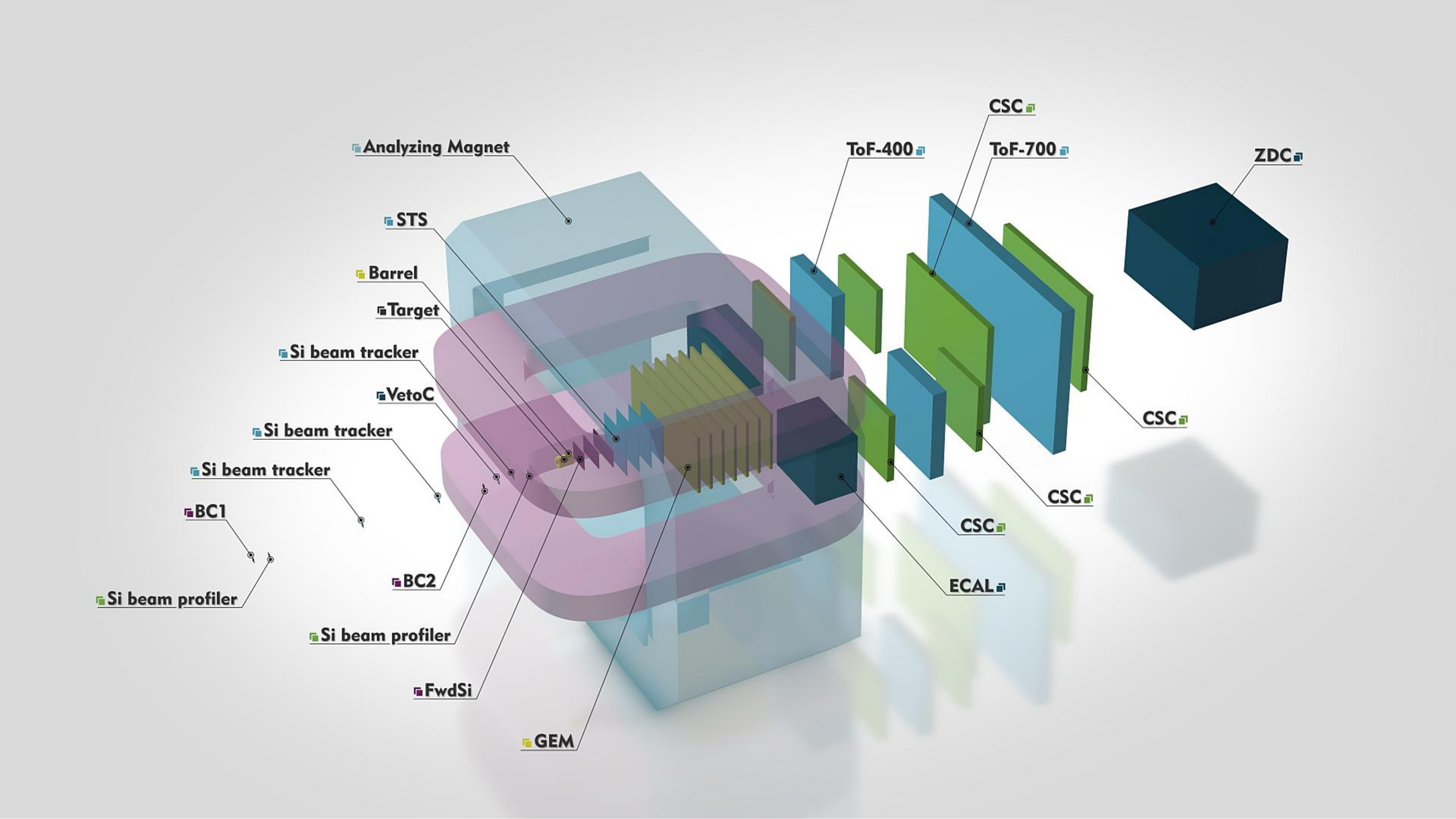
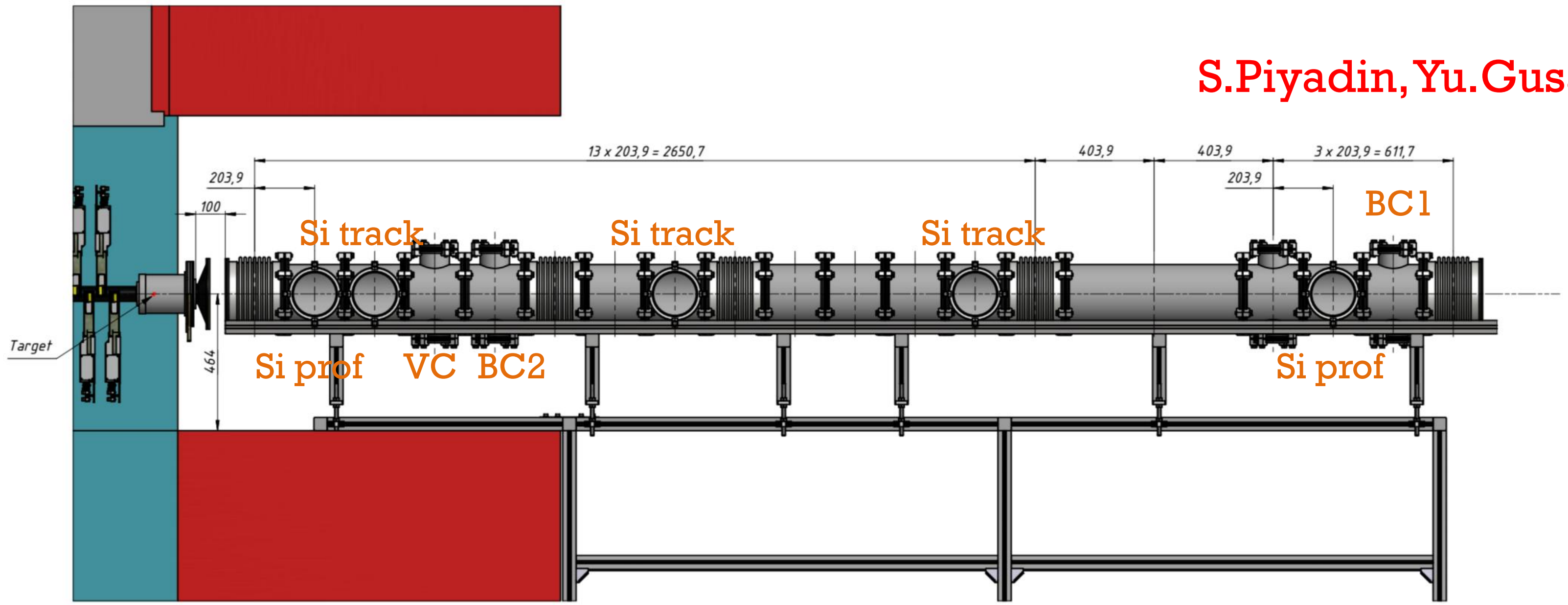
Status of the BM@N detector upgrade

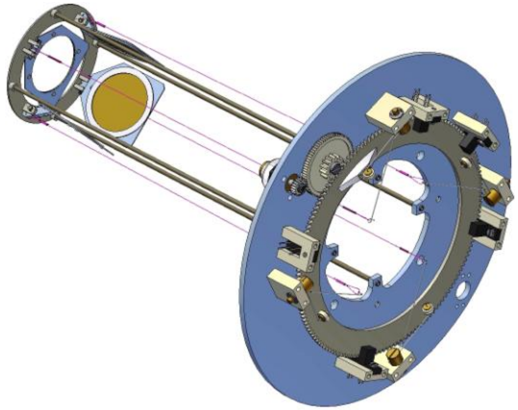
A.Maksymchuk

BM@N Experimental Setup



Beam pipe before the target, target station





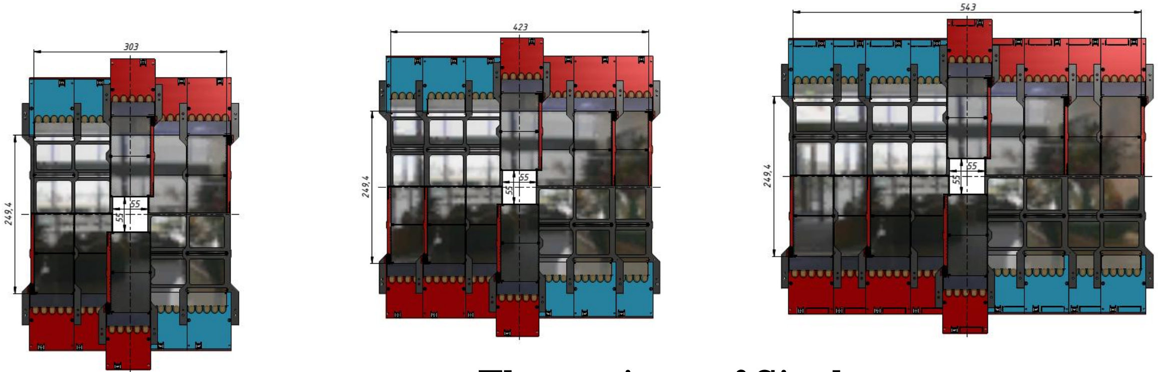
Target station:
Three different target types with d = 30mm and 1 empty target are foreseen for data taking and background evaluation;
Operational in vacuum and magnetic field.

See talk of S.SEDYKH

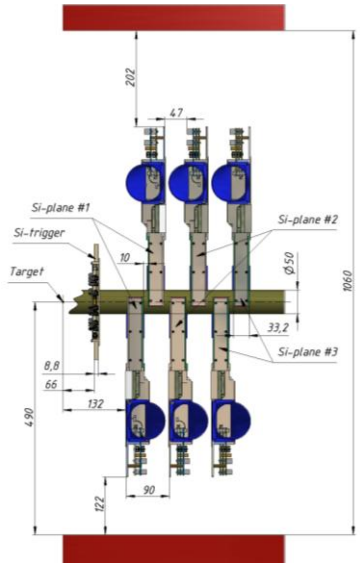
Production of the beam pipe: Belgorod University

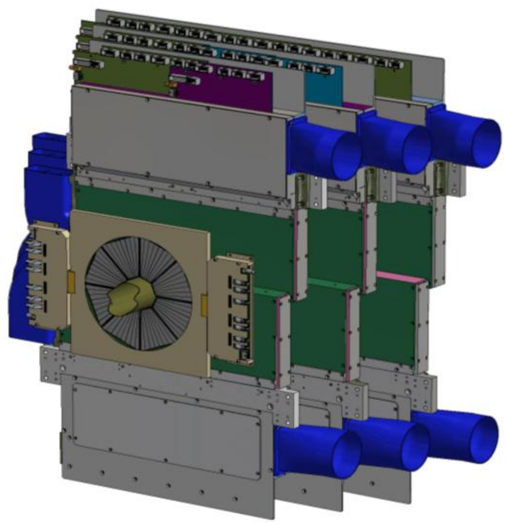
Upgrade of the forward Si tracking detectors

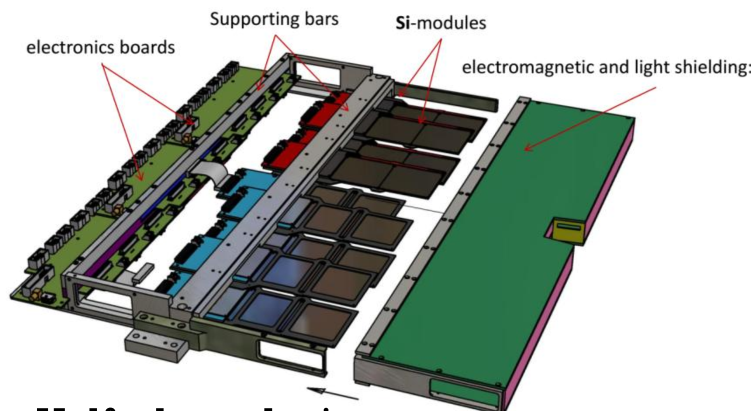
group of N.Zamiatin



Three sizes of Si-planes





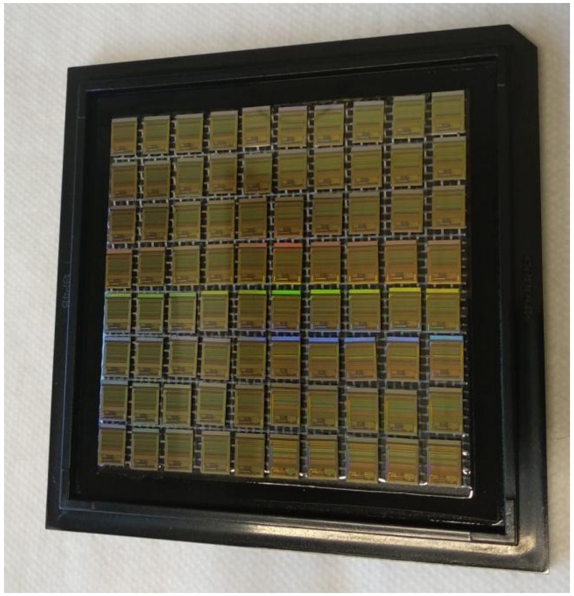


Half-plane design

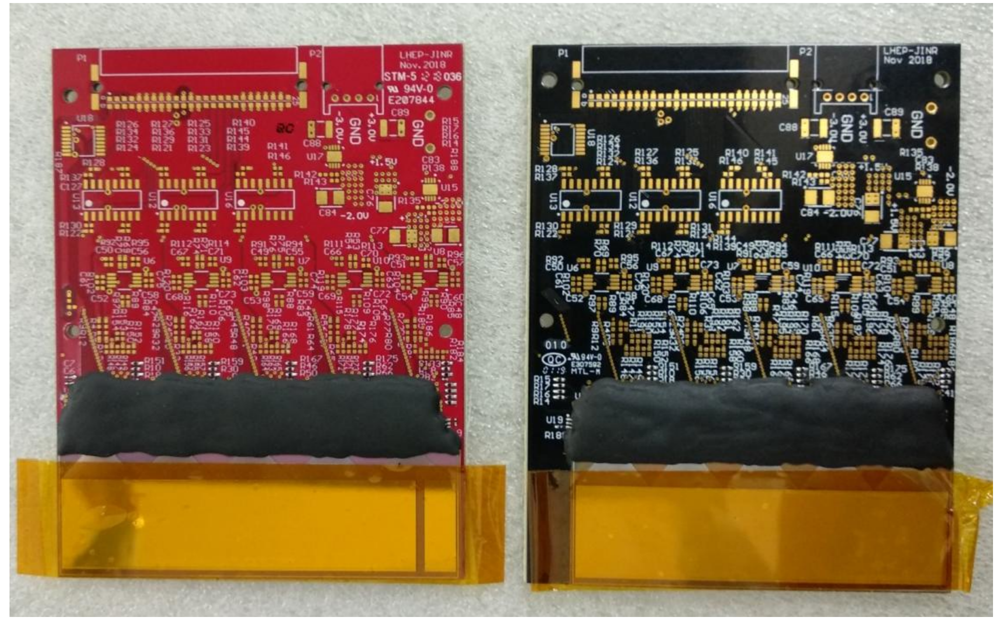
Design of the Si-planes
on the BM@N beam-channel

Station#	Number of DSSD modules	DSSD station square	Number of Readout channels
Station1	10	720 cm^2	12800
Station2	14	1008 cm^2	17920
Station3	18	1296 cm^2	23040
Total	***42***	***~0.3 m^2***	***53760***

Upgrade of the forward Si tracking detectors



ASIC VATAGP7.1 are delivered to JINR



First FEE based on VATAGP7.1 are ready for testing

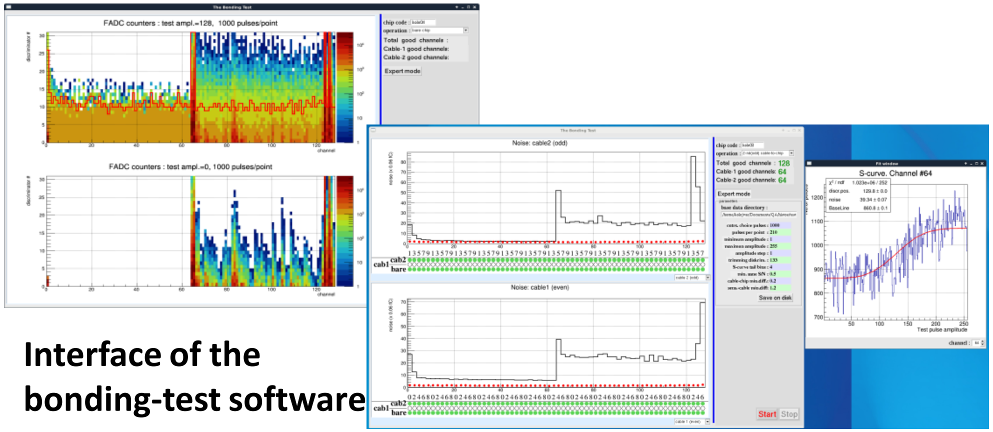
Readout ASIC VATAGP7.1.
Number of sensitive pre-amplifier (CSA) inputs - 128
Input charges (dynamic range) - -30fC ÷ +30fC
Peaking time (slow shaper) - 500ns (typ.)
Good linearity for charges up to +/- 15fC
Reading clock - 4,6MHz

Plans:

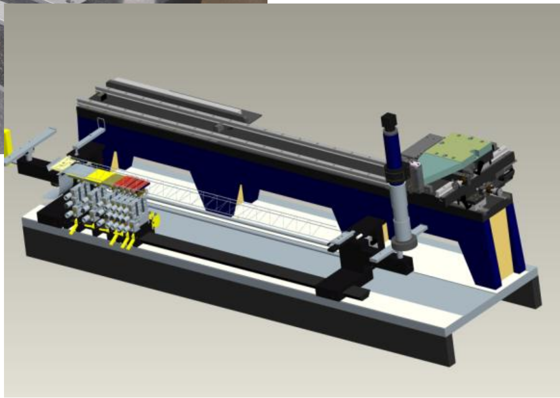
02.2020 – integration of the Si forward tracking detectors into BM@N setup

Status of the BM@N STS

STS group



Interface of the bonding-test software



Device for the Ladder assembly

Assembled module under the shielding cover

Module Assembly

- Assembling of BM@N STS modules has been started in 2019. First modules were assembled.
- Quality assurance system was developed for the tests of the bonding quality during the assembly. It was tested and implemented in the assembly process and DB.
- Full assembling procedure including technological line, DB, QA, endurance and long-term stability tests should be finalized till the end of 2019

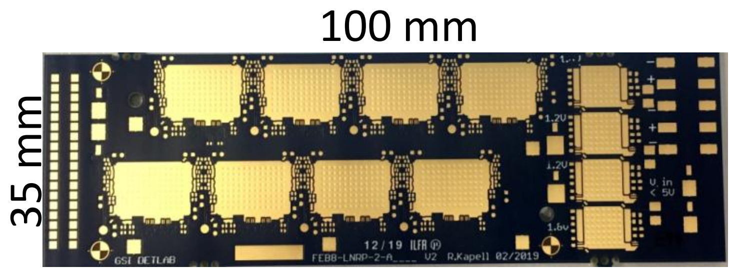
Ladder Assembly

- All components of the ladder assembly device are in the sight
- Complete device should be delivered in the end of June
- Commissioning, staff training and start of ladder assembly supposed at August – September 2019

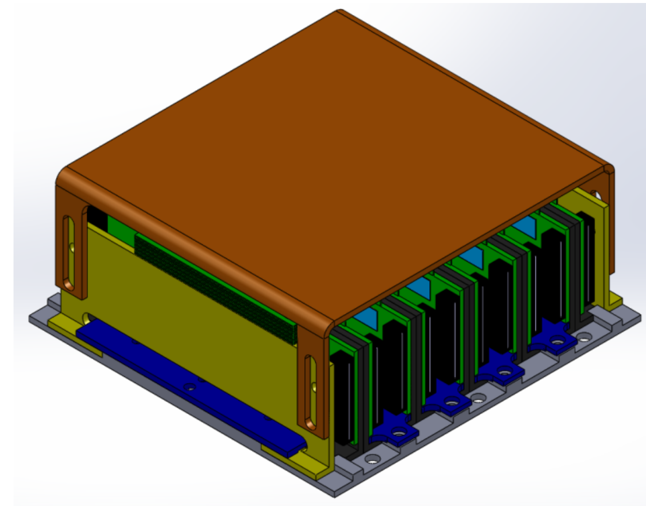
STS group

Status of the BM@N STS

Data processing boards during beam time



New FEB8 designed by R. Kapell



Readout electronics

- New design of the Front-end Board for BM@N STS is under developing. Will be optimized for the new version of ASIC and LDOs, requirements on the cooling and integration. Will be produced in the Oct. 2019
- Firmware for the Data Processing boards with GBT interface was developed and tested during the beam-time at Linac-200
- The following institutes are participating: GSI (Coordination), WUT (Firmware), MSU(FEB design)

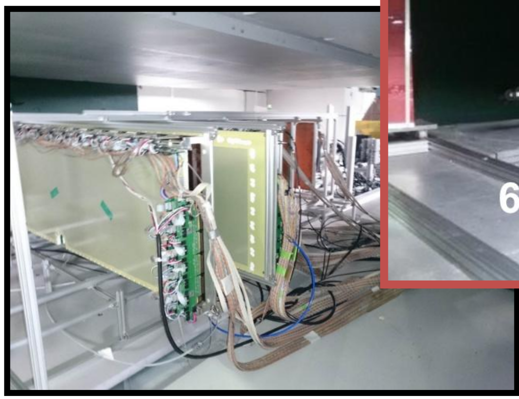
Cooling

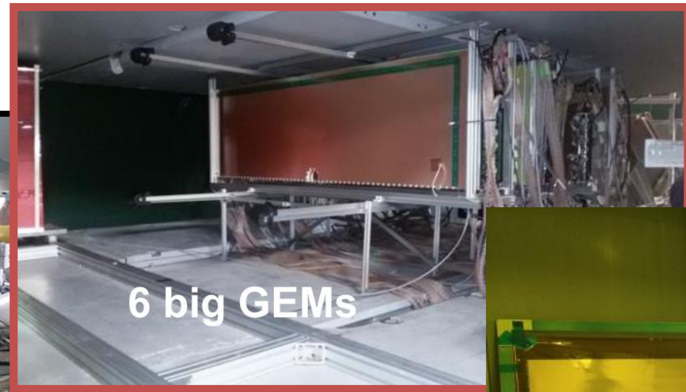
- Thermal simulations of the BM@N STS are now undergoing
- Thermal mockup of the FEB box will be assembled and tested in June 2019
- Thermal mockup of the quarter station will be assembled and tested in Oct 2019
- 2* 14 kW chillers are already in the site
- Thermal simulations will be performed together with a group from WUT and MSU

BM@N STS TDR will be finalized in the fall of 2019

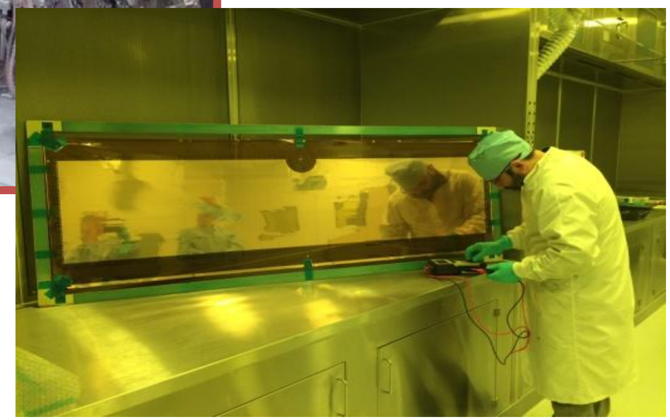
GEM central tracking system

GEM group





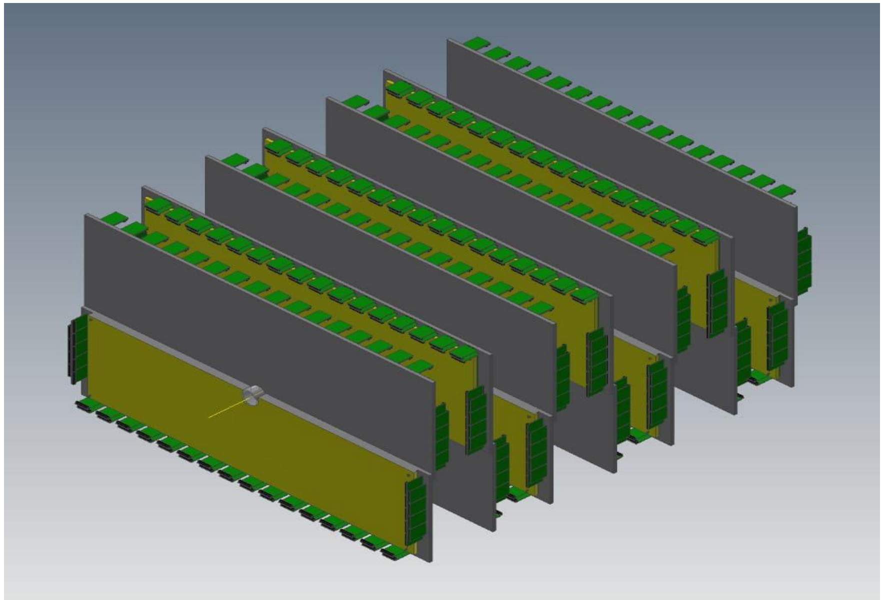
1632x450 mm² GEM chambers at BM@N experimental setup



1632x390 mm² GEM chamber assembly process

- Seven GEM 1632x450 mm² chambers produced at CERN workshop were integrated into BM@N experimental setup. One was defected, to be repaired at CERN.
- Three GEM 1632x390 mm² chambers were assembled, delivered to JINR and tested.

Scheme of the GEM full planes configuration inside the magnet



09.2019 – development
of the mechanics design for GEM
planes precise installation
inside the magnet.

End of the 2019 – mechanics
production.

Upgrade plans:

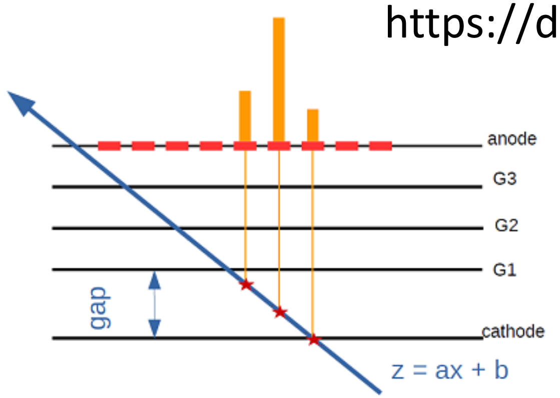
- 12.2019 year - production of 4 GEM chambers of size
1632 mm × 390 mm to cover full vertical acceptance of analyzing magnet

- 03.2020 – integration of the full GEM planes into the experimental setup
(electronics based on the VA-163 chips, ~90000 readout channels)

- Development and tests of FEE based on VMM3 /STSXYTER/TIGER ASICs.

TIGER (**T**urin **I**ntegrated **G**em **E**lectronics for **R**eadout)

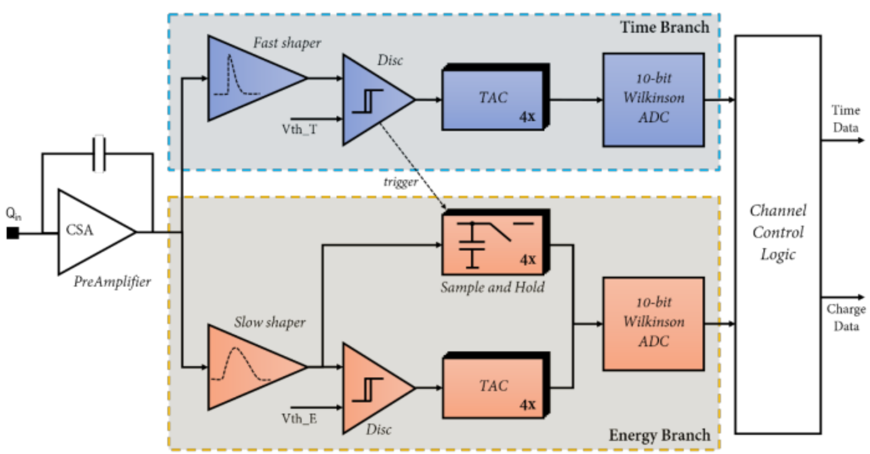
https://doi.org/10.1016/j.nima.2018.09.010



- If known the drift velocity, time information can be used to assign to each fired strip a 2D point
- Particle track is reconstructed from these coordinates
- The spatial resolution can be improved in magnetic field, especially for angled tracks

TIGER v1 - 64-channel readout ASIC was tested at BESIII Experiment (New Inner Tracker based on **Cylindrical Gas Electron Multiplier**)

TIGER channel architecture



TIGER V2. Programmable gain: range 50-300 fC Input

Sustained event rate > 100 kHz/ch

Measured performance of the TIGER ASIC:

Input charge 5-55 fC

TDC resolution 30 ps RMS

Time-walk (5-55 fC range) 12 ns

Average gain 10.75 mV/fC

Nonlinearity (5-55 fC range) 0.5%

RMS gain dispersion 3.5%

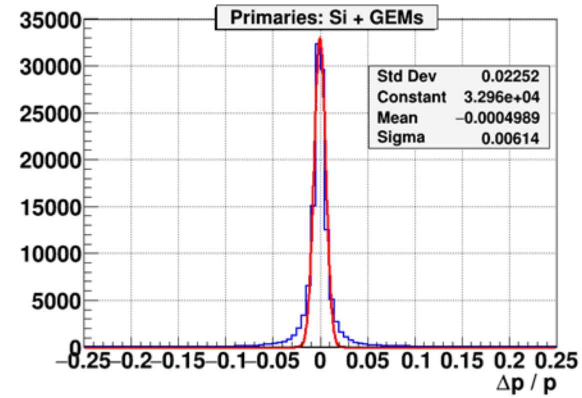
Noise floor (ENC) 1500 $e-$

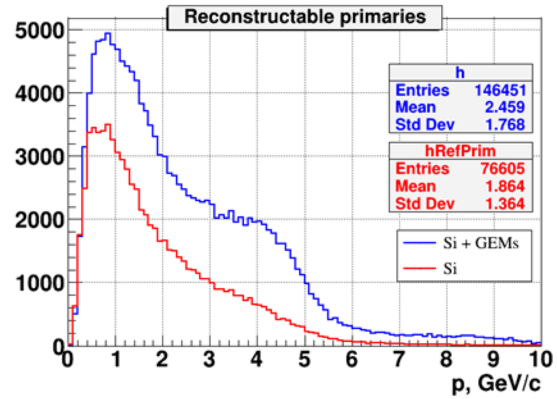
Noise slope 10 $e-$/pF

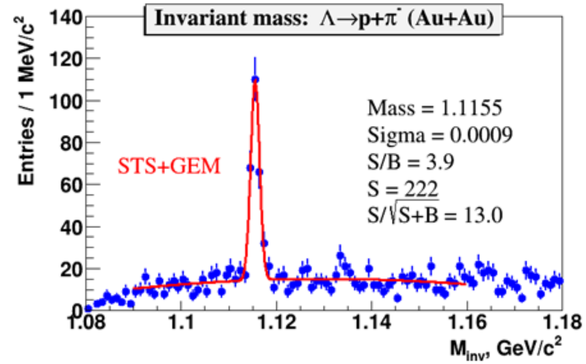
Maximum power consumption 12 mW/ch

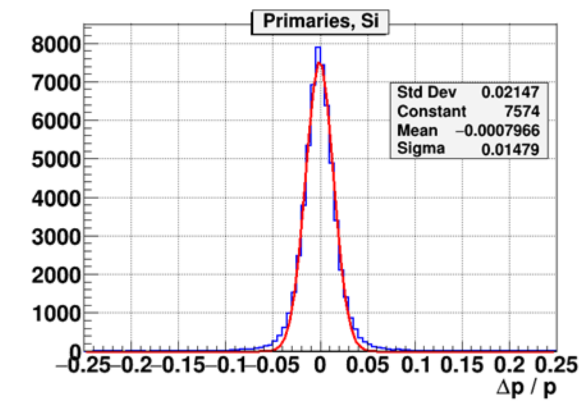
First tests with BM@N GEMs are planed 10.2019 at CERN

Hybrid central tracker for heavy ion runs: STS vs STS +GEM



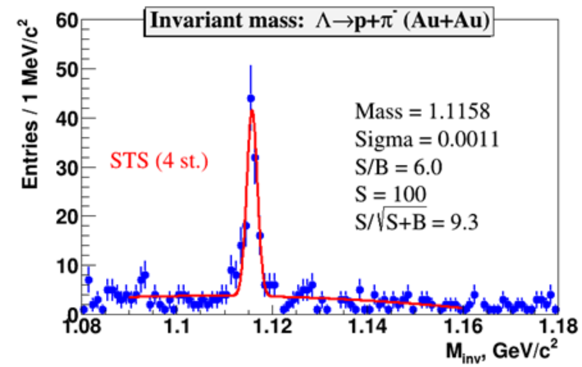






Hybrid STS + GEM tracker:

- ► 2 times increase in number of reconstructed tracks and Λ hyperons
- ► 2 times better momentum resolution

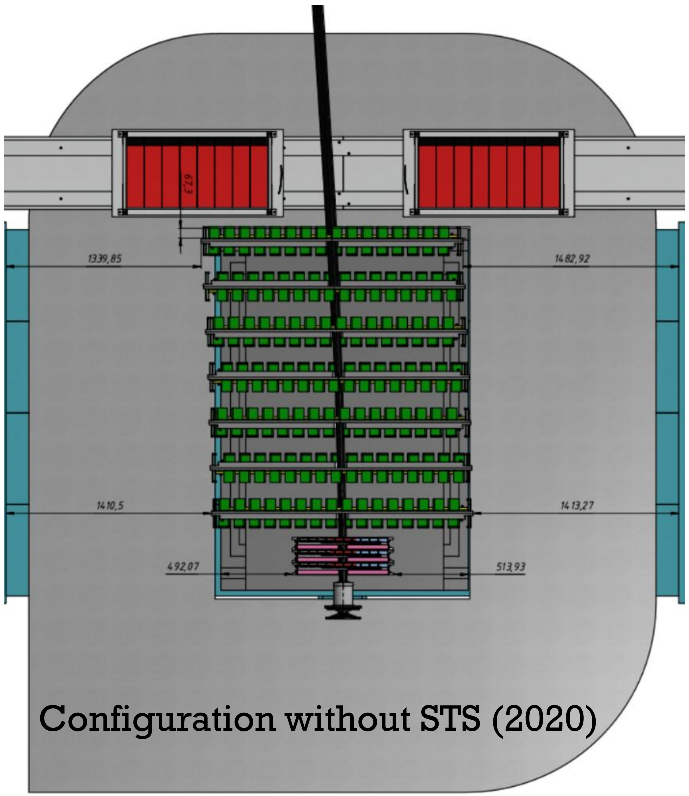


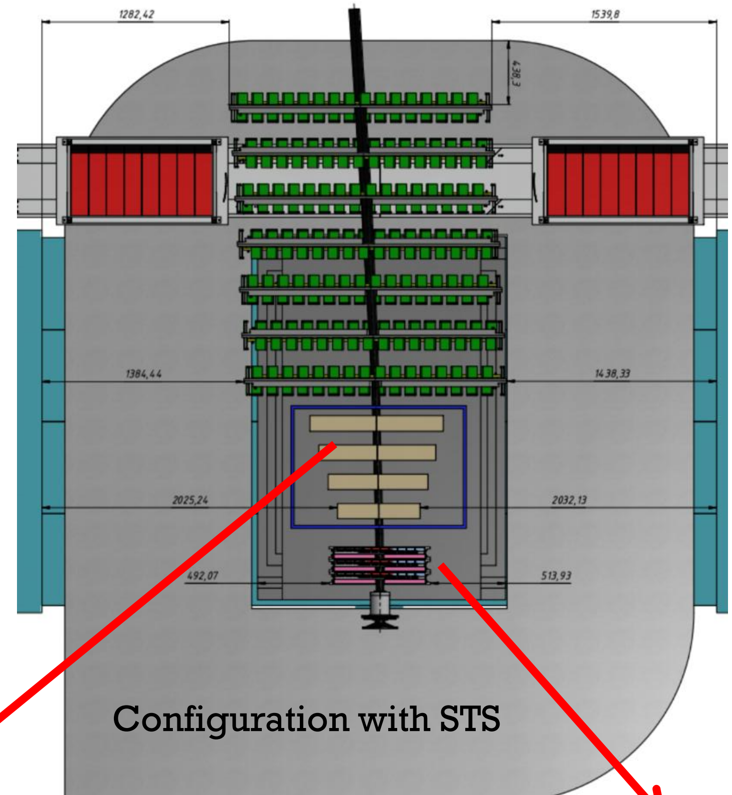
A. Zinchenko, P. Senger

Forward Si+ STS +Gem configuration

Four configurations of the tracking detectors are foreseen:

- Forward Si + 7 GEMs: beam intensity few 10^5 Hz , 2020 - 2021
- Forward Si + “pilot” STS station + 7 GEMs: beam intensity few 10^5 Hz , 2021
- Forward Si + 4 STS stations + 7 GEMs: beam intensity few 10^5 Hz, 2022
- 4 STS stations + 7 GEMs (fast FEE): high beam intensity few 10^6 Hz, 2022-



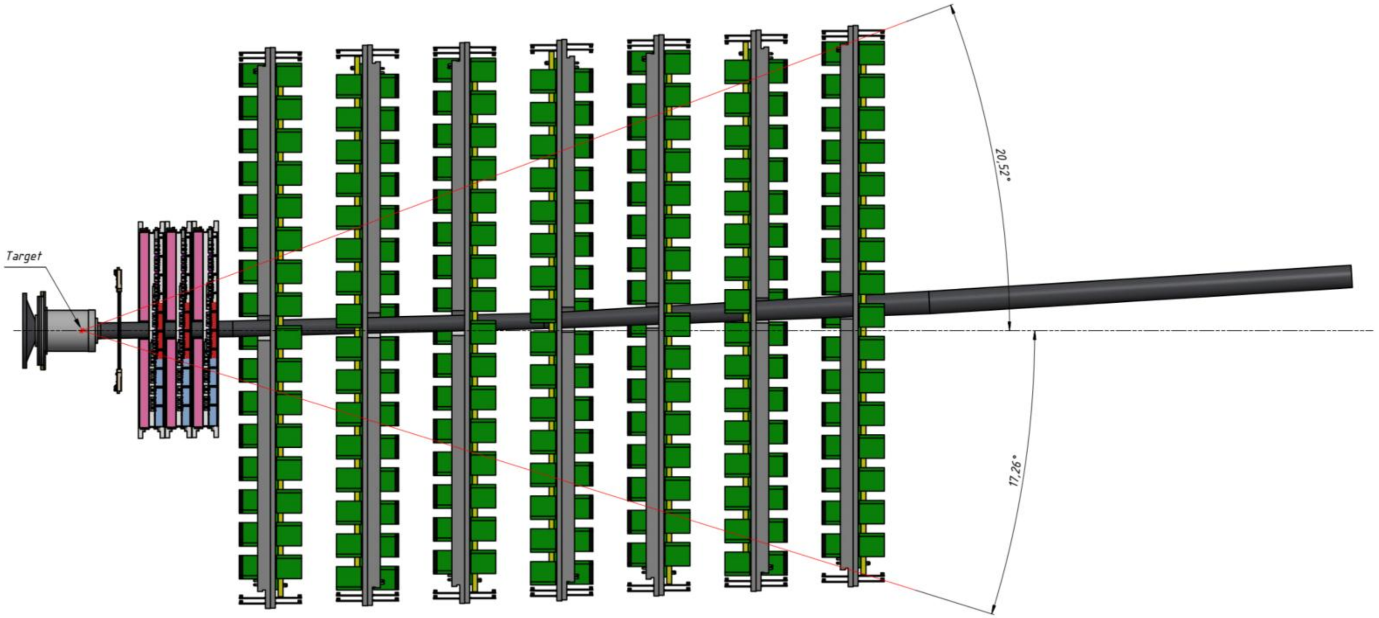


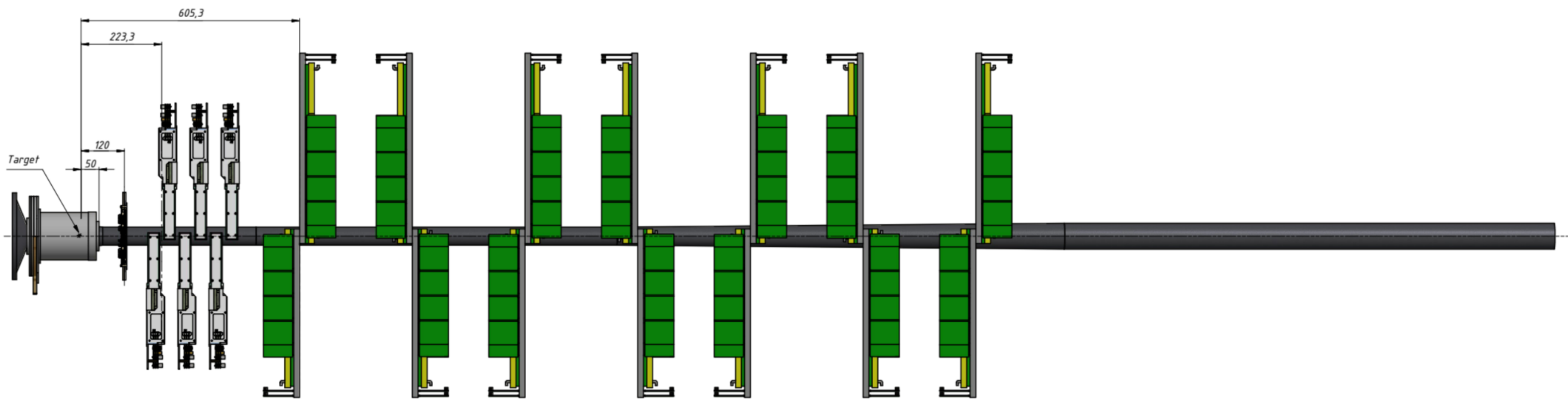
2021 year – “pilot” configuration
2022 year – full configuration

Forward Si will be removed after integration of STS full configuration into BM@N setup (2022 year, high beam intensity - few 10^6 Hz)

2020-21:Forward Si + 7 GEMs

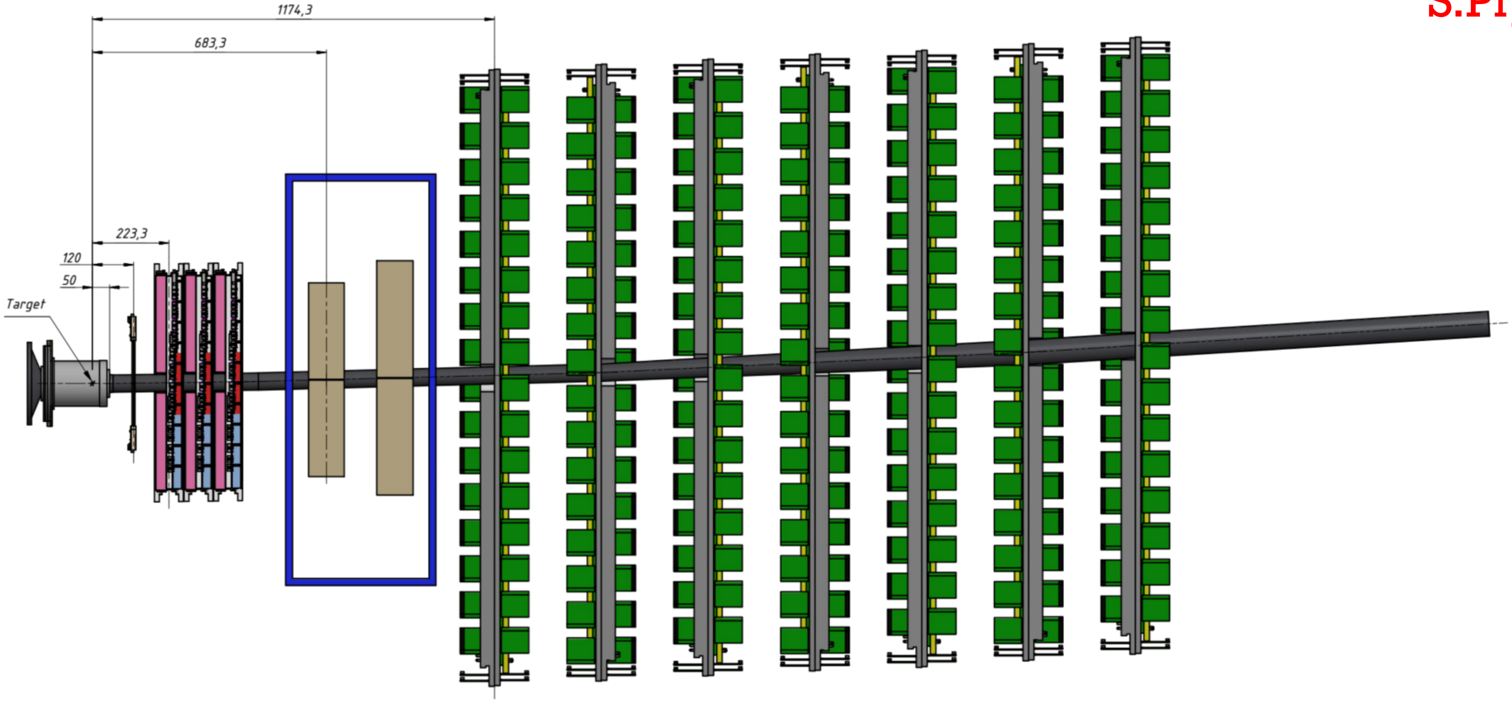
S.Piyadin

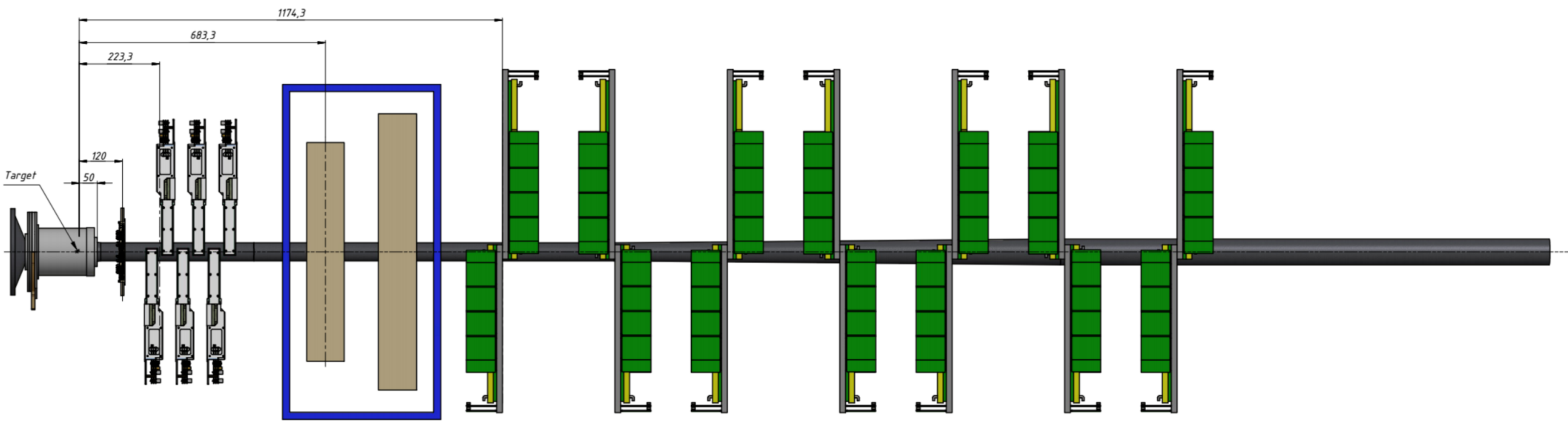




2021: Forward Si + “Pilot STS” + 7 GEMs

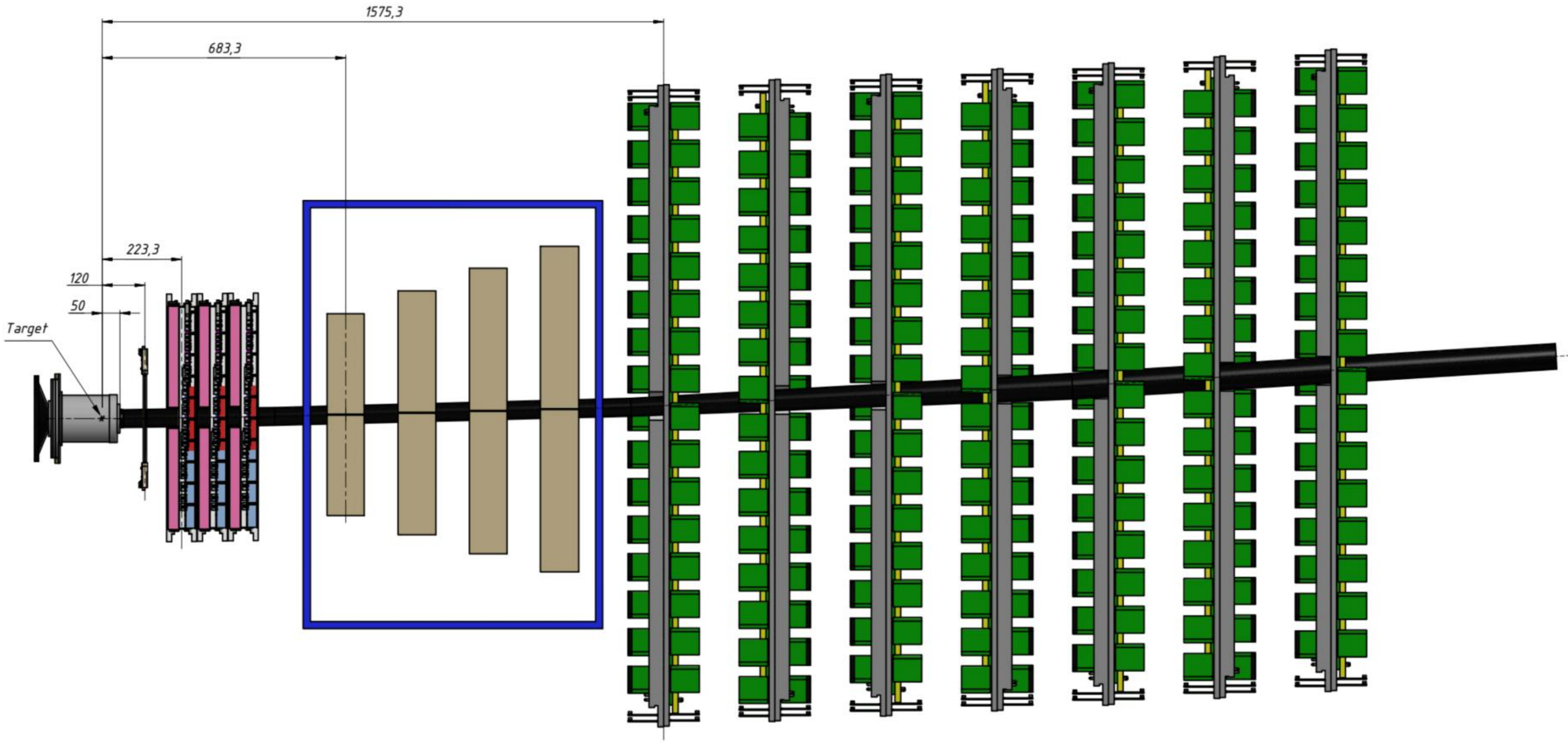
S.Piyadin





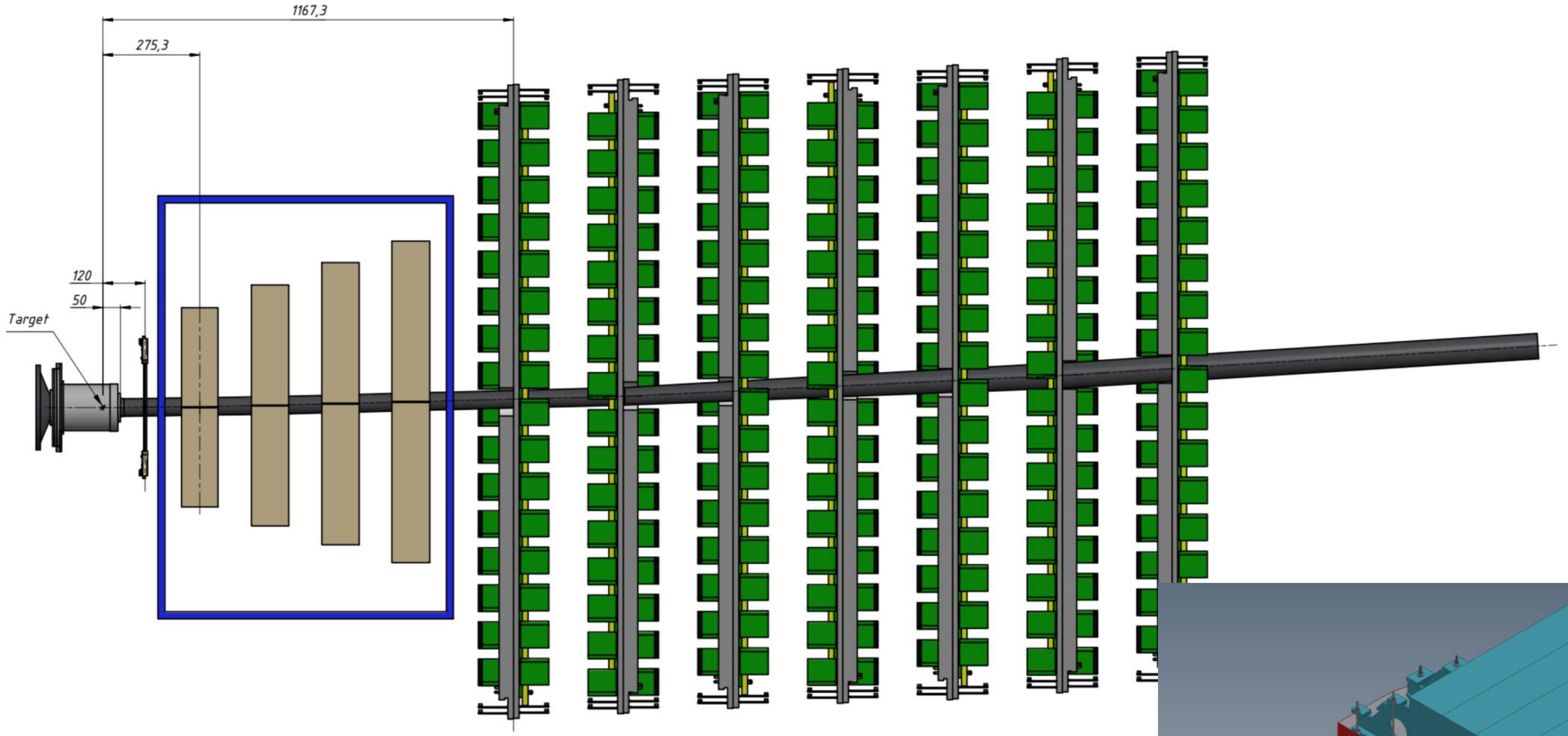
2022: Forward Si + STS + 7 GEMs

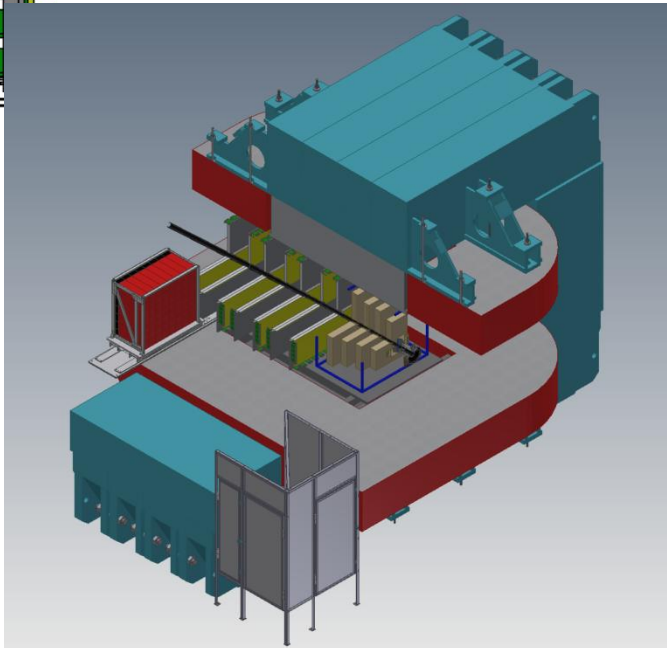
S.Piyadin



2022- : STS + 7 GEMs

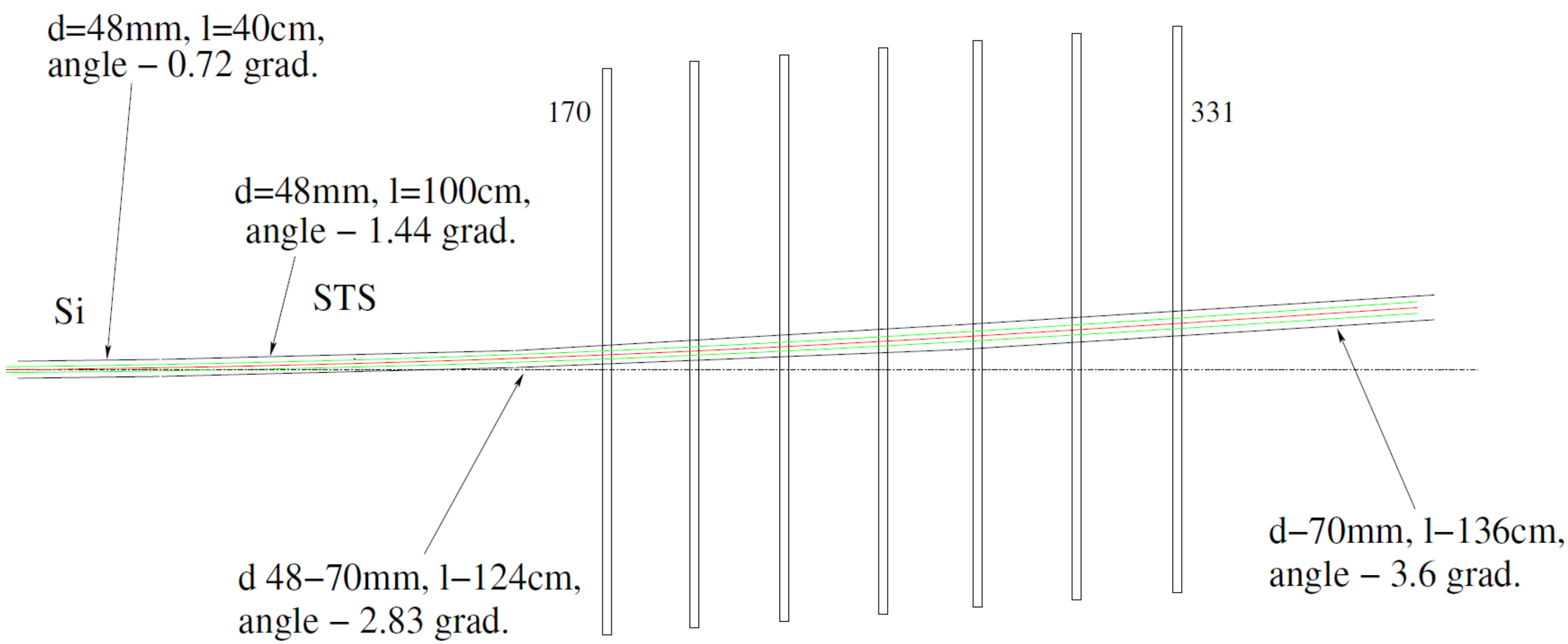
S.Piyadin





Beam pipe inside the SP-41 magnet

S. Piyadin,
V. Spaskov

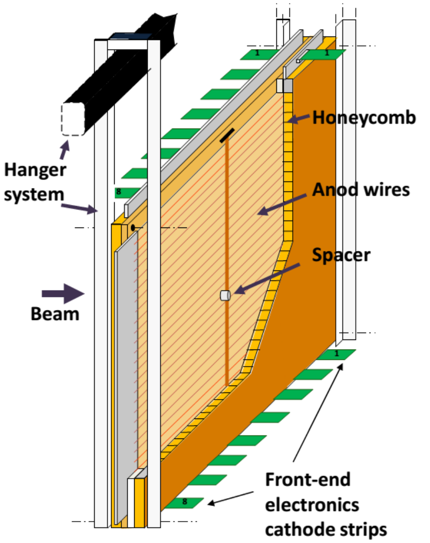


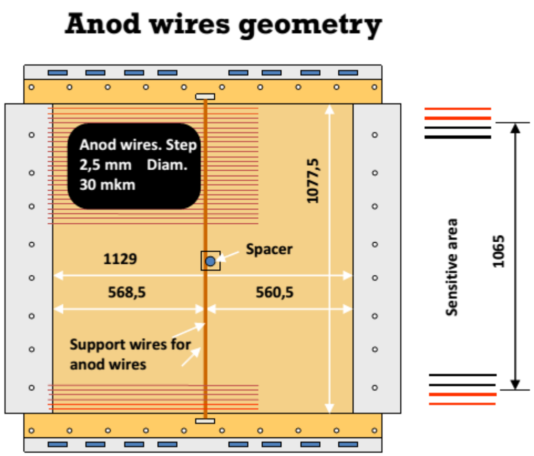
Two possible candidates to perform the carbon beam pipe production:
Prague Technical University (Czech Republic) or DD "Arkhipov" (Moscow, Russia)

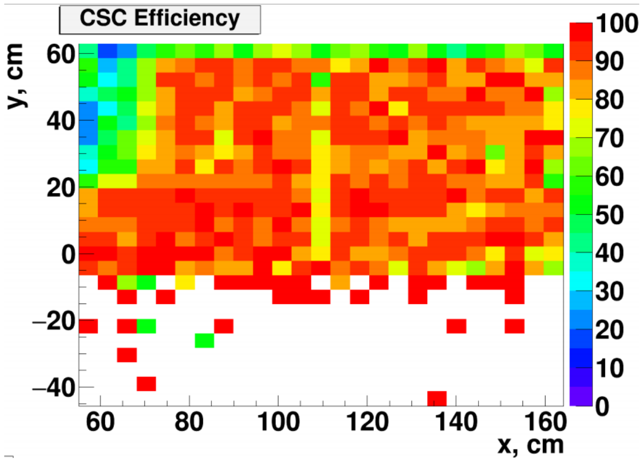
1065x1065 mm^2 CSC chamber

CSC group

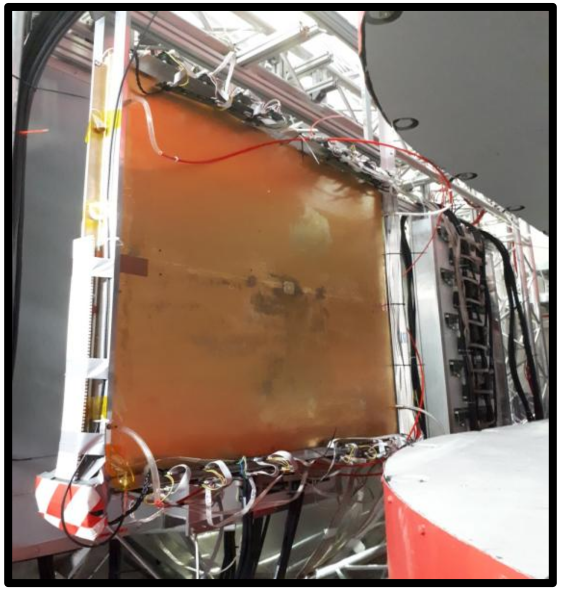
C, Ar and Kr runs in March 2018: CSC chamber is installed in front of ToF-400 to check its performance as outer tracker for heavy ions







CSC efficiency in Ar run
Track extrapolated from GEM
Residual (CSC_hit – GEM) < 2cm



Two CSC 1065x1065 mm^2 are produced. One was tested at Nuclotron beam.

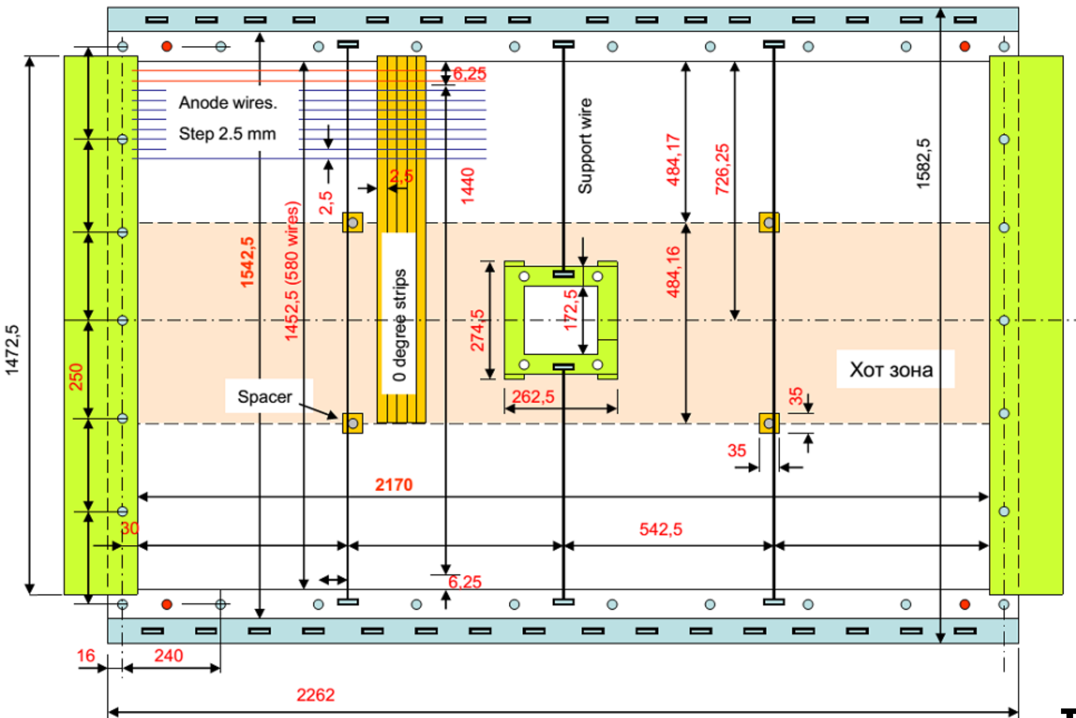
Plans for 2019:

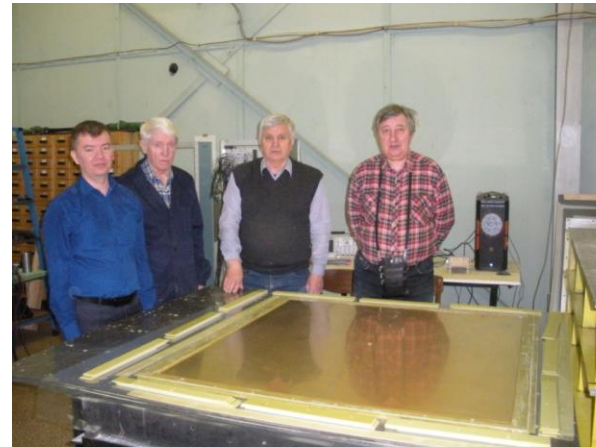
- assembly of the two1065x1065 mm^2 chambers

- assembled chambers are to be tested with r/a source and at cosmic stand

2190x1453 mm^2 CSC chamber

CSC group





Two cathode planes with strips inclined at 0° and 15°

Each cathode plane consists of 8 printed circuit boards.

Each pcb is divided on hot and cold zones.

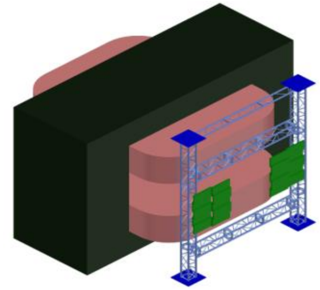
Two 2190x1453 mm^2 CSC chambers are to be installed before and after ToF-700

Design and assembly – JINR LHEP

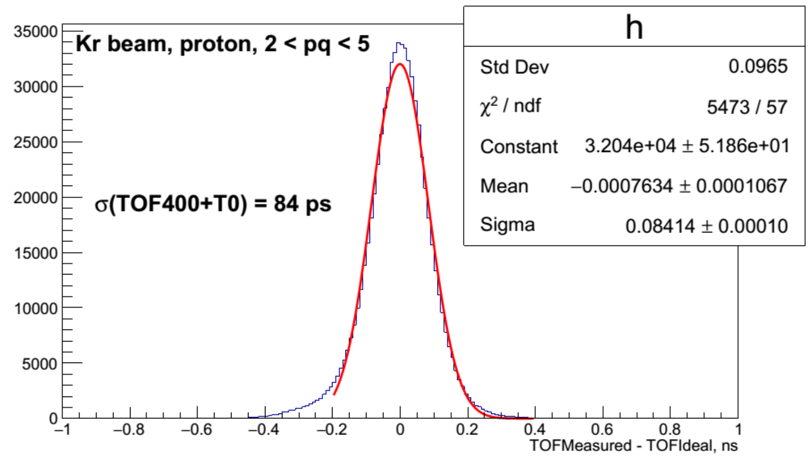
Production plans:

- 08.2019 - design of the cathode planes for 2190x1453 mm^2 CSC chambers
- 10.2019 – production of the cathode planes for 2190x1453 mm^2 CSC chambers
- 02.2020 – Assembly of the first 2190x1453 mm^2 CSC
- 05.2020 - Assembly of the second 2190x1453 mm^2 CSC
- 12.2020 – All chambers are integrated into the BM@N experimental setup

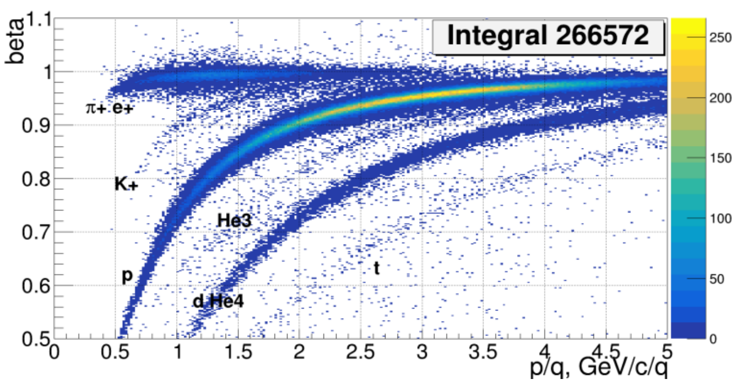
Status ToF-400

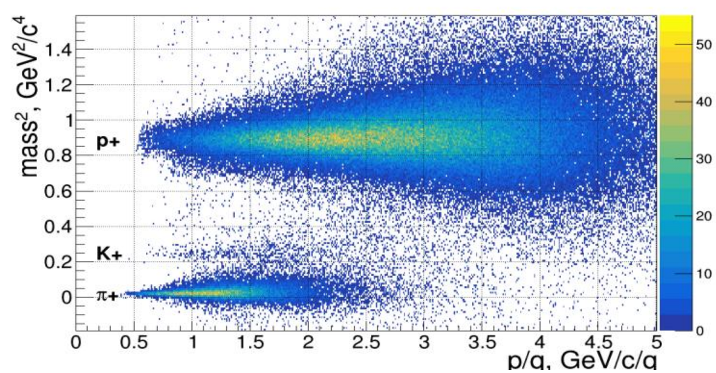


ToF-400
+ V.Plotnikov



Preliminary result of identification, GEM+CSC track extrapolated to ToF-400

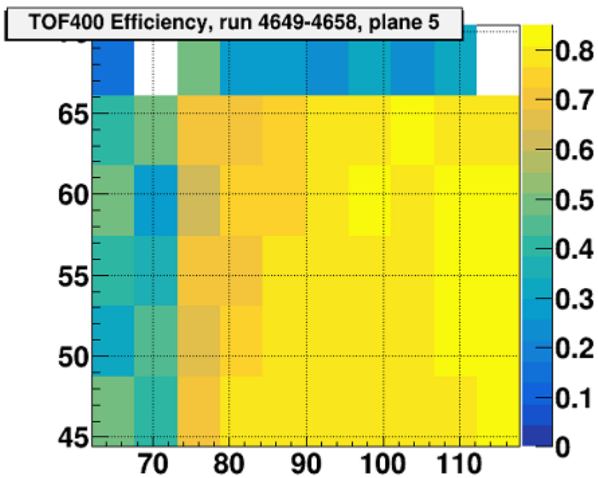


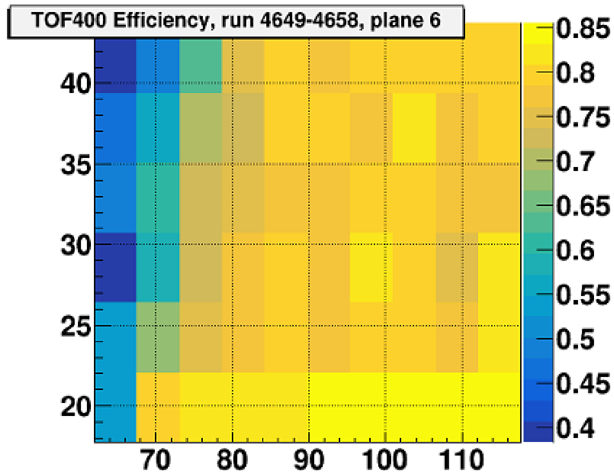


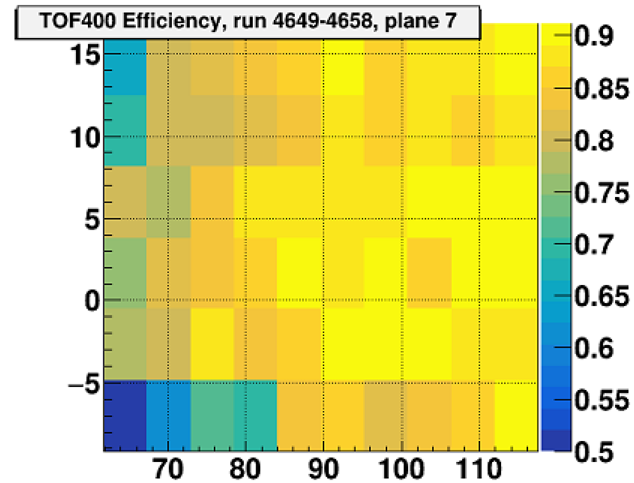
Proton Mass^2 = 0,894 +- 0,081 GeV^2/c^4, Pion Mass^2 = 0,021 +- 0,016 GeV^2/c^4

Status ToF-400

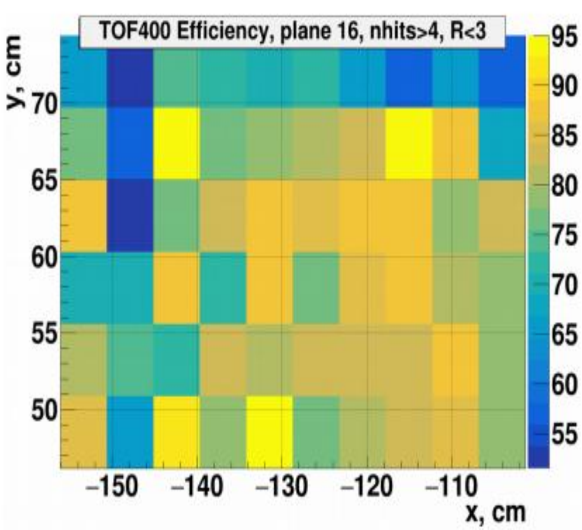
Examples of the efficiency distributions for the ToF – 400 planes located downstream CSC
GEM+CSC tracks extrapolated/ Residual < 3cm/Average efficiency~90%

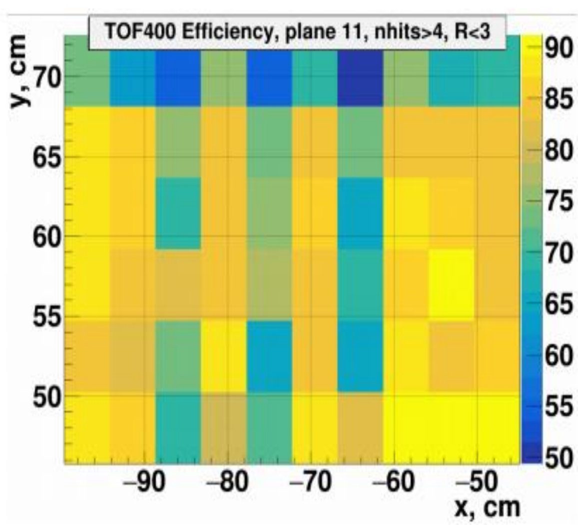


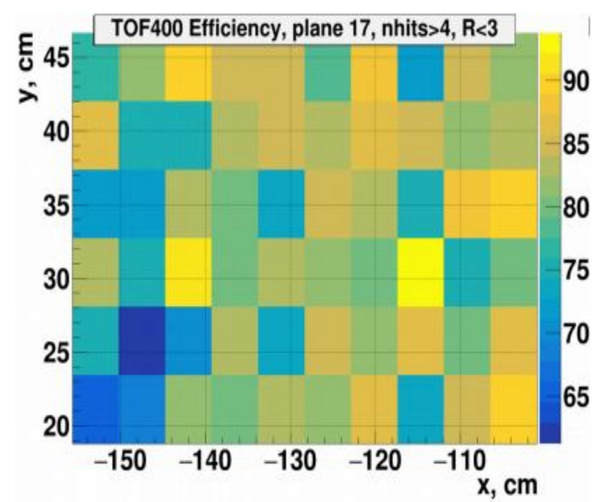




Examples of the efficiency distributions for the ToF – 400 planes (right arm, CSC is not installed)
GEM tracks extrapolated/ Residual < 3cm/Average efficiency~80%

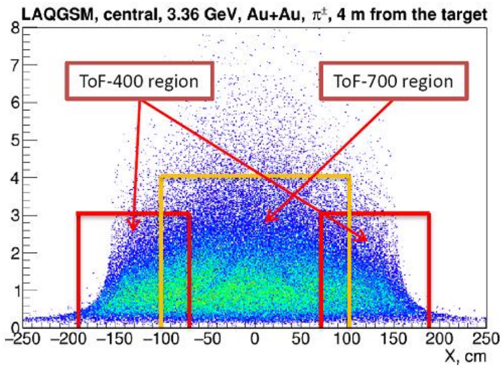




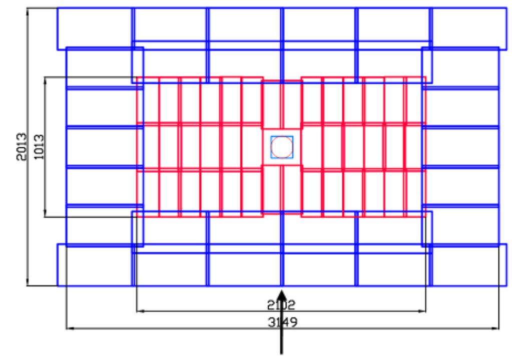


Status ToF-700

Yu.Petukhov, L.Kovachev

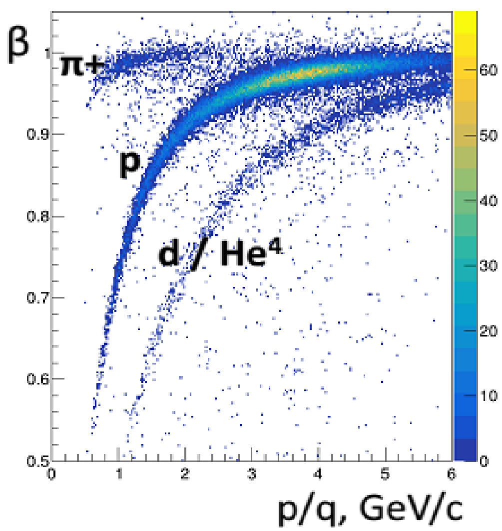


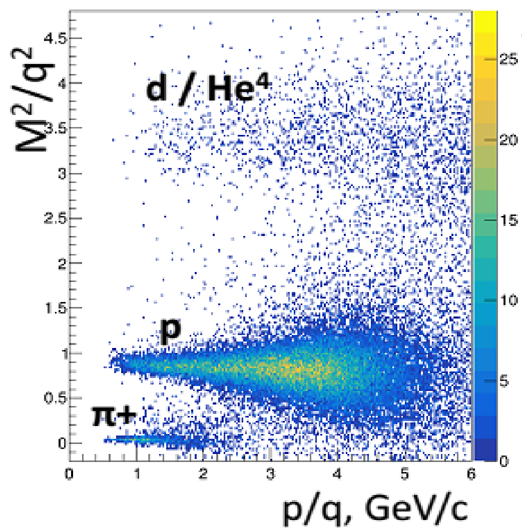
ToF-700 wall



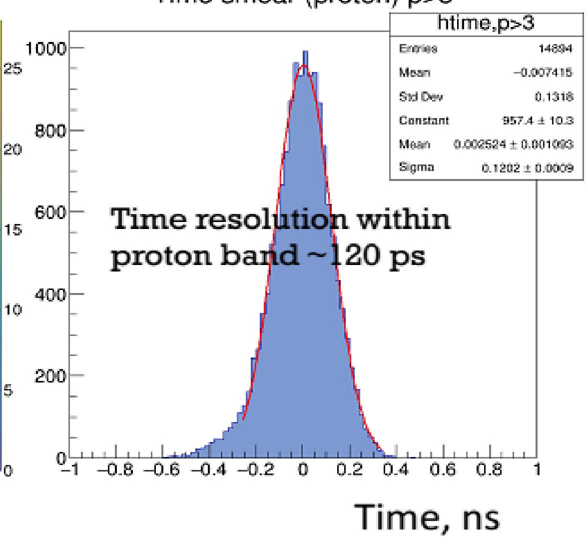
BM@N beam axis

Ar beam , 3.2 AGeV , Ar + Al,Cu → X





Time smear (proton) p>3

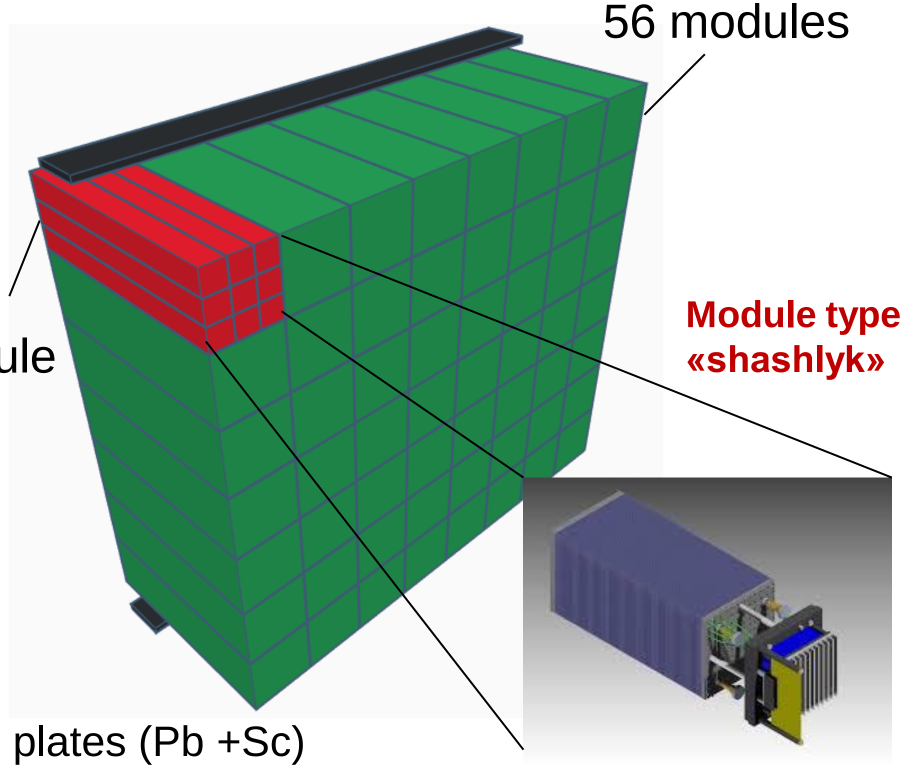


Efficiency estimated for pair of chambers located one for another is ~96%

ToF time calibration procedure was developed. Final tests of the algorithm are being performed.

ECal Design

ECAL group



220 plates (Pb +Sc)

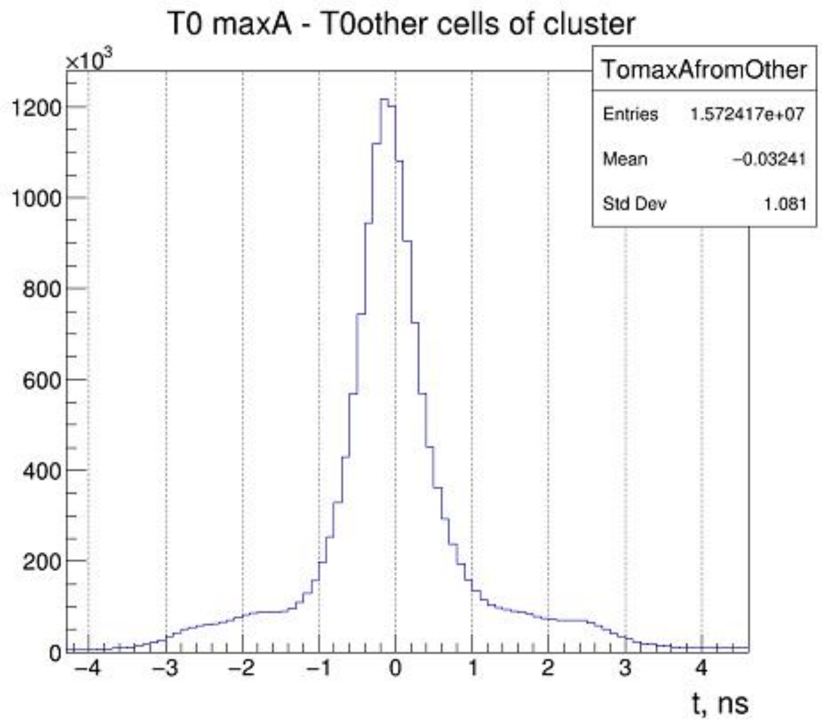
504 cells with MPPC (SiPM) (multipixel photon counter)

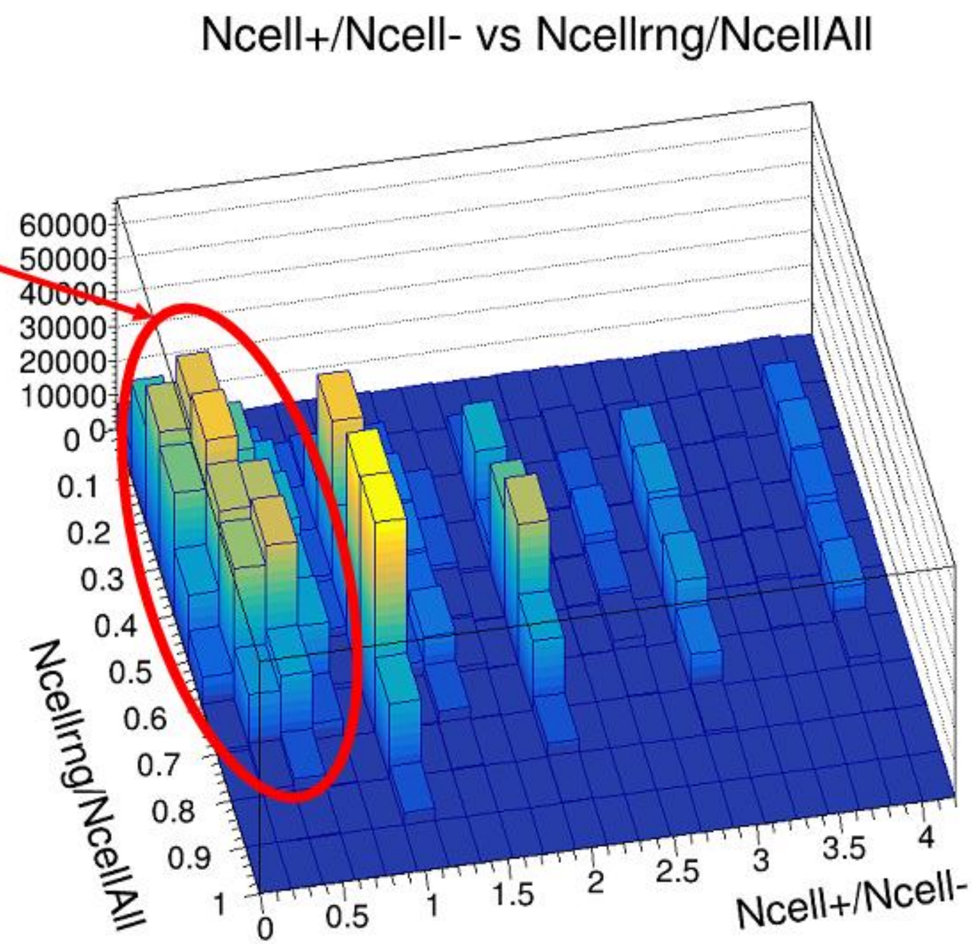
Location of Ecal in the magnet SP-41

$$\frac{(2.98\pm0.05)\%}{\sqrt{E}} \oplus (2.94\pm0.04)\%$$

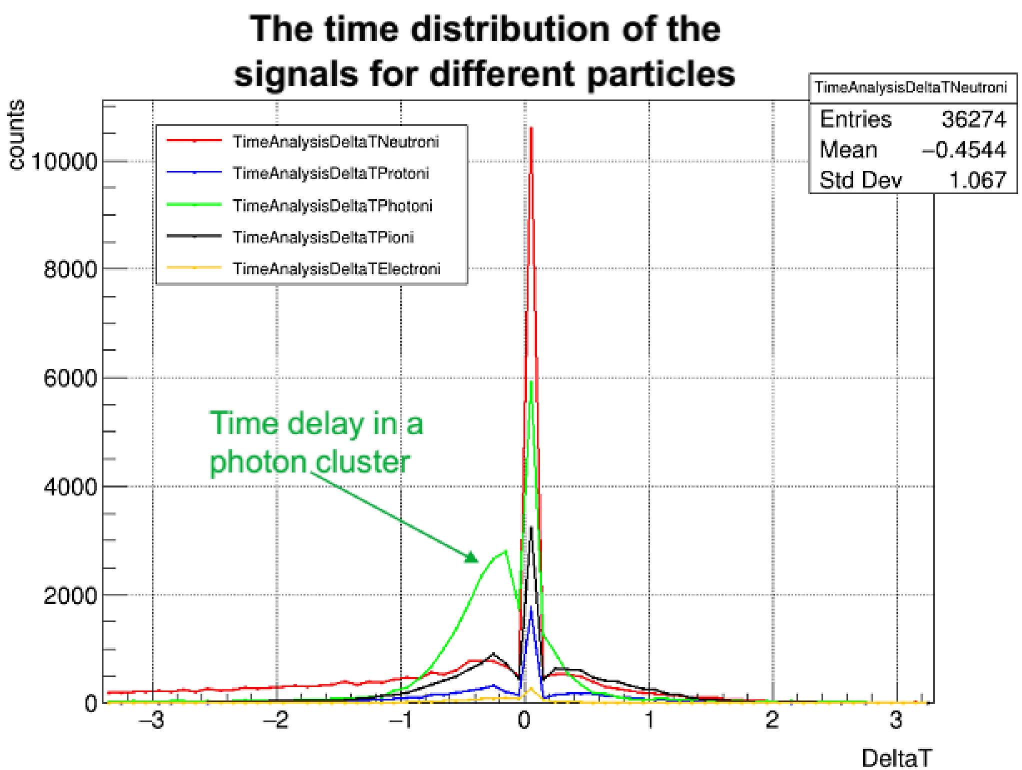
The selection of electromagnetic shower using time analysis of signals

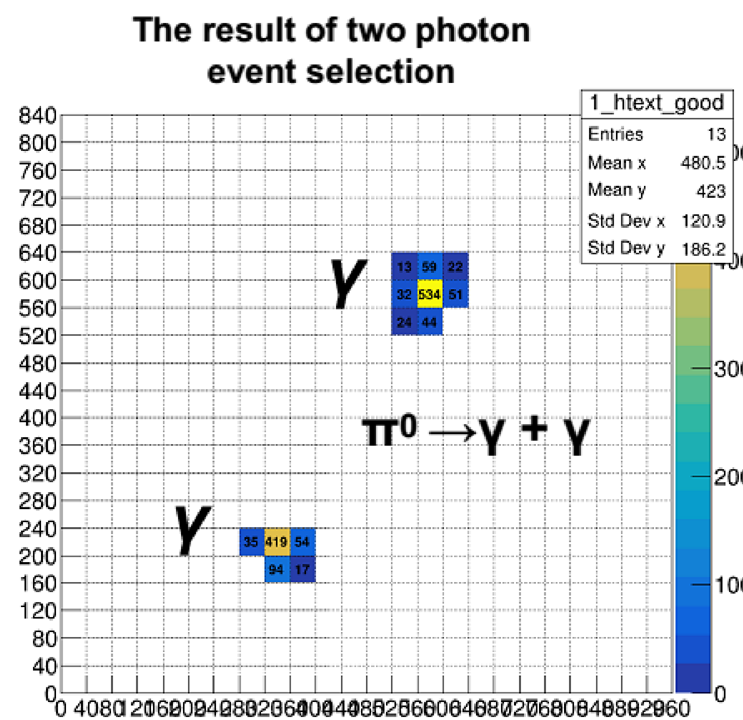
$$\frac{\mathrm{Ncells}(>0.2)}{\mathrm{Ncells}(<-0.1)} < 1$$





The result of the time analysis two photons event selection





Condition for photons separation

$$\frac{\mathrm{Ncells}(> 0.2)}{\mathrm{Ncells}(< -0.1)} < 1$$

The result from 55 nuclotron run

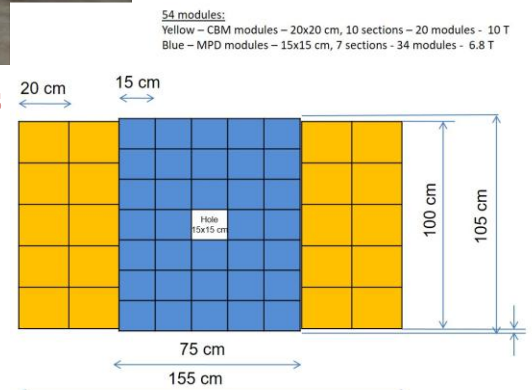
ZDC Status

group of INR RAS Troitsk

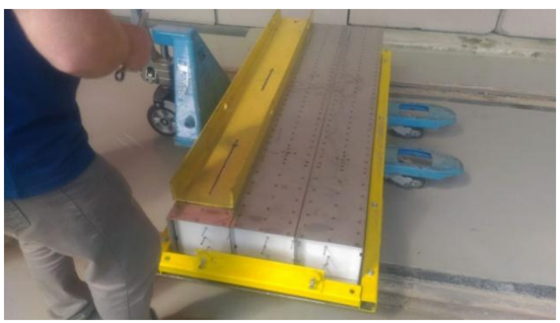
35 FHCAL MPD modules
(16_BM@N+19_MPD)

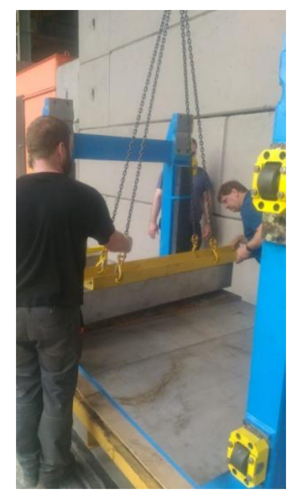
To be replaced

20 PSD CBM modules



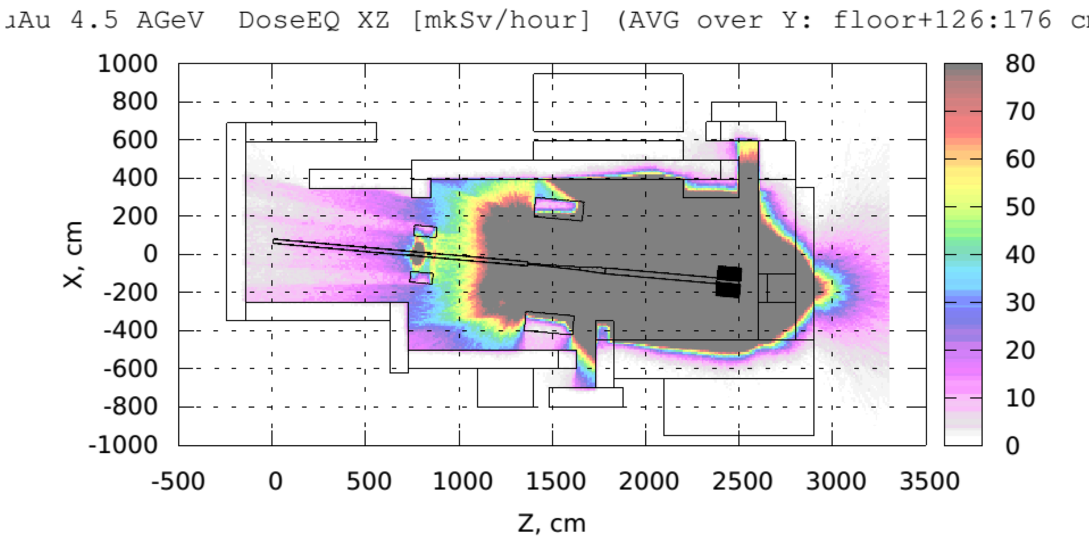
05.2019 - Transportation of CBM modules (20 pcs), FHCAL BM@N modules (16 pcs) and FHCal MPD modules (19 pcs) from INR at JINR was performed.





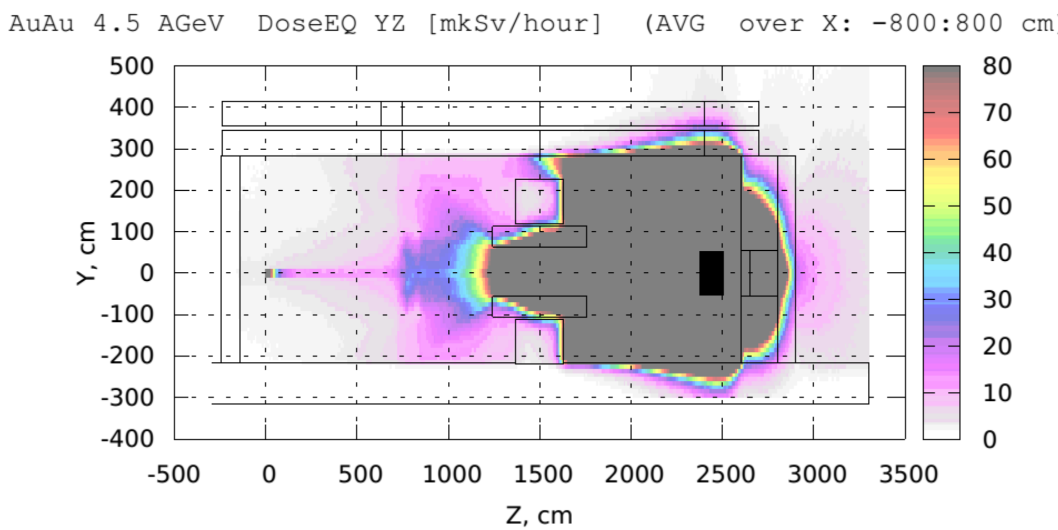
At the moment assembly of FHCAL at JINR is performed

Biological Protection Calculation for Au+Au interactions



XZ projection

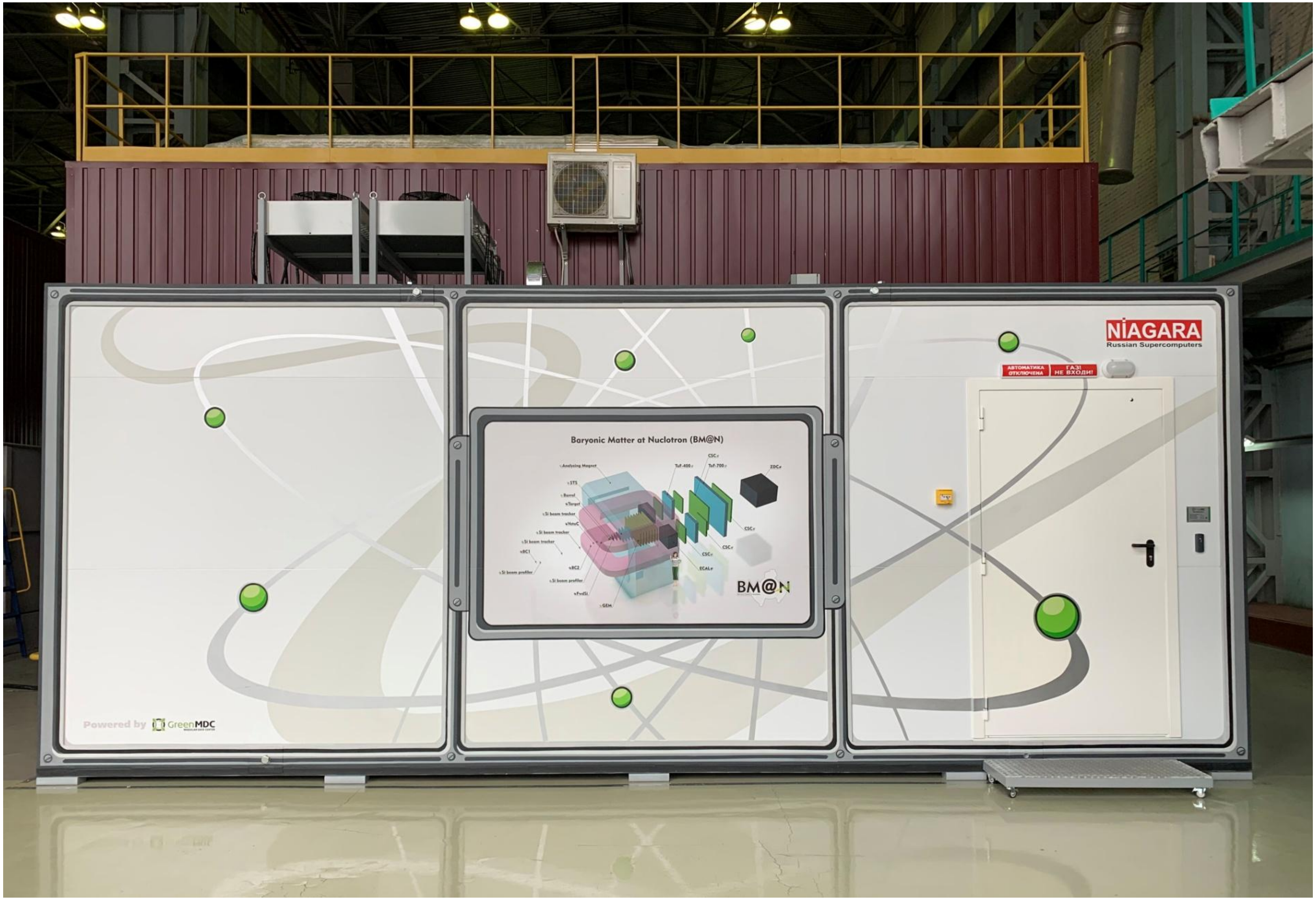
FLUKA calculations of E.Litvinenko



YZ projection

Additional protection to be built before heavy ion beams are delivered to the BM@N experimental setup

MDC(Mobile data storage and DAQ center) was installed at 205 bld.

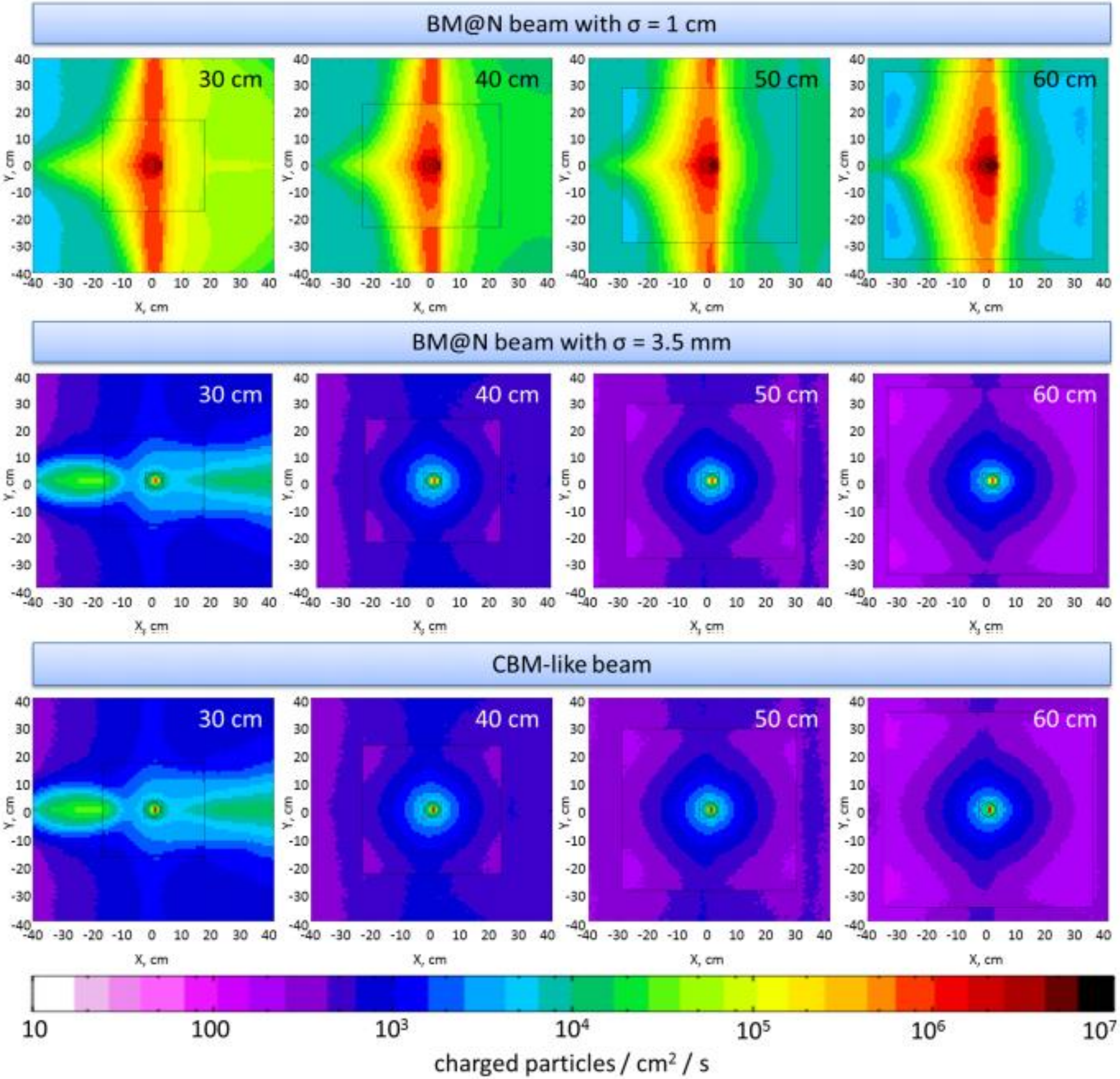


Summary:

Detector Subsystem	Status	Upgrade Status
Beam pipe before the target, target station		end of 2019
Beam pipe downstream the target, in SP-41 magnet		06.2020
Forward Si detectors	3 small planes	3 full-size planes (02.2020)
STS BM@N		42 modules (2021) 292 modules (2022)
GEM	7 top half-planes + 3 bottom half-plane	7 full planes (2019)
CSC	2 chamber 1065x1065 mm^2	4 chambers 1065x1065 mm^2(2019) 2 chambers 2190x1453 mm^2(2020-21)
ECAL	one arm	two arms (2019)
ToF-400	full configuration	
ToF-700	full configuration	
ZDC	ZDC Pb+Sci sandwitch	ZDC (MPD/CBM type) (2019)

Backup

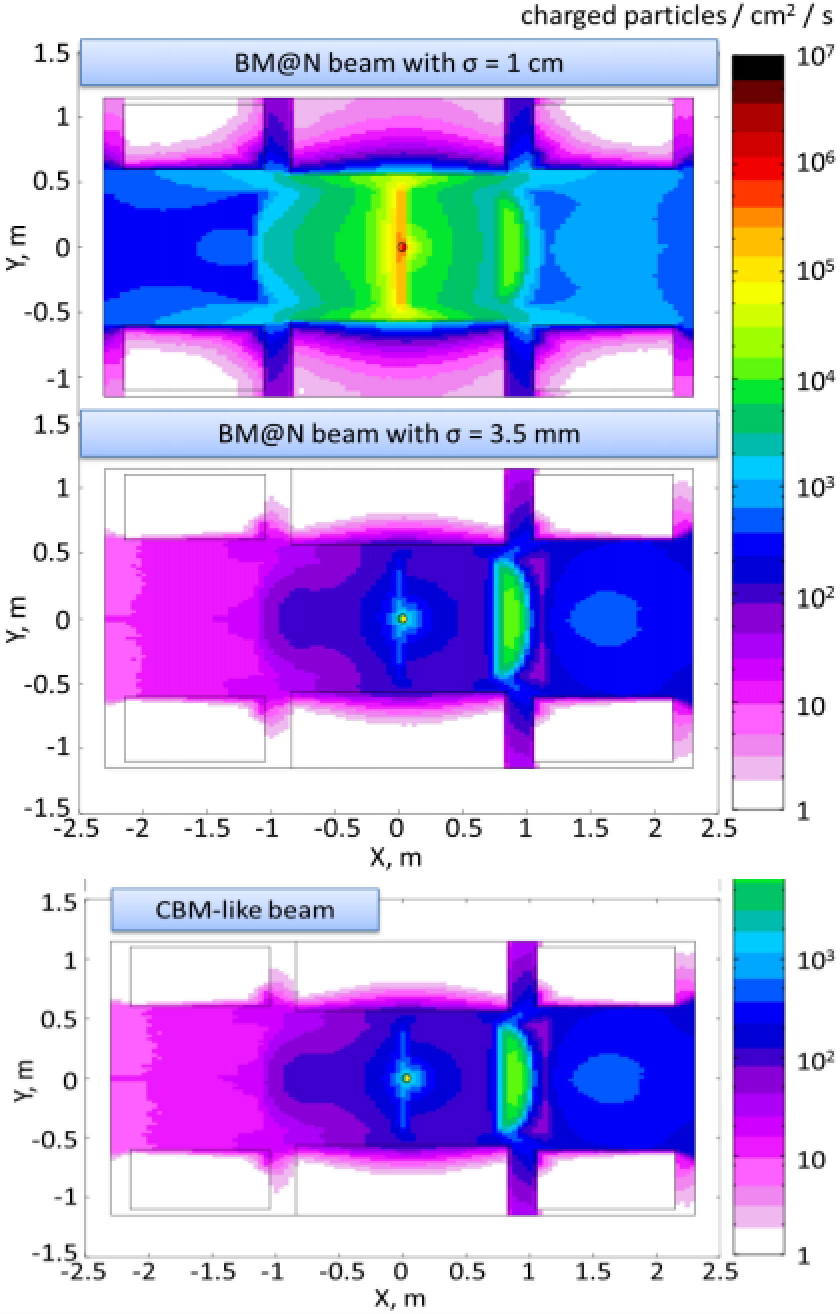
Charged particle densities in the four STS stations



Anna Senger (GSI)

Charged particles in GEM stations at z = 2 m

Anna Senger (GSI)



<u>BM@N beam with σ = 1 cm ($2x10^6$ Au ions/s):</u>
Delta electron rate: 200 kHz/cm^2

Electron rate on one strip (inner zone):
200 kHz/cm^2·1.2 cm^2 = 240 kHz
Channels busy: 240 kHz·2 μs = **48 %**

Electron rate on one strip (outer zone):
200 kHz/cm^2·2.4 cm^2 = 480 kHz
Channels busy: 480 kHz·2 μs = **96 %**

<u>BM@N beam with σ = 0.35 cm ($2x10^6$ Au ions/s):</u>
Delta electron rate: 2 kHz/cm^2

Electron rate on one strip (inner zone):
2 kHz/cm^2·1.2 cm^2 = 2.4 kHz
Channels busy: 2.4 kHz·2 μs = **0.48 %**

Electron rate on one strip (inner zone):
2 kHz/cm^2·2.4 cm^2 = 4.8 kHz
Channels busy: 4.8 kHz·2 μs = **0.96 %**