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

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Multifunctional setups have been developed for testing first prototypes of the **SPD Straw Tracker**.

- Straw tracker is the main component of the SPD detector, especially for Stage 1.
- Should provide good momentum resolution, precise tracking, and particle identification (PID).
- Studies of tracker prototypes concentrate on
  - internal detection properties of straw tubes.
  - choice of optimal parameters for the readout electronics.

The studies are performed with test beams at **SPS and PS at CERN and at SC-1000 at PNPI** using the developed **Straw Testbeam Setups**.

Goals of the testbeam data taking:

tracking performance (spatial resolution):
- SPS H4 (high momentum muons) – timing and tracking, test of various readout options.

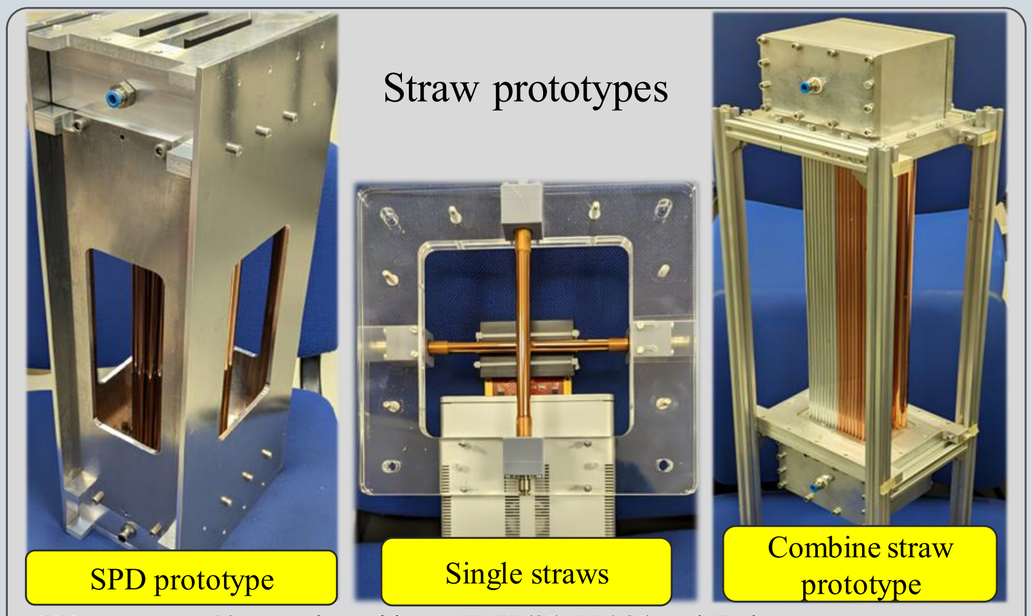
PID performance (resolution of ionization losses and dynamic range):
- PS T9 (low momentum hadrons and electrons 1-2 GeV) .
- PNPI SC-1000 (proton momentum scan in range of 0.4-1.8 GeV/c).

tracker prototype performance: 8-layer small prototype (uSPD: 64 straws, XUVX stereo layers), various readout electronics options.

Straw Testbeam Setups:
- Straw Tracker prototypes or single straws with various readouts.
- Reference timing system (~0.5 ns resolution).
- Reference coordinate system (100 um resolution for MicroMegas-based system, ~10 um for silicon tracker).

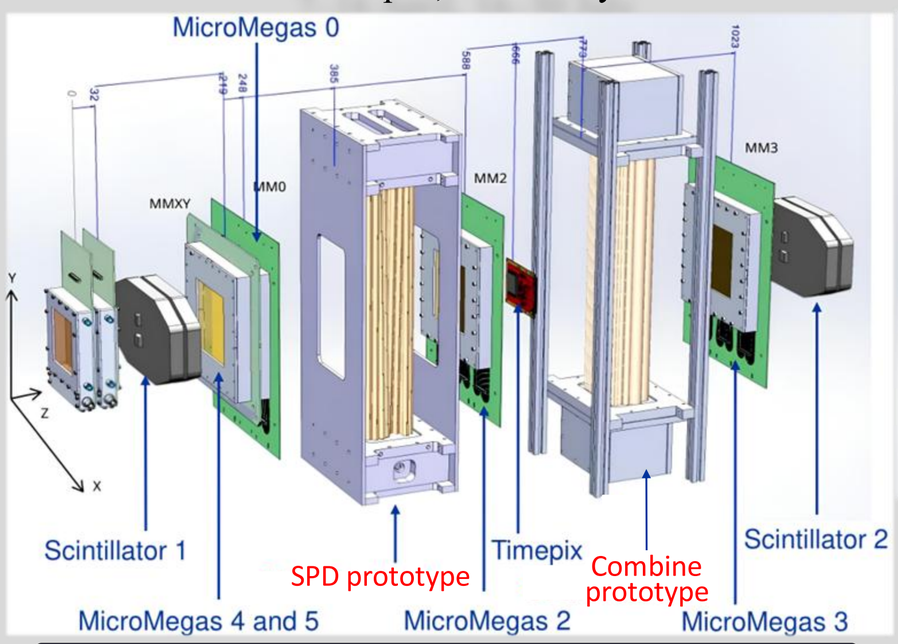
All readout components have own independent Data Acquisition Systems.
Common signals distributed to different DAQ elements allow offline data merging.

Straw prototypes

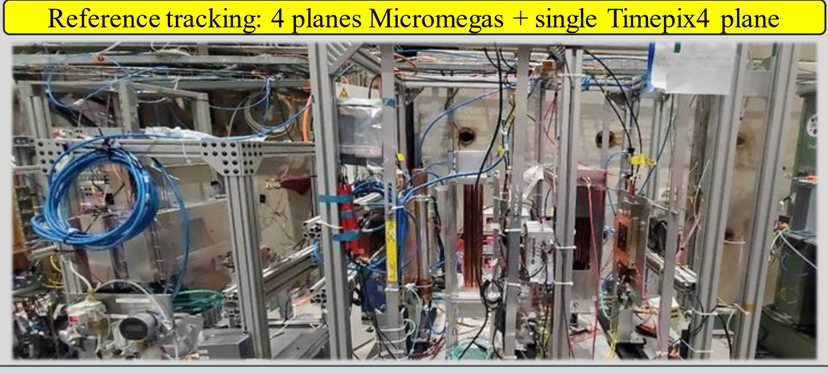


SPD prototype: 10 mm tubes with two X, U (2°), V (-2°) and X planes.
Combine prototype: 5, 10 and 20 mm tubes area.

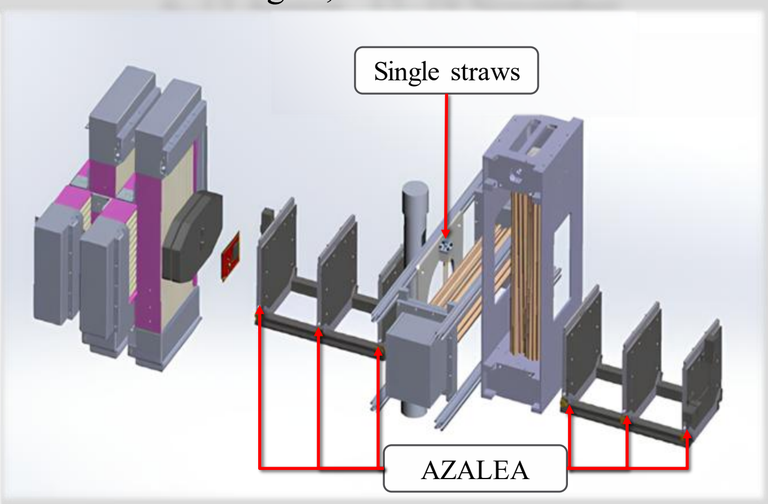
StrawTrackerRD setup at SPS H4 line, 2025
7–16 April, 16–30 July



Reference tracking: 4 planes Micromegas + single Timepix4 plane

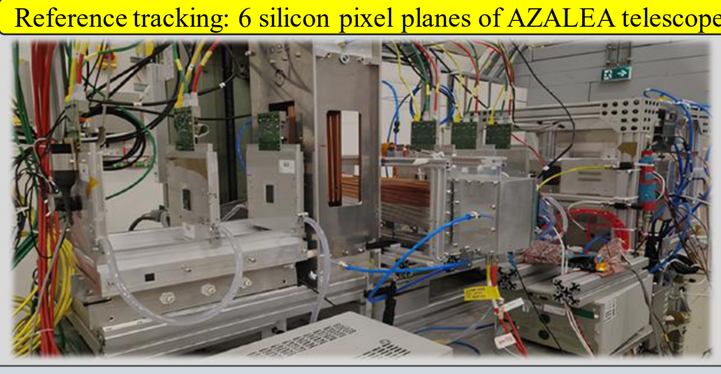


StrawTrackerRD setup at PS, 2025
6–13 August, 12–19 November

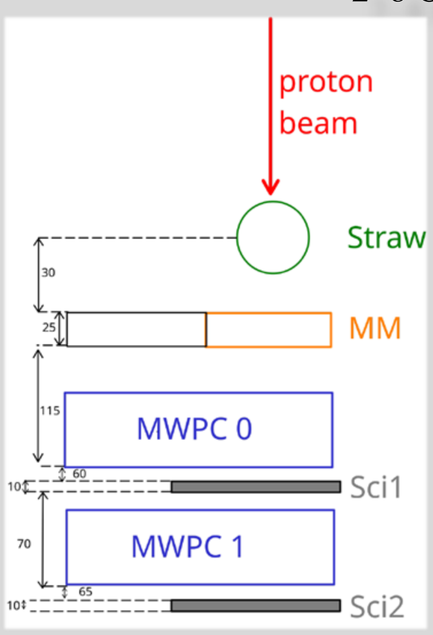


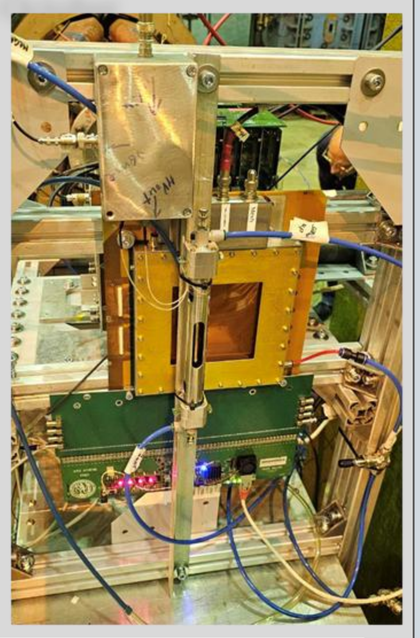
All detector systems are the same as in the SPS test beam, except the **reference tracking system**, which was replaced from **Micromegas** to **AZALEA** – a telescope of **6-pixel silicon detectors** used as the reference tracker.

Reference tracking: 6 silicon pixel planes of AZALEA telescope



StrawTrackerRD setup at PNPI (SC-1000), 2025
2–8 October





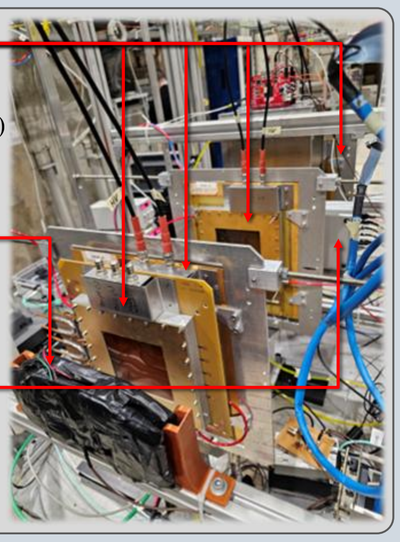
Reference tracking: Micromegas plane + two MWPC planes



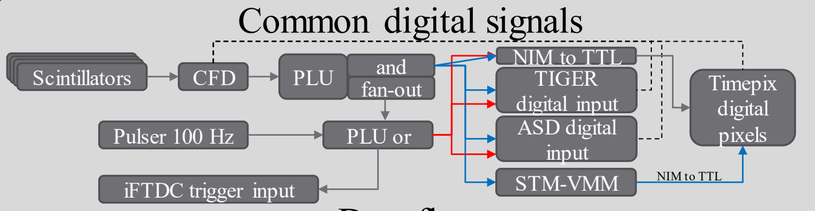
Micromegas
- Tracking reference: XY (two-coordinate) and X (single-coordinate) planes used in the setup
- Gas mixture (Ar/CO_2): 93/7%

Scintillators
- Coincidence serves as the system trigger
- T_0 reference for time measurements

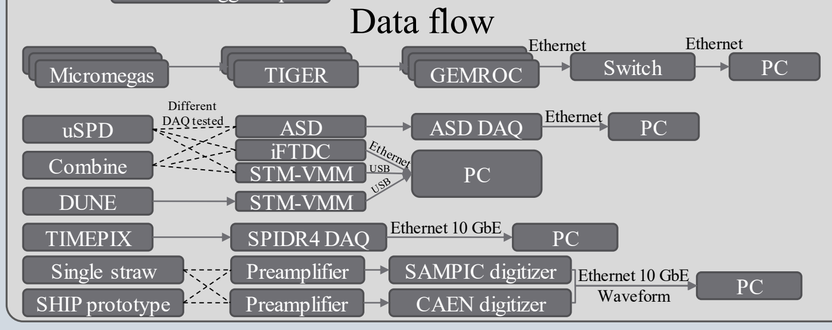
TimePix-4
- Tracking reference: high-precision pixel tracker – provides spatial and timing information



Common digital signals



Data flow



Straw readout

ATLAS sMDT redout with **ASD** chip



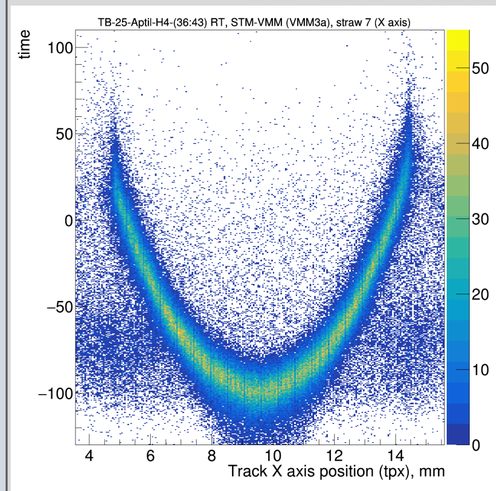
VMM3a-based custom readout ("STM-VMM")



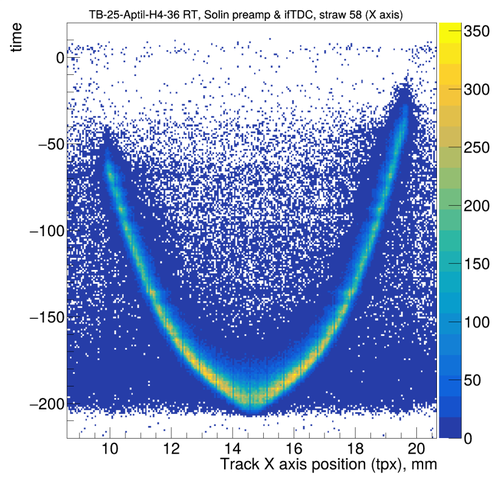
Readout based on NA64 electronics ("**ifTDC**")



Drift time as a function of track position, R(T)

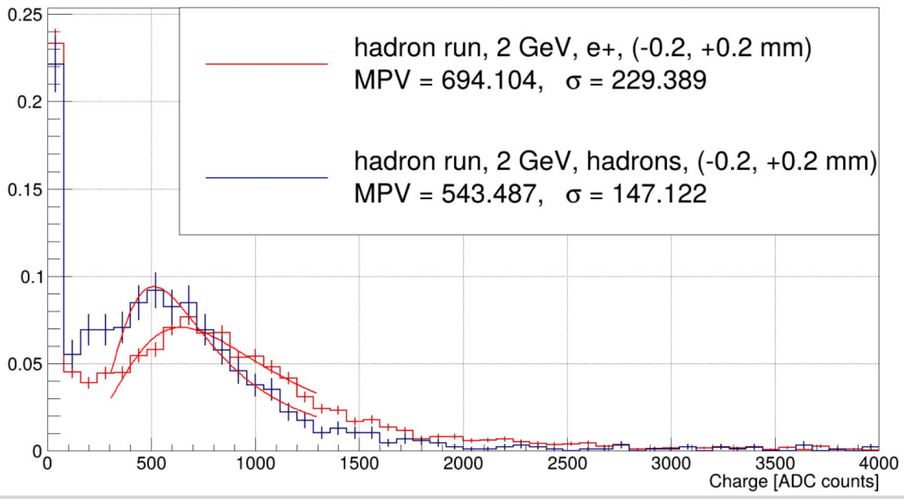


STM-VMM (VMM3a based)

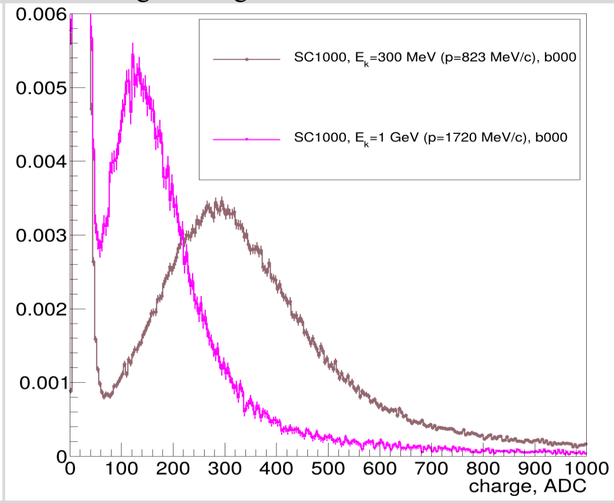


ifTDC (based on NA64 electronics)

Pion and positron ionization energy losses in a single straw



Integral charge distribution in the tube



Summary

- Multipurpose setups are developed for testing SPD Straw Tracker prototypes with test beams at CERN and PNPI
- The developed offline data merging approach allows to combine data from different Data Acquisition Systems of reference detectors and various options of straw readout electronics.

STRAW TEAM