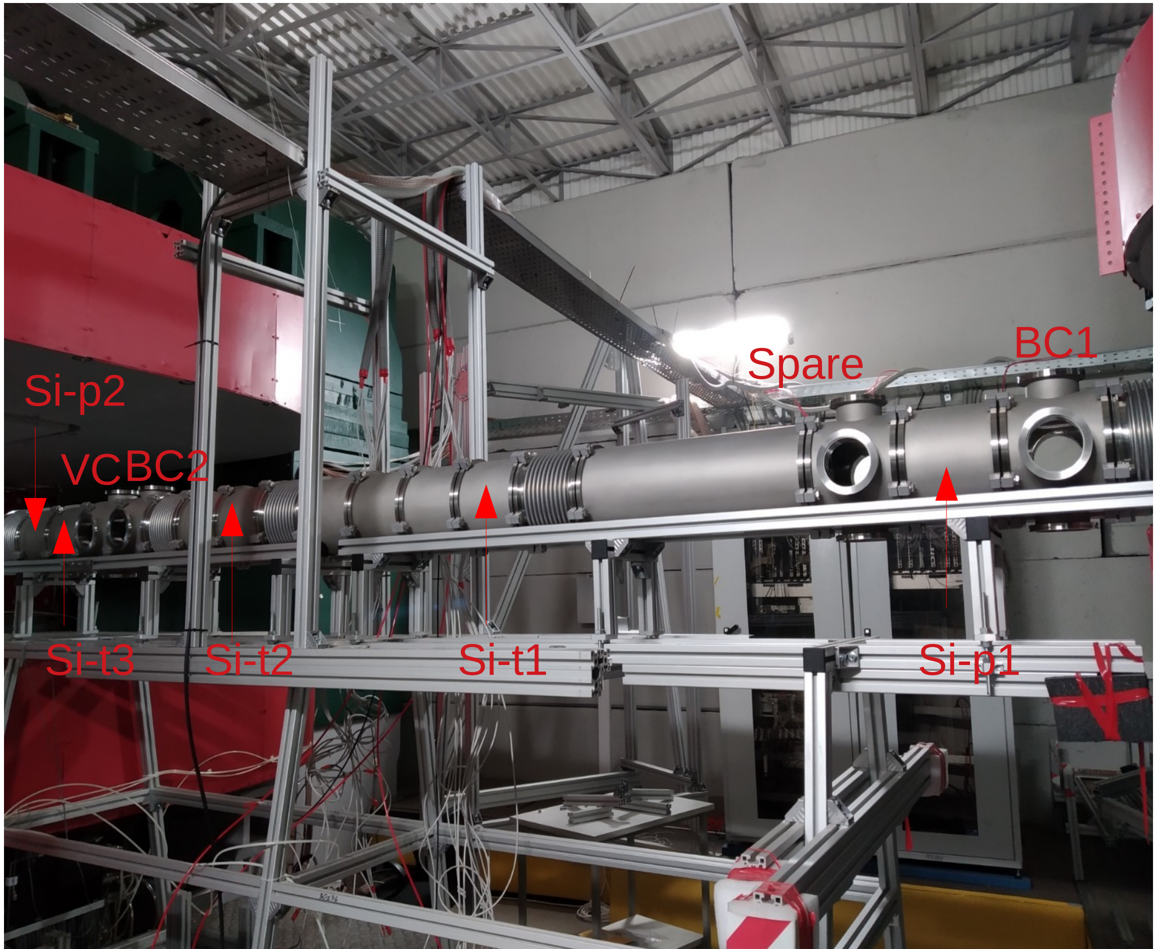
Beam pipe in BM@N before the target

S. Piyadin et al., BSU Group



- Plan to complete vacuum elements upstream of SP-57 in the current stage
- Technical design for focus areas F5-F6 is ready; ordering needed parts is in progress
- Timeline for the whole Nuclotron - BM@N beamline? No estimates
- Prototypes of all major components are made and tested

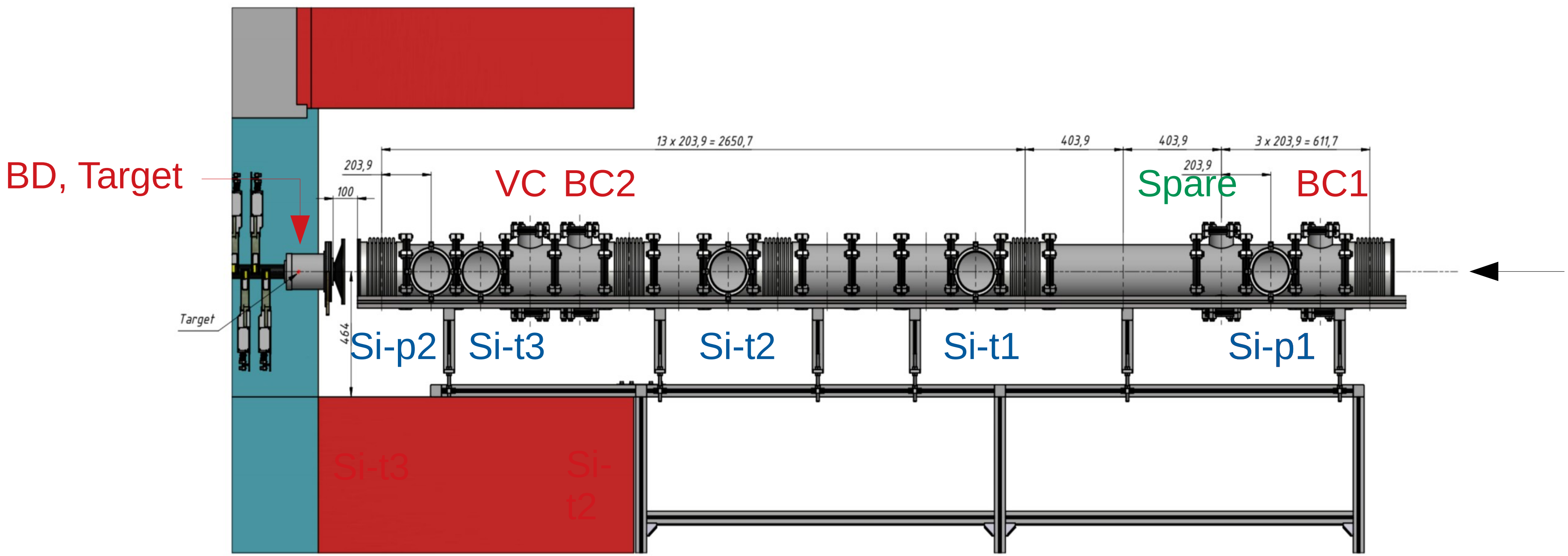
Beam pipe in BM@N before the target



Current status:

- all components were made and tested in the BSU Lab (specs. ~10^{-3} Torr); delivered and assembled at BM@N in Oct.2019
- magnetization of components was found after welding and machining, therefore, one bellow and parts for Si-p2, Si-t3 and VC are being remade of aluminum
- mostly completed, final adjustments are being made for Si boxes)

BM@N beam pipe before the target



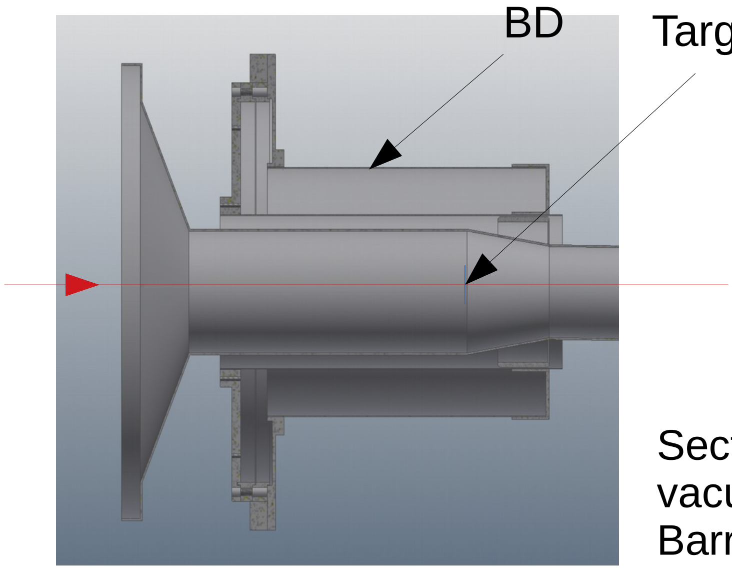
BC1, BC2, VC	beam counters
Si-p1, Si-p2	beam profile detectors (removed after beam tuning)
Si-t1, Si-t2, Si-t3	beam tracker detectors

– Si-p1, Si-p2 and Si-t1, Si-t2, Si-t3 are similar in design

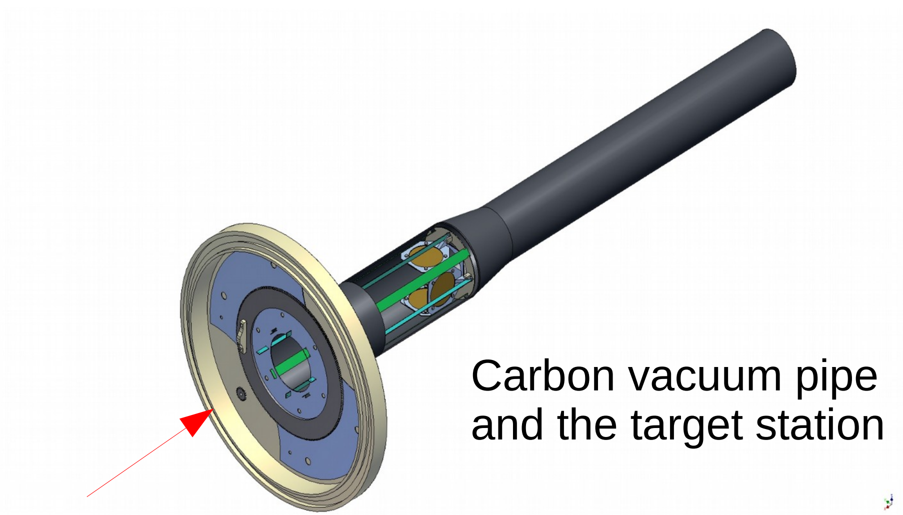
– BC1, VC have the same design
– BC2 the same vacuum box, different PMT mounts

Target station

S.Piyadin, Yu.Gusakov,
BSU Group



Section of carbon vacuum pipe and Barrel Detector

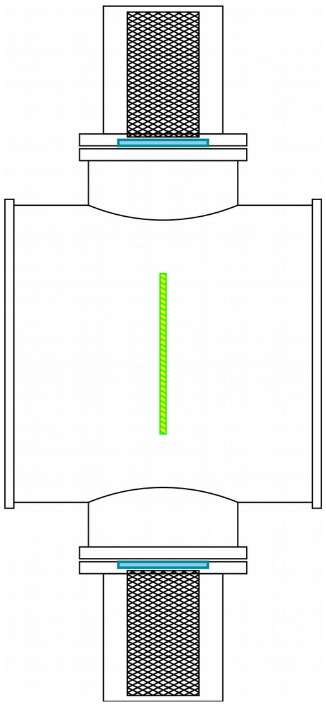


Carbon vacuum pipe and the target station

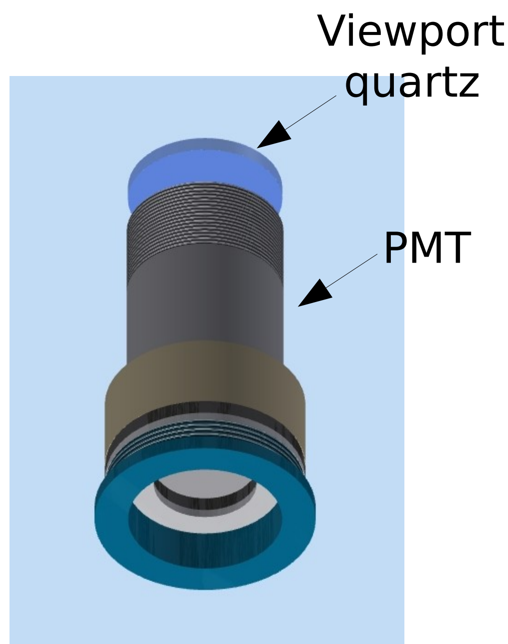
Current status

– developed and tested
– no magnetic materials
– should be able to operate in the magnetic field

Beam Counters: BC1, VC



Sketch of vacuum box
for BC1 and VC



Design of PMT mount
for BC1 and VC

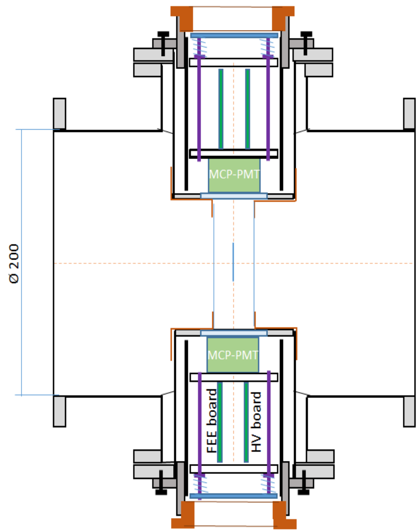
Current status

PMT:
- Hamamatsu R2490-07
  operate in magnetic field <1T
  (available ~14 PMTs, 1 base)
- testing with laser system is planed
- design of PMT mounts (completed)

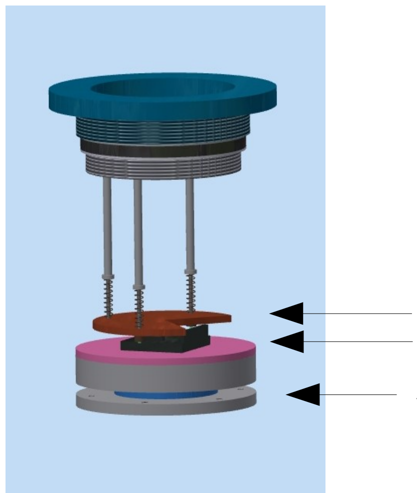
Scintillators (BC400B):
- 100x100x0.25mm^3 (BC1)
- dia.100x10mm
  with hole 27 mm (VC)
  (available)

Scintillator mounts
(design is scheduled for early 2021)

Beam Counters: BC2



Sketch of vacuum box



Design of PMT mount

MCP-PMT XPM85112/A1-Q400
(Photonis)
Similar to FFD PMT but smaller

Photocathode: 25 × 25 mm^2

Current status

MCP-PMT XPM85112/A1-Q400 operate in magnetic field <1T (available)

PMT + FEE mounts (design is close to completion)

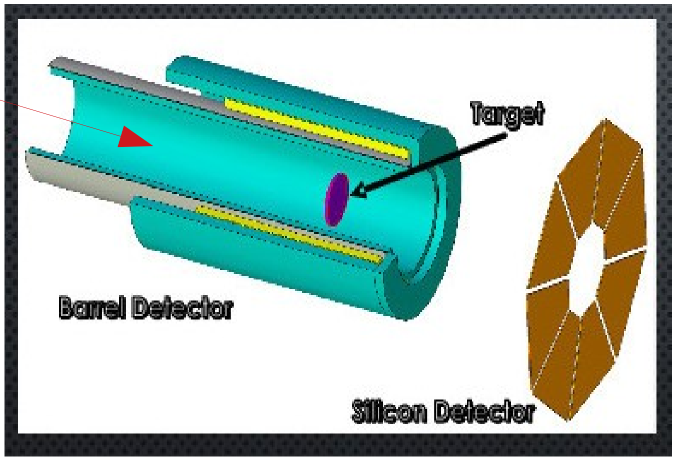
FEE (design is ready, production scheduled for early 2021)

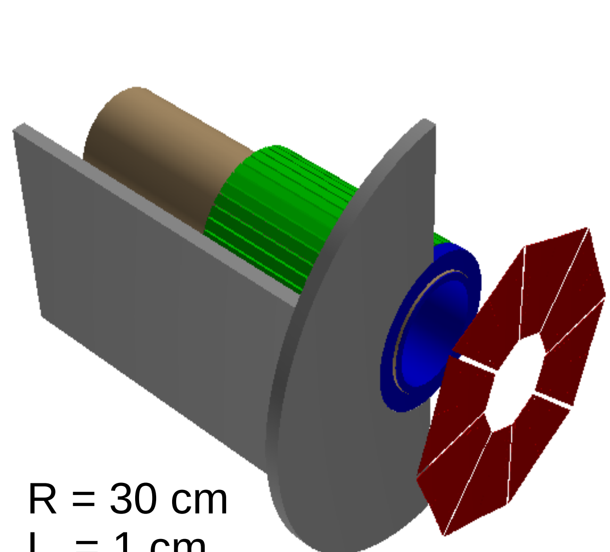
Scintillators BC400B 30x30x0.15mm^3 (available)
Quartz 40x40x0.2 mm^3 (available)

Scintillator mounts (design is scheduled for early 2021)

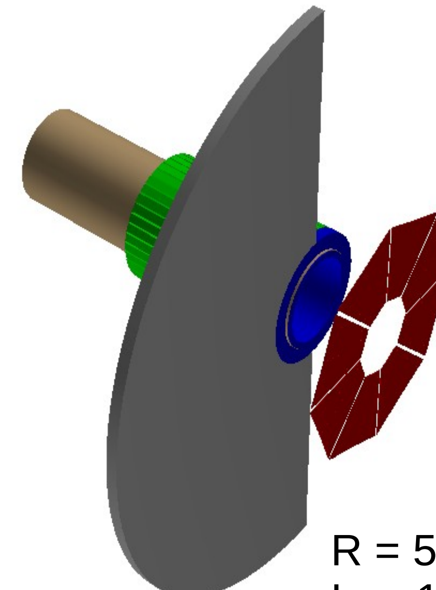
BD Shielding Optimization

N.Lashmanov





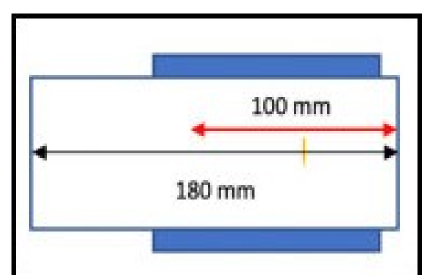
R = 30 cm
L = 1 cm



R = 50 cm
L = 1 cm

Criteria:

– sufficient background suppression;
– reduce material for potential detectors at high *θ;*
– put Pb only where it's needed;
– convenient mounting;

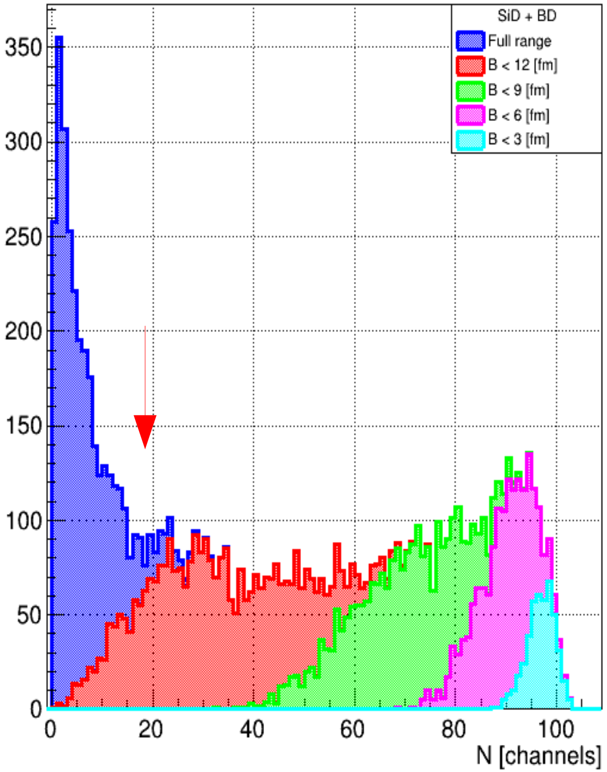


Inner shield (5mm thick)
Reduction in length 180→100 mm results in 1.53 increase in background rate
(Au+Au, 4GeV/n, 300μm)

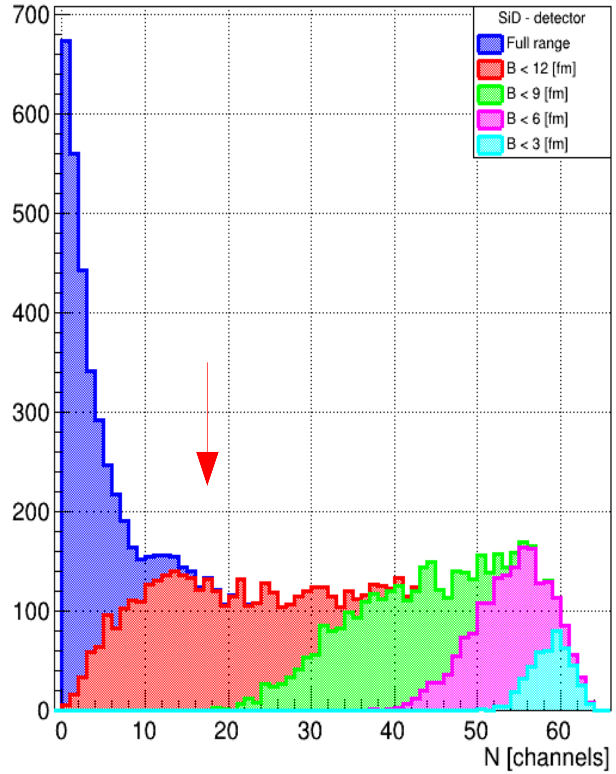
Centrality selection with BD and Si triggers

N.Lashmanov

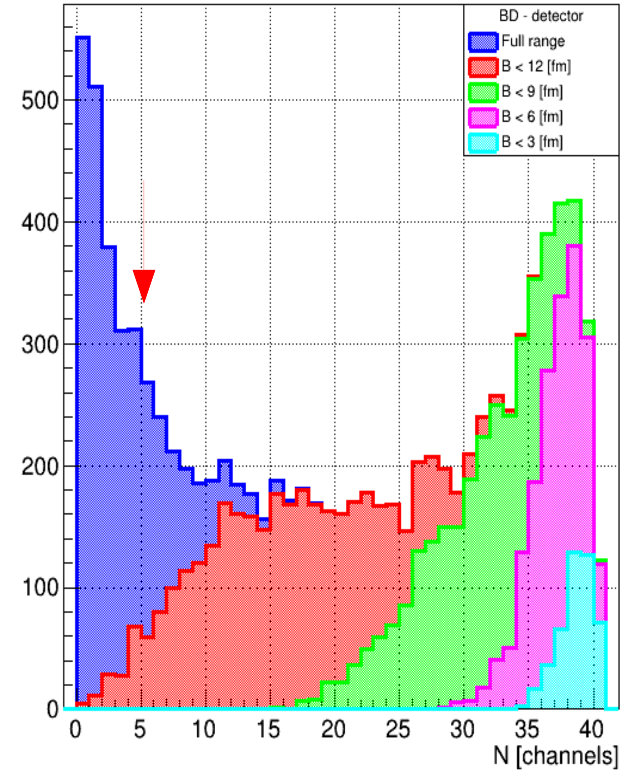
DCM QGSM, Au+Au, 4GeV/n, 300μm



Threshold N(Si+BD) > 18



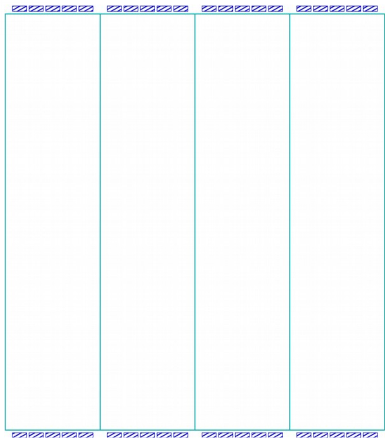
Threshold N(Si) > 18



Threshold N(BD) > 6

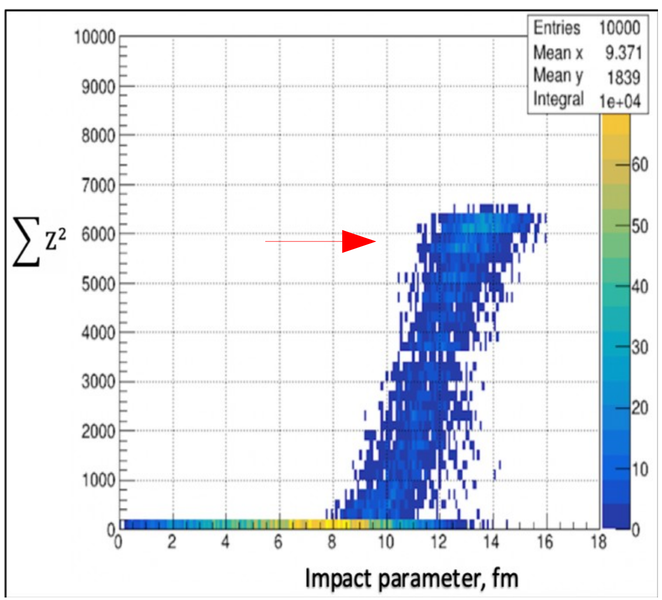
At these thresholds the background level in triggered events is <10%

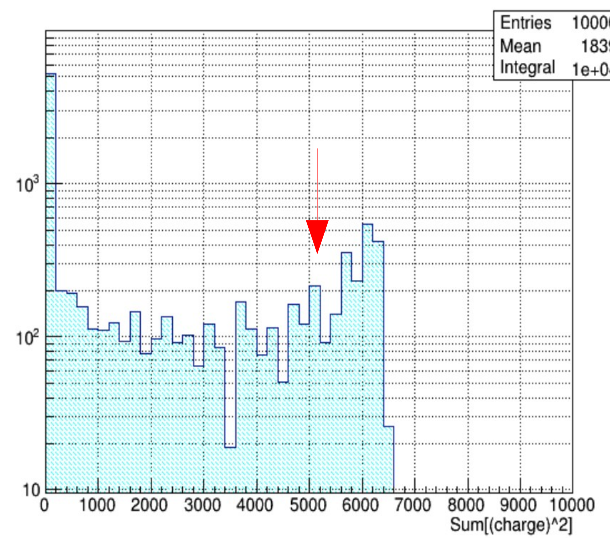
Potential additional triggers – I



Fragment detector

- *160x160 mm², placed near the hole of the FHCal*
- *4 quartz plates, 160x40x6 mm³ (available)*
- *viewed by 4-5 SiPMs from both sides;*
  SiPM SensL 6x6 mm² UV sensitive
  (100 pcs. will be ordered)





DCM QGSM, Au+Au, 4GeV/n, 300μm

Potential additional triggers – II

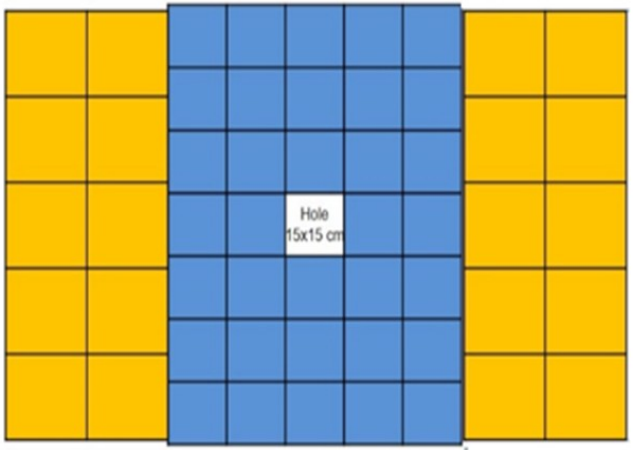
N.Lashmanov

DCM QGSM, Au+Au, 4GeV/n, 300µm

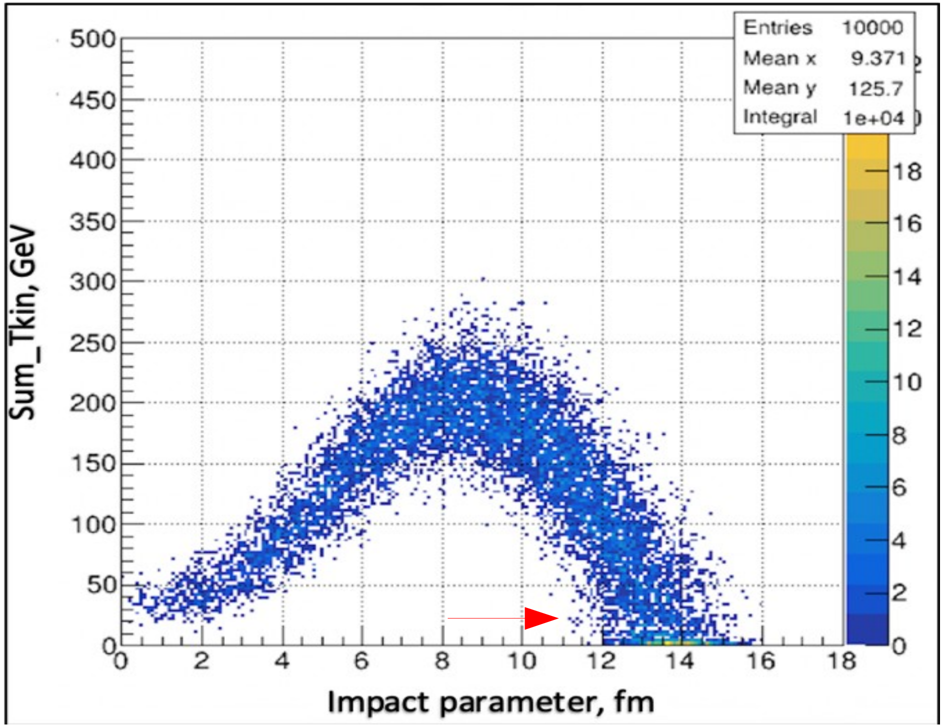
FHCal signals

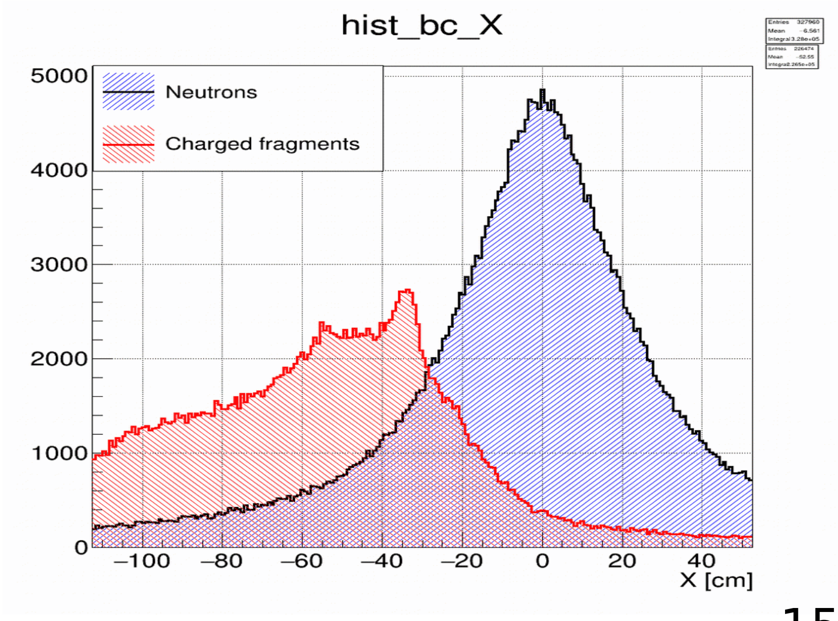
a) neutron zone

b) charged particles zone



Summed energy of all neutrons in FHCal





Modifications in T0U Trigger Module

S.Sergeev,
V.Yurevich,
DAQ Group

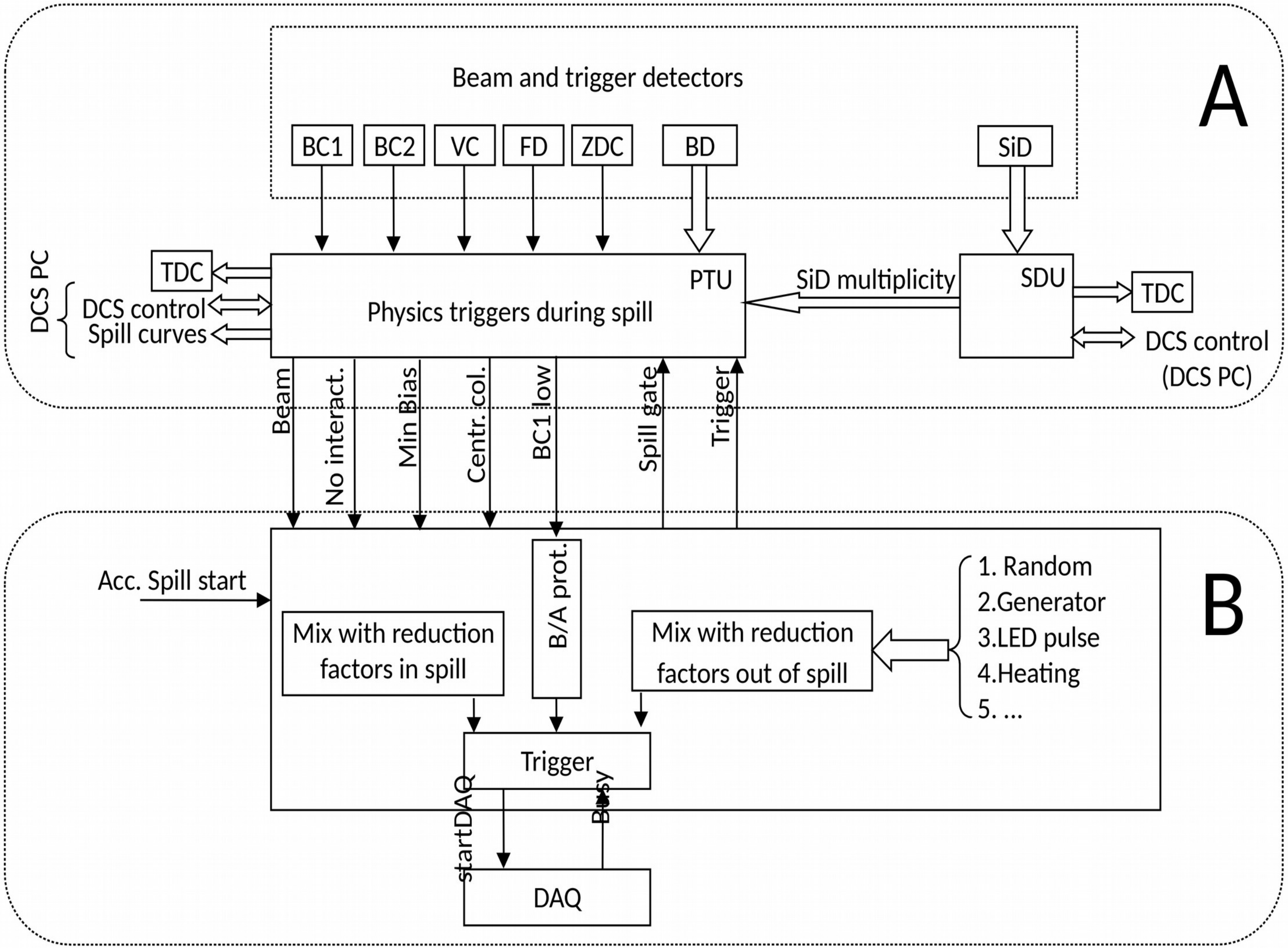


Fig.1. Trigger system for BM@N 2021.

Proposal
(under discussion)

Unit A:
– physics triggers
– managed by trigger group

Unit B:
– mix of physics and special triggers
– trigger downscaling
– Before-After protection
– managed by DAQ group

Thank you for your attention