Status of the beam line and beam detectors

Sergey Sedykh for the BM@N

BM@N Detector Advisory Committee
June 18, 2019

Outline

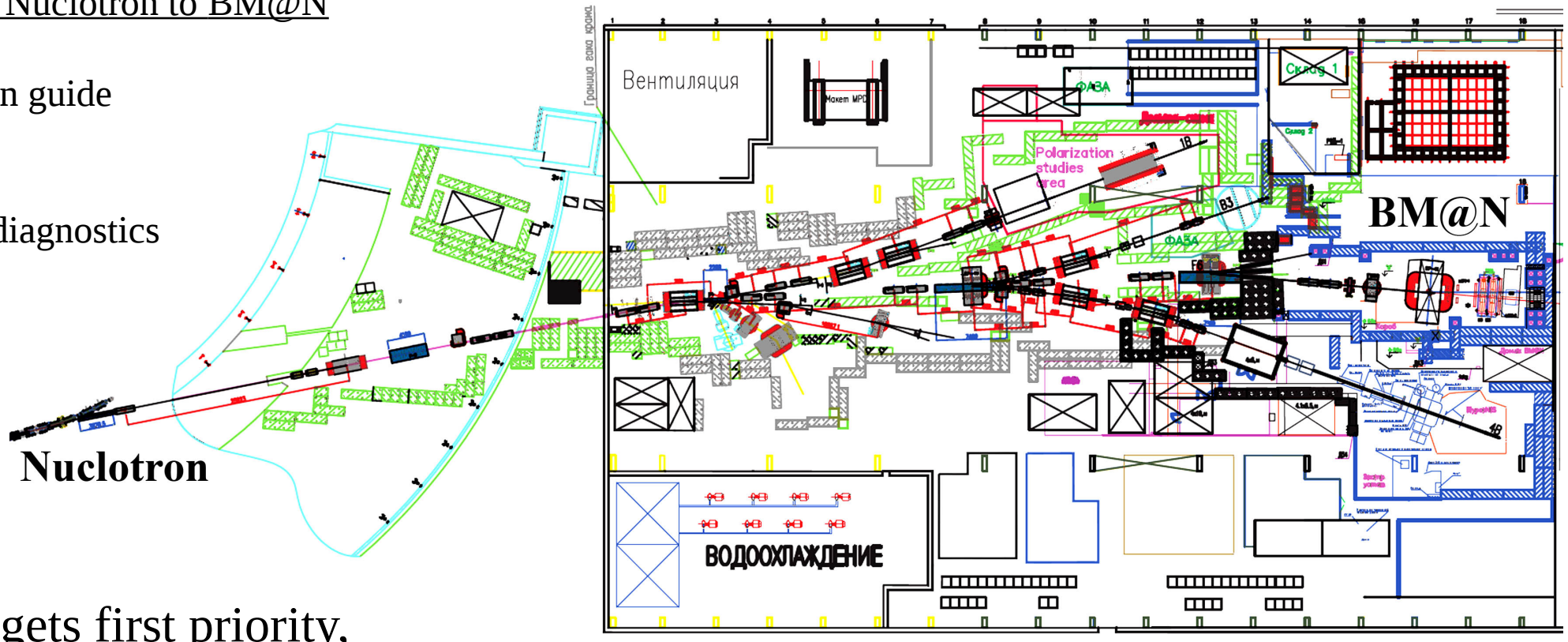
- *Beam transport line from Nuclotron to BM@N*
- *Beam vertex and profile detectors*
- *Beam counters (BC1, BC2, VC)*
- *Target area and trigger multiplicity detectors*
- *Simulations of trigger efficiency and background rate*
- *Ideas about trigger at high intensity*

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,

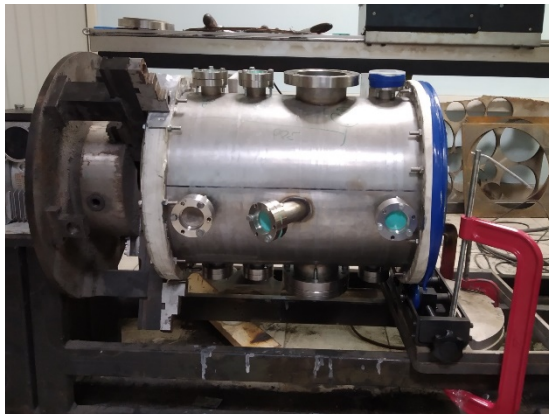
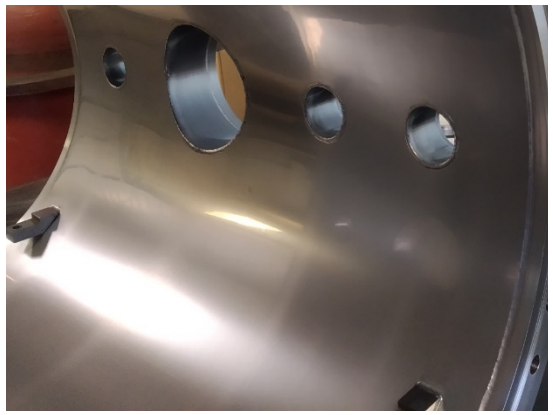
other lines will also later get vacuum.

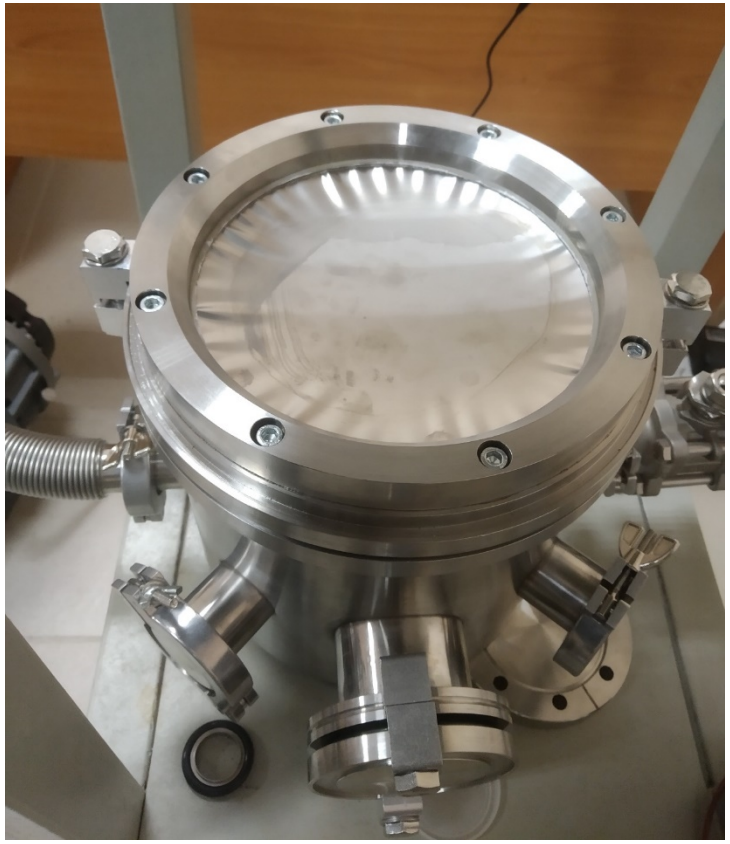
Nuclotron ← 138 m / lenght of the ion guide → **BM@N**

Partner for vacuum ion guide design
Radiation Physics Laboratory of Belgorod State University

Main topics of technical activity

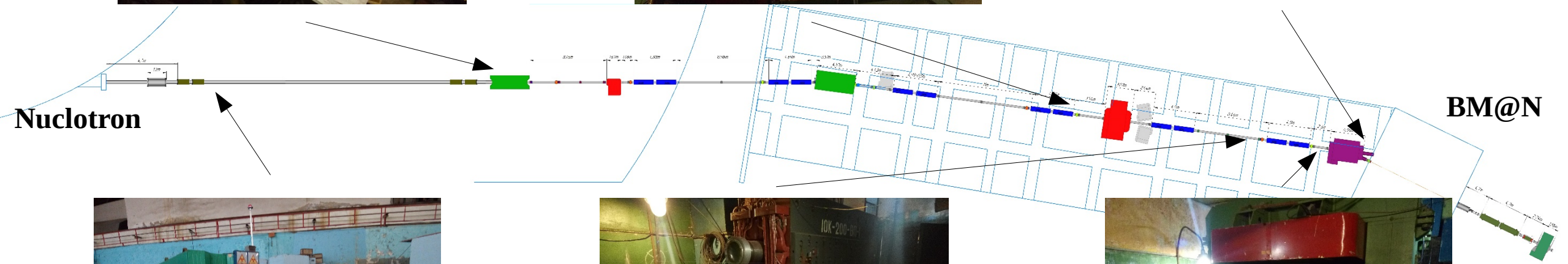
- development and manufacturing of vacuum systems for radiation physics experiments;
- 3D modeling of vacuum chambers construction;
- development of vacuum automated mechanics and control soft development;
- development of new tools for beams diagnostics.

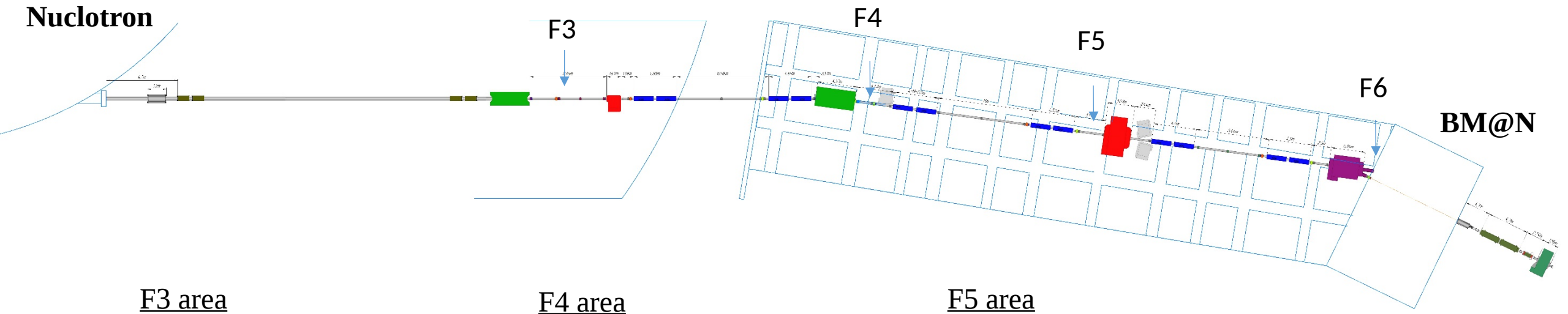
Vacuum ion transport line from Nuclotron to BM@N

Current state of the ion guide

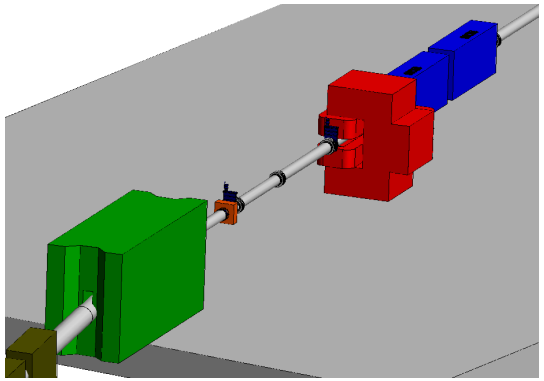


Vacuum ion transport line from Nuclotron to BM@N

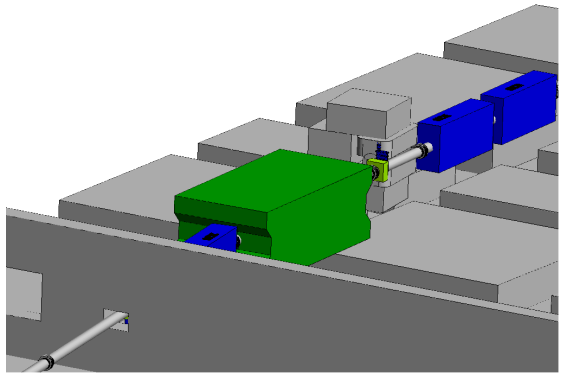
Detailed 3D model of the ion guide
(Done in Feb-Mar 2019)



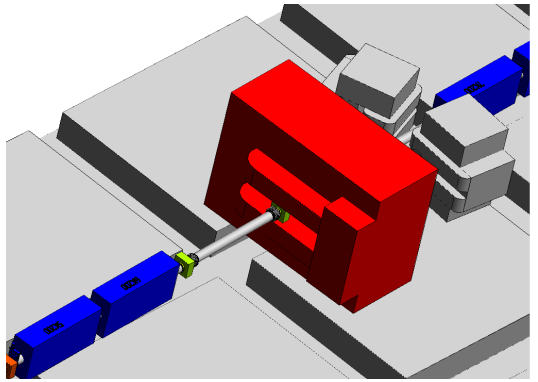
F3 area



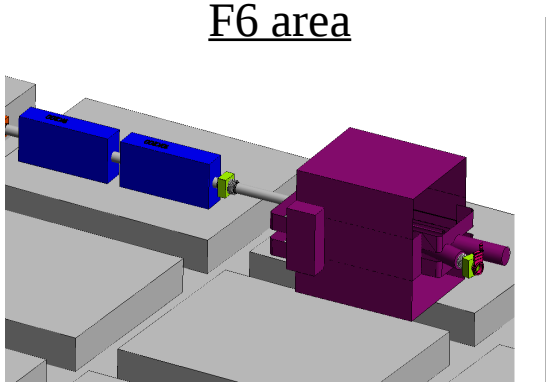
F4 area



F5 area

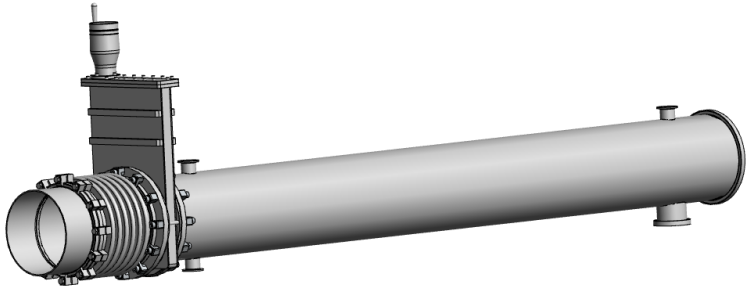


F6 area

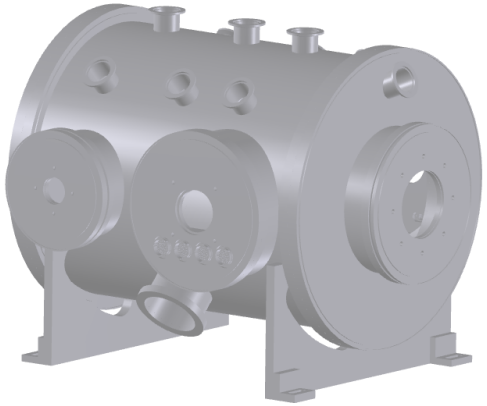


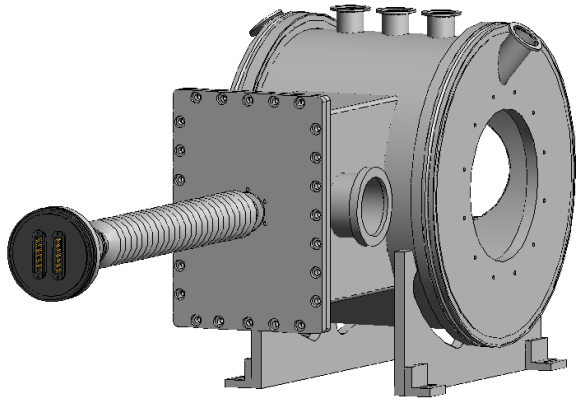
Vacuum ion transport line from Nuclotron to BM@N

Examples of designed parts of the ion guide

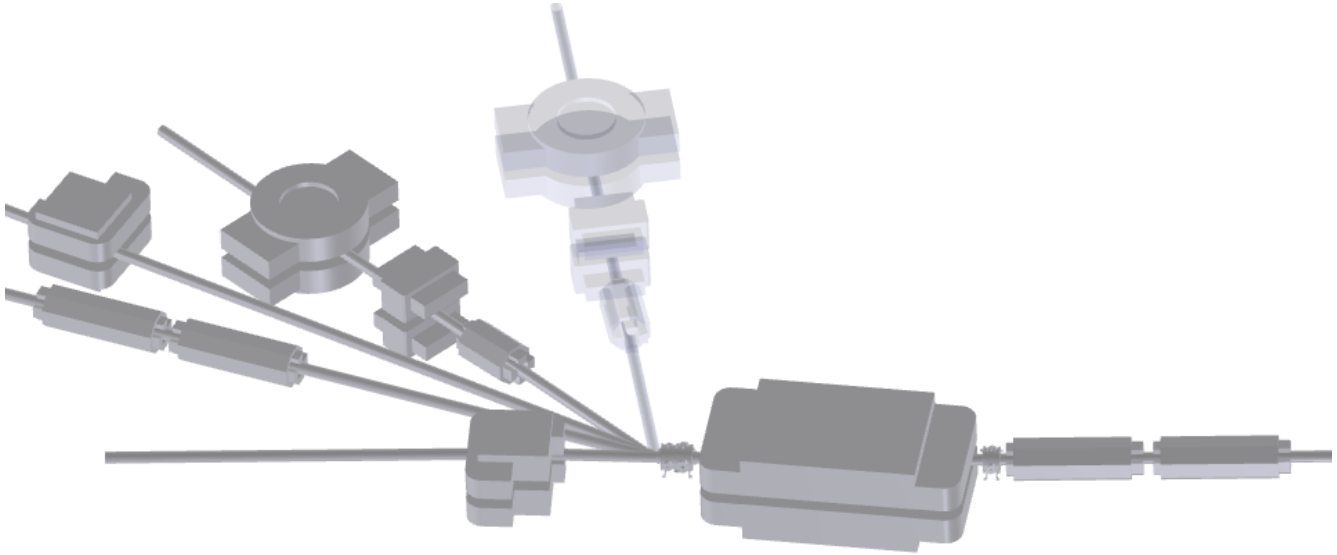


Basic part of the ion guide - vacuum pipe with ISO-K, KF flanges assembled with bellow and gate valve

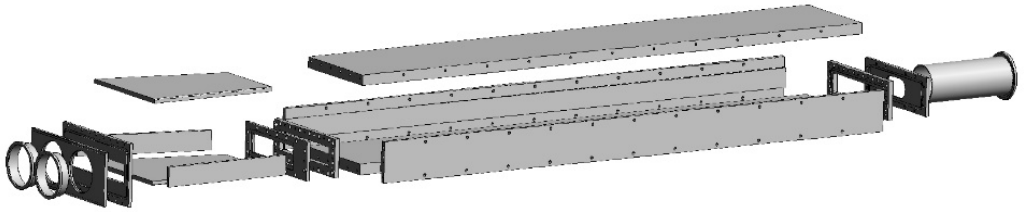




Multitask vacuum boxes for modern beam diagnostics tools and experimental research



F4 focus area with MARUSYA experimental setup



Vacuum box of a magnet

Beamline from Nuclotron to BM@N

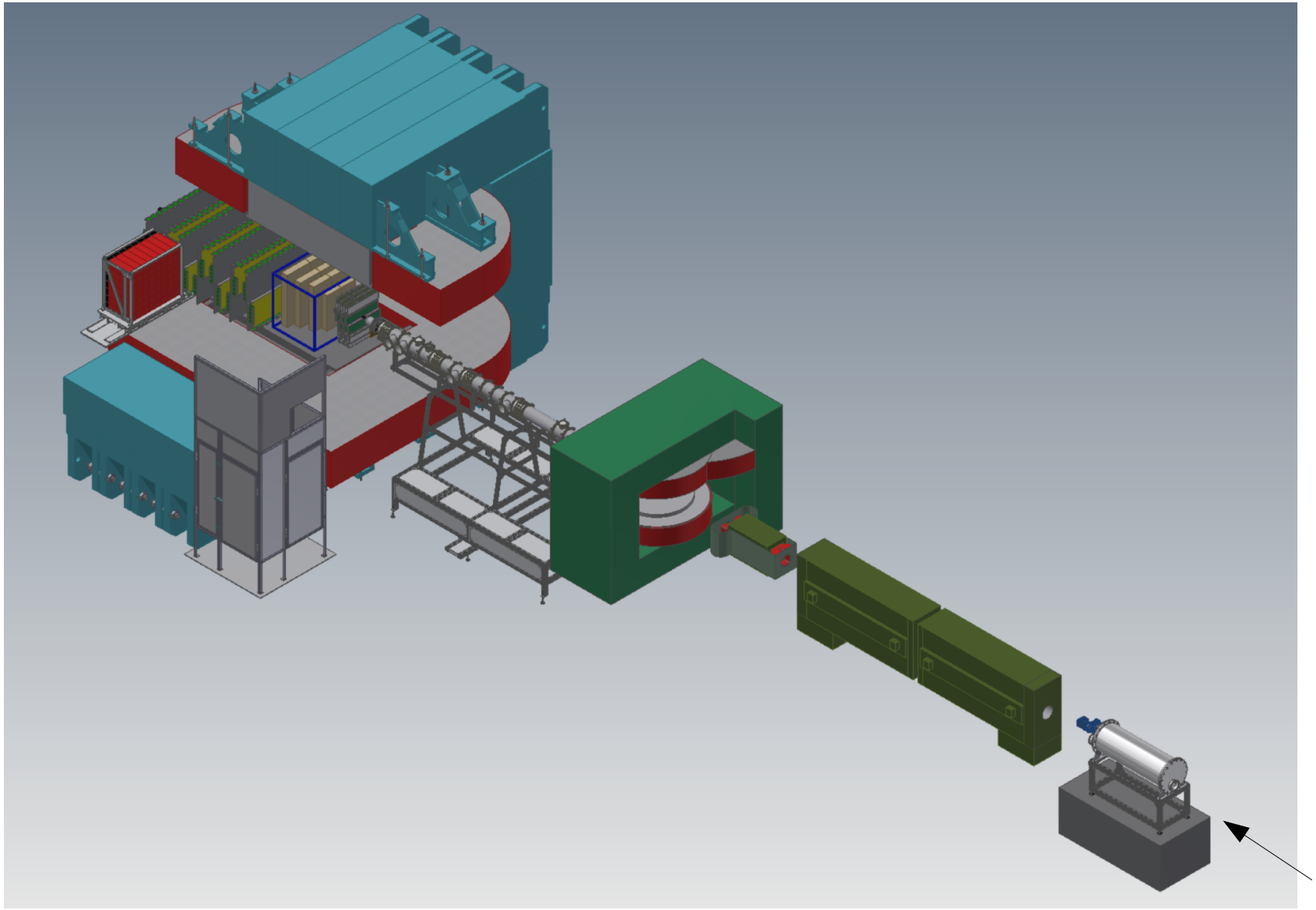
Overview of the current status

- *Complete measurement of the beamline components with 3D model (done)*
- *Technical details and design of major components (done)*
- *Some standard parts are being ordered*
- *Formal tender and official order (in progress, expected by the end of August 2019)*

- *Overall completion: expected by the end of Spring 2020*

Beam pipe in BM@N before the target

S. Piyadin



Chosen vacuum standard:
- Vacuum pipe dia: 20 cm
- Standard ISO-K

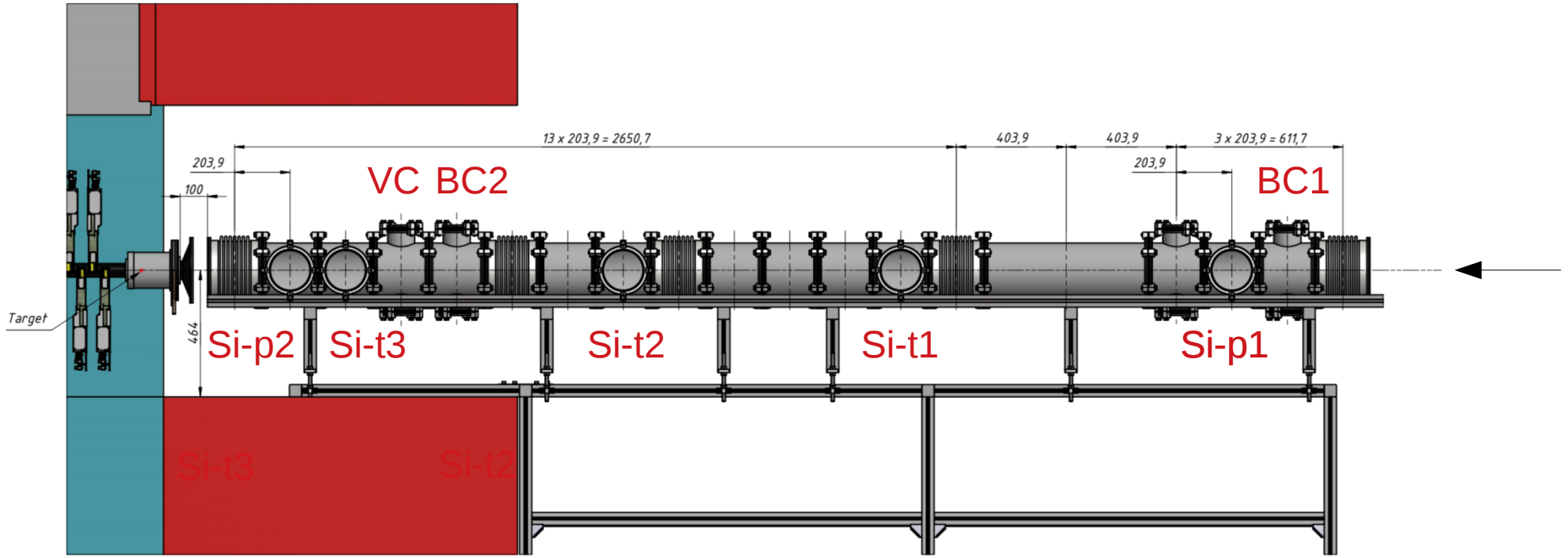
Most of the non-standard components will be also produced by the BSU group

Experience with Vacom® (Jena, Germany):

- difficulty with non-standard components
- some vacuum connectors are not provided in Russia

BM@N beam pipe before the target

S. Piyadin



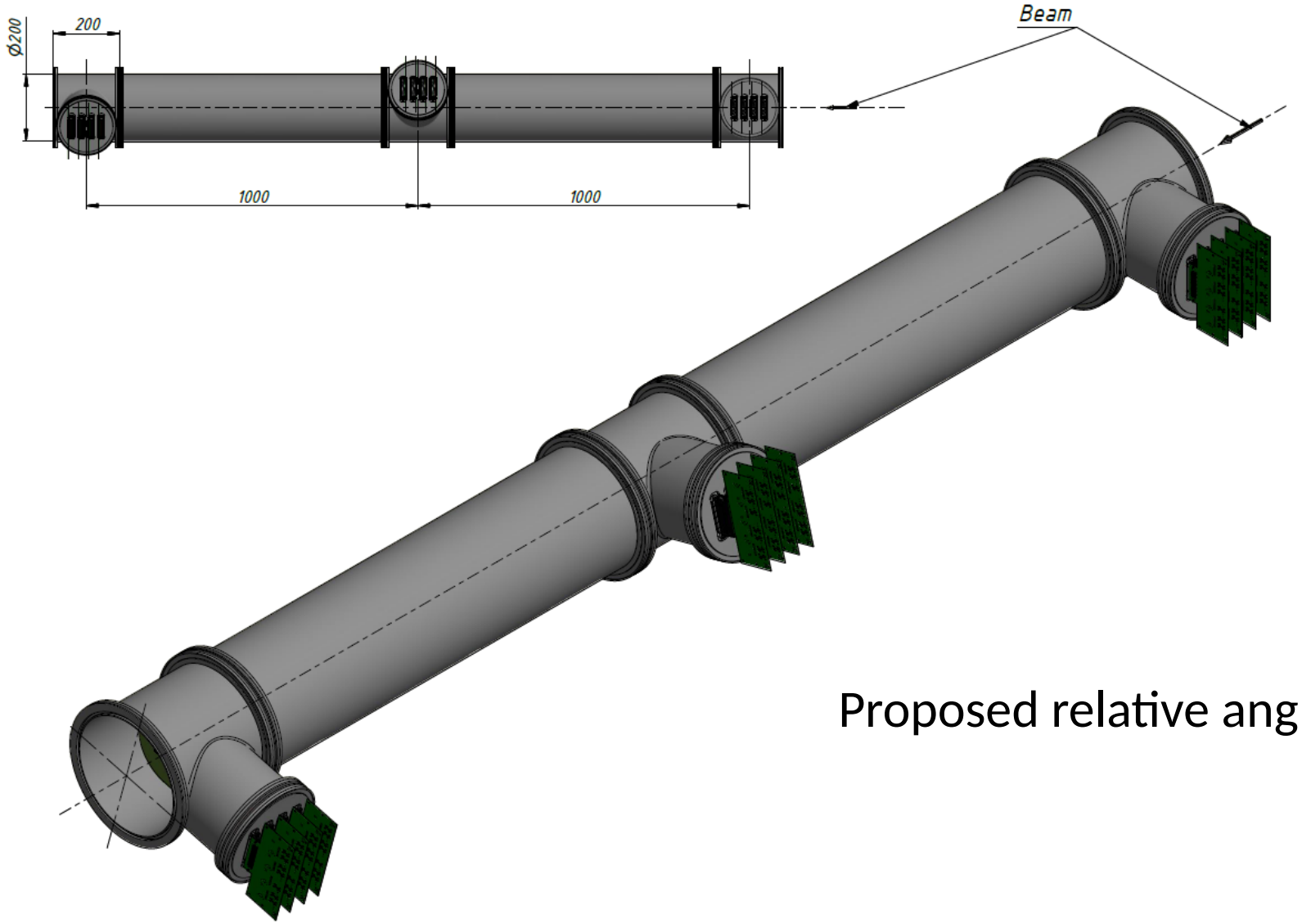
BC1, BC2, VC beam counters

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

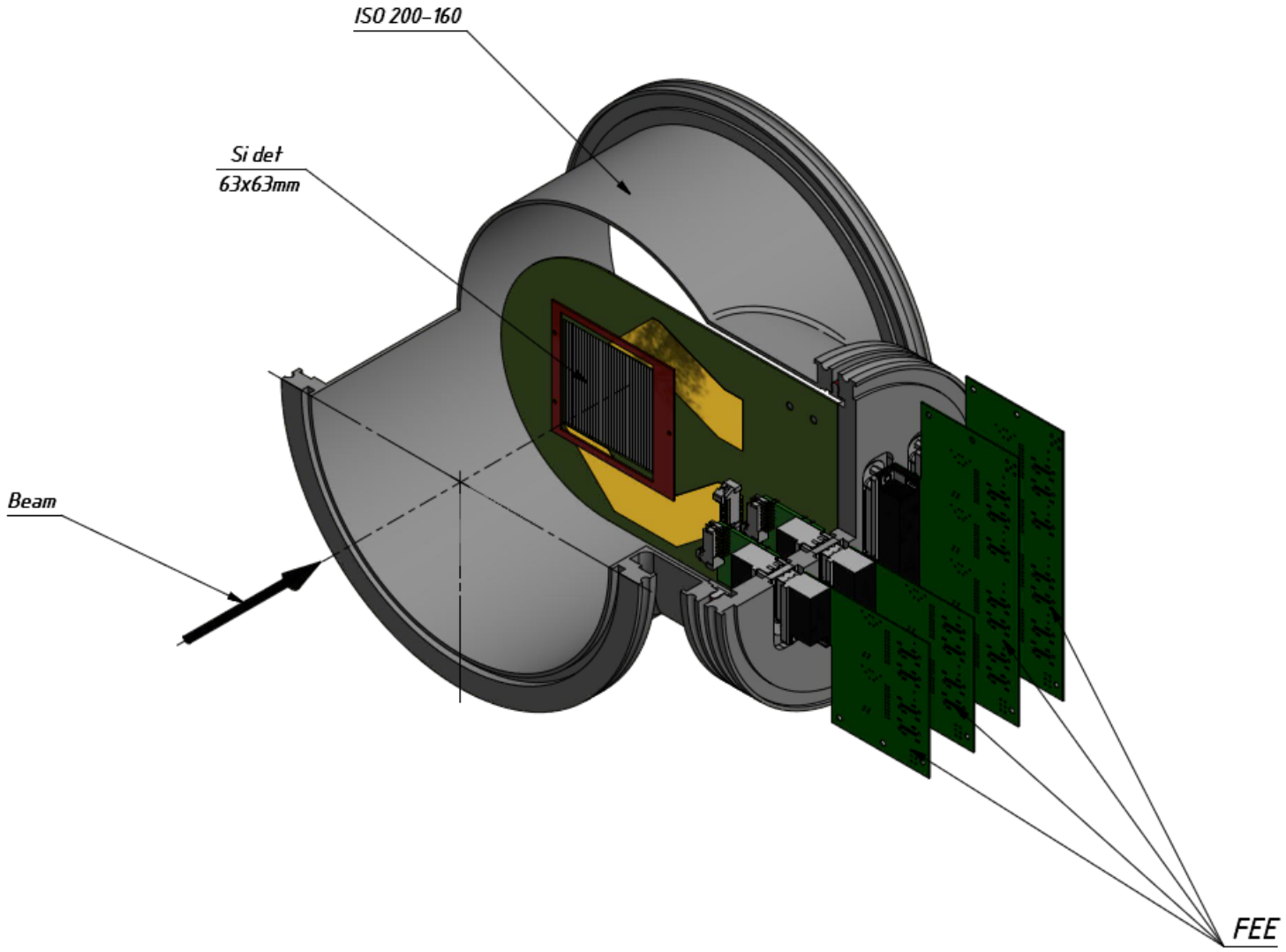
Silicon Beam Tracker Detectors. Relative Orientation



Proposed relative angle ±15°

Silicon Beam Tracker and Beam Profile Detectors

Group of N.Zamjatin



Tracker

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

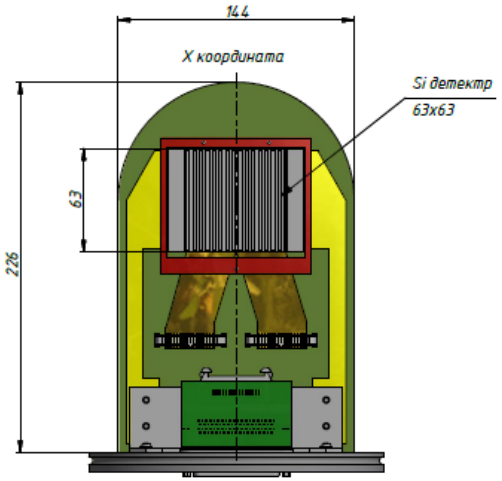
Minor changes in the design since Jan.2019 due to different vacuum connectors

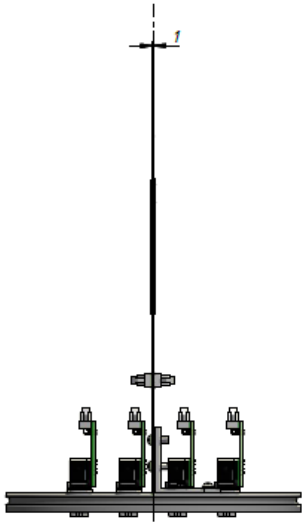
Profilometer

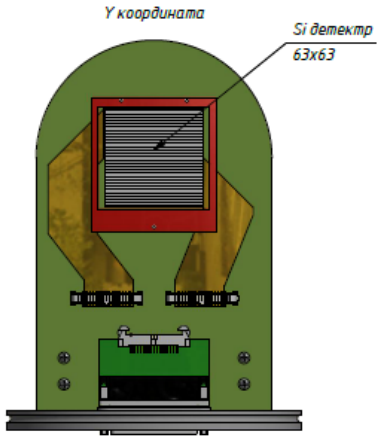
– double-sided
– active area 60 x 60 mm
– pitch 1.87 mm
– 32 x 32 strips
– thickness 175 μm

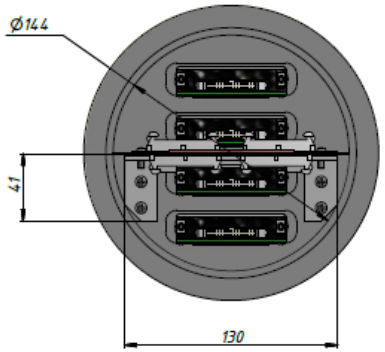
Design is not yet finished

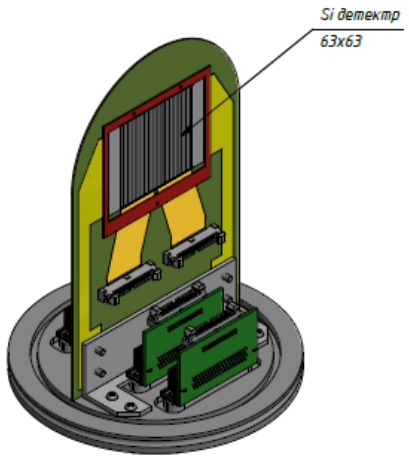
Beam Silicon Detectors: FEE electronics

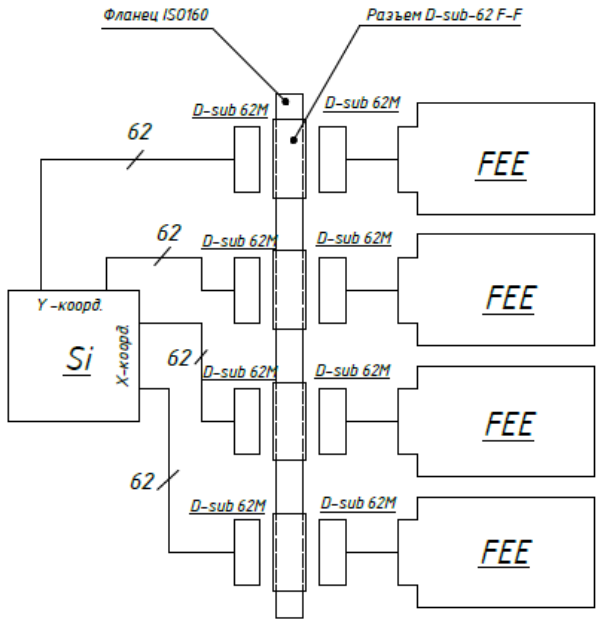












Beam Silicon Detectors: FEE electronics

FEE is based on VATAHDR16.2 charge sensitive ampilifier
with large dynamic range (+/- 20 pC), 64 inputs, short shaping time (50÷300 ns)

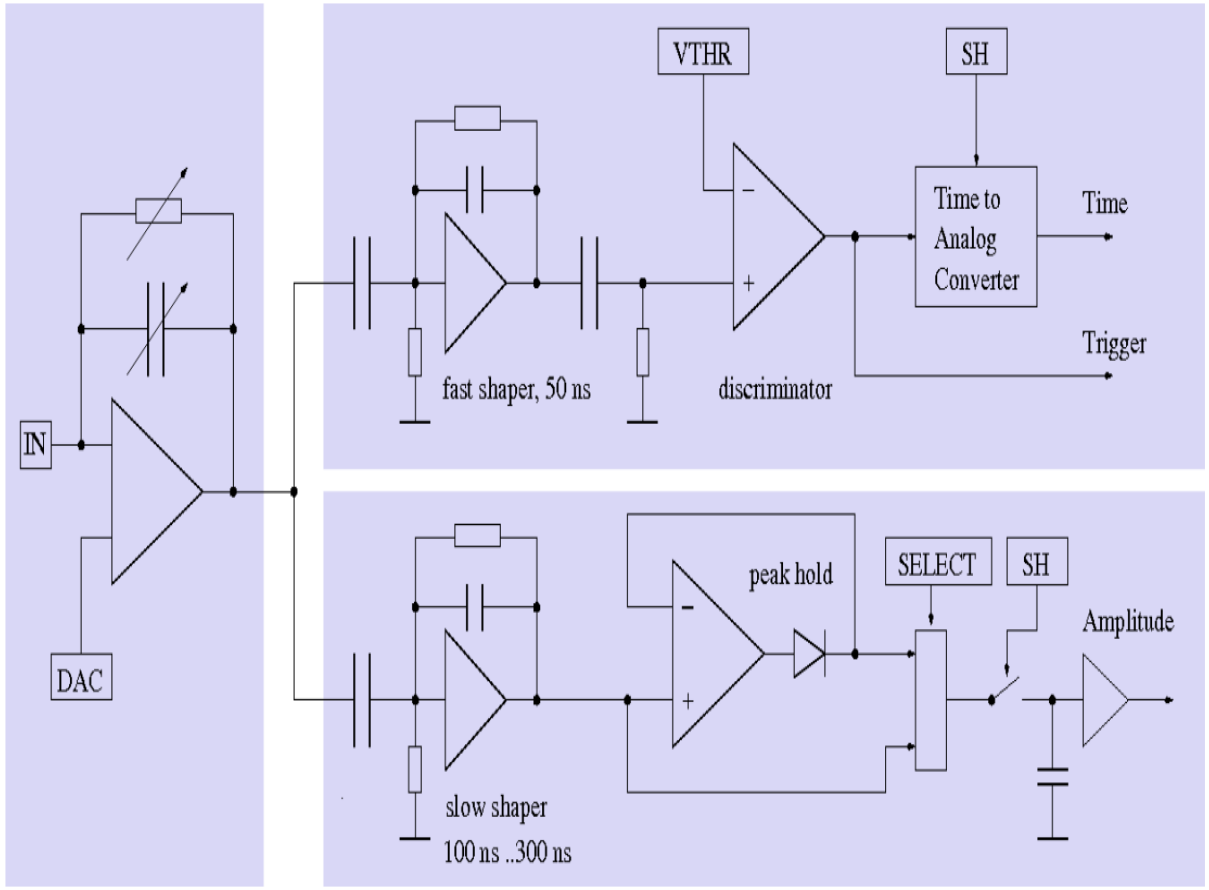


Figure 5: Block diagram of the readout channel.

No. of inputs	64
Input charge (dynamic range)	-20pC ÷ +50pC
Shaping time of read-out signals	50ns, 100ns, 150ns, 300ns. Programming
Trigger output	1 trigger output (Trigger-OR)
Shaping time of trigger signal	50ns
Noise level	ENC = 1fC without load
Adjustable trigger threshold	External + 4-bit threshold trim-DAC/ch.
Gain	2-gain settings programmable
Output	Analog multiplexed output 64 pulse height samples, serial output Differential current and voltage output
Power consumption of 64-ch. ASIC	960mW max. depending on settings
Power	+2.5V, -2.5V

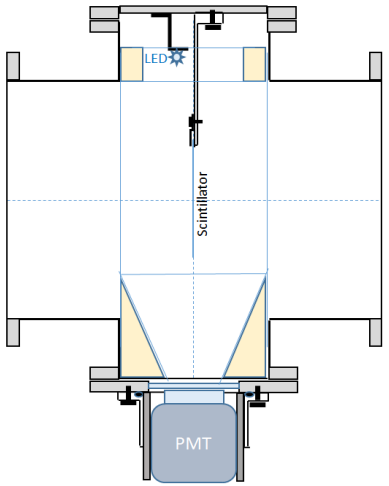
Silicon Beam Tracker and Beam Profile Detectors

Overview of the current status

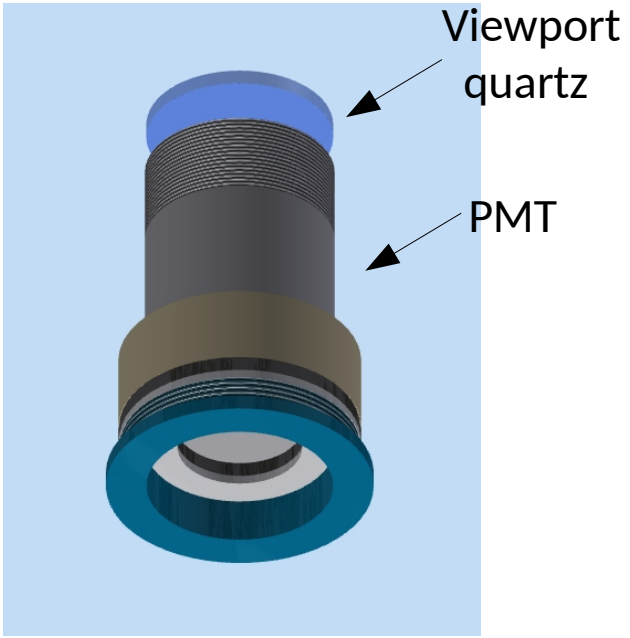
– *Mechanics for mounting tracker plates (completed, "Atom", resp. E.Zubarev)*
– *84 pitch adapters (completed, Nanotechnology Center, Zelenograd)*
– *Design of vacuum components (completed, resp. O.Tarasov)*
– *Production of vacuum components (expected by mid.August, resp. BSU team)*
– *Production of detectors (ordered, in progress, NIIMV, Zelenograd)*
– *FEE design (in progress)*
VATAHDR16.2 (need clearance for delivery from Norway)
– *Stand for testing assembled detectors (in progress, resp. S.Khabarov)*
– *Assembly Room 115 bldg.215 (renovation in progress)*
Ultrasonic wire bonder Devoltec-M17S (should be purchased)

– *Start of assembly (expected in Sept. 2019)*

Beam Counters: BC1, VC



Sketch of vacuum box for BC1 and VC



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

Status

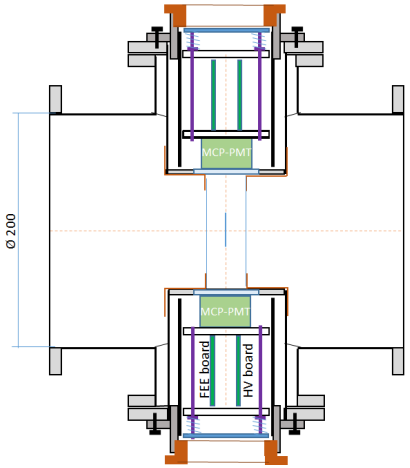
– Hamamatsu R2490-07 operate in magnetic field <1T (available)

– Vacuum boxes (designed, exp. mid. August)

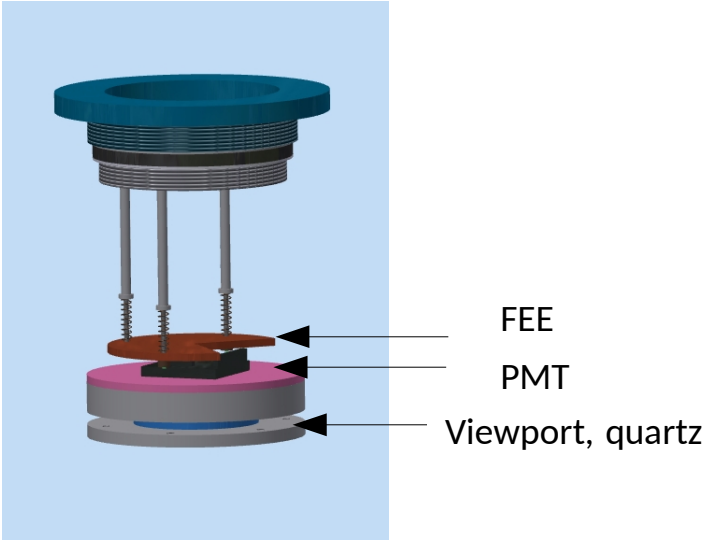
– PMT mounts (design is close to completion)

– 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

Status

– MCP-PMT XPM85112/A1-Q400 operate in magnetic field <1T (delivered, March 2019)

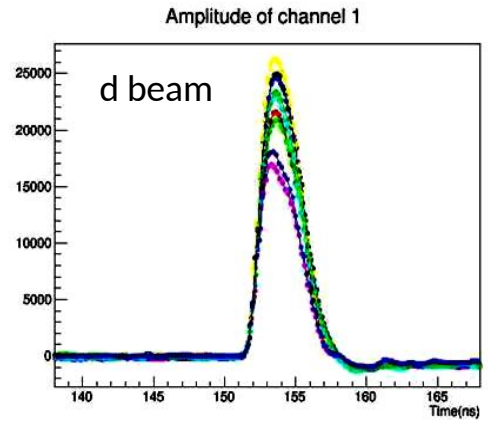
– Vacuum boxes (designed, exp. mid. August)

– PMT mounts (design is close to completion)

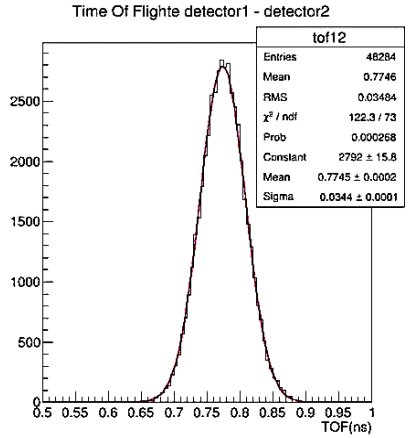
– Scintillator mounts (not yet designed)

Relevant to BC2 in BM@N: Time resolution results with FFD prototypes

Ev.B. DRS4 readout

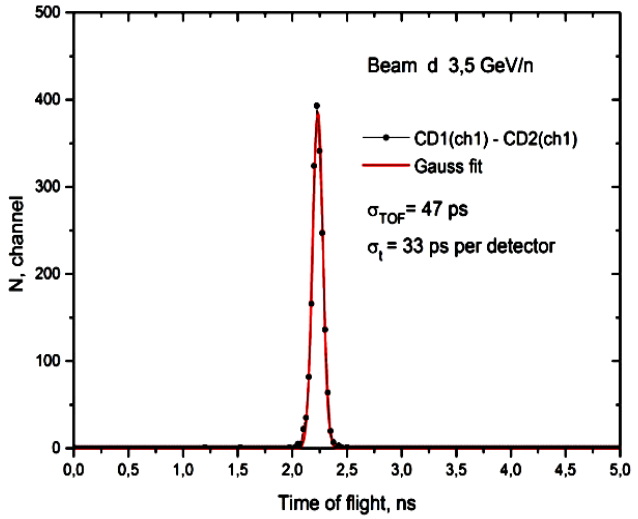


Typical pulses



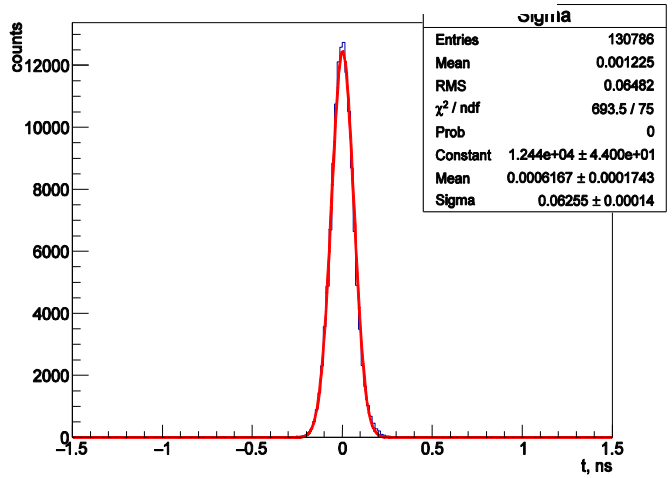
Time resolution (TOF)

CAEN mod.N6742 readout



Time resolution (TOF)

TDC72VHL readout



Time resolution (TOF)

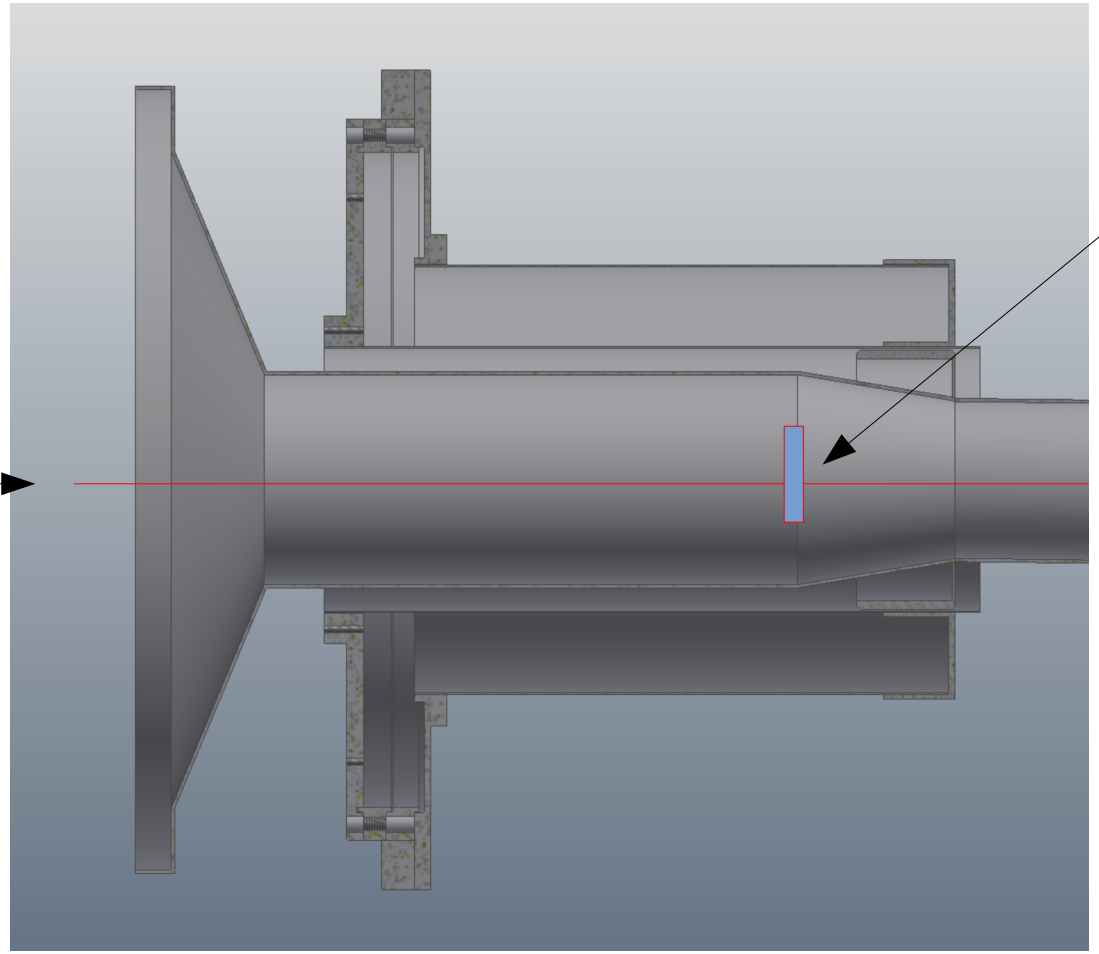
Conclusions

- Time resolution of FFD module itself - 21.5 ps
- with readout by E.B. DRS4 digitizer - 24 ps
- with readout by digitizer CAEN mod.N6742 - 34 ps
- real chain with readout by TDC72VHL - 44 ps

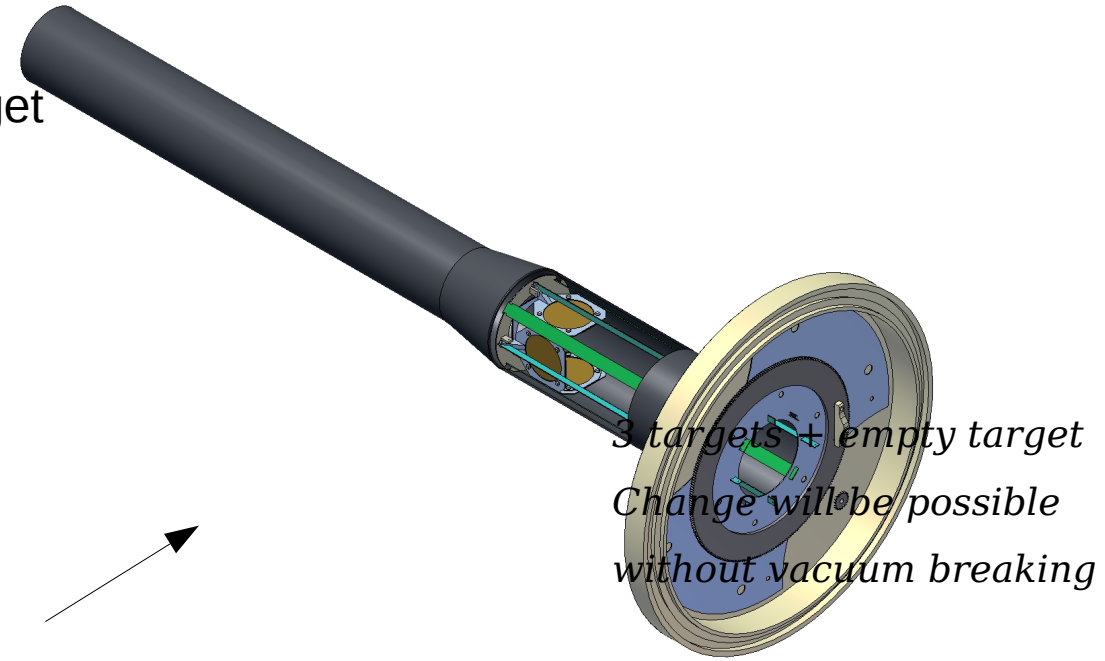
Resolution in C beam (2018):

Target area with Barrel Detector

S.Piyadin, Yu.Gusakov



Target



Carbon vacuum pipe and the target station

First section of the carbon vacuum pipe and Barrel Detector

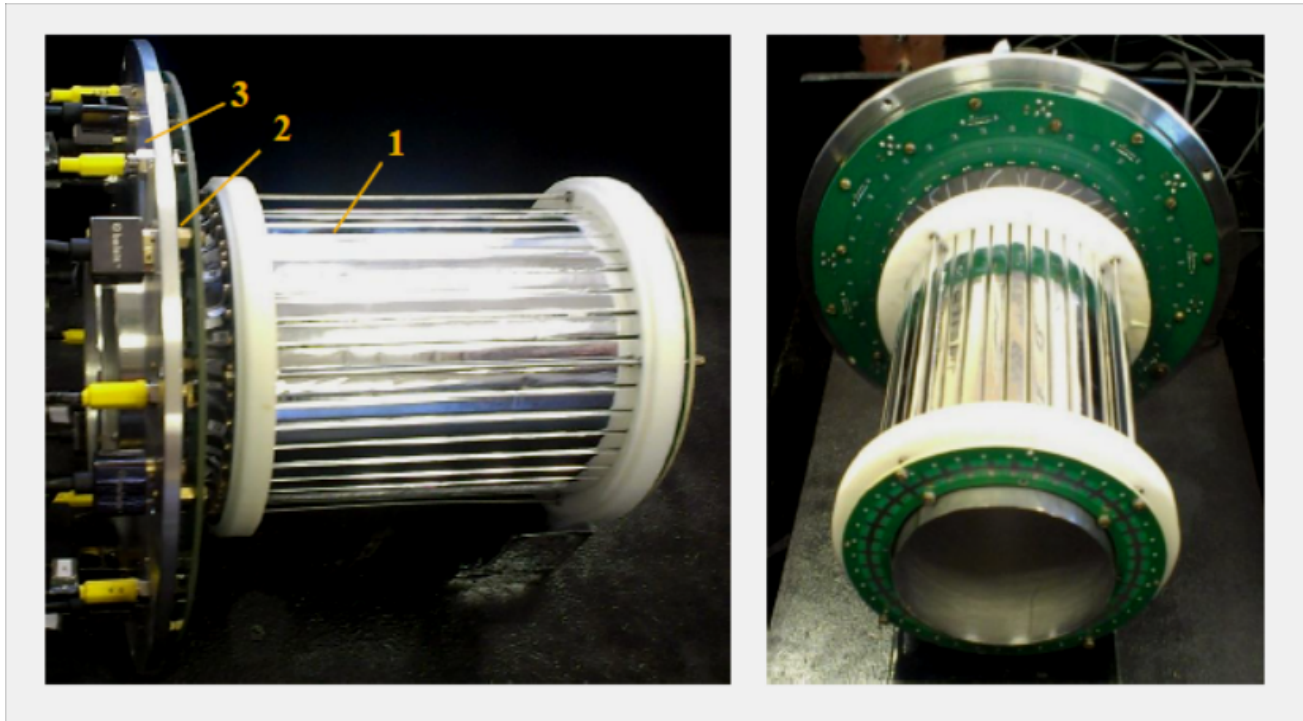
Dia. 200 → 66 → 50 mm

Status

– no major changes in the design
– effect of target material on BD trigger not yet studied

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 the Au runs:

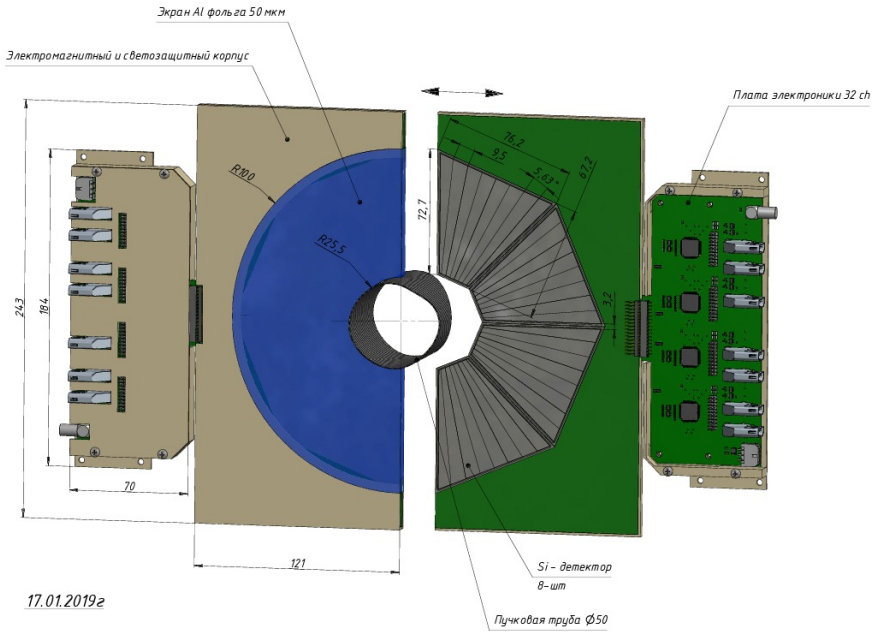
- inner and outer Pb shielding will be added

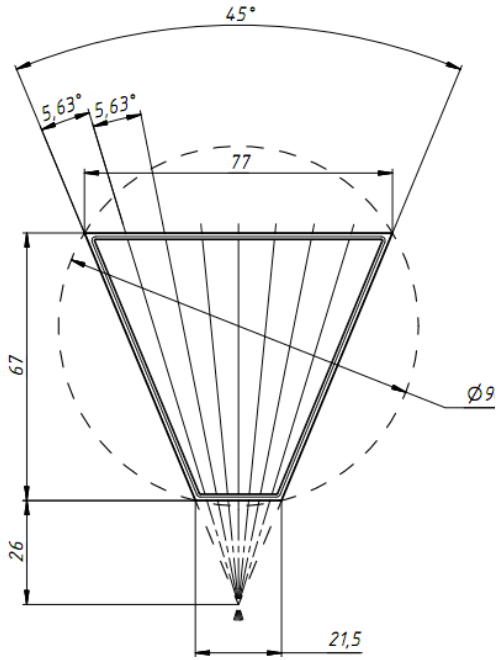
- new FEE (less noise, resp. V.Rogov)

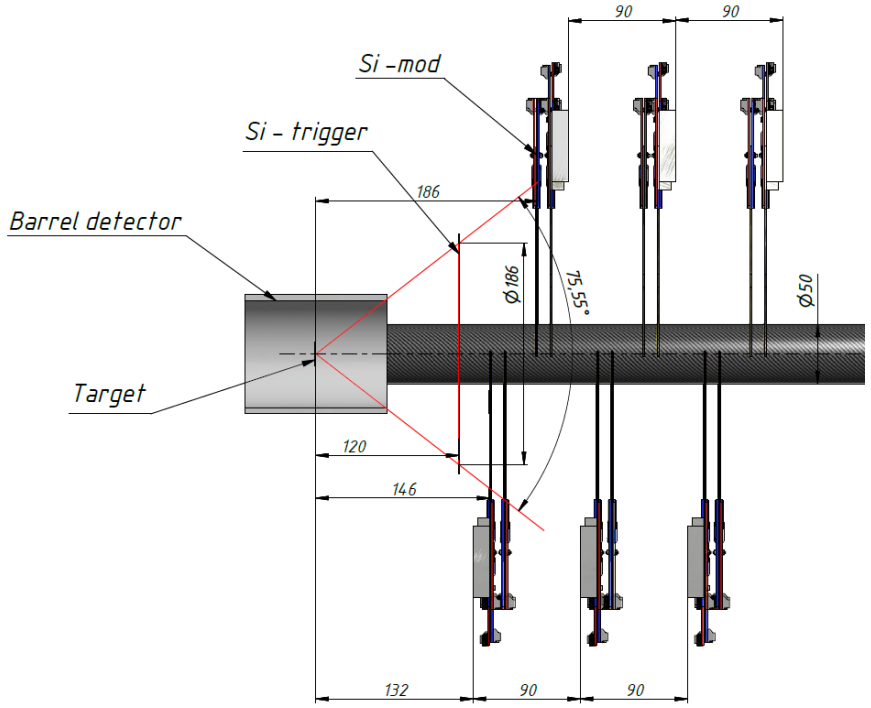
Upgrade of Silicon Multiplicity Detector

Group of N.Zamjatin

The Si detector has 64 independent segments / channels and it provides fast determination of multiplicity of charged particles emitted in forward direction by measuring a number of fired segments.







Placement at 12 cm from the target

Reason for the upgrade:

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

Status

– design of the detector is done
– design of the mounting frame is in progress

N.Lashmanov

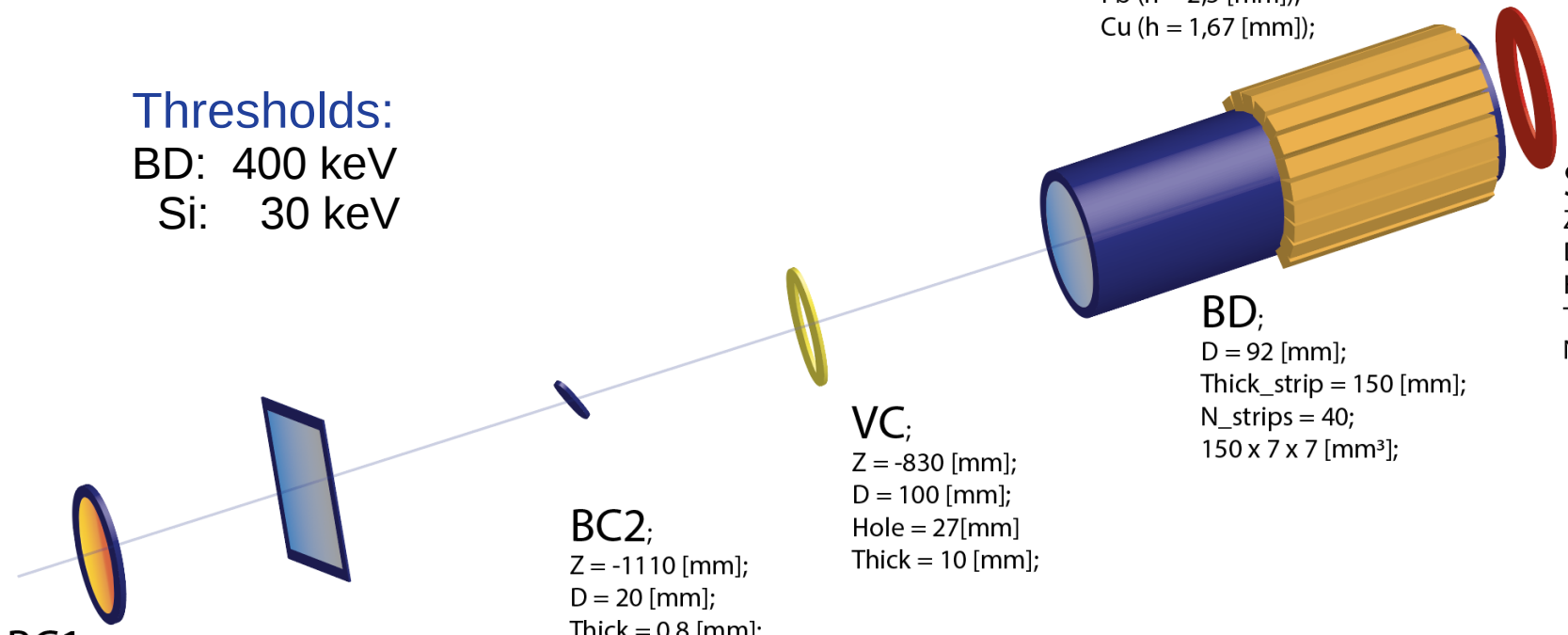
Simulation of trigger efficiency and background from δ-electrons

Reactions:

Ar + Cu, 3.2 GeV/n
Au + Au, 4.0 GeV/n

Thresholds:

BD: 400 keV
Si: 30 keV



Inner :

Target:
D 34 [mm];
Pb (h = 2,5 [mm]);
Cu (h = 1,67 [mm]);

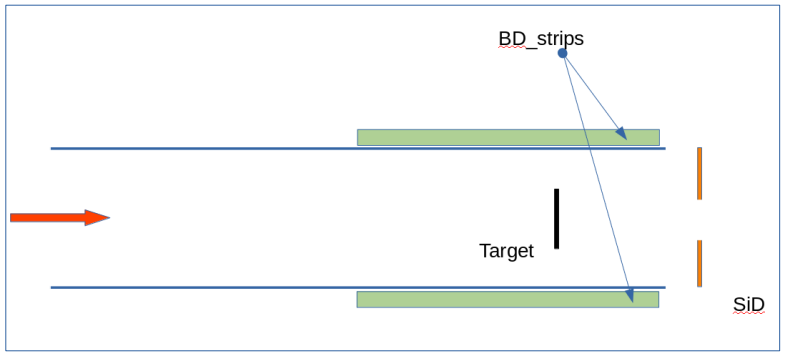
SiD;
Z = 70[mm];
D = 86 [mm];
Hole = 32 [mm]
Thick = 0,525 [mm];
N_strips = 64;

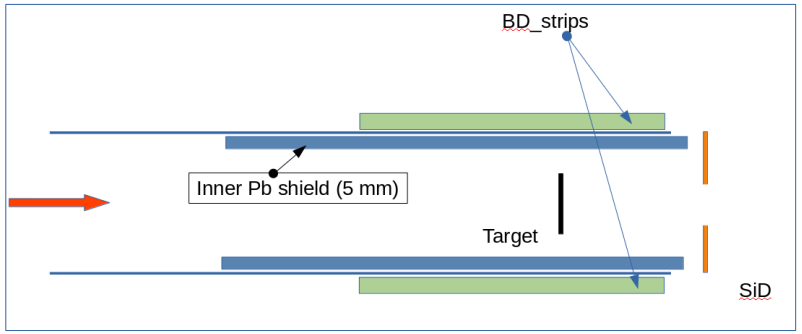
BD;
D = 92 [mm];
Thick_strip = 150 [mm];
N_strips = 40;
150 x 7 x 7 [mm³];

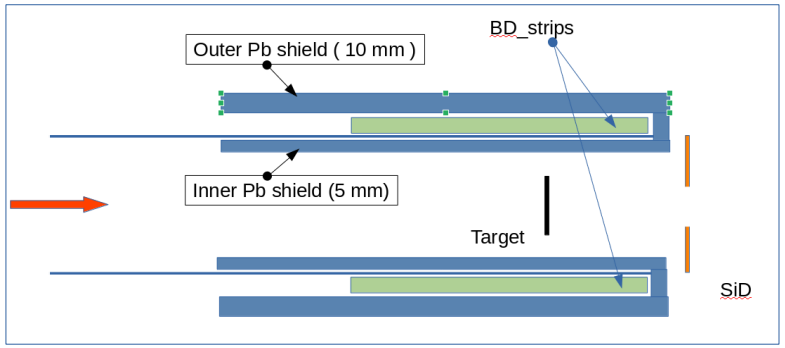
VC;
Z = -830 [mm];
D = 100 [mm];
Hole = 27[mm]
Thick = 10 [mm];

BC2;
Z = -1110 [mm];
D = 20 [mm];
Thick = 0.8 [mm];
Angle 45°;

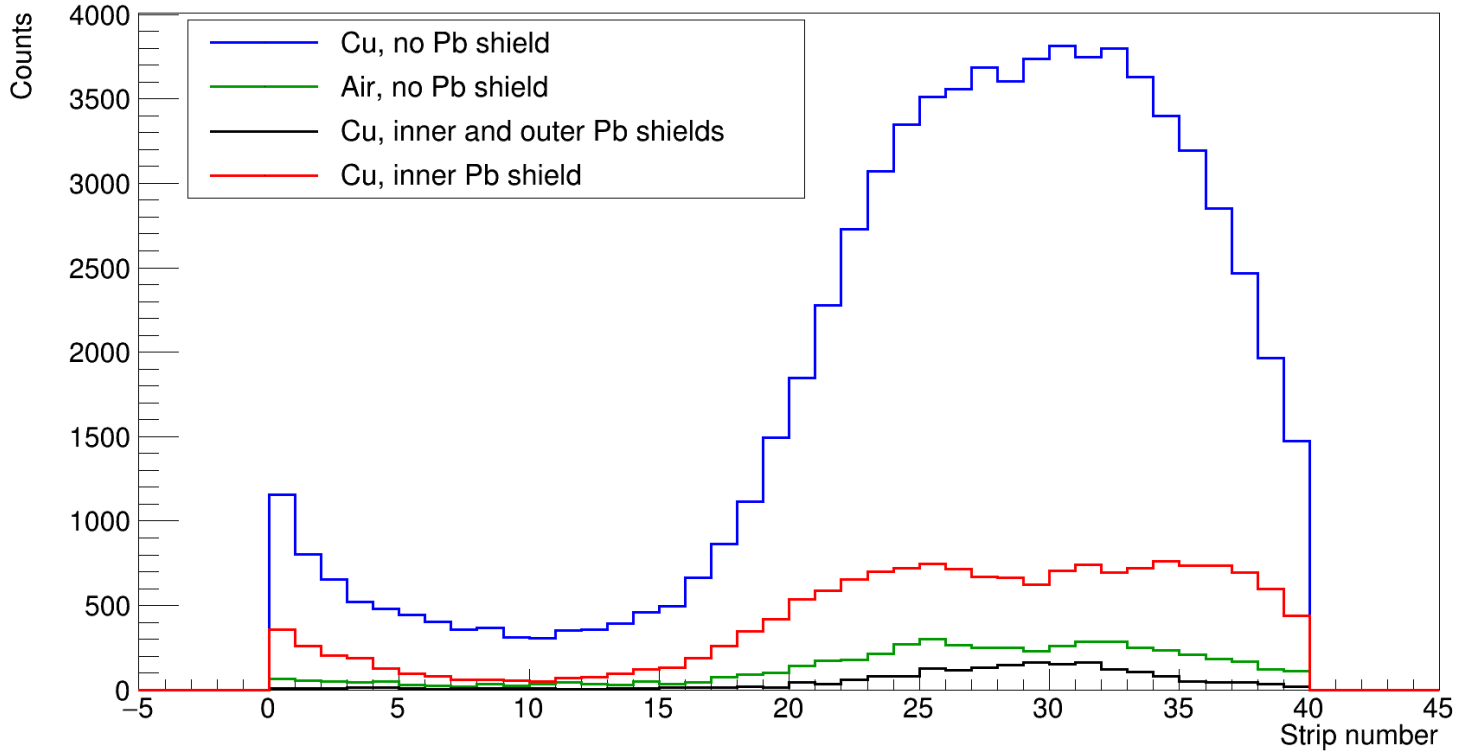
BC1;
Z = -3860 [mm];
D = 150 [mm];
Thick = 3 [mm]





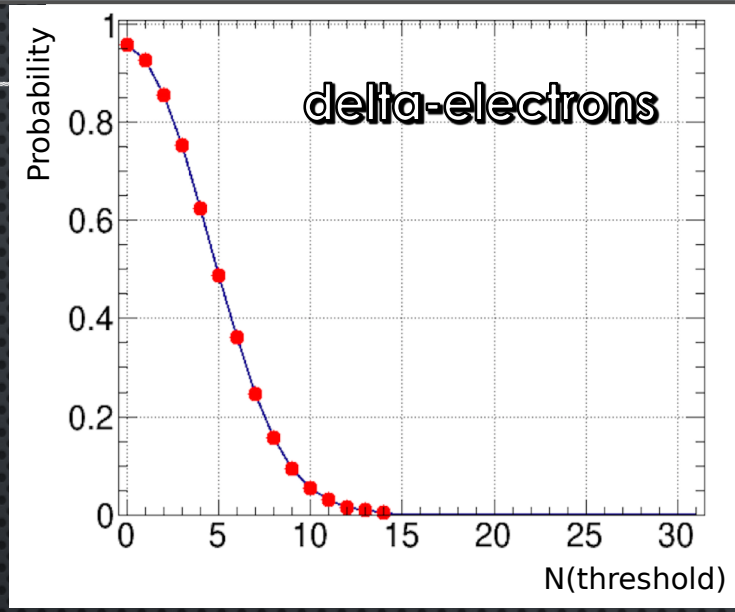


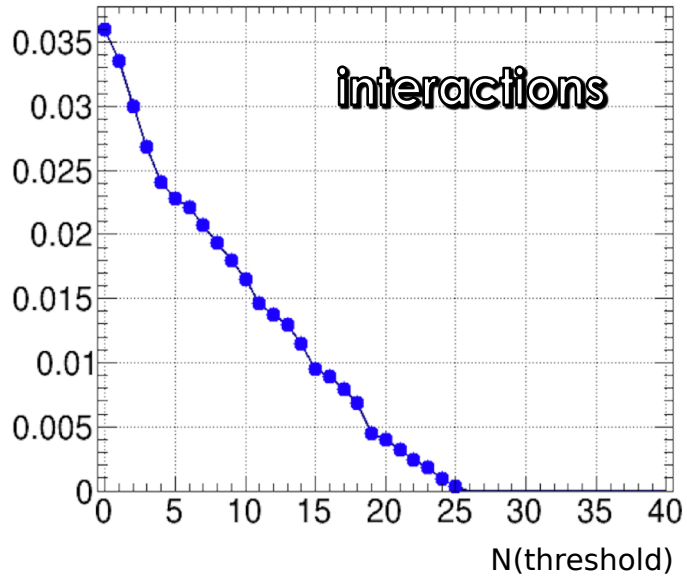
Ar+Cu, no interaction, counts in BD

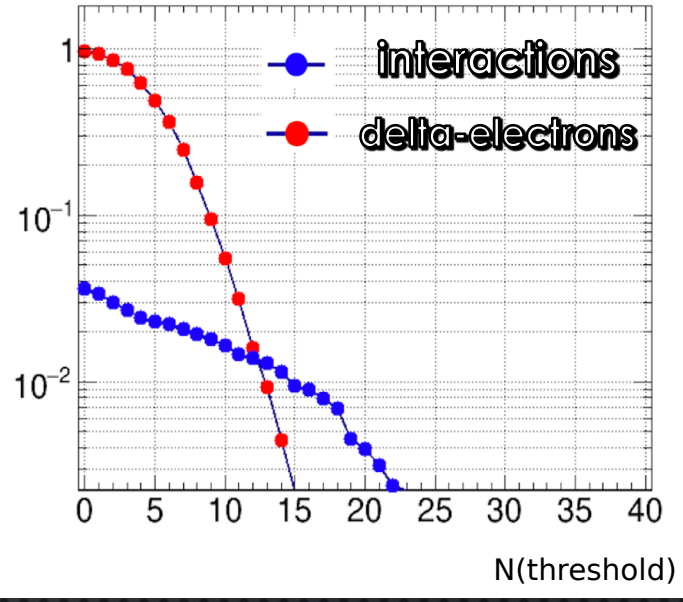


Ar + Cu(1670μm), E = 3,2 GeV/n, B = 0,9 T.

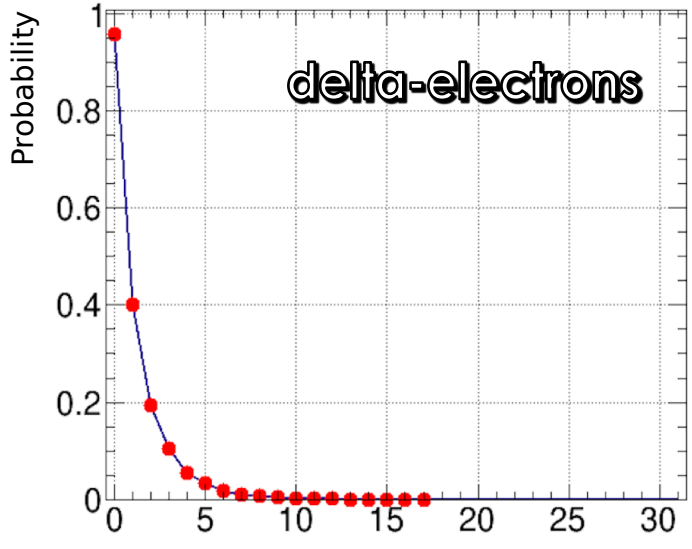
Barrel Detector(BD)

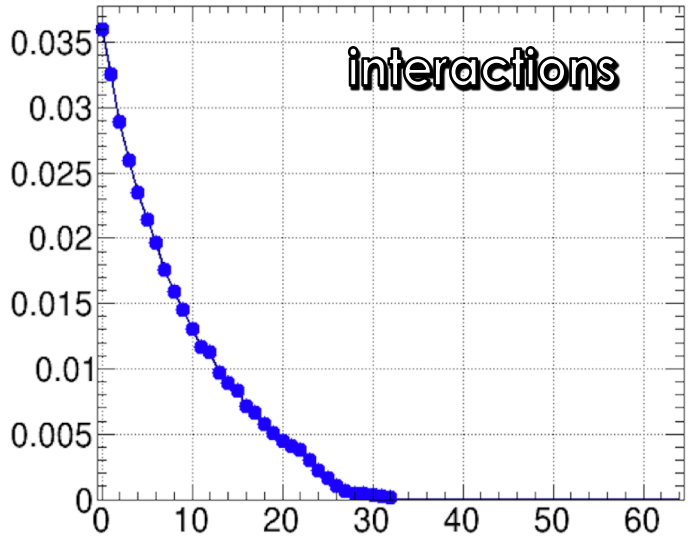


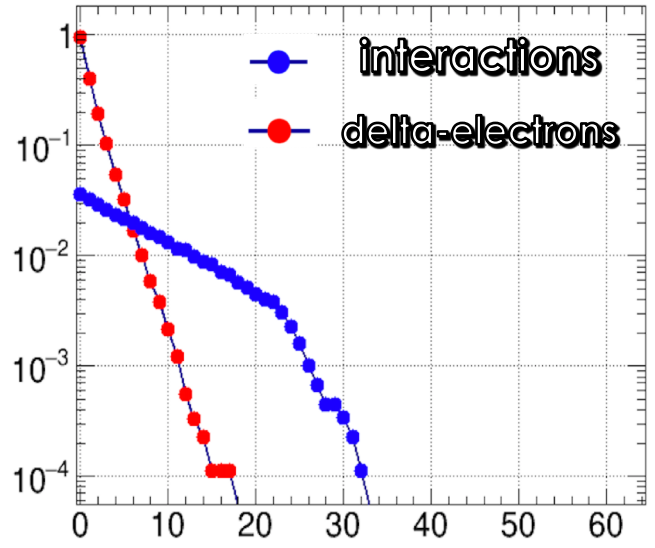




Silicon Detector(SiD)

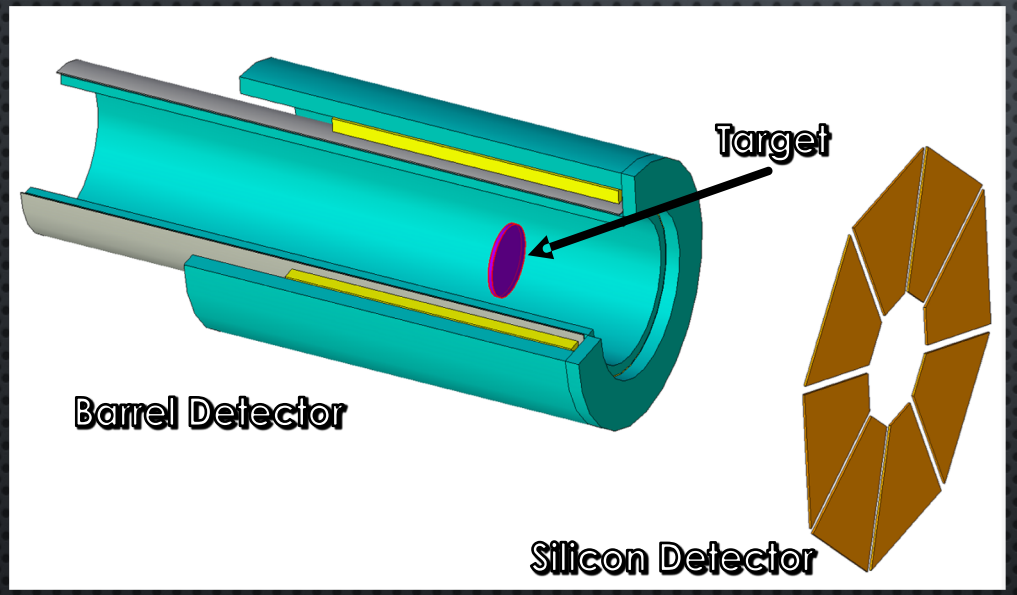


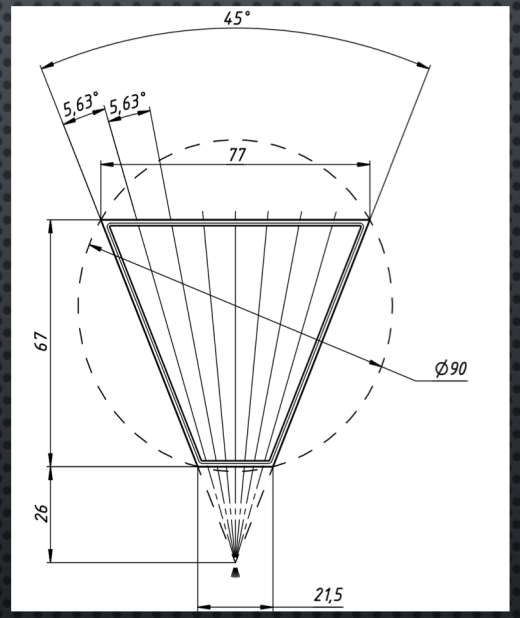


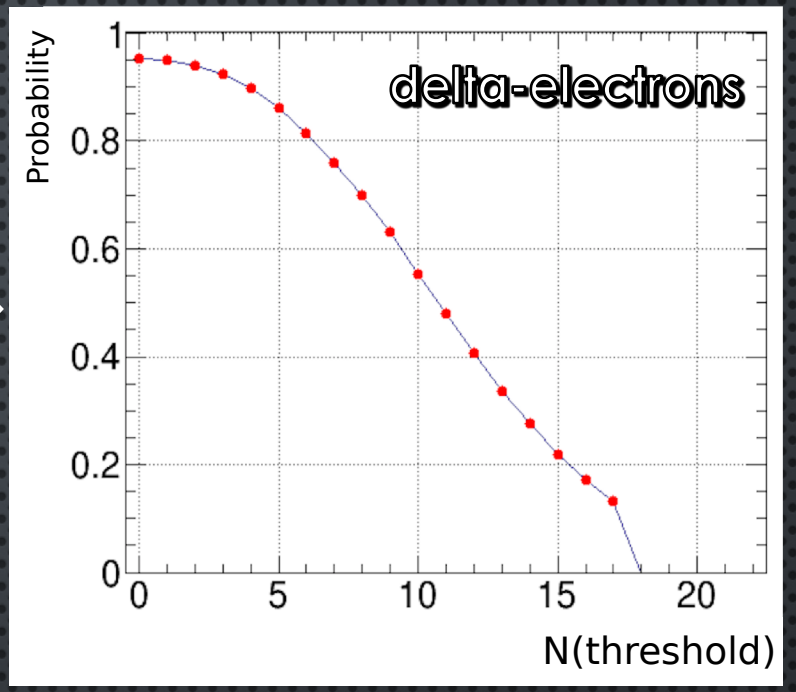


Au + Au(300μm), E = 4 GeV/n, B = 0,9 T.

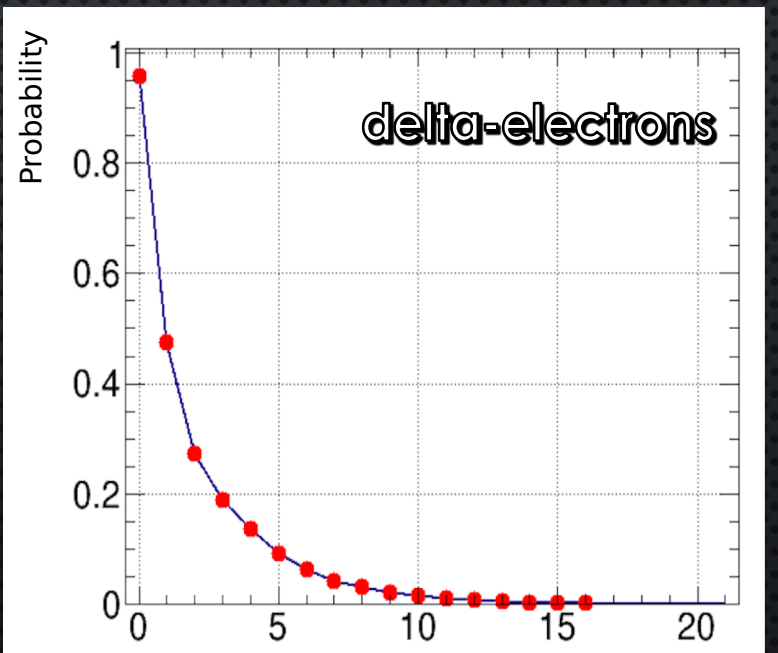
Position of SiD
at a distance 70 [mm]





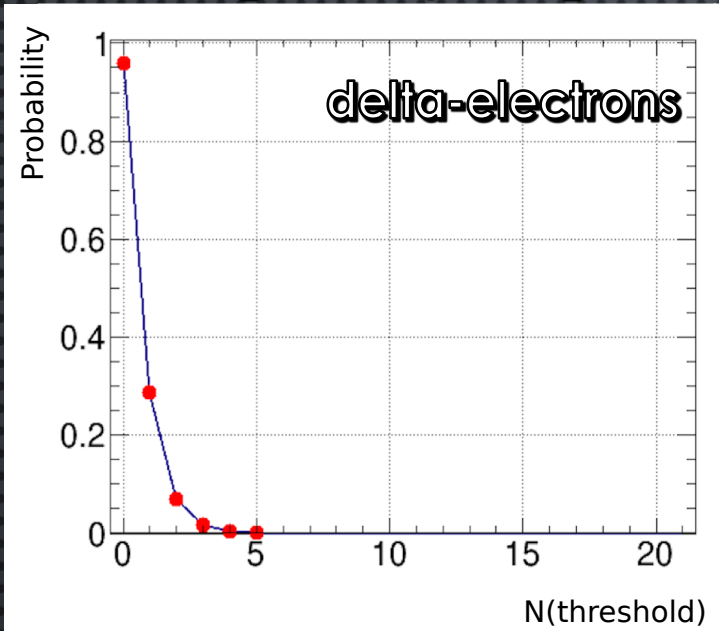


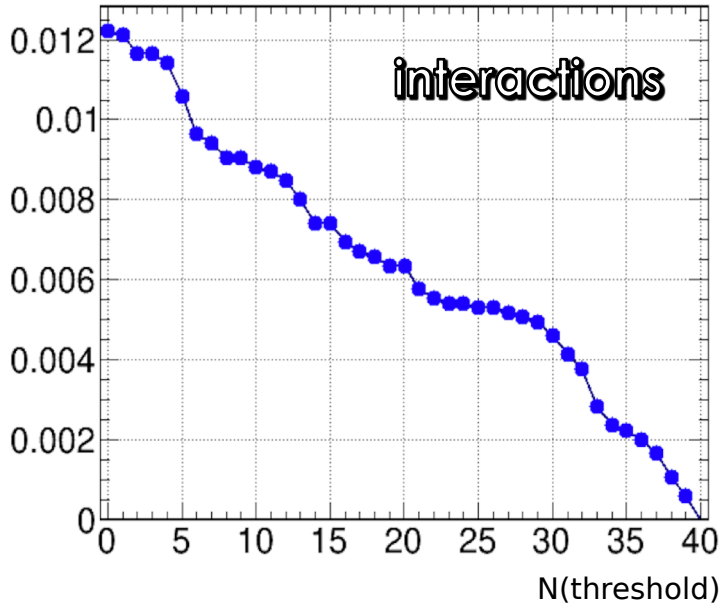
Position of SiD
at a distance 120[mm]

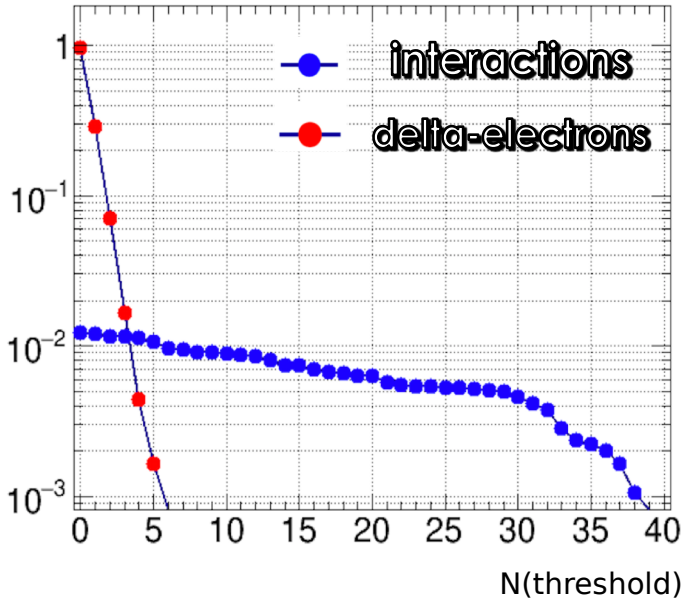


Au + Au(300μm), E = 4 GeV/n, B = 0,9 T.

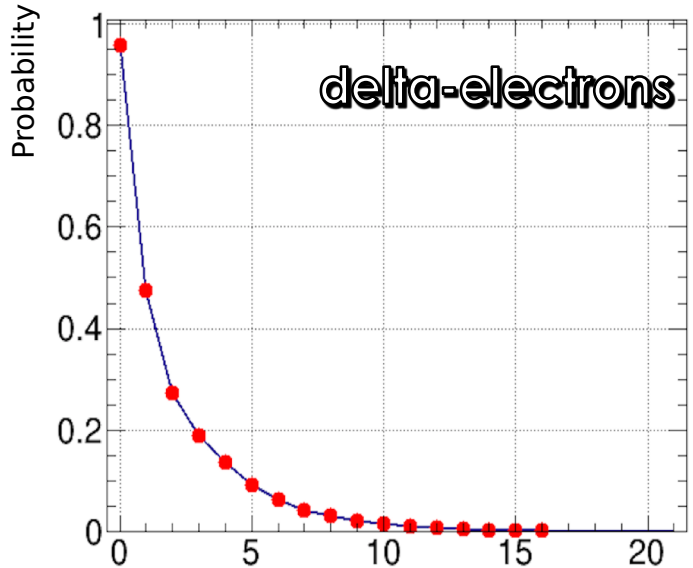
Barrel Detector (BD)

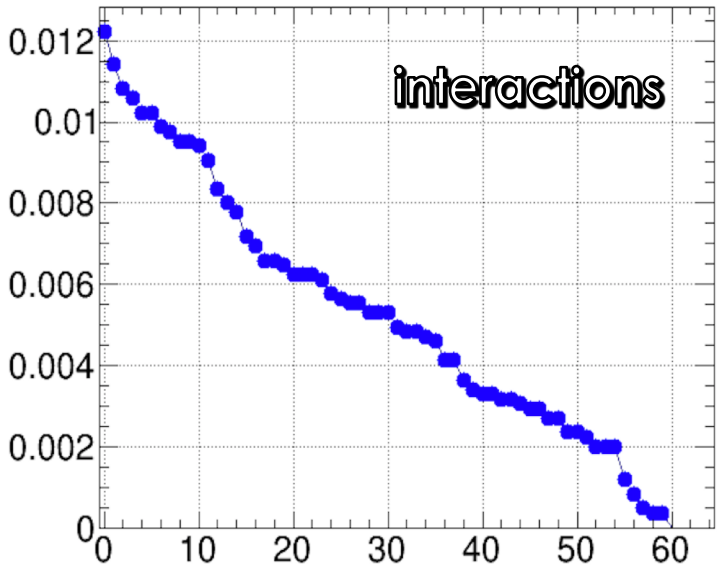


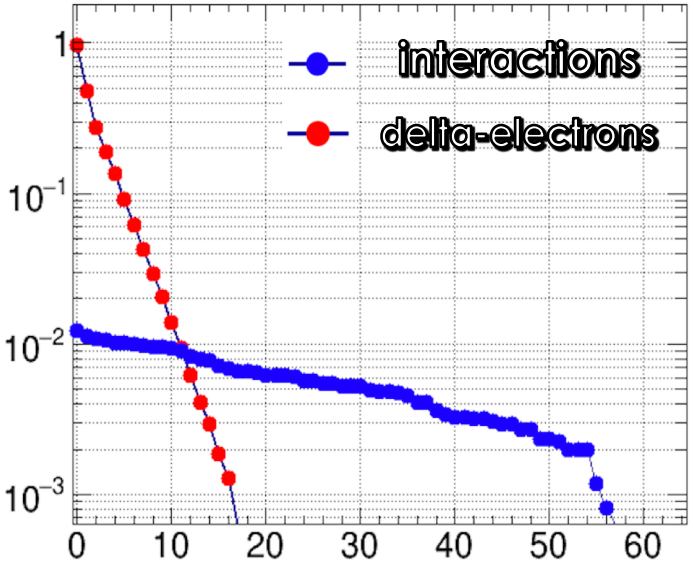




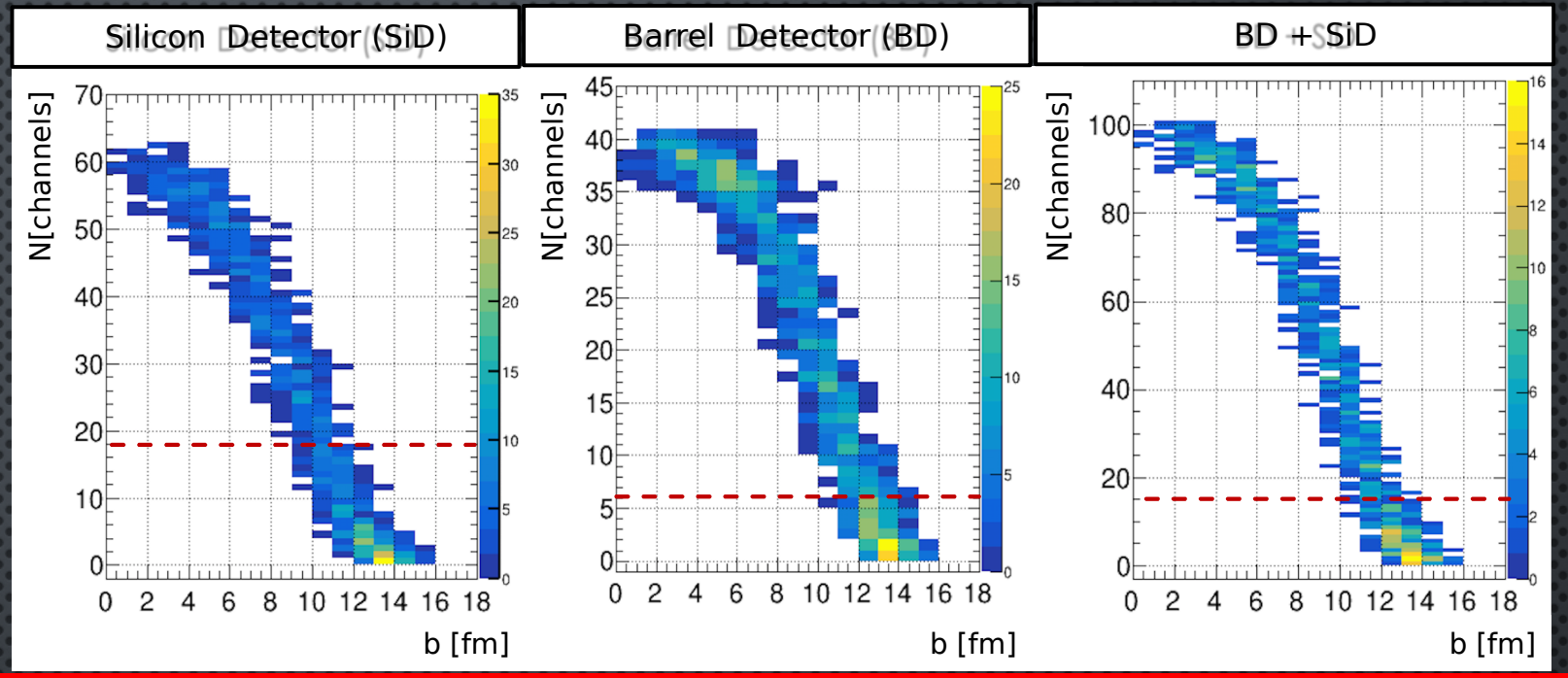
Silicon Detector (SiD)





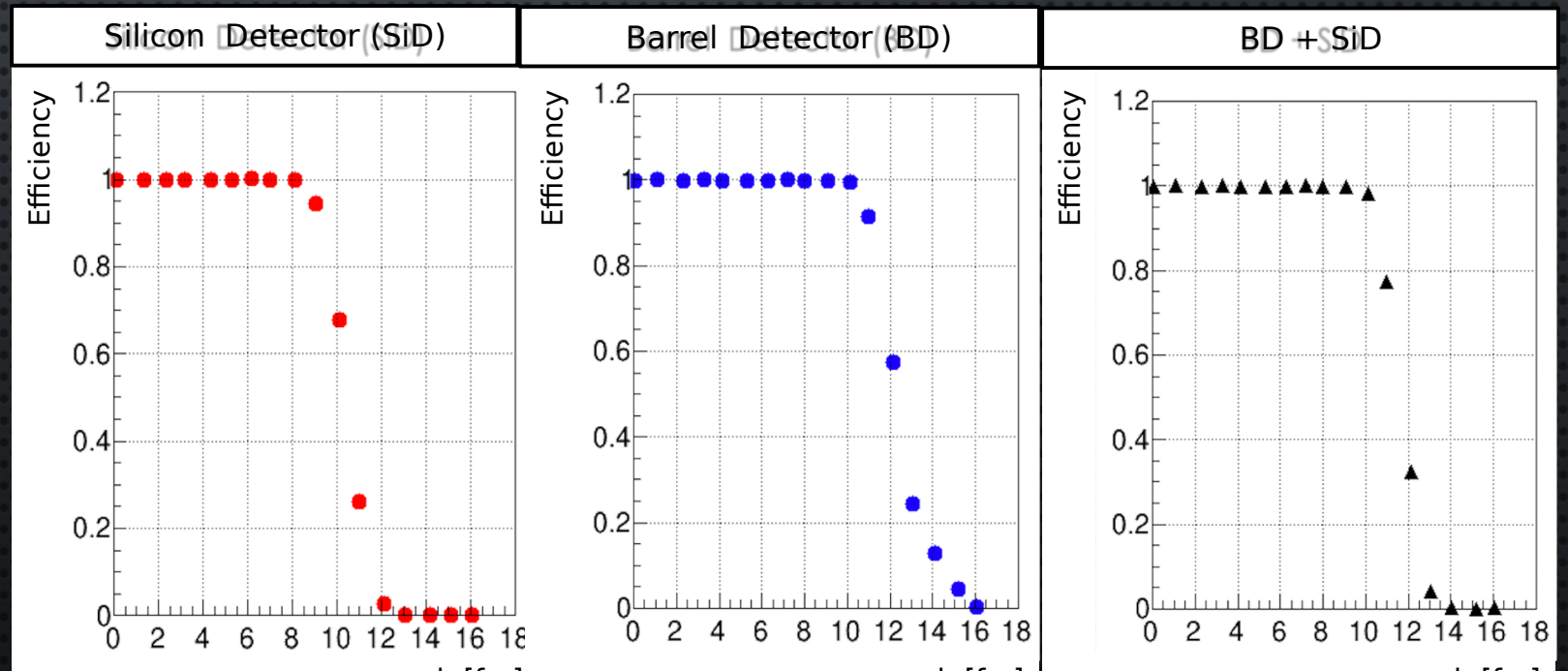


Number of fired channels
(BD, SiD, BD +SiD)



Trigger efficiency
for Au + Au($300_{\mu m}$) collisions
at energy 4 GeV/n,
B = 0.9 T

	N(threshold)
BD	6 [strips]
SiD	18 [strips]
BD+SiD	18 [strips]



Status of Simulations

Trigger detectors geometry in BnmRoot (done)

Simulation of Au+Au 4 GeV and Au+Au 2 GeV
(with Pb shielding in Barrel) (done)
5 mm inner and 10 mm outer shield will be sufficient

Shift of Silicon Detector by 5 cm downstream
(7→12 cm) from the target significantly reduces background

Comparison with Ar and Kr data (not done)

Trigger options at high beam intensity, $5 \cdot 10^7$

All Beam Detectors (including BC2) will be removed after beam tuning

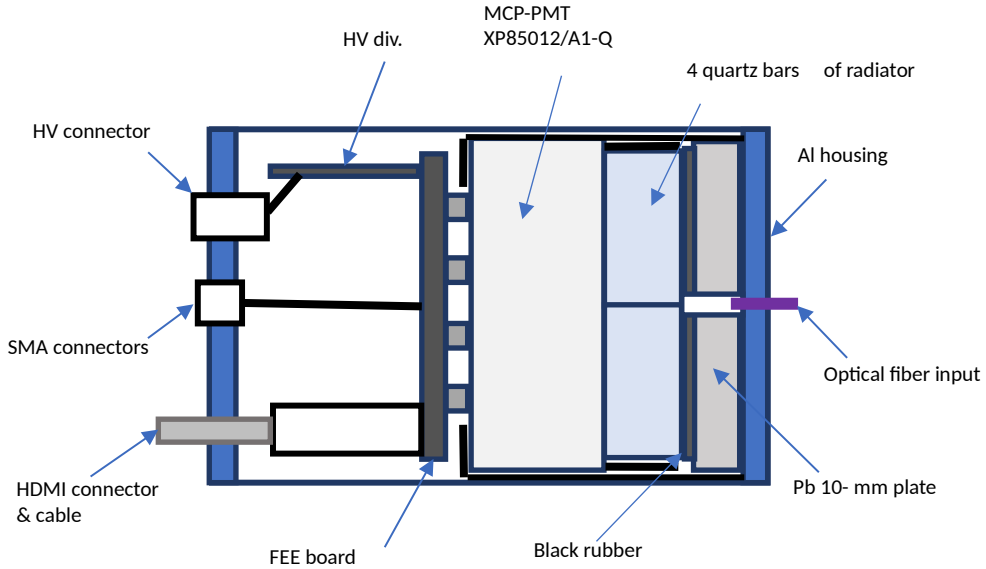
1) Neutron Detector (for example, ZDC)

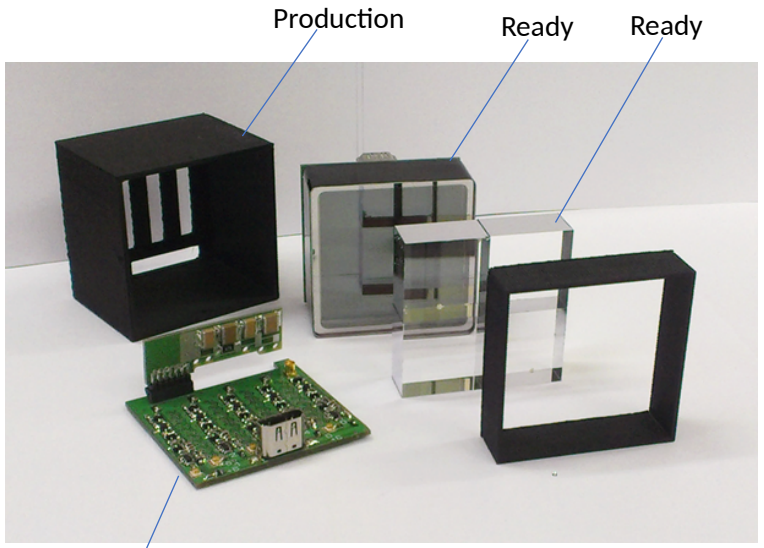
- *poor timing*
- *no space to place both: new FHCAL and ZDC*
- *this trigger does not introduce asymmetry*

2) FFD type of counters near BD – detect γ-s

- *will introduce asymmetry*
- *no space limitation, the detectors are available*
- *potential for good timing*

FFD modules



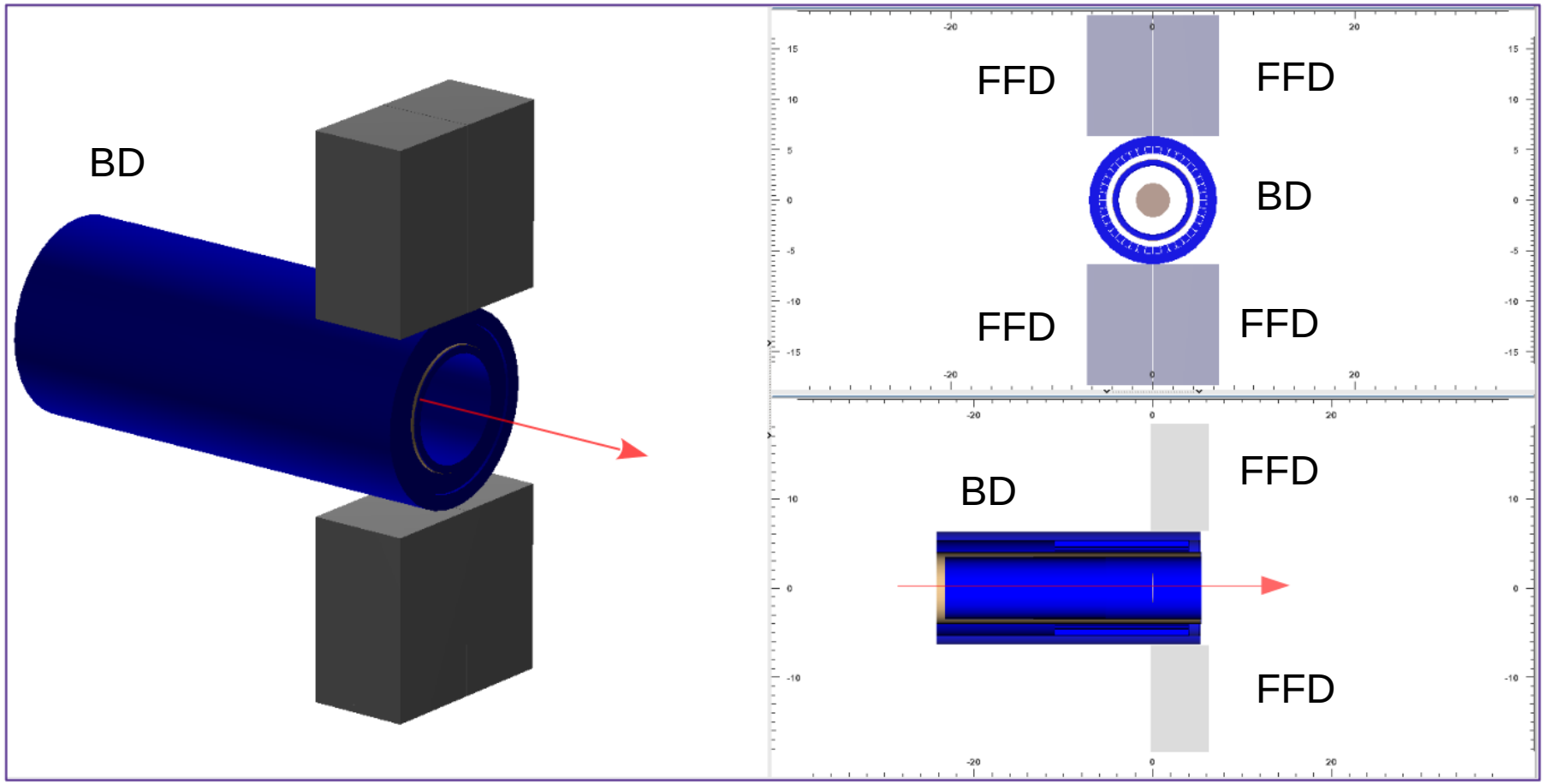


For BM@N trigger the Pb plates in FFD modules can be removed
Pb-Shielding around BD will serve as coverter

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

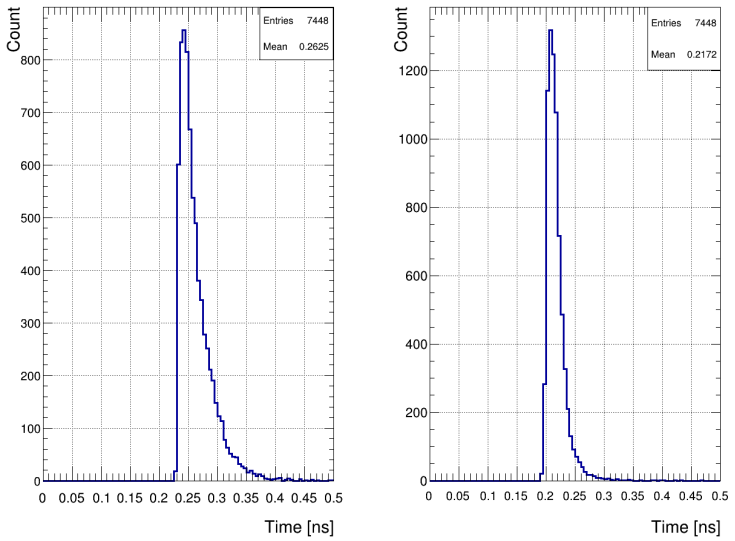
N.Lashmanov

Detection condition: arrival of more than 800 photons
in about 100 ps time window after the first photon

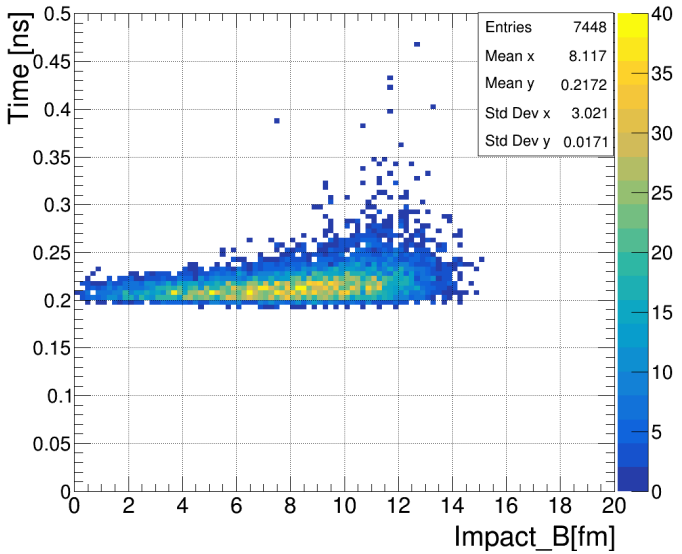


FFD-Trigger efficiency simulation: Au + Au, 4 GeV/n

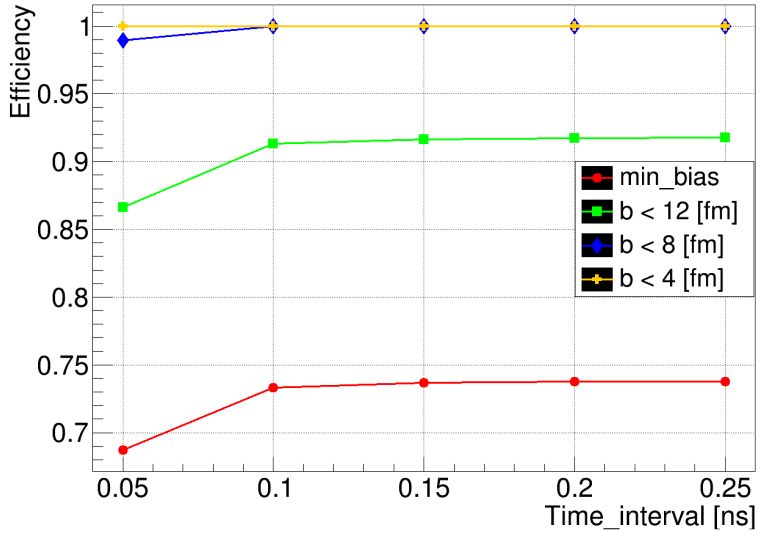
N.Lashmanov



Arrival time of the first photon. Alignment



Arrival time of the first photon.
Centrality dependence



Efficiency vs centrality

Status

– work in progress
– first results look promising