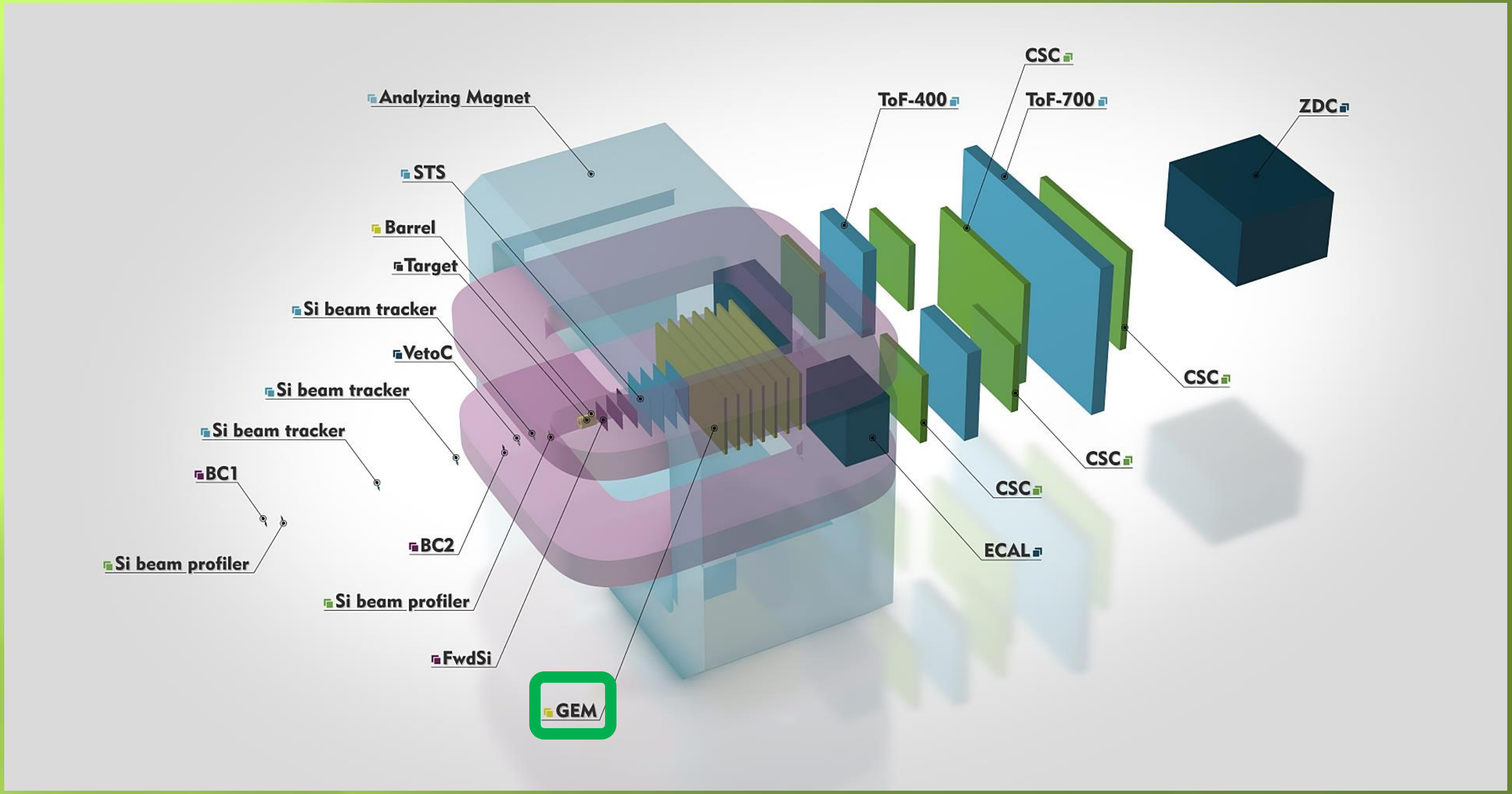
STATUS OF THE GEM TRACKING SYSTEM

Elena Kulish on behalf of BM@N Collaboration

BM@N experiment



The basic requirements for the tracking system are:

- capability of stable operation in conditions of high loadings up to 10^5 Hz/cm^2;

- high spatial and momentum resolution;

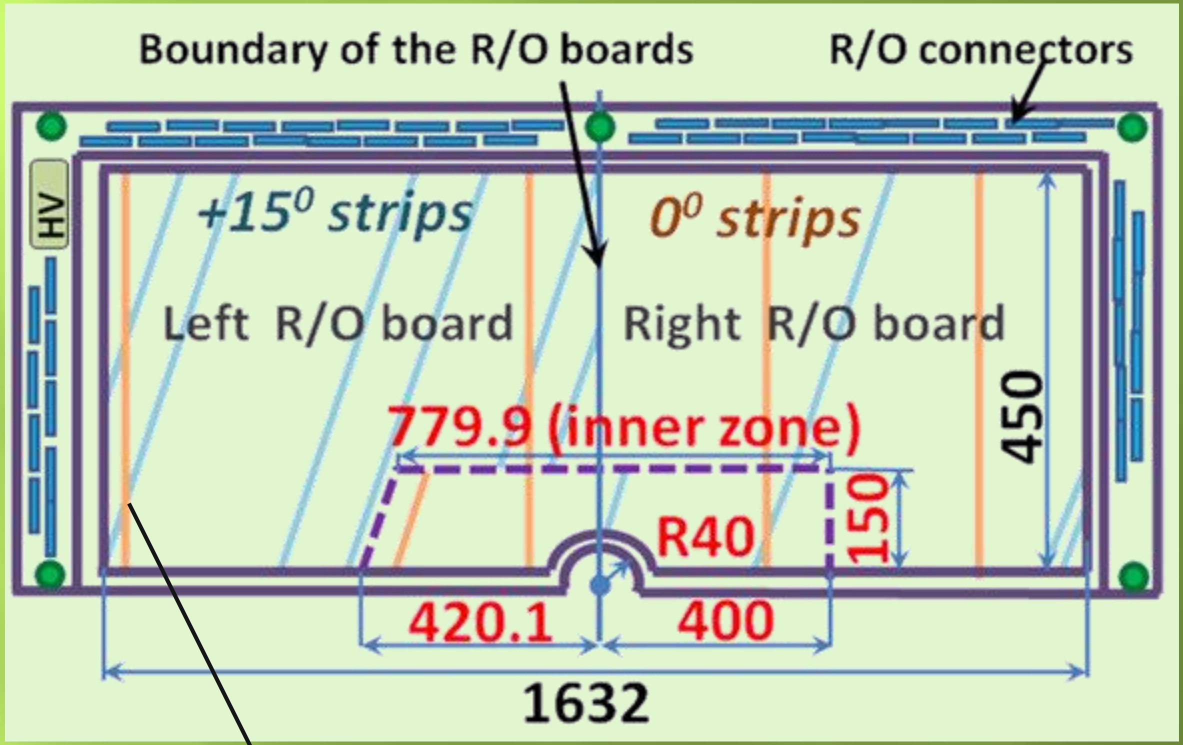
- high geometrical efficiency (better than 95%);

- maximum possible geometrical acceptance within the BM@N experiment dimensions;

- tracking system detectors must function in a 0.8 T magnetic field.

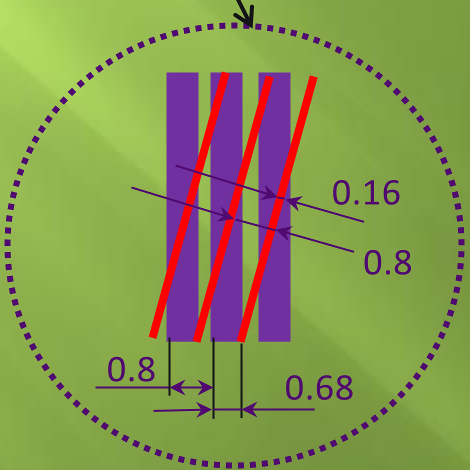
BM@N GEM 1632x450 mm^2 chambers

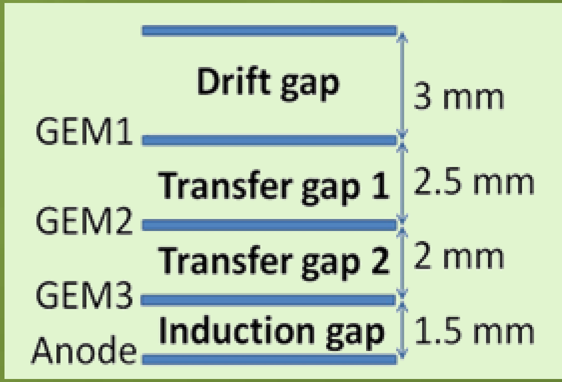
A scheme of two-coordinate readout for 1632x450 mm2 chamber



Readout consists of two parts (left and right) and is divided to hot and cold zones.

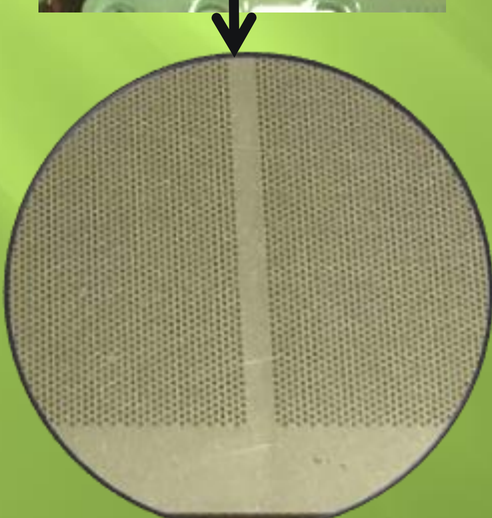
X and Y strips parameters

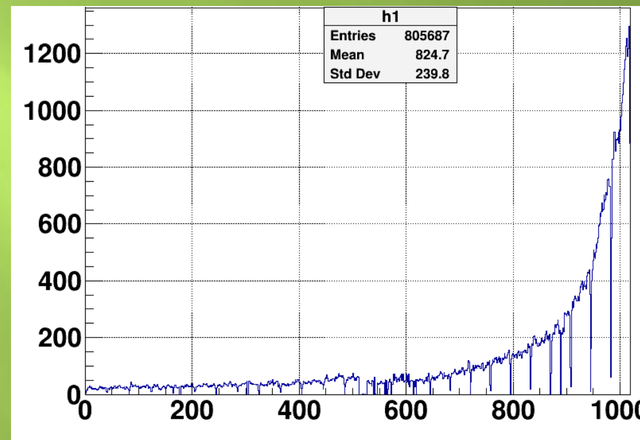




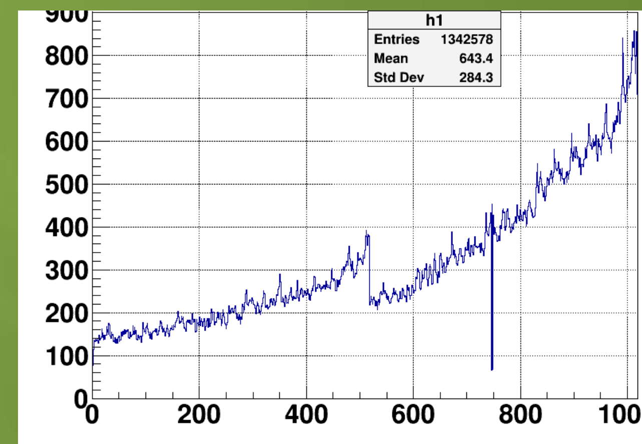
Schematic cross section of BM@N triple GEM detector

GEM foil sector design and occupancy

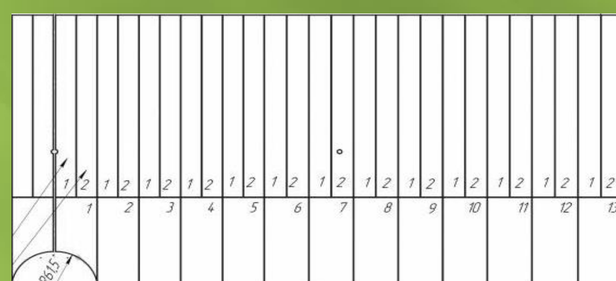




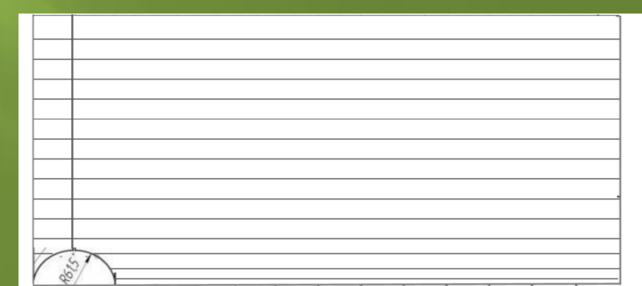
X occupancy



X occupancy



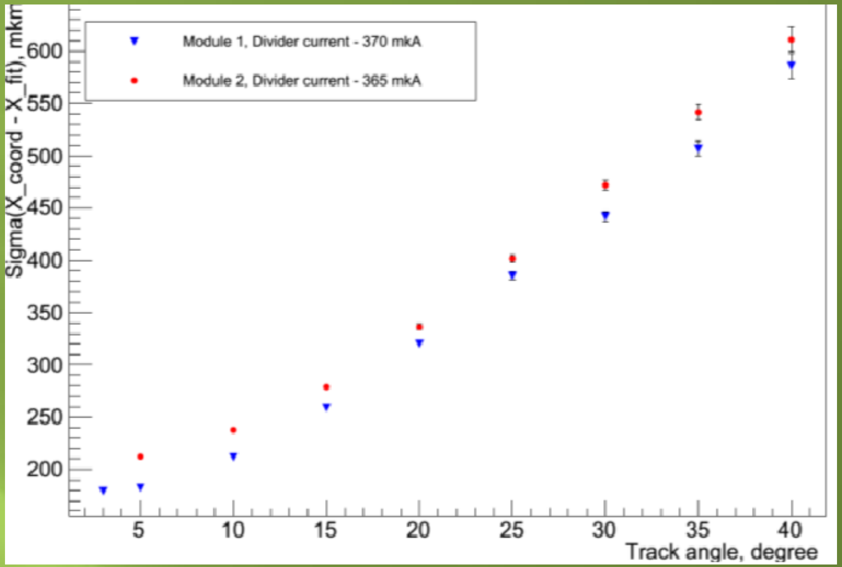
Vertical sectors



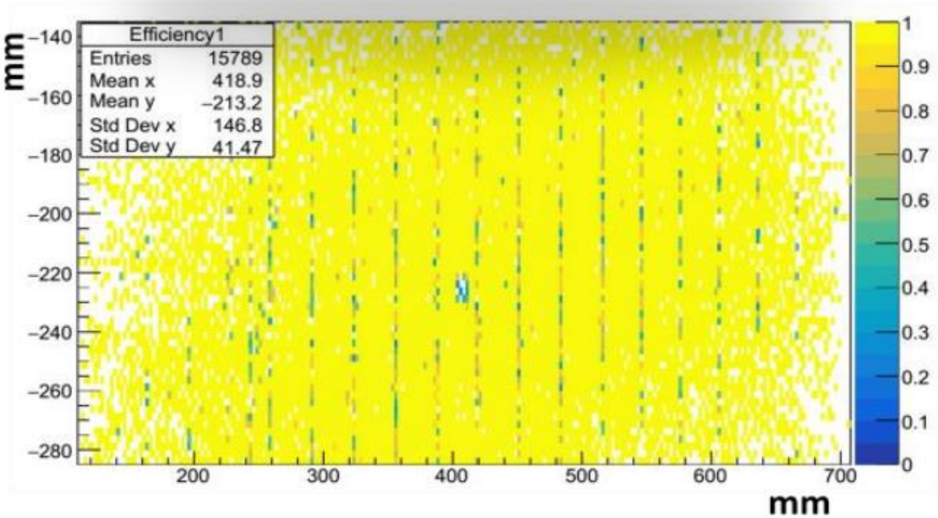
Horizontal sectors

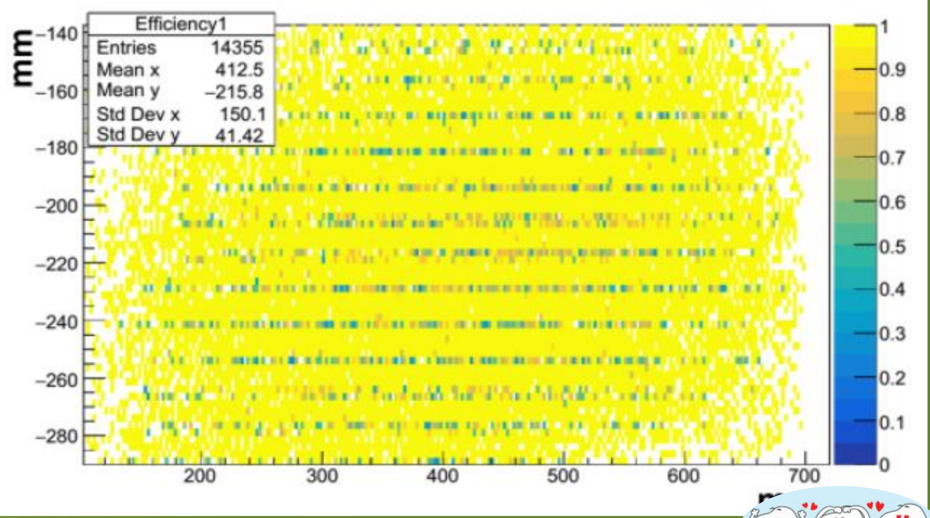
GEM cosmic tests

Cosmic stand



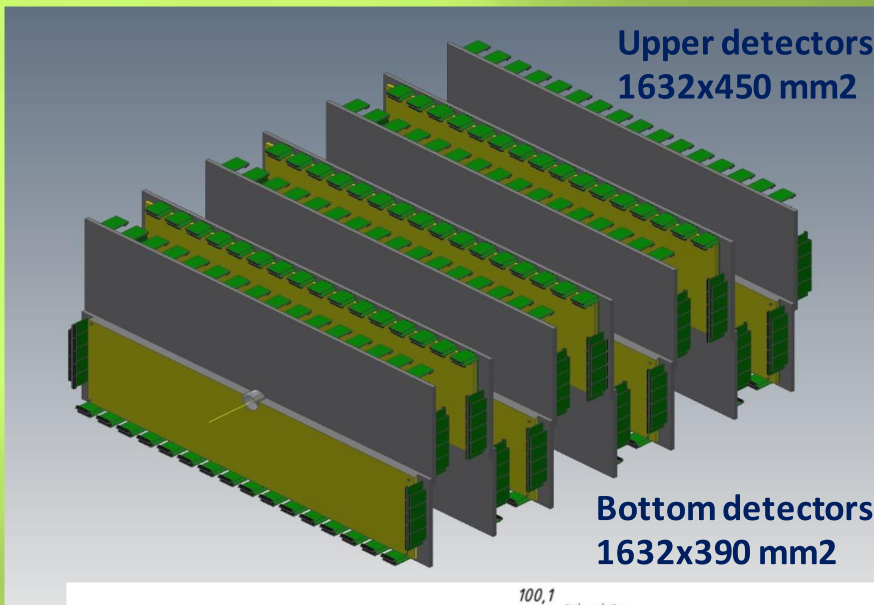
GEM residuals vs track angle

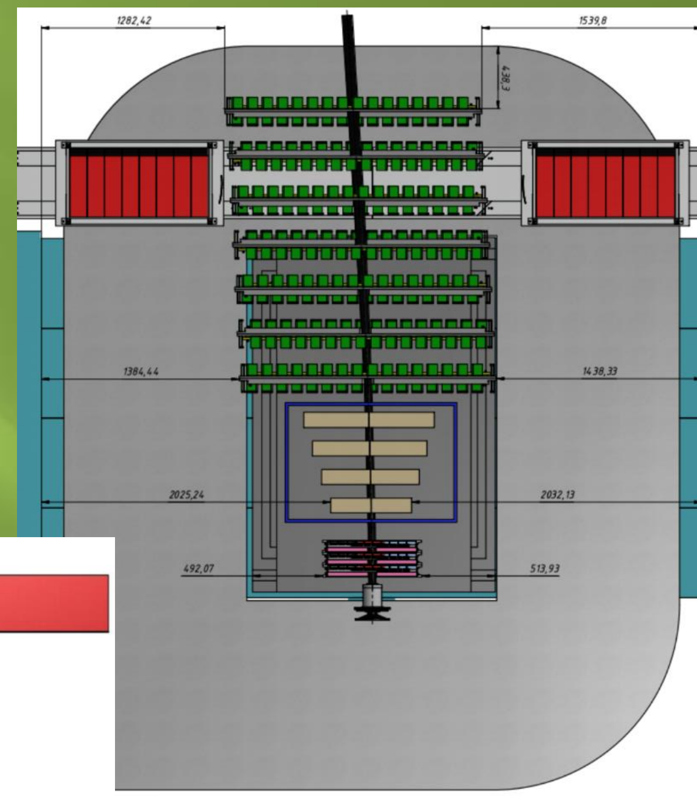


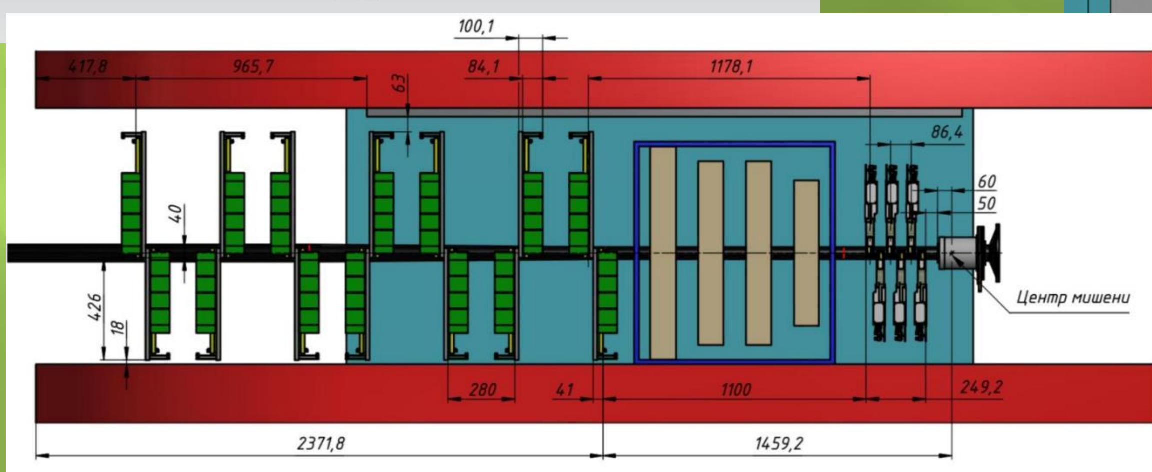


GEM geometrical efficiency

Scheme of the GEM full planes configuration inside the magnet

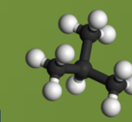






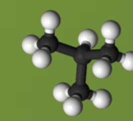
Bracing system for FEE

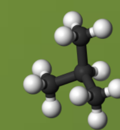
Gas system



Now we have: 1 channel with Argon (80%) + Isobutane (20%) gas mixture, flow = 3 l/h through all series-connected GEM-detectors.
What we want: 7 independent channels to each GEM-plane; reduce and control oxygen and moisture contaminations in gas mixture.

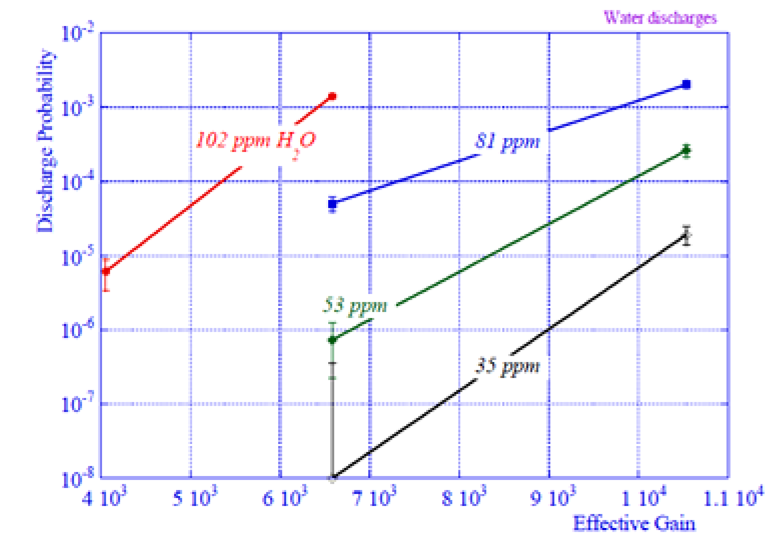
Multi gas controller → $Ar+C_4H_{10}$ mixture → Inline H_20 and 0_2 filter → H_20 and 0_2 analyzer → Distribution panel with rotameters and flow meters





For one channel

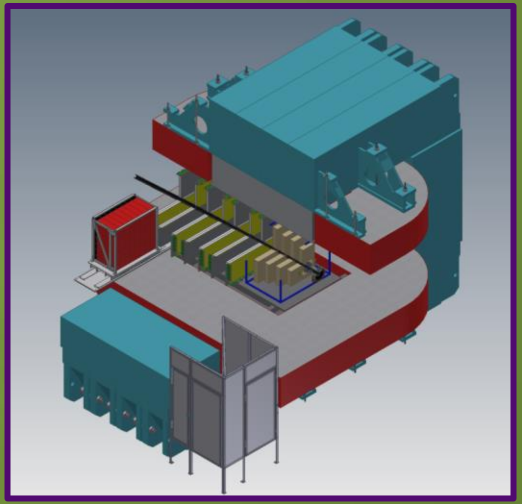
PTFE tube → GEM plane → H_20 and 0_2 analyzer → Oil gate



Discharge probability on alphas as a function of moisture level in the gas. COMPASS

Control O2 by GE sensing oxy.IQ
Control H2O by GE sensing IQ.probe + GE sensing dew.IQ

Conclusions



An upper half of GEM tracking system has been assembled and studied in the d, C, Ar, Kr beams of the Nuclotron accelerator. The measured parameters of the GEM detectors are consistent with the design specifications. Seven GEM chambers with the size of 1632 mm × 450 mm are the biggest GEM detectors produced in the world for today.

7 GEM chambers 1632 × 450 mm^2 and 3 GEM chambers 1632 × 390 mm^2 are produced and already tested at JINR.

Bracing system for FEE is developed and in production.

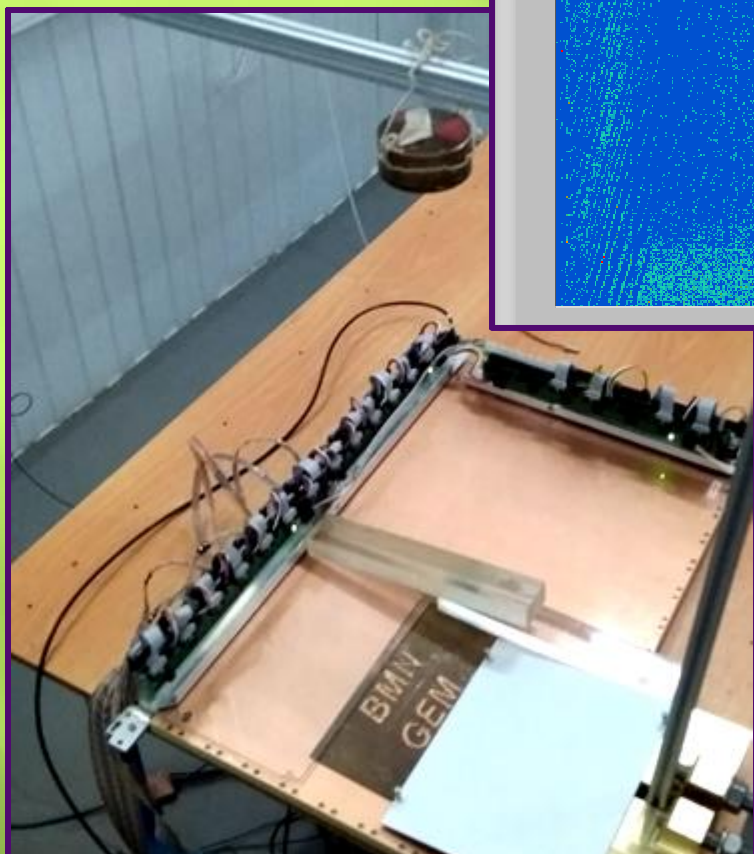
O2 and H2O contamination tests are in process.

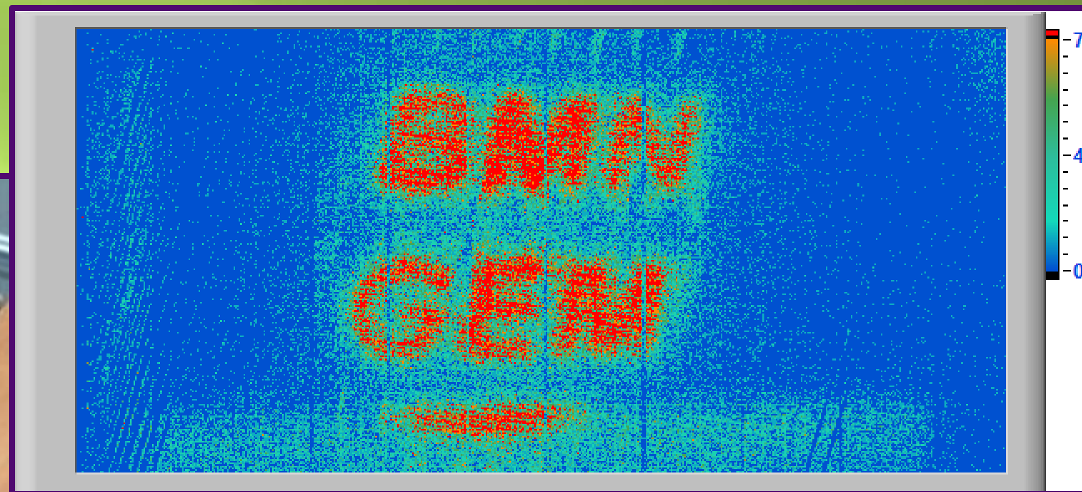
Stand for cosmic tests is assembled.

Design of patch-panels for cables is performed.

Plans

- **12.2019 – production of 4 GEM chambers of size 1632 mm × 390 mm to cover full vertical acceptance of the analyzing magnet**
- **12.2019 – development of the mechanics design for GEM planes precise installation inside the magnet. 03.2020 – mechanics production.**
- **02.2020 – cosmic test of all GEM chambers**
- **03.2020 – integration of the full GEM planes into the experimental setup (electronics based on the VA-163 chips, ~90000 readout channels)**
- **12.2020 – development and tests of FEE based on VMM3/TIGER ASICs**
- **2022 – integration of new FEE**

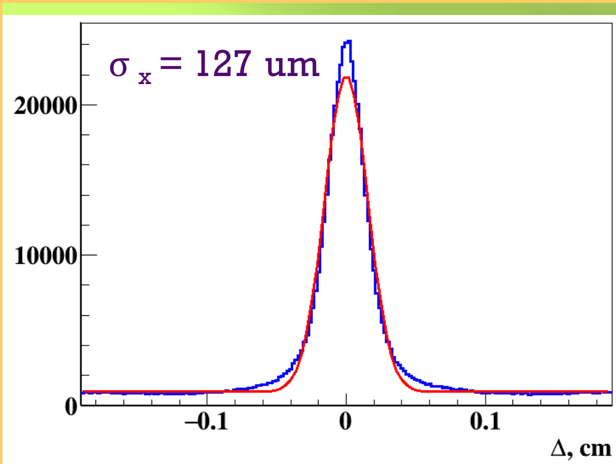




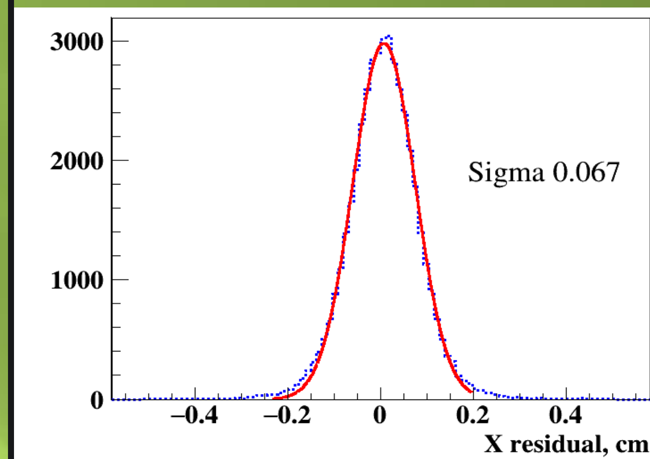
Thank you for your attention!

Back-up slides

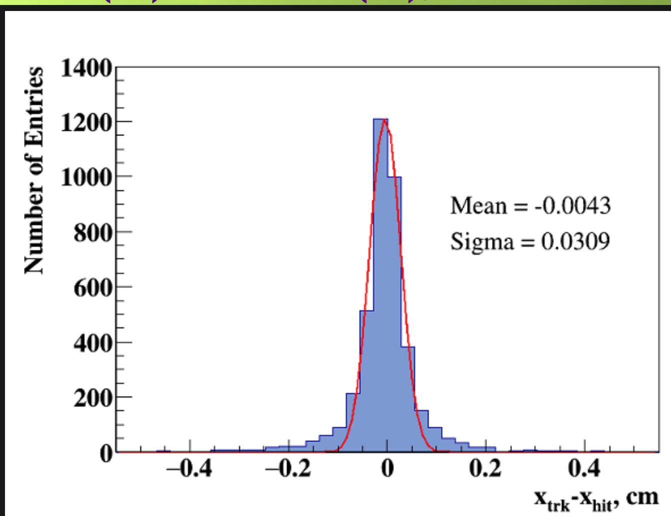
GEM tests at Nuclotron d, C, Ar beams



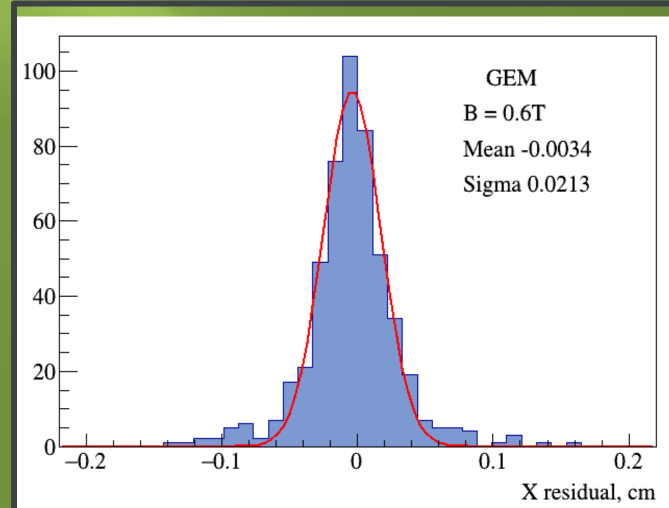
GEM hit residuals, w/o magnetic field,
Ar(90)/IsoButane(10), deuteron beam



GEM hit residuals, magnetic field 0.79 T,
Ar(90)/IsoButane(10), deuteron beam

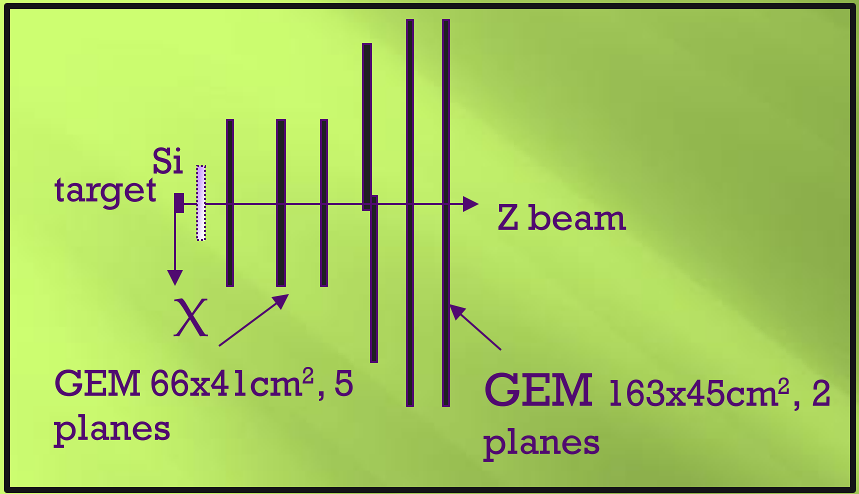


GEM hit residuals, magnetic field 0.59 T,
Ar(70)/CO2(30), carbon beam

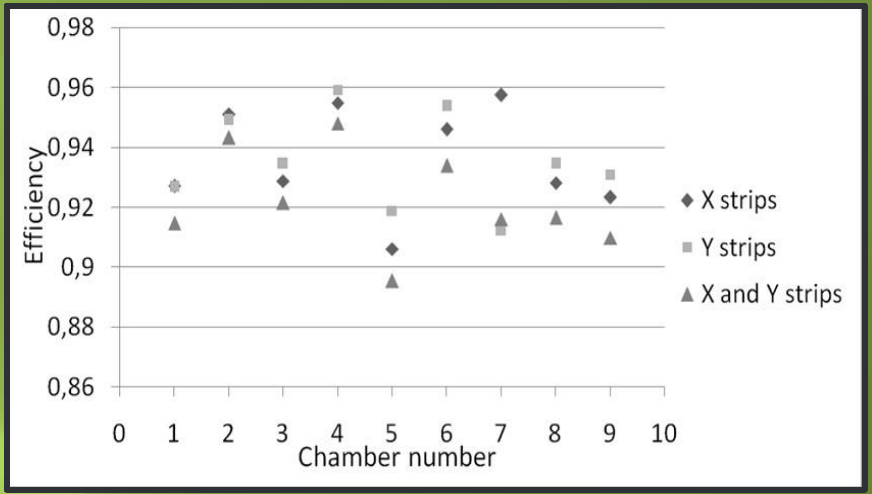


GEM hit residuals, magnetic field 0.6 T,
Ar(80)/Isobutane(20), Ar beam, Edrift = 1.5kV/cm

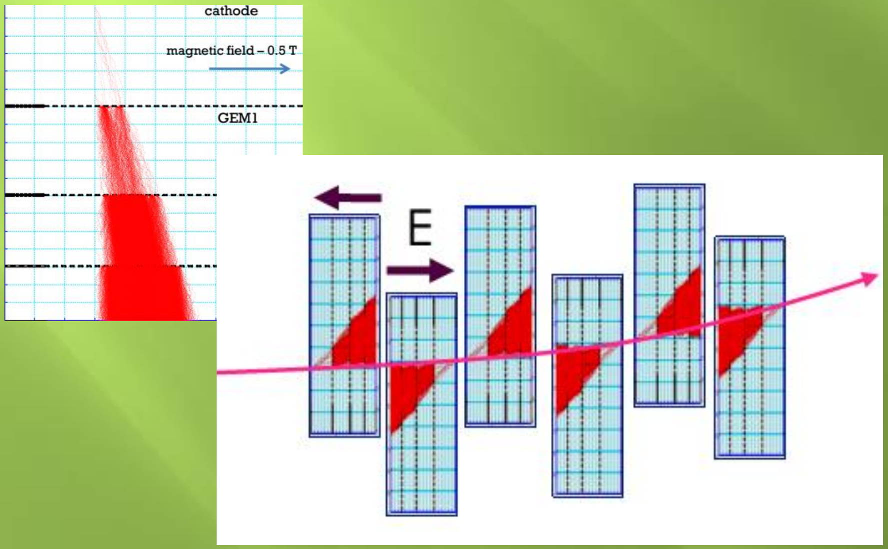
GEM tests at Nuclotron deuteron beam

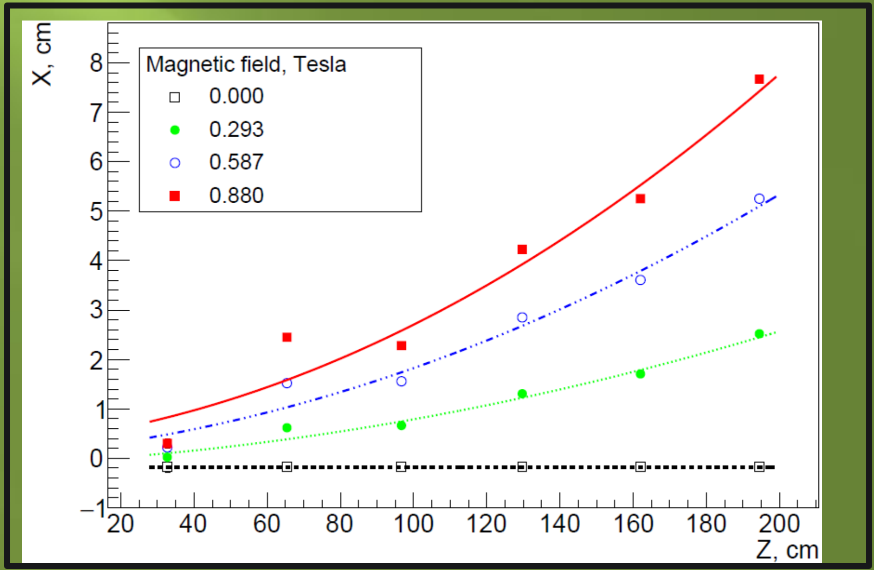


GEM configuration



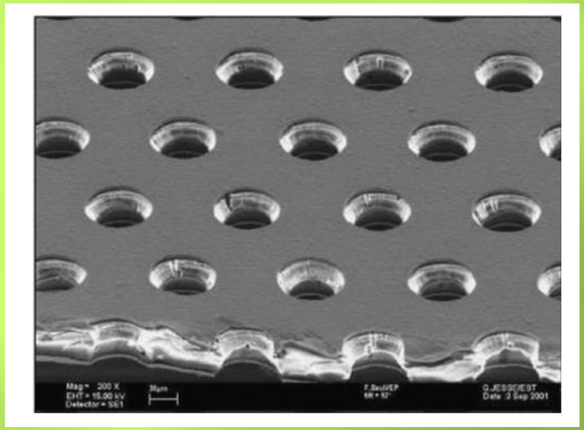
GEM efficiencies



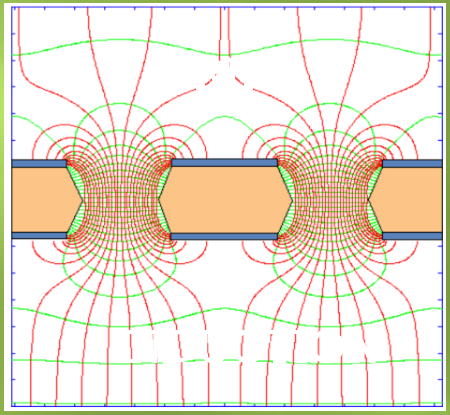


The average trajectories of the deuteron beam and the average Lorentz shifts of an electron avalanche in 6 GEM planes measured for four values of the magnetic field.

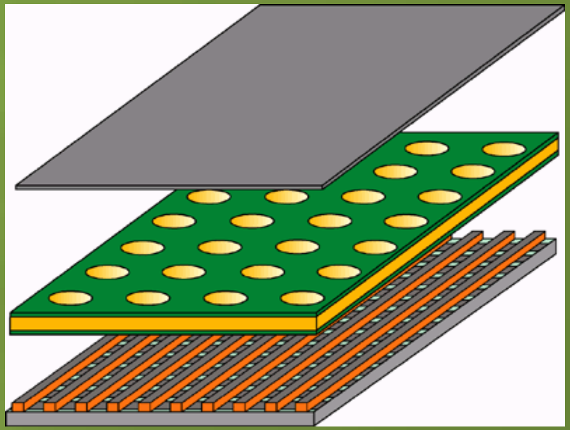
The gas electron multiplier (GEM)



Electron microscope picture of a section of typical GEM electrode, 50 μm thick. The holes pitch and diameter are 140 and 70 μm, respectively.

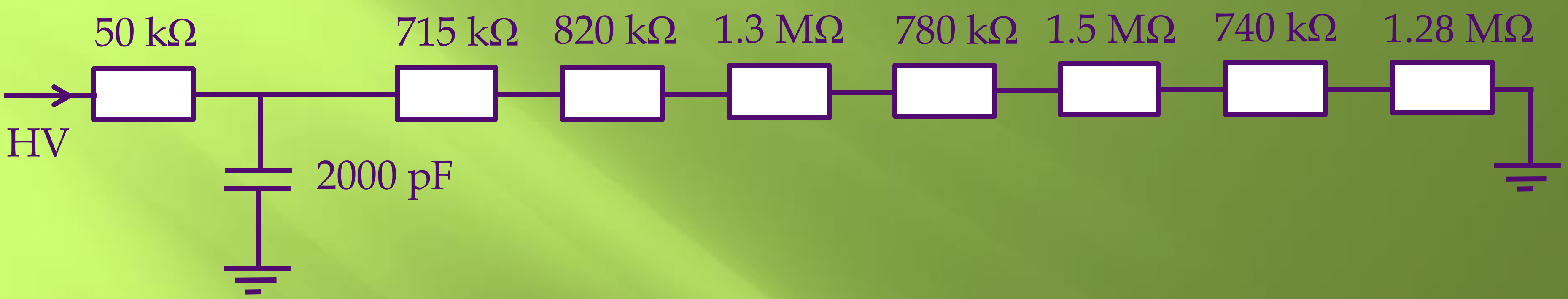


Electric field in the region of the holes of a GEM electrode



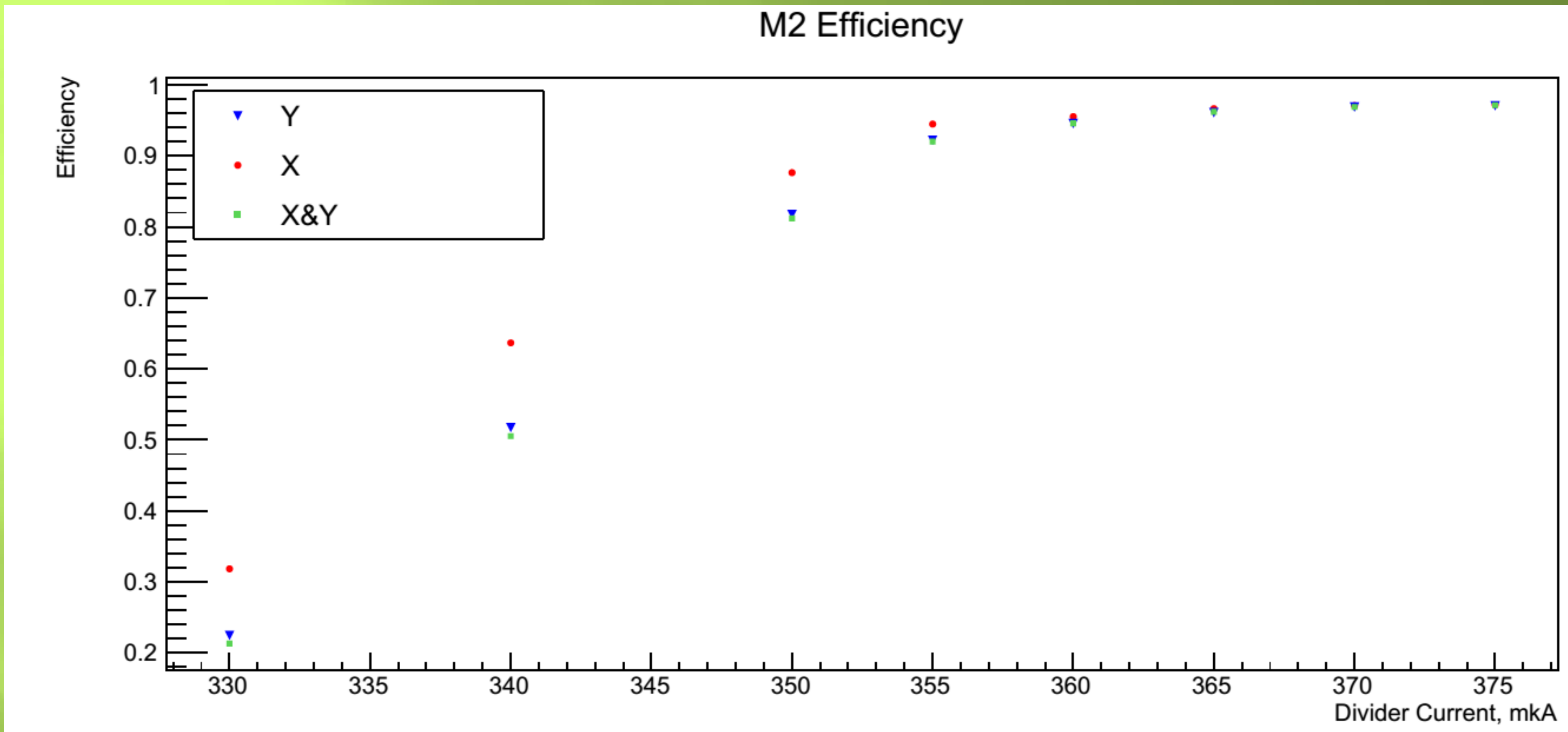
Schematics of single GEM detector with Cartesian two-dimensional strip readout.

GEM HV divider scheme

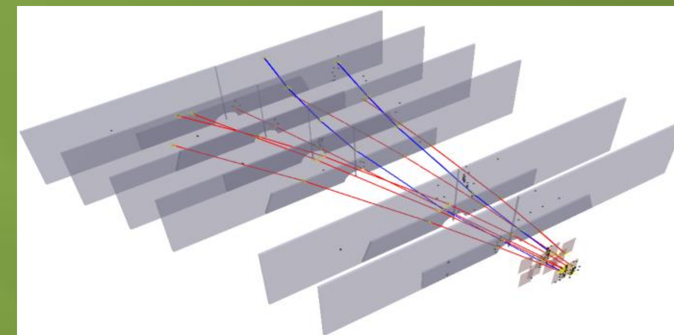


I, mkA	DR, kv/cm	G1, v	TR1, kv/cm	G2, v	TR2, kv/cm	G3, v	IND, kv/cm
370	0.88	303.4	1.92	288.6	2.78	273.8	3.16
490	1.17	402	2.58	382	3.68	363	4.18

370 mkA – working point for Ar(90)/Isobutane(10) gas mixture
490 mkA – working point for Ar(70)/CO2(30) gas mixture


M2 Efficiency
Efficiency
Y
X
X&Y
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
330
335
340
345
350
355
360
365
370
375
Divider Current, mkA

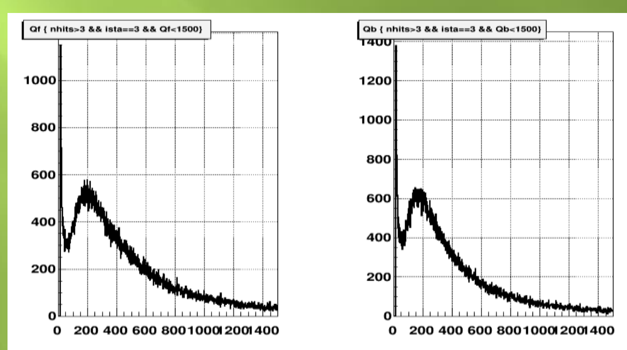
GEM central tracking system performance at Ar and Kr beams (March 2018)



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

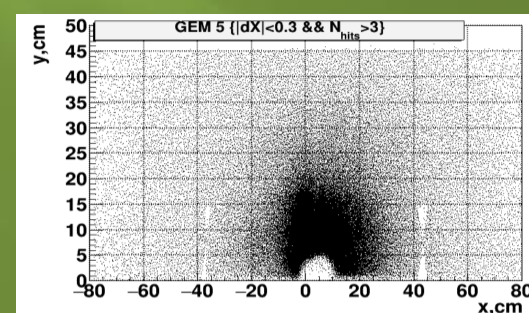
Seven GEM 1632x450 mm^2 chambers produced
at CERN workshop were integrated into BM@N experimental setup.

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



Amplitude, ADC counts Amplitude, ADC counts

GEM X&Y amplitude distributions



Fragments of Ar beam in one
of the GEM chambers