

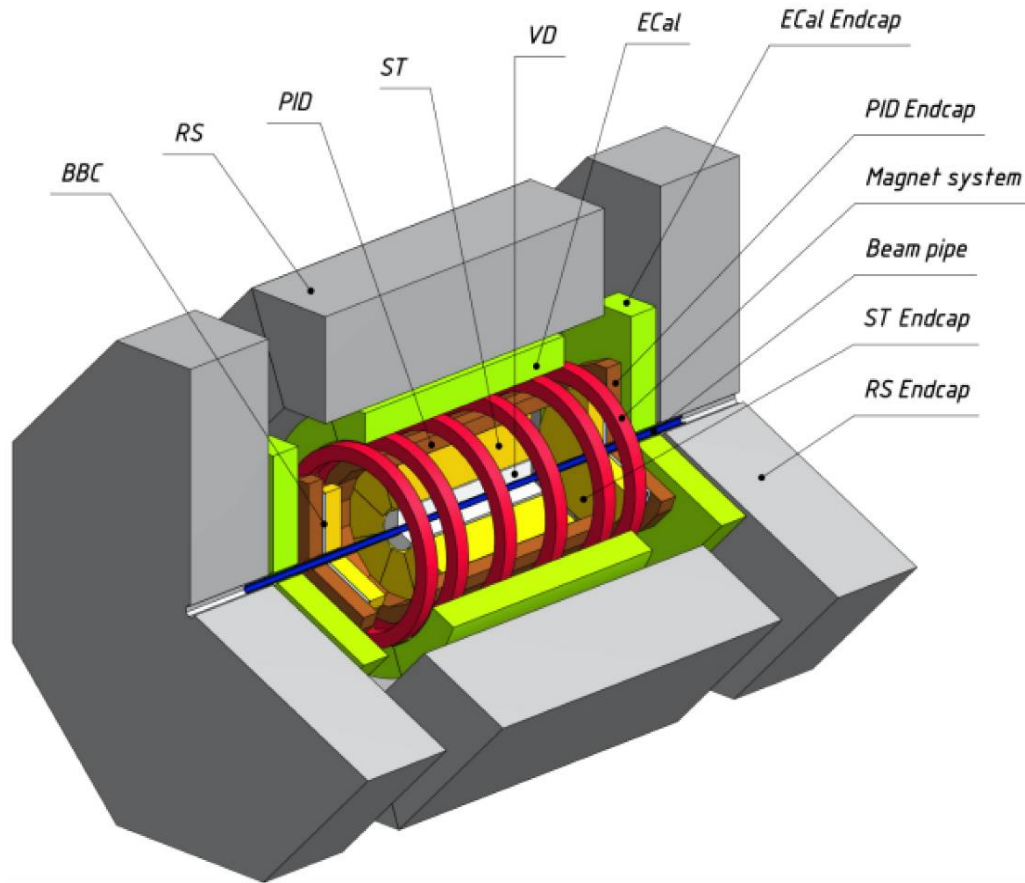
Reference Tracking System for Performance Studies of Small Straw Tracker Prototypes for the Future SPD Detector at the NICA Collider

M. Banchshikova* (Al-Farabi Kazakh National University) and StrawTrackerRD team

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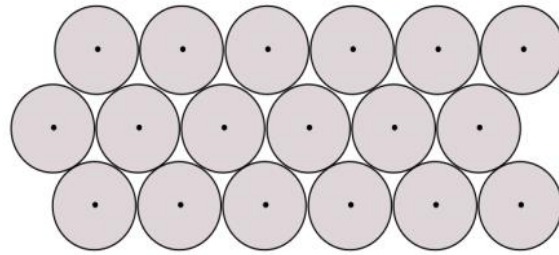
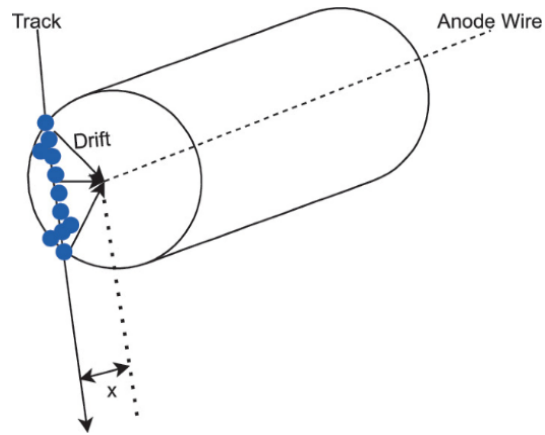
SPD NICA. Straw tracker



- The Spin Physics Detector (SPD) at the NICA collider is being developed to measure the nucleon spin structure.
- Precise tracking of charged particles is crucial for spin asymmetry measurements.
- Tracking detectors allow to register particle coordinates and to reconstruct particle track.
- In SPD thin gas filled straw tubes will be used for precise tracking and optionally for particle identification at small track momenta.
- Performance validation at the Tracker development stage is needed before installation => lab and test beam measurements with small tracker prototypes.

Goal is to analyze data taken during straw performance studies on muon beam at CERN. Data quality monitoring and initial analysis results of the reference tracking system based on Timepix4, MicroMegas detectors and scintillators are presented.

Straw Tracker

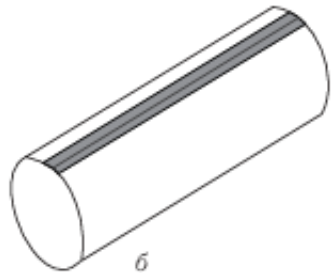
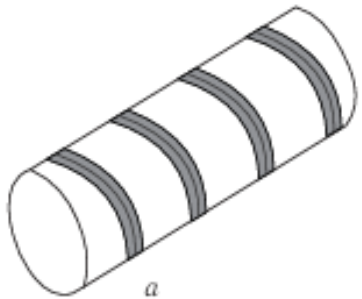


Straw Tracker is an array of straws

Straws production

Winding

Ultrasonic welding



Straw is a kind of a drift detectors, consisted of thin cylindrical tube with a central anode wire and cathode wall.

Principle:

- When particle goes through the gas ionization occurs.
- Electrons drift radially to the wire, where amplification occurs.
- Coordinate derived from drift time.

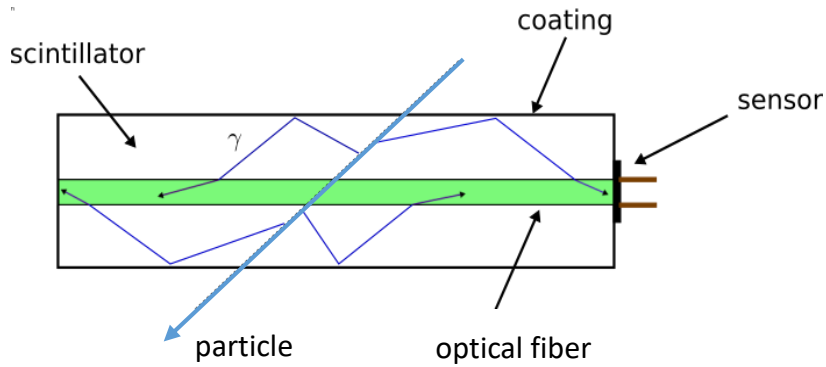
Advantages:

- High spatial resolution.
- Low material budget.
- Simple construction and maintenance.
- Stable operation at high rates.
- Good time response and signal uniformity. 3

Reference Timing and Tracking Systems

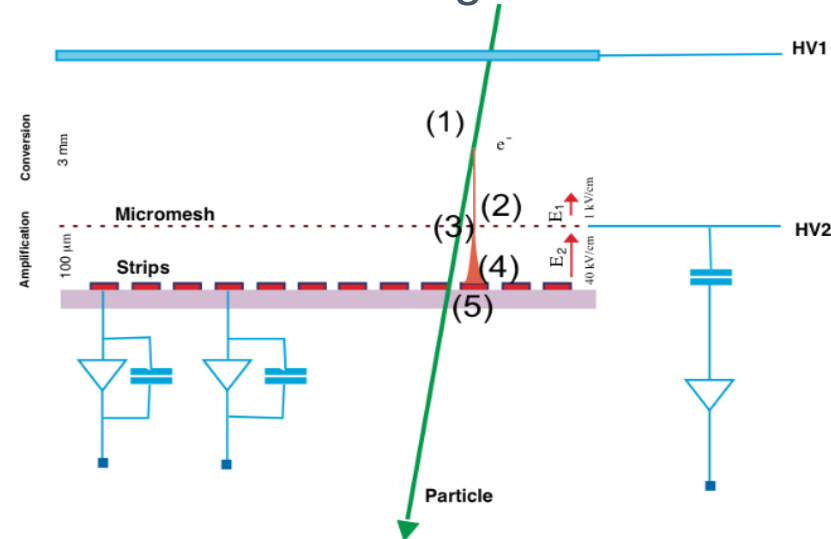
detectors operation principles

Scintillators



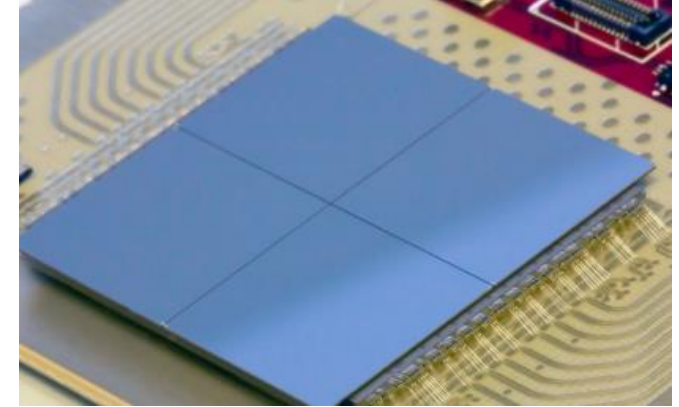
- A charged particle passes through the scintillator material.
- It excites atoms or molecules, which then emit photons.
- The light is collected by optical fibers or a light guide.
- It is converted into an electrical signal by PMT or SiPM.
- The signal provides timing information for particle detection.

MicroMegas



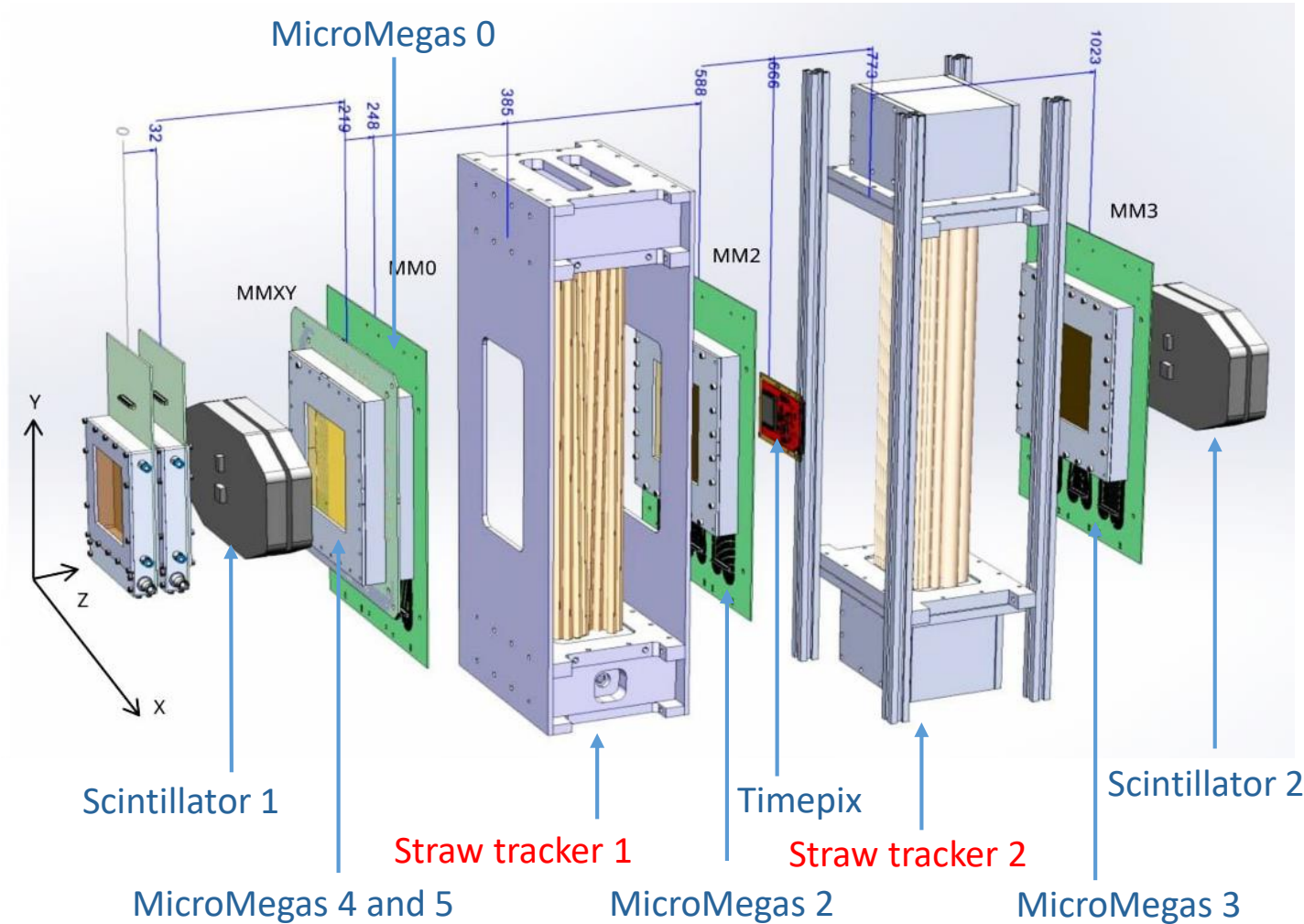
- Drift gap (few mm) and a thin amplification gap (~100 μm) separated by a micromesh.
- Ionization caused by a particle occurs.
- Electrons drift to mesh, then undergo avalanche near the readout plane.
- Count rate capability, time and position resolution, granularity and stability are high.

Timepix4



- Silicon sensor that consists of pixels.
- A charged particle deposits energy in silicon → creates electron-hole pairs.
- Electrons drift to pixel electrodes under an electric field.

StrawTrackerRD setup



Reference tracking:

1. MicroMegas:

- Ar/CO₂: 93/7%.
- Readout: TIGER ASIC.

Axis	MicroMegas ID
X	MM 0
X	MM 2
X	MM 3
X (XY)	MM 4
Y (XY)	MM 5

2. Timepix-4:

- Pixel size: 55 μm .
- Number of pixels: 448 x 512.

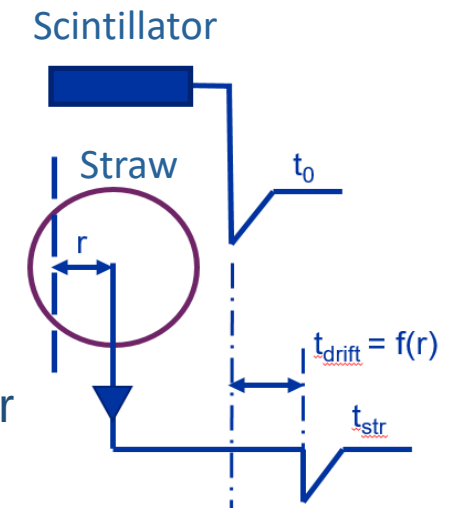
Reference timing:

Scintillators:

- Reference time measurements (t_0)

Straws:

- Ar/CO₂: 70/30%.
- Prototype 1: diameter – 10 mm.
- Prototype 2: diameter – 5, 10, 20 mm.



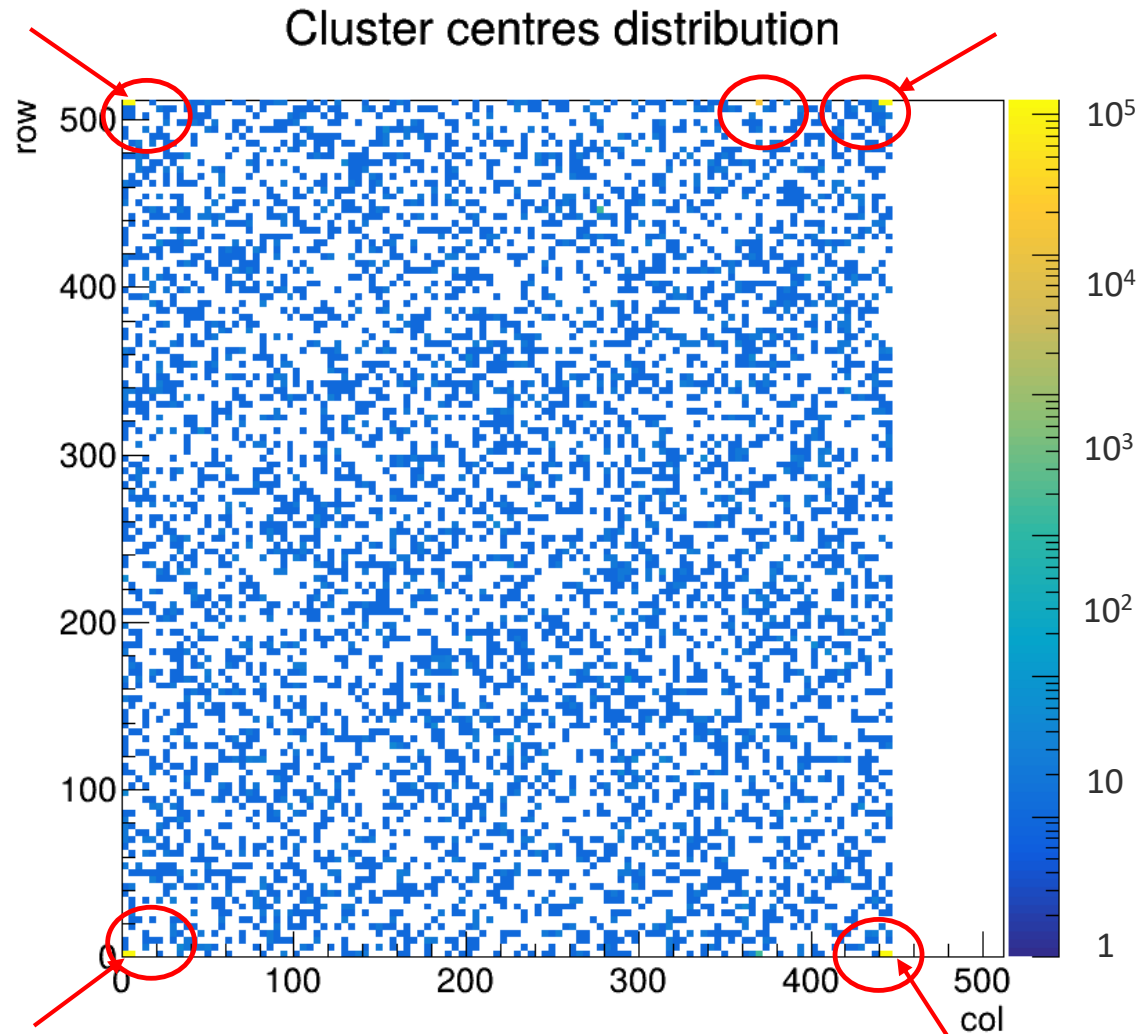
Data acquisition & merging

- Readout of MicroMegs detector signals is done using the TIGER ASIC (Torino Integrated GEM Electronics for Readout Application-Specific Integrated Circuit).
- For the straw tracker prototype a custom readout based on VMM3a ASIC was used.
- Data from MicroMegs, Timepix and Straw Tracker were taken with independent data acquisition system and data merging was done offline.
- Timepix4: Each ionizing particle crossing the silicon sensor → activates one or several pixels above threshold. 4 external inputs:

Input number	Purpose	
1	Scintillator coincidence	Common synchronization signals
2	Scintillator 1	
3	Scintillator 2	
4	STM-VMM	Used for offline synchronization of two systems

Common digital signal for Timepix4 and STM-VMM -> Common events -> **Data merging**

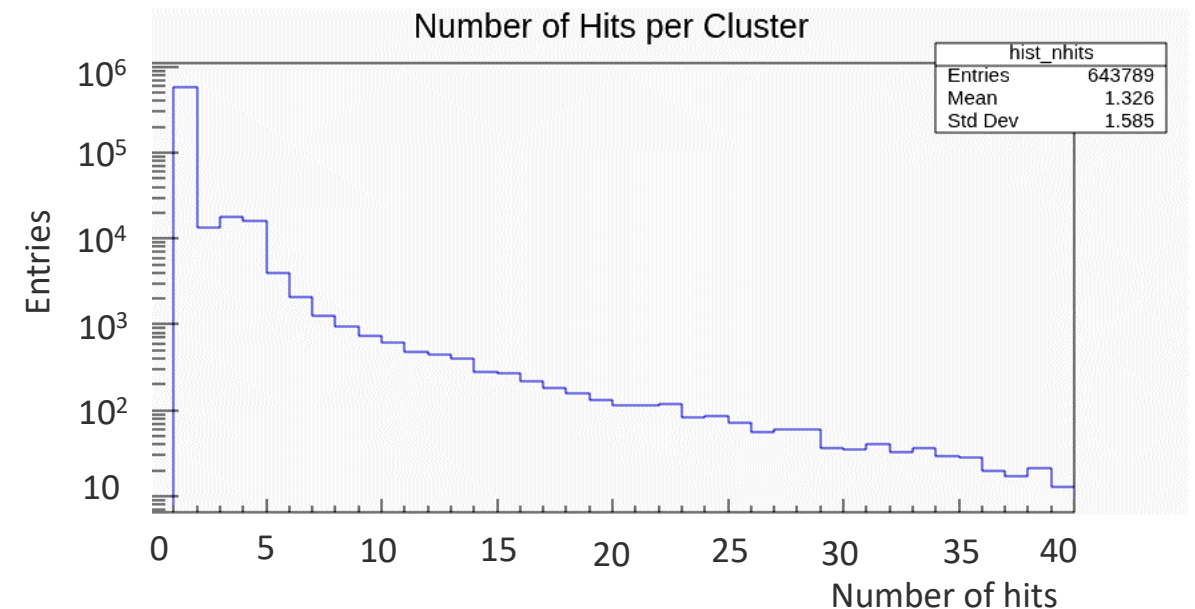
Timepix detector data analysis



External signal pixels

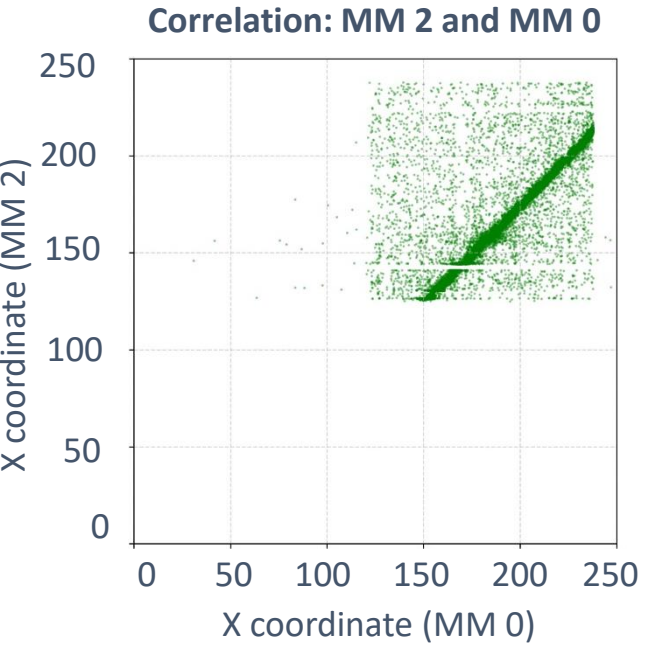
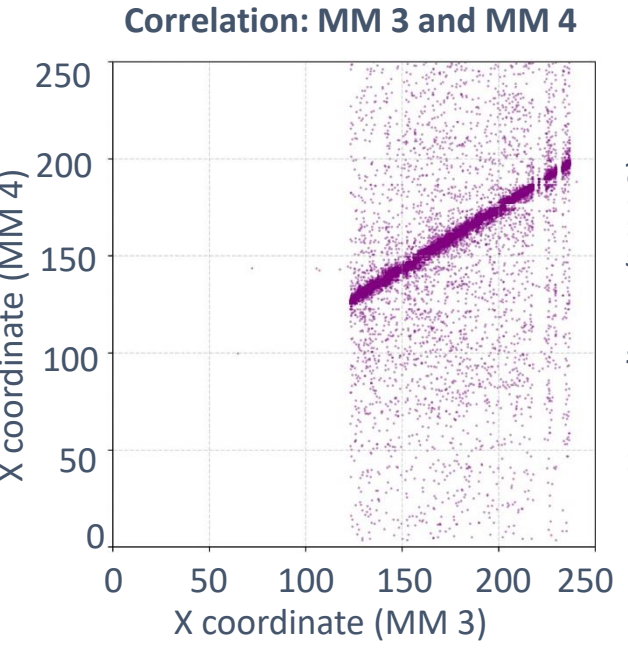
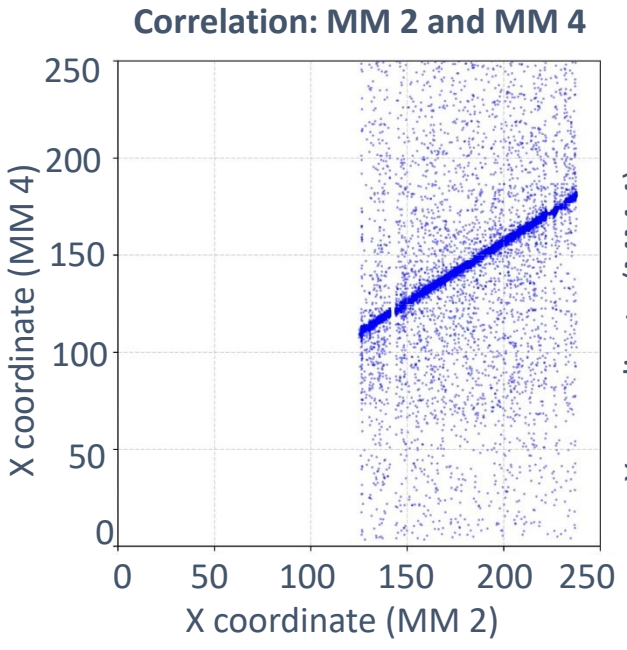
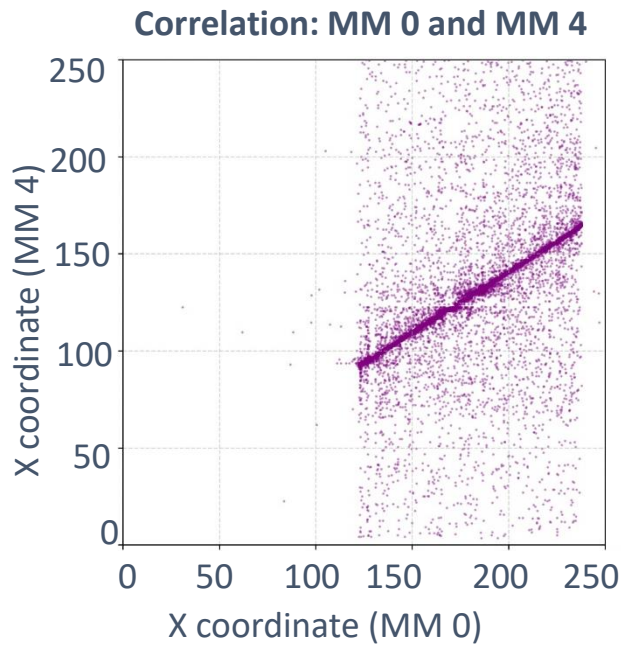
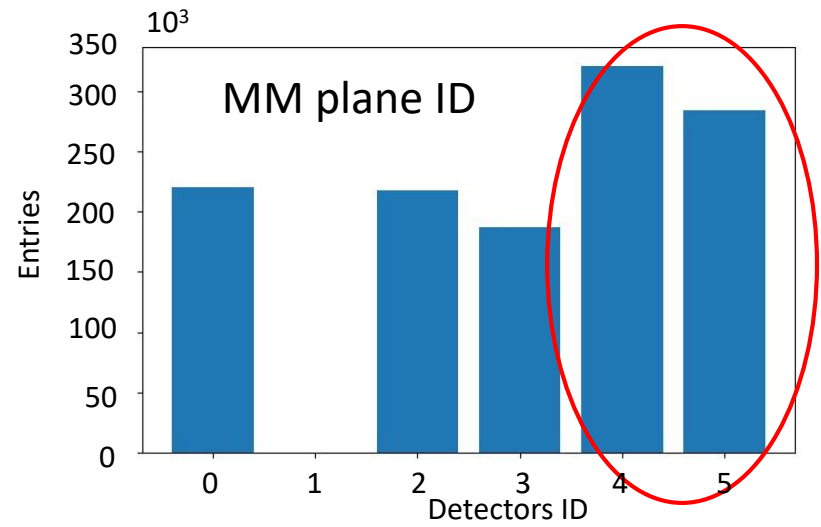
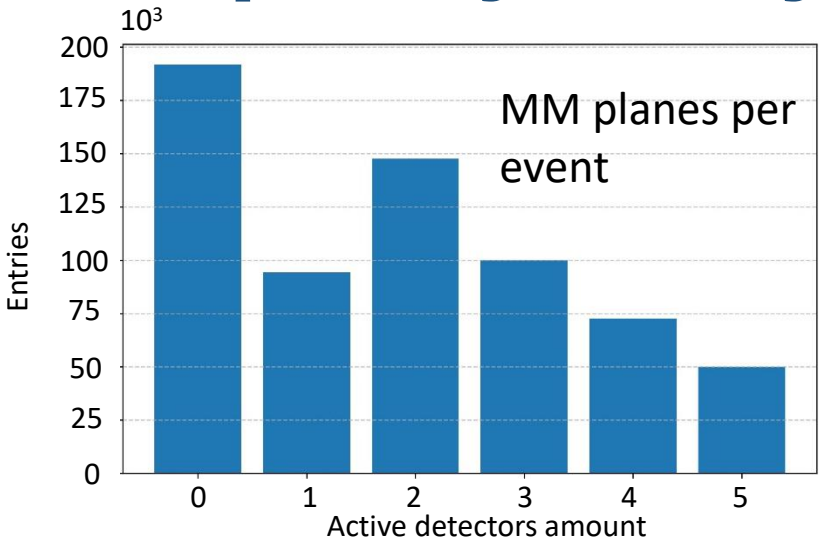
Input number	Purpose	Pixels
1	Scintillator coincidence	{2,508}, {6,509}, {443,510}, {447,511}
2	Scintillator 1	{0,508}, {4,509}, {441,510}, {445,511}
3	Scintillator 2	{0,0}, {4,1}, {441,2}, {445,3}
4	STM-VMM	{2,0}, {6,1}, {443,2}, {447,3}

Masking digital pixels + hit clusterization



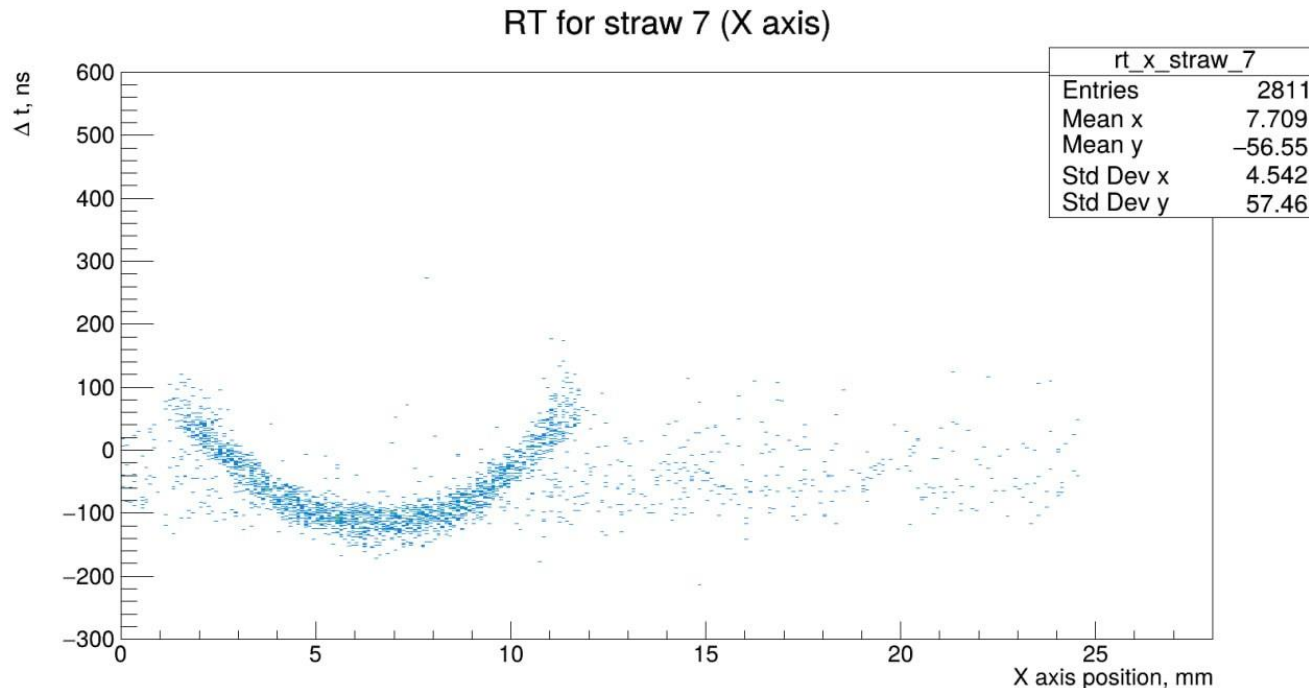
MicroMegas data quality analysis

Axis	MM ID	Readout area, cm ²	Strip pitch, um
X	MM 0	3x3	250
X	MM 2	3x3	250
X	MM 3	3x3	250
X (XY)	MM 4	10x10	400
Y (XY)	MM 5	10x10	400



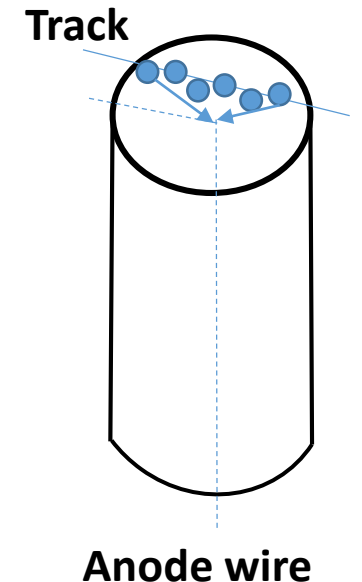
Prompt look at Straw Time vs Reference coordinate (Timepix only)

RT (Radius–Time) curve describes the relation between drift time of electrons and the distance (radius) from the anode wire.



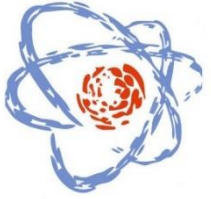
RT-curve after 10 minutes of data tacking
[provided by D. Sosnov]

- The closer to the anode, the shorter is drift time.
- The non linearity is caused by a slight change of the drift velocity along the straw radius.
- The minimum of the curve corresponds to tracks passing near the anode wire.



Summary

- Consistent correlations between hit coordinates measured with different Micromegas in a given event.
- Agreement with the fact that MM4 and MM5 detectors have larger readout area.
- Detectors are aligned in the optimal way except for MM0.
- From 2D cluster position distribution, clusters with high occupancy can be clearly seen four of them corresponds to the above external inputs/noisy channels.
- Straw response shows expected RT-behavior and clear correlation with reference coordinates.
- Future analysis is needed.



Reference Tracking System for Performance Studies of Small Straw Tracker Prototypes for the Future SPD Detector at the NICA Collider

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