JINR

Development of a position-sensitive detector system using the CAEN Front-End Readout System DT5202

Romakhov S.[1,2], **Gavrishchuk O.**[1], **Enik T.**[1]

[1] Laboratory of High Energy Physics, Joint Institute for Nuclear Research, 141980 Dubna, Russia

[2] Dubna State University, 141980 Dubna, Russia

SPD NICA

Introduction

A **position-sensitive detector** (PSD) has been designed based on a plastic scintillator plate, coupled to an array of silicon photomultipliers (SiPMs) through fiber strips. Main goal is to measure the transverse coordinate (x) of traversing charged particles such as cosmic-ray muons – by analyzing the light yield in multiple readout channels. This poster describes the detector's design, the electronic front-end provided by **CAEN FERS DT5202**, data acquisition methods, and the subsequent data processing and coordinate reconstruction in CERN ROOT.

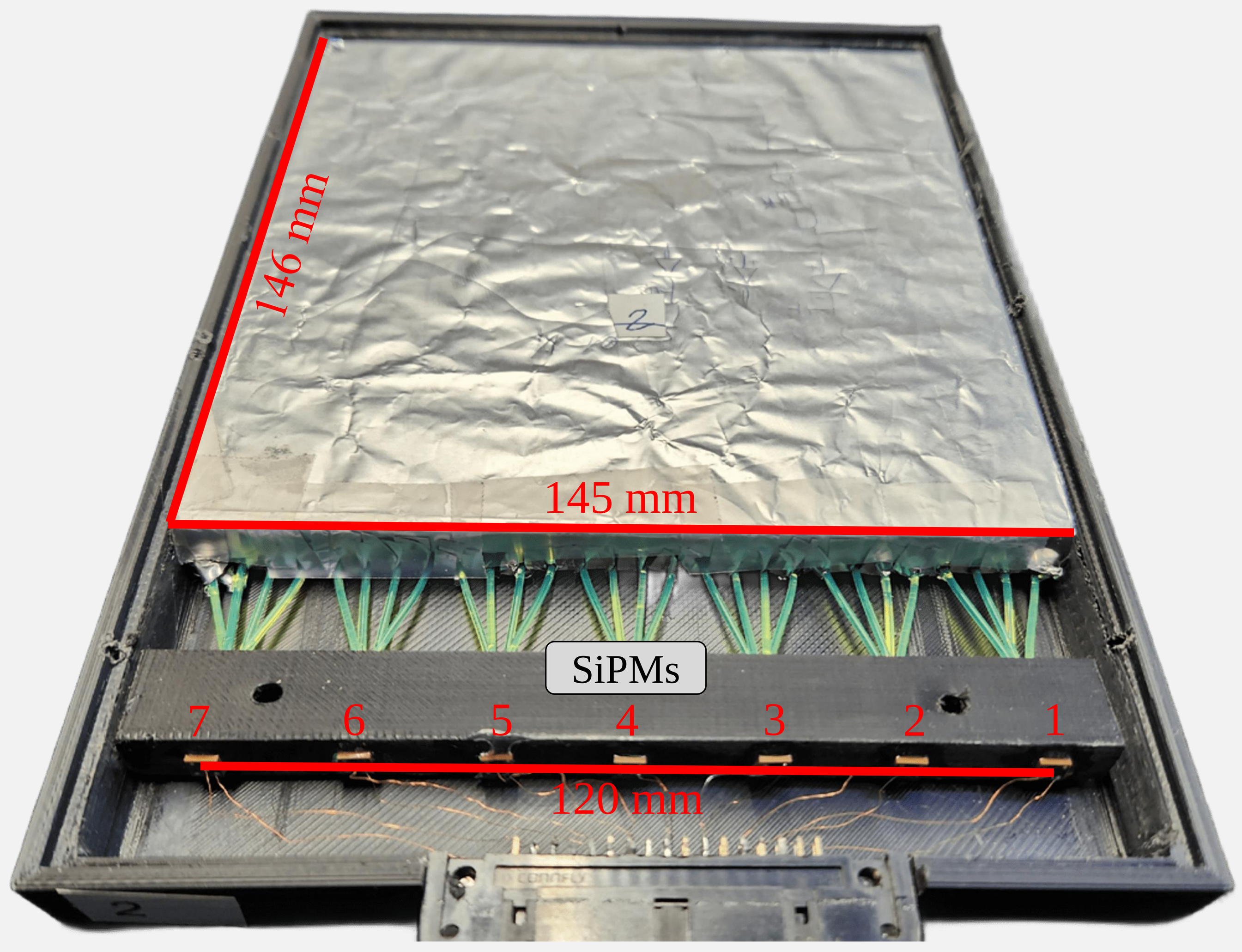

Fig. 1. Close-up geometry, showing fiber arrangement from 10 mm up to 130 mm

Detector Design and Parameters

Scintillator and Fiber Geometry

- The detector uses a **plastic scintillator** with embedded or surface-mounted **light-guiding fibers** arranged in parallel strips.
- Each strip (4 fibers) transmits scintillation light produced by an ionizing particle to one of several **SiPM** readout channels.
- Current geometry has **7 strips**, each associated with one SiPM channel. The lateral size (transverse to the beam) is roughly 15 × 15 cm^2.

Position Reconstruction

- The coordinate along the direction of these fiber strips is extracted from the **amplitudes** of multiple channels.
- The distance between SiPMs is **20 mm**, and the first channel starts at $\boldsymbol{x}$ **= 10 mm**, so the channels cover the region x = 10, 30, 50, 70, 90, 110, 130 mm.
- A weighted-sum approach (e.g $\Sigma A_i x_i / \Sigma A_i$) with normalization factors k is applied.

Fig. 2. The PSD next to the CAEN FERS DT5202 front-end electronics.

Data Acquisition and Processing

1. **Data Acquisition**
   - Each event consists of digitized signals (ADC counts) from 7 channels.
   - Time-stamp and event ID are also recorded to correlate hits in time.
2. **Calibration and Normalization**
   - Each channel's raw amplitude distribution is fit with a **Landau** function (Fig. 3). This yields a mean or MPV-based normalization coefficient (k) to equalize the response across strips.
3. **Coordinate Reconstruction**
   - For each triggered event, channels with sufficiently high amplitude are selected.
   - Applyed a weighted approach:

$$x = \frac{\Sigma_i (A_i x_i k_i \omega_i)}{\Sigma_i (A_i k_i \omega_i)}$$

where $A_i k_i$ – is the normalized amplitude,

$$\omega_i = \exp(-\alpha |x_i - x_{max}|)$$

can be an additional weighting factor (e.g., from geometry or exponential suppression).

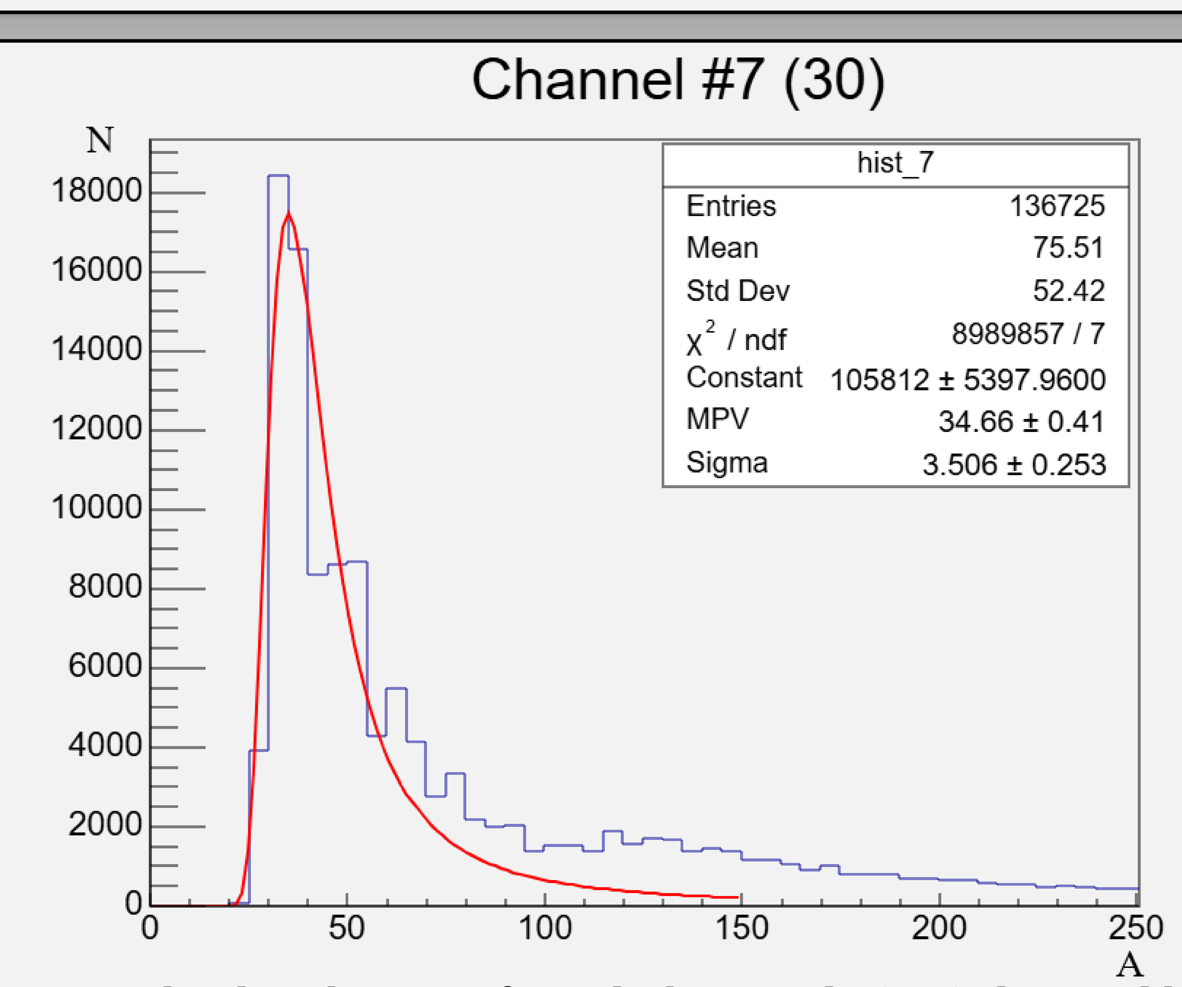

Fig. 3. The distribution of raw light signals (LG) detected by Channel #7 (SiPM 30) with a Landau fit applied.

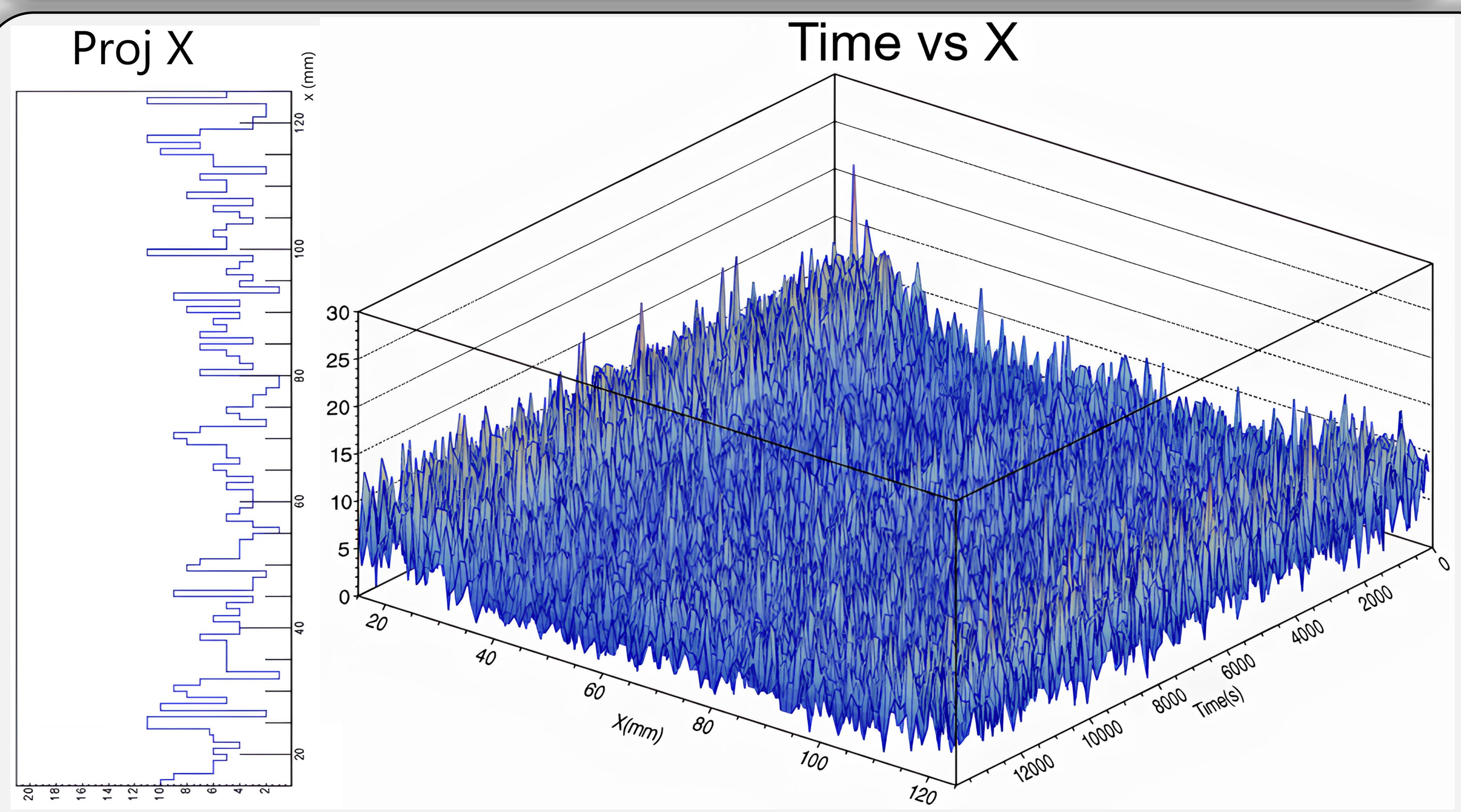

Fig. 4. The 2D histogram on the right depicts the particle coordinates (x) versus event timestamps. The projection along the x-axis on the left represents the spatial distribution of detected events.

Conclusion

This work establishes the groundwork for advancing position-sensitive detectors that utilize a monolithic plastic scintillator with fiber-strip readout and SiPM detection, integrated with CAEN FERS DT5202 electronics. Through amplitude-based reconstruction and calibration, this system can measure the transverse coordinate of charged particles with good uniformity. The approach is readily adaptable to cosmic-ray muon detection, beam diagnostics, or general tracking applications.

Key Results:

- Demonstrated stable ADC calibration using Landau fits.
- Successfully implemented a weighted-sum coordinate reconstruction technique.
- Achieved continuous coverage from x = 10 mm to x = 130 mm using 7 strips, with potential extension using more channels.
- Confirmed consistent time vs. x distributions for random cosmic-ray events.

References:

1. Integration of the CAEN Front-End Readout System for Calorimeters within the miniSPD Setup, presented at the 28th International Scientific Conference of Young Scientists and Specialists (AYSS-2024), BLTP, JINR, Dubna, Russia, October 27 – November 1, 2024.
2. CAEN S.p.A. documentation CAEN FERS DT5202. – URL: https://www.caen.it/;
3. CERN. ROOT Data Analysis Framework. – URL: https://root.cern/;
4. Hamamatsu Photonics. S14160-4060HS Series. – URL: https://www.hamamatsu.com/resources/pdf/ssd/s14160_series.