Upgrade of the beam pipe, beam detectors and trigger system

Sergey Sedykh for the BM@N

4th Collaboration Meeting of the BM@N Experiment
October 14, 2019

Outline

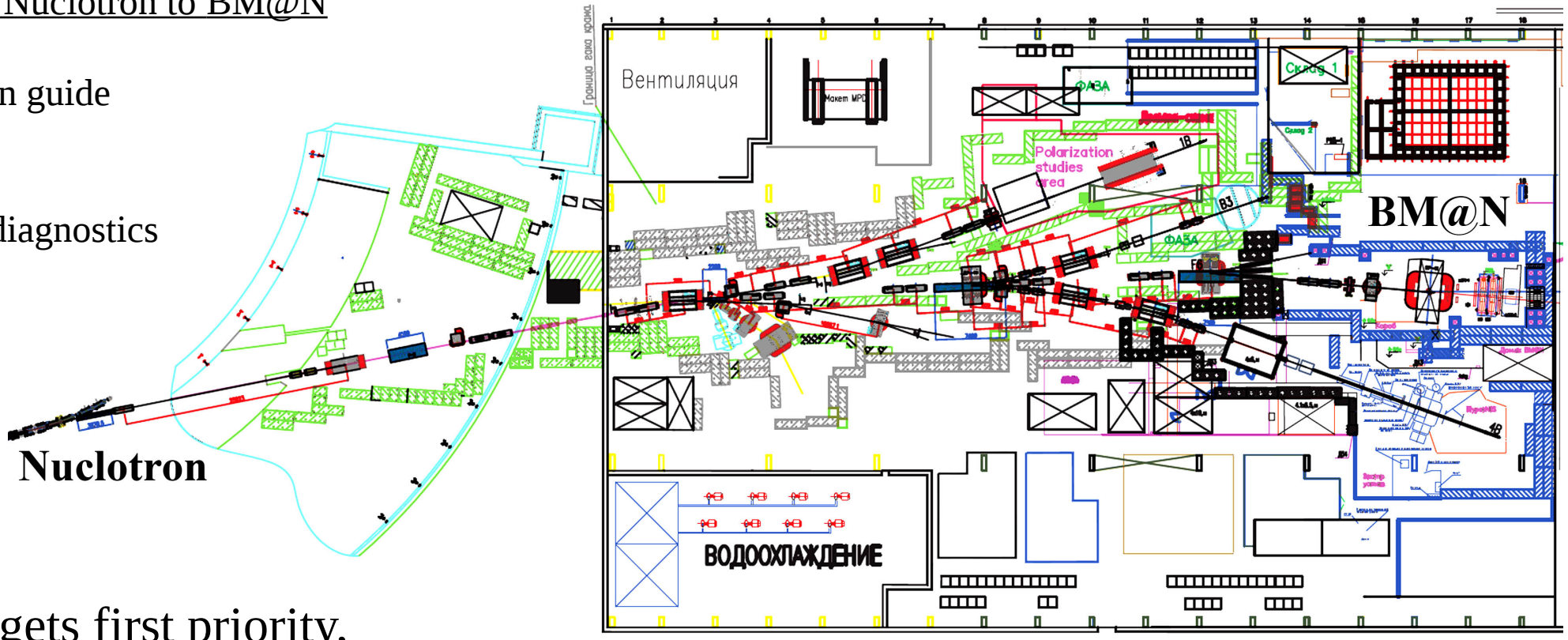
- *Beam transport line from Nuclotron to BM@N*
- *Beamline at BM@N before the target*
- *Beam tracker and profile detectors*
- *Beam counters (BC1, BC2, VC)*
- *Target area and trigger multiplicity detectors*
- *Ideas about T0 for TOF at high intensity Au+Au*

Vacuum ion transport line from Nuclotron to BM@N

Radiation Physics Laboratory of Belgorod State University
Head: A. Kubankin

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)



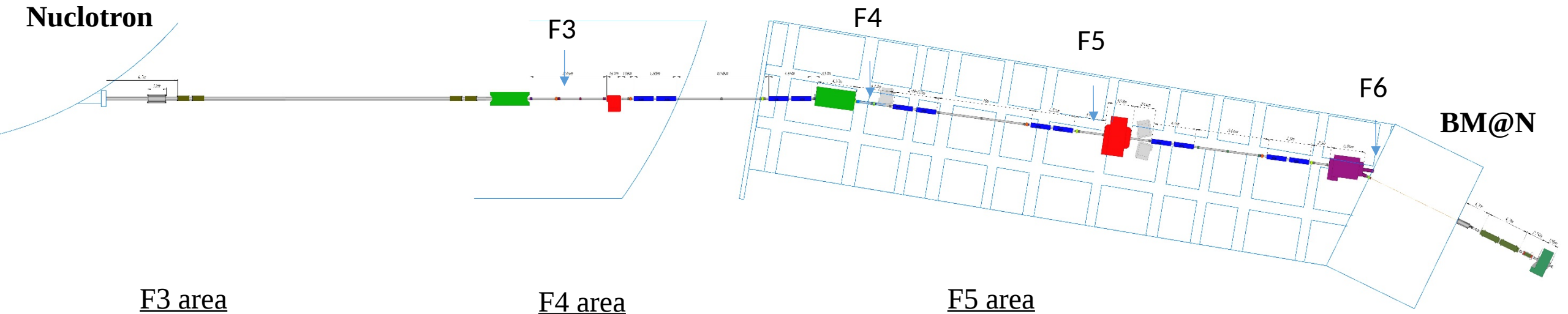
BM@N beamline gets first priority,

other lines will also get vacuum later.

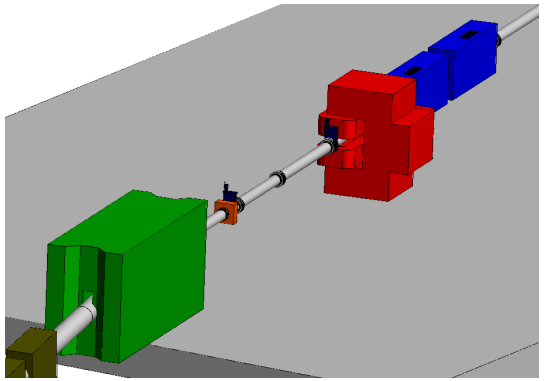
Nuclotron ← 138 m / lenght of the ion guide → **BM@N**

Vacuum ion transport line from Nuclotron to BM@N

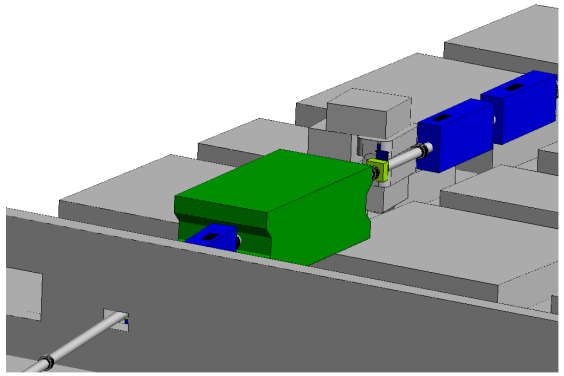
Detailed 3D model of the ion guide
(Done in Feb-Mar 2019)



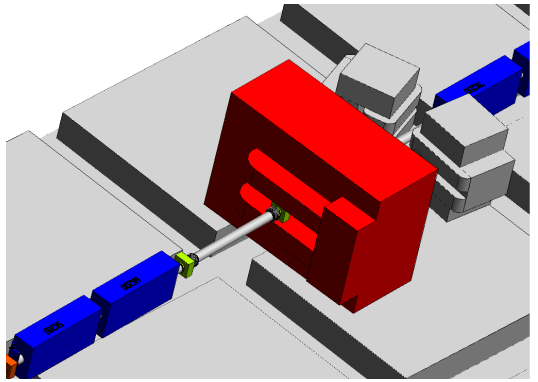
F3 area



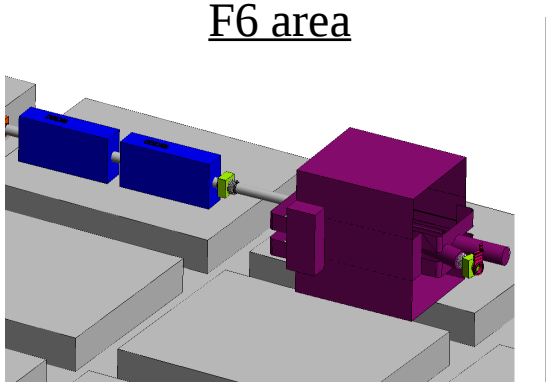
F4 area



F5 area

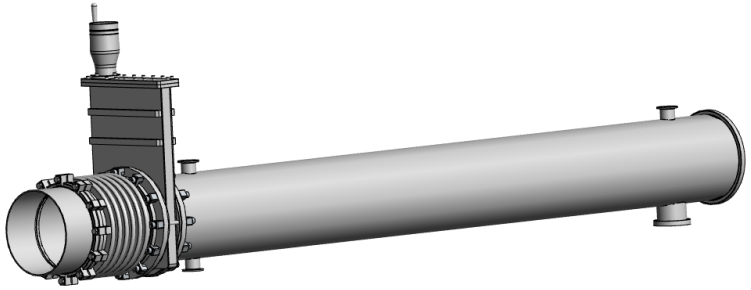


F6 area

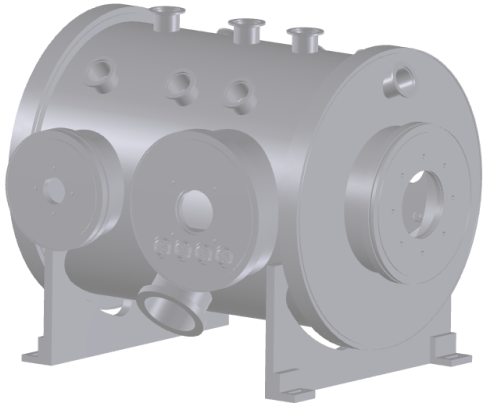


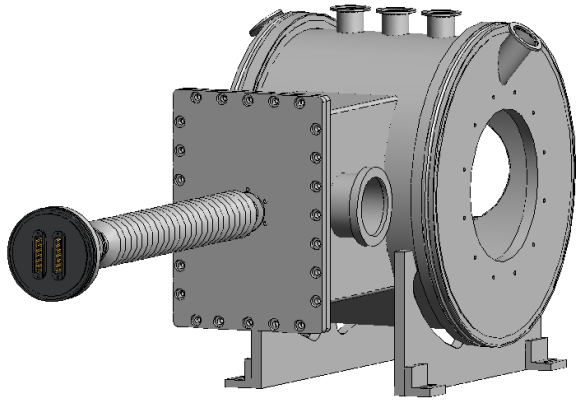
Vacuum ion transport line from Nuclotron to BM@N

Examples of designed parts of the ion guide

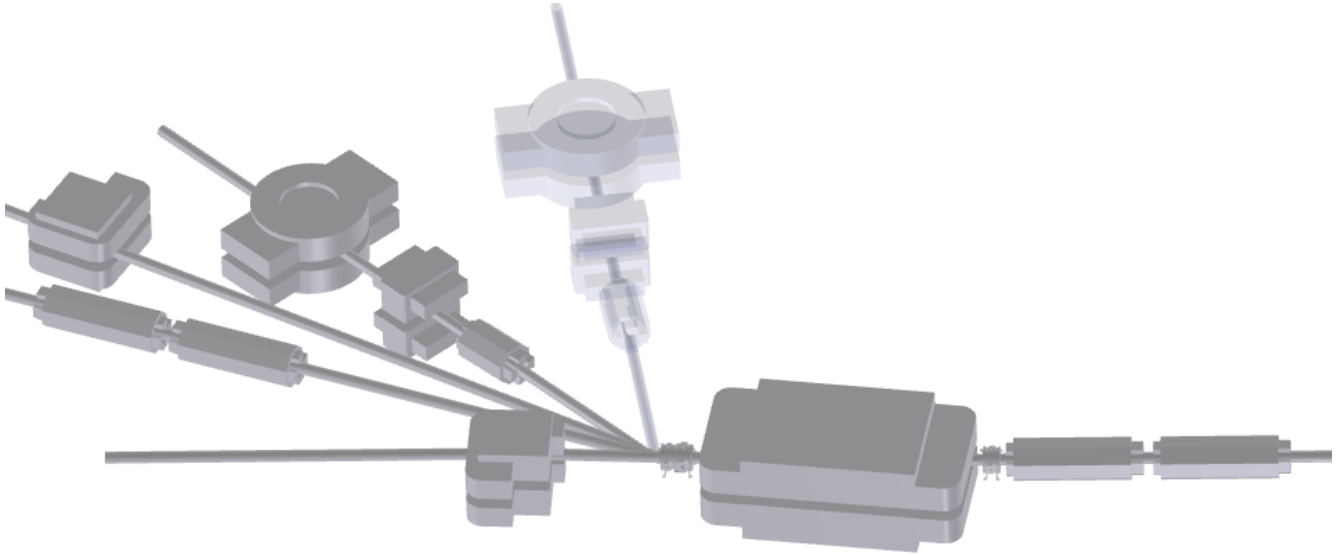


Basic part of the ion guide - vacuum pipe with ISO-K, KF flanges assembled with bellow and gate valve

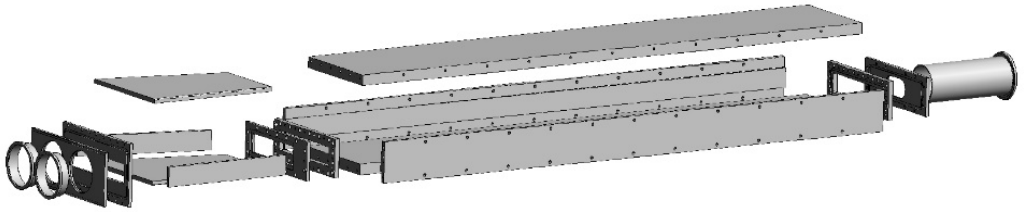




Multitask vacuum boxes for modern beam diagnostics tools and experimental research



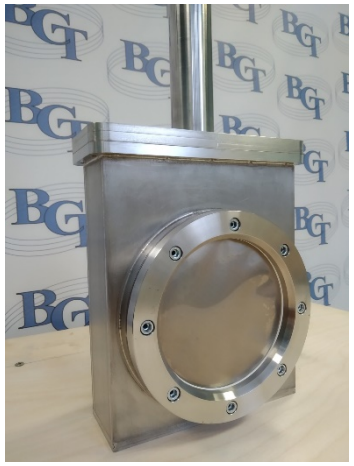
F4 focus area with MARUSYA experimental setup



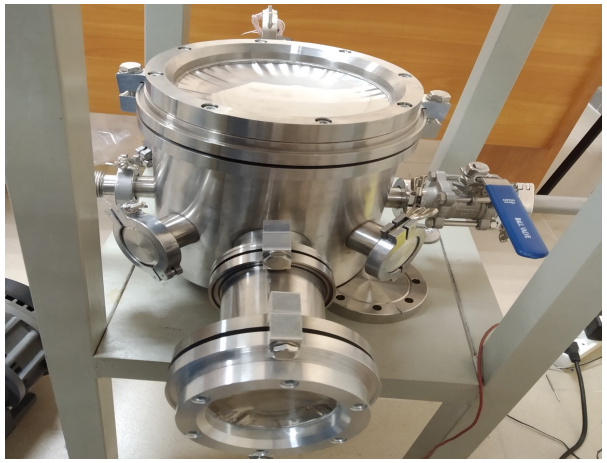
Vacuum box of a magnet

Maufactured prototypes of the pipe parts

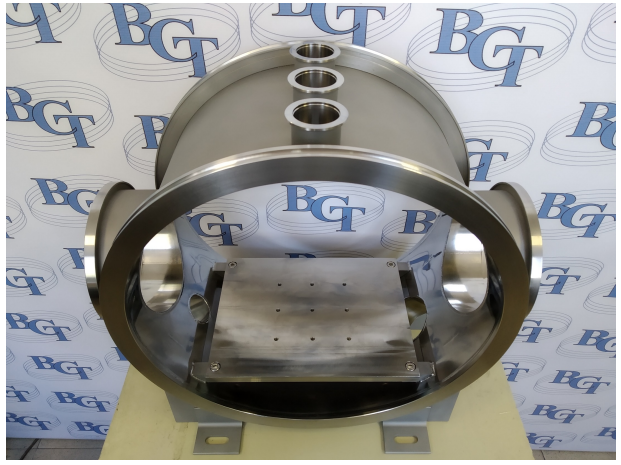
Motorized translator stages for detectors and targets



Vacuum box with thin titanium window for diagnostics detectors

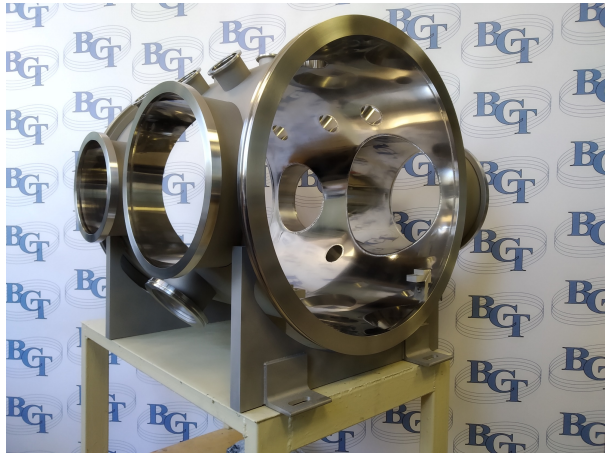


Setup for thin windows testing



Vacuum chamber for diagnostics tools

Vacuum parts of the beam pipe



Vacuum chamber for diagnostics tools and targets

Beamline from Nuclotron to BM@N

Overview of the current status

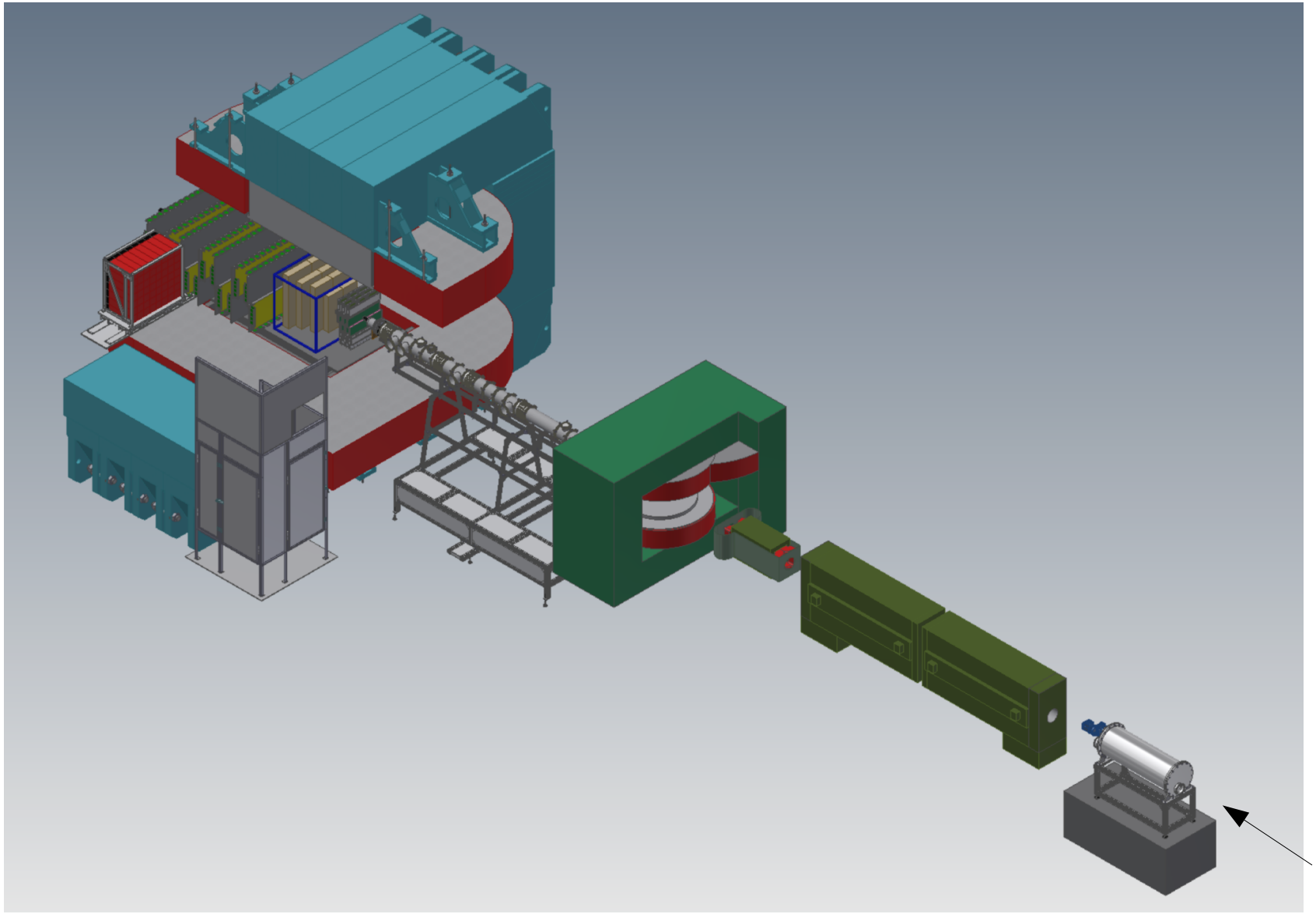
- *Measurement of the beamline components with 3D model (done)*
- *Technical documentation and design of major components (done)*
- *Prototypes of all major components (manufactured and tested)*
- *Formal tender and official order (delayed, not yet completed)*

- *Expected start of production: December 2019*
  (Works on BM@N vacuum components should be finished before that)

- *Expected completion of parts production: October 2020*
- *Expected overall assembly and testing: November 2020*

Beam pipe in BM@N before the target

S. Piyadin et al.,
BSU Group



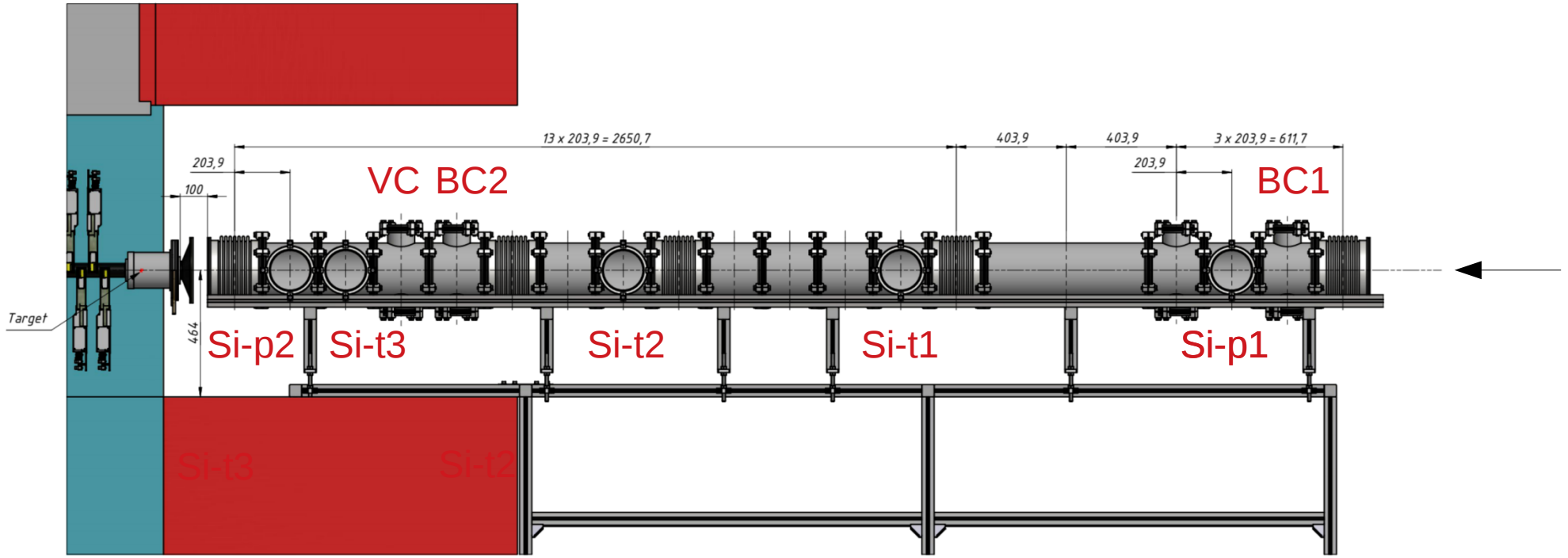
Switch from Vacom® (Jena) to BSU Group:

- high cost of non-standard components in Vacom
- some vacuum connectors are not provided in Russia

- BSU: experience with vacuum systems for scientific research
- flexibility and contribution to the design

BM@N beam pipe before the target

S. Piyadin et al.



BC1, BC2, VC beam counters

Si-p1, Si-p2 beam profile detectors (removed after beam tuning)

Si-t1, Si-t2, Si-t3 beam vertex detectors

– Vacuum boxes are 20 cm long in Z (non standard)
– 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 but different PMT mounts

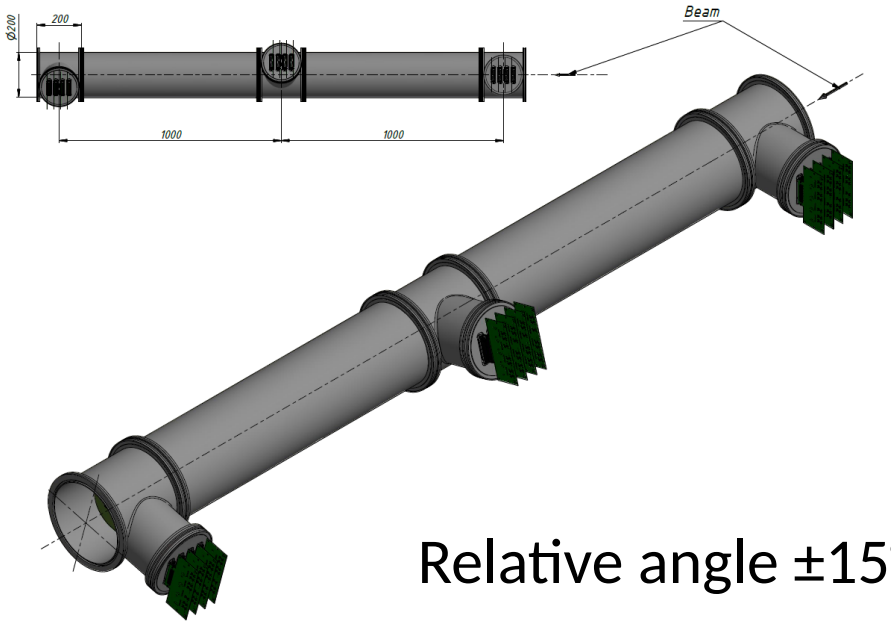
Beam pipe in BM@N before the target

Current status:

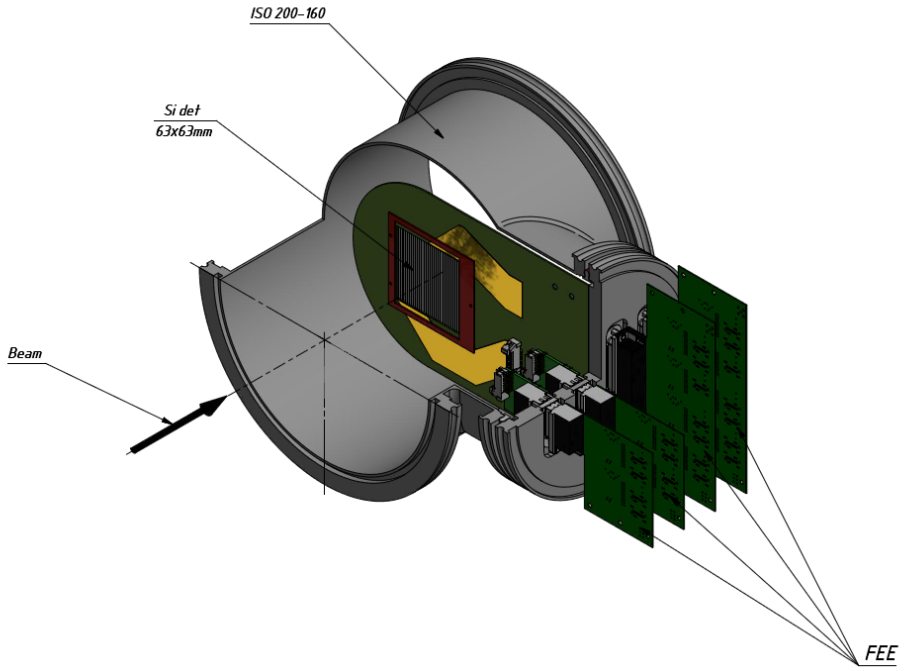
- all ordered components were made and tested in the BSU Lab (specs. 10^{-3} Torr, actual 10^{-6} Torr)
- delivered and assembled at BM@N (last week)
- minor adjustments and proposed inprovements are under discussion
- tests of the whole line is foreseen after complete assembly
- design of mechanics for moving Si-Profile detectors in and out of the beam is in progress (completion exp. Dec.2019)

Silicon Beam Tracker Detectors

Group of N.Zamjatin



Relative angle ±15°



Detector

– double-sided
– active area 63 x 63 mm
– pitch 470 μm
– 128 x 128 strips
– thickness 175 μm

FEE

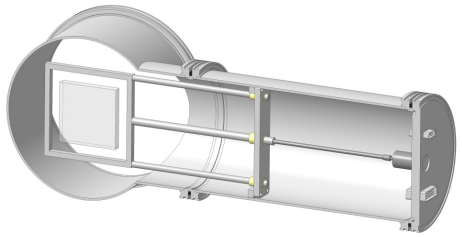
– based on VATAHDR16.2 ampl.
– large dynamic range (+/- 20 pC)
(but not enough to cover C and Au, will start with Au settings)
– 64 inputs
– short shaping time (50-300 ns)

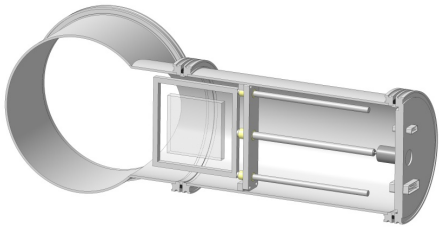
Current status

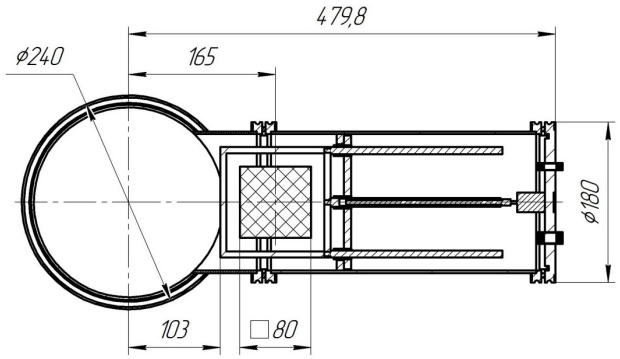
– mounting and connectors available for testing
– FEE design in progress
– 3 detectors delivered,
12 more expected by 30.10.19
– assembly and tests planned 03.2020

Silicon Beam Profile Detectors

Group of N.Zamjatin







Tentative design (by BSU Group) of moving mechanics for Si Beam Profile Detectors

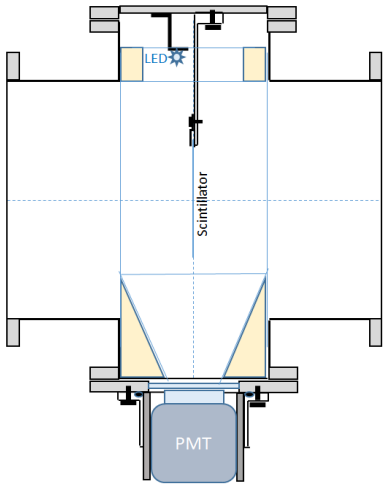
Detector

– double-sided
– active area 60 x 60 mm
– pitch 1.87 mm
– 32 x 32 strips
– thickness 175 μm

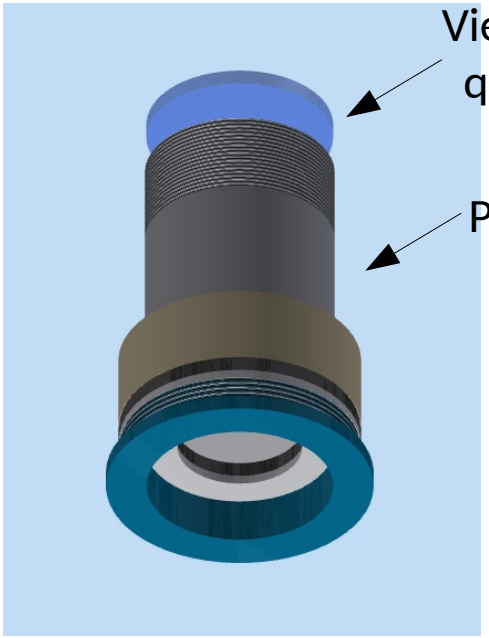
Current status

– mounting and connectors available for testing
– FEE design in progress
– two sets of FEE, for C and Au beam
– 10 detectors expected by 30.10.19
– assembly and tests planned 03.2020

Beam Counters: BC1, VC



Sketch of vacuum box for BC1 and VC



Parts of 3d design of PMT mount for BC1 and VC

Current status

– Vacuum boxes (available)

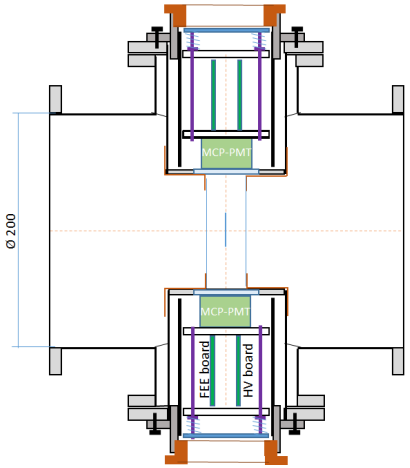
– PMT Hamamatsu R2490-07
operate in magnetic field <1T
(available)
Tests of rate handling with 500 kHz laser (~01.2020), design of other bases if needed (~2 month)

– PMT mounts (design completed)

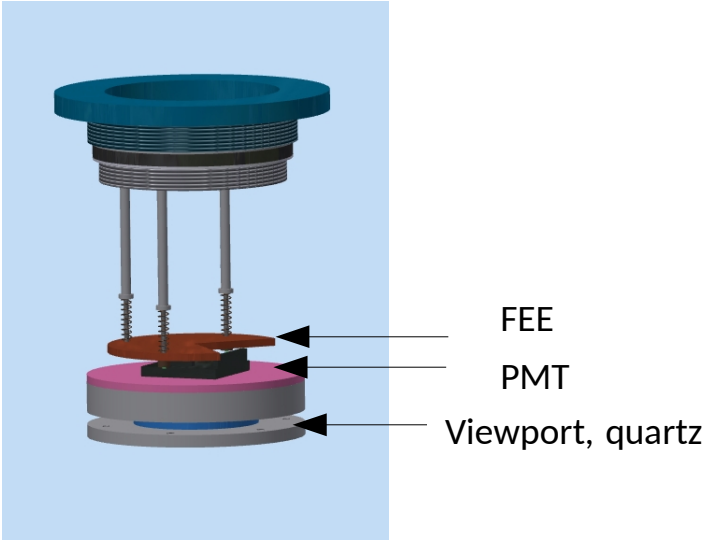
– Scintillators (available)
(for BC1: BC400B 100x100x0.25)

– Scintillator mounts
(not yet designed)

Beam Counters: BC2



Sketch of vacuum box for BC2



Parts of 3d design of PMT mount for BC2

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

Photocathode: 25 × 25 mm^2

Current status

– Vacuum boxes (available)

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

– PMT mounts (design completed)

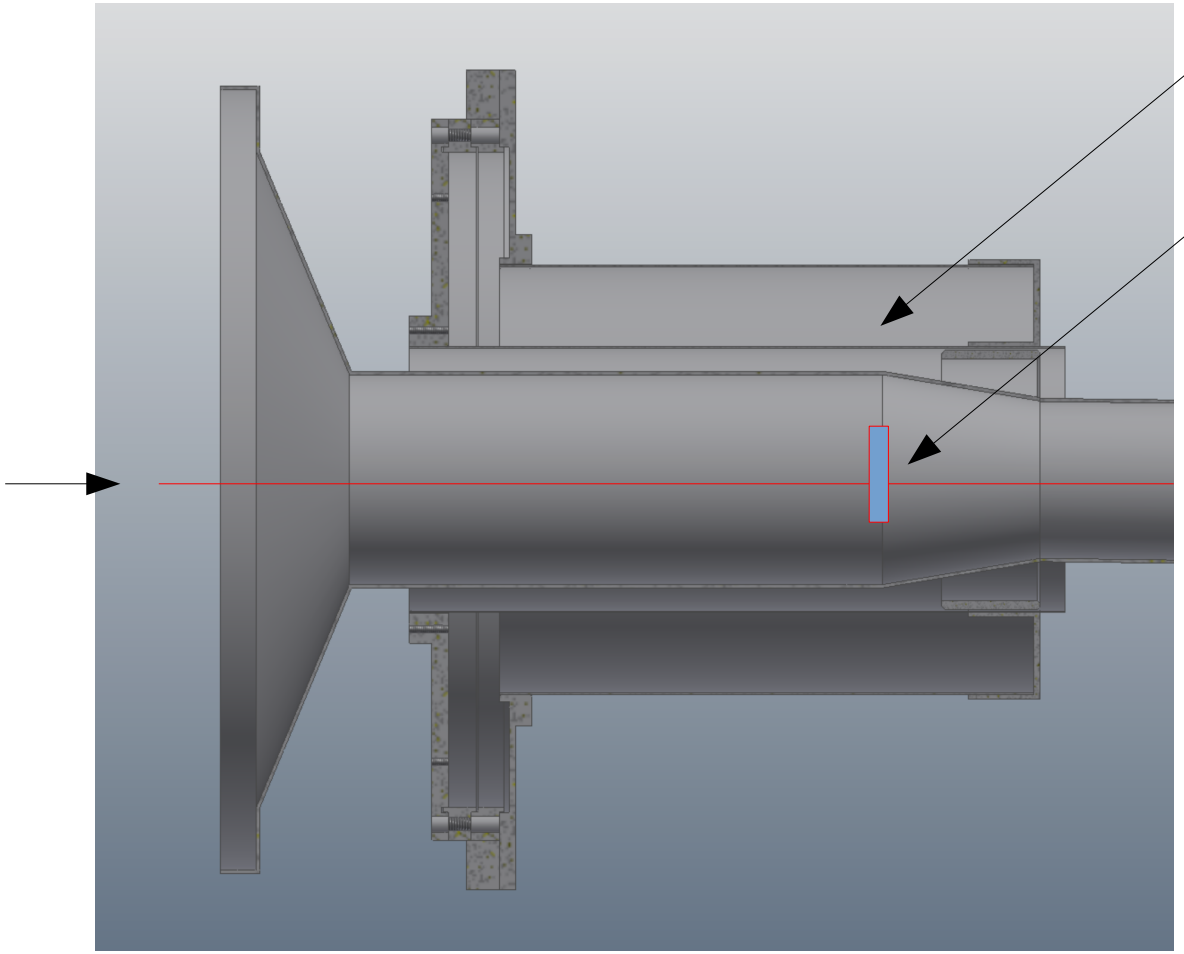
– FEE development (2020, ~2 month)

– Scintillators (available) (BC400B 10x10x0.15 mm^3)

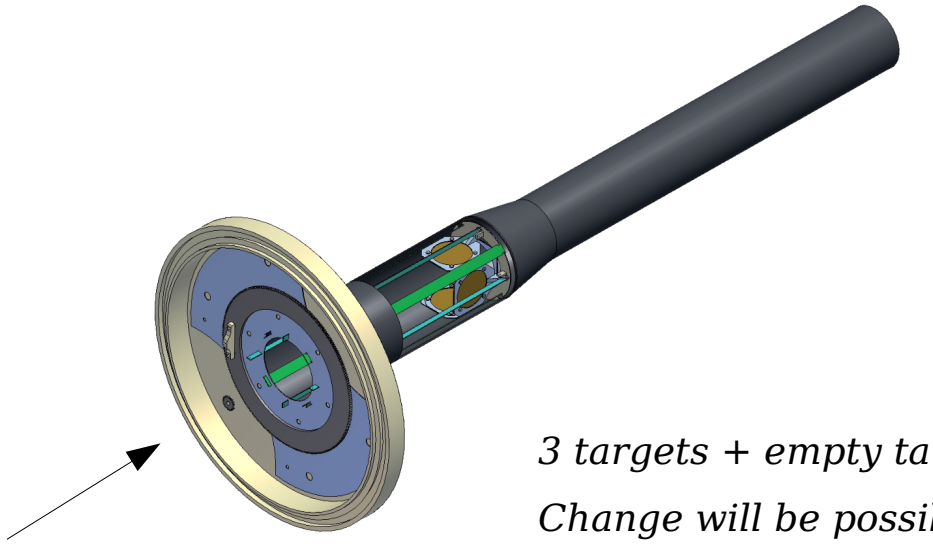
– Scintillator mounts (not yet designed)

Target area with Barrel Detector

S.Piyadin, Yu.Gusakov



First section of the carbon vacuum pipe and Barrel Detector
Dia. 200 → 66 → 50 mm



3 targets + empty target.
Change will be possible without breaking vacuum.

Carbon vacuum pipe and the target station

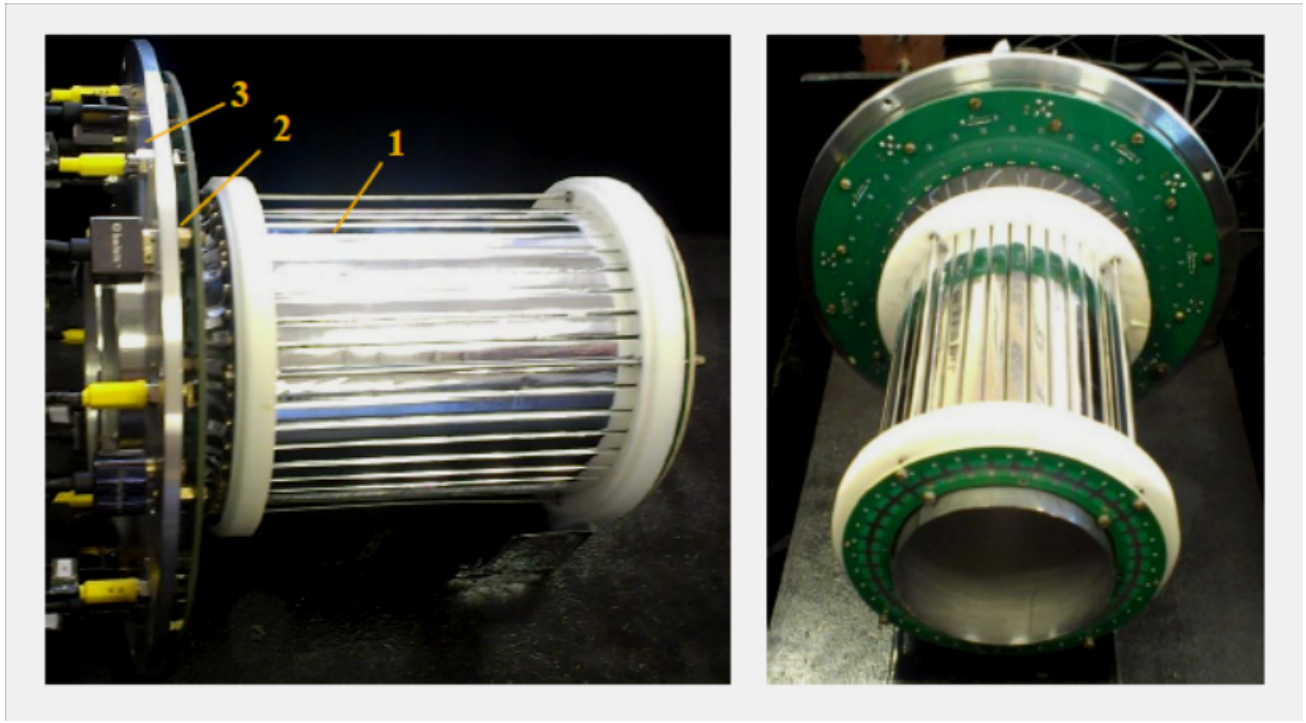
Current status

– no changes in tentative design
– final design (in progress)
– exp. production June 2020

Upgrade of Barrel Detector (BD)

The active area of BD has radius of 45 mm and length of 150 mm and it consists of 40 strips 150 × 7 × 7 mm^3 made from polished scintillator BC418 wrapped by Al- mylar.

Each strip is directly connected with SiPM Micro FC-60035-SMT, 6 × 6 mm^2.



A view of the BD prepared for run 2018:
1 – the scintillation strips, 2 – the board with SiPMs,
3 – the board of front-end electronics.

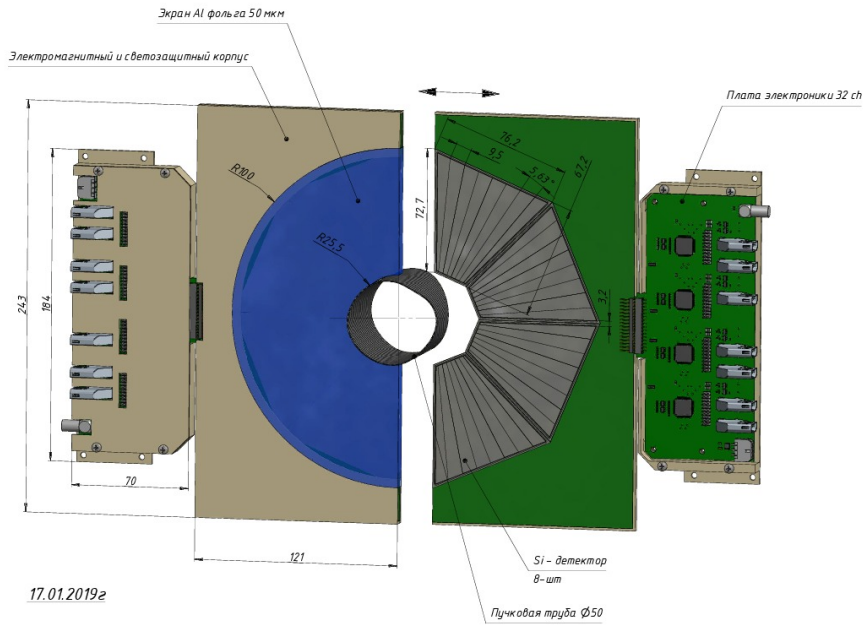
Planned upgrade for Au runs:

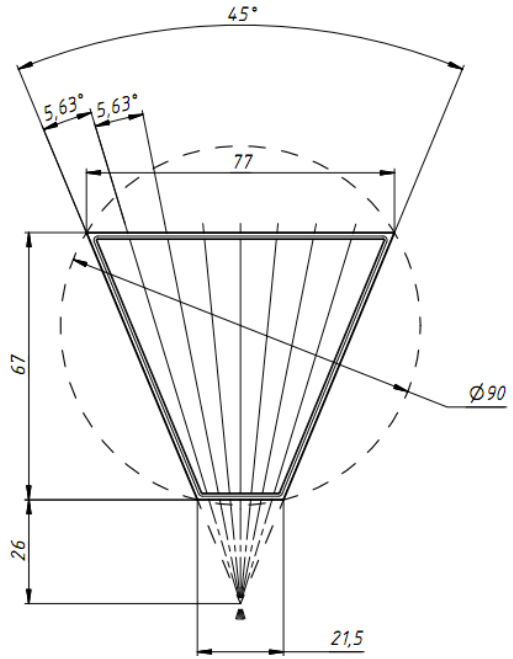
- inner (5 mm) and outer (10 mm) Pb shielding will be added (will be done by the trigger group)

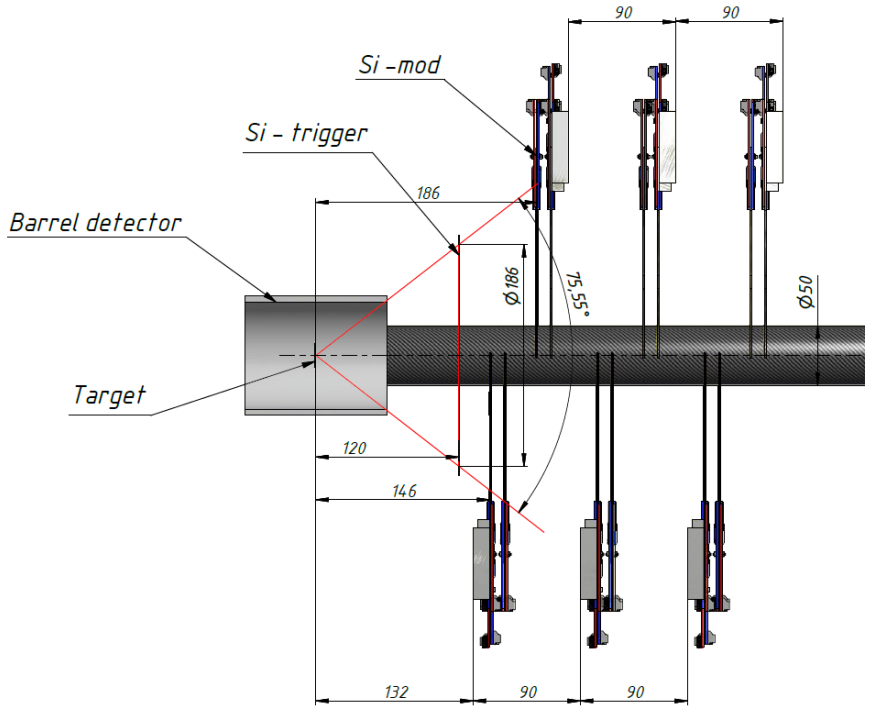
- new FEE (less noise)

Upgrade of Silicon Multiplicity Detector

Group of N.Zamjatin







64 strips, similar to previous version

Placement at 12 cm from the target

Reason for the upgrade:

larger opening for the beam. Dia. 28 → 50 mm

Current status

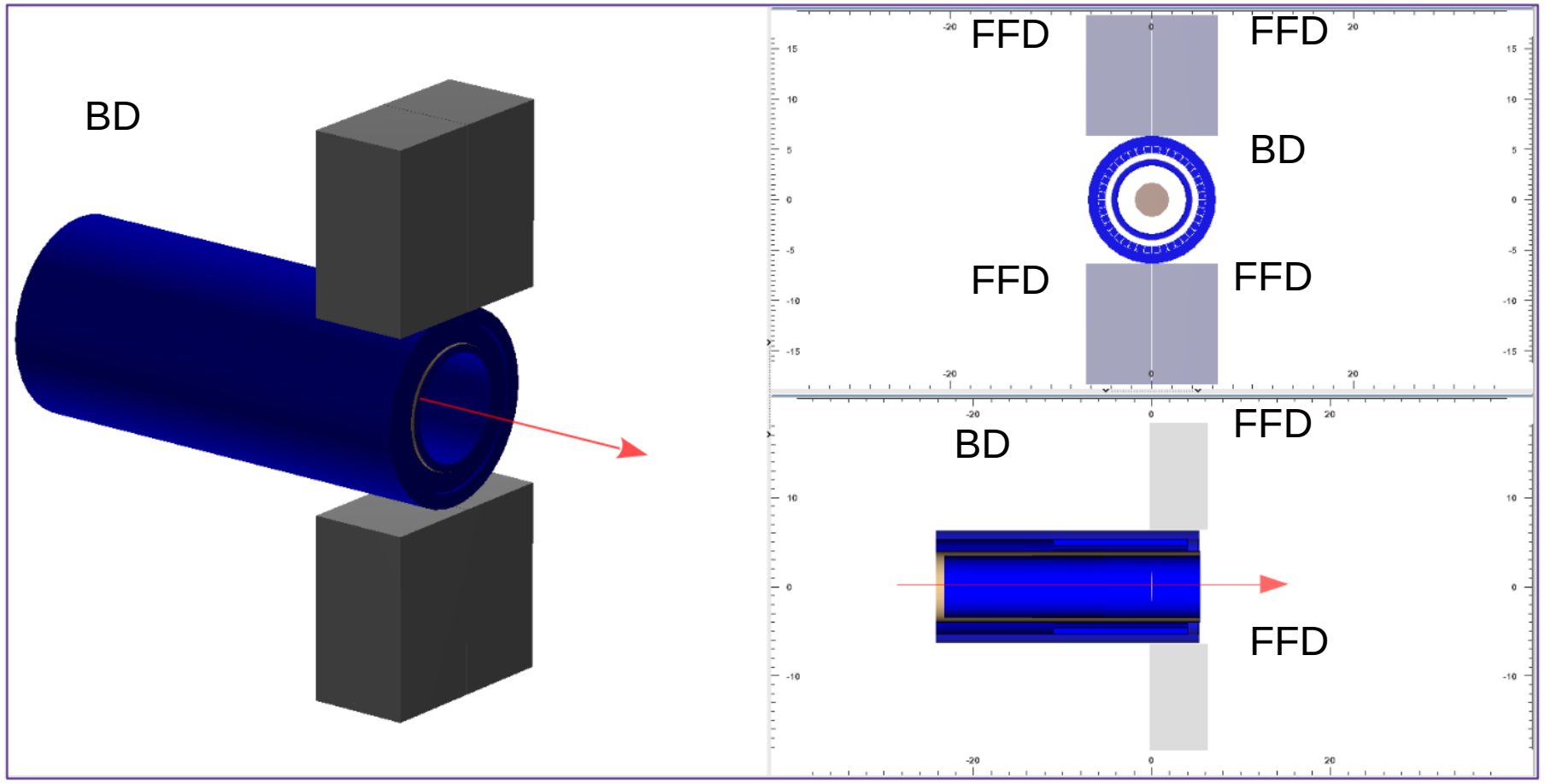
– design of the detector (done)
– design of the mounting frame (in progress)
– electronics (ready)
– detectors production (expected 20.12.2019)
– assembly and testing (May 2020)

T0 options at high beam intensity, Au+Au, $5 \cdot 10^7$

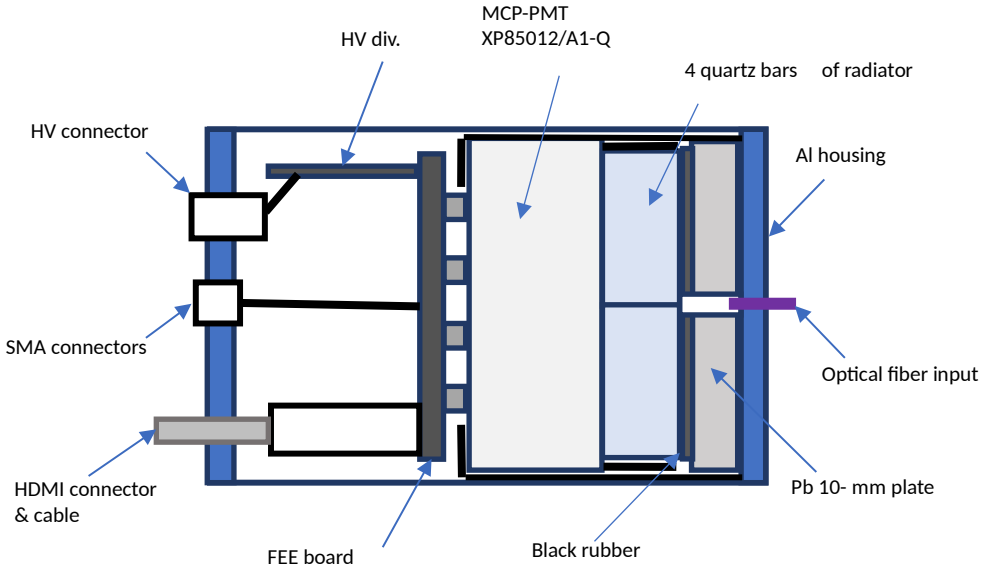
N.Lashmanov

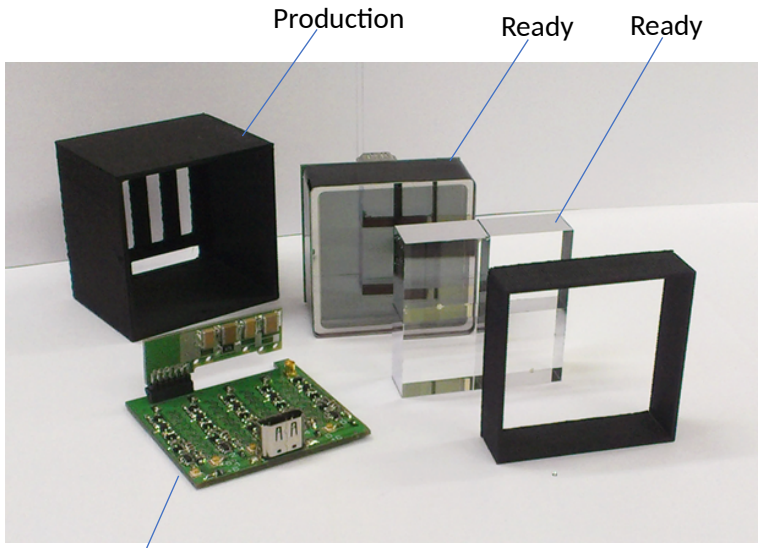
1) FFD-Type T0

Main idea: put fast counters close to the target and detect β=1 particles



FFD modules

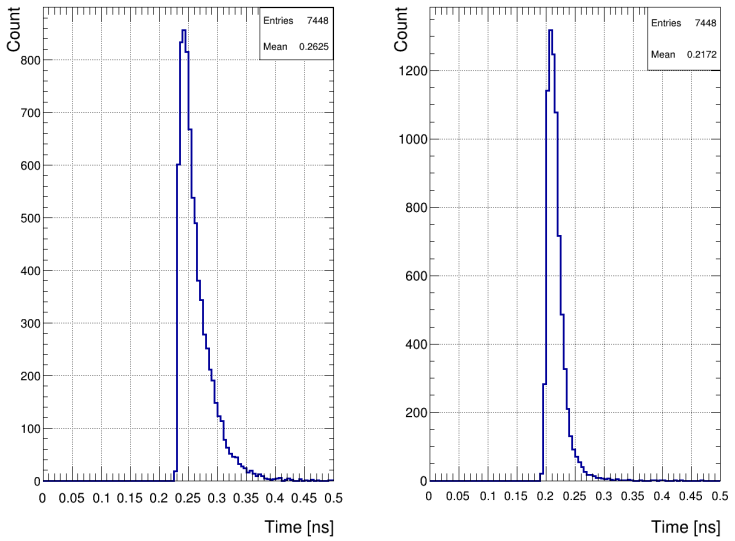




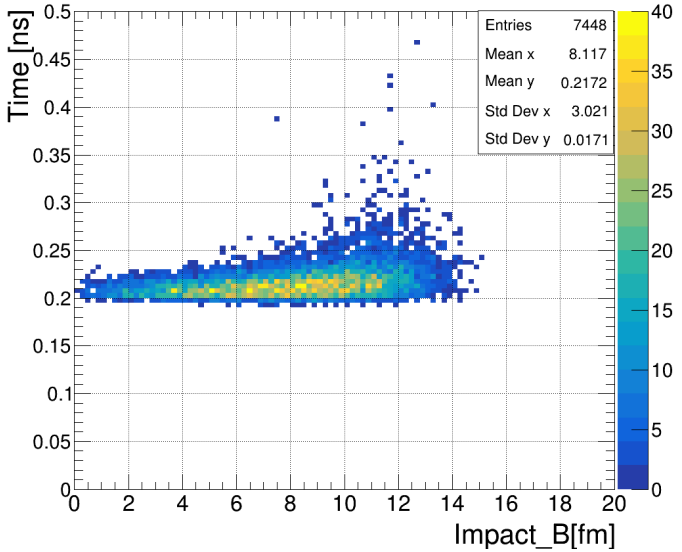
4 quartz bars 28 x 28 x 15 mm^3 in every FFD module
For BM@N trigger the Pb plates in FFD modules can be removed
Pb-Shielding around BD will serve as coverter

FFD-Type T0 efficiency simulation: Au + Au, 4 GeV/n

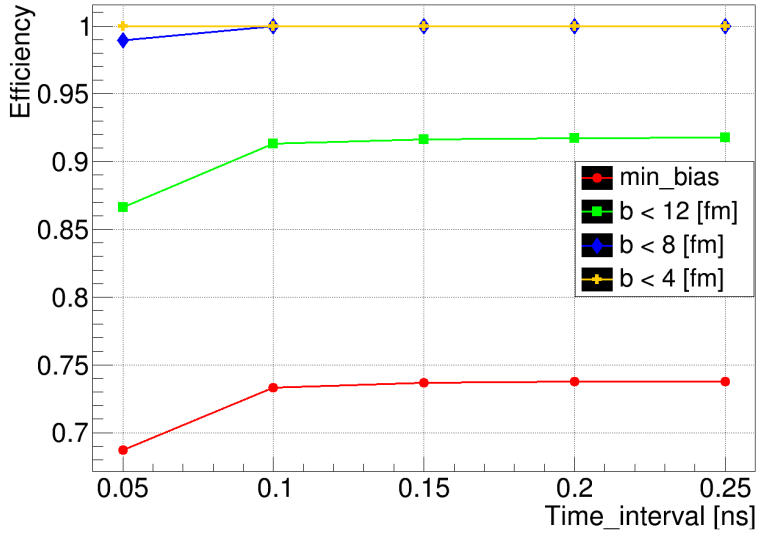
N.Lashmanov



Arrival time of the first photon. Alignment



Arrival time of the first photon.
Centrality dependence



Efficiency vs centrality

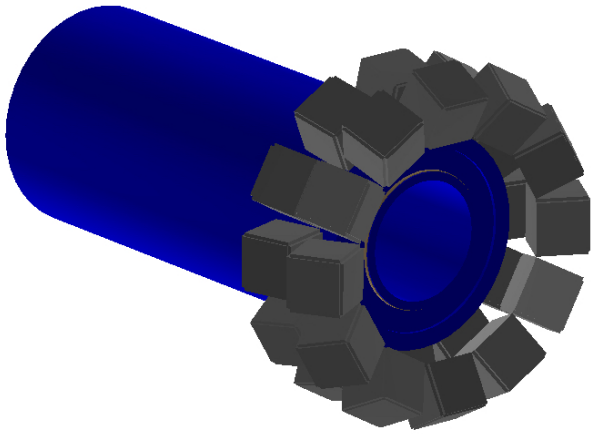
Detection condition:
arrival of more than 800 photons
(sum in all 4 FFD modules)
in 50-250 ps time window
after the first photon

T0 options at high beam intensity, Au+Au, $5 \cdot 10^7$

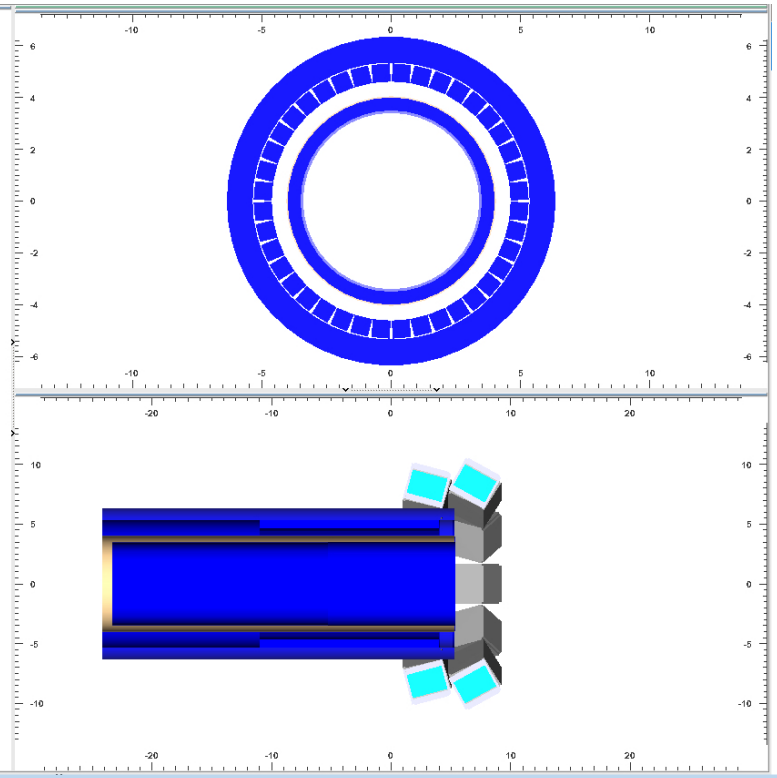
2) Quartz + SiPM T0

Two rings of 12 quartz radiators 30 x 30 x 20 mm^3 , each viewed by 16 SiPMs 6 x 6 mm^2.
Detection condition: more than N x 100 photons registered by SiPM's (in any of the modules)
in 50-200 ps time window after the first photon.

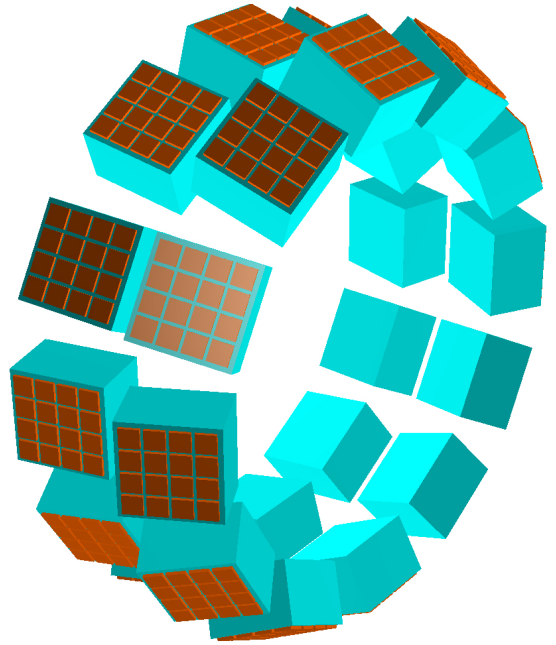
BD



Quartz+SiPM

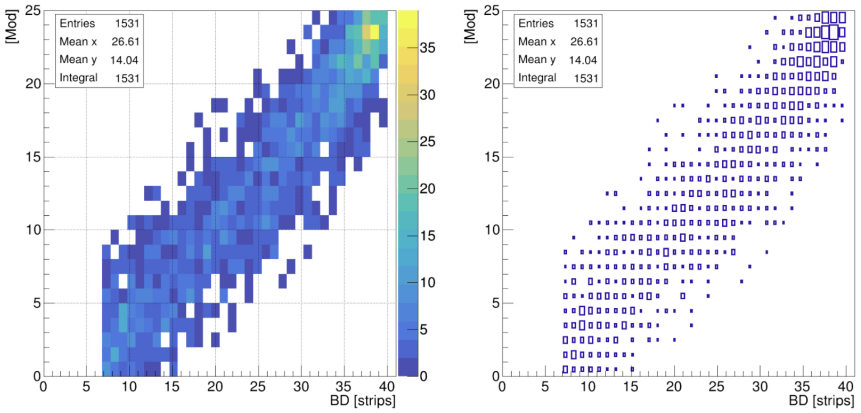


Quartz+SiPM

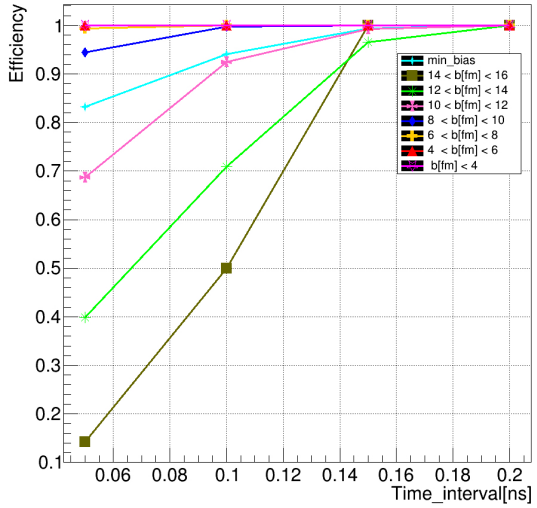


Quartz+SiPM T0 efficiency simulation: Au + Au, 4 GeV/n

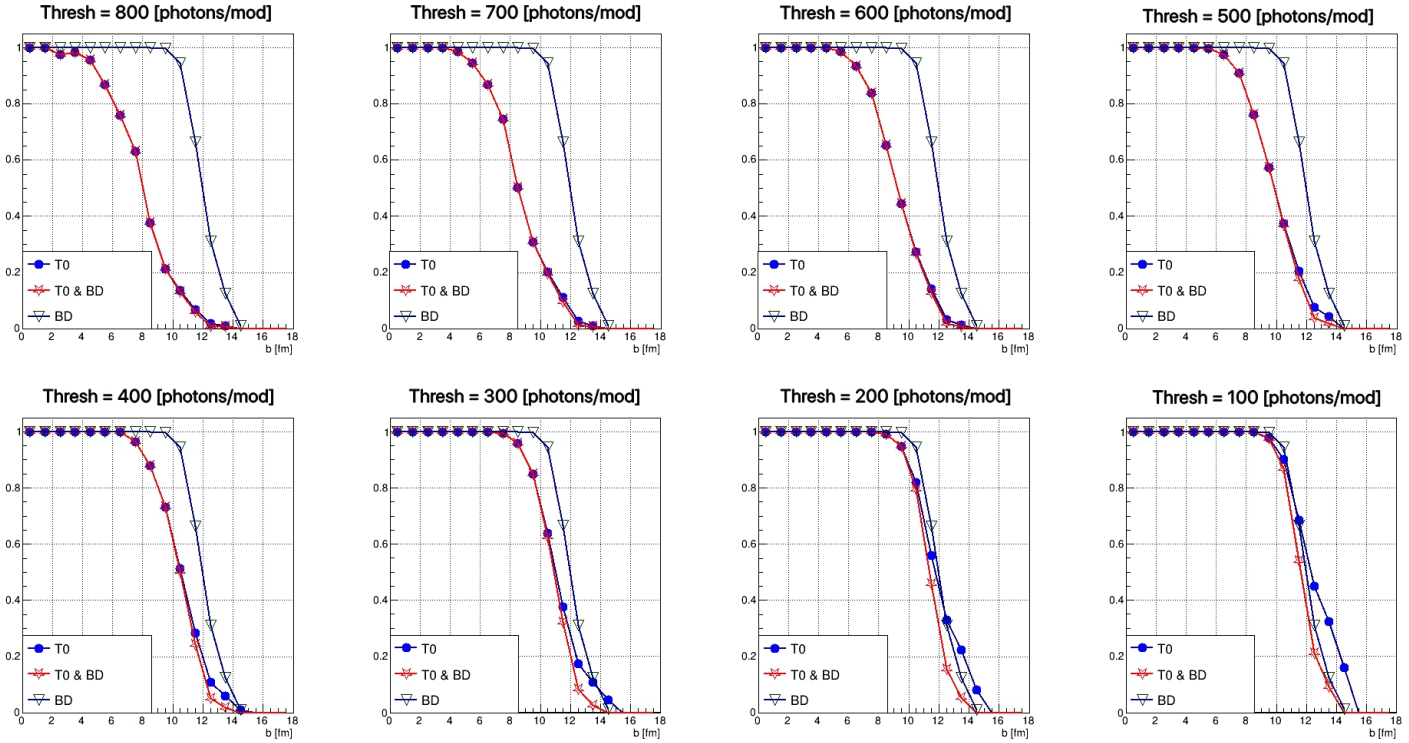
N.Lashmanov



BD counts vs. T0 counts



Centrality dependence
of T0 efficiency.
More than 100 detected photons
(QE folded in) in time windows
of 50, 100, 150, 200 ns.



Efficiency vs centrality for different thresholds in T0 modules

Current status

– work in progress
– both options look promising
– FFD option can be tested
In the next run

Thank you for your attention