Upgrade of the beam pipe, beam detectors and trigger system

Sergey Sedykh for the BM@N

5th Collaboration meeting of the BM@N experiment
April 20, 2020

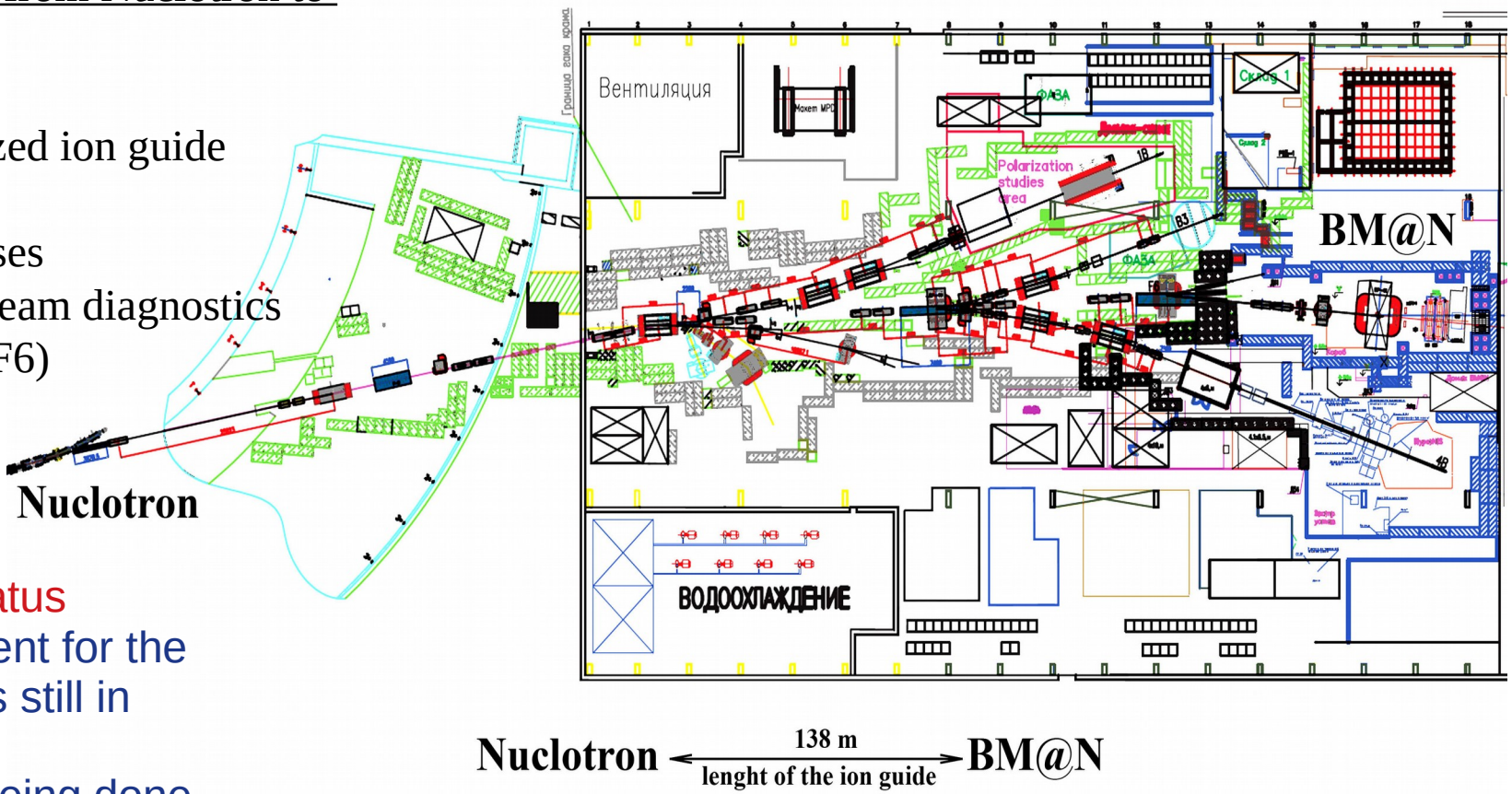
Outline

- *Beam transport line from Nuclotron to BM@N*
- *Beam tracking 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

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)

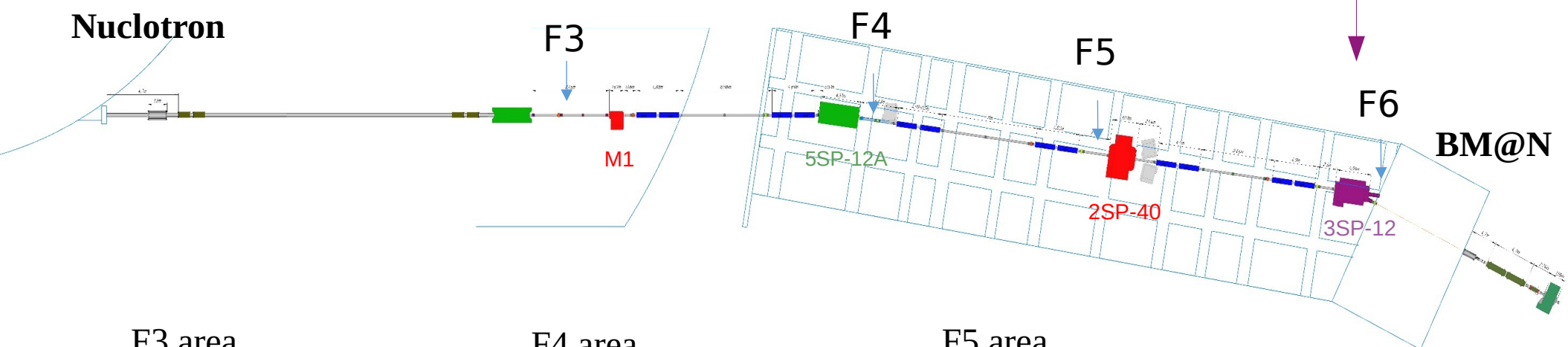


Current status

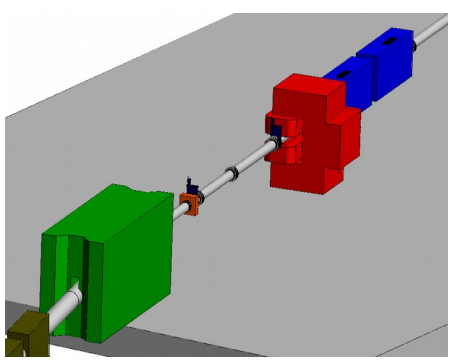
– formal agreement for the whole project is still in preparation
– some work is being done in advance

Vacuum ion transport line from Nuclotron to BM@N

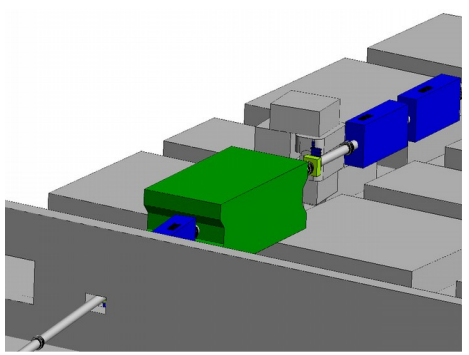
– detailed 3D model of the ion guide done in Feb-Mar 2019
– in March 2020 vacuum chamber was installed in SP-12 in F6



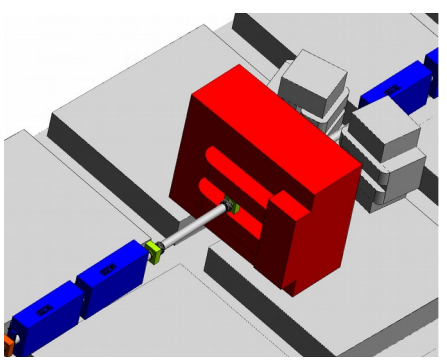
F3 area



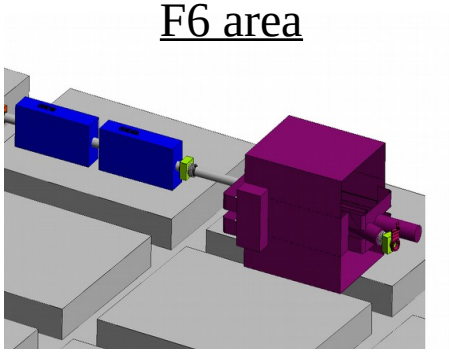
F4 area



F5 area

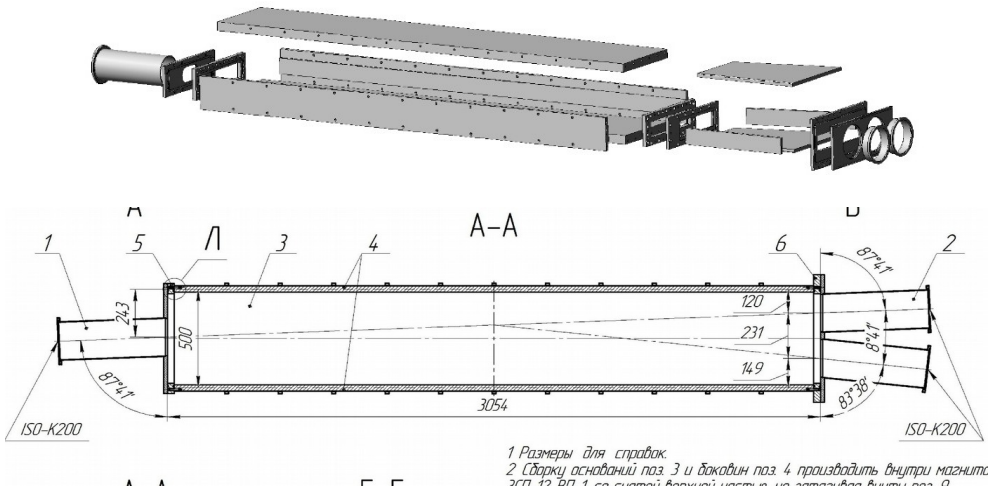


F6 area



R&D VACUUM

Vacuum chamber for SP12 in F6



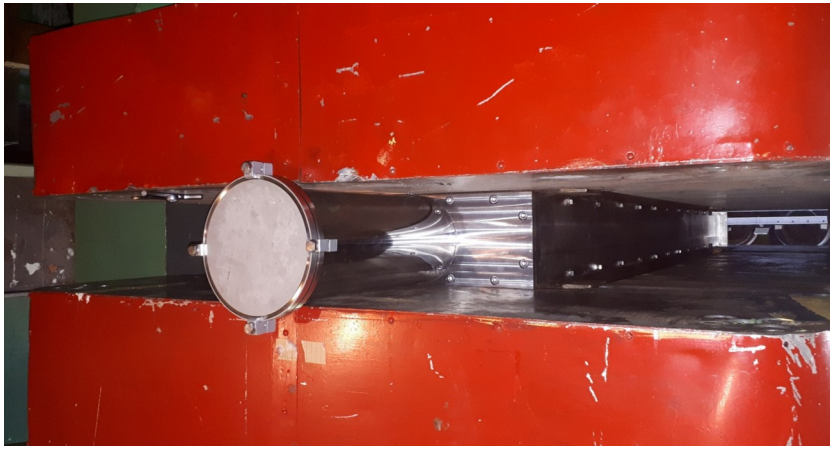
Sketch and final design of the vacuum chamber

Requirements and parameters

– inner part from the steel same to the poles
– should fill vertically the whole magnet
– vacuum <10^{-2} Torr
– side parts from stainless steel, no welding
– length ~4m; weight ~1.5t

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)



Installation involved

– removal of RP concrete blocks

– lifting of the upper part of the magnet (32 t)

Control tests of vacuum chamber for SP12 in F6

Results of the tests

– $5 \cdot 10^{-3}$ Torr reached in ~30 min with vacuum pump Pfeiffer Duo 35, (pressure measured with Pfeiffer Vacuum D-35614)

– less than $3 \cdot 10^{-10}$ Pa·m^3/s leakage measured with Pfeiffer ASM 340 detector

– when the chamber was left closed, after 17 hrs, pressure went up to 10^{-1} Torr (acceptable rate)

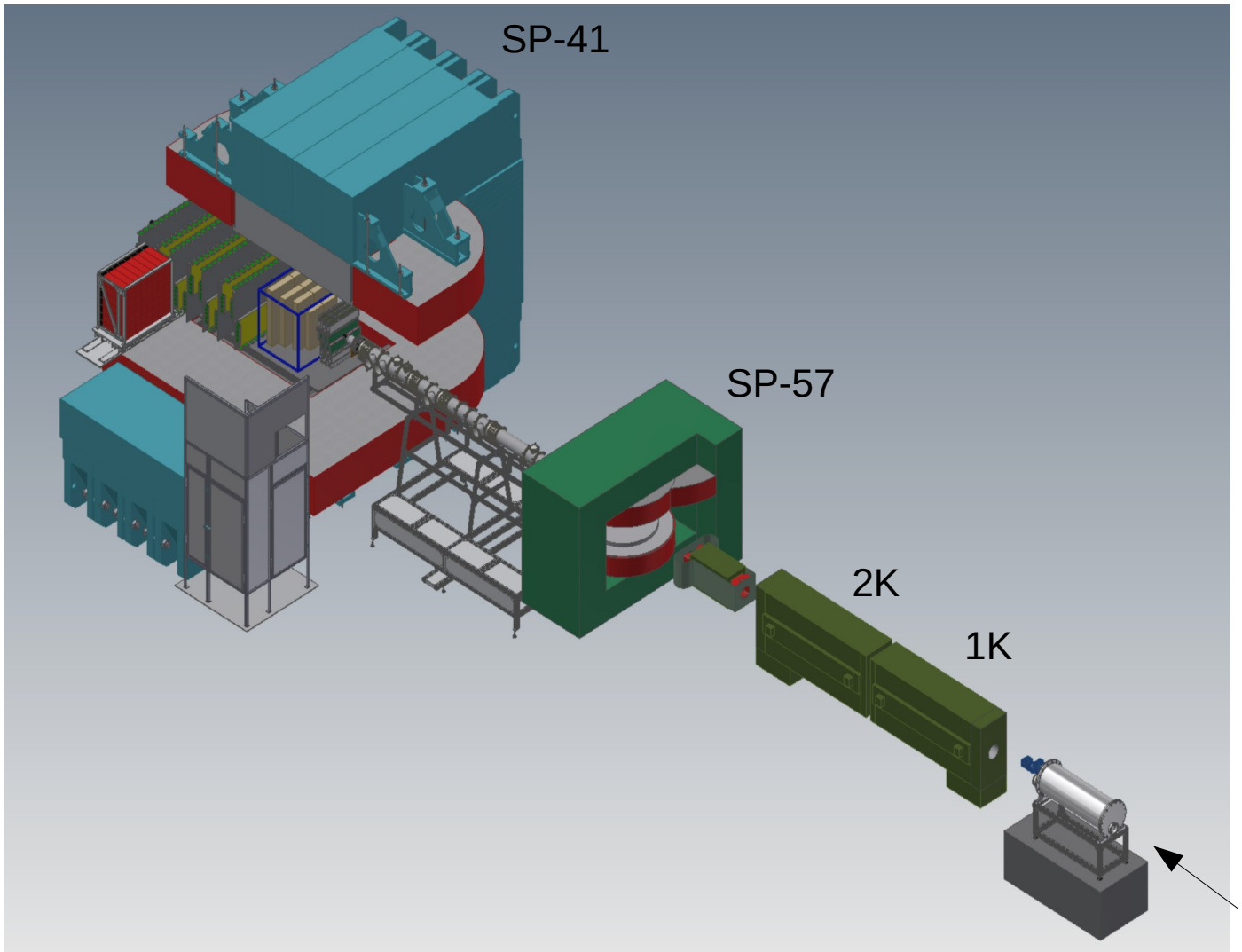
Beamline from Nuclotron to BM@N

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)*
– *Chamber for SP-12 magnet upstream of BM@N (done)*
– *Formal official contract (in progress)*

– *Expected start of production: (delayed, depends on the contract)*
– *Expected completion of parts production: (start + 9-12 month)*
– *Expected overall assembly and testing: (Summer 2021)*

Beam pipe in BM@N before the target

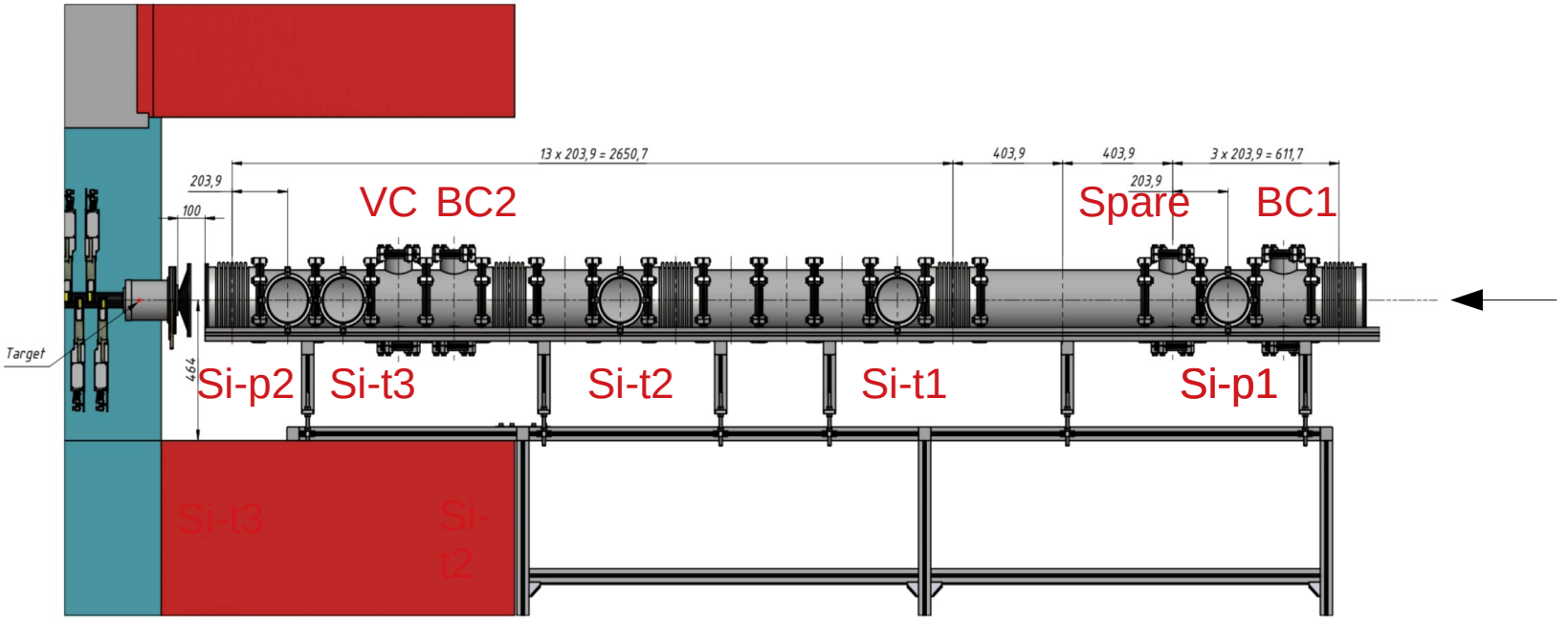


S. Piyadin et al.,
BSU Group

- So far work was done in area between SP-57 and SP-41, where all beam detectors are placed
- Vacuum elements upstream of SP-57 are planned for later stages
- Lenses of 1K and 2K will need special treatment

BM@N beam pipe before the target

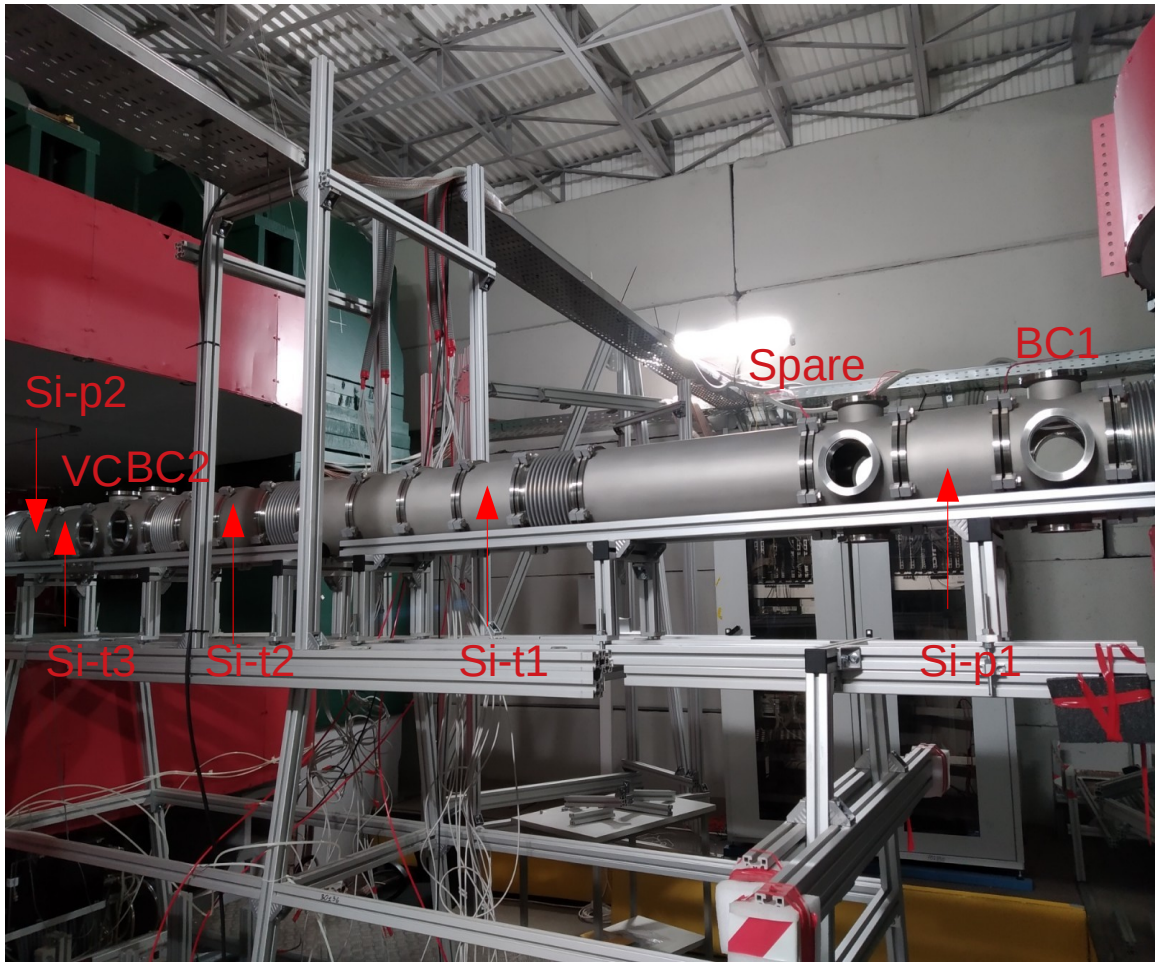
S. Piyadin et al., BSU Group



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

– 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, different PMT mounts

Beam pipe in BM@N before the target

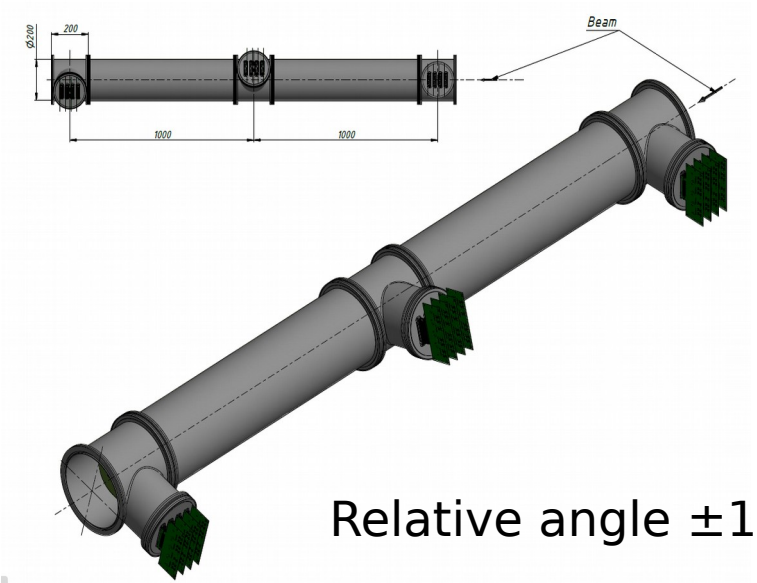


Current status:

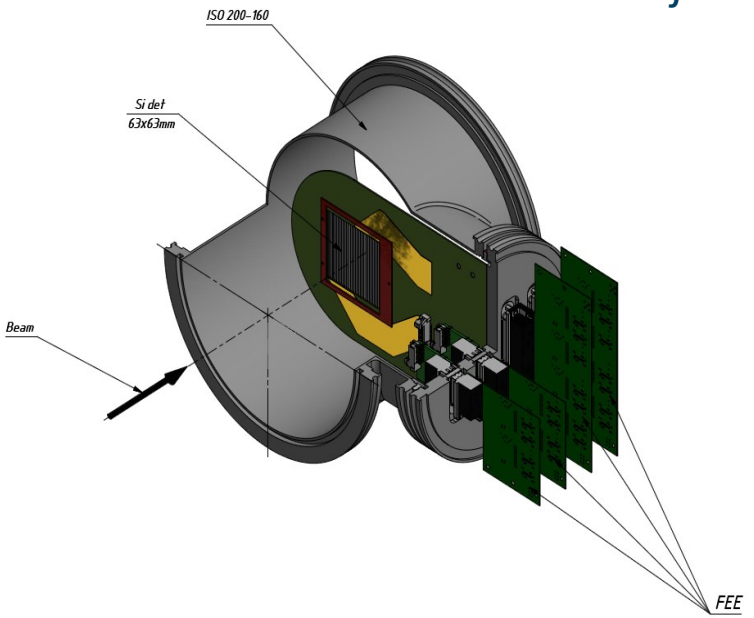
- all components were made and tested in the BSU Lab (specs. ~10^{-3} Torr)
- delivered and assembled at BM@N in Oct.2019
- magnetization of components was found after welding and machining, therefore, one bellow and parts for Si-p2, Si-t3 and VC are being remade of aluminum (close to completion)
- tests of the whole line is foreseen after complete assembly

Silicon Beam Tracker Detectors

Group of N.Zamjatin



Relative angle ±15°



Detector:

– double-sided
– area 63x63 mm^2
– pitch 475 μm
– 128 x 128 strips
– thickness 175 μm

Status of DSSD and FEE:

– 15 detectors delivered (NIIMV, Zelenograd)

– 20 VATA64-HDR16 purchased

– PCB design is in progress

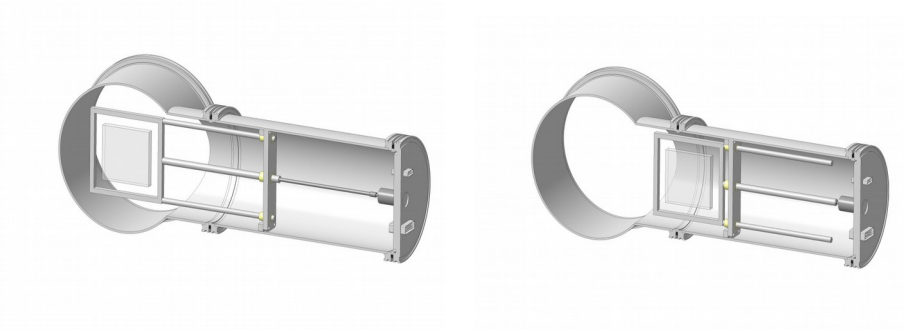
Status of vacuum components:

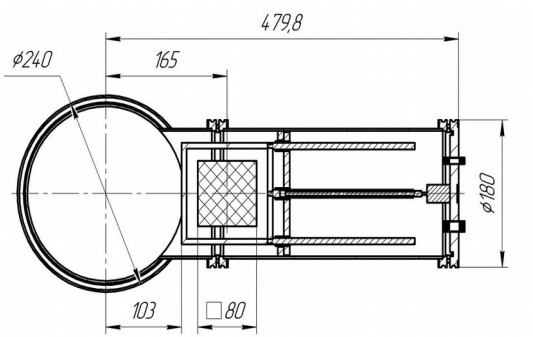
– Si-t1, Si-t2 are ready, Si-t3 is being remade of aluminum

– one flange with connectors is available for testing

Silicon Beam Profile Detectors

Group of N.Zamjatin,
S. Piyadin, BSU Group





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

Current status of vacuum parts:

– Si-p1 box is completed,
Si-p2 box is being remade of Al
– moving mechanics design is ready,
some details need final approval
– available UltraSonic motor needs
testing of operation in magnetic
field (for Si-p2)
– flanges with connectors are ready
for testing

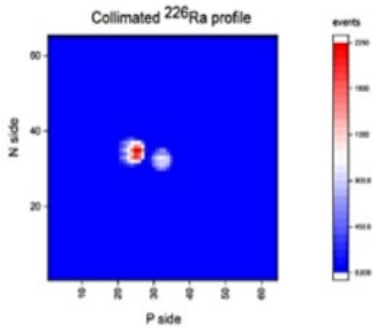
Status of DSSD and FEE:

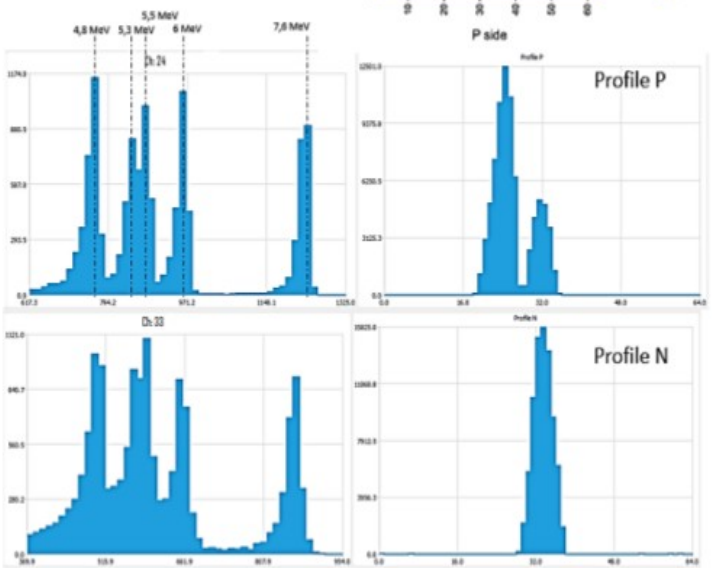
– 10 detectors delivered
(NIIMV, Zelenograd)
– VA163 and VA32HDR11
are available
– PCB design is in progress
(see talk of Yu.Ivanova)

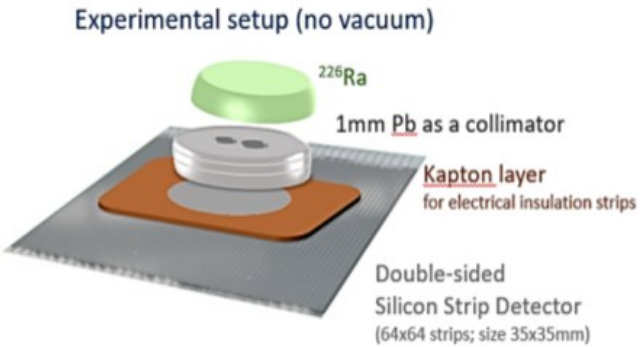
Silicon Beam Profile Detectors
Tests of prototype

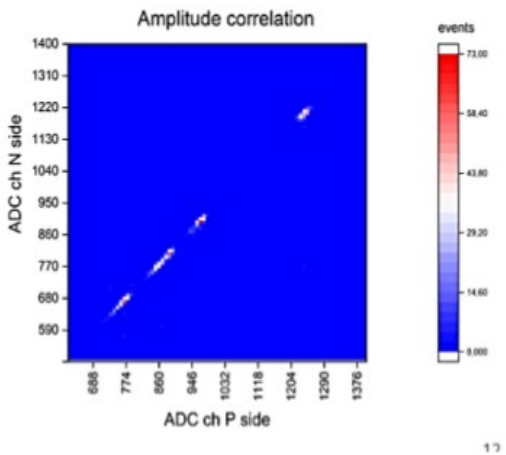
Group of N.Zamjatin

Test with collimated ^{226}Ra (VA162)









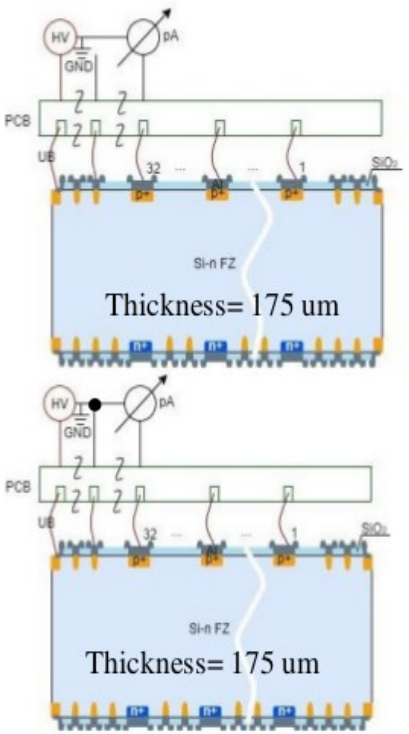
Prototype

– area 32 x 32 mm^2
– pitch 0.5 mm
– 64 x 64 strips
– thickness 300 μm
– ASIC VA162

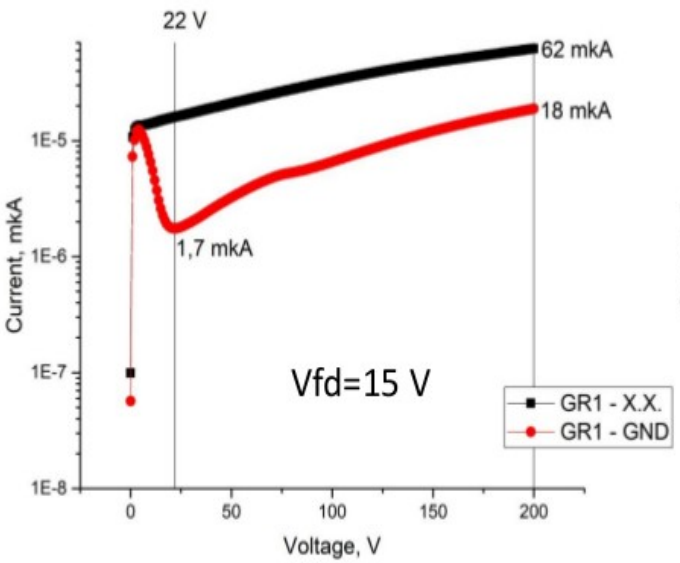
Beam Profile

– area 60 x 60 mm^2
– pitch 1.87 mm
– 32 x 32 strips
– thickness 175 μm
– ASICs: VA163 (0.7 pC, ^{12}C), VA32HDR11 (30 pC, Kr and Au)

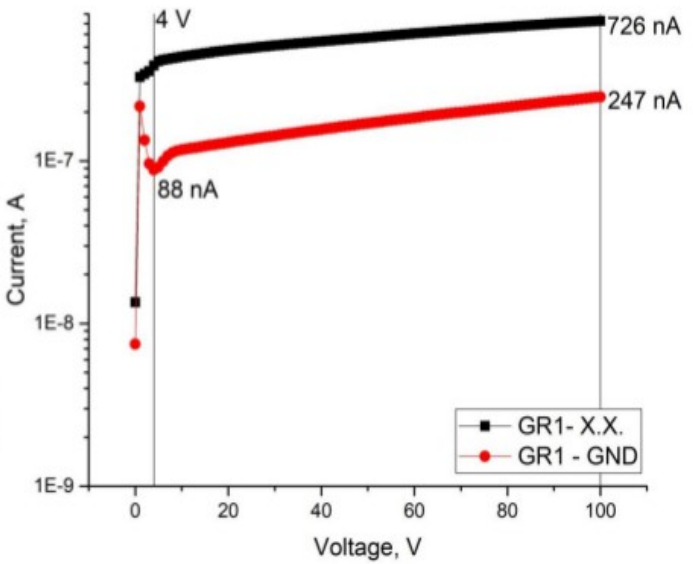
IV-tests for beam profilometer and tracker DSSDs



Measurement scheme of summary dark current beam profilometer and beam tracker DSSDs, Inner guard ring at floating (top), Inner guard ring at GND (bottom).



Summary beam profilometer DSSD Dark Currents, Inner GR at floating (black) Inner GR at GND (red) at T= +24,2 ºC



Summary beam tracker DSSD Dark Currents, Inner GR at floating (black) Inner GR at GND (red) at T= +24,1 ºC

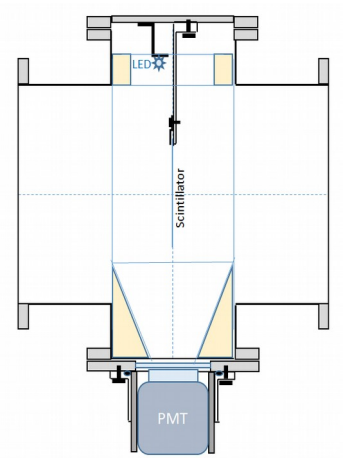
Beam Profile and Tracker Detectors

planned actions and schedule

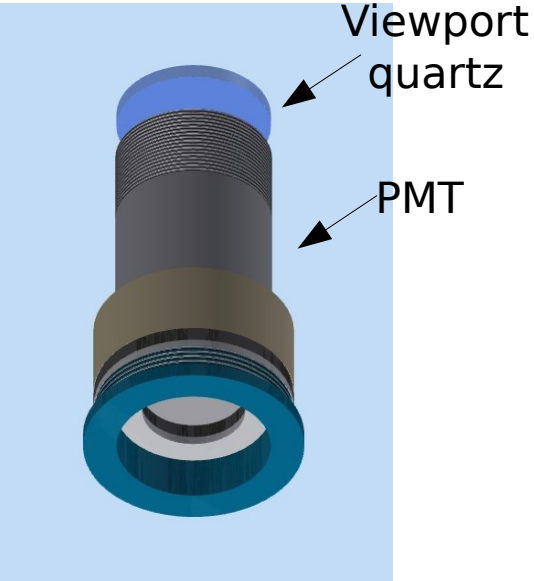
Group of N.Zamjatin

– *tests of vacuum flanges with connectors (O.Tarasov, Spring/2020)*
final production (O.Tarasov and BSU group, Summer/2020)
– *design of PCBs (S.Khabarov, Spring/2020)*
order of PCBs for production (S.Khabarov, Spring->Summer/2020)
– *assembly and tuning PCB+FEE*
(S.Khabarov, Yu.Ivanova, Yu.Kovalev, Spring-Fall/2020)
– *tests of DSSD mounted on plates*
(O.Tarasov, N.Zamjatin, Summer/2020)
– *tests of trackers with BM@N DAQ (Fall/2020)*
– *tests of beam profile detectors with stand-alone read-out (Fall/2020),*
– *profile distribution copy to beam transport group*
(+P.Rukoyatkin, by the end of 2020)
– *full assembly with vacuum parts (12/2020)*

Beam Counters: BC1, VC



Sketch of vacuum box for BC1 and VC



Design of PMT mount for BC1 and VC

Current status

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

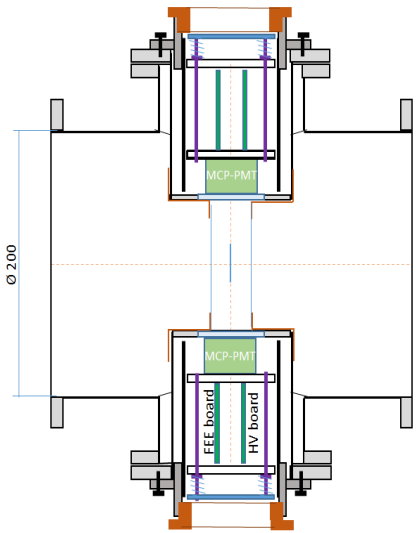
– Vacuum boxes
(BC1 ready, VC in production)

– PMT mounts
(design is close to completion)

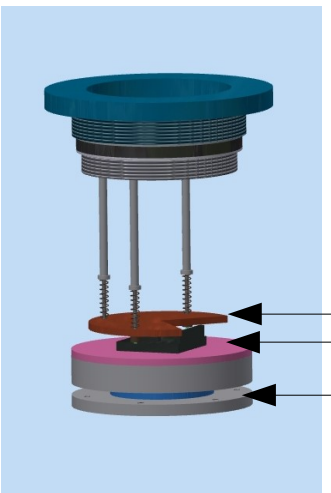
– Scintillator BC400B
100x100x0.25mm^3
(available)

– Scintillator mounts
(design planned Summer 2020)

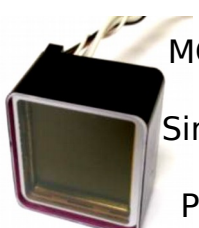
Beam Counters: BC2



Sketch of vacuum box for BC2



Design of PMT mount for BC2



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

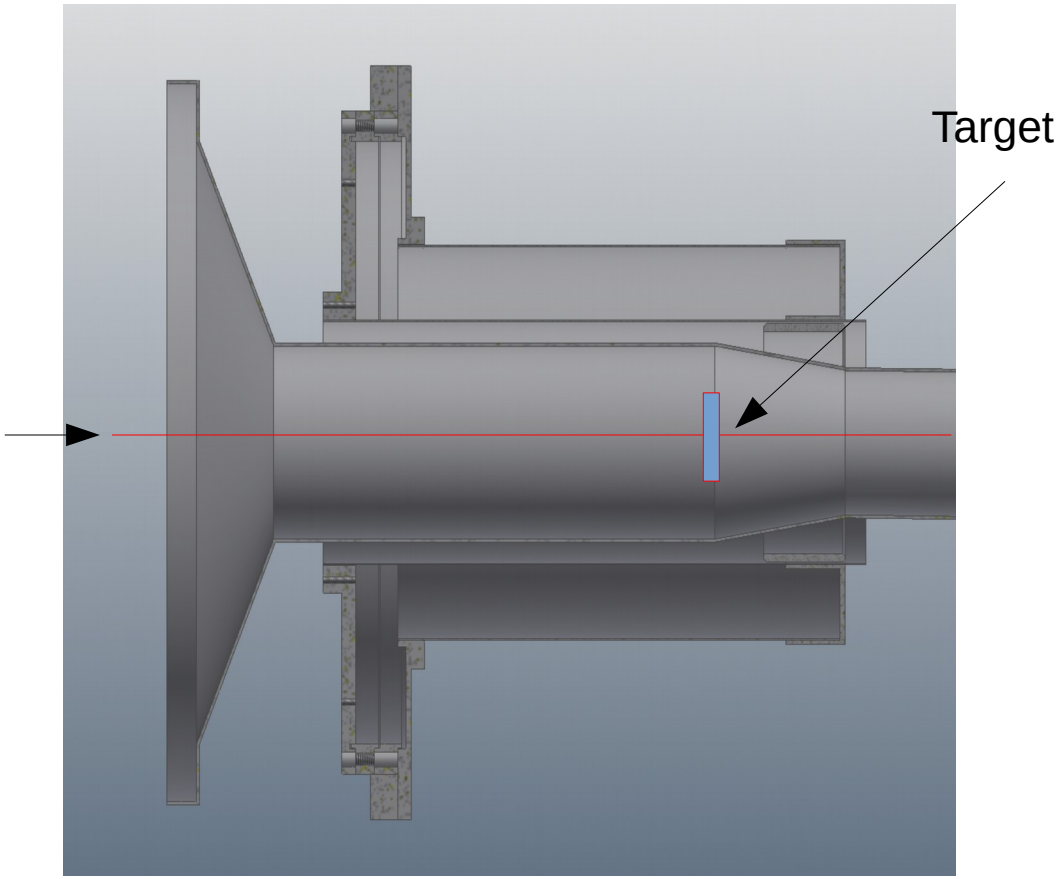
Photocathode: 25 × 25 mm^2

Current status

- MCP-PMT XPM85112/A1-Q400 operate in magnetic field <1T (available)
- Vacuum boxes with quartz windows (sent back to BSU for minor improvements)
- PMT + FEE mounts (design in Summer 2020)
- FEE design and production (~2 month, Summer-Fall 2020)
- Scintillators BC400B 10x10x0.15mm^3 (available)
- Scintillator mounts (design Summer-Fall 2020)

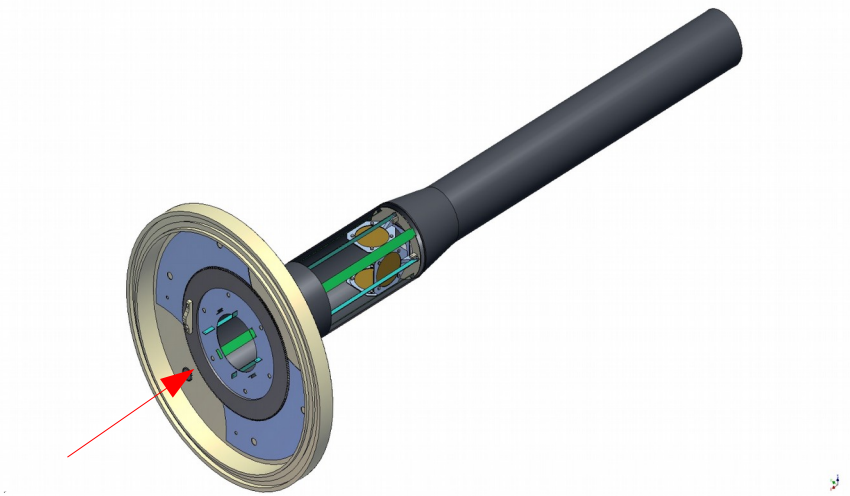
Target area with Barrel Detector

S.Piyadin, Yu.Gusakov,
BSU Group



First section of the carbon vacuum pipe and Barrel Detector

Dia. 200 → 66 → 50 mm

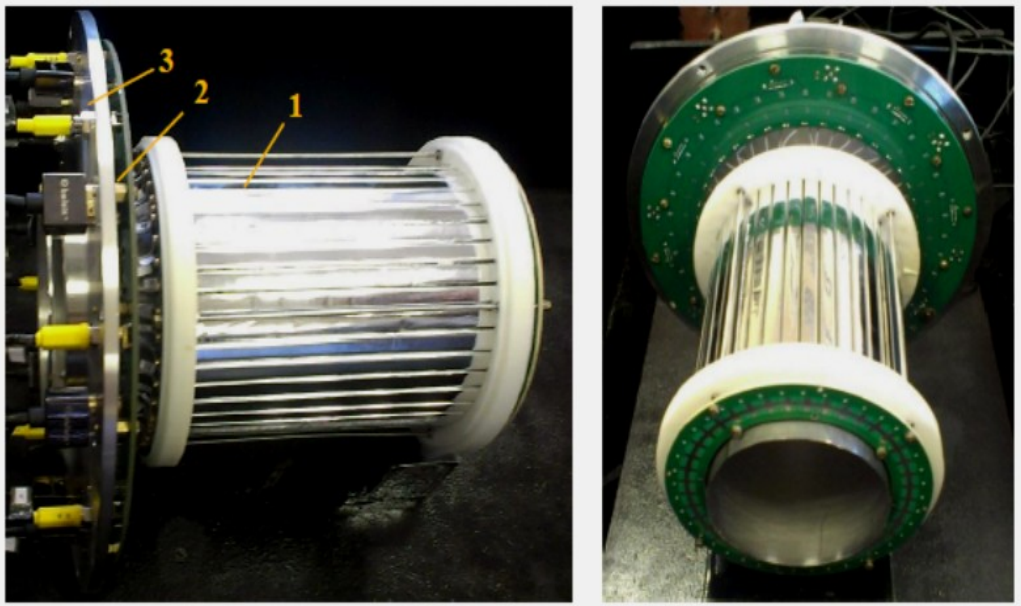


Carbon vacuum pipe and the target station

Current status

– mechanical parts (production is started in Belgorod)
– motor is available (will be sent to BSU for testing the whole assembly)

Upgrade of Barrel Detector (BD)



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:

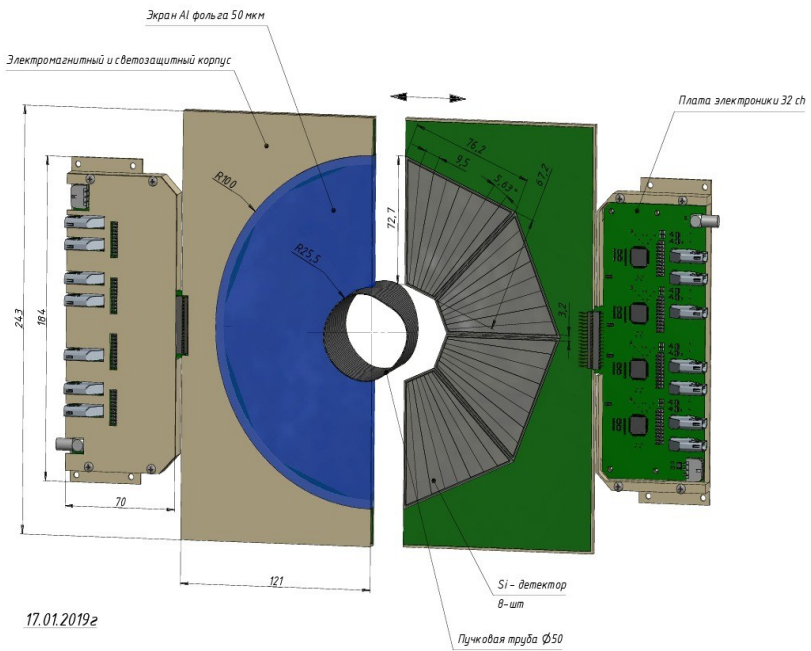
- inner (5 mm) and outer (10 mm) Pb shielding will be added (will be done by the trigger group)

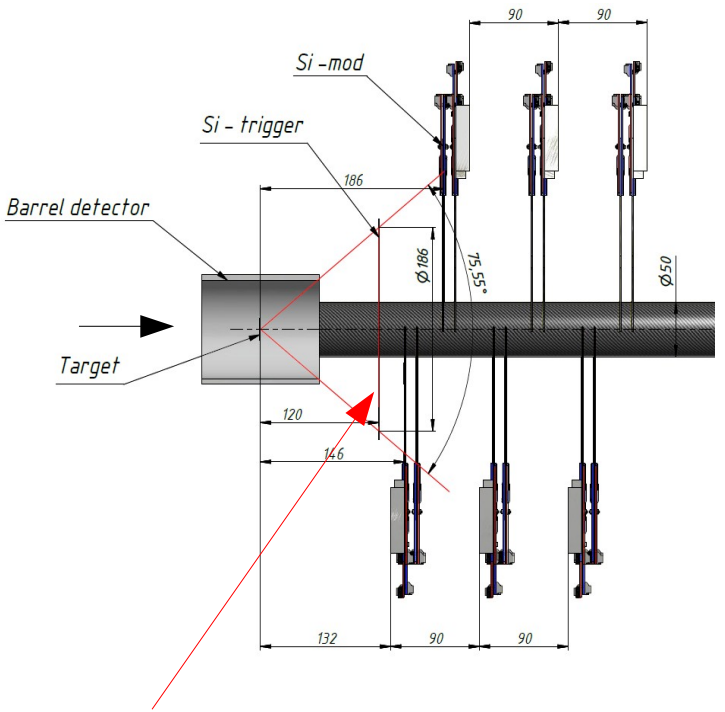
- new FEE (less noise)

Upgrade of Silicon Multiplicity Detector

Group of N.Zamjatin

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

Upgrade of Silicon Multiplicity Detector

current status and schedule

Group of N.Zamjatin

– *trapezoidal detectors, 8 strips, 525 μm*
(NIIMV Zelenograd, 16 detectors delivered 12/2019)

– *tests and selections of detectors*
(E.Streletskaya, Yu.Kopylov, Spring/2020)

– *detector frame design including EM and light screens, will be based on experience with Si MD detector of 2018 (O.Tarasov, Spring/2020)*

– *design of PCBs (S.Khabarov, Spring/2020)*

– *order of PCBs for production, 2x2 half-planes*
(S.Khabarov, Summer/2020)

– *FEE of 2018 with minor corrections (S.Khabarov, Spring/2020)*

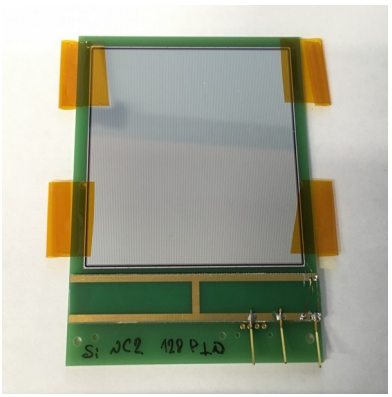
– *detector assembly, tests and tuning with radioactive source*
(O.Tarasov, N.Zamjatin Spring-Summer/2020)

– *integration of signals to trigger logic unit*
(with trigger group, by 12/2020)

T0 option for high beam intensity, Au+Au, >5·10^6

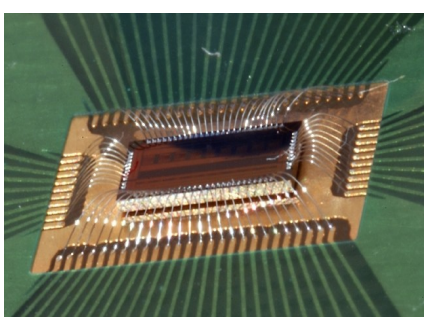
Si-tracker detector + TOF Nino chip

Group of N.Zamjatin and TOF Group



Si Tracker Detector:

– double-sided
– active area 63 x 63 mm^2
(take middle area 30 x 30 mm^2)
– pitch 475 μm
– 128 x 128 strips
(take middle part 64 x 64 strips)
– thickness 175 μm



NINO ASIC:

– 8 channel chips
– developed in CERN for TOF applications
– BM@N TOF Group has positive experience with them
– Basic idea:
Si 2x64 signals → 16 NINO cards → 2TDCs

Current status:

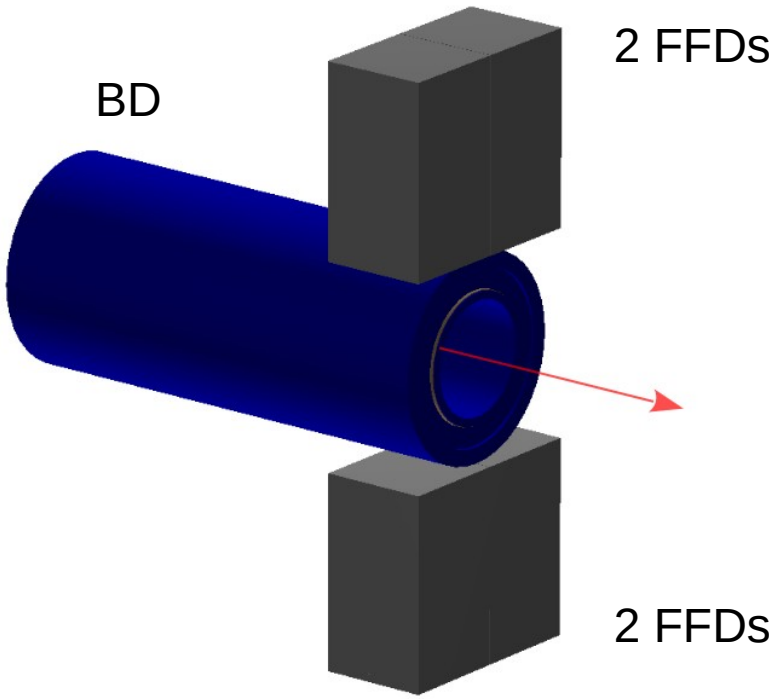
– under discussion
– planned for testing

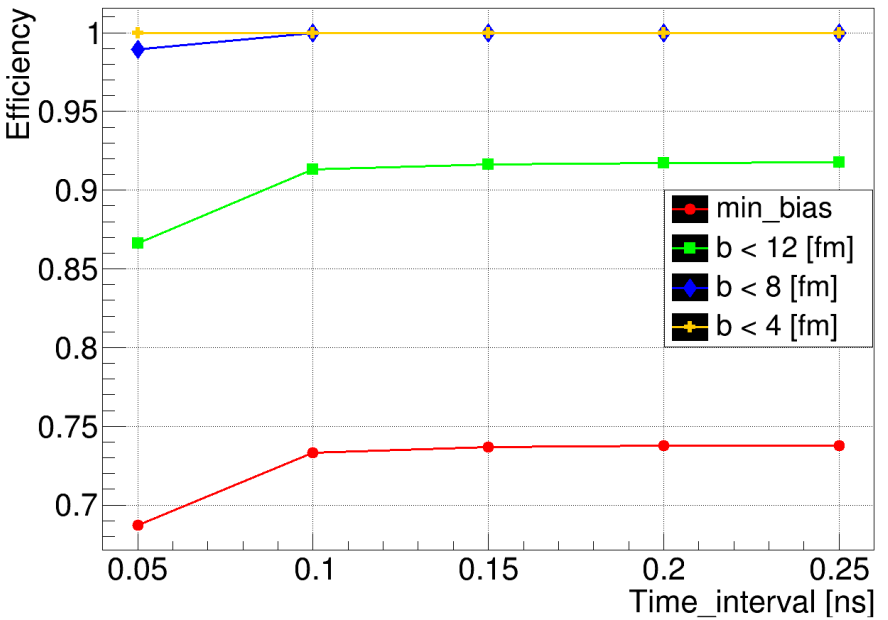
Planned checks of MCP-based PMT rate effects :

– BC2 Ar+Kr data
– LED+Laser System Lab Tests (Summer 2020)

T0 option for the highest beam intensity, Au+Au, $5 \cdot 10^7$

(reminder from the previous meeting)



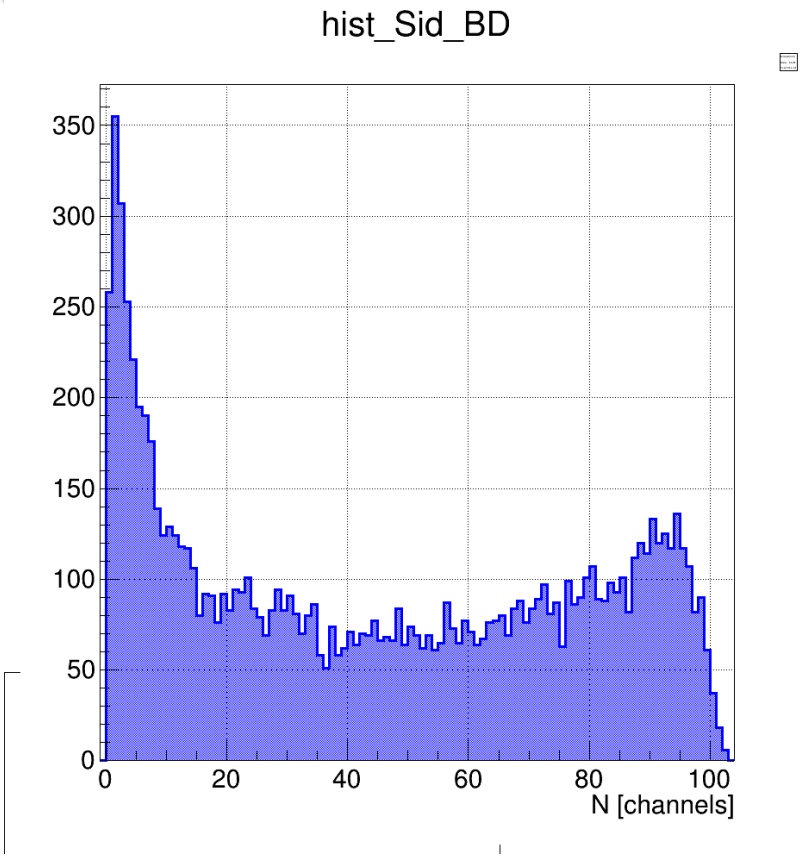


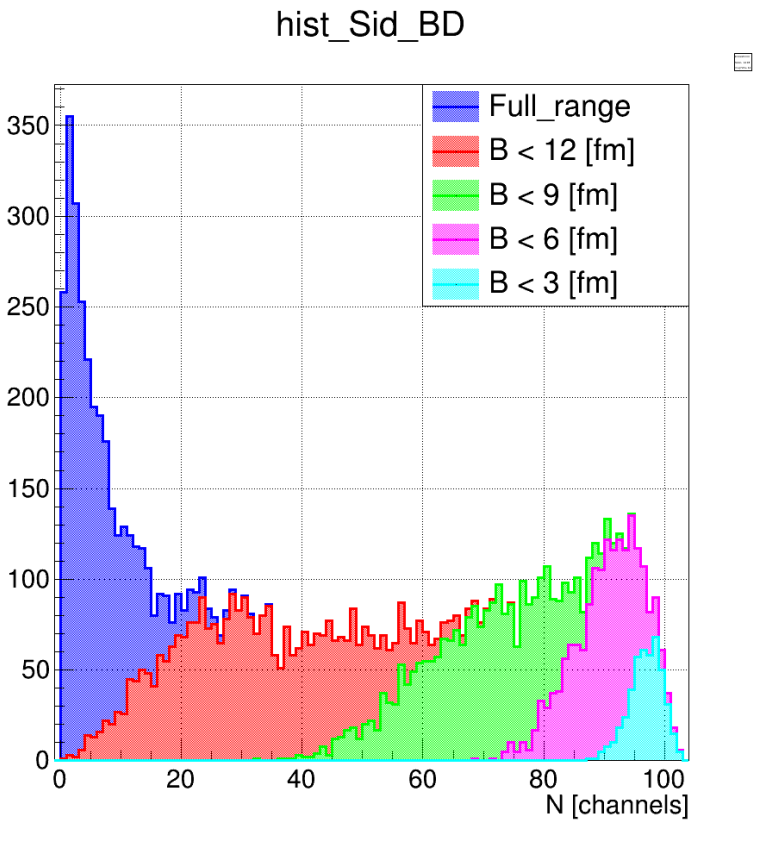
This option can (should?) be tested
In the next run

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

Simulation of trigger response for Au+Au

N.Lashmanov





Next steps: correlation of response of the trigger multiplicity detectors and ZDC (particularly in neutron region) and the Cherenkov fragment hodoscope

Thank you for your attention