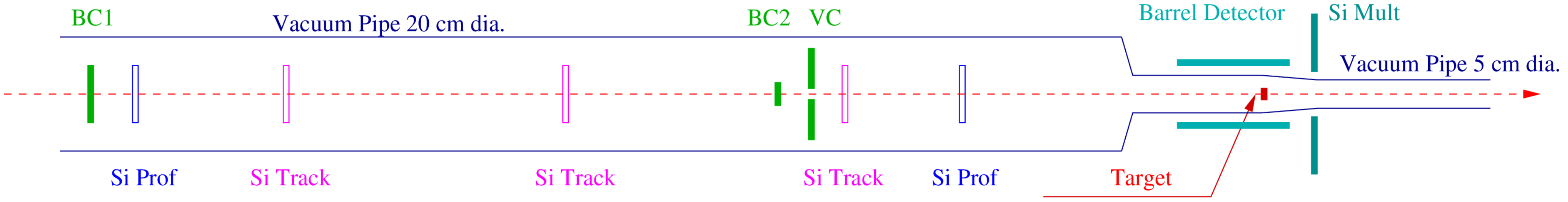
Status of BM@N Detector Upgrade

(Trigger and Beam Detectors)

Sergey Sedykh

Schematic layout of Beam Line and Trigger Detectors



Beam particle selection: BC1 × BC2 × _VC

Trajectory of incoming ion: Si1 – Si2 – Si3

Interaction trigger: BD(N>N1) × Si Mult(N>N2)

BC2 also provides T0 for TOF

Si Prof. Detectors in beam line only during the beam tuning

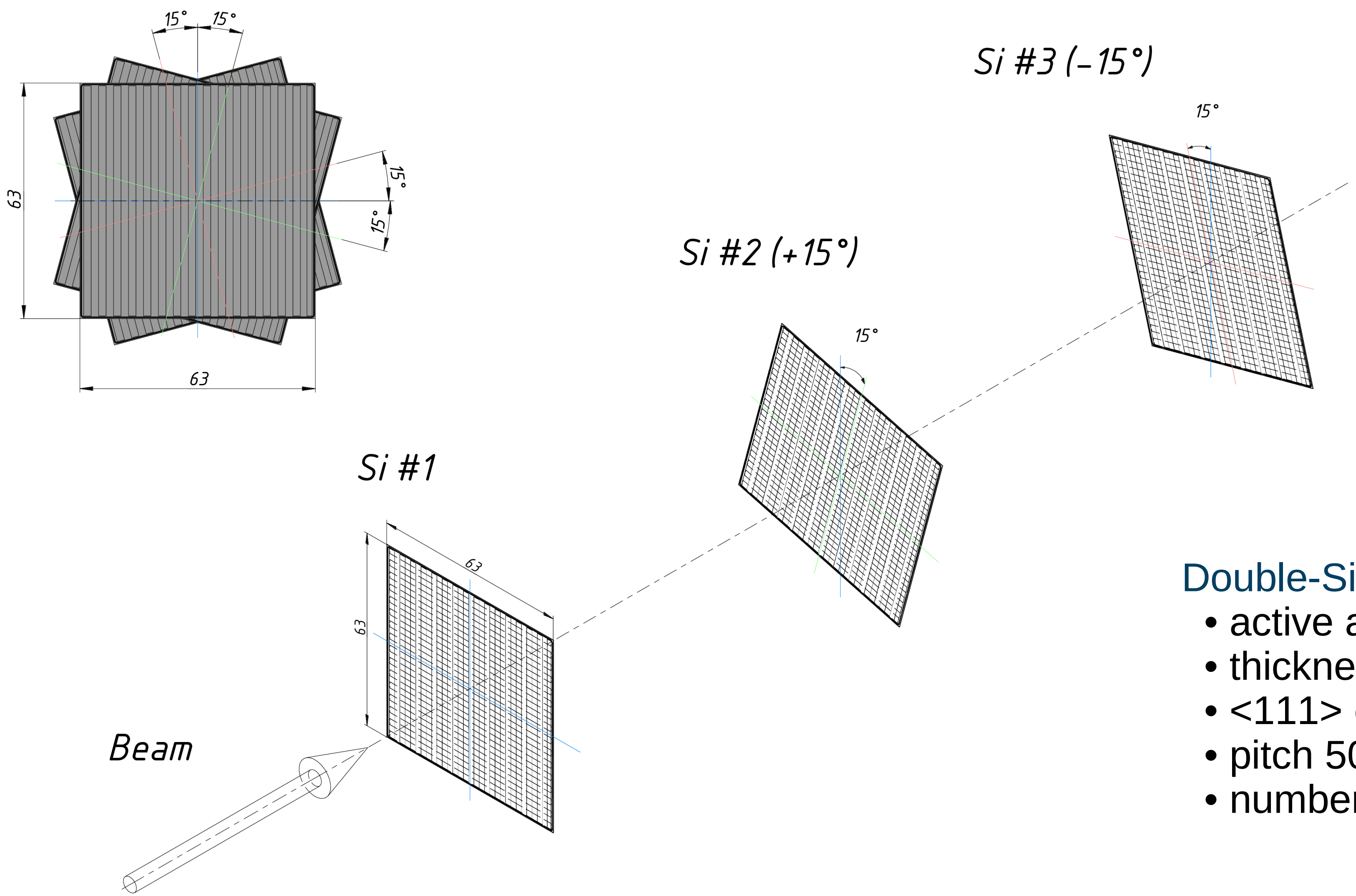
Beam Profile Silicon Detectors

Main responsibility – by the beam transport group (P. Rukoyatkin).
Detector design and readout – by the group of N.Zamjatin.
Integration in the vacuum pipe – by S.Piyadin.

- in the beam only during the beam tuning
- simple read-out based on VATAHDR16.2 chip
  (independent from the main DAQ)
- 2 planes in BM@N (10 overall)
- double-sided strip detectors, XY orientation
- 175 µm, 60 x 60 mm^2, 1.87 mm pitch, 32 x 32 strips

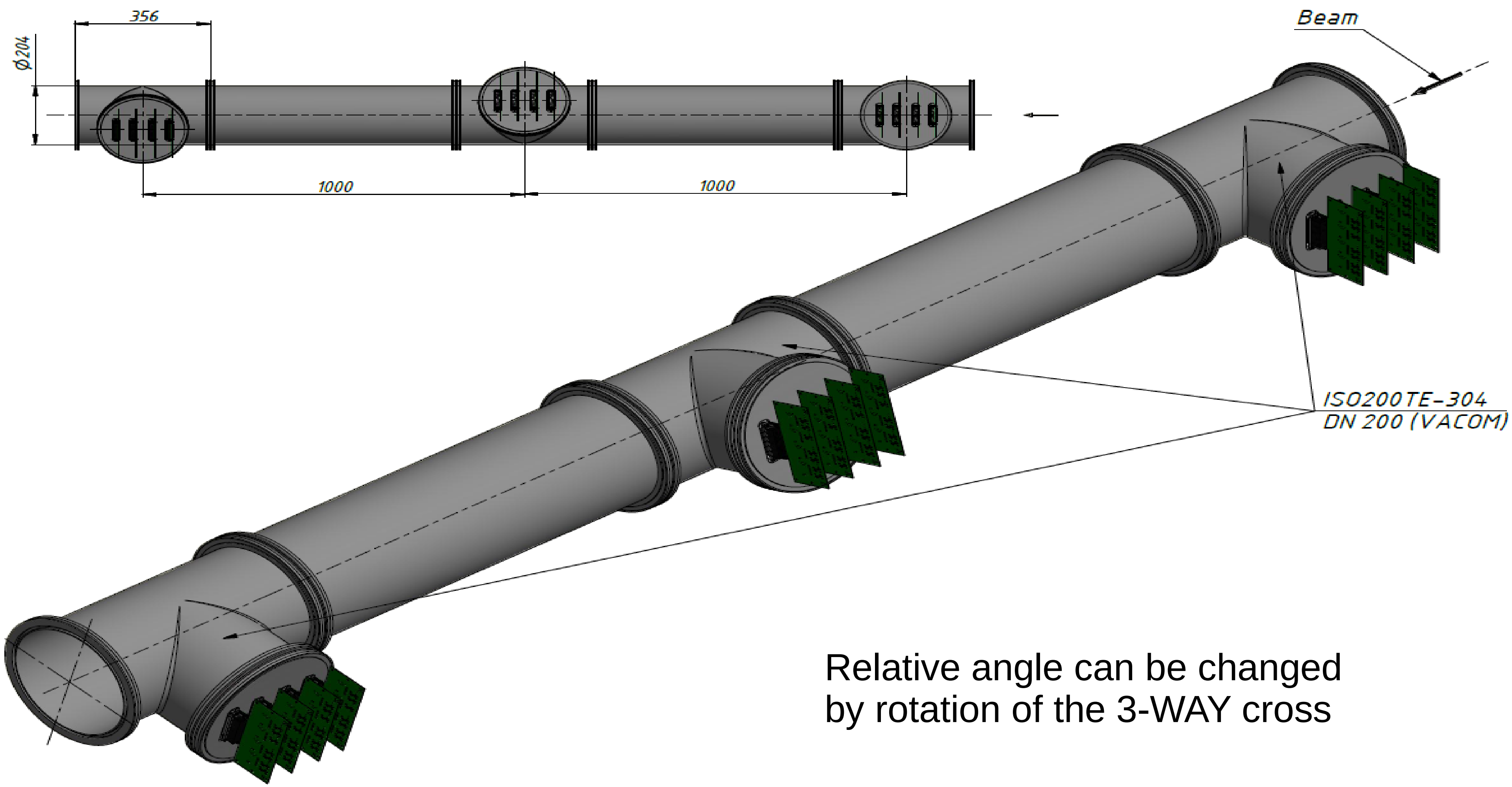
Beam Vertex Silicon Detectors

Group of N.Zamjatin



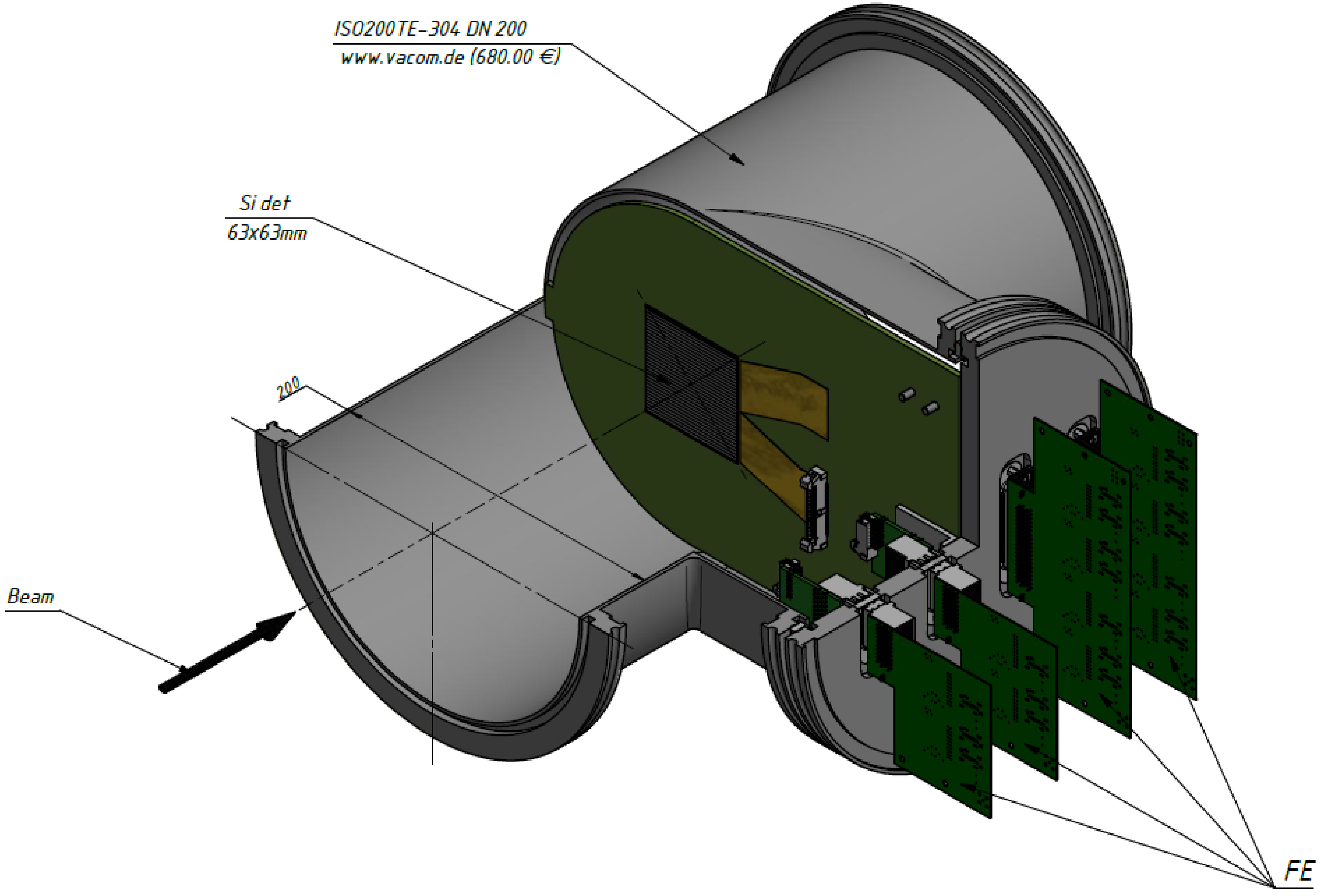
Double-Sided Strip Detectors
- active area 60 x 60 mm^2
- thickness 175 μm
- <111> orientation
- pitch 500 μm
- number of strips 128 + 128

Beam Vertex Silicon Detectors: vacuum pipe components

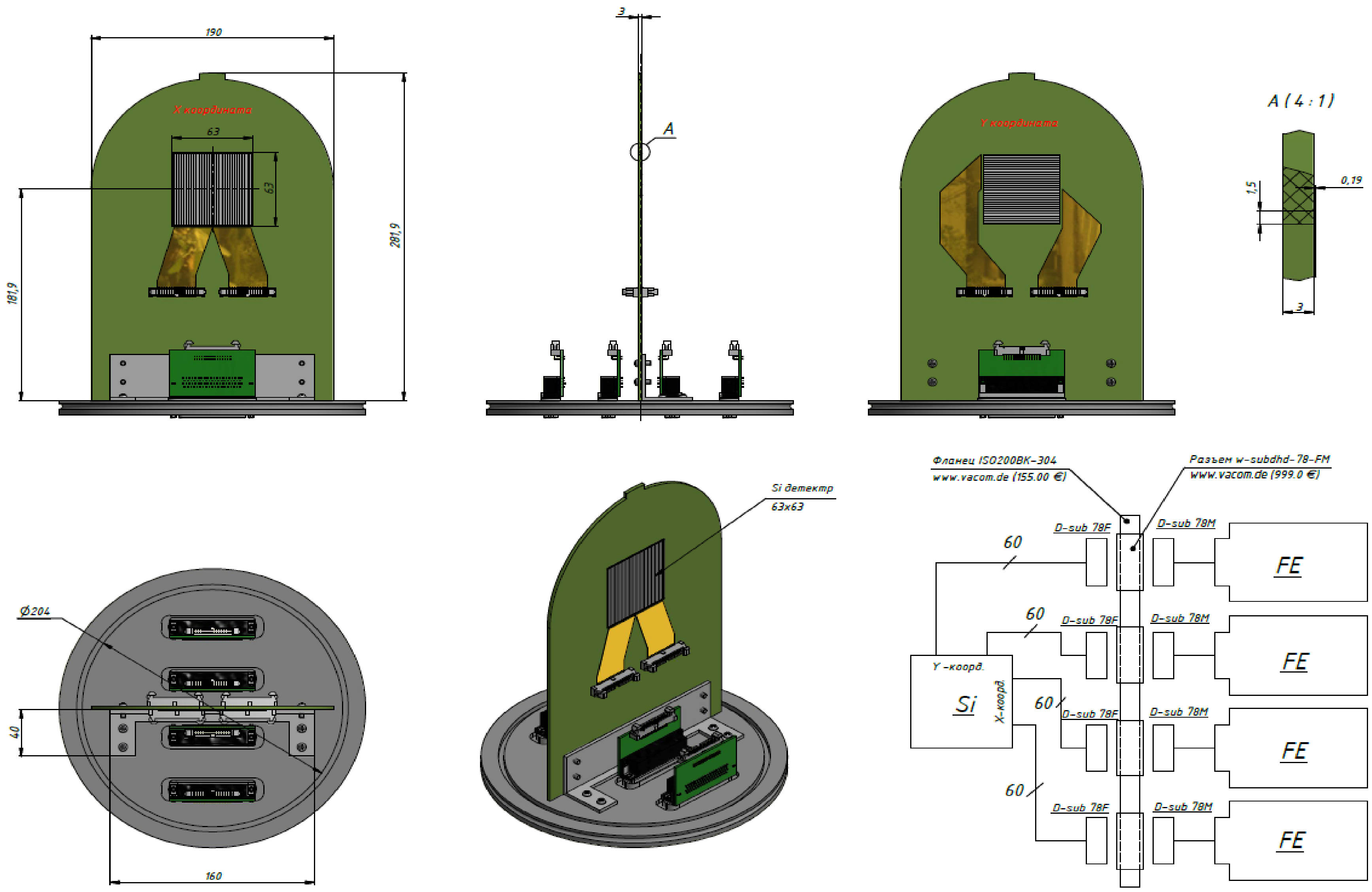


Relative angle can be changed
by rotation of the 3-WAY cross

Beam Vertex Silicon Detectors: placement in the vacuum pipe



Beam Vertex Silicon Detectors: FEE electronics



Beam Vertex Silicon Detectors: timeline for upgrade

- Design of the boards (done)

- Manufacturing of the boards (Zelenograd)
  tentative agreement (done)
  detailed order (exp. 07/2019)

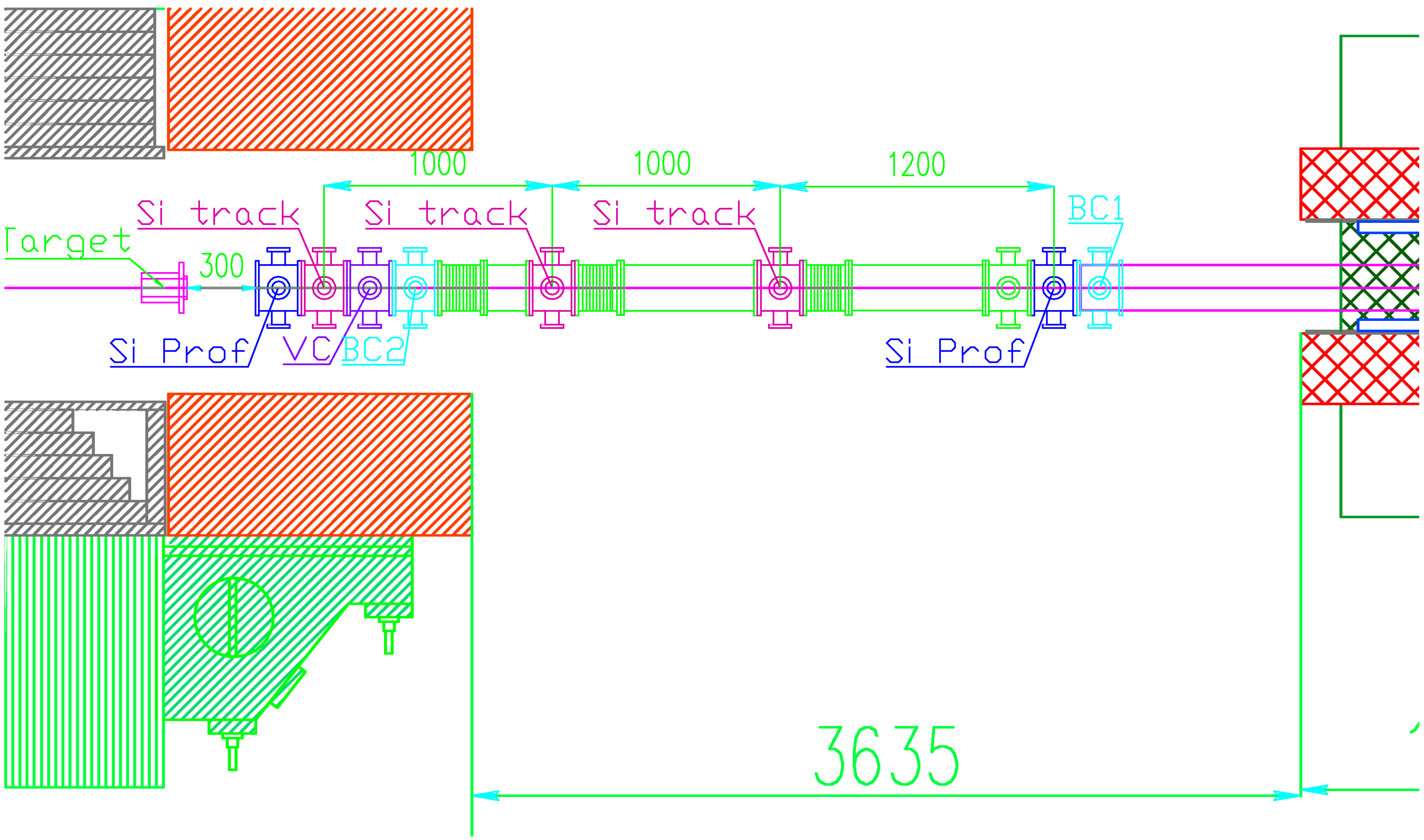
- FEE design based on VATAHDR16.2 chip (planed for ordering)

- Finalization of the read-out
  - 768 ADC channels (favored, but expensive)
  - or 12 ADC channels with x64 multiplexing (also discussed)

- Integration in the vacuum line (depends on other detectors)

Beam Line with Vacuum Components

S. Piyadin

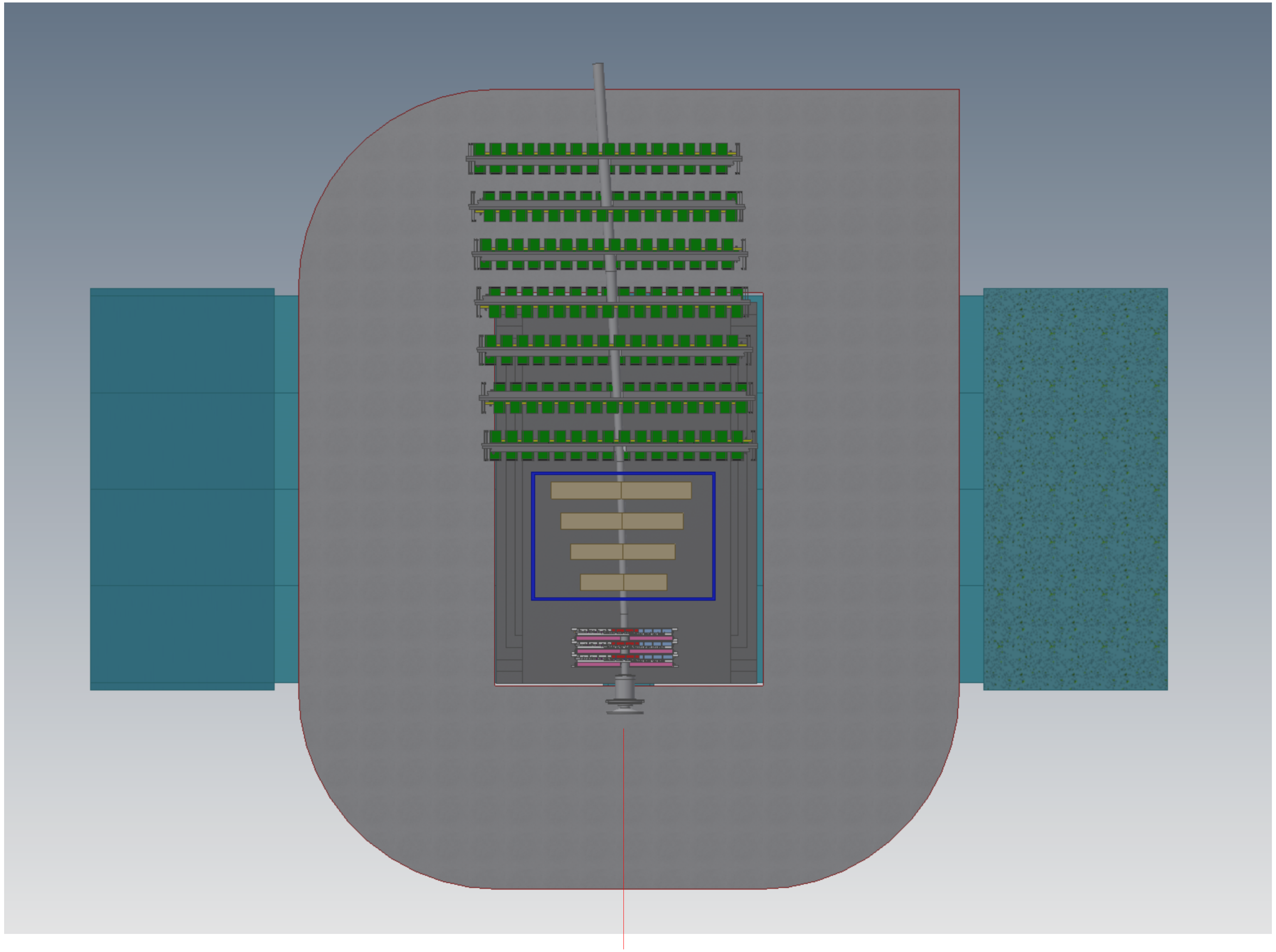


Vacom® (Jena, Germany)
- standard components
- specific requests

Particular difficulties:

- tight space for 9 detector stations
- pipe dia.: 20 cm → 5-7 cm
- junction to the target area

Downstream vacuum pipe



Material: carbon, wall thickness 1 mm

Four sections:

1: 650 mm, dia. 200 → 66 → 50 mm, $0^\circ \rightarrow 0.72^\circ$ relative Z axis

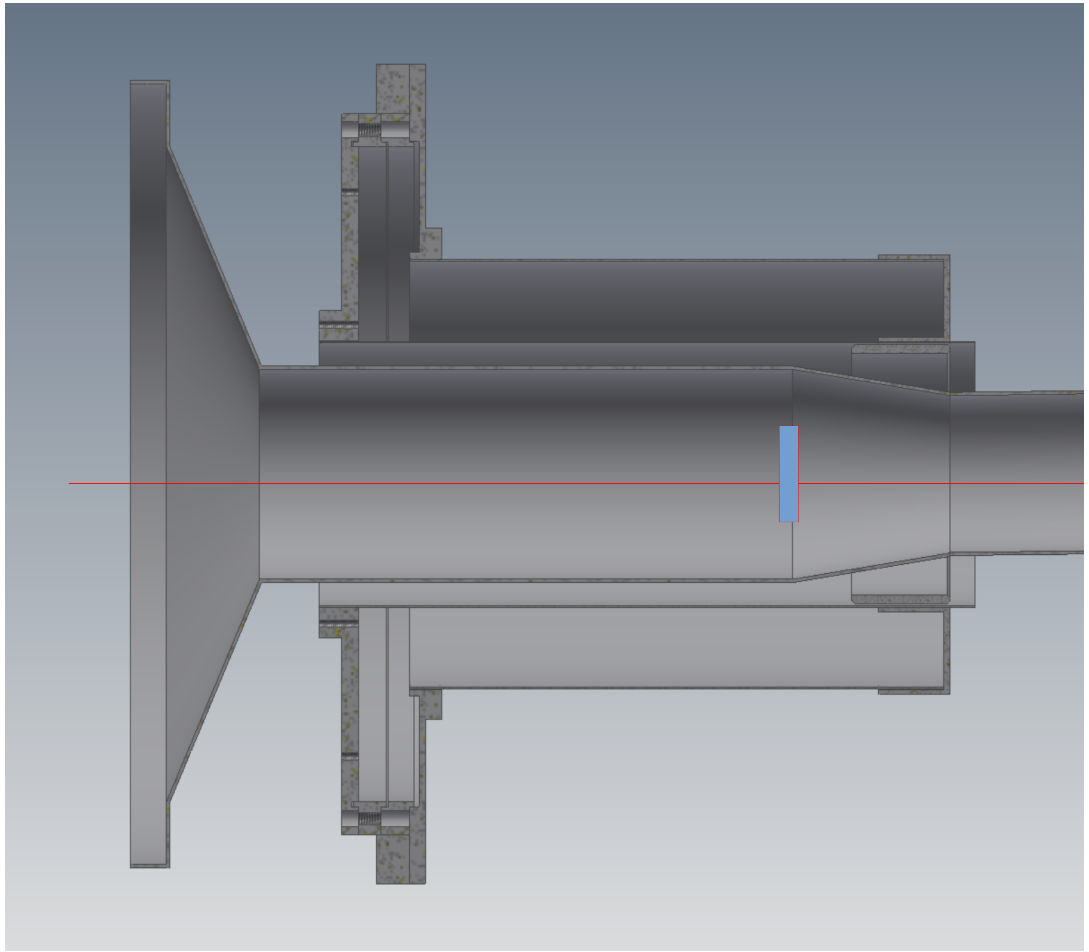
2: 1000 mm, cylinder dia. 50 mm, 1.44° relative Z axis

3: 1240 mm, cone dia. 50 → 72 mm, 2.83° relative Z axis

4: 1360 mm, cylinder dia. 72 mm, 3.60° relative Z axis

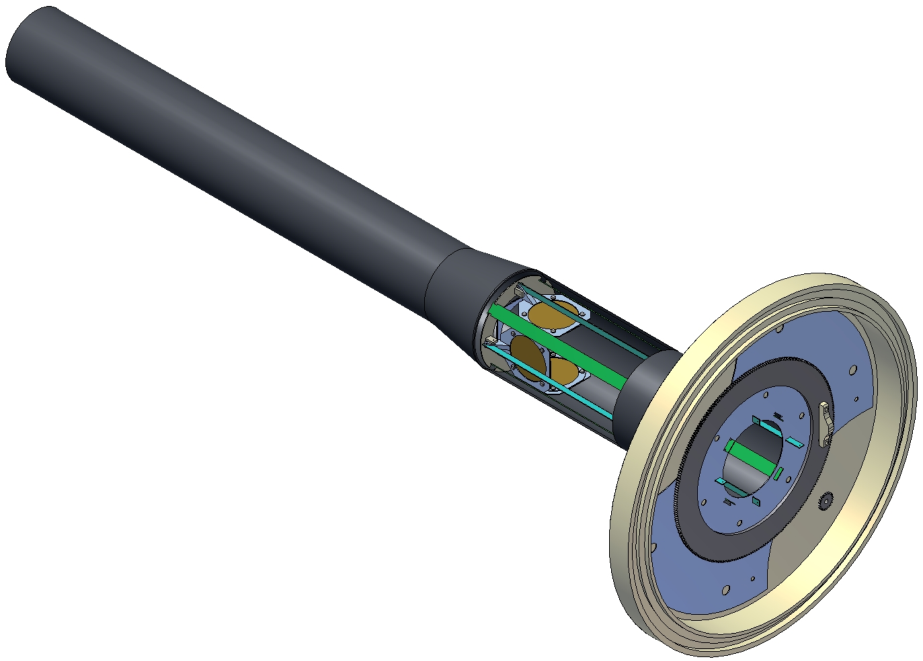
Tree joints can be moved +/- 0.5°

Target area with Barrel Detector



First section of the carbon vacuum pipe and Barrel Detector

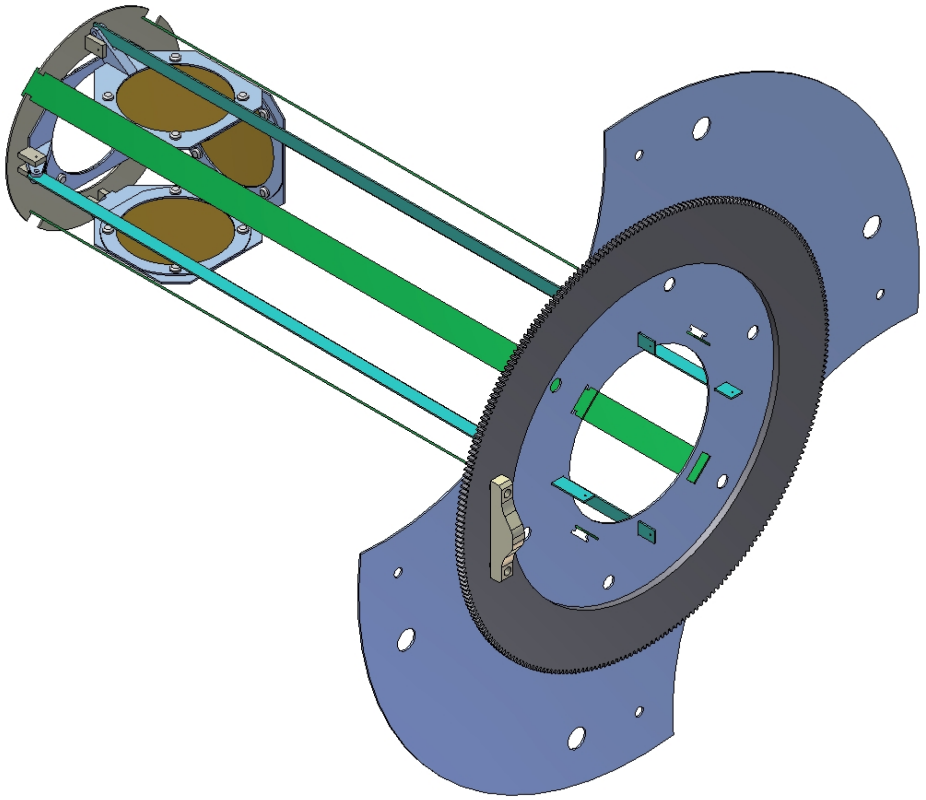
Dia. 200 → 66 → 50 mm



Carbon vacuum pipe and the target station

Proposal for the Target Station

S.Piyadin, Yu.Gusakov

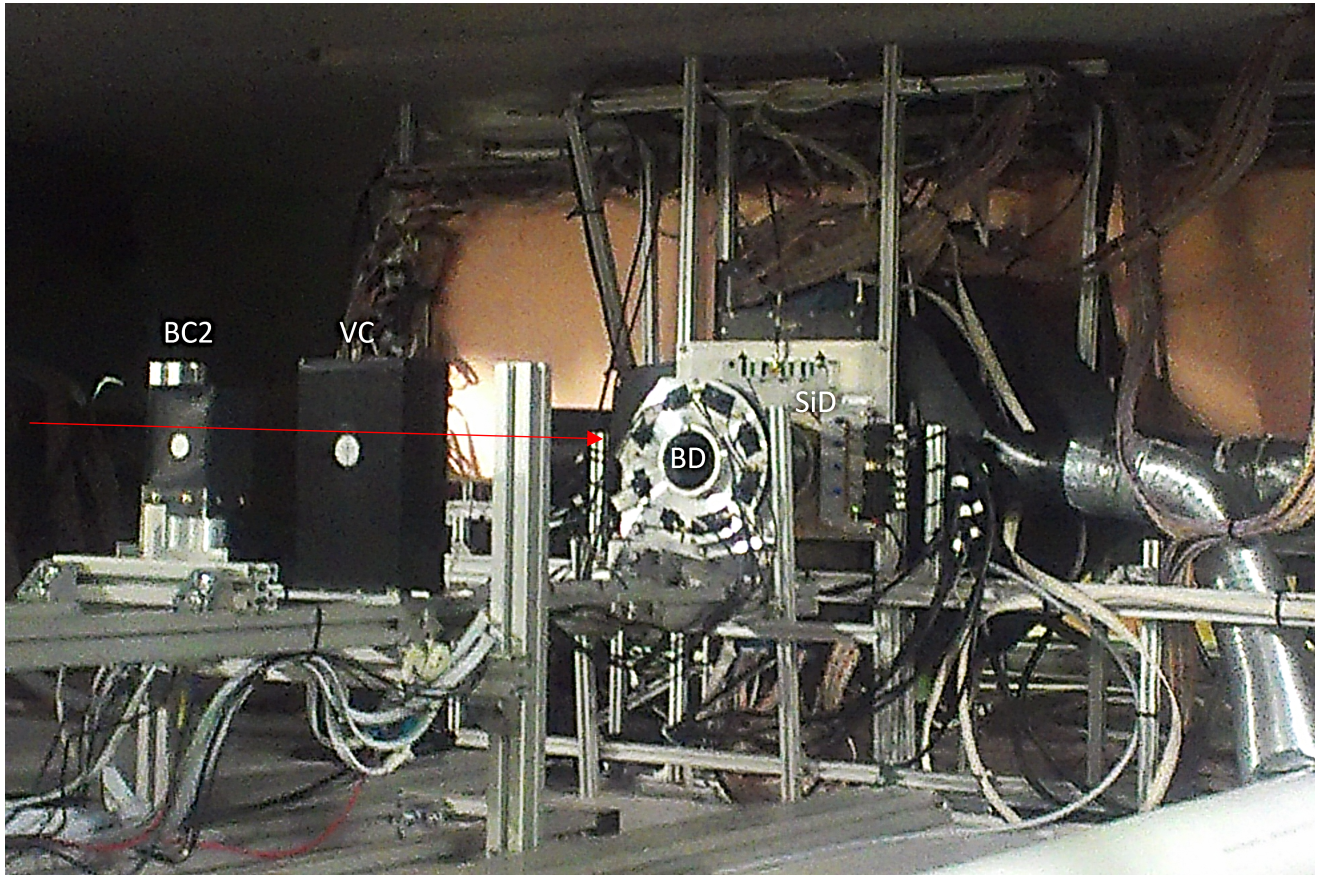


3 targets + empty target

Change will be possible

without vacuum breaking

Beam Counters in Run 2018 with Ar and Kr ions



BC1: plastic scintillator, 150diam. × 3 mm^3, PMT XP2020

BC2 (T0) detector: plastic scintillator, 20diam. × 0.8, angle 45^o, MCP-PMT PP0365G (Photonis)

Time resolution with ^{12}C beam <60 ps (no special measurements for Ar and Kr)

VC detector: plastic scintillator, 100diam. × 10 mm^3, hole 27diam.mm, MCP-PMT XP85012 (Photonis)

All detectors except BD will be upgraded for Au run
– placement in vacuum
– change of scintillators, change of PMTs

Proposal parameters of Beam and Trigger Detectors

Detector	Active area (mm)	Photodetector	Granularity
BC1	BC400B 100 x 100 x 0.25	R2490-07 (2 units)	1
VC		R2490-07 (2 units)	1
BC2(T0)	BC400B 10 x 10 x 0.15	XPM85112/A1-Q400 (2 units)	1-4
BD	BC418 90 diam. x 150	SiPMs (Sensl) Micro FC-60035-SMT, 6 × 6 mm^2	40
BC3	BC400B 30 x 30 x 0.15	SiPMs (Sensl) Micro FC-60035-SMT, 6 × 6 mm^2	1

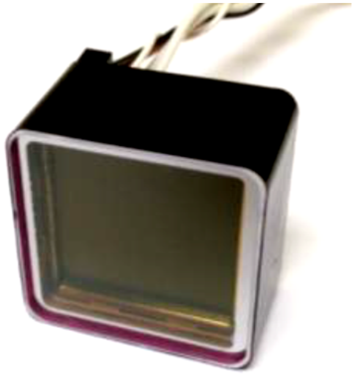
Material Budget of vacuum beam line for Au ions

Material	H (mm)	P (%)
BC1 scintillator	0.25	0.67
Si1	0.175	0.41
Si2	0.175	-
Si3	0.175	-
BC2 scintillator	0.15	0.40
Al (exit window)	0.050	0.12
Air	60	0.10
Au (target)	0.40	1.64
Air	20	0.04
BC3 scintillator	0.15	0.40

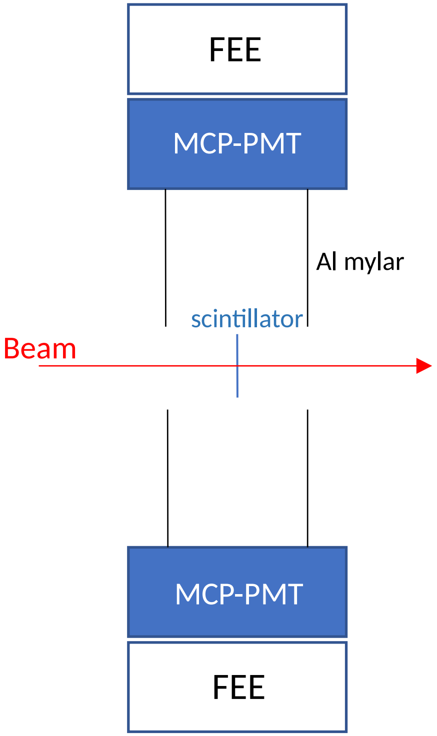
H – thickness
P – nuclear interaction probability

BC2 (T0 for the TOF)

Photodetectors



MCP-PMT XPM85112/A1-Q400
(Photonis)
Photocathode: 25 × 25 mm^2



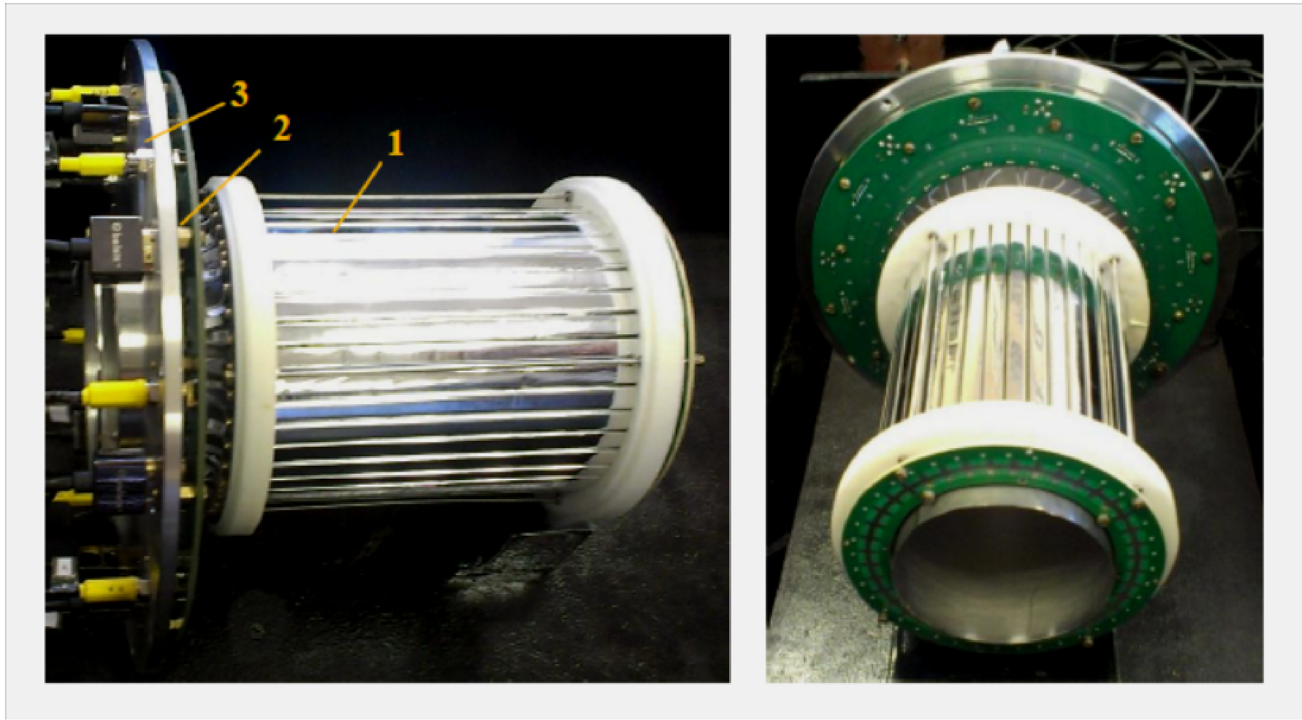
- T0 pulse for TOF detectors with $\sigma_t < 50$ ps
- Should be able to operate in magnetic field
- PMTs are ordered (exp. delivery 02/2019)
- Placement in vacuum not yet designed,
  will be based on 6-way crossing (with 2 quarz windows)
- Plan to switch to Cherenkov radiator
  at high beam intensity and well focused beam

BC1, VC have similar status, 4 PMT's (R2490-07) are available.

Responsible persons for the new trigger detectors design:
V.Yurevich, S.Sedykh, V.Rogov, V.Tikhomirov

Interaction trigger. Barrel Detector (BD)

The active area of BD has radius of 45 mm and length of 150 mm and it consists of 40 strips $150 \times 7 \times 7$ 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.

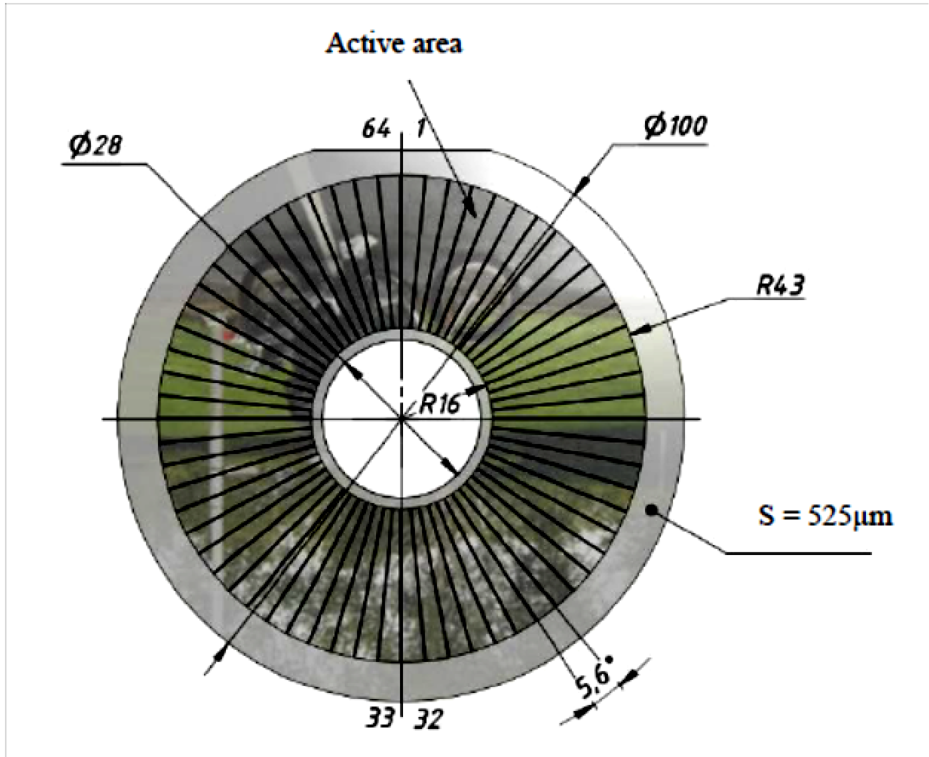
Planned upgrade for the Au runs:

- Pb shielding will be added
- new FEE (less noise, resp. V.Rogov)

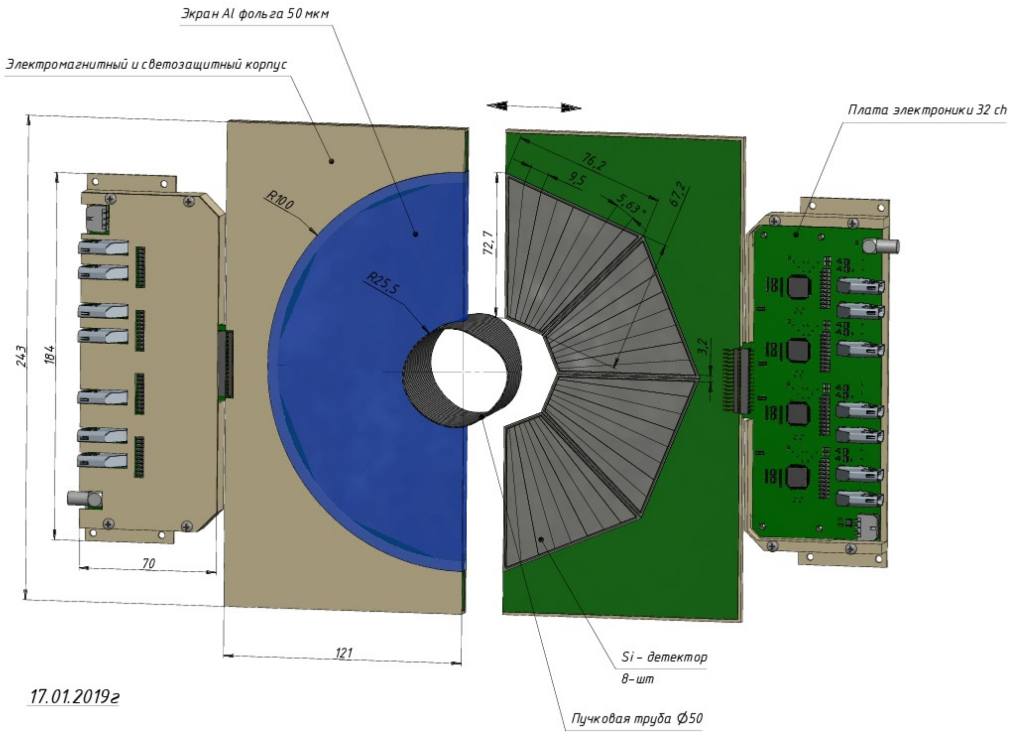
Group of N.Zamjatin

Interaction trigger. Si detector

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.



A view of the front side of Si detector (2018).



Proposal for the upgrade: larger opening for the beam: dia. 28 → 50 mm

Trigger interface and electronics

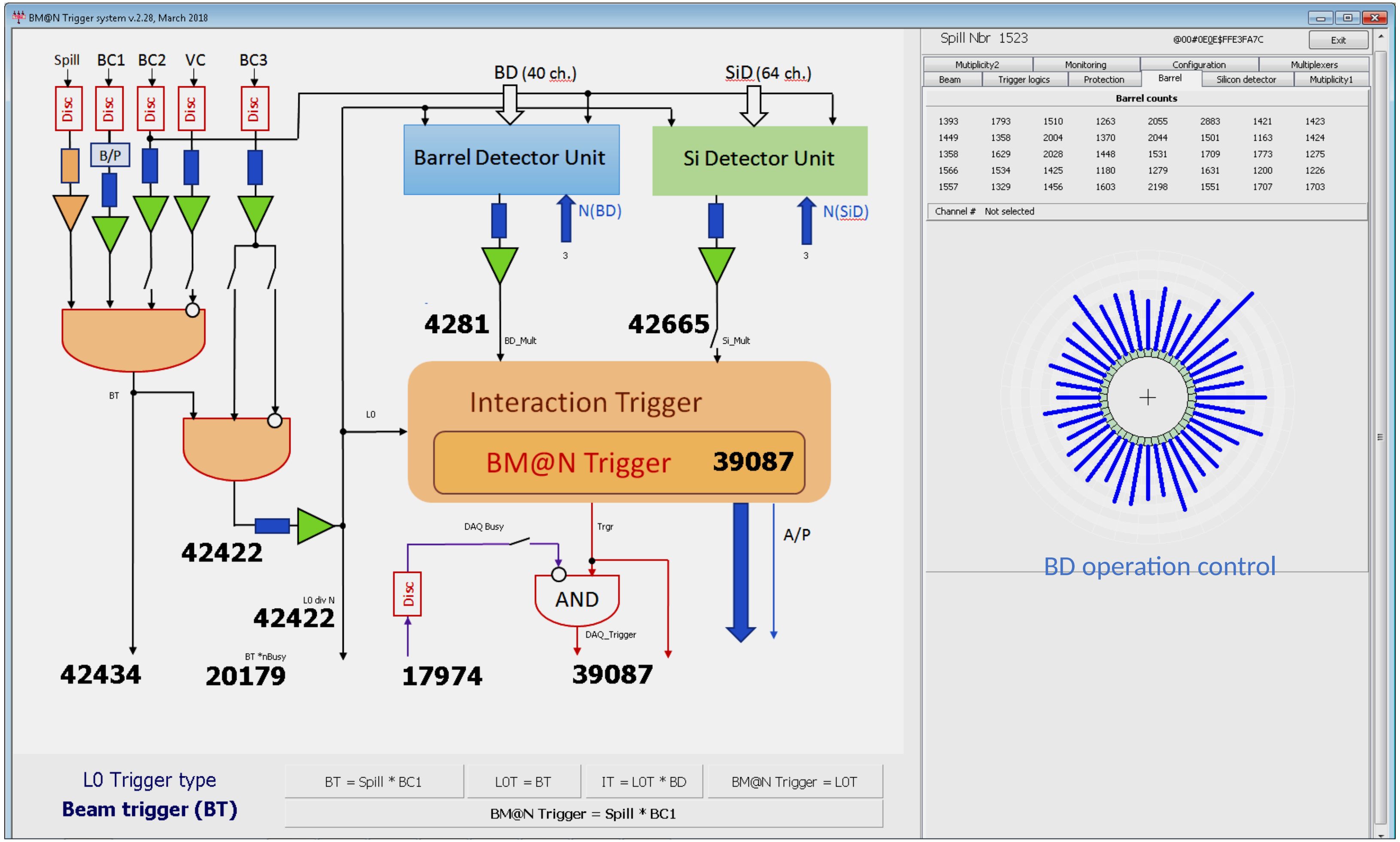
Upgrade based
on 2018 run experience:

- minimize the need to recompile FPGA code

- add flexibility for minor changes

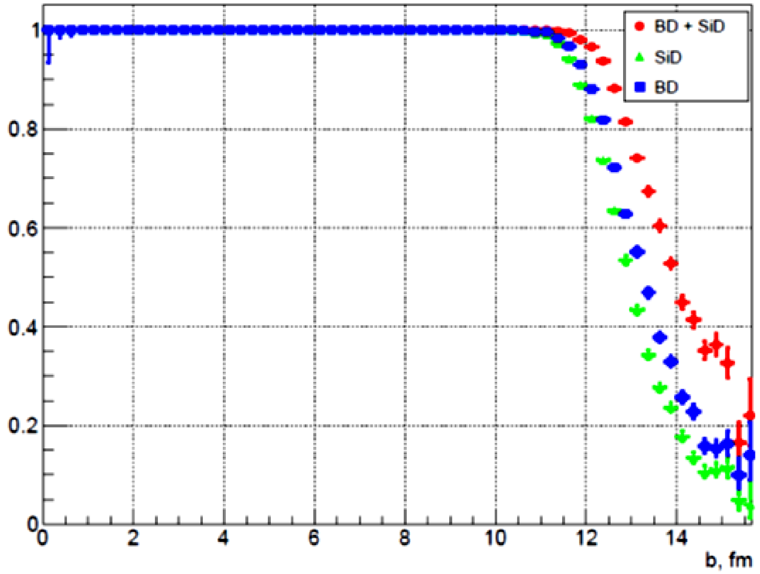
- consider adding trigger mixture with downscaling (proposal should be fixed 2 months before the run)

Responsible for the upgrade:
Trigger electronics – D.Bogoslovskiy
Trigger interface – S.Sergeev

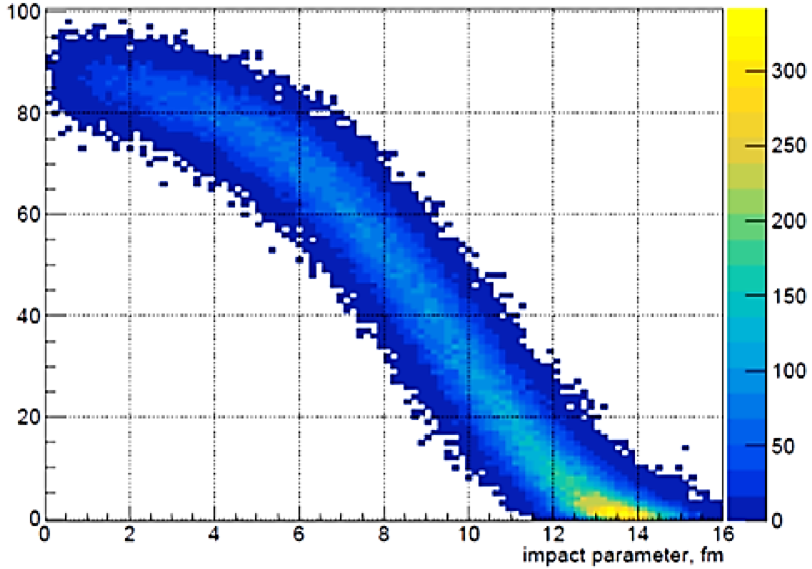


Simulation and analysis of trigger performance

Au + Au, QGSM+GEANT4, 4 GeV/n, 0.9 T (done by S.Lobastov prior to the 2018 run)



Trigger efficiency as a function of impact parameter.



Number of fired channels BD + SiD
as a function of impact parameter

Plans for 2019:

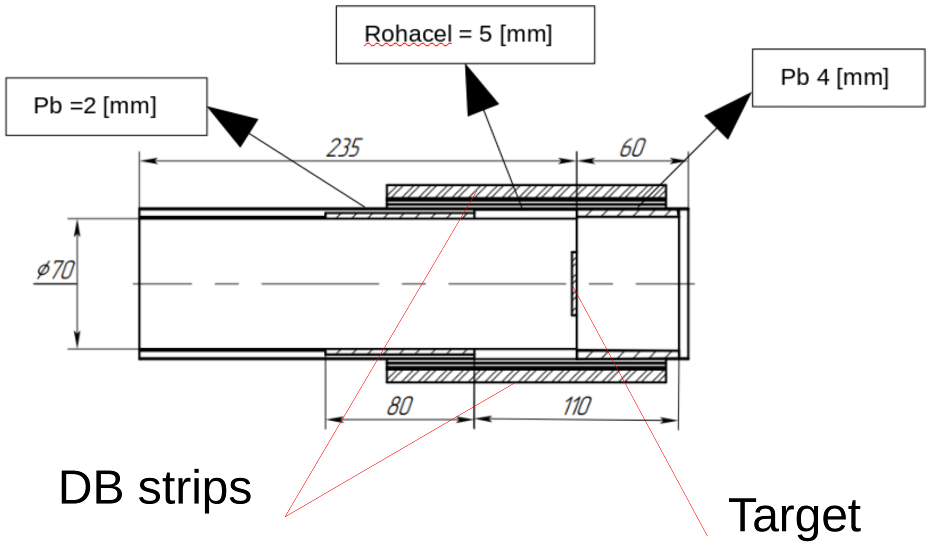
- add QGSM simulation for Ar and Kr
- add simulations of the counts from δ-electrons
- compare with the data
- optimize Pb shielding for the Au runs

(responsible:
S.Sedykh, N.Lashmanov, V.Yurevich)

Strong background from δ-electrons was observed in the multiplicity trigger detectors in the Ar and Kr run.
It was not simulated prior to the 2018 run and the magnitude of it was not unexpected.

Simulation of background counts in the Barrel Detector

N.Lashmanov

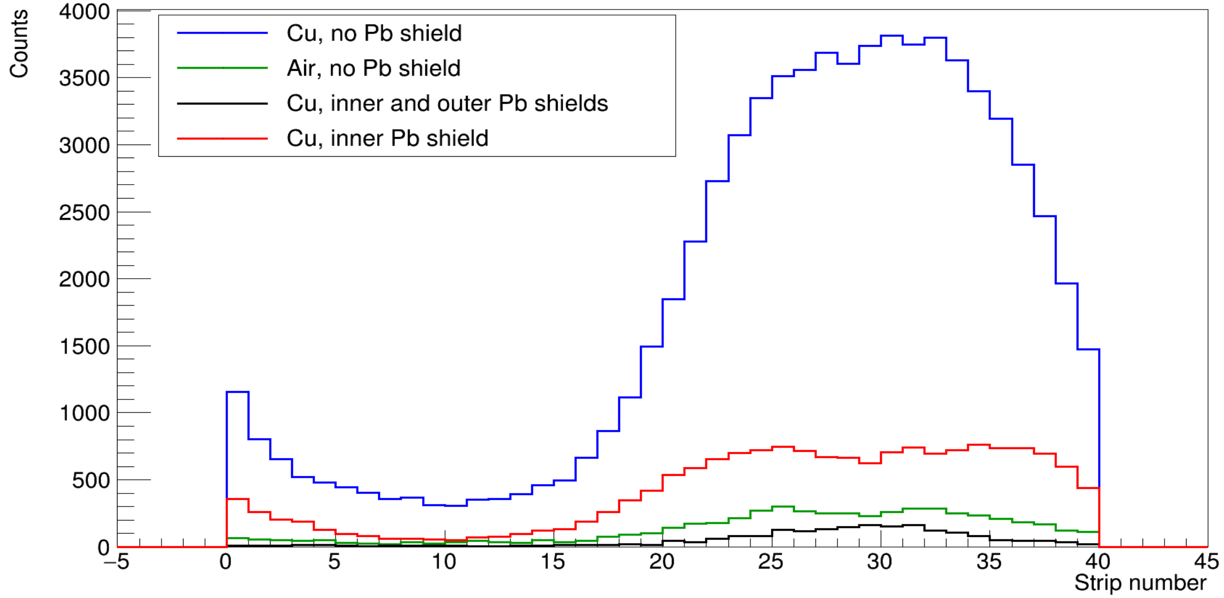


Conditions in the 2018 Ar, Kr run:

– no Pb shield for Ar beam
– two inner Pb shields for part of the Kr beam

Potential upgrade:
adding a trigger counter at the end of beamline near FHCAL will be helpful.

Ar ion passes through the target without interaction.
Counts from all electrons with more than 0.4 MeV deposition



Early results of the simulations:

– the most important source of the δ-electrons is the target itself, in this sense the vacuum will not help

– inner Pb-shielding is not sufficient, one has to add an outer Pb-shield

Thank you for your attention