JINR

SPD NICA

Areas of application for the CAEN Front-End Readout System

Sergey Romakhov

Straw-tracker Team

Laboratory of High Energy Physics, JINR

romakhov@jinr.ru

Motivation

- Checking the capabilities and testing of modern electronics
- Checking the applicability of the CAEN readout electronics for the miniSPD stand
- Obtain real data from cosmic rays
- Using prototype SPD detectors
- Measurement of detector characteristics
- Checking the stability of the detector and readout electronics over a long period of operation

MiniSPD setup

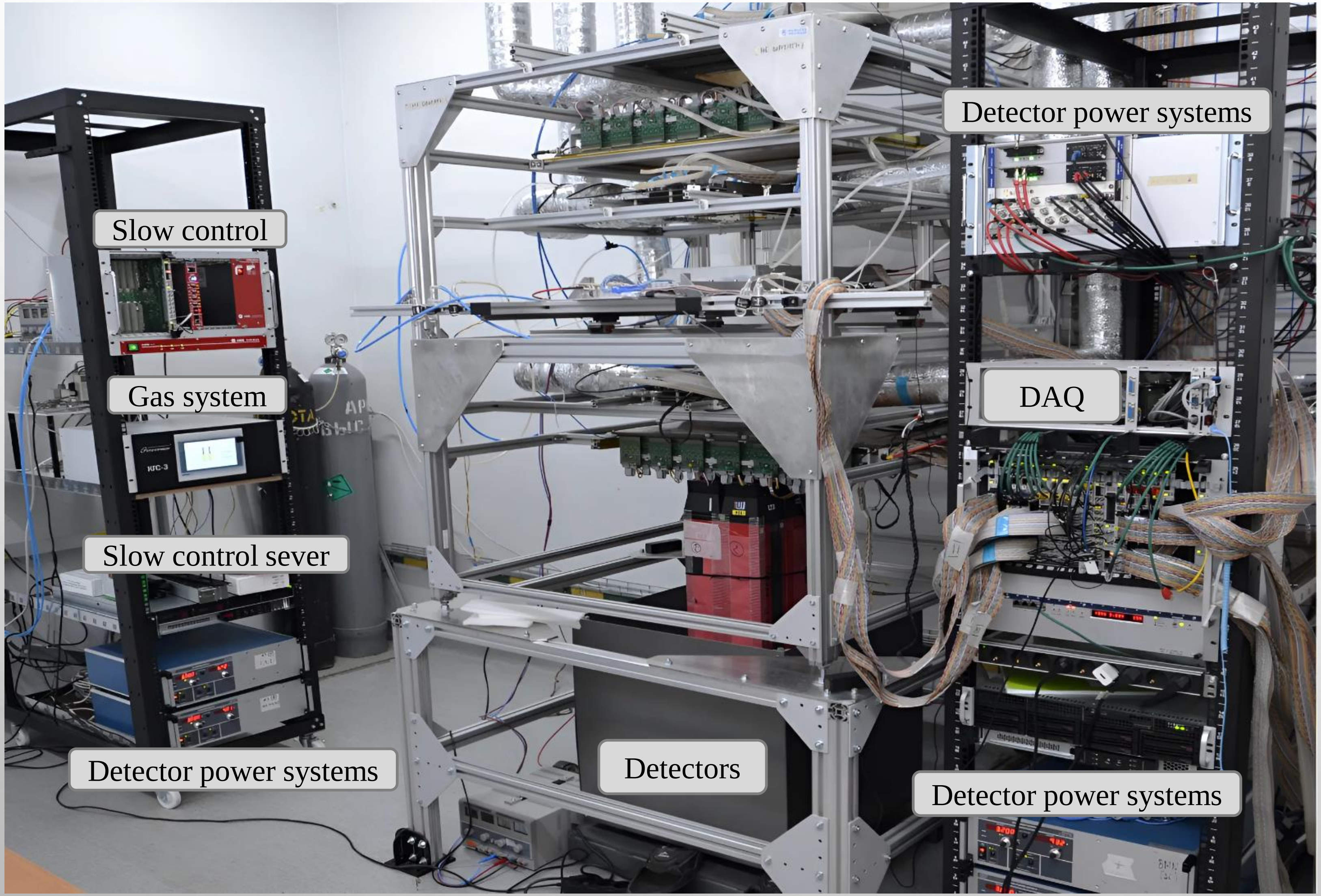


Fig. 1. Main view of the miniSPD stand

- **MiniSPD** is a facility for space muon testing of all types of detectors that will be used in the SPD facility.
- It includes a trigger system, straw, silicon and GEM trackers, electromagnetic calorimeter modules and a lead filter to remove the soft component of cosmic rays.
- The stand will be used to measure such important parameters as spatial and temporal resolution, efficiency, drift characteristics, gain, etc.
- The installation is also intended for testing the data collection system, slow control and online monitoring.

FERS DT5202 system

Fig. 2. FERS DT5202 64-channel unit

FERS represents a distributed and easily scalable system, where each front-end unit functions as a versatile card capable of various roles, including a traditional analog spectroscopy chain, a digital front-end (TDC or trigger logic board), or a switched capacitor array.

The initial unit based on two ASICs Citiroc 1A chip (Weeroc) for SiPM readout. Data collection for cosmic rays involves a Hamamatsu 64-channel SiPM matrix (fig.3) paired with plastic scintillator, and a 2-pin adapter is used for the straw chamber prototype (fig. 4).

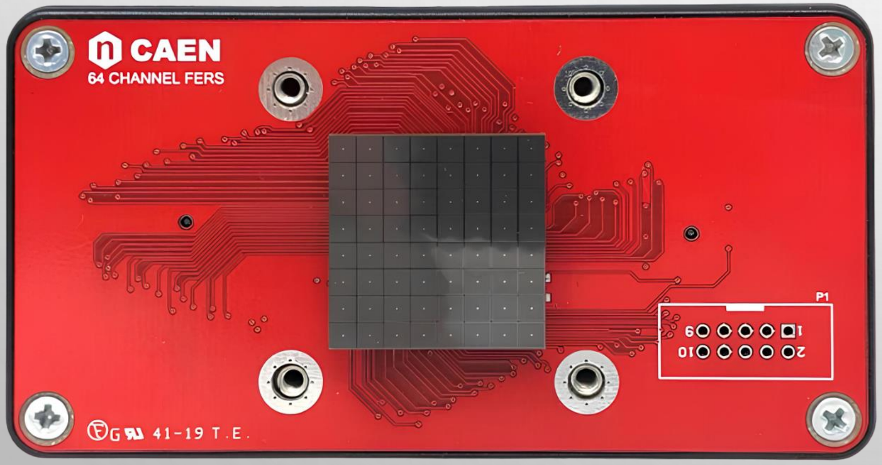


Fig. 3. General view of MPPS header adapter with Hamamatsu S13361 SiPM matrix

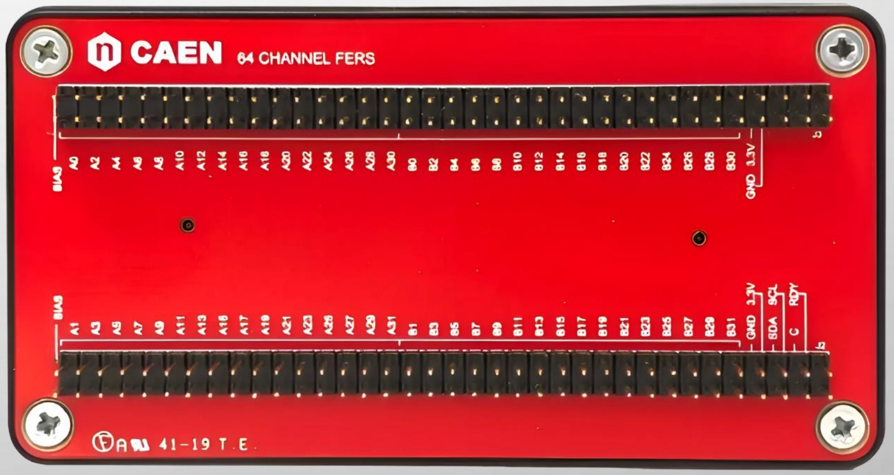


Fig. 4. General view of header adapter with 32 bias (cathode)/signal (anode) couples

The staircase spectrum

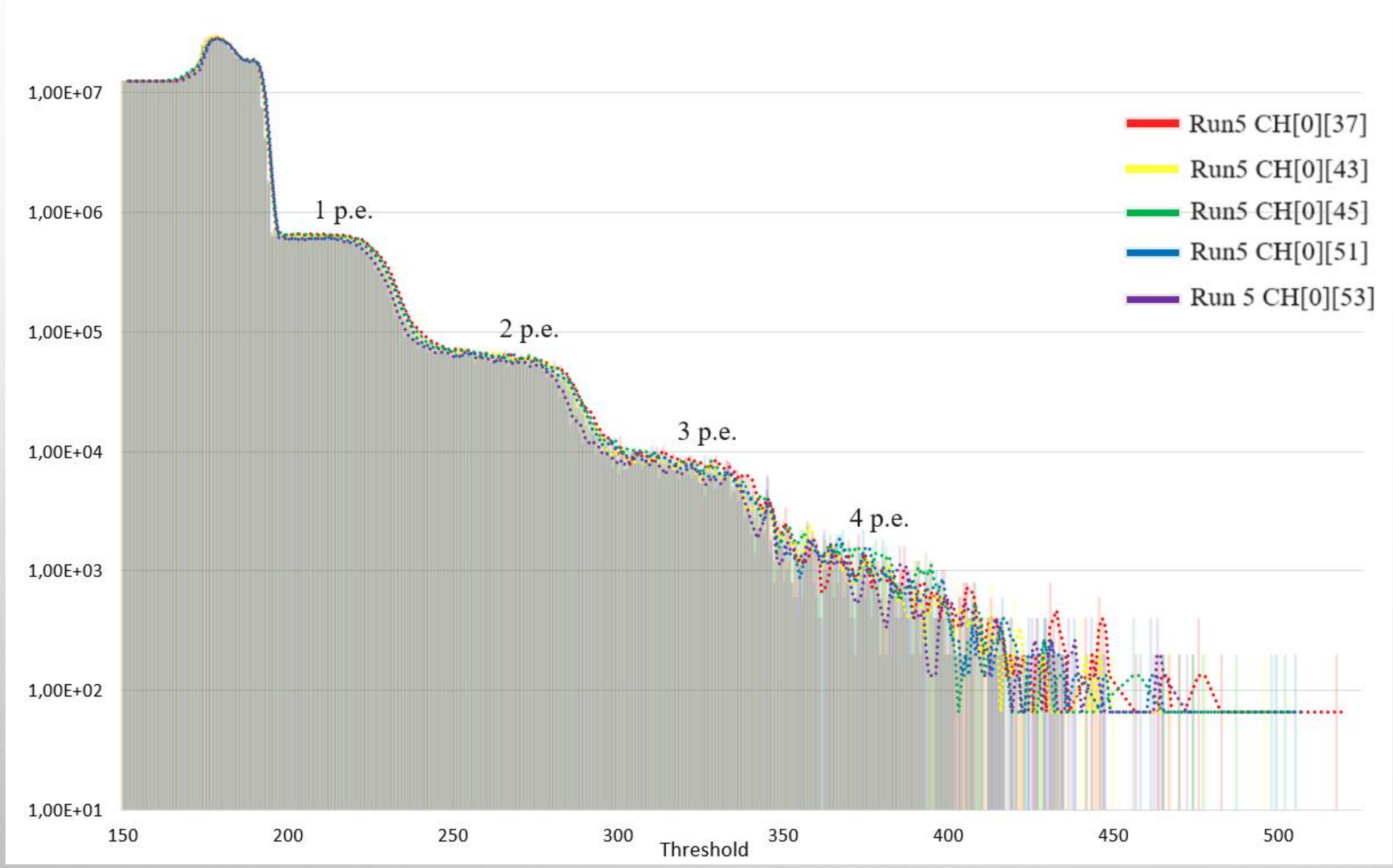


Fig. 5. Counts vs Threshold (Staircase) from the OR of the SiPM matrix pixels connected to high-gain channels of the DT5202

The staircase spectrum is a plot illustrating the relationship between the **threshold level** set for triggering events and the corresponding counts observed in the detector. It is essential for optimizing the threshold and reducing noise interference.

Photonic peaks (1 p.e., 2 p.e., etc.) represents the detection of a specific number of photoelectrons. As the threshold is lowered, the detector starts capturing individual photons, leading to distinguish able peaks in the spectrum.

Cosmic rays

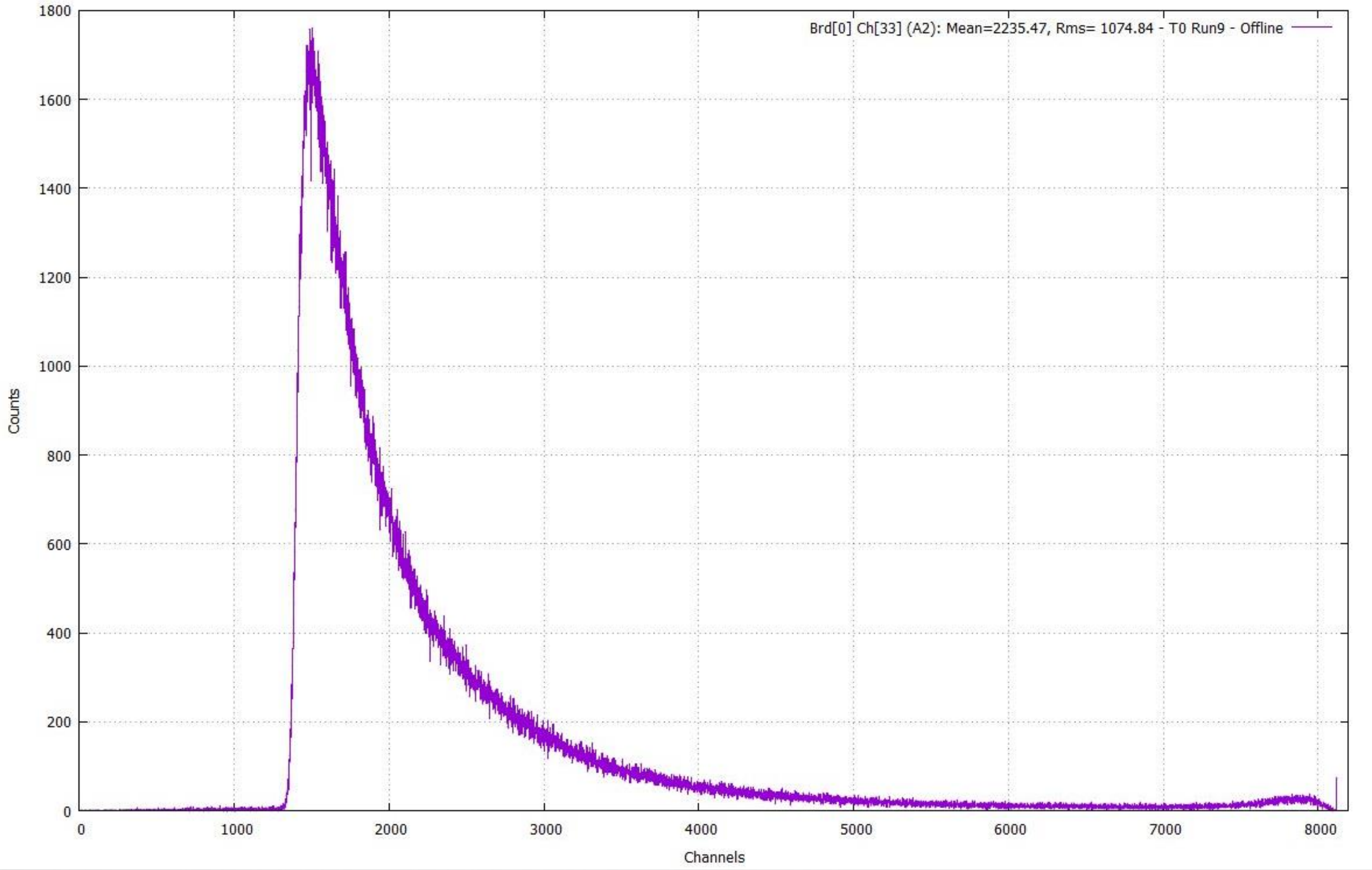


Fig. 6. Landau distribution of Cosmic Rays

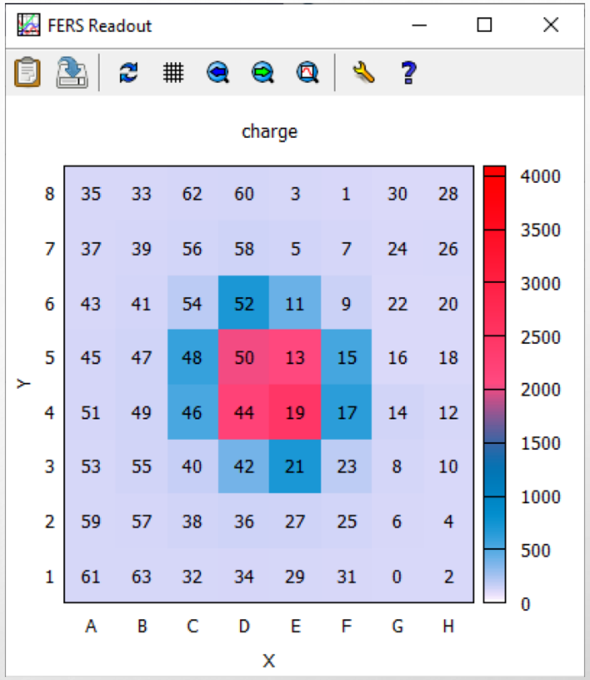


Fig. 7. 8x8 real-time charge-trigger matrix

The Landau spectrum was produced using the plastic scintillator and Hamamatsu matrix, illustrating the energy loss distribution for relativistic muons.

Figure 7 presents a 8x8 matrix illustrating **charge-trigger events** in response to cosmic radiation. Each cell in the matrix corresponds to a specific position in the SiPM array, providing a visual representation of the spatial distribution of charge-trigger events.

Spectrum of Fe-55

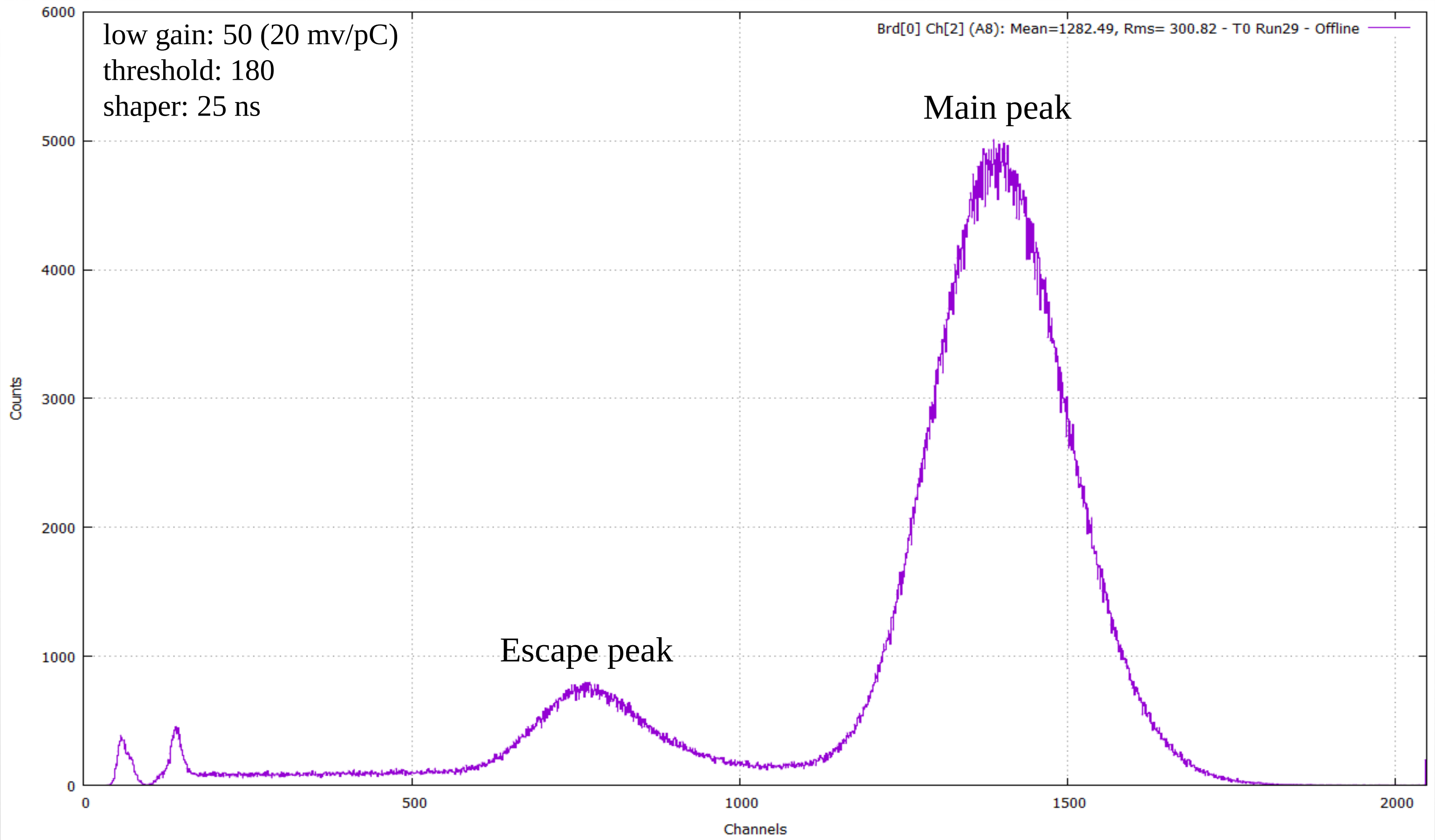


Fig. 8. Gamma-ray spectrum of Fe-55 source

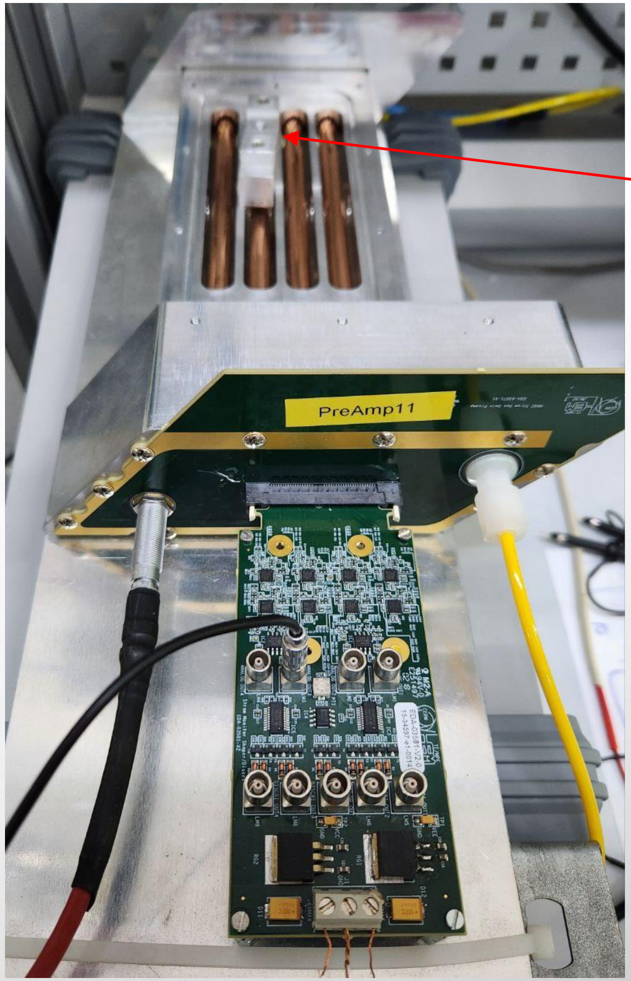


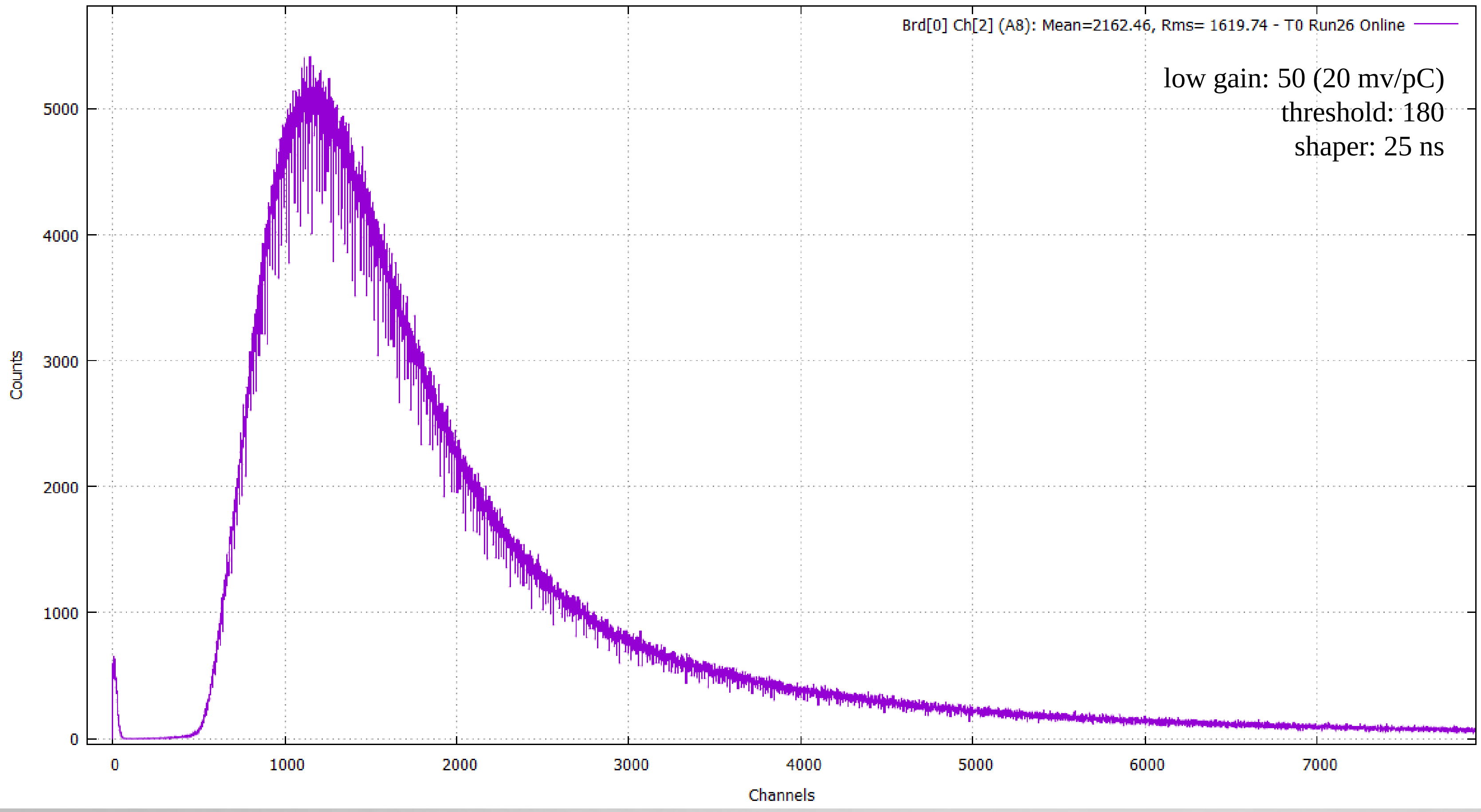
Fig. 9. General view of straw chamber prototype

Parameters: 9,8 mm straw; 30 µm wire; 1500 volt; 80% (Ar) / 20% (CO_2) gas mixture.

Main Peak: The main peak observed at an energy of 5.9 keV is due to the transition of the Fe-55 nucleus to a lower energy level, lead by the emission of a gamma-ray.

Escape Peak: The escape peak appears due to the interaction of gamma-rays emitted by the source with the detector material. This interaction leads to the ejection of electrons from the detector, which carry away some of the energy. The escape peak is typically located at an energy that is 3 keV lower than the energy of the main peak. Therefore, for Fe-55 with a main peak at 5.9 keV, the escape peak will be observed at approximately 2.9 keV.

Spectrum of Ru-106



Fir. 10. The beta spectrum of Ru-106

The beta spectrum of Ru-106 is a continuous spectrum with a high-energy limit. The high initial intensity rapidly decreases as energy increases, forming a broad distribution. This makes Ru-106 particularly useful for testing the performance of electronic readout systems due to its broad energy range and high activity.

Medical applications

Universal multichannel electronics for position-sensitive gamma-detectors

Possible applications:

- Computer tomography (CT)
- Single-photon-emission computer tomography (SPECT)
- Positron-emission tomography (PET)

FERS can be combined with SiPM matrices coupled to a monolithic scintillation crystal:

- Light distribution over the matrix → XY coordinates of the interaction
- Z coordinate can be also estimated by the light distribution shape
- Good ER → well background suppression
- High and low range → SiPMs calibration during data taking

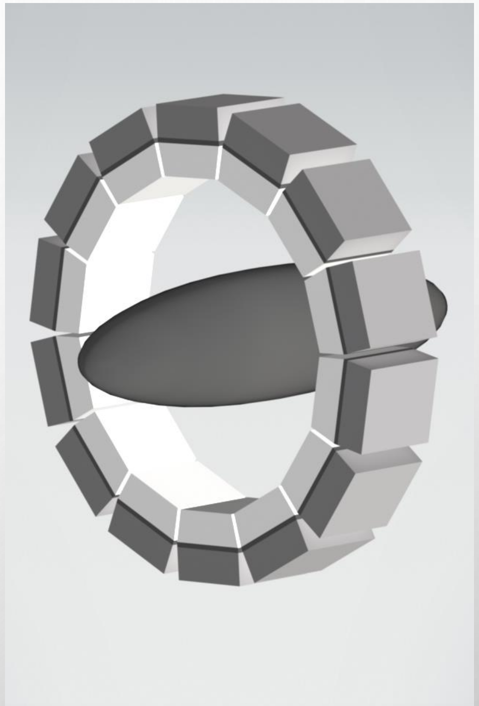


Fig. 11. MicroPET based on monolithic scintillators

Conclusion

- The data presented provide valuable information for the ongoing evaluation of the effectiveness of FERS.

- The capabilities of Citiroc 1A, including its wide range of amplification, allow for direct observation of results from the straw chamber without the need for preamplifiers.

- The system's flexibility, along with continuous calibration, makes it a perfect fit for integrating into various systems with changing needs and types of detectors.

- Looking ahead, during the reconstruction and improvement process of the miniSPD, the integration of the FERS system is planned. This system will be used primarily as the trigger electronics with a self-trigger mode, but also as the readout electronics for individual miniSPD elements.

Thank you for your attention