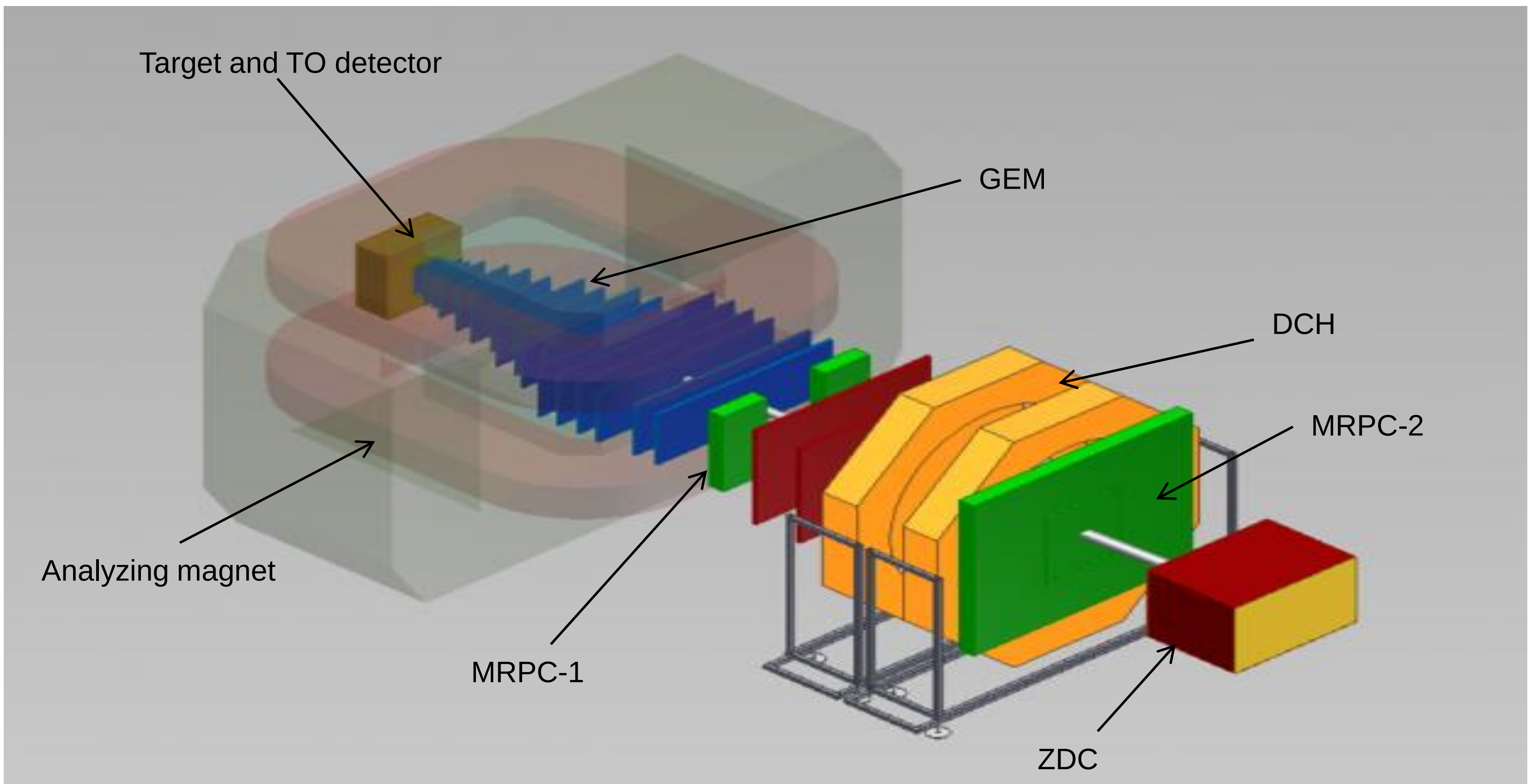
GEM central tracking detectors

Anna Maksymchuk on behalf of BM@N Collaboration

BM@N experiment

Collisions of Nuclotron heavy ion beams with fixed targets provide a unique opportunity to study strange mesons and multi-strange hyperons close to the kinematic threshold. One of the main goals of the experiment is to measure yields of light hyper-nuclei, which are expected to be produced in coalescence of Λ-hyperons with nucleons.



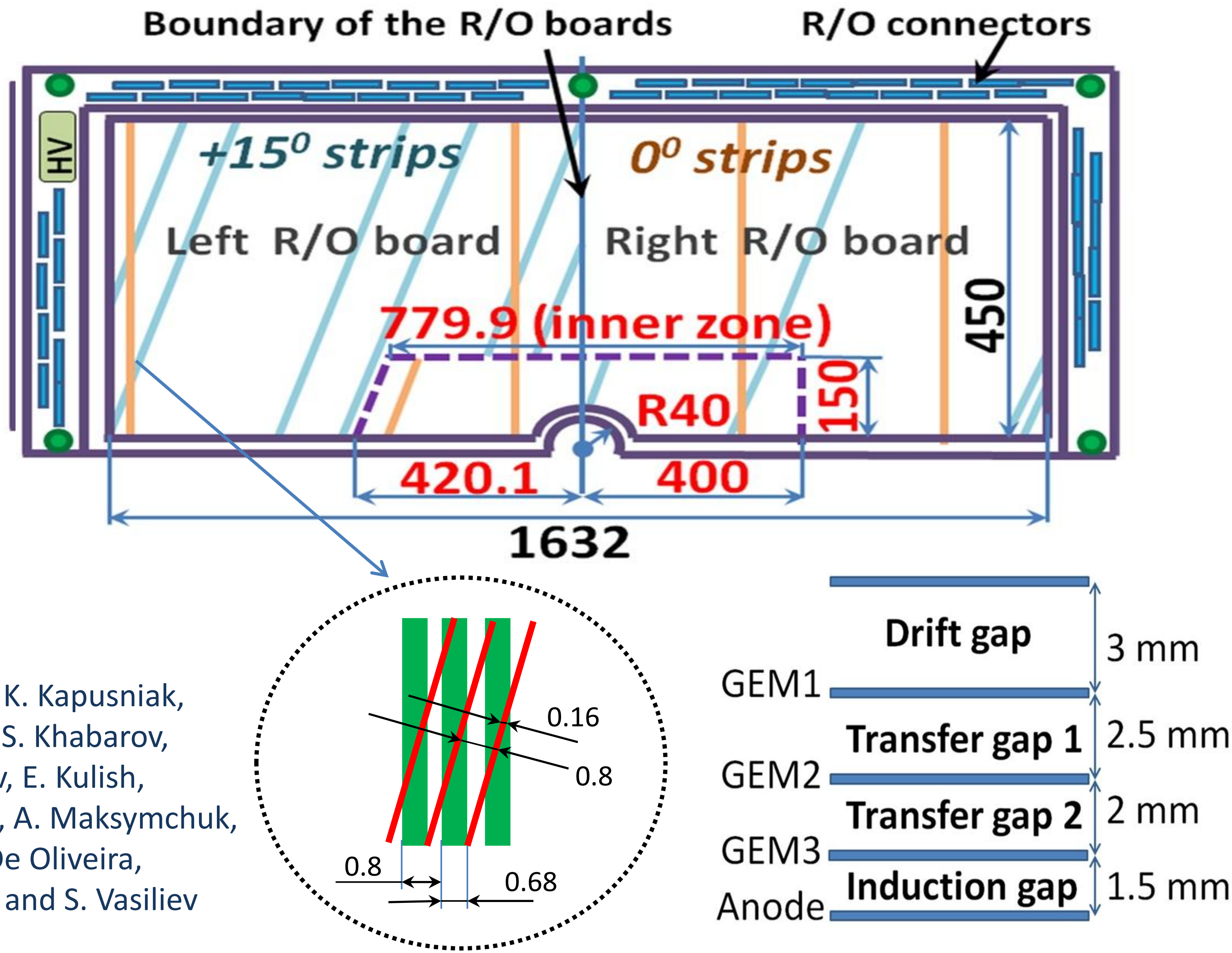
Basic requirements for the BM@N tracking system

Tracking system of the BM@N experiment will provide precise momentum measurements of the cascade decays products of multi-strange hyperons and hyper-nuclei produced in central Au-Au collisions. All physics measurements will be performed in conditions of high beam intensities in collisions with large multiplicity of charged particles. This requires the use of detectors with the capacity to resolve multi tracks produced at very high rate.

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



GEM group:
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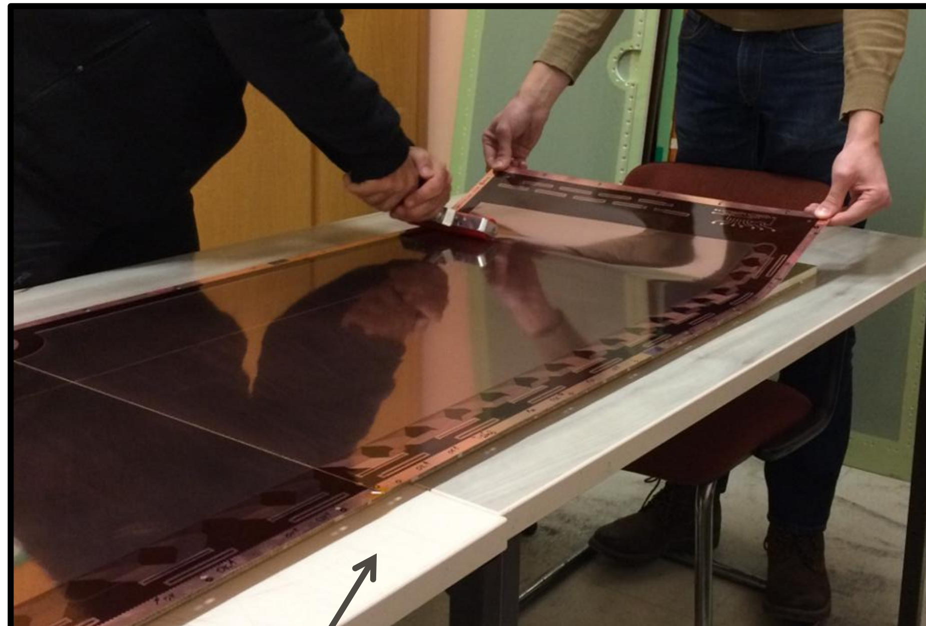
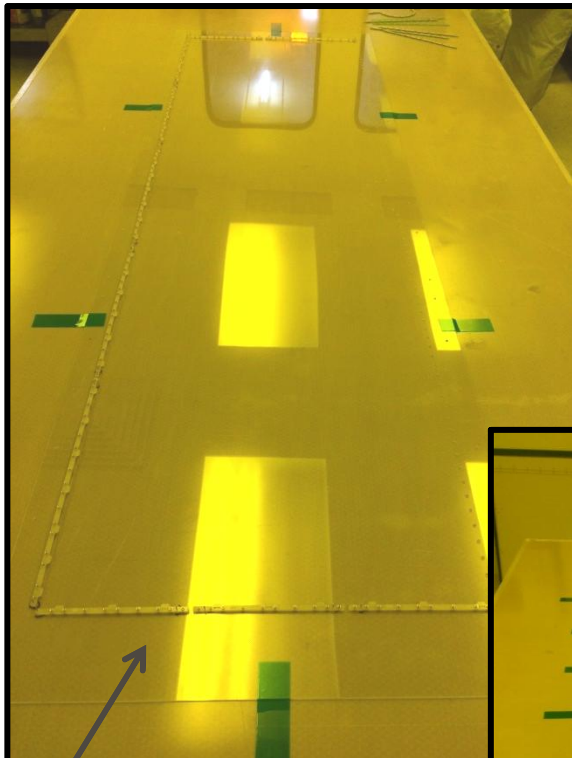
GEM assembly at CERN Workshop
Readout board preparation

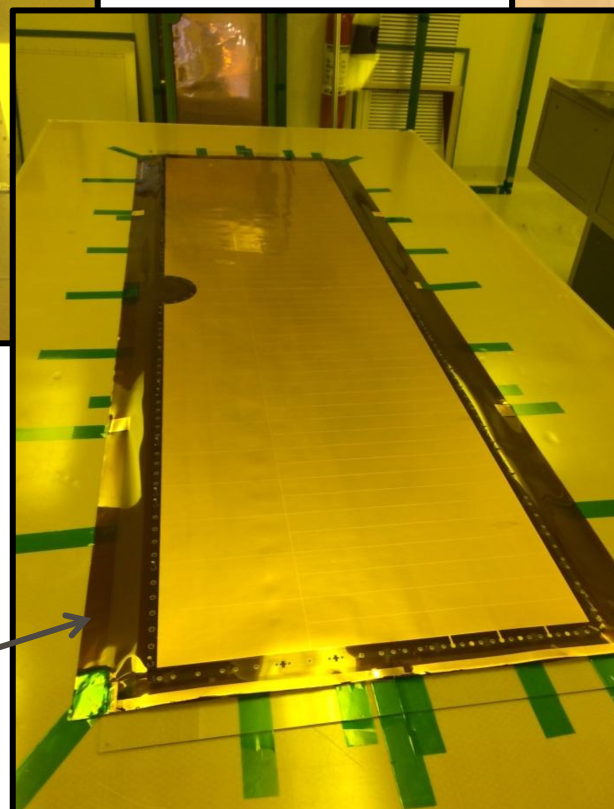


Right readout board

Gluing of the readout boards
on the honeycomb support plane

GEM assembly at CERN Workshop



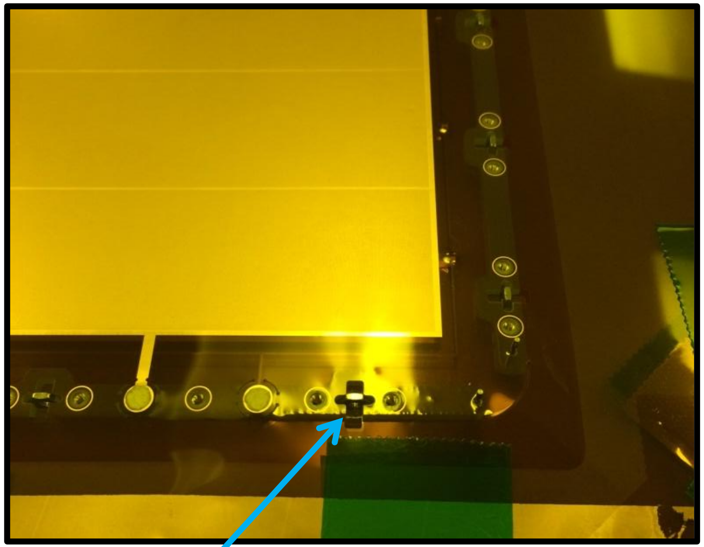


Base plastic frame

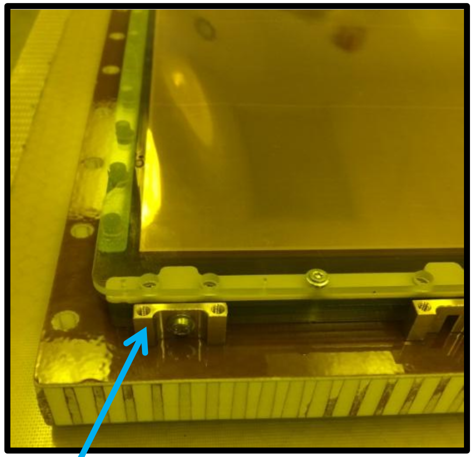
GEM foil tests

GEM foil preliminary stretching

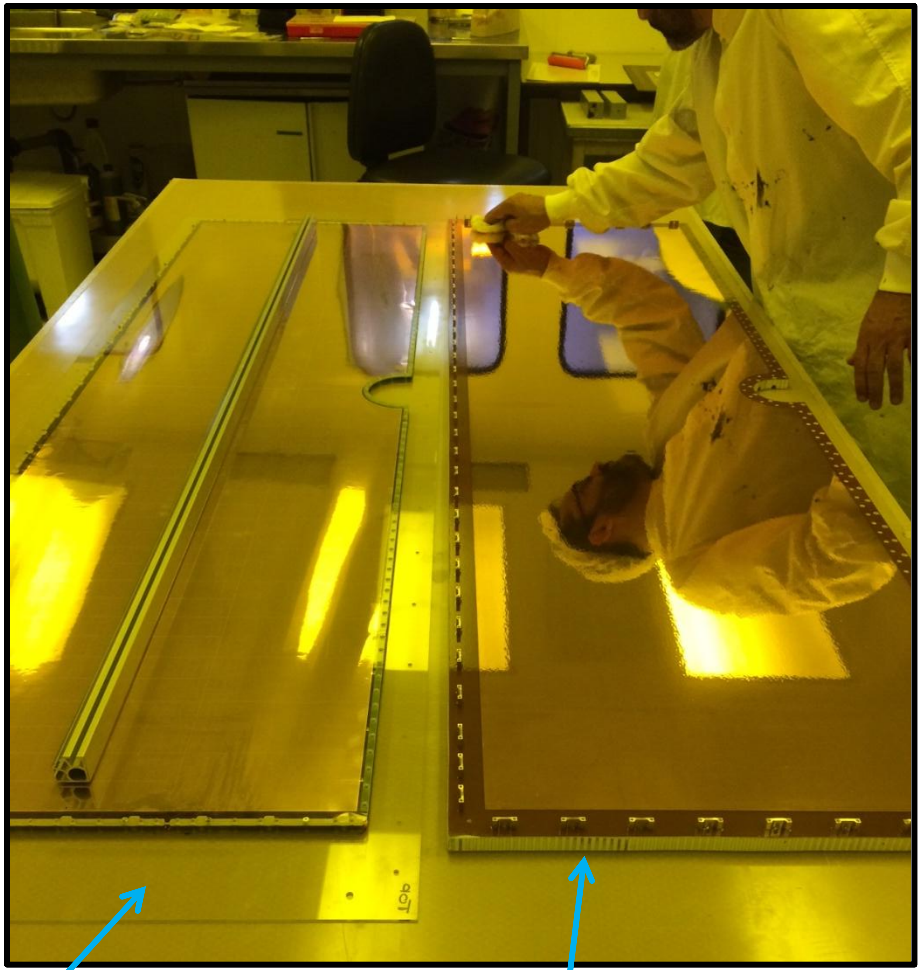
GEM assembly at CERN Workshop



Nuts in plastic frames



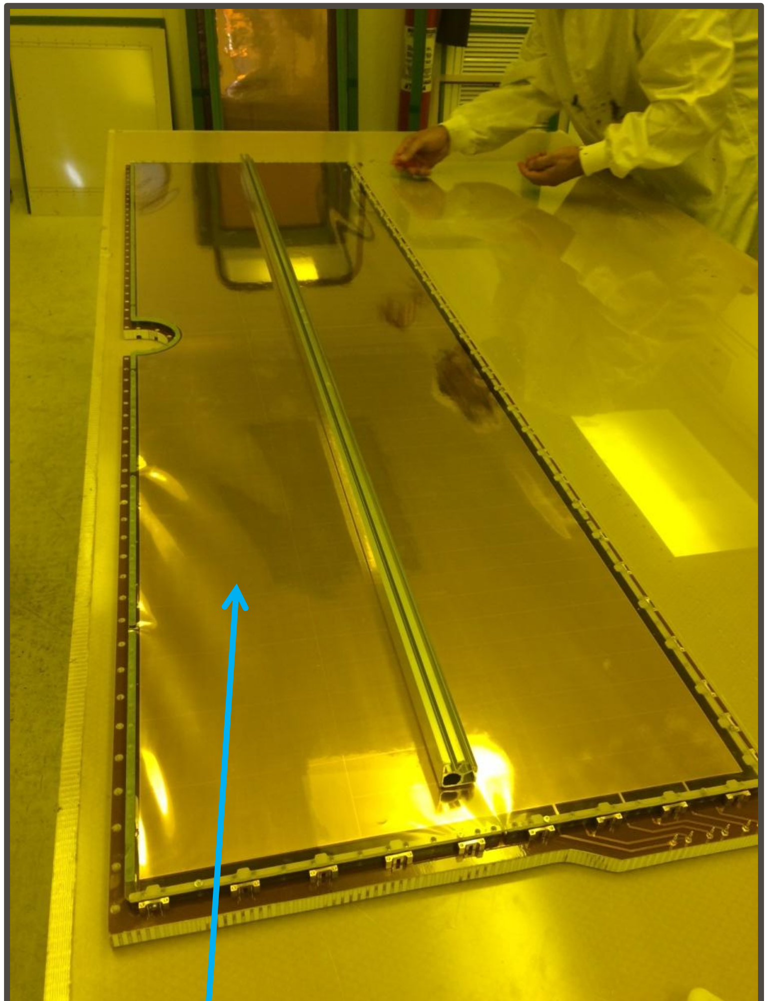
Brass fitting

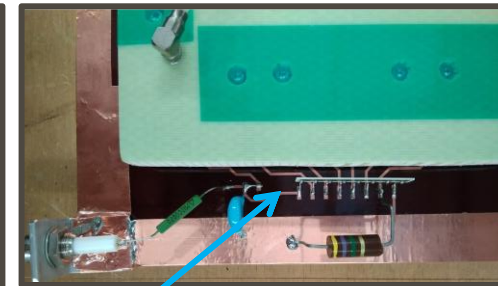


Stack of 3 GEMs

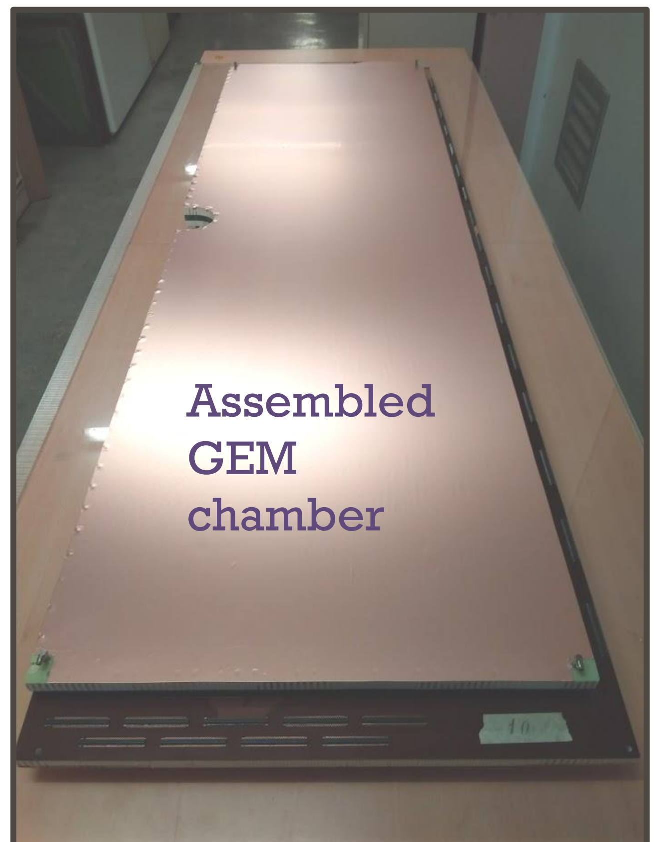
Cathode plane

GEM assembly at CERN Workshop





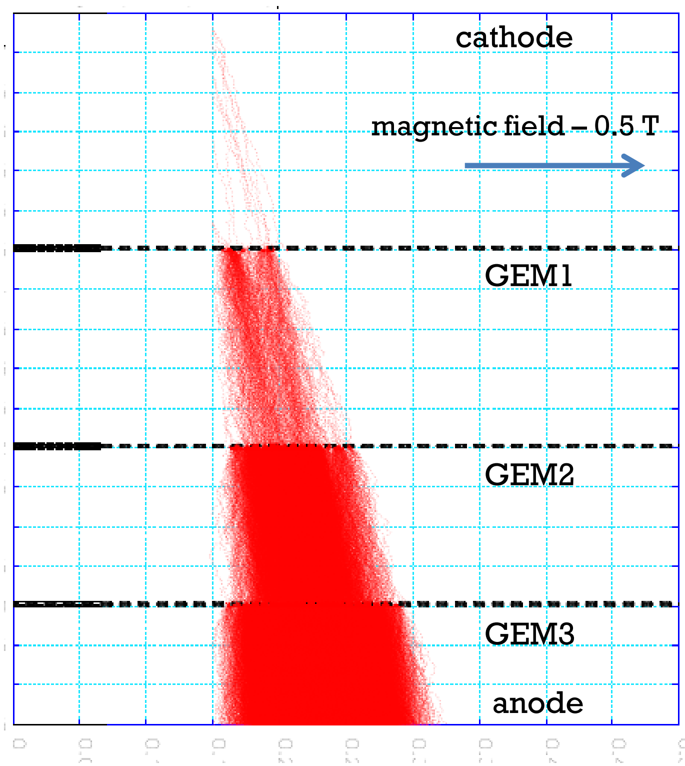
HV divider



Stretching process

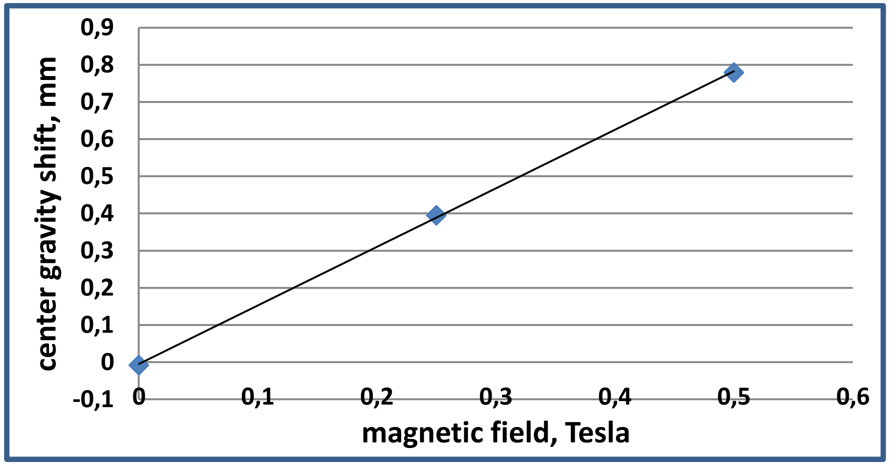
Electrons drift due to magnetic field (Garfield & Maxwell simulations)

Simulation of electron shift in magnetic field

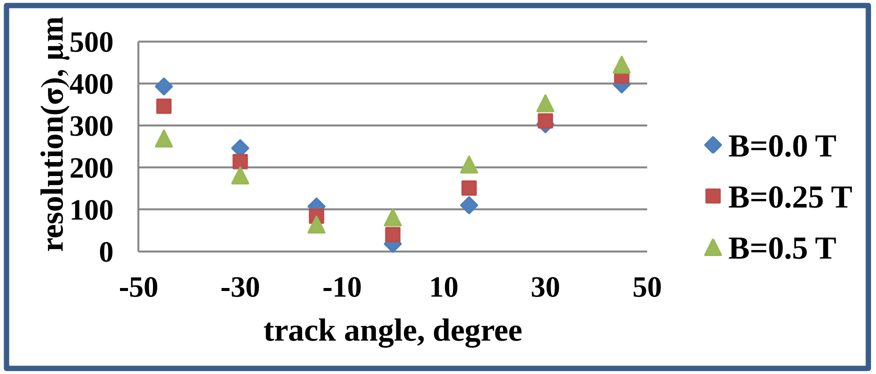


Ar(70)/CO_2(30) gas mixture

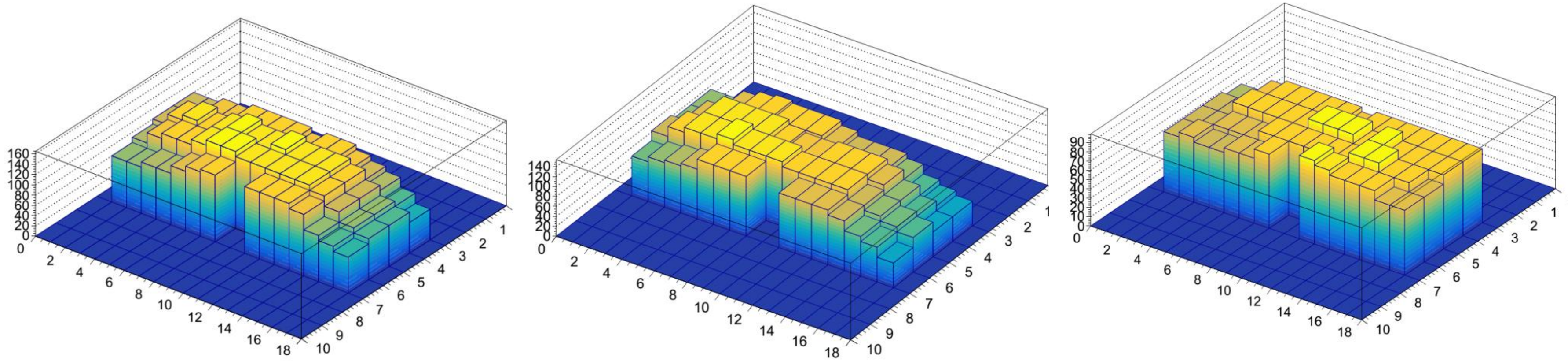
Center gravity shift vs magnetic field



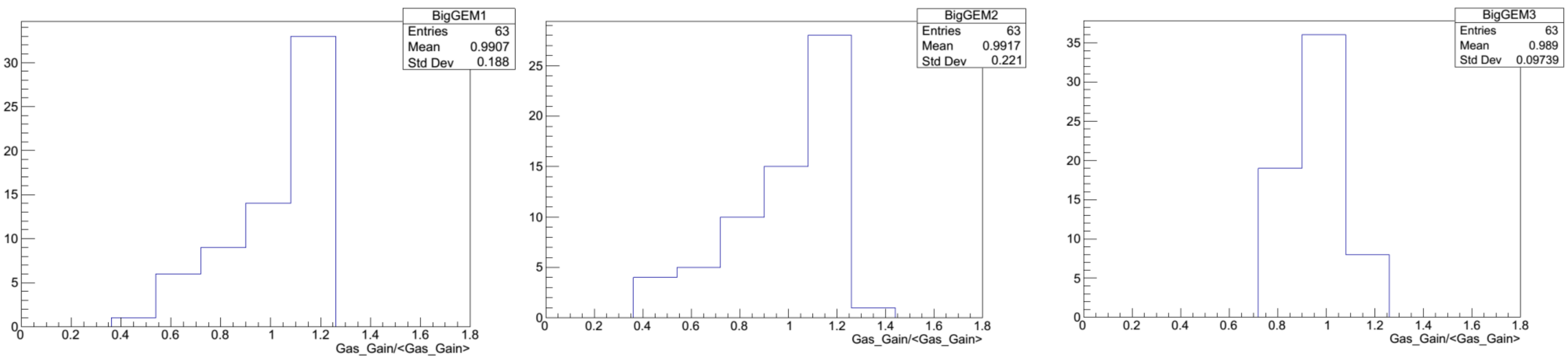
Space resolution vs magnetic field and track angle



GEM 1632x450 mm^2 response uniformity



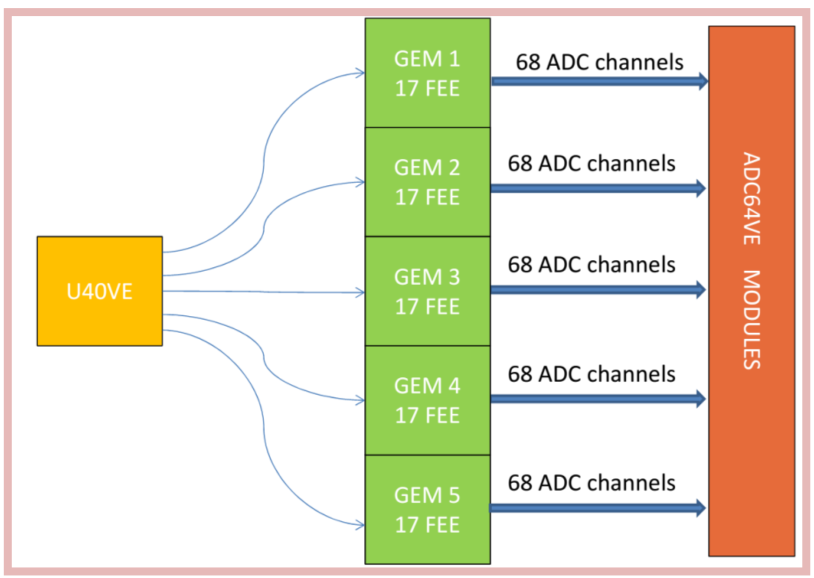
Response uniformity 3D plot of three 1632x450 mm^2 chambers, Ar(90)/Isobutane(10) gas mixture

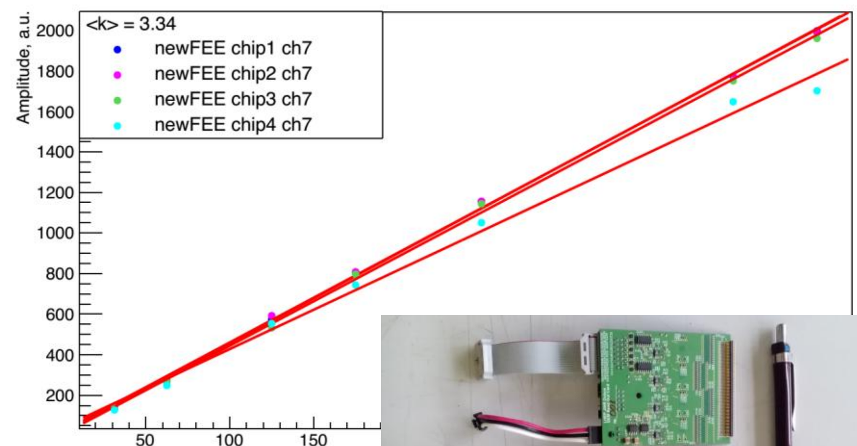


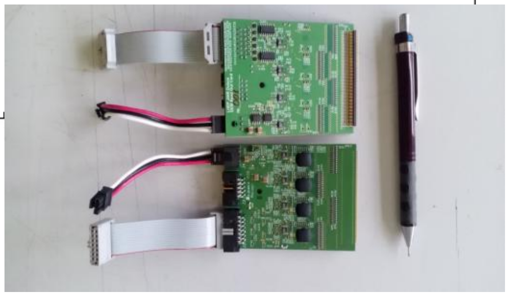
Gas gain distribution normalized on average gas gain for three 1632x450 mm^2 chambers, Ar(90)/Isobutane(10) gas mixture

GEM Electronics

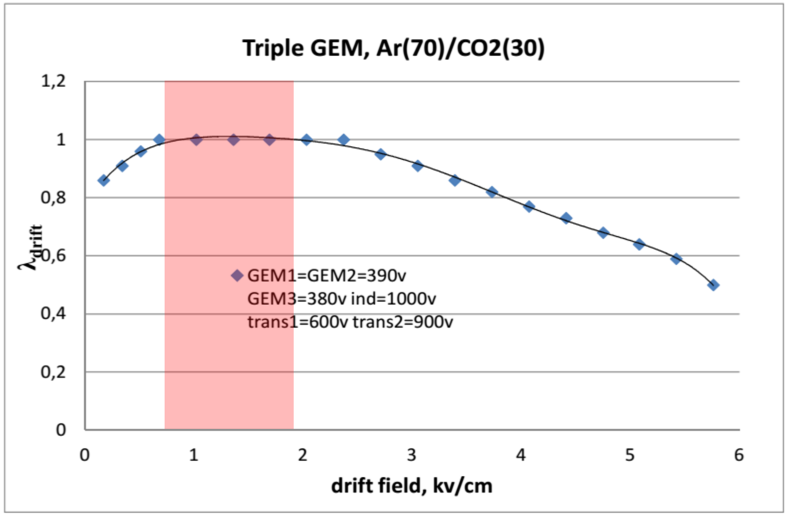
	VA162	VA163
Number of channels	32	32
Input charge	-1.5pC ÷ +1.5fC	-750fC ÷ +750fC
Shaping time	2÷2.5μs	500ns
Noise	2000e ENC at 50pF load	1797e ENC at 120pf load
Linearity positive charge	1%	0.5%
Linearity negative charge	3%	1.4%
Gain	0.5 μA/fC	0.88μA/fC
Total power max.	66mW	77mW

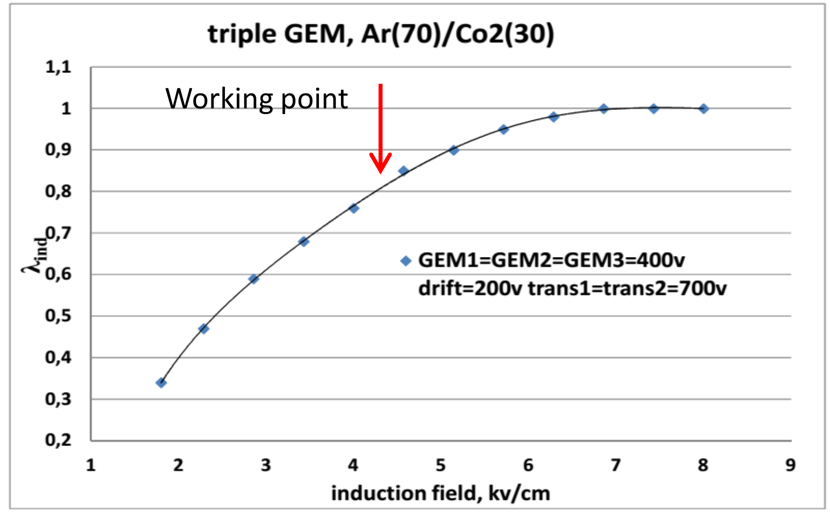


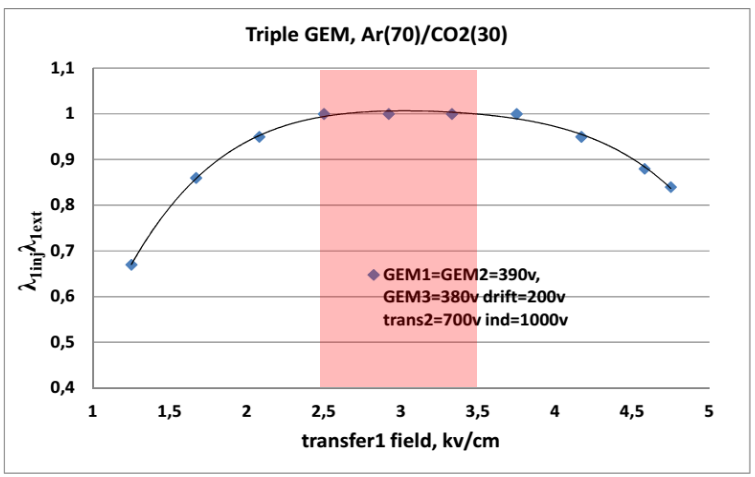


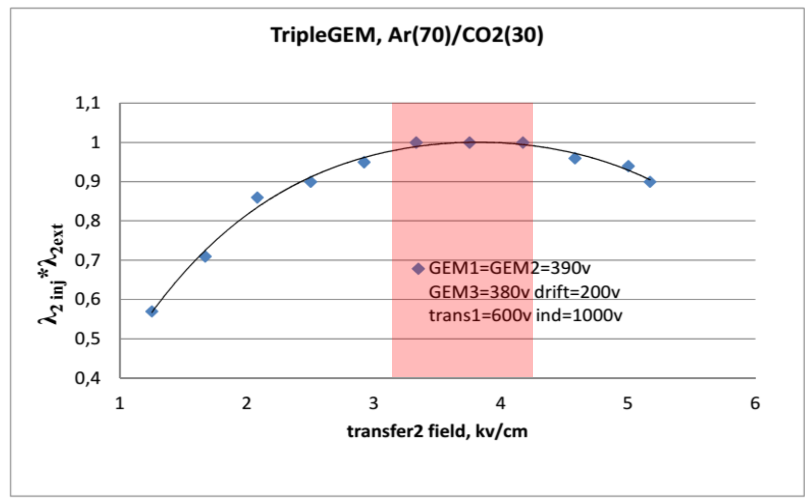


GEM Optimization



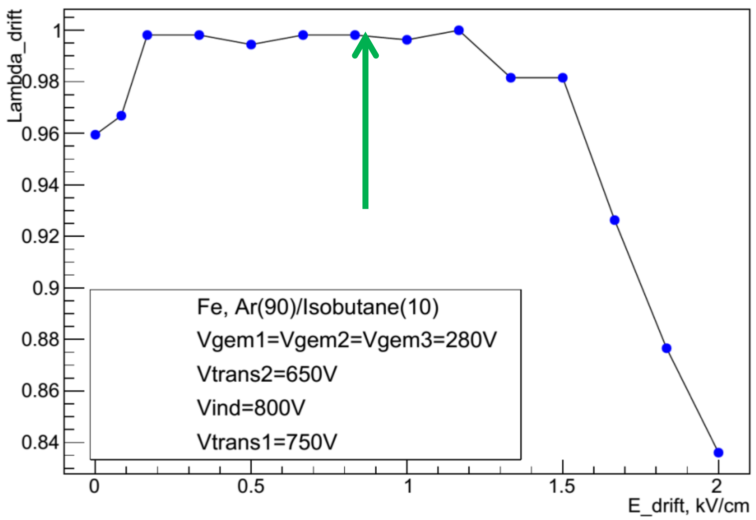


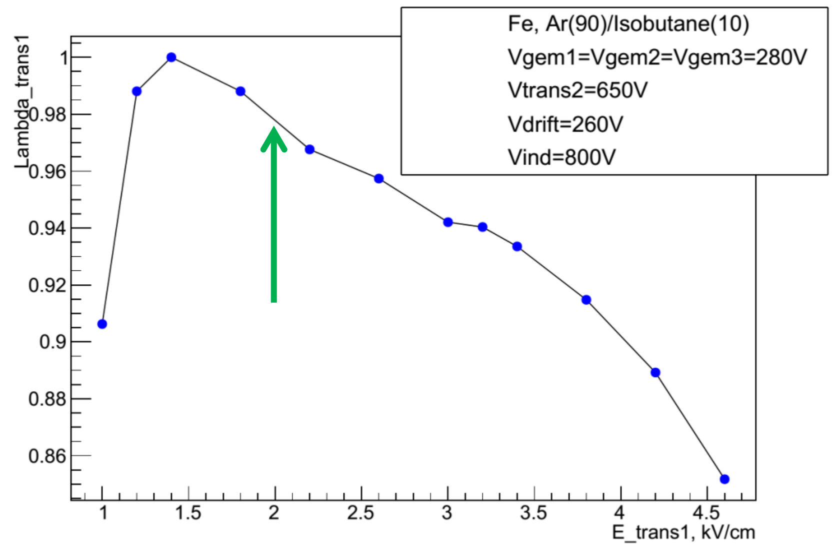


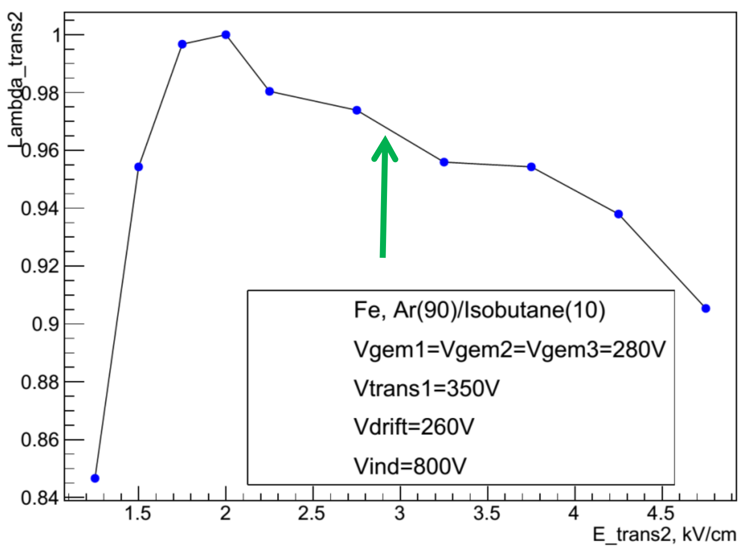


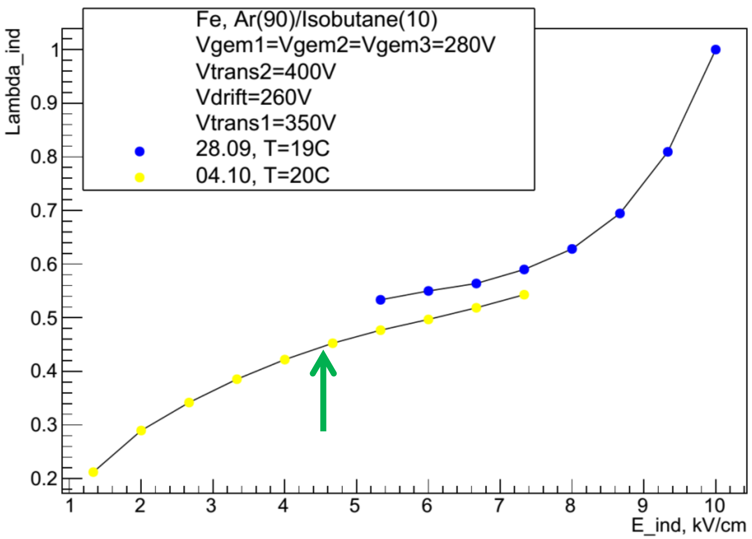
- Working range of field, kV/cm (Ar(70)/CO_2(30)gas mixture)

GEM Optimization (Ar(90)/IsoButane(10) gas mixture)



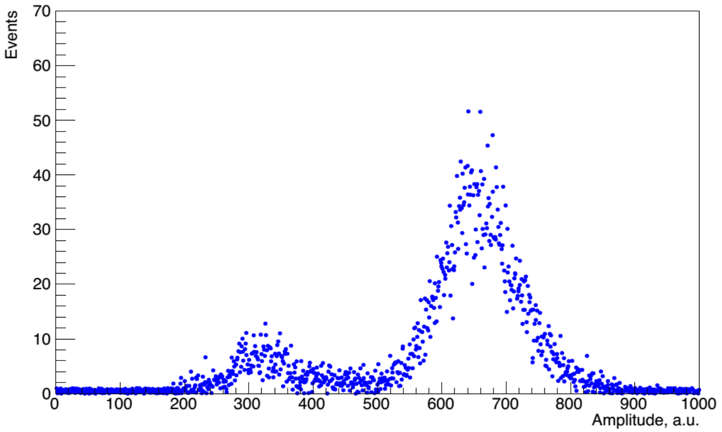




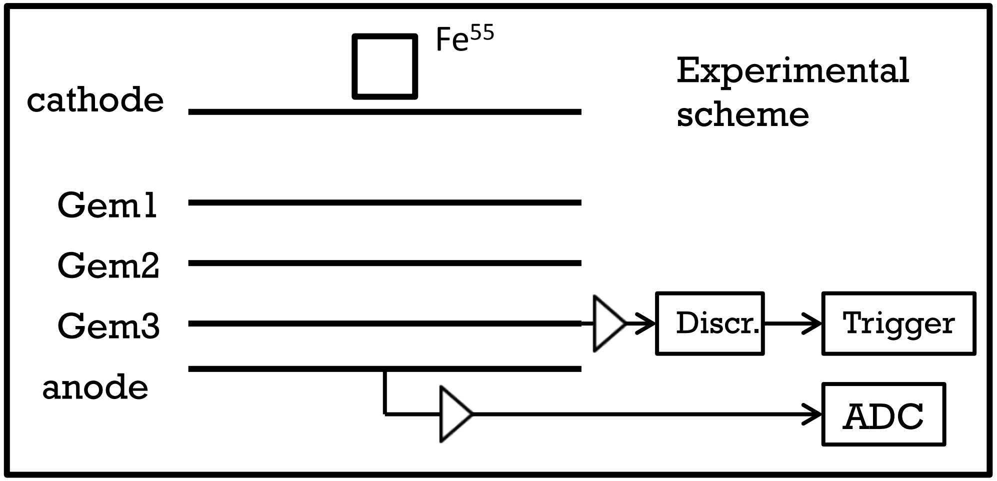


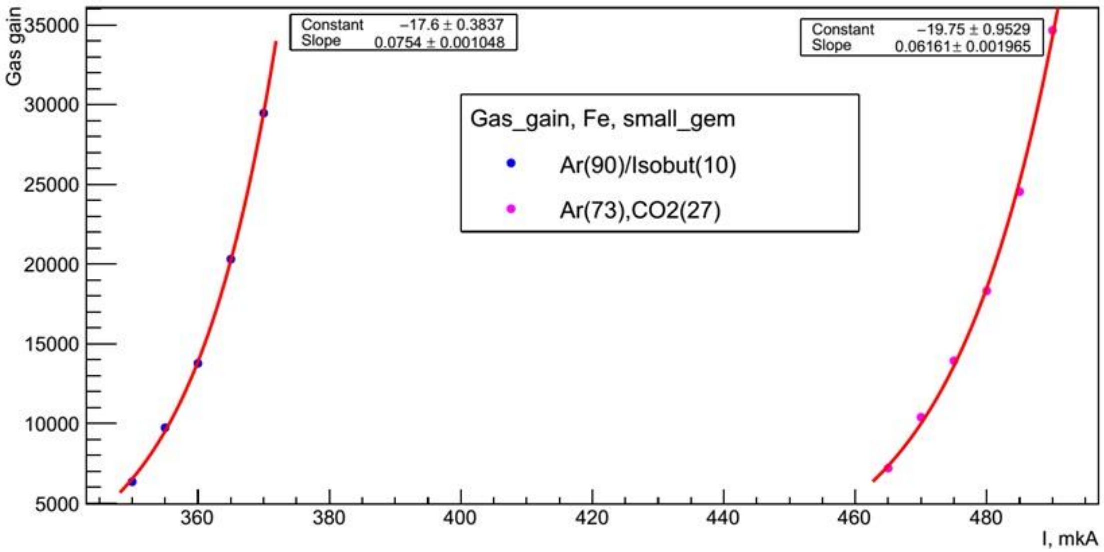
Lambda summary = 0.86

GEM gas gain measurements



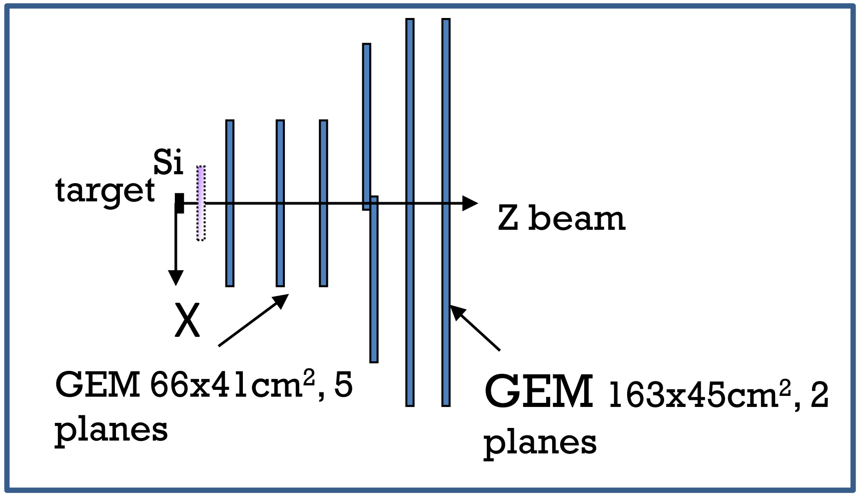
Amplitude distribution, Ar(70)/CO2(30), Fe^{55}



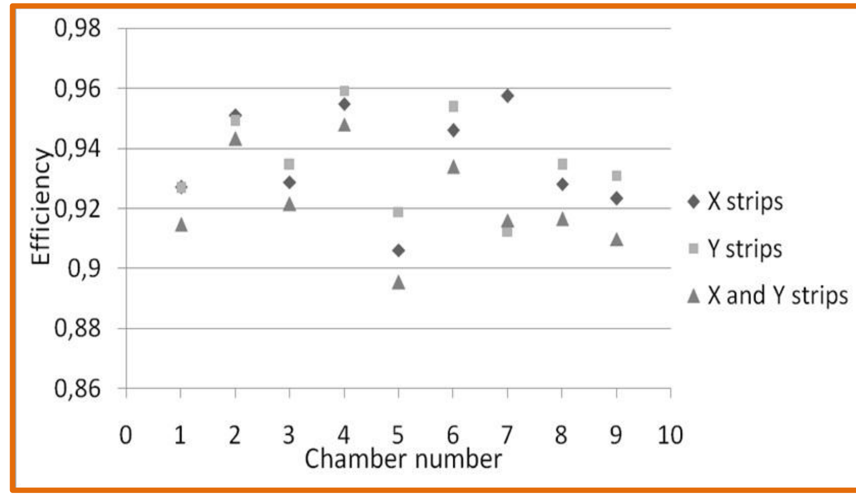


GEM gas gain for Ar(70)/CO2(30) and Ar(90)/Isobutane(10) gas mixtures

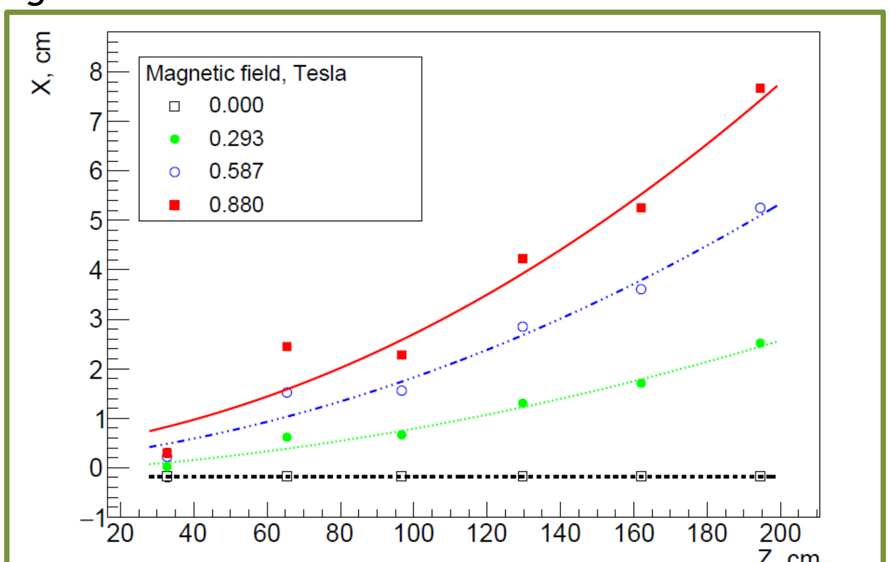
GEM tests at Nuclotron deuteron beam



GEM configuration

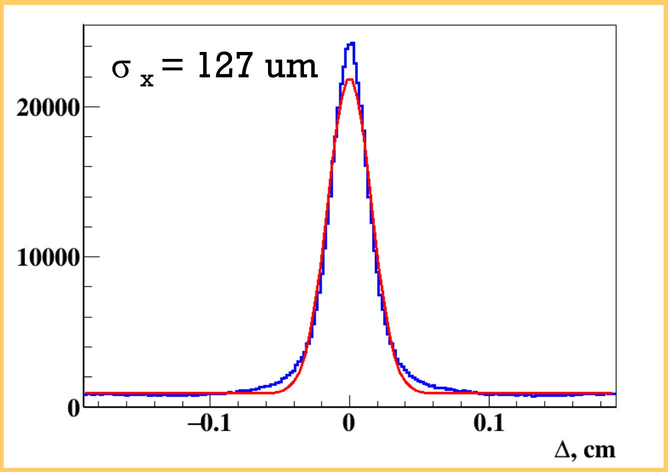


GEM efficiencies

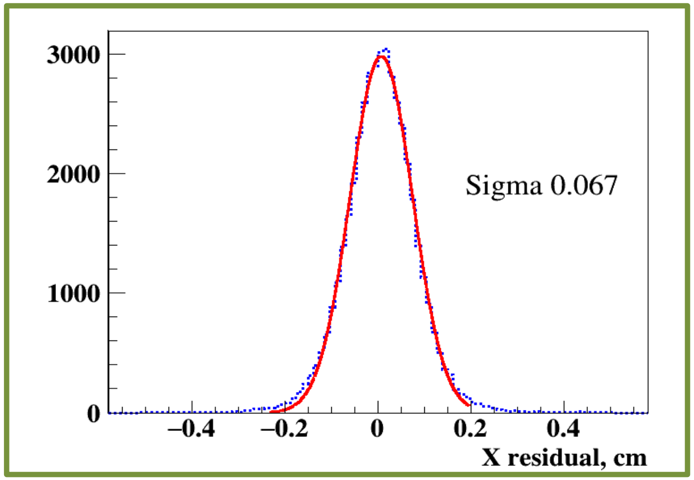


The average trajectories of the deuteron beam and the average Lorentz shifts of an electron avalanche in 6 GEM planes measured for four values of the magnetic field.

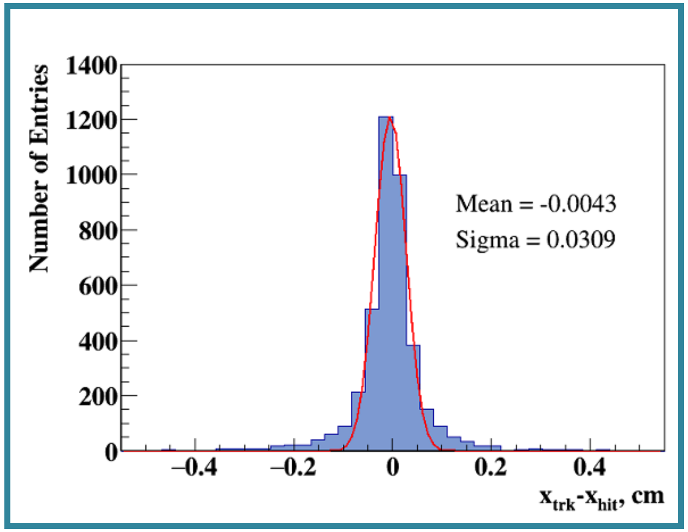
GEM tests at Nuclotron d and C beams



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



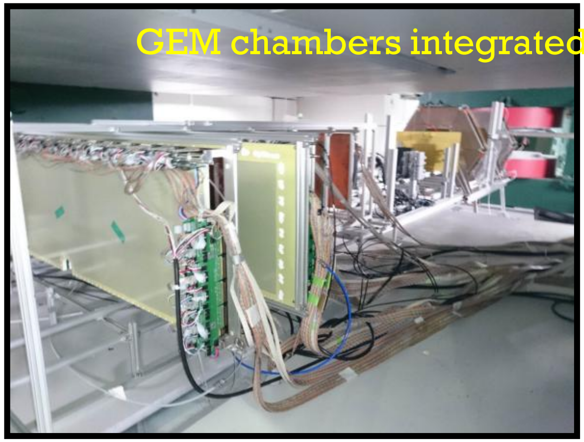
GEM hit residuals, magnetic field 0.79 T,
Ar(90)/IsoButane(10), deuteron beam

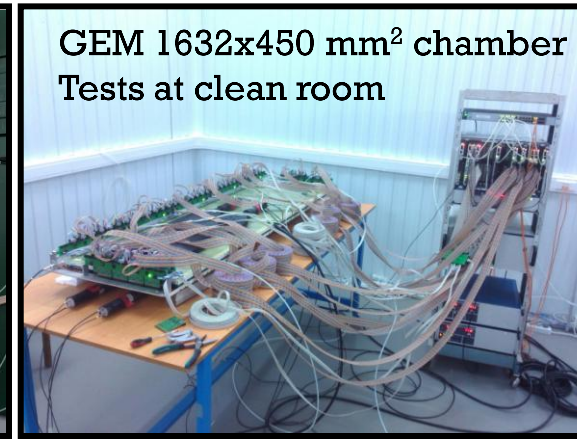


GEM hit residuals, magnetic field 0.59 T,
Ar(70)/CO2(30), carbon beam

Conclusions

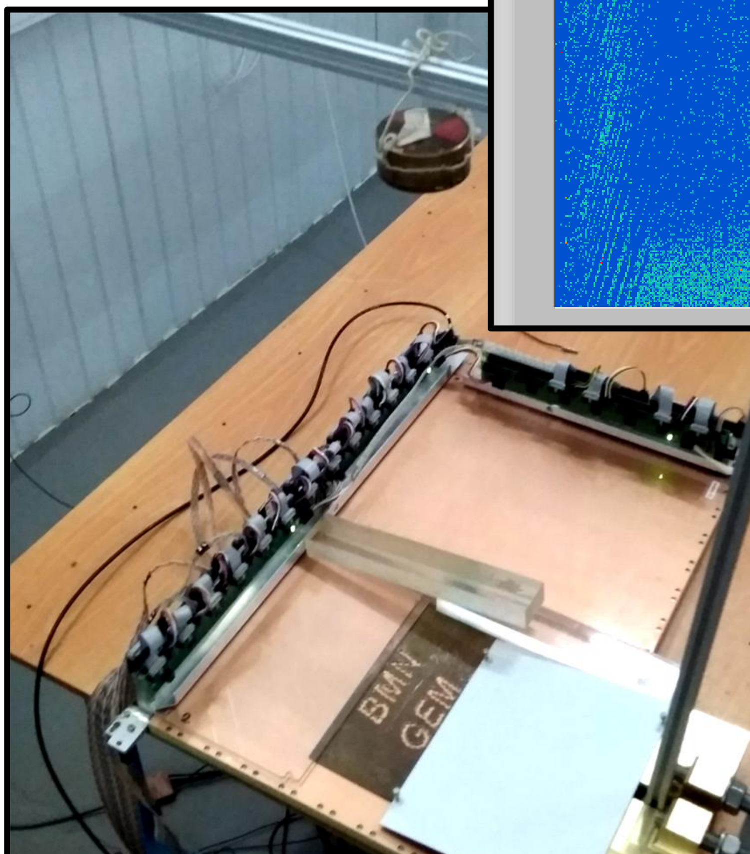
Triple GEM detectors of the BM@N tracker system have been assembled and studied in the d, C, Ar, Kr beams of the Nuclotron accelerator. The measured parameters of the GEM detectors are consistent with the design specifications. Seven GEM chambers with the size of 1632 mm × 450 mm are the biggest GEM detectors produced in the world for today.

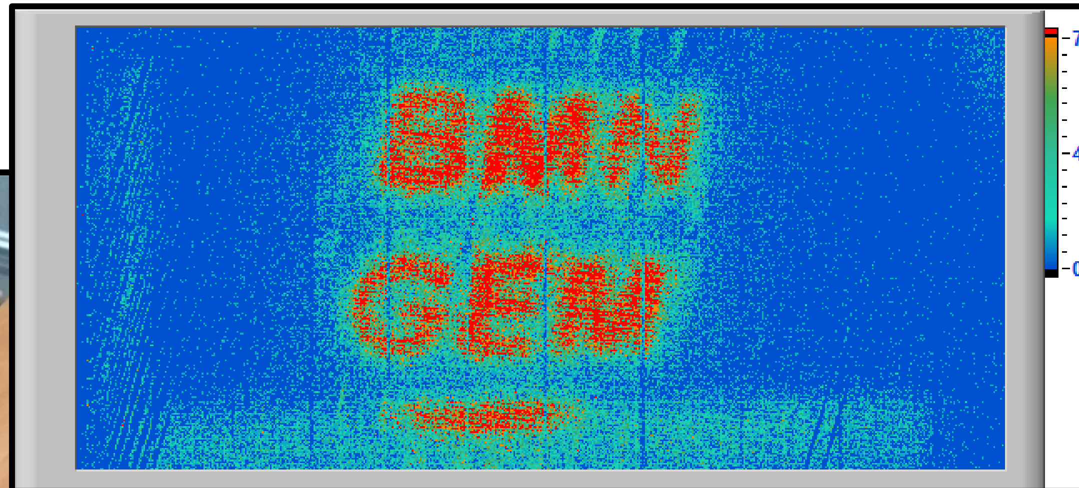




For today GEM tracking system is:

- 12 chambers 660x412 mm^2 (5) and 1632x450 mm^2 (7),
- ~ 6.5 m^2 active area,
- ~ 1 billion of independent amplification channels,
- ~ 45000 strips/electronics channels,
- > 3 km of control and readout cables.

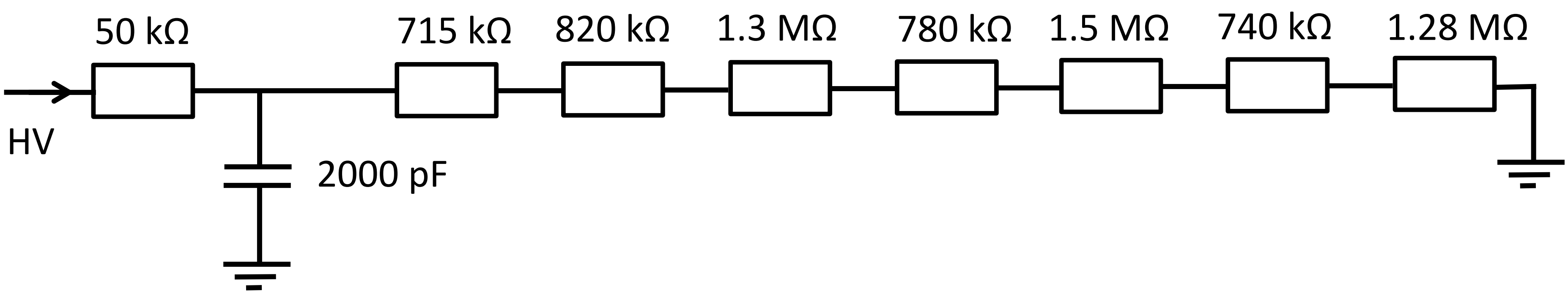




Thank you for your attention!

Back-up slides

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)/CO_2(30) gas mixture