



Budker INP



Novosibirsk State
University

Study of spatial resolution of low-material GEM tracking detectors

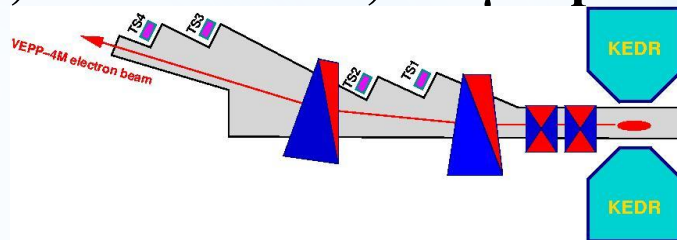
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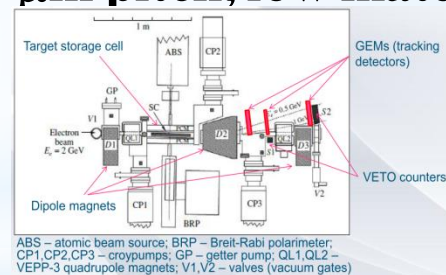
Novosibirsk State University, 630090, Novosibirsk, Russia

Projects with tracking GEM-detectors in BINP:

- ❑ **KEDR tagging system (in operation since 2010)**
8 modules up to $250 \times 100 \text{ mm}^2$ size, stereo readout, $500 \mu\text{m}$ pitch

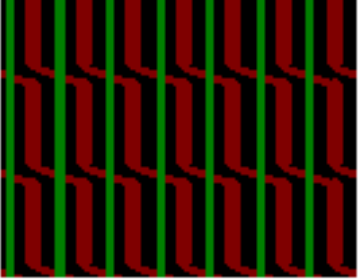


- ❑ **DEUTRON photon tagging system (first physics run – September 2016)**
3 modules $160 \times 40 \text{ mm}^2$, stereo readout, $500 \mu\text{m}$ pitch, low material



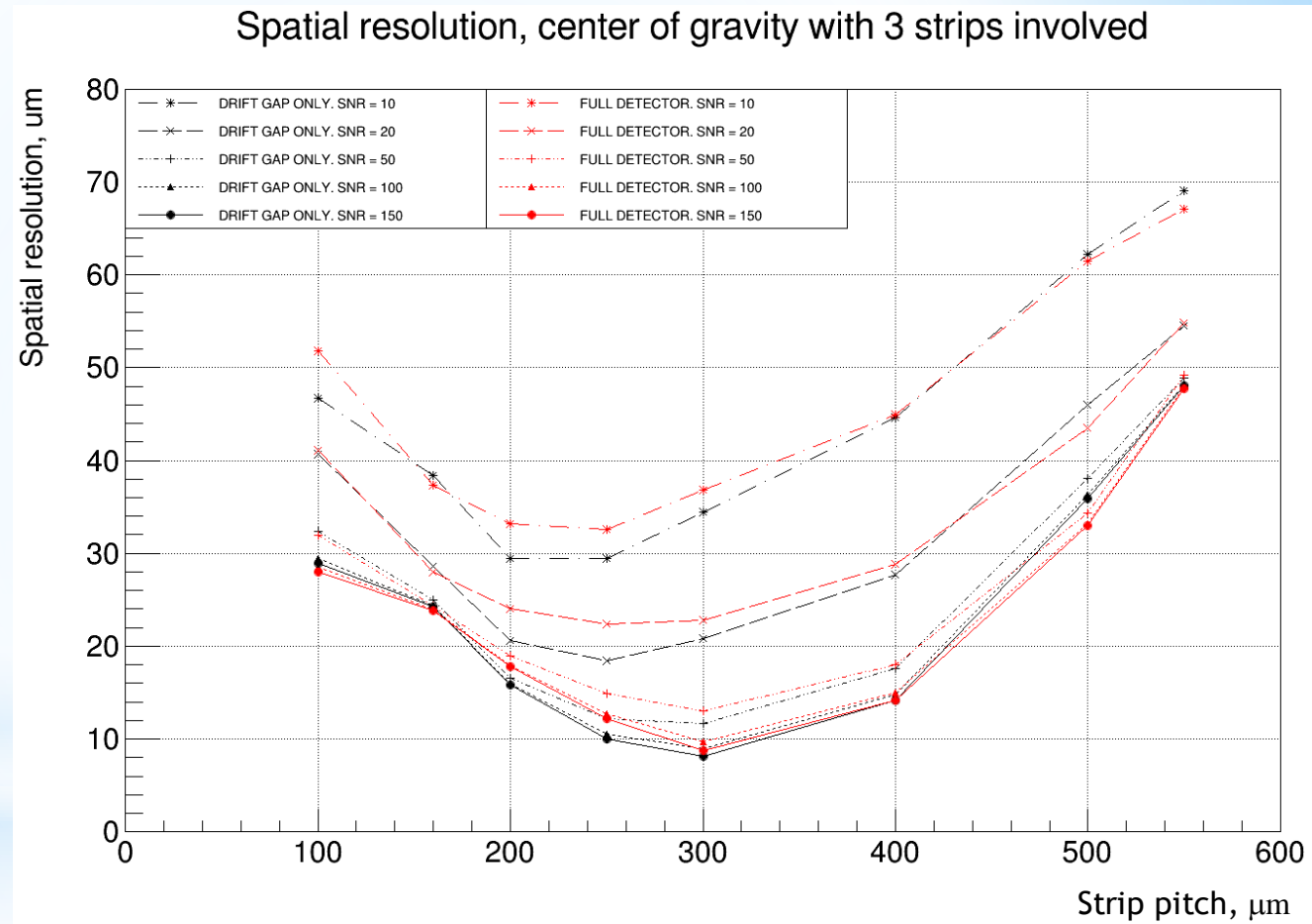
- ❑ **Tracking detectors for the extracted electron beam facility at VEPP-4M storage ring (operation in 2016), 4 modules $128 \times 64 \text{ mm}^2$, XY readout, $250 \mu\text{m}$ pitch**

Simulation:

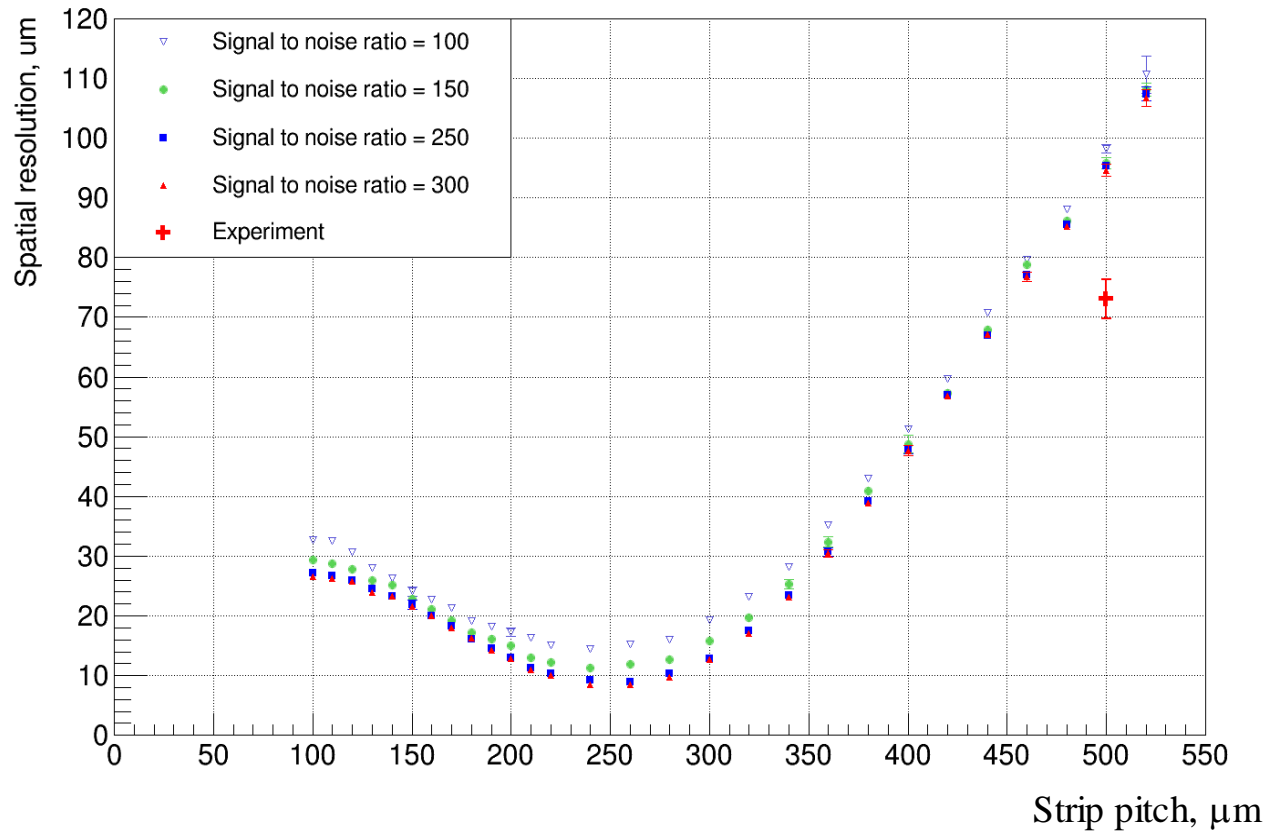
- GEANT4 transport of primary electrons through realistic detector model (1 GeV electrons, orthogonal to the detector plane, randomly distributed initial position)
- Post-processing of energy depositions in the drift gap:
 - transversal diffusion of electrons
 - fluctuations of gas amplification
 - distribution of charge between readout electrodes 
 - accounting of electronic noise at each readout electrode
 - application of center of gravity algorithm

Gas mixture: Ar-CO₂ (75%-25%)

Difference between low-material and regular triple-GEM detectors

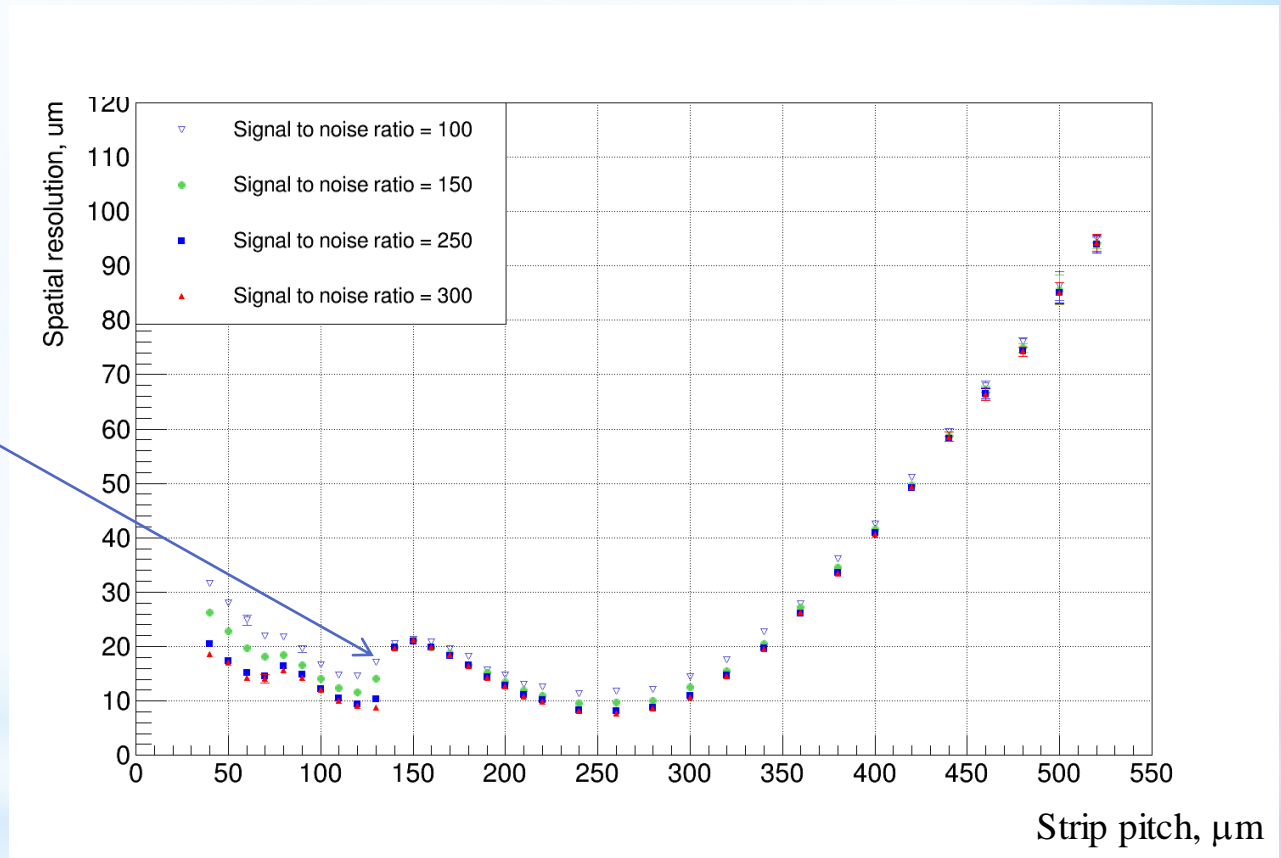


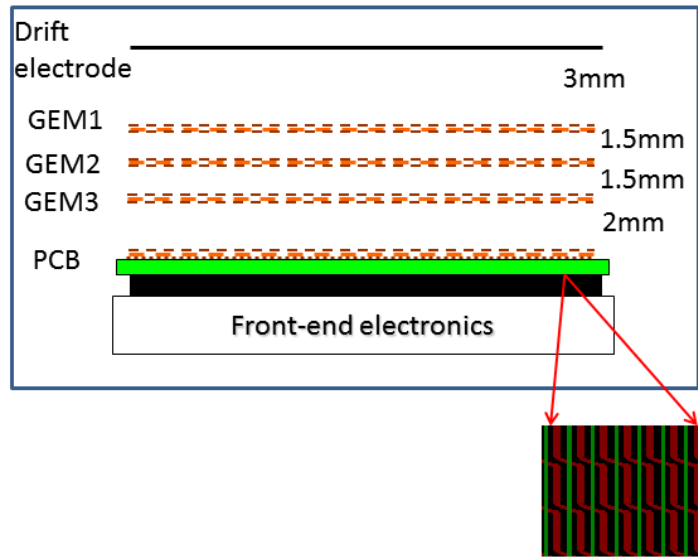
Spatial resolution of triple-GEM detector with strip readout structure of TS-KEDR



Spatial resolution of the detector with the readout structure of DEUTRON-PTS and with flexible COG algorithm

Change of the number of strips involved





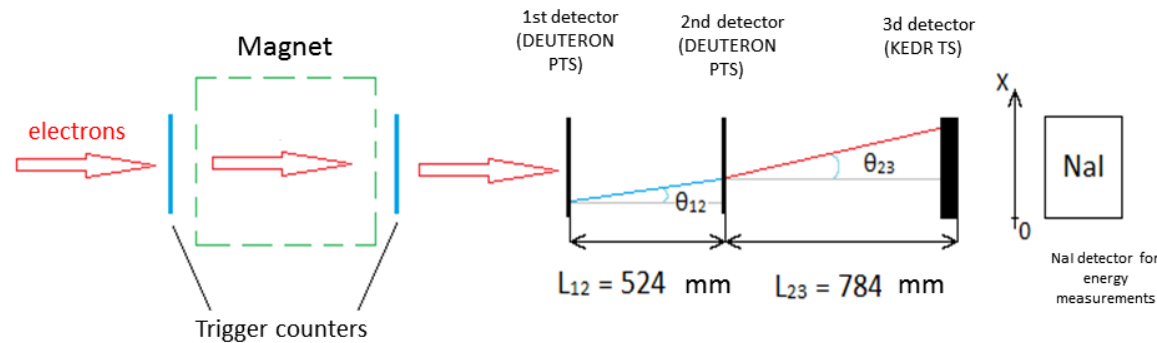
All measurements were performed with low-material triple-GEM detector for the photon tagging system of the DEUTRON facility at VEPP-3

Gas mixture: Ar-CO₂ (75%-25%)

Electron beam at the extracted beam facility of VEPP-4M storage ring was used

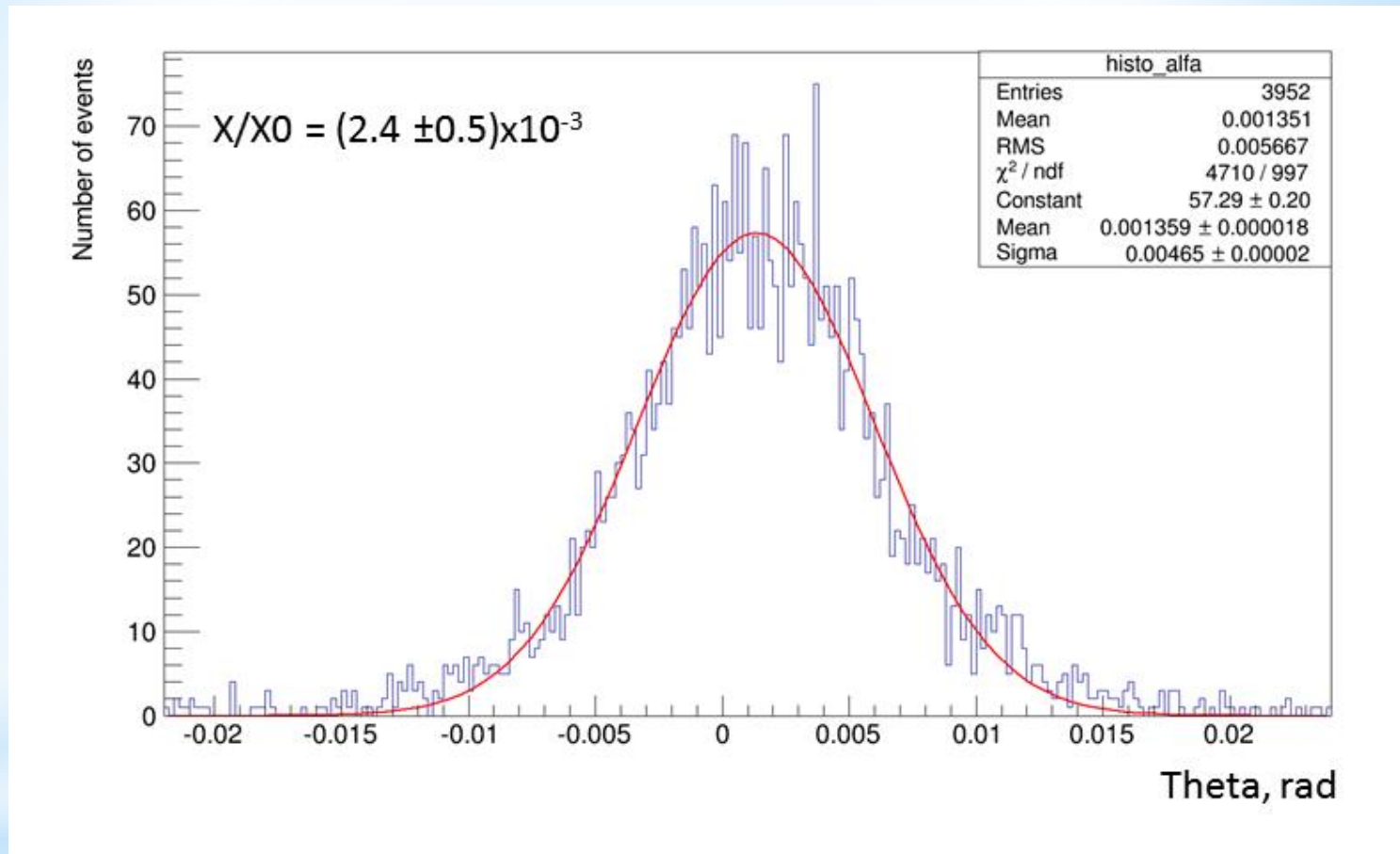
Set-up for the measurements of the amount of material (100 MeV electrons)

For the measurements of spatial resolution the distances were reduced to 80 mm and 75 mm and 500 MeV electrons were used



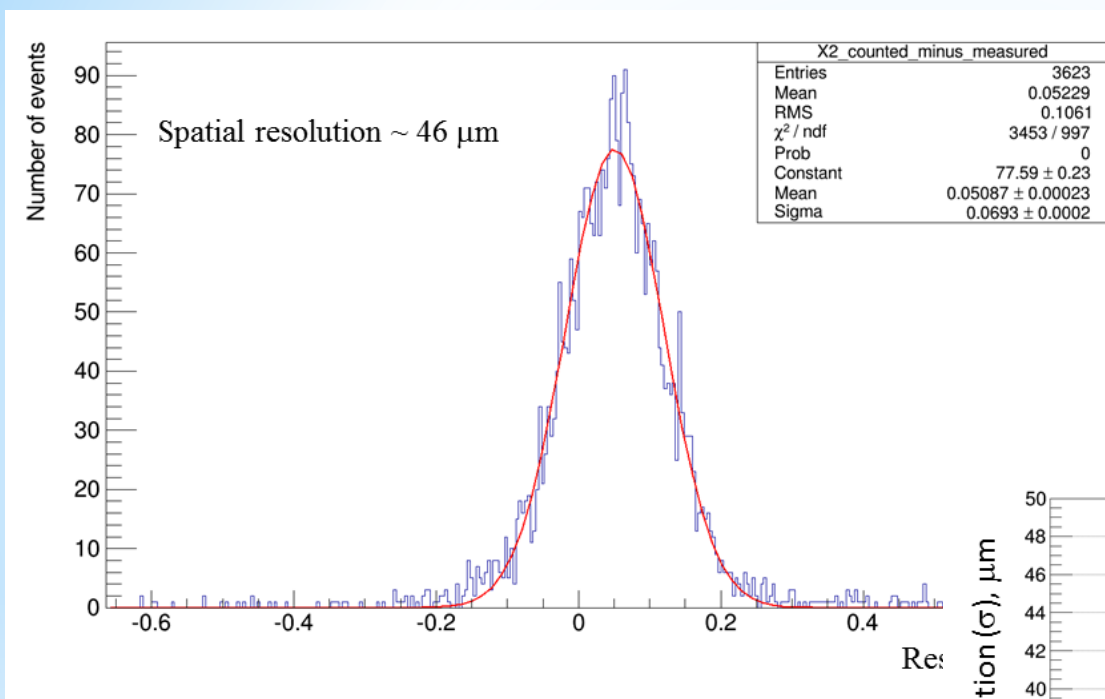
Multiple scattering from the 2nd detector

The amount of material corresponds to $\sim 3 \mu\text{m}$ thickness of copper at GEMs and readout flex



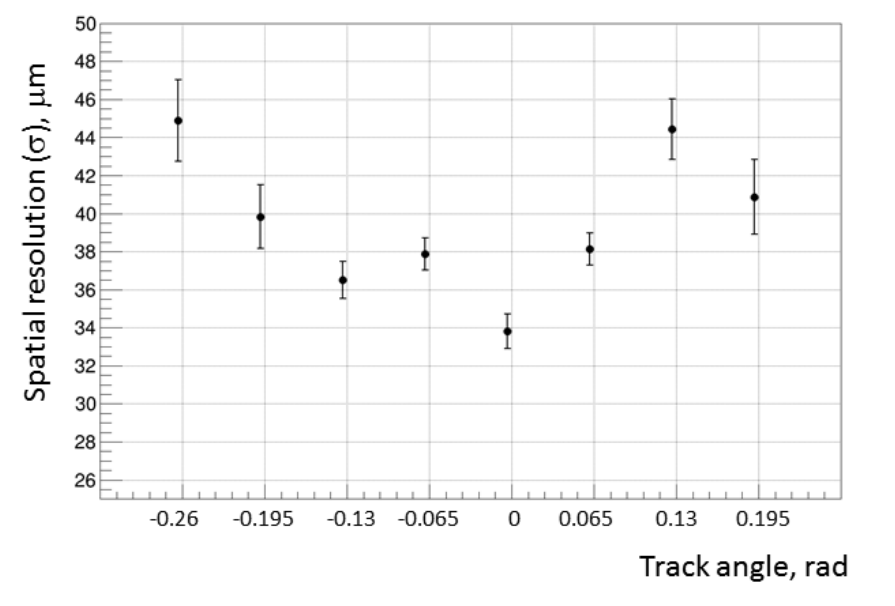
Measurements of spatial resolution of the triple-GEM detector (strip pitch 0.5 mm)

Experimental results are corrected for multiple scattering and limited resolution of the tracking detectors



Resolution vs angle

Spatial resolution over wide area ($\sim 3 \times 1 \text{ cm}^2$ bea



Conclusions:

Ultimate resolution of the triple-GEM detectors for high energy charged particles is 10-20 μm and it can be reached at a strip pitch around 250 μm for the gas mixture Ar-CO₂(75%-25%)

At a pitch values larger than 300 μm the simulations show worse resolution than the measurements. The reason is not clear yet.

Next steps:

Simulation of the system with 3 detectors (include fluctuations of track coordinates and multiple scattering)

Different gas mixtures

Measurements with higher beam energies (up to 3 GeV) to reduce multiple scattering

Measurements with the detector with 250 μm strip pitch