



Advanced setup for performance studies of small straw-tracker prototypes for the SPD detector

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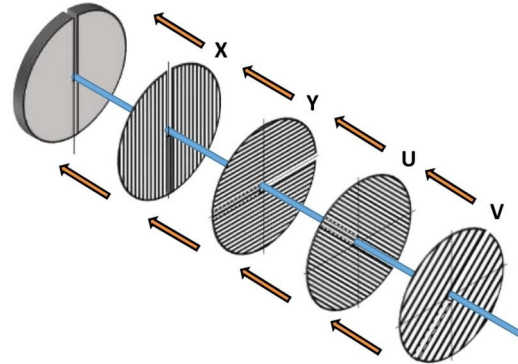
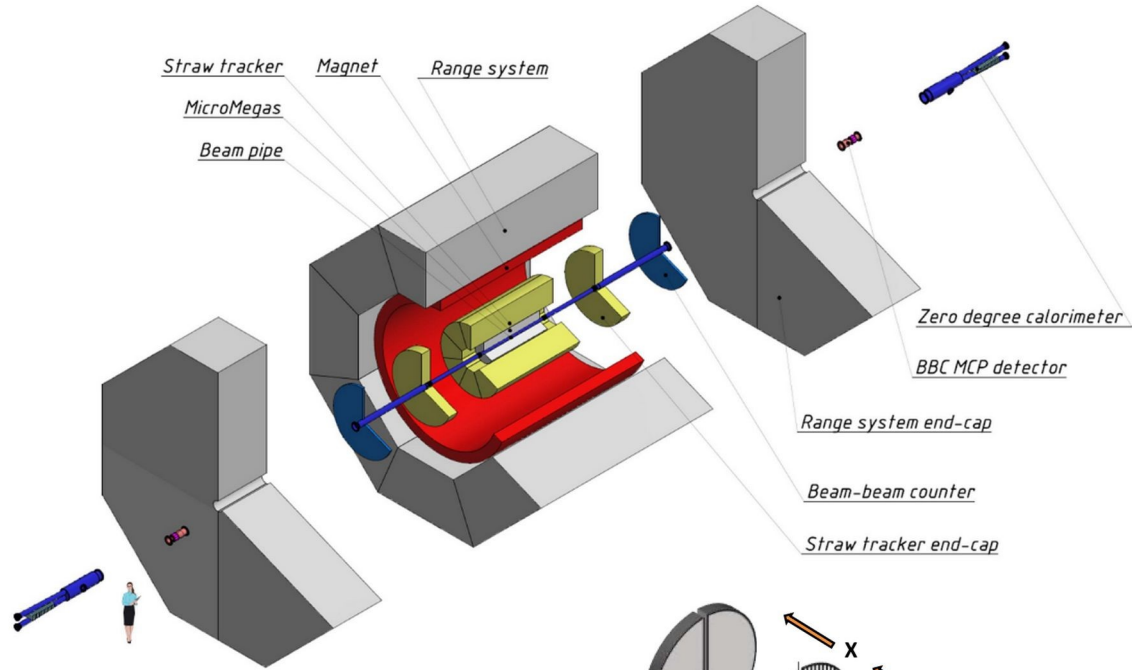
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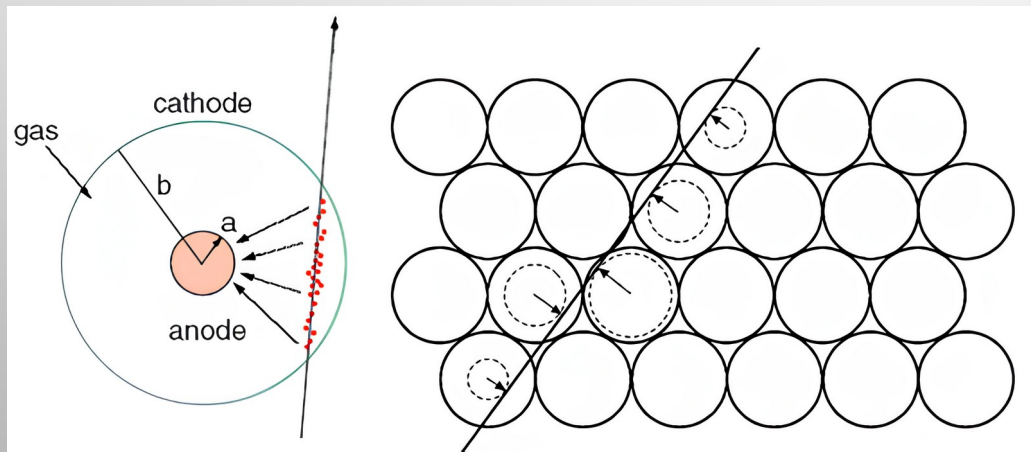
Motivation

- Development of the SPD straw-tracker requires beam tests of the first small tracker prototypes.
- A multifunctional setup has been developed to study performance of tracker prototypes operating with various readout electronics. The setup includes reference tracking and timing systems
- Prototypes with different straw diameters and layer geometries, including stereo angle are being tested
- Comparison of various front-end electronics (Tiger, ASD, ifTDC, etc.) helps to identify the most efficient readout approach.
- Synchronization of independent DAQ systems enables unified event reconstruction and joint detector performance analysis.



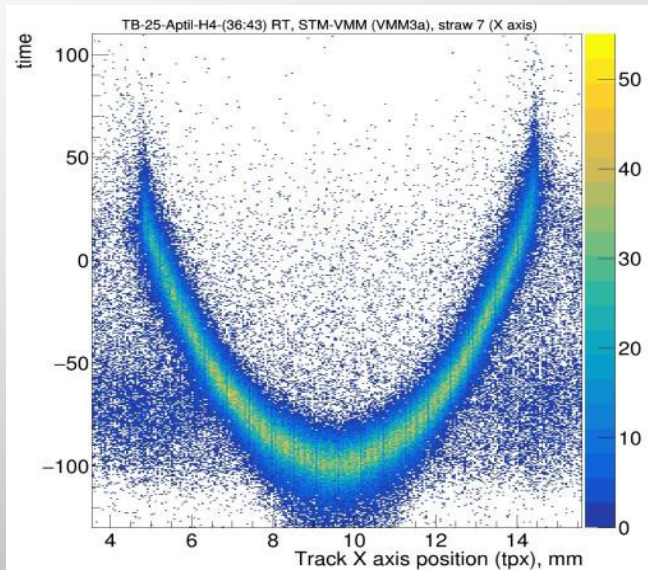
Straw Tube Tracker — Tracking and Particle Identification

- When a charged particle passes through the straw tube, it ionizes the gas.
- Electrons drift toward the central anode wire – the drift time depends on the distance from the wire.
- Measuring the difference between the drift time and the **reference time (T_0)** of a particle crossing the tracker makes it possible to precisely reconstruct the track position using the **RT relation**.
- A straw tracker with a sufficient number of layers can also be used for **particle identification (PID)** if the charge of the straw signals is measured.

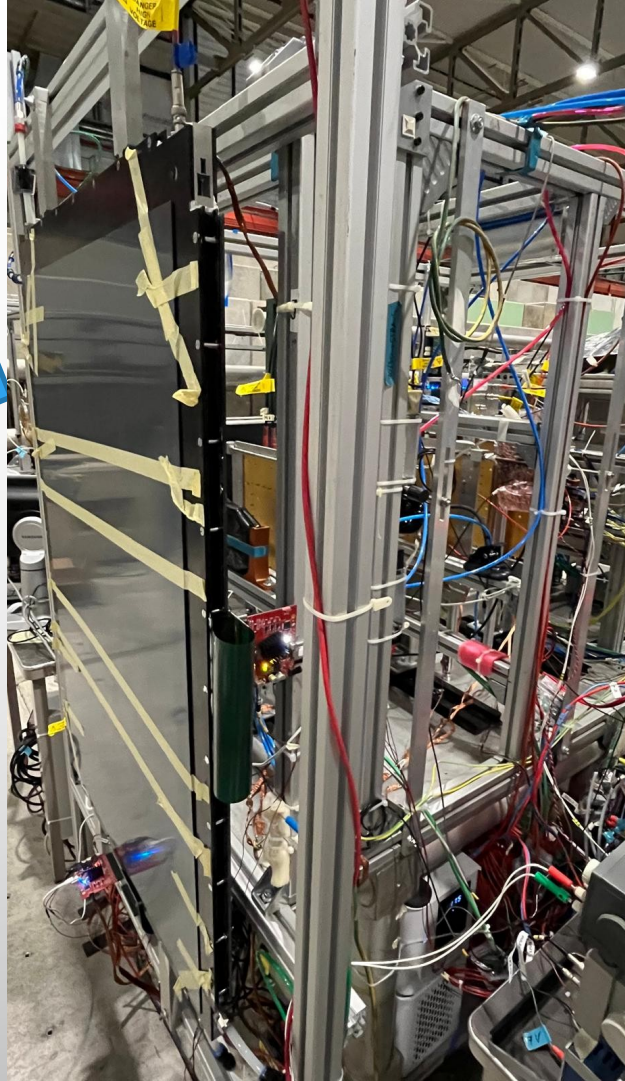
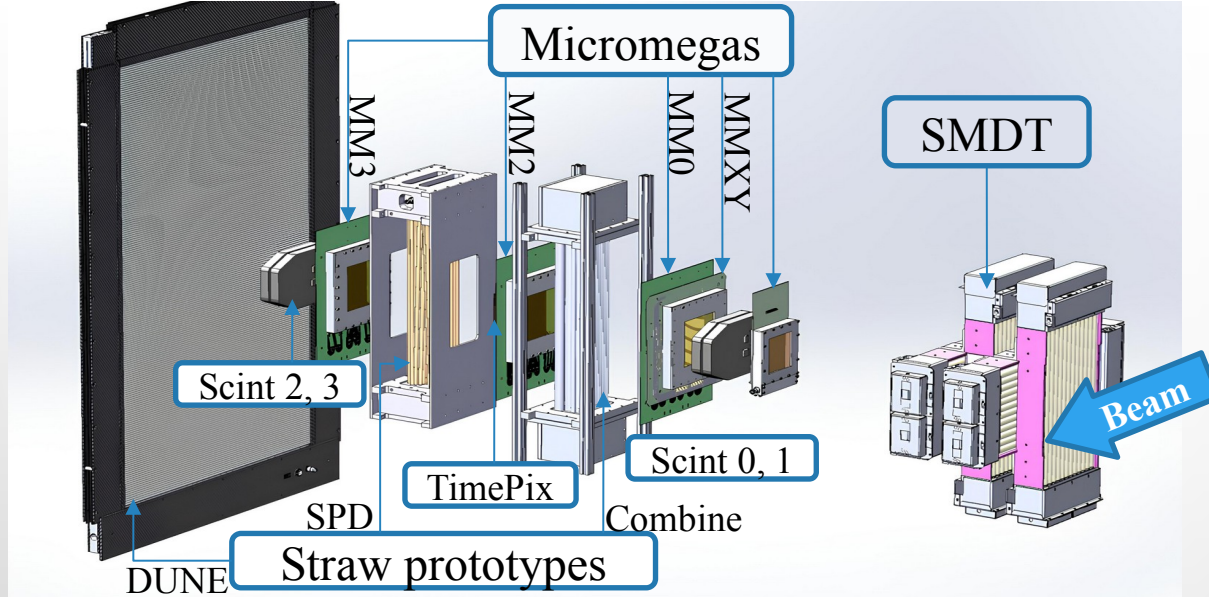
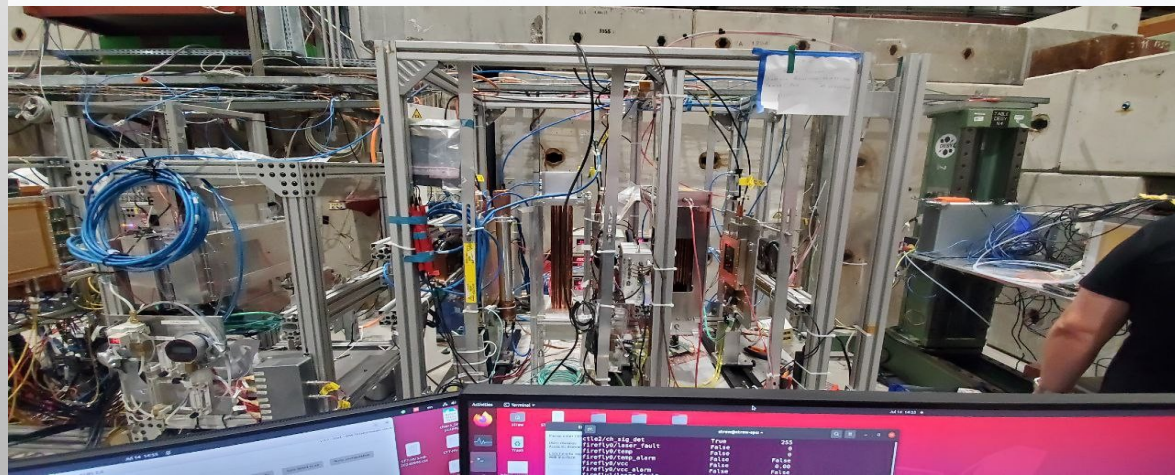


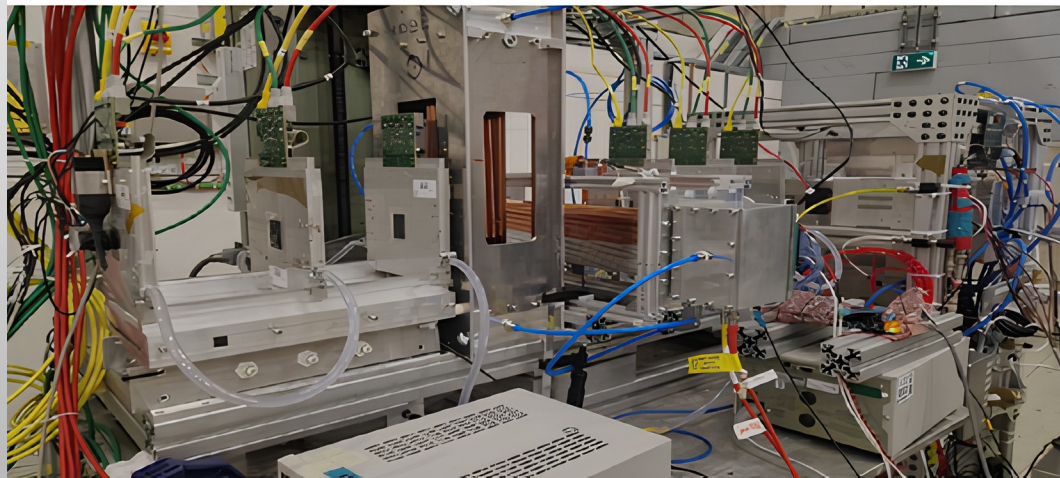
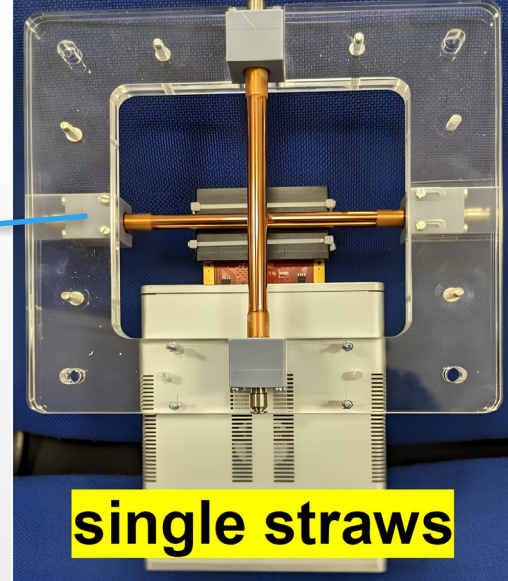
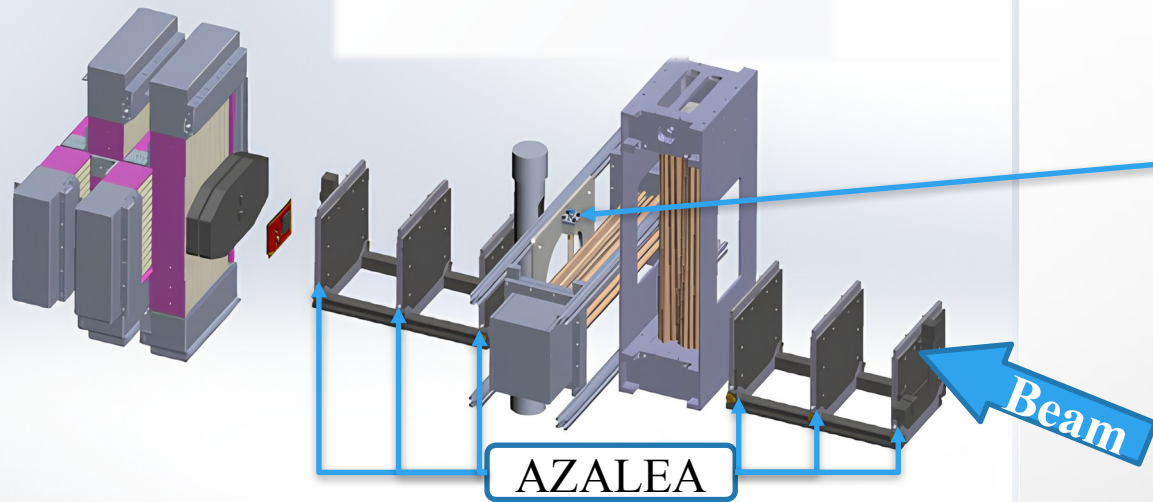
RT (Radius–Time) curve:

Shows the relation between electron drift time and distance to the anode wire – the minimum of the curve corresponds to tracks passing near the wire.



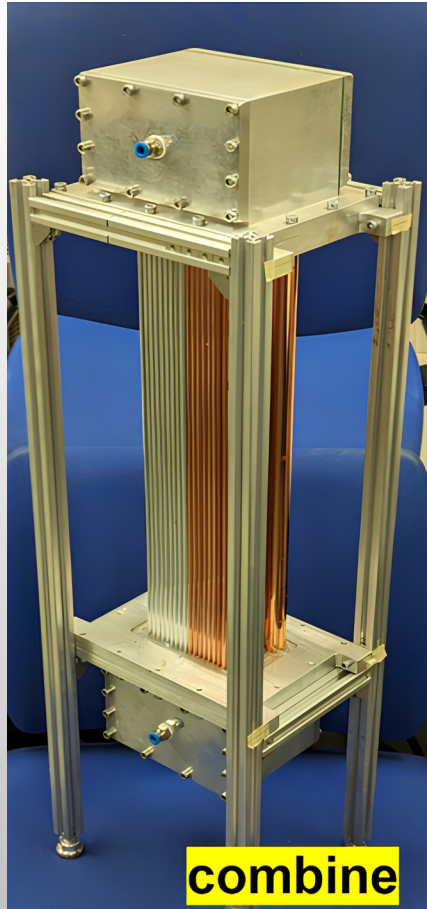
4 StrawTrackerRD setup at SPS H4 line



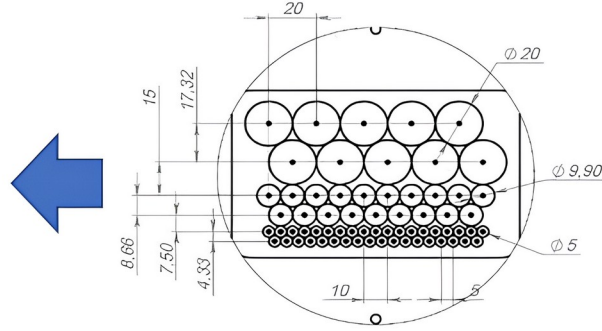


All detector systems are the same as in the SPS test beam, except the **reference tracking system**, which was replaced from **Micromegas** to **AZALEA** – a telescope of **6 pixel silicon detectors** used as the reference tracker.

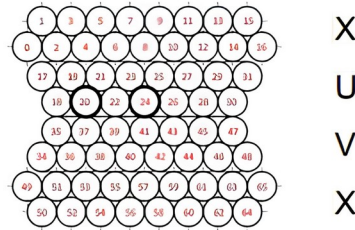
Straw prototypes



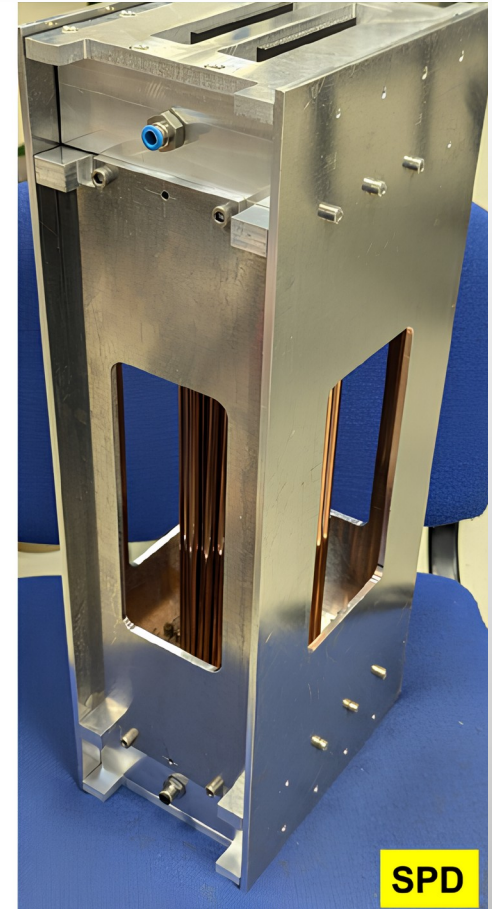
Gas mixture
(Ar/CO₂): 70/30%



Combine prototype: 5, 10 and 20 mm tubes area



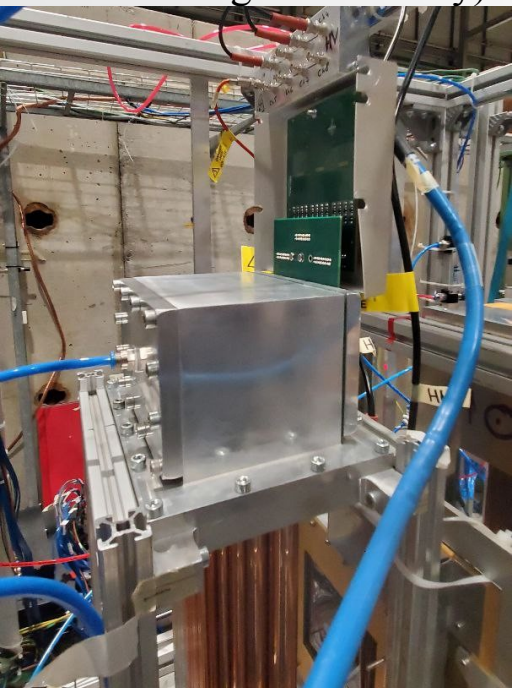
SPD prototype: 10 mm tubes with two X
planes, two U planes (2°), two V planes
(-2°) and two X planes



Straw tube diameters in different experiments:
5 mm – DUNE; 10 mm – SPD, NA62; 20 mm – SHIP.

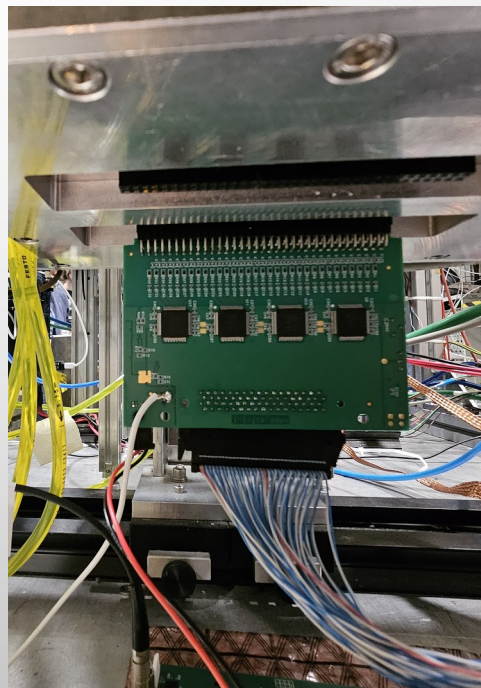
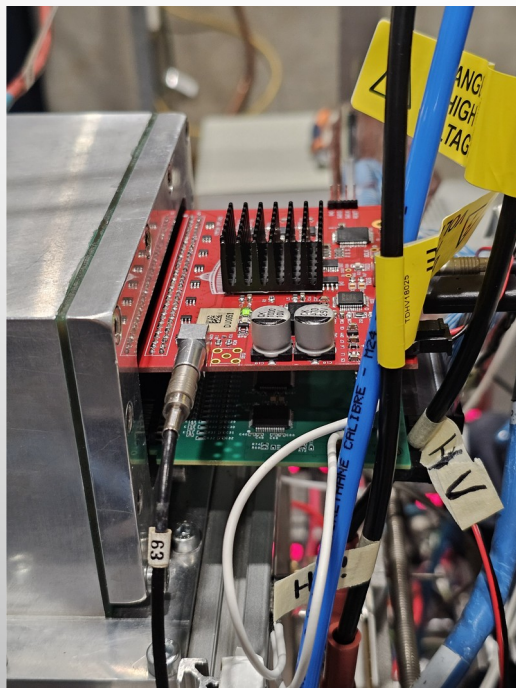
Redout

Combine straw prototype:
ATLAS sMDT redout with
ASD chip (operated together
with Michigan university)

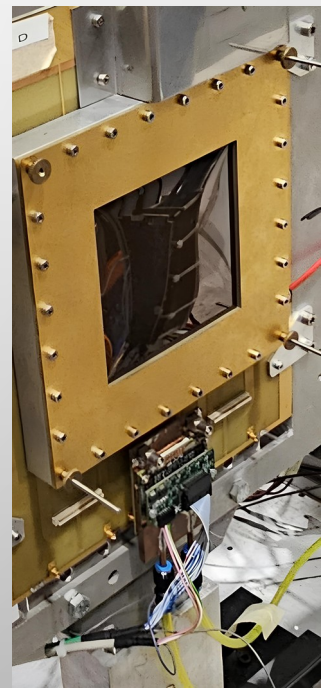


SPD prototype:

VMM3a-based custom readout ("ST-VMM") and
readout based on NA64 electronics ("ifTDC")



Micromegas:
TIGER ASIC



Micromegas

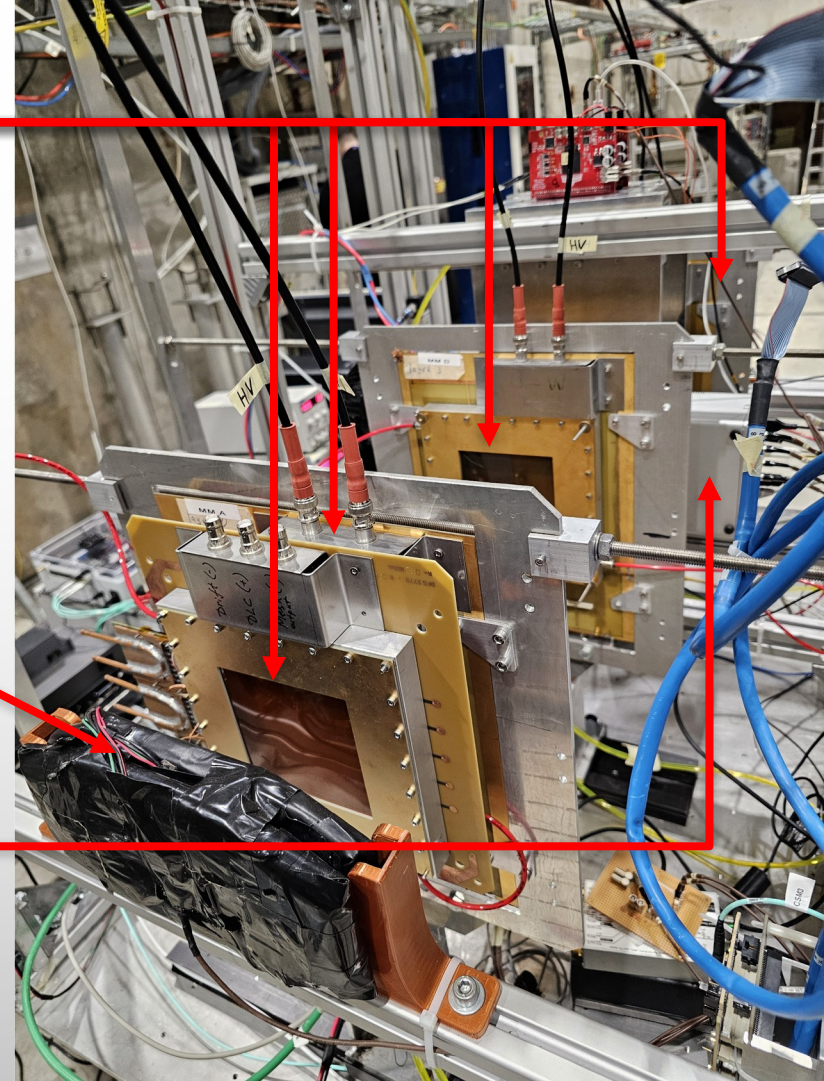
- Tracking reference: XY (two-coordinate) and X (single-coordinate) planes used in the setup
- Gas mixture (Ar/CO₂): 93/7%

Scintillators

- Coincidence serves as the system trigger
- T₀ reference for time measurements

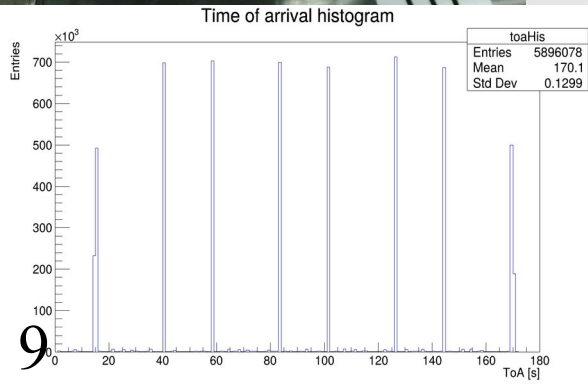
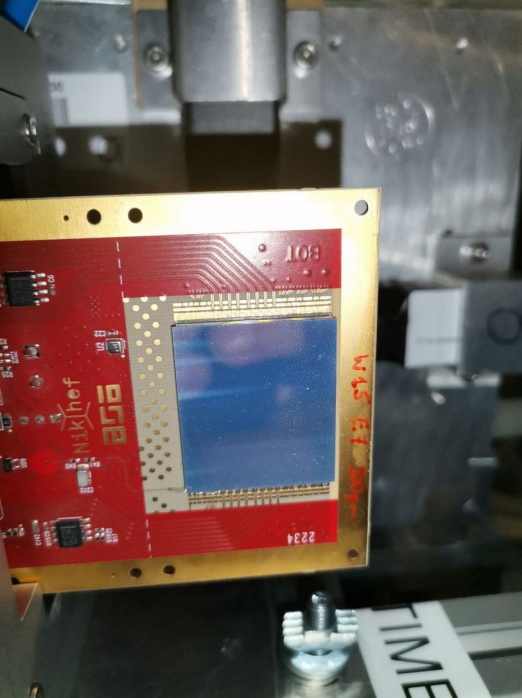
TimePix-4

- Tracking reference: high-precision pixel tracker – provides spatial and timing information

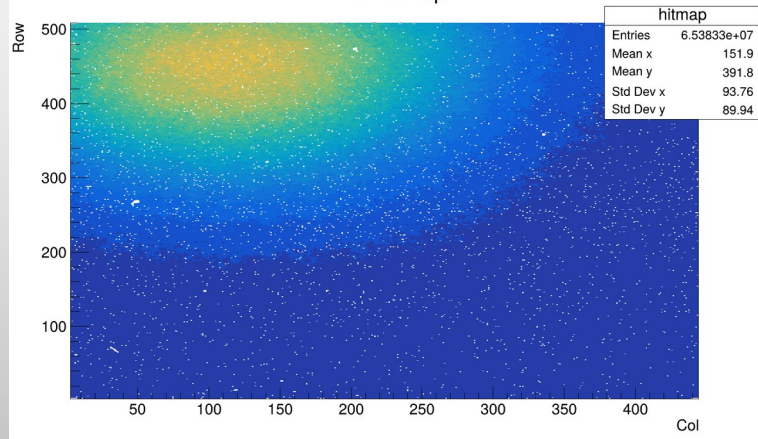


TimePix-4

- DAQ — SPIDR4
- Semiconductor hybrid pixel detector
- Si sensor 500 μm 100 V
- 448 x 512 pixels 55x55 μm
- Time resolution 1.5 ns
- 4 digital pixels
- External clock 40 MHz
- Measure ToT and ToA



Pixel hitmap



Results from the current test beams were also presented by members of **StrawTrackerRD** team at the AYSS-2025 conference:

- **S. Bulanova** – Garfield/LTSpice studies of the straw tube time and charge resolution for various readout parameters
- **M. Banchshikova** – Reference Tracking System for Performance Studies of Small Straw Tracker Prototypes for the Future SPD Detector at the NICA Collider

Summary

- The main goal of the study was to develop and validate small-scale prototypes of the straw tracker for the SPD experiment.
- Several straw modules with different diameters (5, 10, and 20 mm) were assembled and tested together with Micromegas, Timepix4, and the AZALEA pixel telescope at CERN test beams.
- The setup allowed a detailed investigation of RT-relations, spatial and time resolutions, and synchronization between different DAQ systems.
- Various straw readout options are investigated, including front-end electronics based on TIGER, VMM3/3a, ASD ASICs
- A reliable multi-DAQ synchronization has been achieved, and first combined data from straw and reference detectors were successfully collected.
- Preliminary results confirm good detector performance and validate the overall design approach for the SPD straw tracking system.
- Future work will focus on optimizing straw geometry, refining time-calibration procedures, and performing a full reconstruction analysis with the reference telescope.

Test beam setup logic

