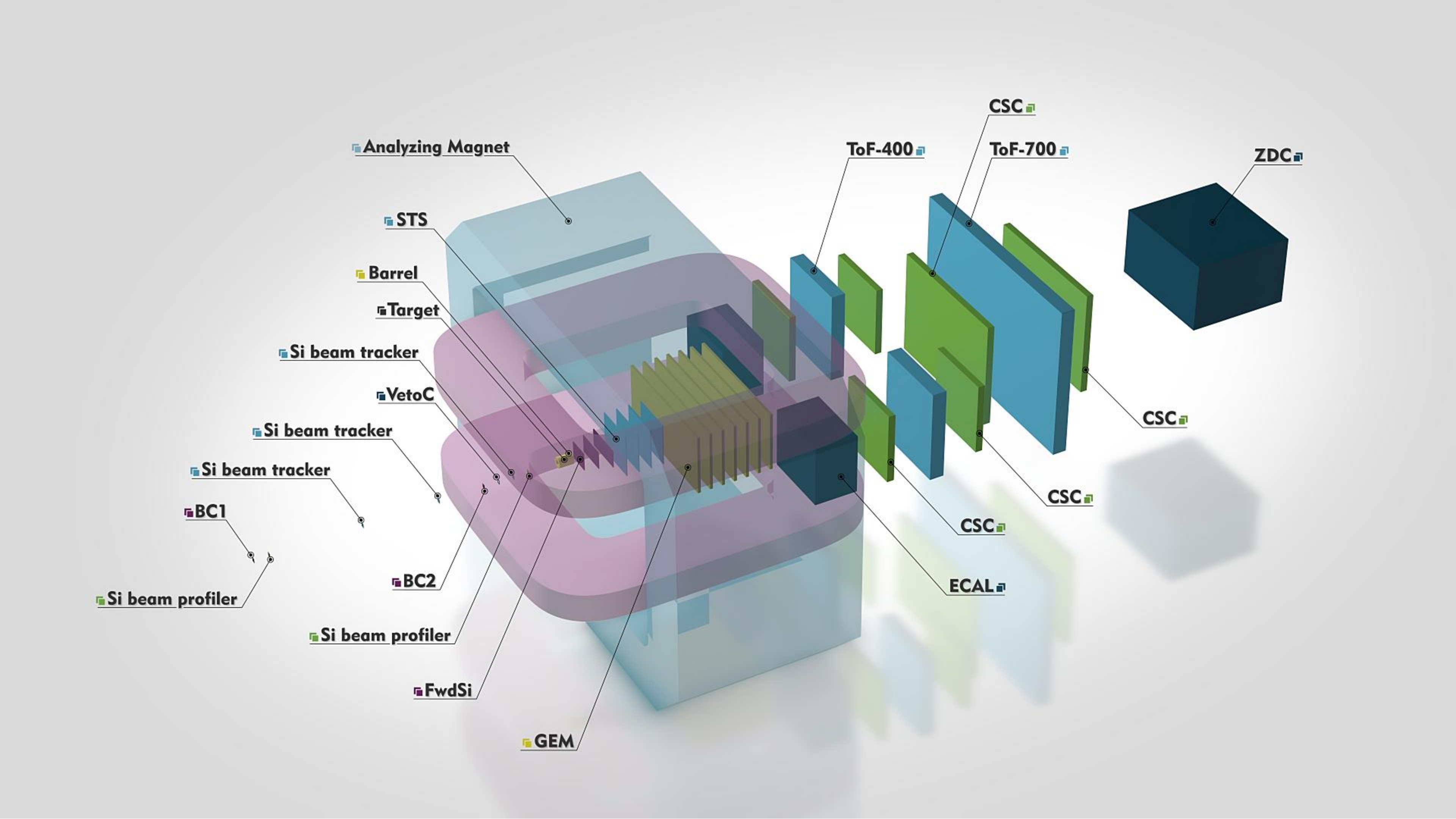
Status of the BM@N detector upgrade

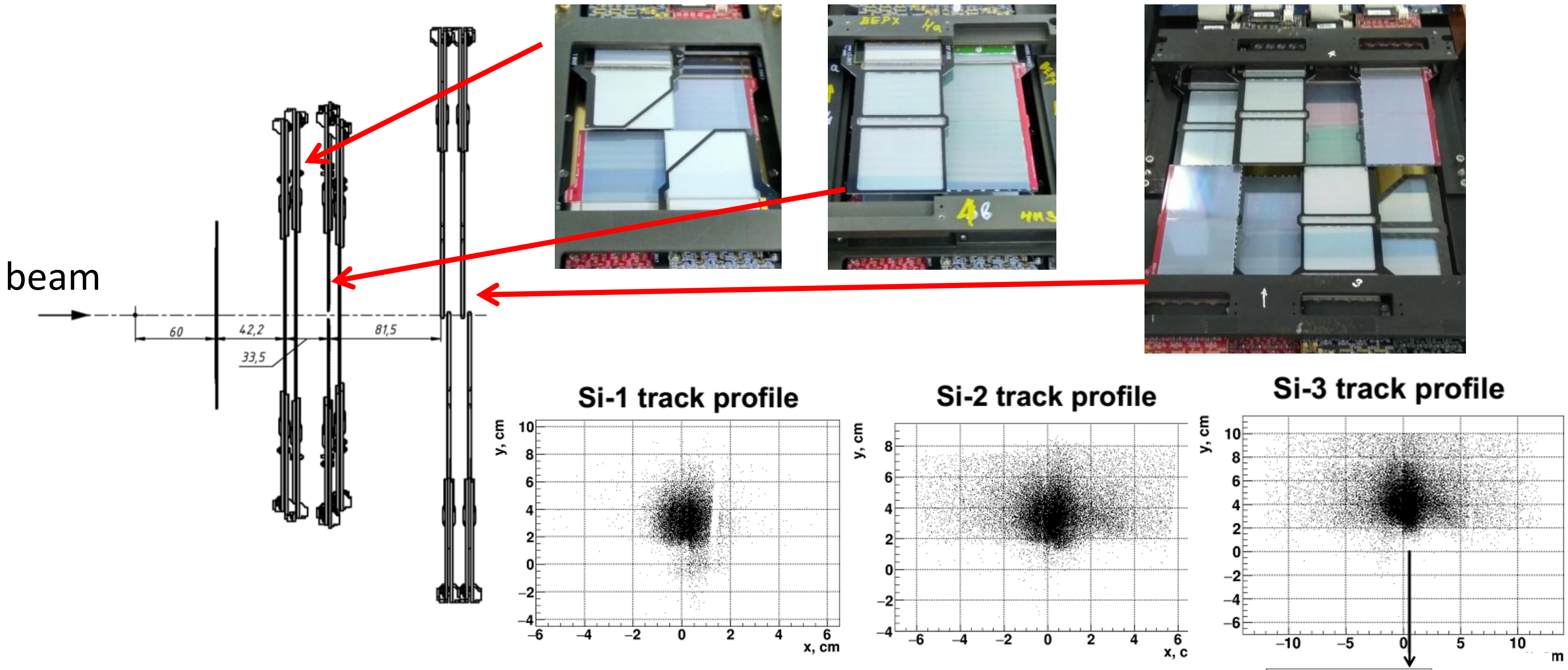
A.Maksymchuk

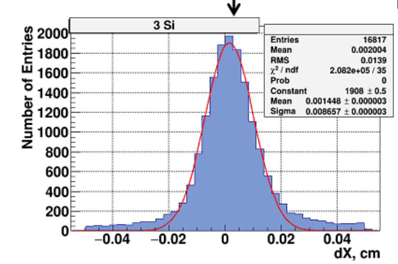
BM@N Experimental Setup



Forward Si tracking detectors performance at Ar and Kr beams (March 2018)

Si-Vertex plane-1 *Si-Vertex plane-2* *Si-Forward plane*



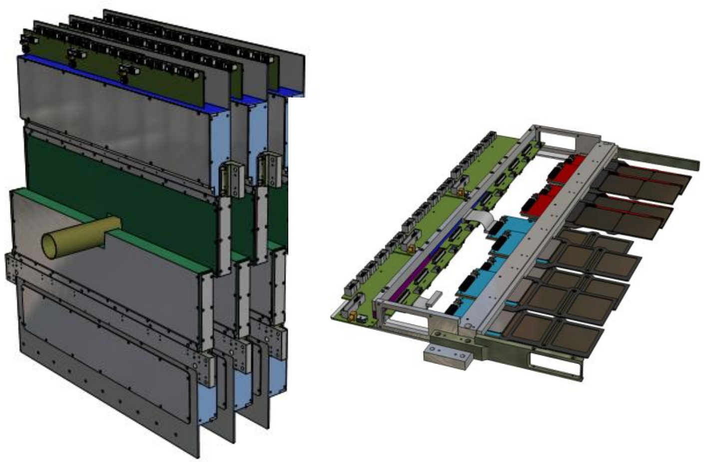


Si-3 detector residual vs GEM+Si track ~ 86 μm

- Si-Forward plane consists of two-coordinate Si sensors, X-X'(±2.5°) with strip pitch of 95/103 μm, sensitivity area 25 × 25 cm², 10240 strips
- Vertex plane-1 consists of 4 modules with sensitivity area 12,5×12,5cm², 5120 strips
- Vertex plane-2 consists of 2 modules with sensitivity area 12,5×12,5cm², 2560 strips

Upgrade of the forward Si tracking detectors

Three sizes of Si-planes



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***

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:
06.2019 - ASIC VATAGP7.1 delivery
02.2020 – integration of the Si forward tracking detectors into BM@N setup

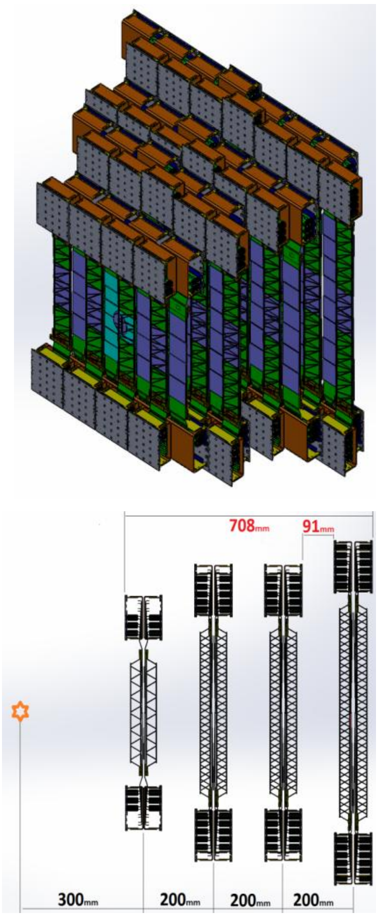
Tentative Design of the BM@N STS

Preliminary layout of BM@N STS was developed.

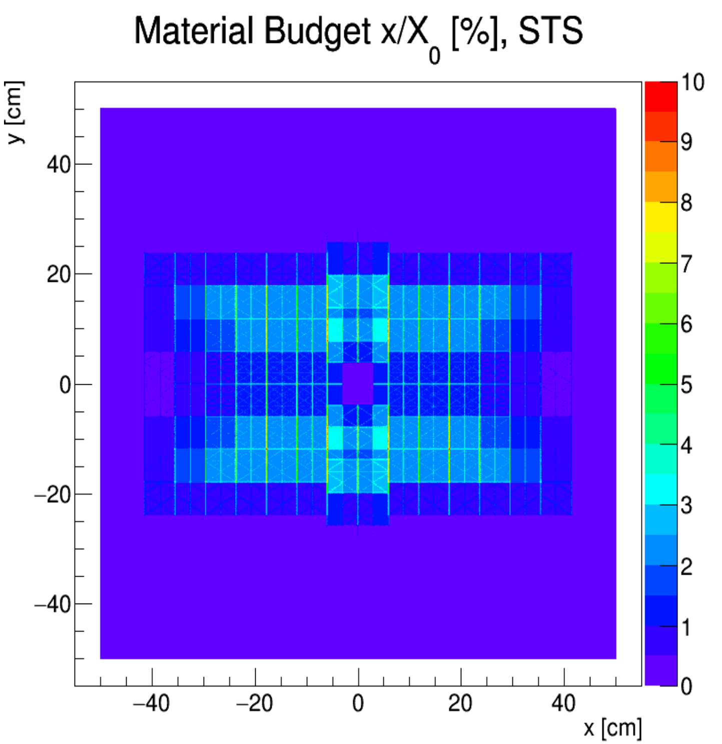
Geometry was tested in simulations in CbmRoot (E. Lavrik) and BmnRoot (S. Mertz)

Four stations are based on CBM-type modules with double-sided microstrip silicon sensors:

- Pitch 58μ
- Stereo angle 7.5°
- Thickness 300μ
- Sizes: 62x62, 62x42, 62x22 mm^2
- Produced by two vendors: CiS (Germany) & Hamamatsu (Japan)



Tentative design of BM@N STS stations



Total material budget (by E. Lavrik)

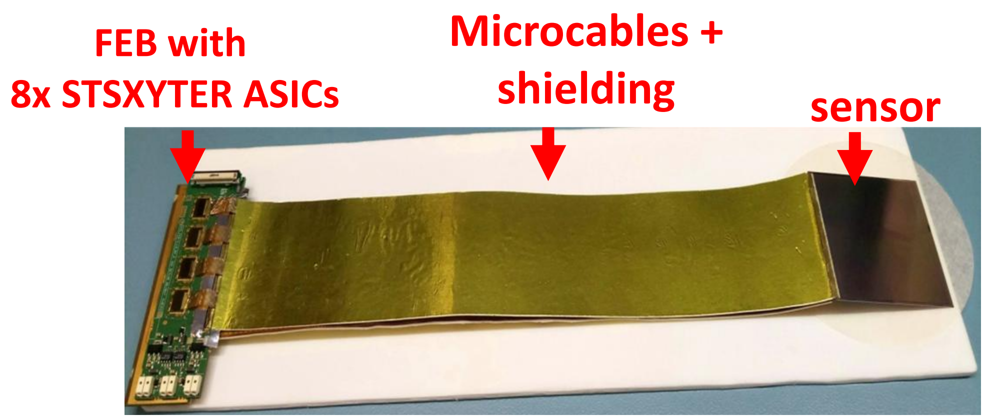
Number of modules: 292
Number of channels: ~600k
Power consumption: ~15 kW

Plans:
2020 – first 42 modules integration into BM@N;
2022 – BM@N STS full configuration (292 modules)

Assembling of BM@N STS modules at JINR

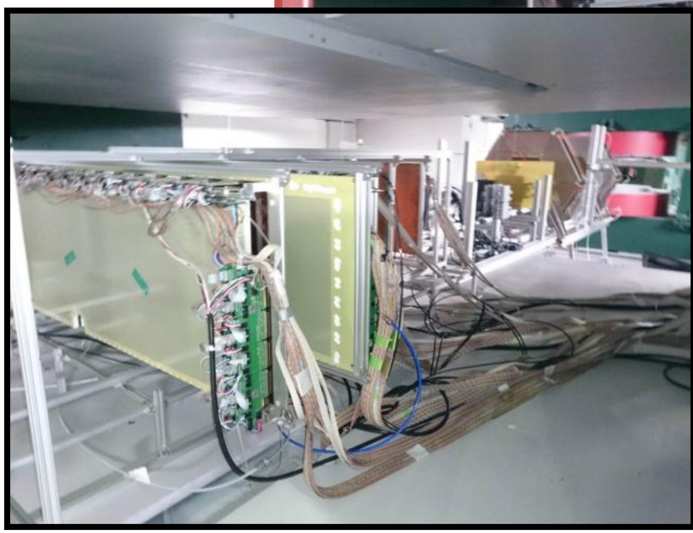
- Two clean rooms are already equipped for the module assembly
- Full set of jigs was developed, produced and tested on mockups
- QA procedure for all steps of assembling was developed
- Two technicians and two engineers are currently fully involved into assembling of BM@N modules
- First operable module was assembled and now is under tests

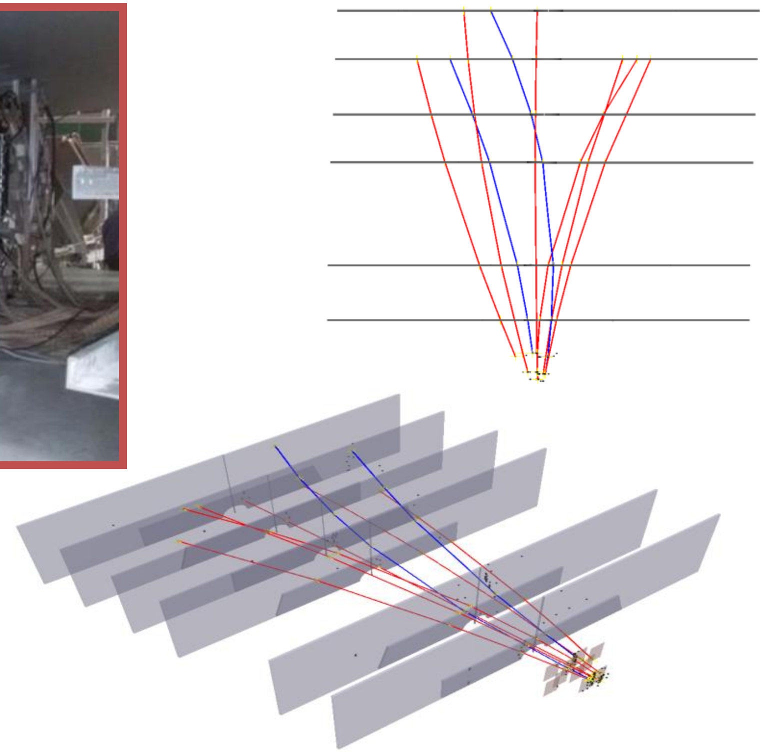
Assembling of the mockups of BM@N STS modules



First assembled module with 62x62 mm^2 sensor

GEM central tracking system performance at Ar and Kr beams (March 2018)

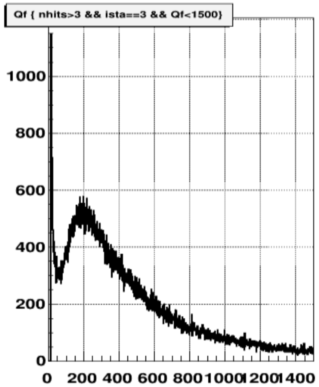




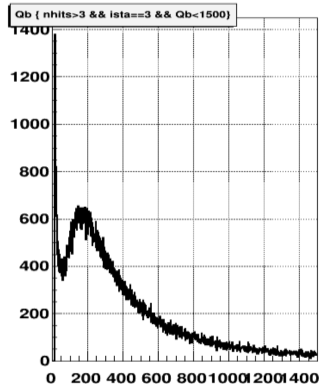
Example of the event reconstruction in the central tracker in Ar+Al interaction

Seven GEM 1632x450 mm^2 chambers produced at CERN workshop were integrated into BM@N experimental setup.
One was defected, to be repaired at CERN (Spring 2019).

GEM tests at Ar beam

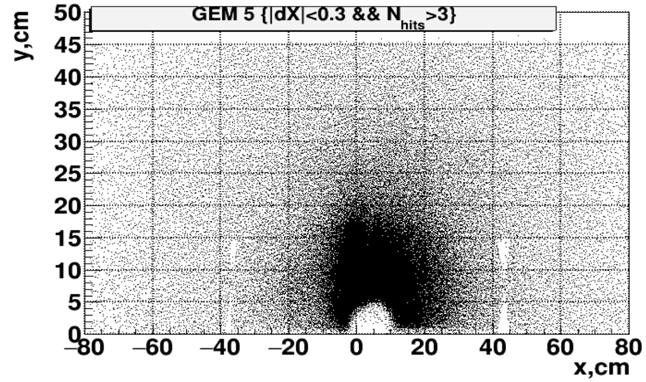


Amplitude, ADC counts



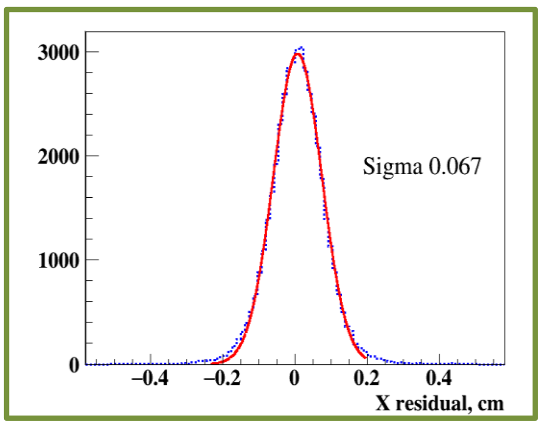
Amplitude, ADC counts

GEM X&Y amplitude distributions

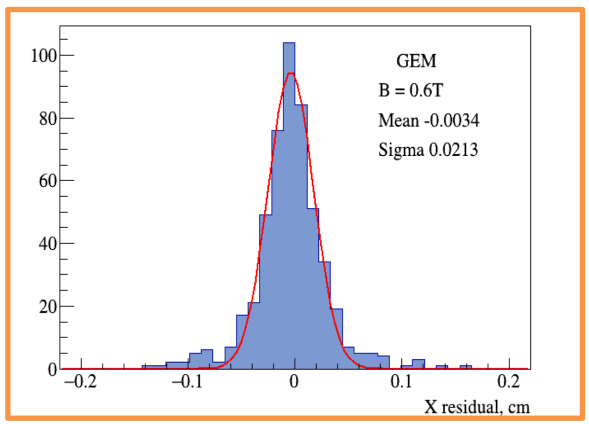


Fragments of Ar beam in one of the GEM chambers

Pile-up suppression in Ar, Kr runs: 3 μs before and 0.5 μs after trigger signal



Magnetic field 0.6 T,
Ar(90)/Isobutane(10),
d beam, Edrift = 0.8kV/cm

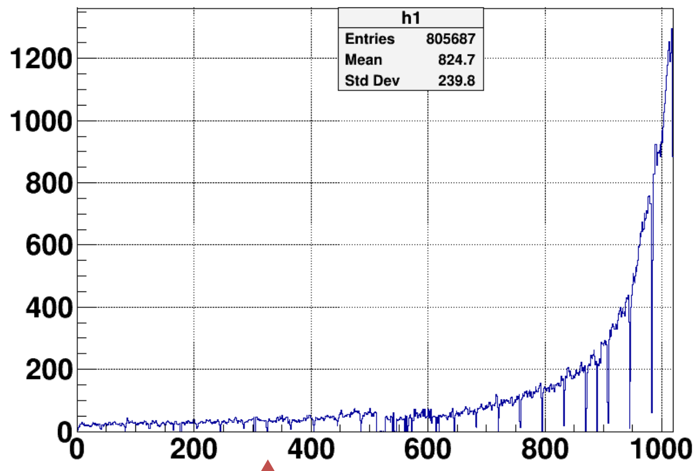


Magnetic field 0.6 T,
Ar(80)/Isobutane(20),
Ar beam, Edrift = 1.5kV/cm

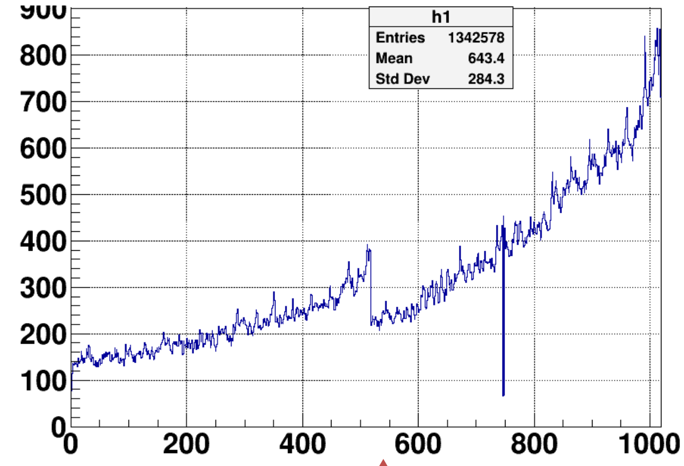
In Ar and Kr runs the value of electric field in drift gaps of GEM chambers was increased. The gas mixture was changed to Ar(80)/Isobutane(20). The Lorentz shift of electrons avalanche was decreased.

Gleb Pokatashkin

GEM occupancy

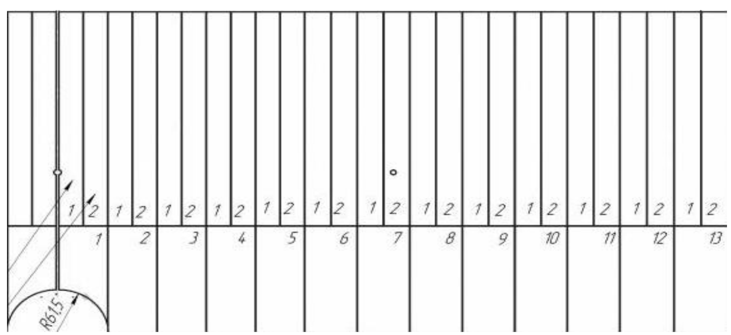


X occupancy

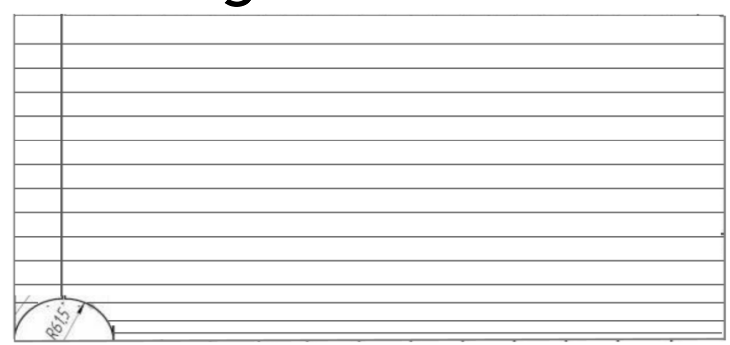


X occupancy

GEM foil sector design



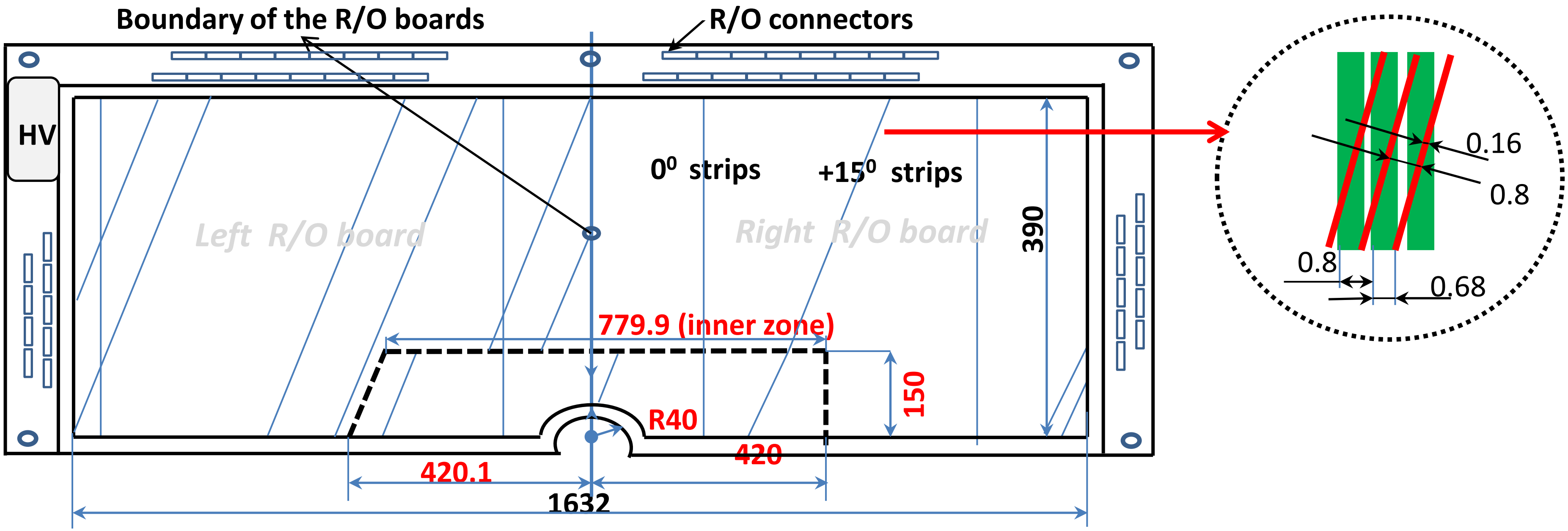
Vertical sectors



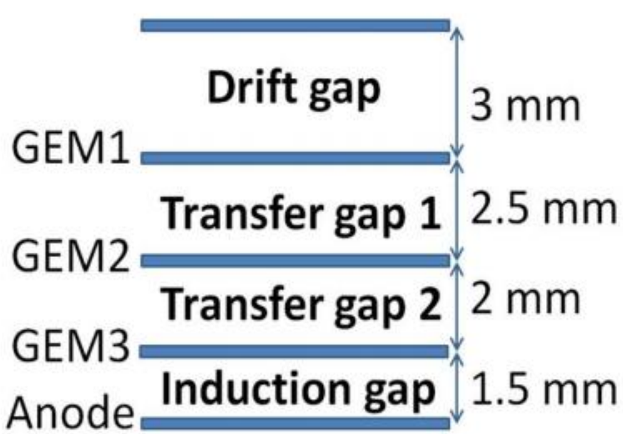
Horizontal sectors

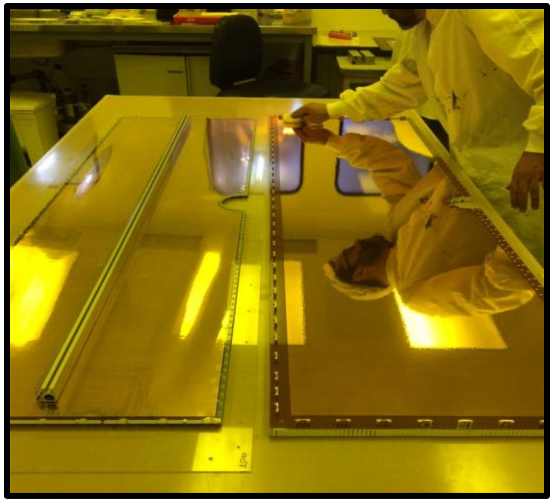
Two GEM 1632x450 mm^2 chambers with vertical sectors, five GEM 1632x450 mm^2 and seven GEM 1632x390 mm^2 chambers with horizontal sectors

First BM@N GEM 1632x390 mm^2 chamber was assembled at CERN (December 2018)

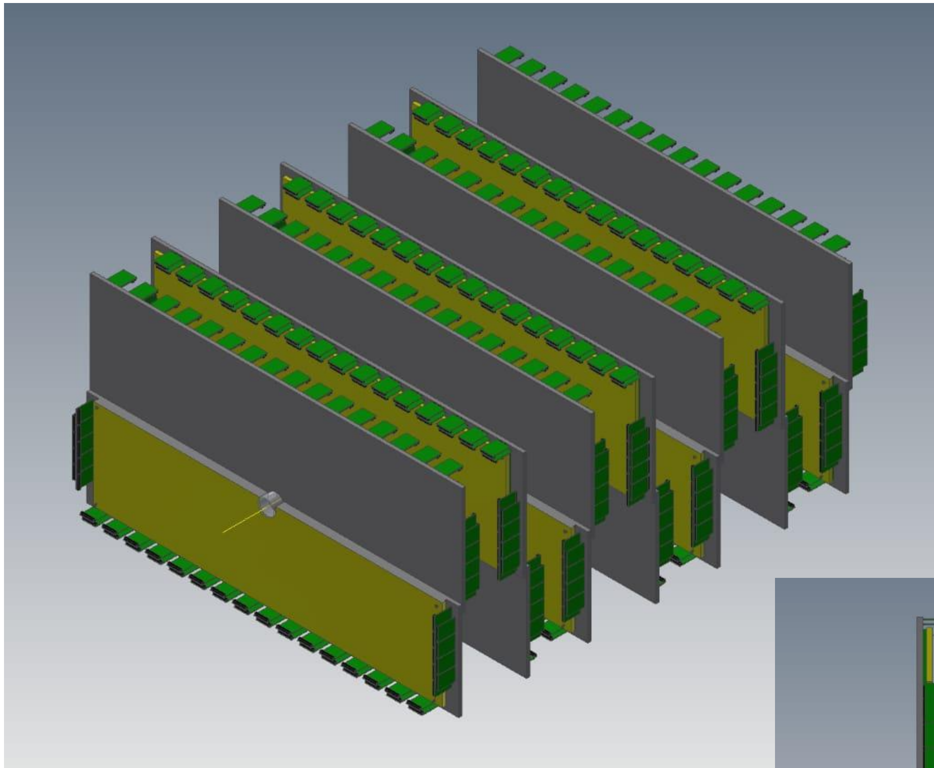


Schematic cross section of BM@N triple GEM detector

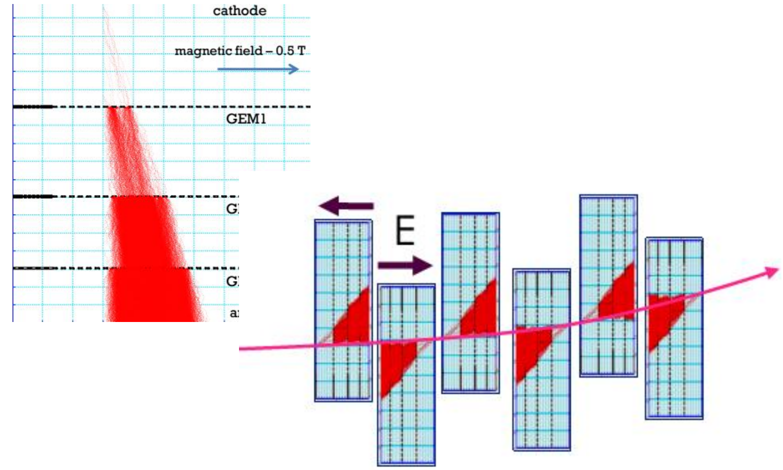


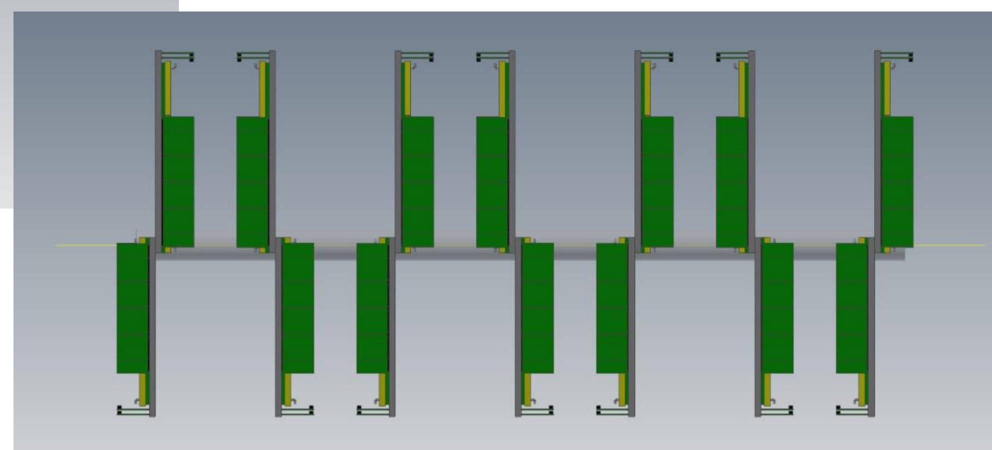


Scheme of the GEM full planes configuration inside the magnet



Lorentz shifts of an electron avalanche in GEM planes





First half of the 2019 – development of the mechanics for GEM planes precise installation inside the magnet.

End of the 2019 – mechanics production, installation of the GEM planes.

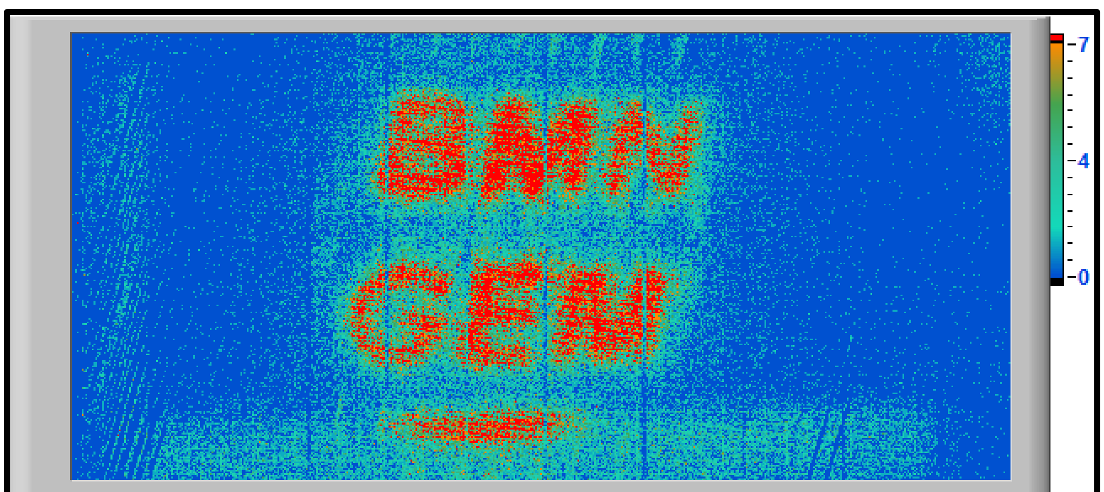
Plans:

- 02.2019 – tests of the first 1632 mm × 390 mm chamber at JINR

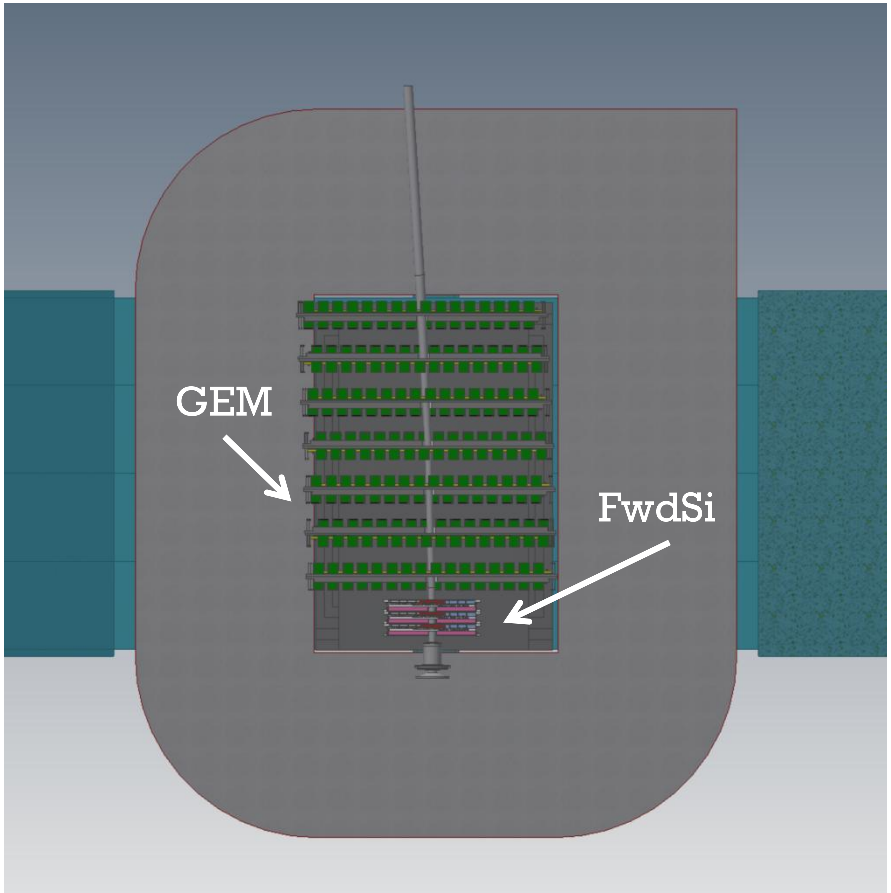
- First half of the 2019 year - production of 6 GEM chambers of size 1632 mm × 390 mm to cover vertical acceptance of analyzing magnet

- End of the 2019 – integration of the full GEM planes into the experimental setup (electronics based on the VA-163 chips, ~90000 readout channels)

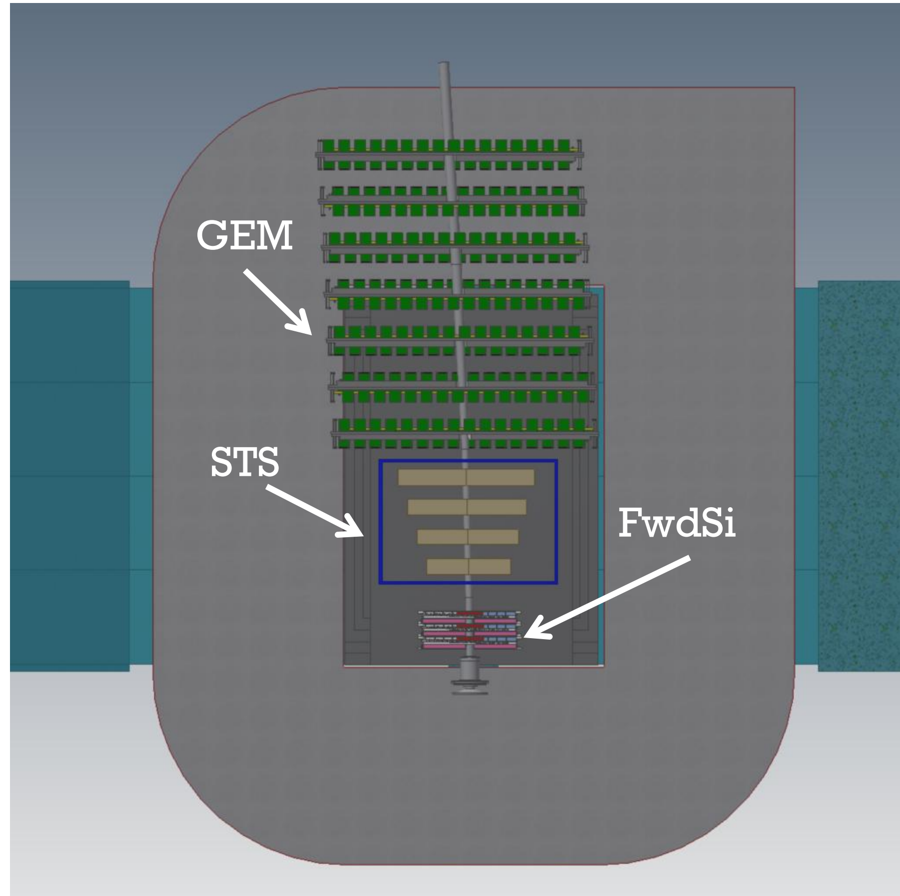
- Tests of the VMM3 and STSXYTER ASICs.



Forward Si, STS, GEM detectors installation scheme

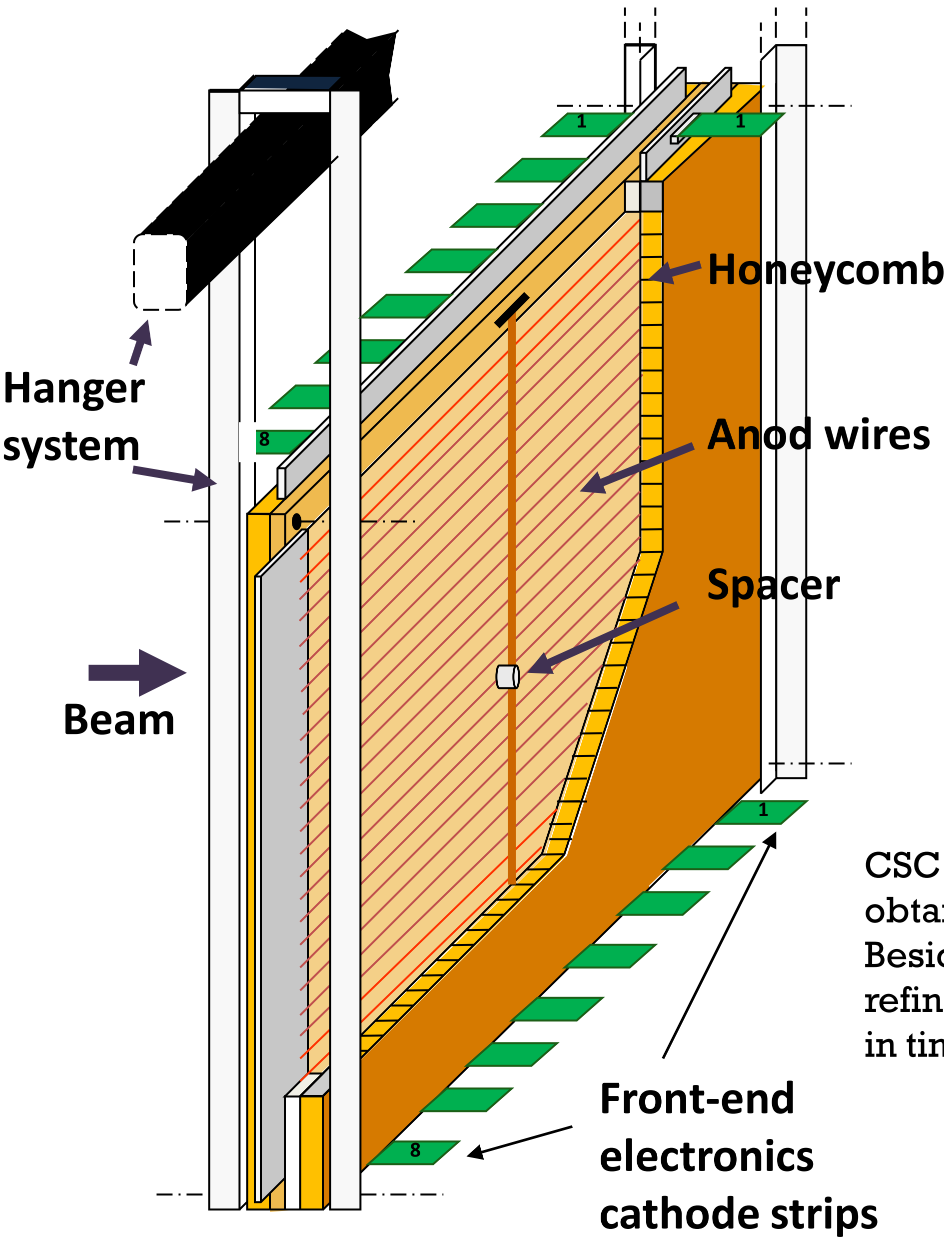


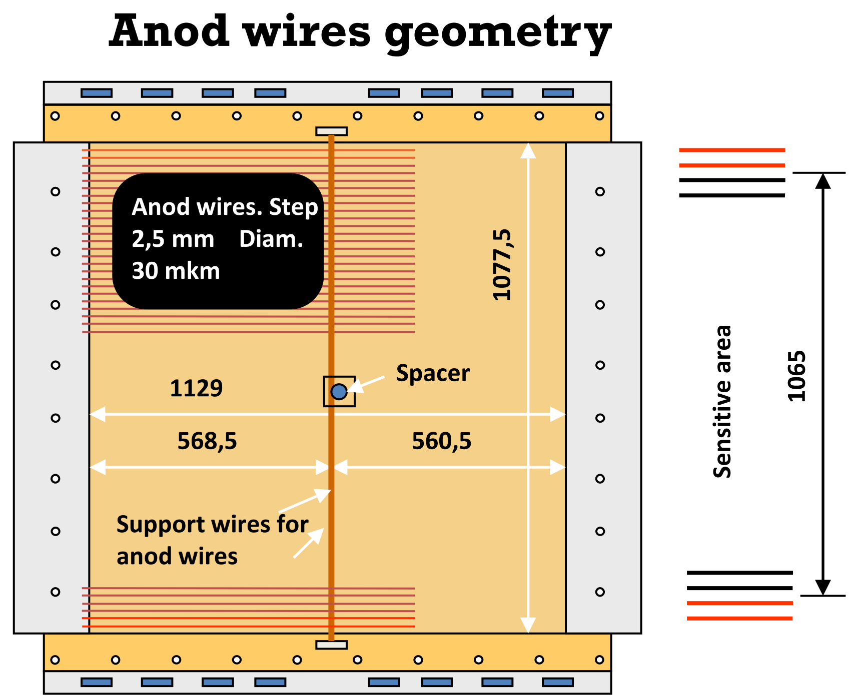
2020 year



2022 year

Schematic view of 1065x1065 mm^2 CSC



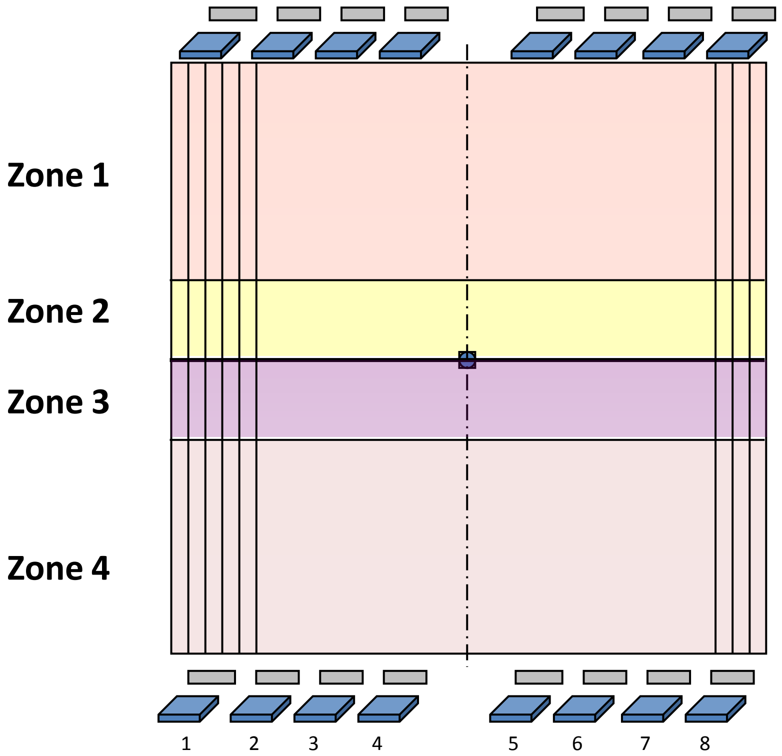


CSC is intended to precise parameters of tracks, obtained in GEM detectors inside the analyzing magnet. Beside improvement of particles momentum identification, refined track in CSC is used to find corresponding hit in time-of-flight system (ToF400).

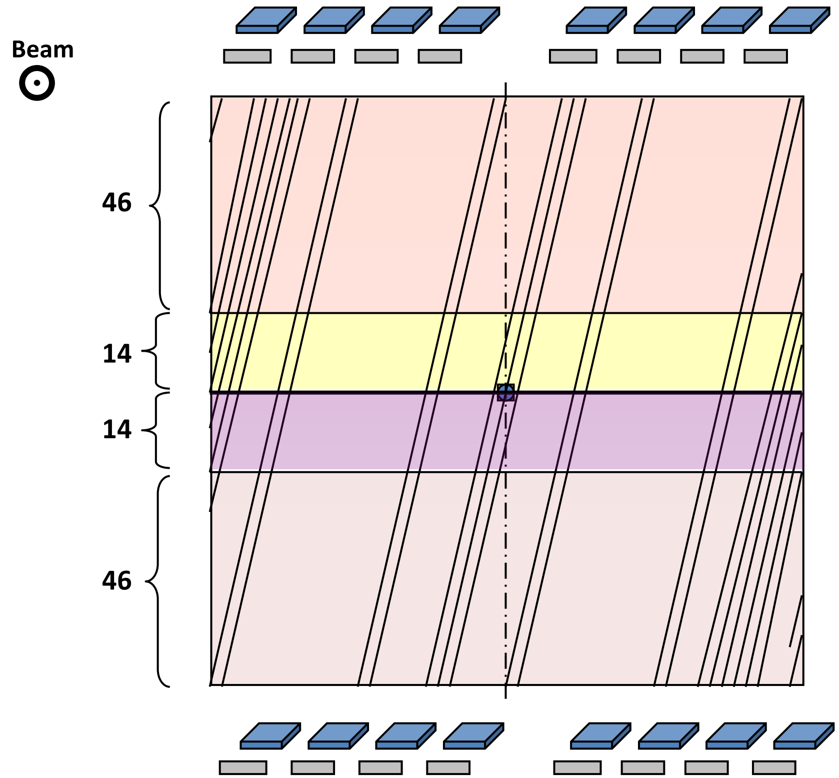
Design and assembly – JINR LHEP

Readout cathode planes

Each cathode plane consists of two printed circuit boards. Each pcb is divided on hot and cold zones.

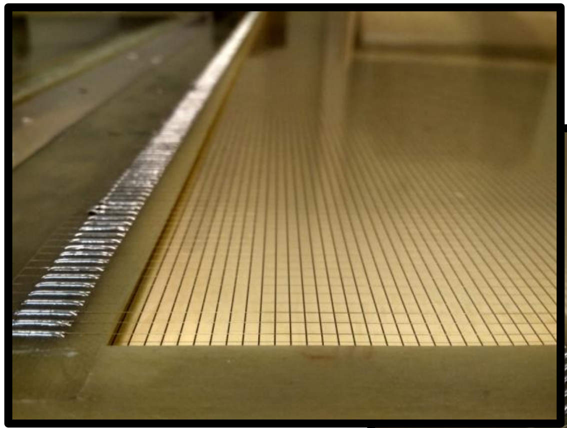


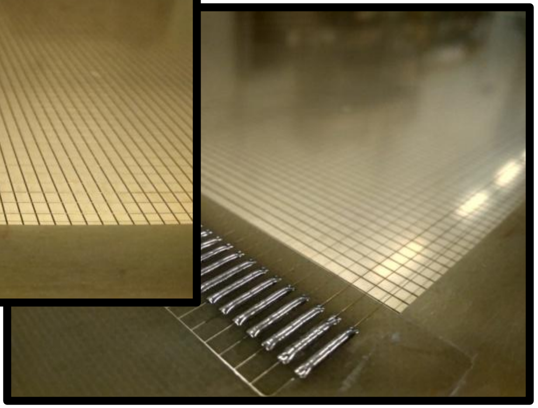
Vertical (X) strips

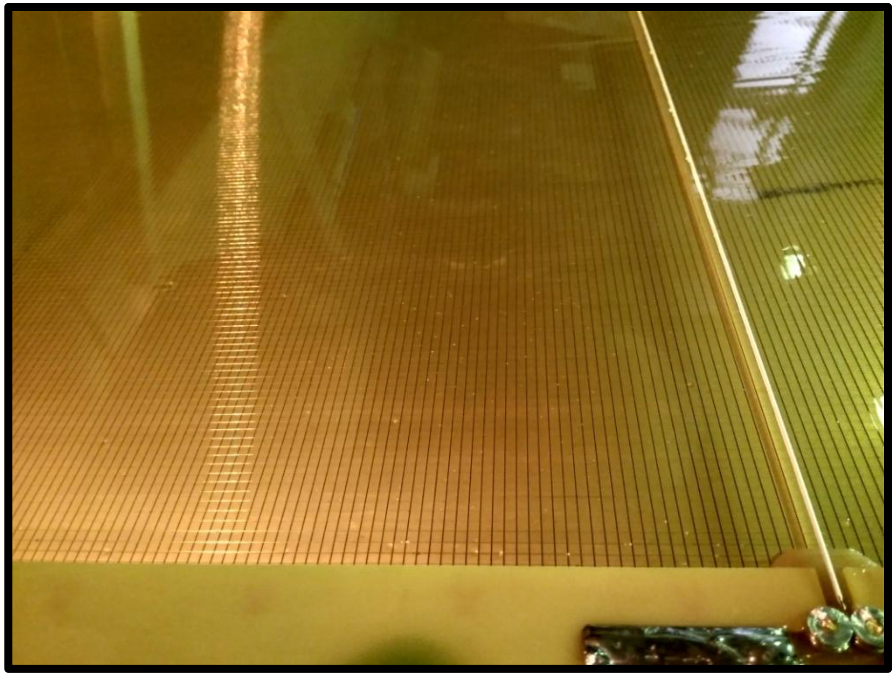


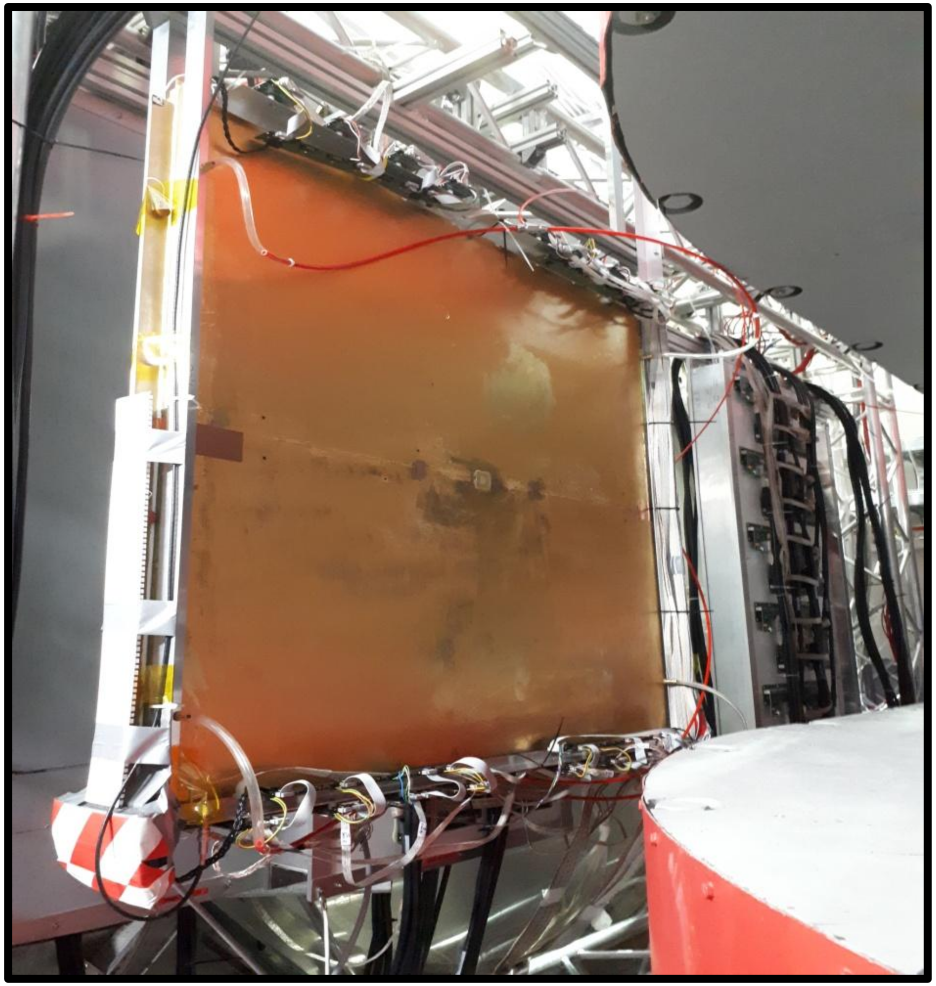
Inclined (Y) strips

CSC chamber 1065x1065 mm^2



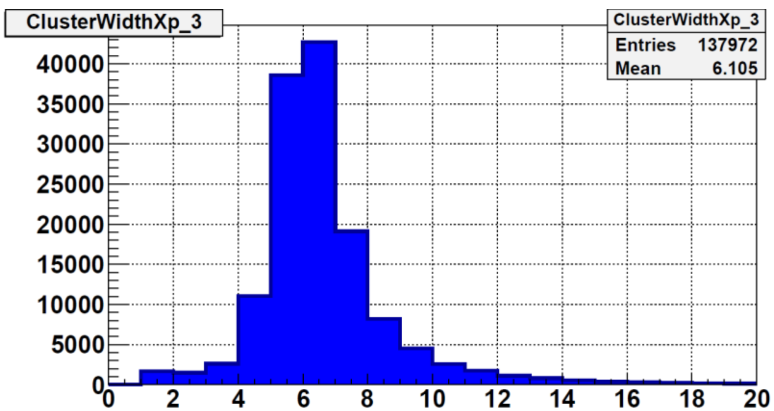




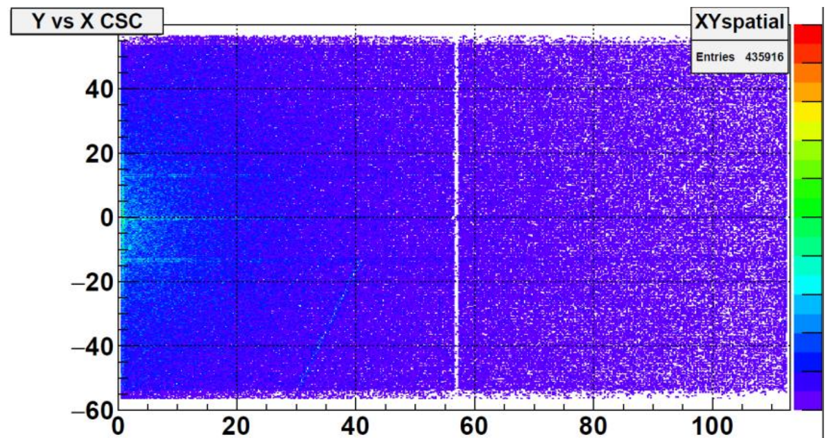


First beam test of CSC

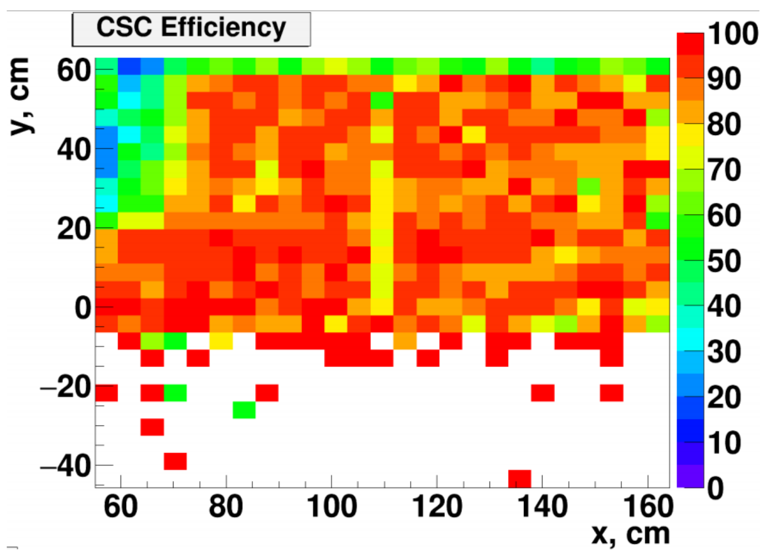
C, Ar and Kr runs in March 2018: CSC chamber is installed in front of ToF-400 to check its performance as outer tracker for heavy ions



Cluster width

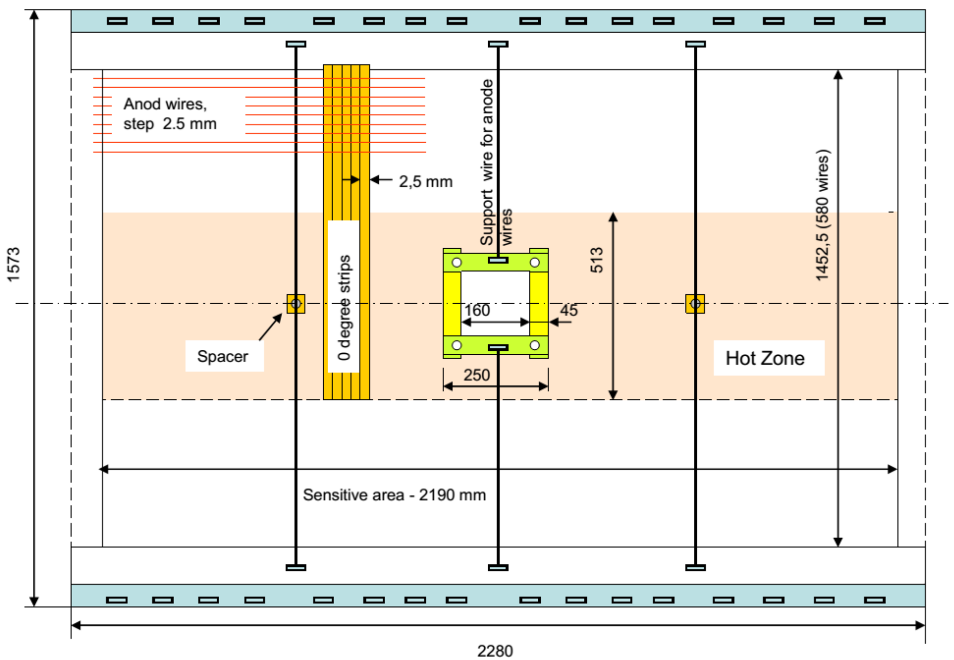


Events distribution on the chamber surface



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

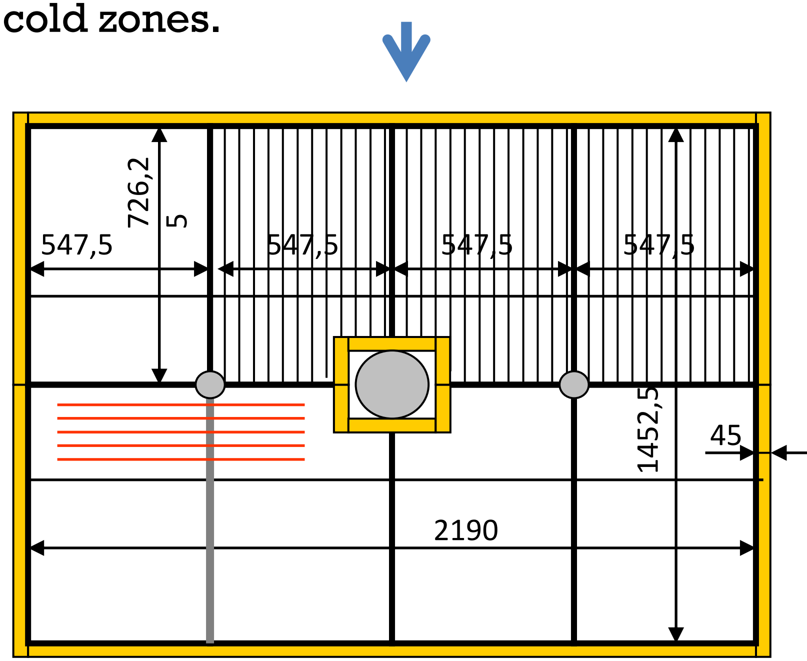
Schematic view of 2190x1453 mm^2 CSC



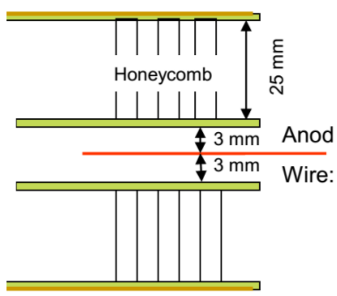
Two cathode planes – 0° and 15° strips

Each cathode plane consists of 8 printed circuit boards.

Each pcb is divided on hot and cold zones.



Cathode plane with 0° strips



Schematic cross section of BM@N CSC detector

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

Design and assembly – JINR LHEP

Plans:

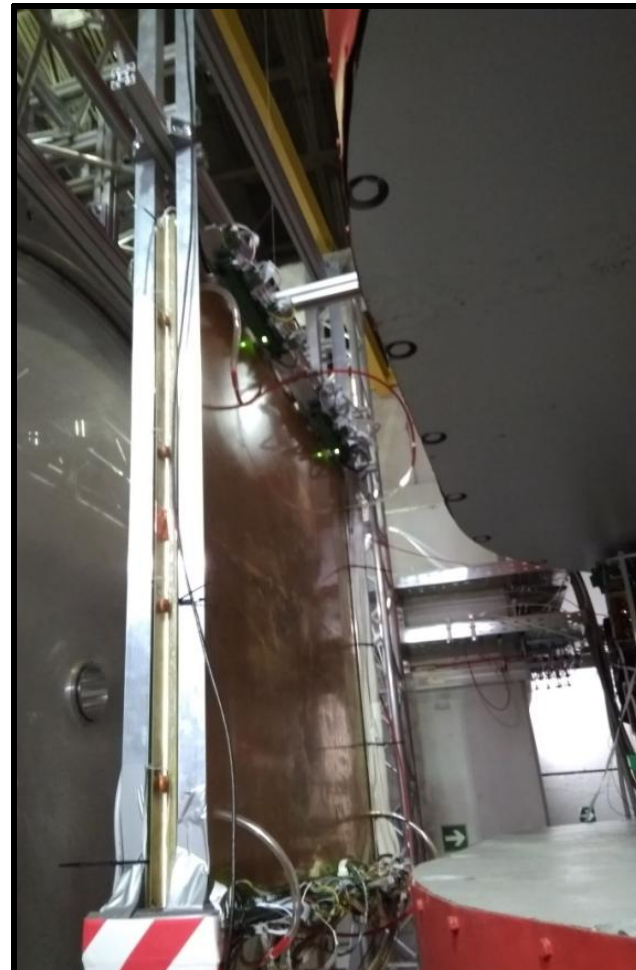
- 04.2019: production of three 1065x1065 mm^2 chambers and design of the cathode planes for 2190x1453 mm^2 CSC chambers

-10.2019 – production of the cathode planes for 2190x1453 mm^2 CSC chambers

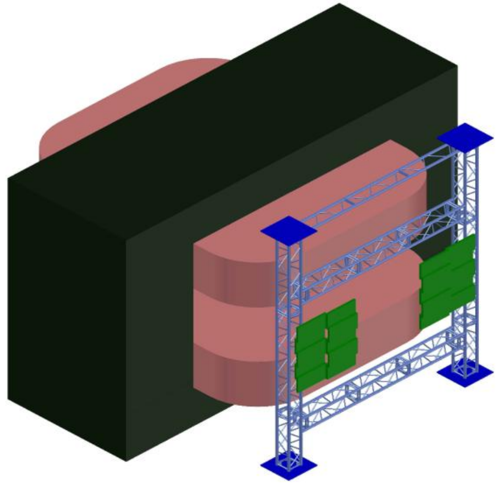
- 02.2020 – Assembly of the first 2190x1453 mm^2 CSC

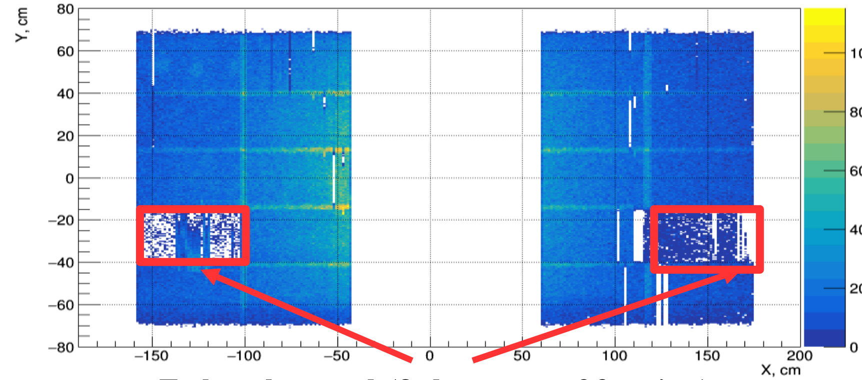
- 05.2020 - Assembly of the second 2190x1453 mm^2 CSC

- 12.2020 – All chambers are integrated into the BM@N experimental setup



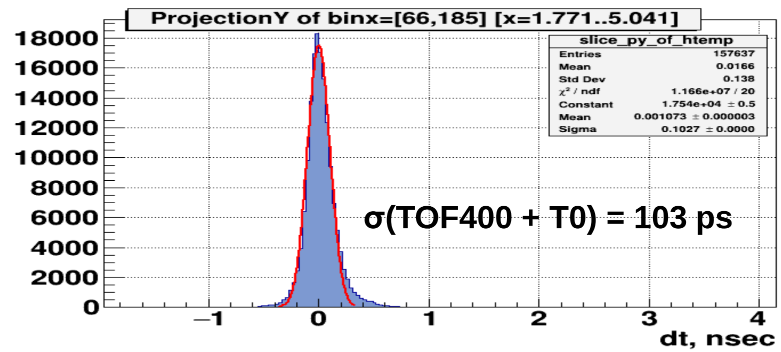
Status ToF-400



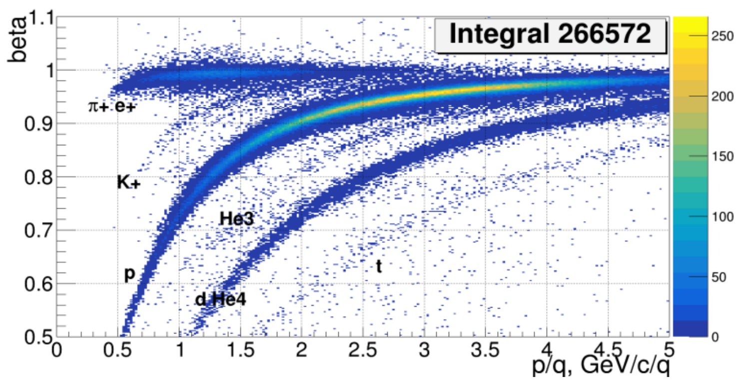


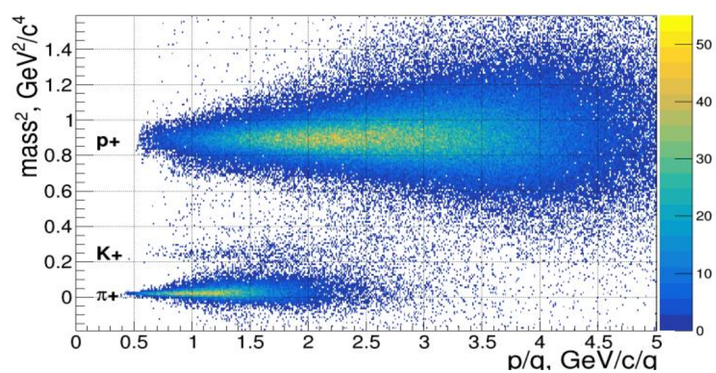
To be changed (2 detectors, 96 strips)

# Detectors	20
# Strips (300*10 mm^2)	960
# FEE	1920
Area total	~3,36 m^2



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

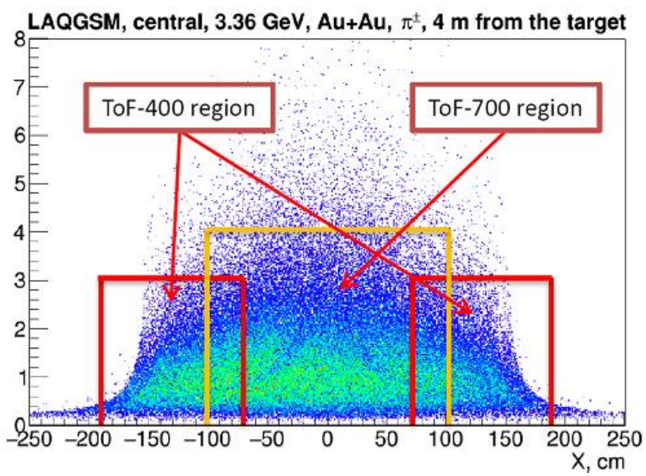


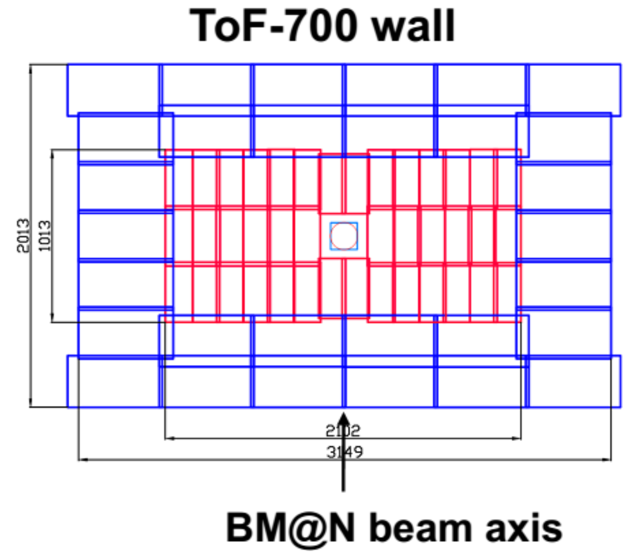


Proton Mass^2 = 0,894 +- 0,081 GeV^2/c^4, Pion Mass^2 = 0,021 +- 0,016 GeV^2/c^4

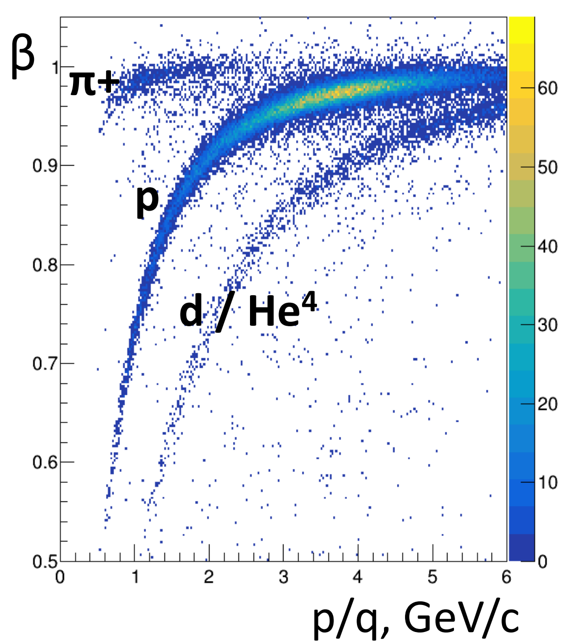
See talk of V.Plotnikov

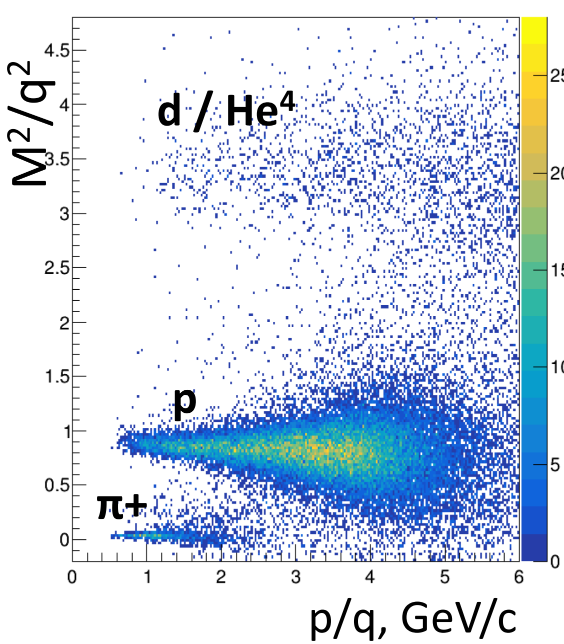
Status ToF-700

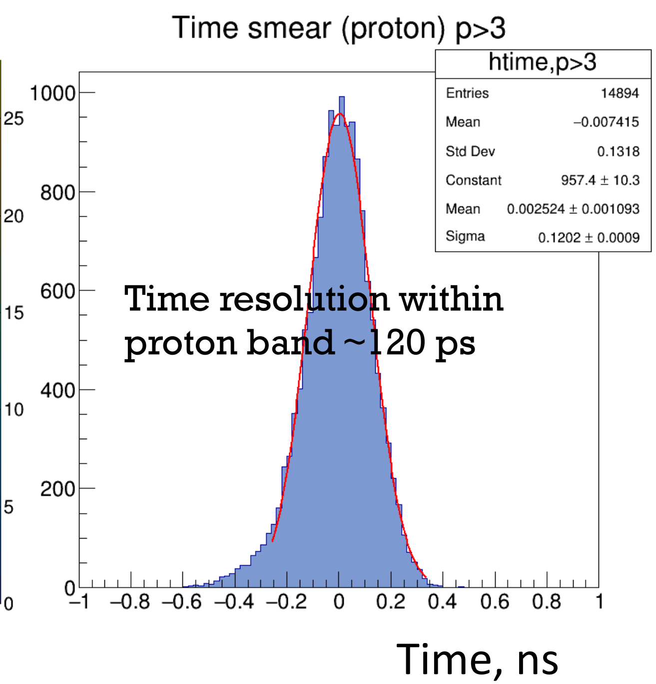




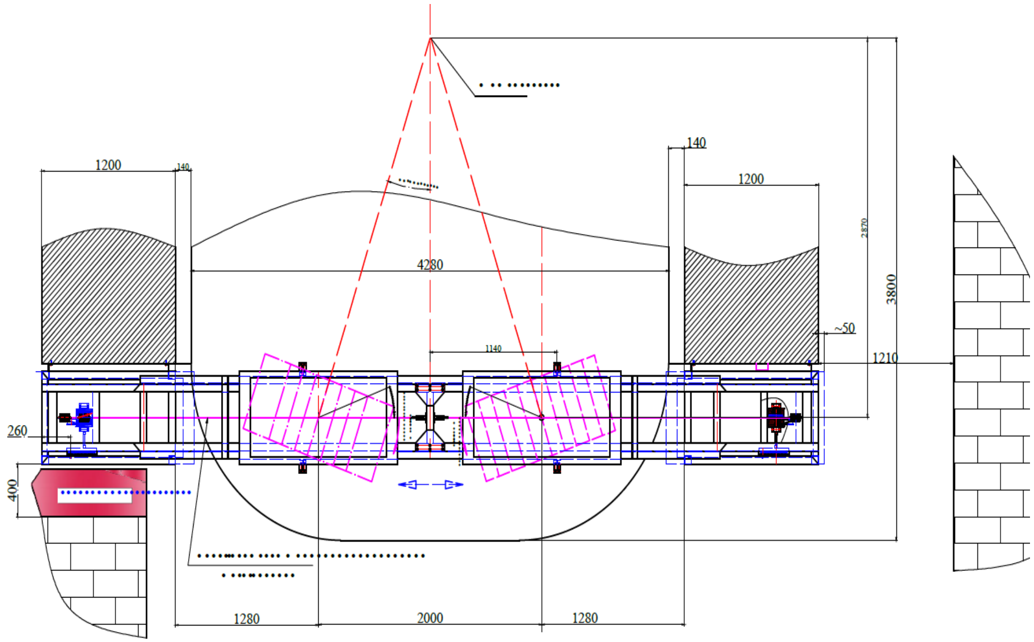
Ar beam , 3.2 AGeV , Ar + Al,Cu → X







ECAL upgrade status

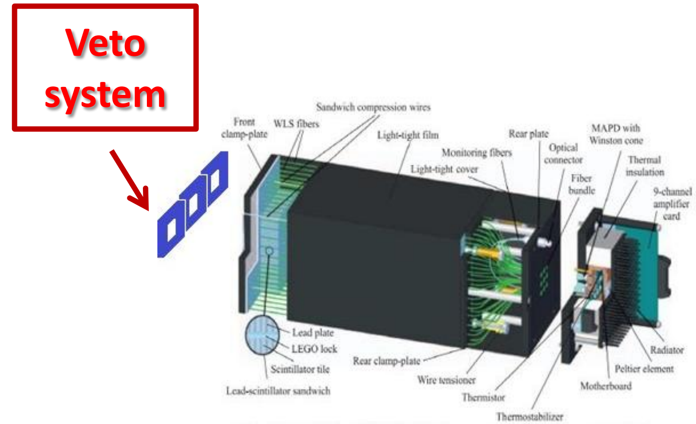


Position of the two ECAL arms

Plan for 2019:

-Perform the assembly of the two ECAL arms in the magnet

- Develop and test a veto detector for ECAL

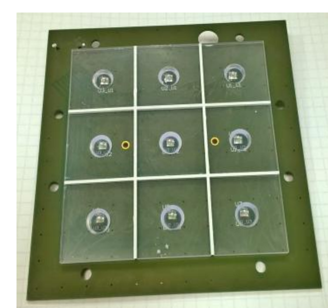


Design of the Shashlyk type calorimeter module

Prototype of the veto-module (9 cells)

Printed circuit board (PCB) with mounted sensors.

PCB is combined with the scintillator. The scintillator is divided into 9 cells.



ZDC Status

To be replaced

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

20 PSD CBM modules

Plans:

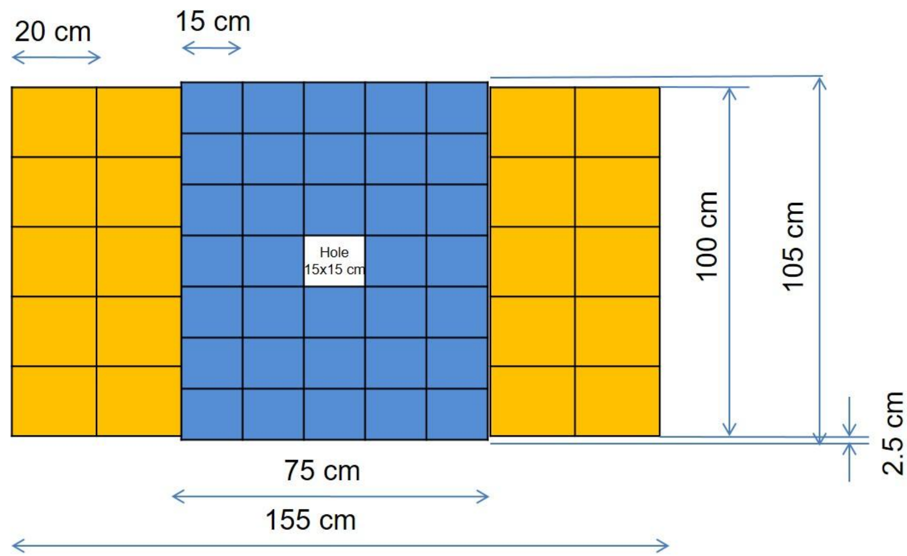
02.2019 – data analysis and ZDC calibration on cosmic muons will be performed by INR group

03.2019 – Tests of quartz hodoscope prototype at HADES and mCBM (GSI). Hodoscope will be installed after the calorimeter to precise the centrality measurements resolution and provide additional data on nucleus fragmentation

04.2019 - Transportation of CBM modules (20 pcs), FHCAL BM@N modules (16 pcs) and FHCal MPD modules (19 pcs) from INR at JINR.

05.2019 – Assembly of FHCAL at JINR

54 modules:
Yellow – CBM modules – 20x20 cm, 10 sections – 20 modules - 10 T
Blue – MPD modules – 15x15 cm, 7 sections - 34 modules - 6.8 T

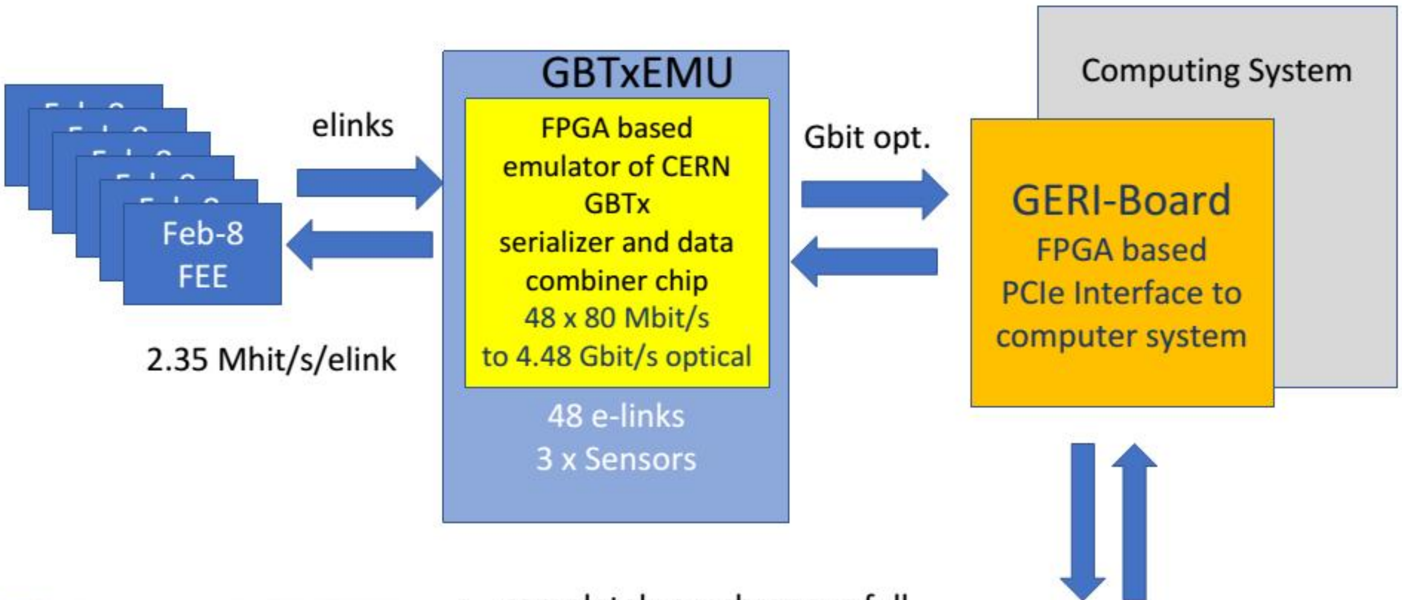


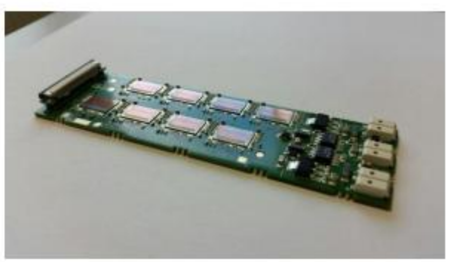
Summary:

Detector Subsystem	Status	Upgrade Status
Forward Si detectors	3 small planes	3 full-size planes (02.2020)
STS BM@N		42 modules (2020) 292 modules (2022)
GEM	7 half planes (1 to be repaired)	7 full planes (2019)
CSC	1 chamber 1065x1065 mm^2	4 chambers 1065x1065 mm^2(2019) 2 chambers 2190x1453 mm^2(2020)
ECAL	one arm	two arms (2019)
ToF-400	full configuration	
ToF-700	full configuration	
ZDC		ZDC (MPD/CBM type) (2019)

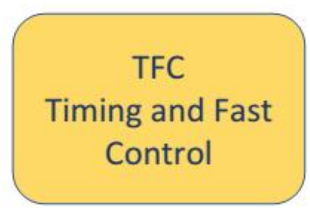
Back-up slides

Readout electronics for BM@N STS





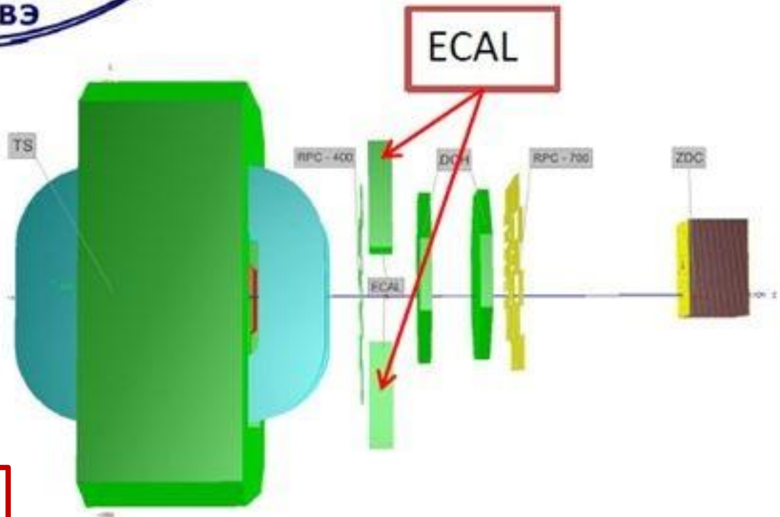
- completely synchronous full system operation,
- generating free streaming, self triggered data
- time-stamp-clocks on all chips need to be synchronous



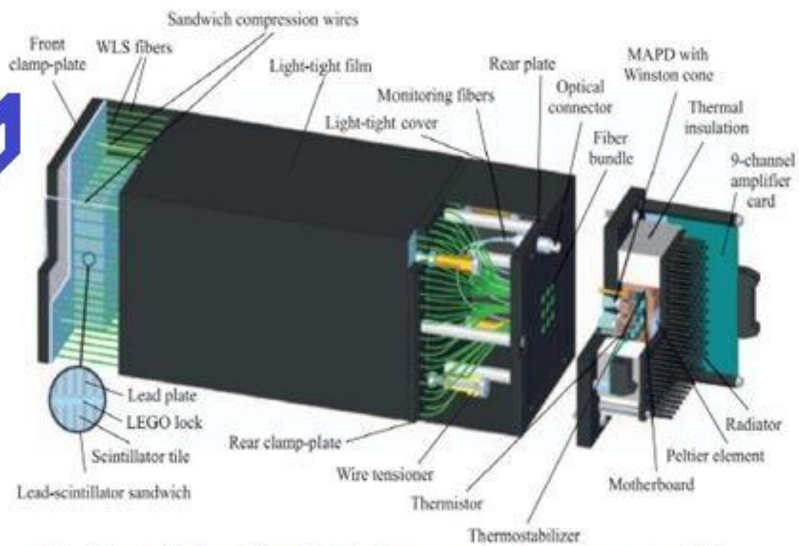
Firmware GBTxEMU, GERI:
WUT Warshow, W. Zabolotny

Firmware TFC:
KIT Karlsruhe, Vladimir Sidorenko

Electromagnetic calorimeter

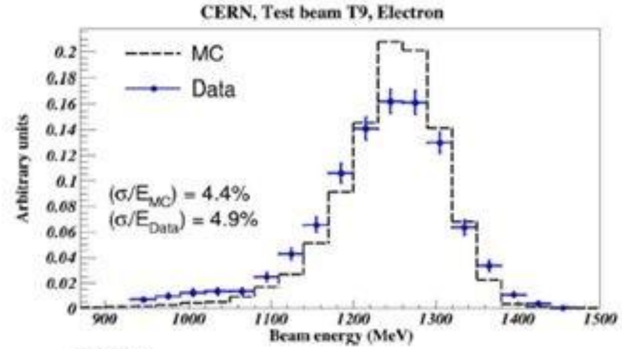


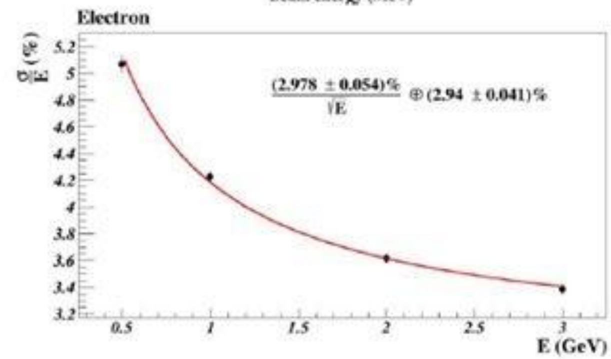
Veto system



Design of the Shashlyk type calorimeter module

Energy resolution



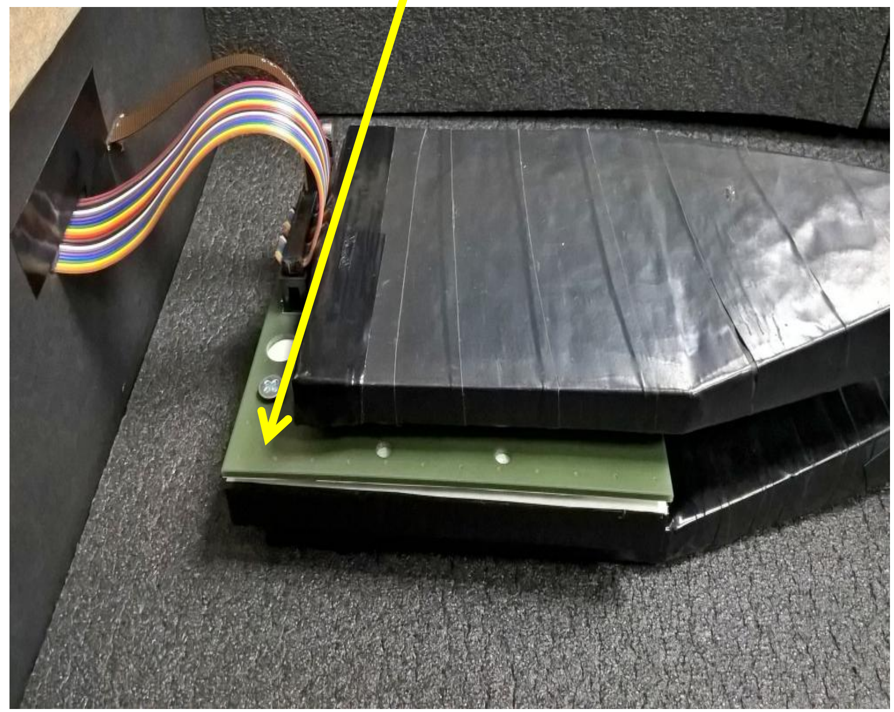


Parameters	
Transverse size, mm²	40x40
Module size, mm²	120x120
Number of layers	220
Lead absorber thickness, mm	0.3
Polystyrene scintillator thickness, mm	1.5
Moli'ère radius, mm	26
Radiation length, X_0	11.8

ADC64 is a 64-channel 12-bit 62.5 MS/s ADC device with signal processing core and Ethernet interface

9-channel power supply system

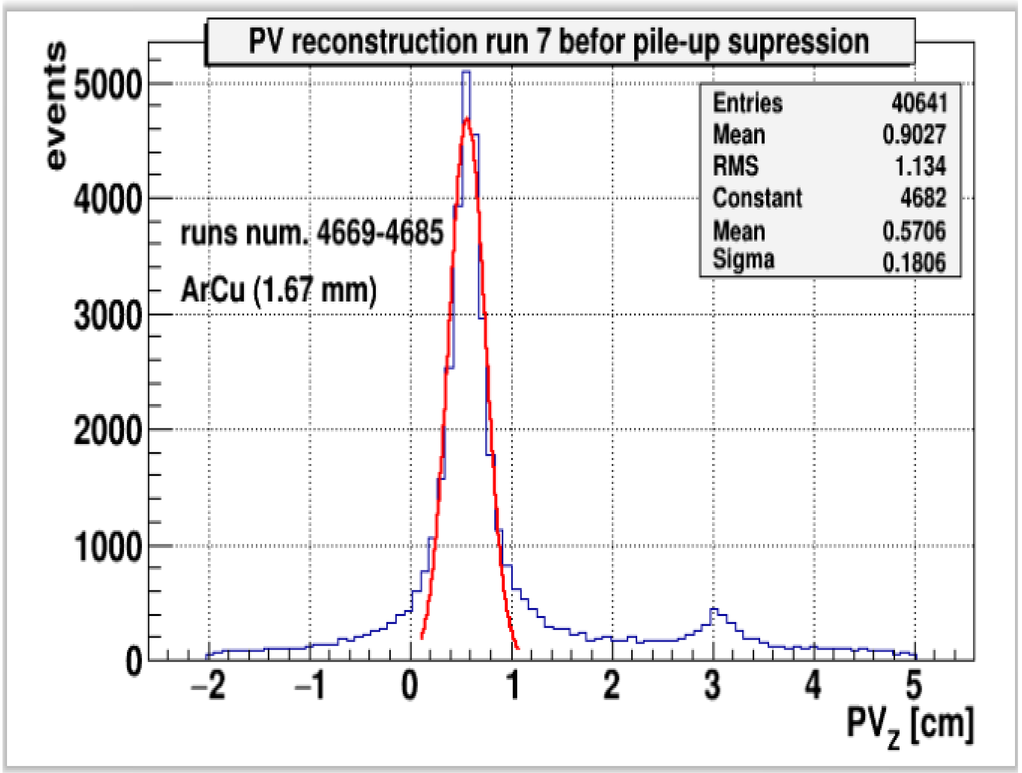
Cosmic test of the 9-cells module.



Detector council:

A.Maksymchuk	Technical coordinator, head of the detector council
S.Pijadin	BM@N chief engineer, infrastructure of the BM@N experimental zone
V.Slepnev	Coordination of BM@N and Nuclotron
V.Yurevich	Trigger and T0 detectors
N.Zamiatin	Forward silicon detectors, beam silicon detectors
D.Dementyev	STS detectors
S.Vasiliev	GEM detectors
A.Vishnevskiy	CSC detectors
M.Rumyancev	ToF-400
S.Afanasyev	ECAL
Yu.Petukhov	ToF-700
F.Guber	ZDC (MPD/CBM type)
S.Bazylev	DAQ
S.Habarov	Electronics for GEM, CSC, forward silicon detectors
V.Shutov	Slow control

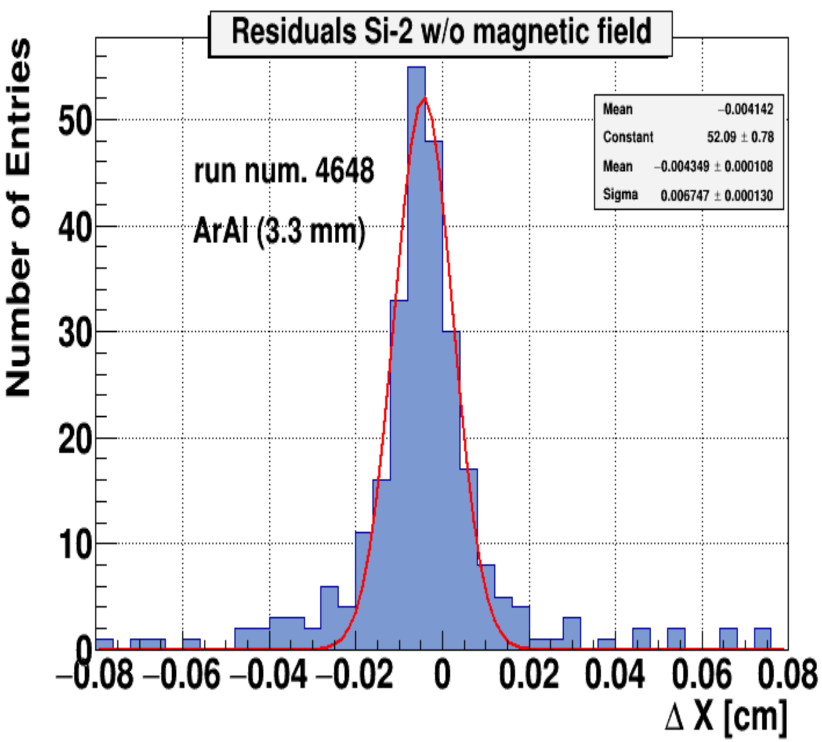
Reconstruction of the primary vertex Si+GEM track (>=2 track),
Ar-beam, Cu-target/1.67 mm
(slide from G.Pokatashkin et al.)

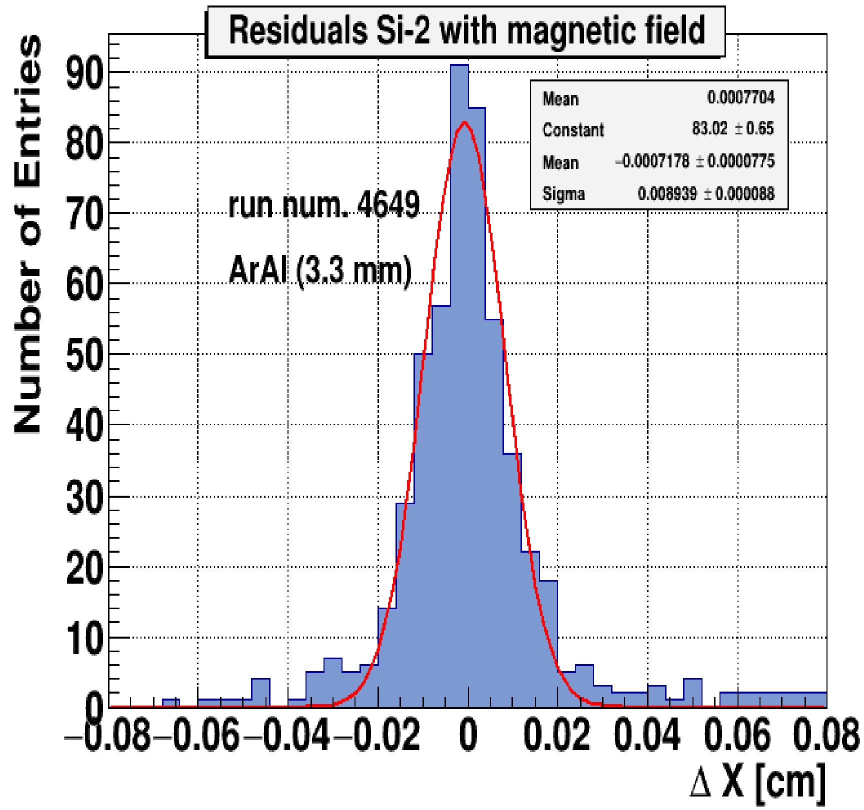


Primary Vertex resolution of Z-coordinate σ_z = 1.8 mm at target thickness = 1.67 mm (without pile-up suppression)

Track residual of Si-2 (plane) vs Si+GEM track in magnetic field

(slide from G.Pokatashkin, Yu.Gornaya, M.Kapishin, I.Rufanov, V.Vasendina, A.Zinchenko)





Si-2 plane residual σ = 67.5 µm vs Si+GEM (>=7 hits/track) track at H = 0 Tl

Si-2 plane residual σ = 89.4 µm vs Si+GEM track at H=0.6 Tl