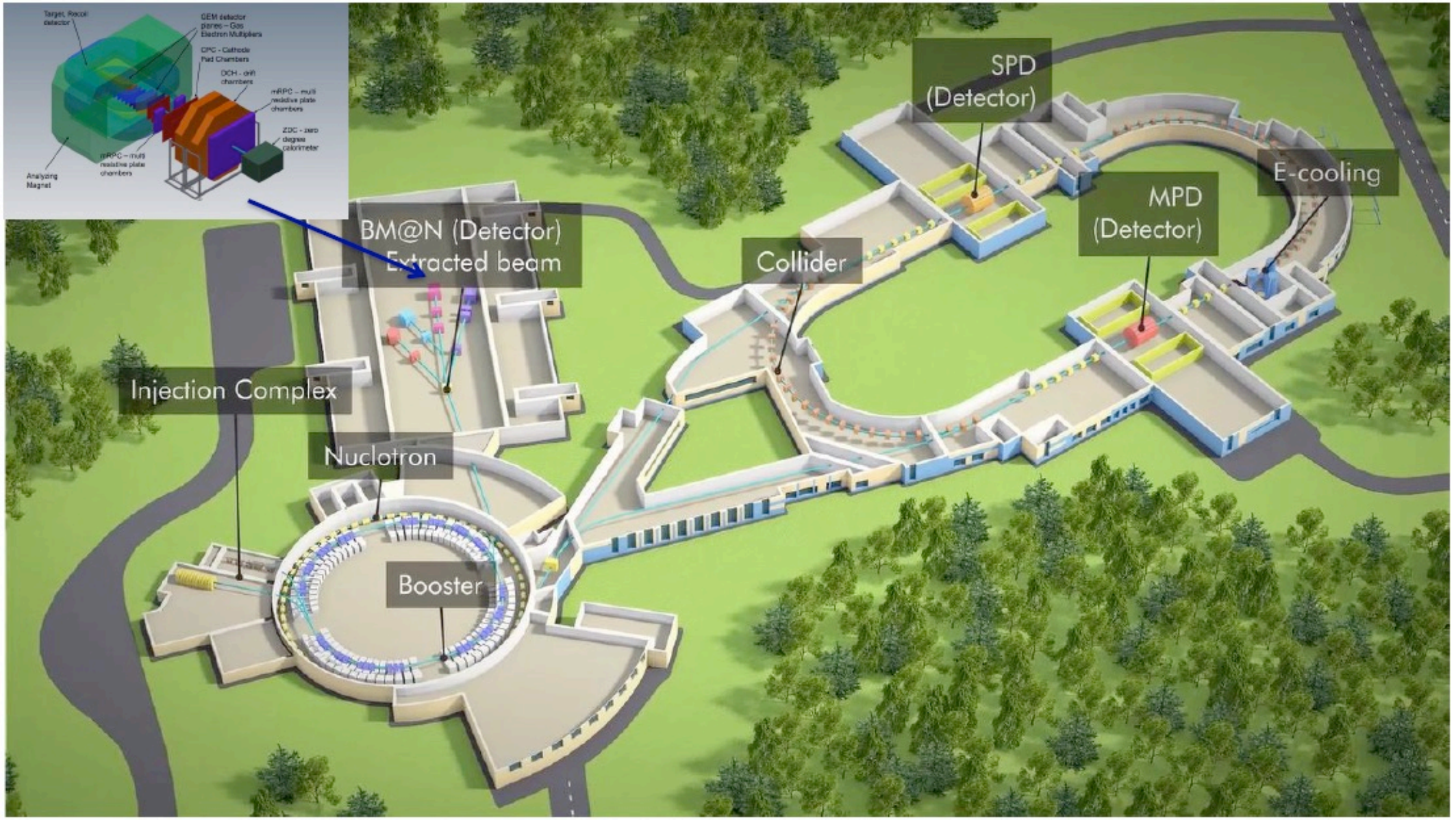
BM@N setup upgrade for future heavy ion physics program

Yury Stepanenko
28/09/2020

JINR Young Scientists and Specialists Association Workshop "Alushta-2020"

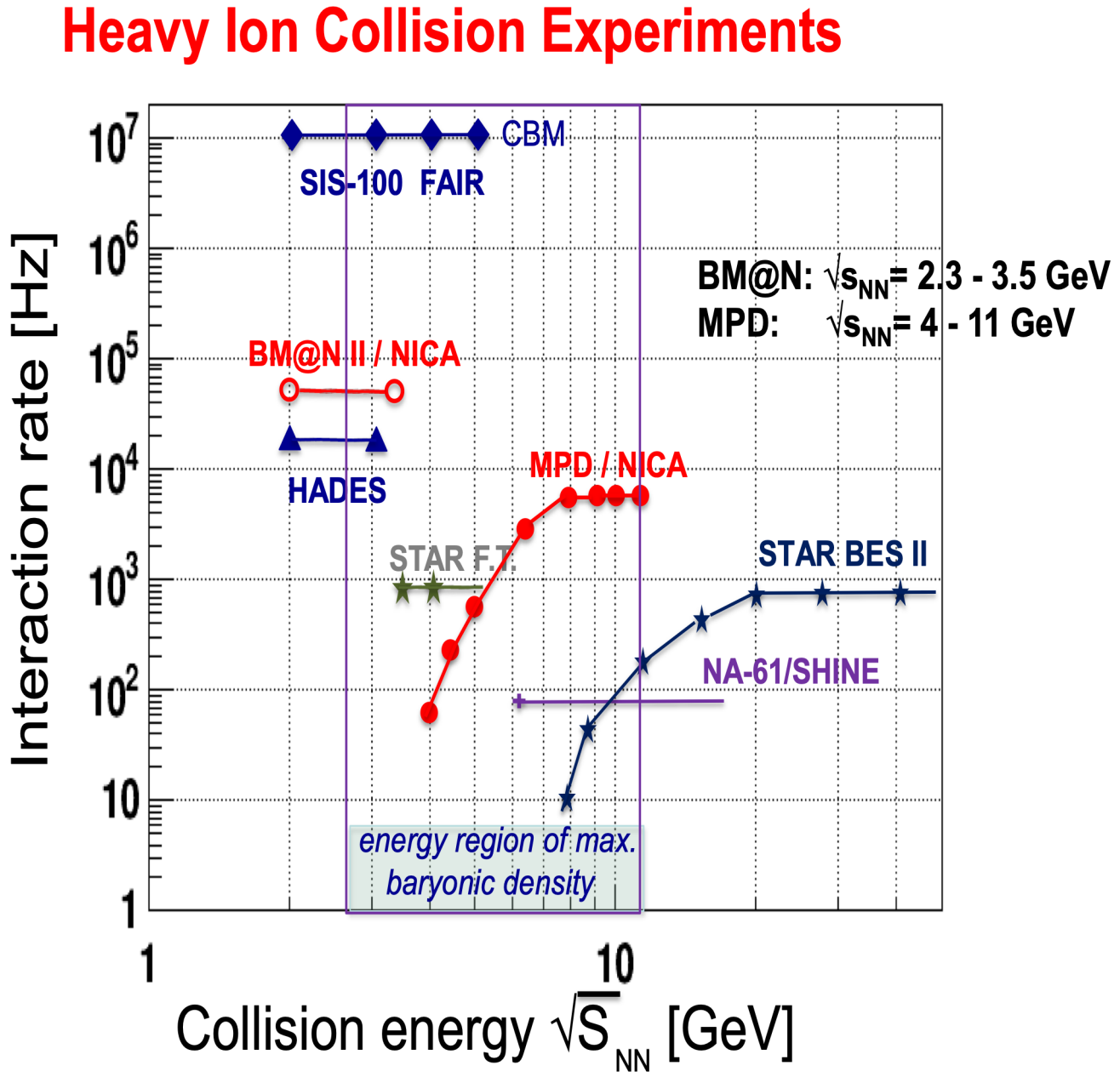
NICA Heavy Ion Complex



BM@N experiment

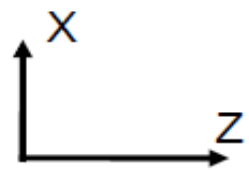
The BM@N (Baryonic Matter at Nuclotron) is the first experiment undertaken at the accelerator complex of NICA-Nuclotron. The BM@N scientific program includes studies of dense nuclear matter in heavy ion beams

The first experimental run was performed in the carbon beam of the 4 and 4.5 AGeV kinetic energy with fixed targets.

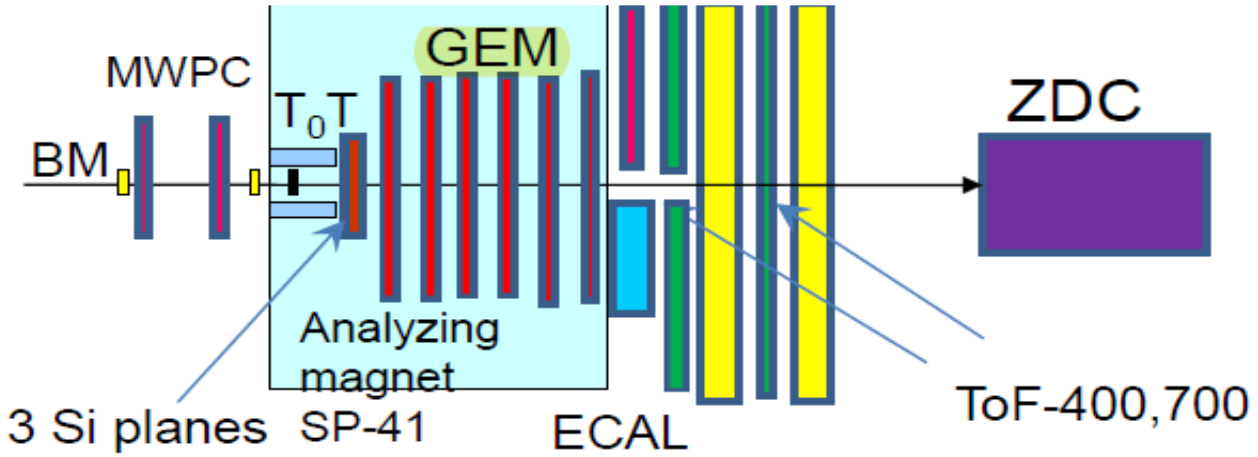


Run7 configuration

Ar beam, T_0= 3.2 GeV/n



Kr beam, T_0= 2.4 (2.9) GeV/n



- **Central tracker inside analyzing magnet → 6 GEM detectors 163 x 45 cm² and forward Si strip detectors for tracking**
- **ToF system, trigger detectors, hadron and EM calorimeters, outer tracker**

Program:

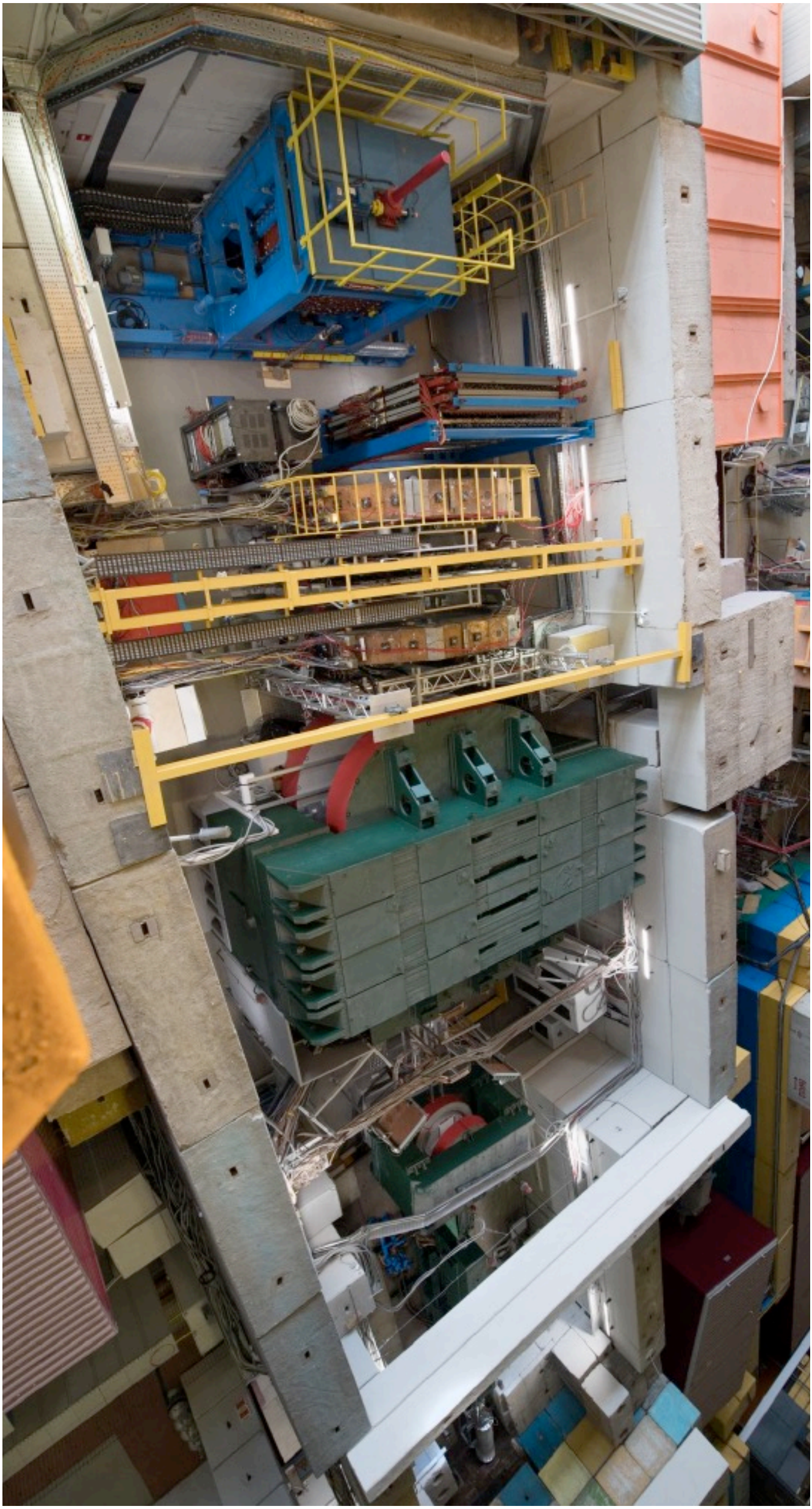
- **Measure inelastic reactions Ar (Kr) + target→ X on targets C,Al,Cu,Sn,Pb**

→ Hyperon production measured in central tracker (Si + GEM)

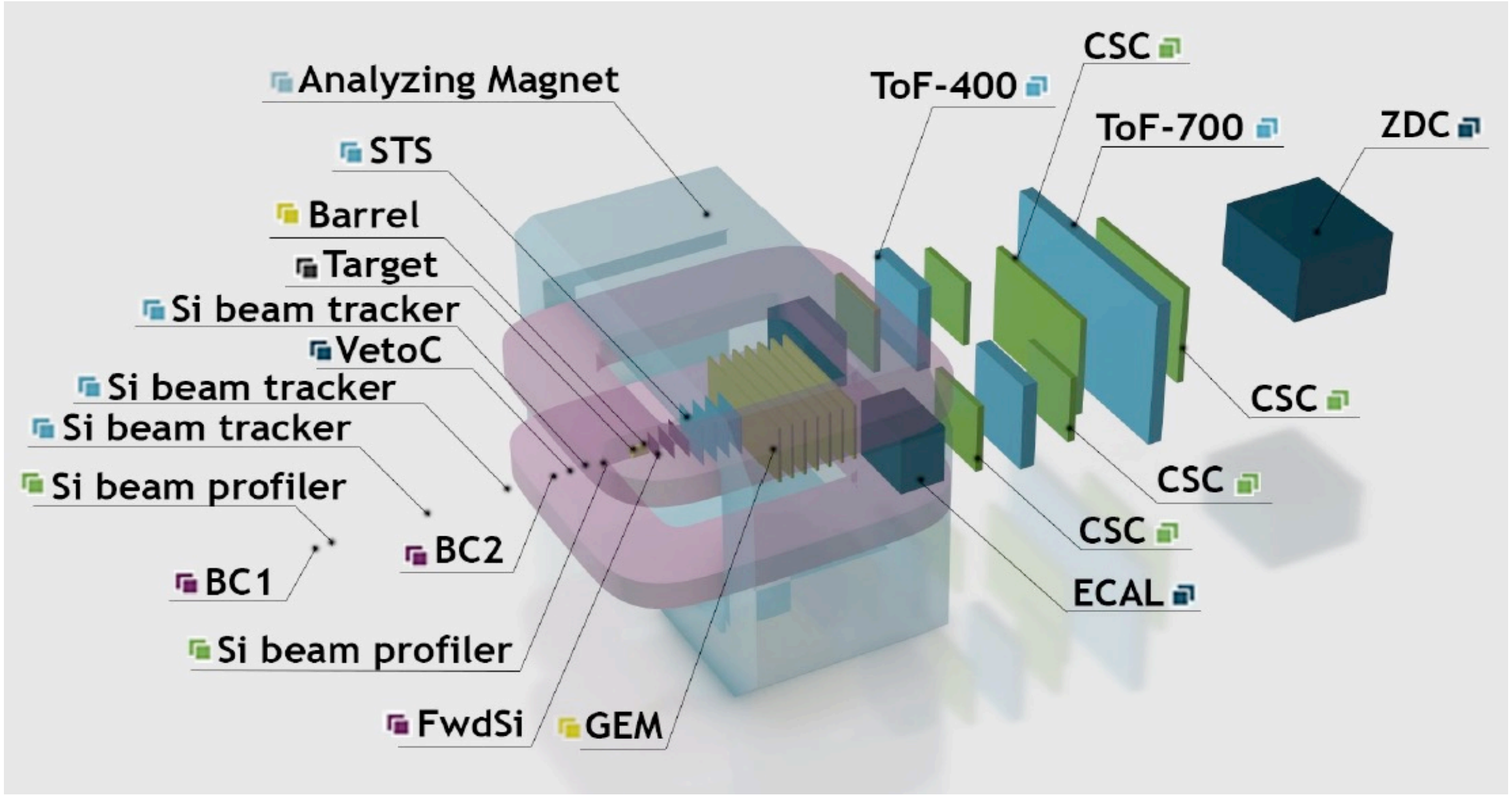
→ Charged particles and nuclear fragments identified with ToF

→ Gamma and multi-gamma states identified in ECAL

+ analyze data from previous technical run with Carbon beam of 3.5 - 4.5 GeV/n

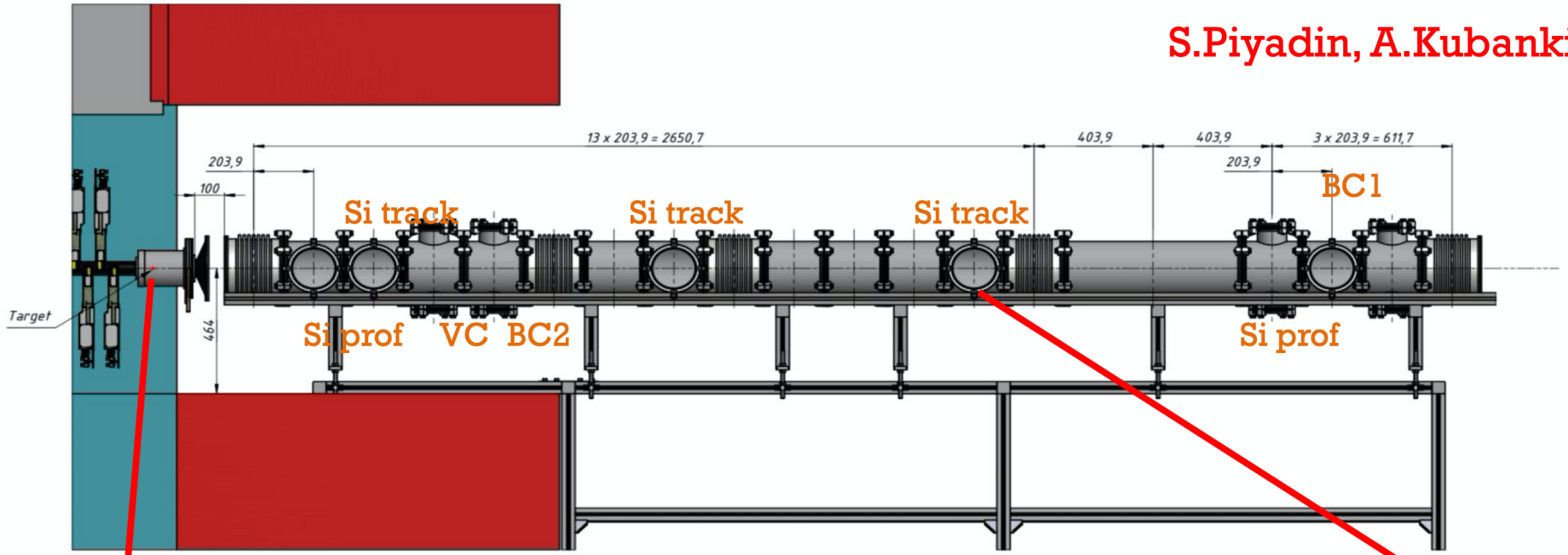


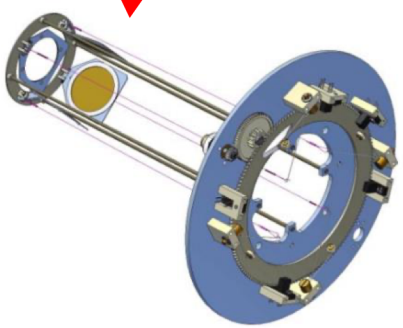
Future configuration 2021 (w/o beam pipe)

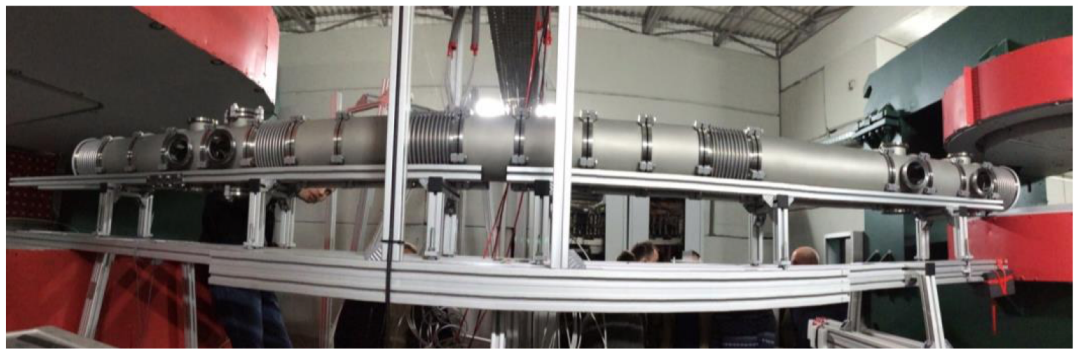


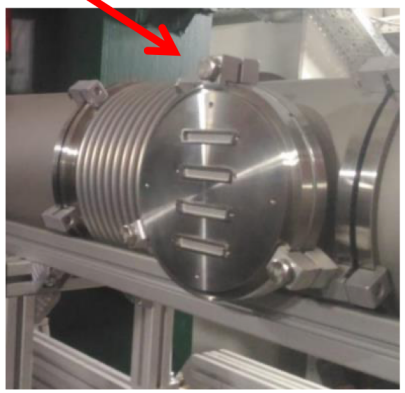
Beam pipe before the target

S.Piyadin, A.Kubankin



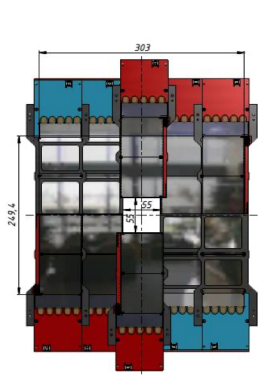


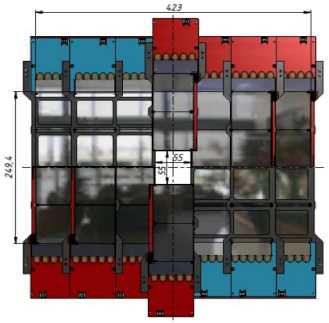


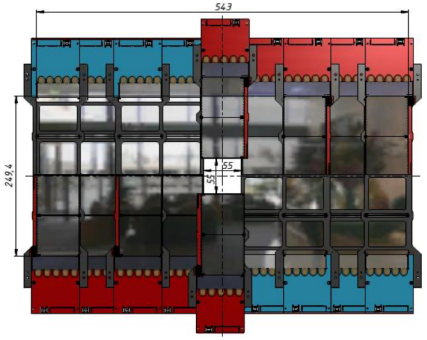


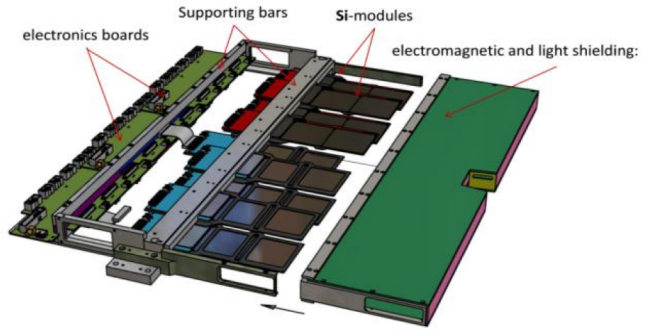
Four stainless steel vacuum boxes downstream the target will be replaced by aluminum ones. The design and production of the target station mechanics will be performed by A.Kubankin group

Upgrade of the forward Si tracking detectors



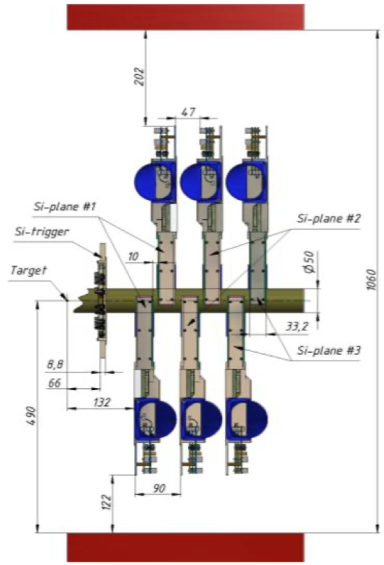


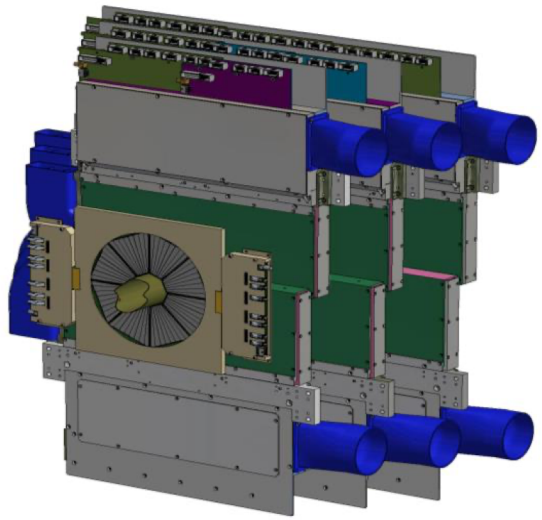


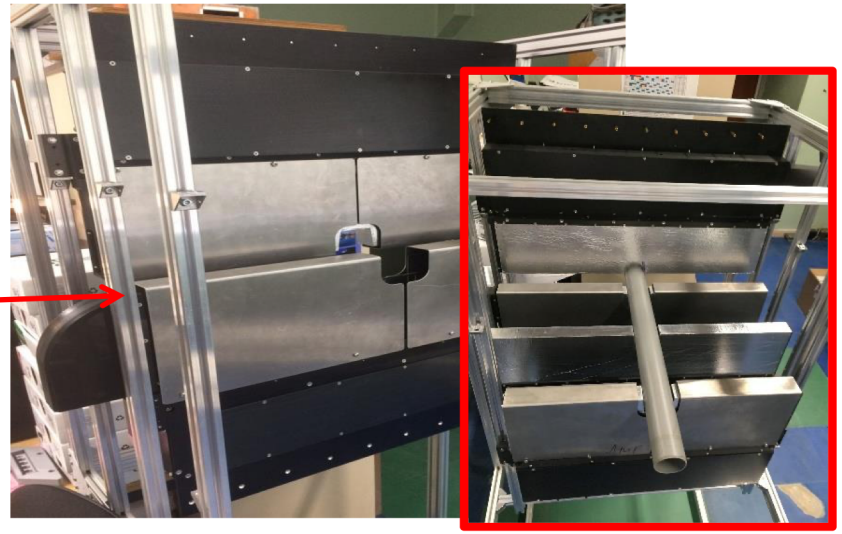


Three sizes of Si-planes

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***

group of N.Zamiatin

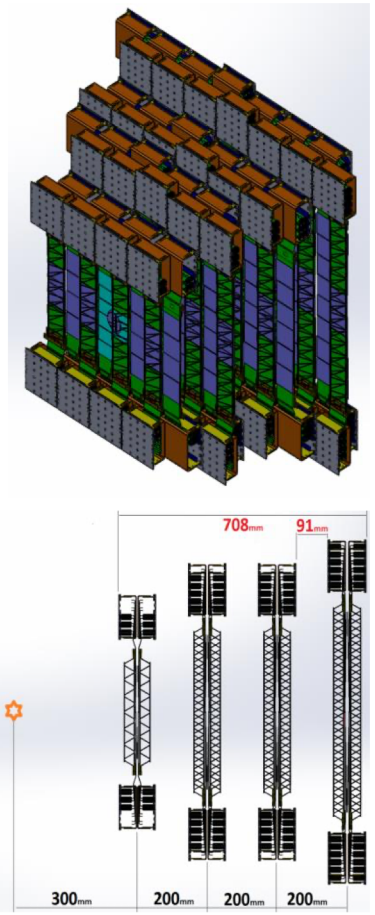
BM@N STS

Preliminary layout of BM@N STS was developed.

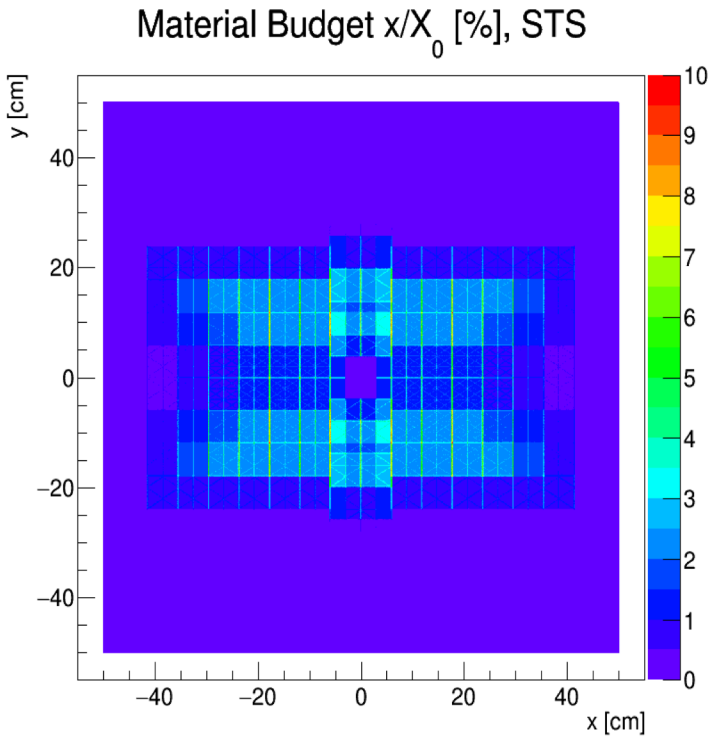
Geometry was tested in simulations in CbmRoot (E. Lavrik) and BmnRoot (S. Mertz)

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 mm²
- Produced by two vendors: CiS (Germany) & Hamamatsu (Japan)



Tentative design of BM@N STS stations



Total material budget (by E. Lavrik)

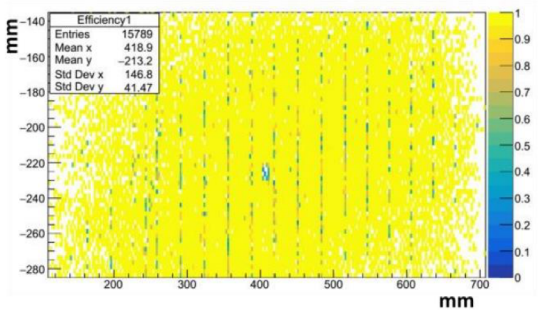
Number of modules: 292
Number of channels: ~600k
Power consumption: ~15 kW

Plans:
2022 – "pilot" configuration, first 42 modules integration into BM@N;
After 2022 – BM@N STS full configuration (292 modules)

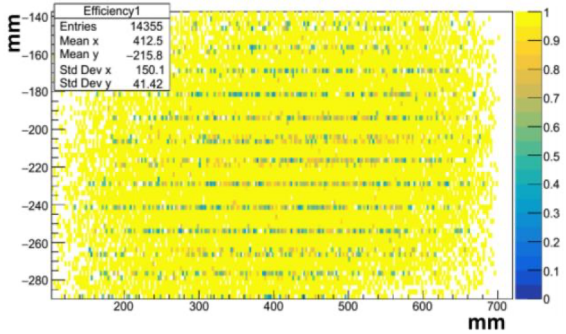
GEM group

GEM central tracking system

Stand for cosmic tests



Spatial efficiency for
Different sector design

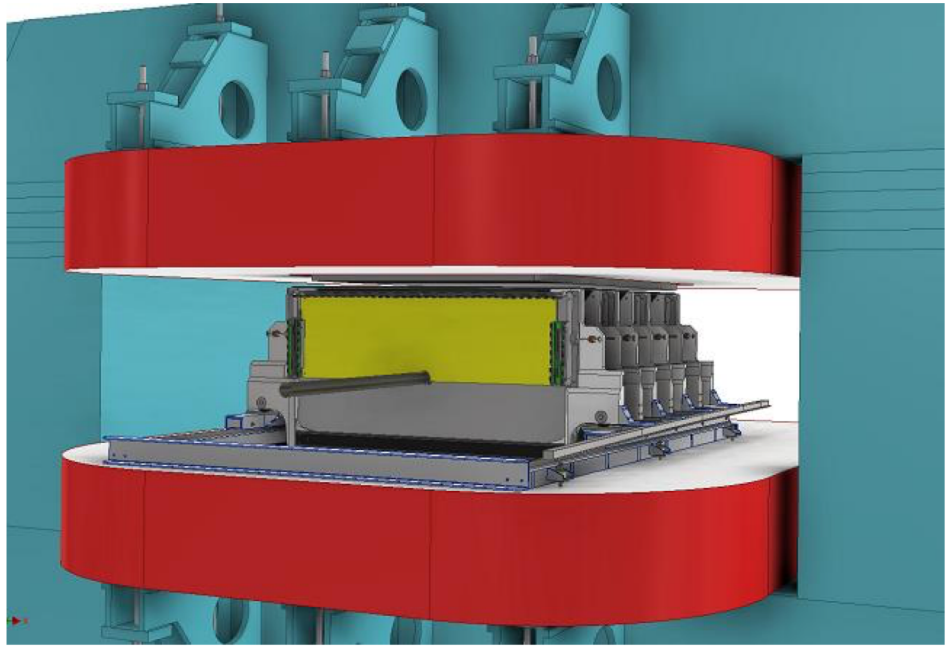


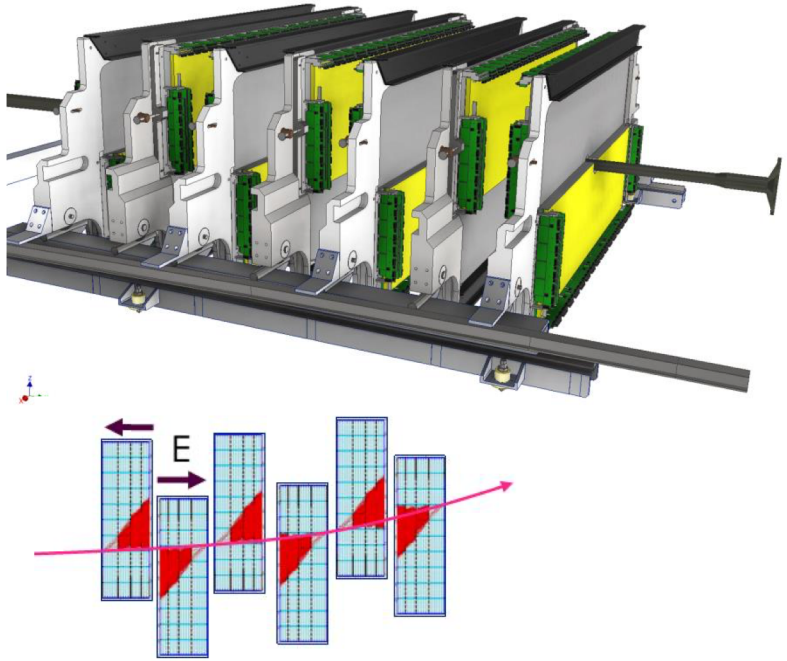
Four last1632x390 mm² GEM chambers were assembled at CERN

New bracing system for FEE was designed and produced

- Seven GEM 1632x450 mm² chambers produced at CERN workshop were integrated into BM@N experimental setup. One was defected and repaired at CERN.
- Seven GEM 1632x390 mm² chambers were assembled and delivered to JINR.
- Two spare chambers are to be produced by the end of 2020

Preliminary mechanics design for GEM planes precise installation inside the magnet





Upgrade plans:

09.2020 – development of the mechanics design (Pelcom Dubna) and mechanics production for GEM planes precise installation inside the magnet.

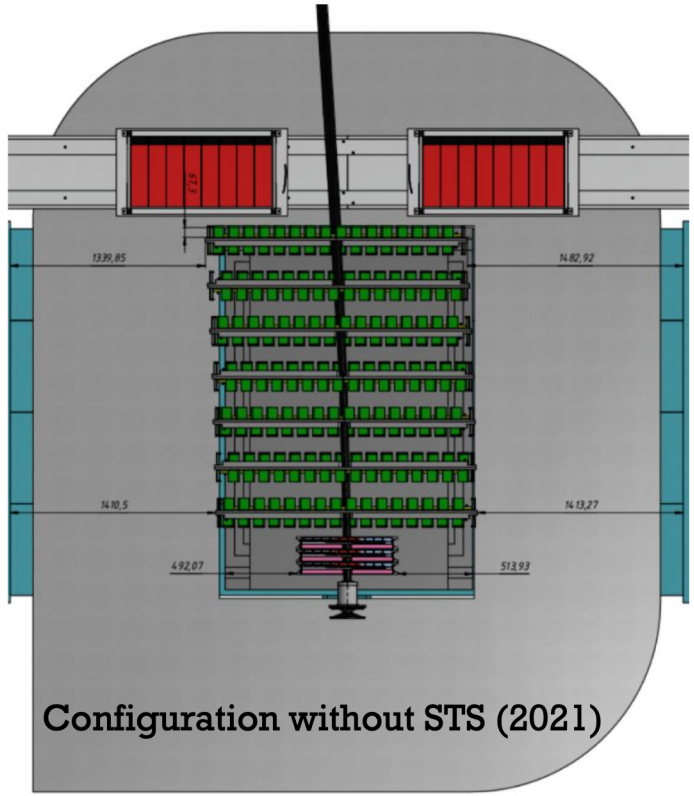
12.2020 – integration of the full GEM planes into the experimental setup (electronics based on the VA-163 chips, ~90000 readout channels)

2022 - Development, tests and integration of FEE based on VMM3/TIGER ASICs.

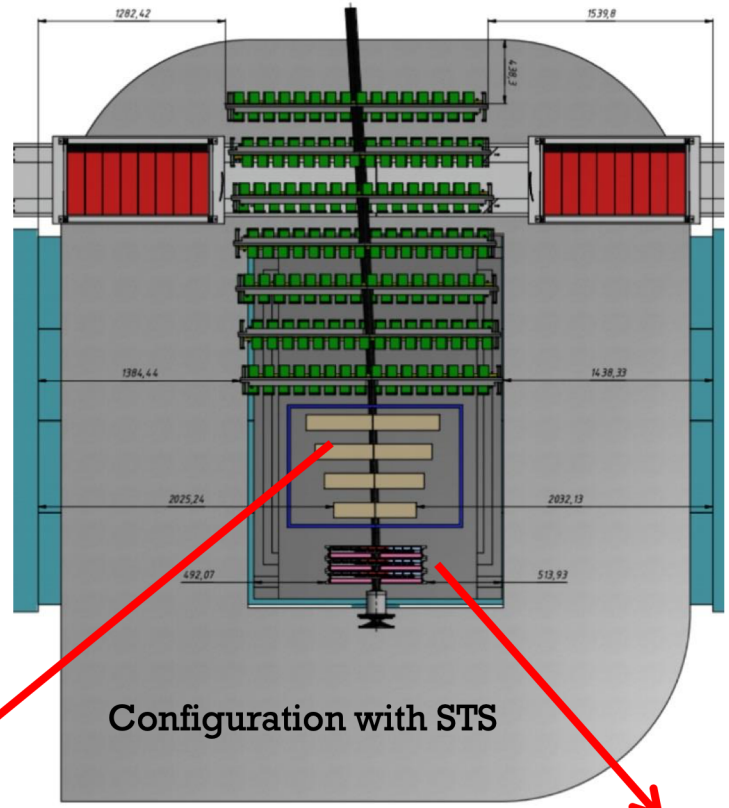
Forward Si+ STS +Gem configuration

Four configurations of the tracking detectors are foreseen:

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



Configuration without STS (2021)



Configuration with STS

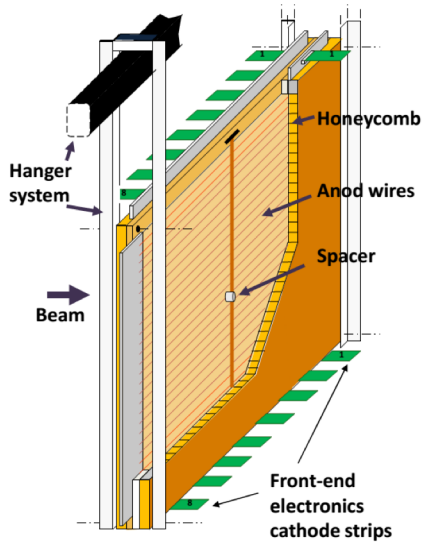
2022 year – “pilot” configuration
After 2022 year – full configuration

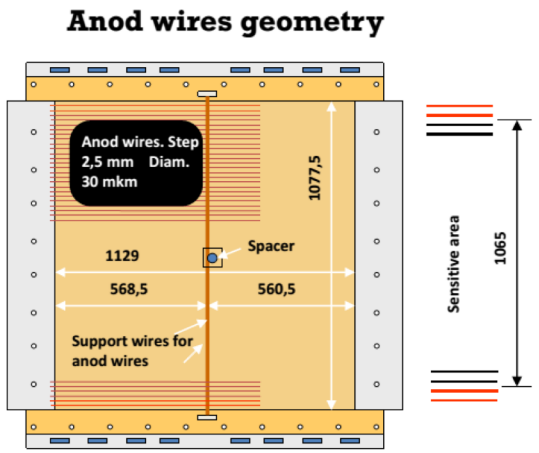
Forward Si will be removed after integration of STS full configuration into BM@N setup
(after 2022 year, high beam intensity - few 10^6 Hz)

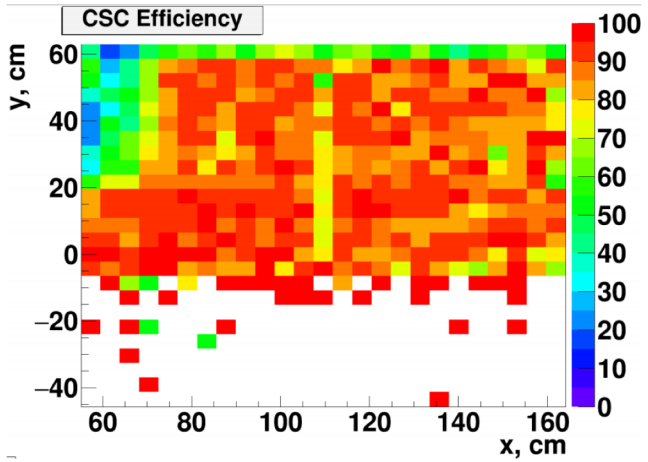
1065x1065 mm^2 CSC chamber

CSC group

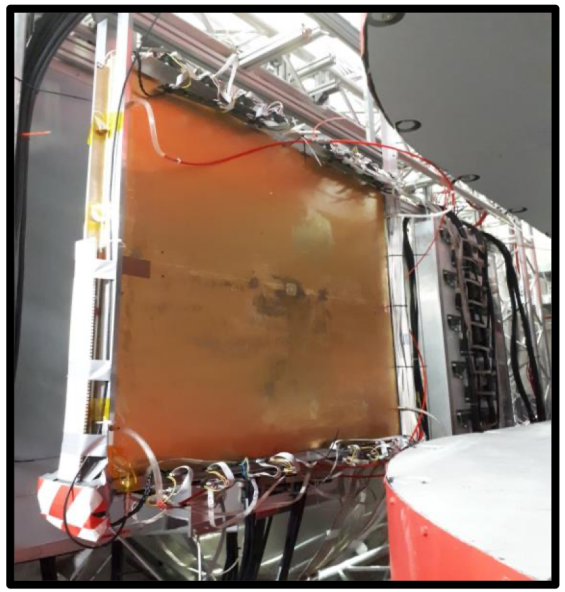
C, Ar and Kr runs in March 2018: CSC chamber is installed in front of ToF-400 to check its performance as outer tracker for heavy ions







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



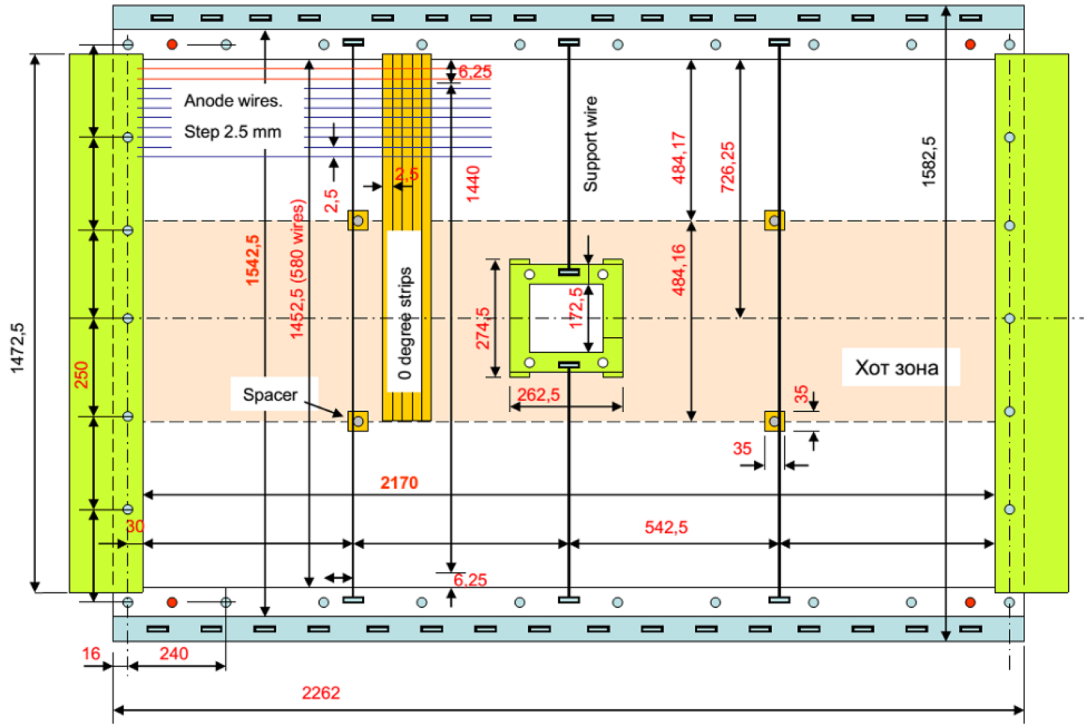
One CSC 1065x1065 mm^2 is produced and tested at Nuclotron beam.

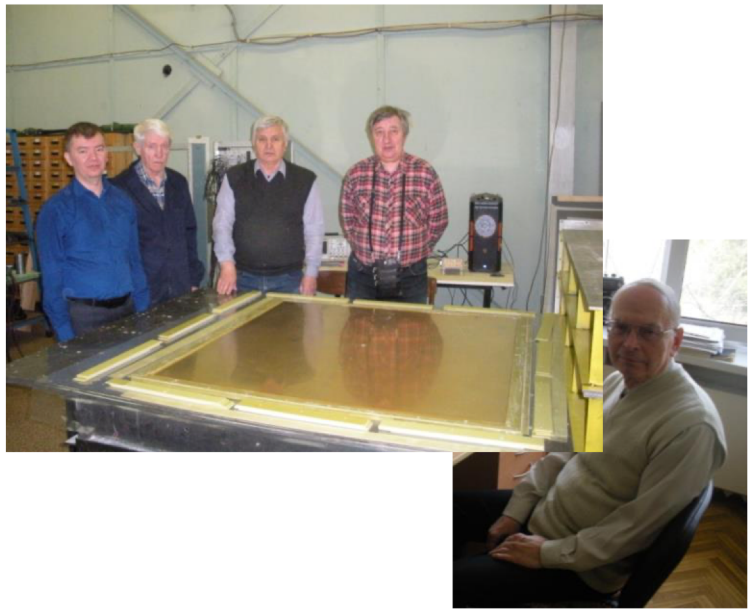
Plans:

- assembly of the three1065x1065 mm^2 chambers is at the final stage: gluing process is finished; delays with wire boning is due to pandemic control measures at JINR
- in autumn 2020 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.

Design of the first PCB is finished.

Design and assembly – JINR LHEP

Production plans:

- 09.2020 – design and production of the cathode planes for 2190x1453 mm^2 CSC chambers

- 03.2021 – Assembly of the 2190x1453 mm^2 CSC

- 09.2021 – All chambers are integrated into the BM@N experimental setup

Status of upgrade

Forward Si tracking detectors:

►Proven technology and FEE readout electronics → used in C, Ar, Kr runs

►Development, production, tests and installation according to time schedule → spring 2021

Beam, Si tracking detectors and target station:

►All detectors and target station to be ready in spring 2021

► Detector performance in heavy ion beam should be tested in first run

GEM tracking detectors:

►All detectors produced at CERN, → tested in C, Ar, Kr runs

►No proven fast FEE for high intensity beam

BM@N STS tracker:

►Complicated module, readout cables and ladder assembly, FEB board and GBTxEMU data transmission board are still in development

►Trigger mode in BM@N instead of free stream for CBM should be proven → probable delay and long commissioning phase

CSC chambers for Outer tracker:

►4 chambers to be ready by end of 2020

►Risk of delay in production of 2 big CSC chambers

ToF identification systems:

►Detectors and readout electronics are ready

►Full setup of ToF-400 and ToF-700 was already in operation in spring 2018

Stages of BM@N experiment

Year	2016	2017 spring	2018 spring	fall 2021	2022
Beam	d(↑)	C	Ar,Kr, C(SRC)	Kr,Xe	up to Au
Max.intensity, Hz	0.5M	0.5M	0.5M	0.5M	0.5M
Trigger rate, Hz	5k	5k	10k	10k	10k
Central tracker status	6 GEM half planes	6 GEM half planes	6 GEM half planes + 3 forward Si planes	7 GEM full planes + forward Si planes	7 GEM full planes + forward Si + 2 large STS planes
Experimental status	technical run	technical run	technical run+physics	physics run	stage1 physics

Thank you for attention!