Towards an integrated and high-density Silicon strip measurement system

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First CAEN-Micron joint measurement

Silicon strip detectors play a central role in applied nuclear physics thanks to the high channel density and almost 100% detection efficiency. In particular, **double-sided silicon strip detector** (DSSSD) enable very accurate 2D position sensing. Their principle of operation is straightforward, but the full exploitation of their potential requires many independent readout channels

In this work we explore the possibility to achieve a **comprehensive and reliable multi-channel position sensing system** using off-the-shelf Micron Semiconductor Ltd. Si detectors and CAEN readout electronics**.** This effort is to be intended as a proof of concept aiming at studying **extremely integrated solutions** that could be used in a variety of fields, including High-Energy Physics as well as Nuclear Security applications.

A multi-channel alpha particles detection system

The system is based upon the W1-140 DSSSD [1] manufactured by Micron Semiconductor UK Ltd. The readout chain (preamplifier, shaping amplifier and peak sensing ADC) is composed by well-established CAEN modules [2][3][4]. This chain allows to **count** and measure the **energy** of particles hitting each Si strips. The tuning of the acquisition parameters for each readout channel is described in [5].

In this way, we were able to put in place a **integrated multi-channel measurement system for the detection of alpha particles.**

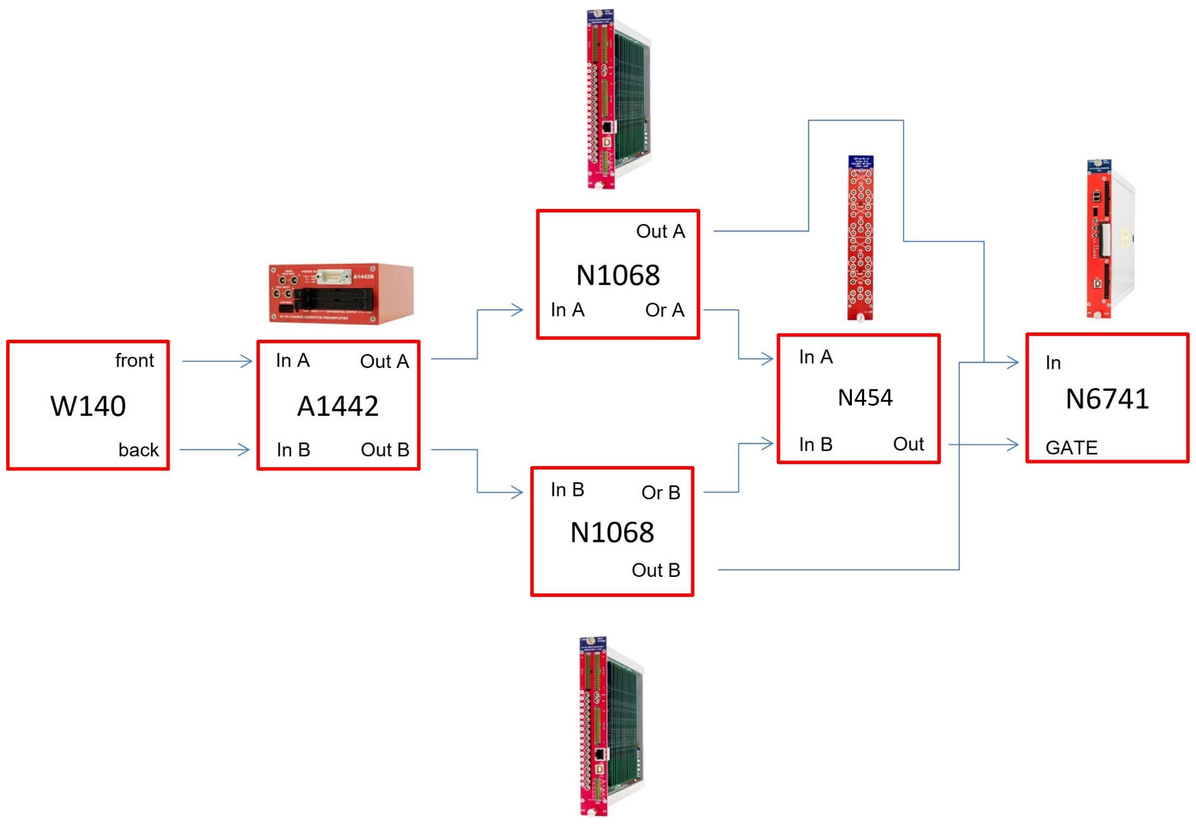

Fig. 1. Sketch of the electronics chain used to readout Si strip detectors.

Successful 2D position sensing

We measured the position of an ^{241}Am alpha source when placed at approximately 2 cm from the detector in three different positions. The **alpha particles position** is mapped by summing the counts from the strips forming the ”pixel”. The contour plots in Fig. 2 show the correct radioactive source **position** and **dimensions** (nearly 16 mm).

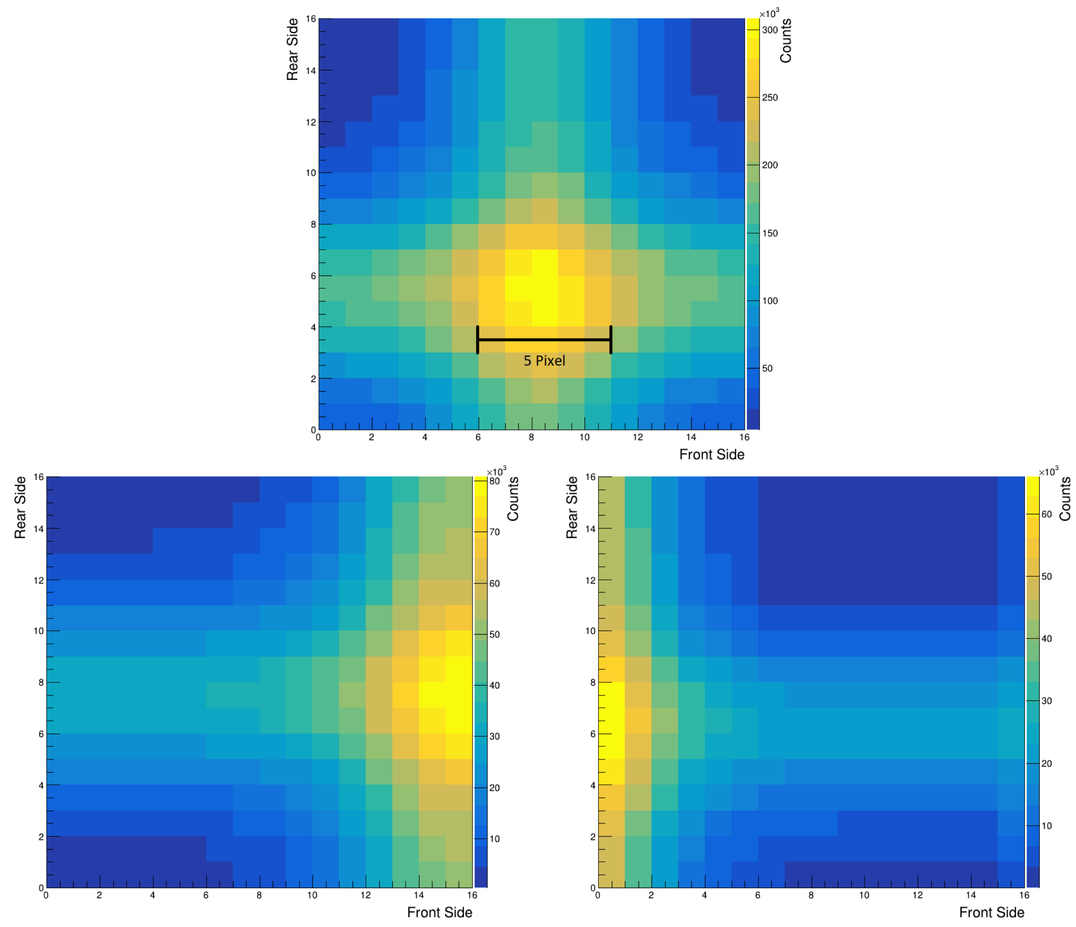

Fig. 2. The alpha radiation map with the source in the centre, right and left of the strip detector

Future perspectives

We built a position sensing proof of concept for Alpha particles using off-the-shelf electronics and a well-established segmented Silicon strip detector.

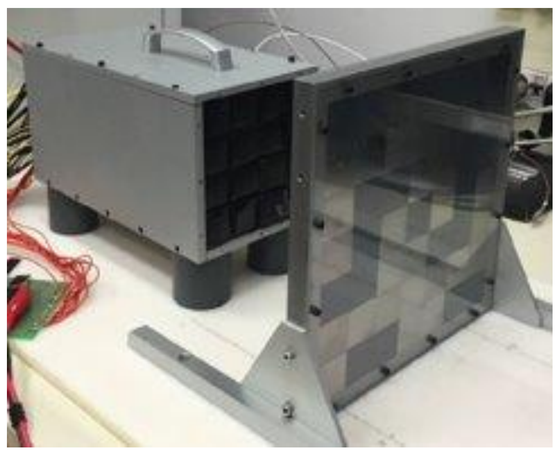

Fig. 4. the HERGA prototype, shown as an example of integration of CAEN electronics for Gamma-rays monitoring.

This joint effort is leading the way to the development of a **highly-integrated alpha particles detector**. A similar approach has already been used and resulted in the development of the HERGA Gamma Camera [6] for NORM/TENORM radioactivity detection. In the exact same way, it would be possible to firmly establish the use of Si strip detectors to **Societal Challenges**, where the availability of a cost-effective portable equipment may result in a strong benefit.

CAEN has developed a **compact**, **high-channel count** and **scalable** platform [7] that has been successfully used for the readout of Silicon Photomultipliers. The same hardware may be used, with minor changes, to build integrated solutions to map Alpha radiation, relying upon Si strips.

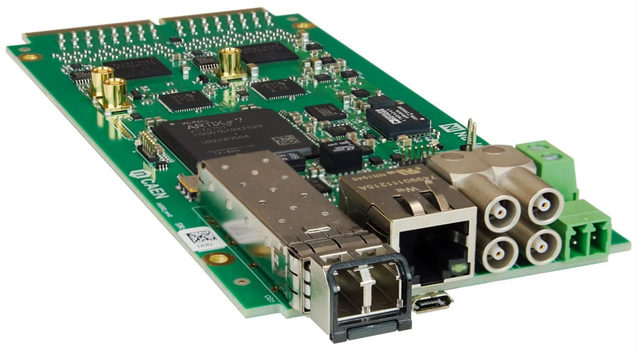

Fig. 5. CAEN FERS-5200 suitable for the development of highly-integrated solutions exploiting Silicon strips compactness and cost-effectiveness.

The way towards radionuclides identification

Fig.3 shows an energy spectrum collected using the readout chain in Fig.1, where the peak is the sum of the 5.443 MeV and the 5.486 MeV alphas emitted by ^{241}Am. which we were not able to resolve, because we performed our measurement in air, which scatters and absorbs alpha within 2 to 5 cm. The spectroscopic ability of our proof-of-concept is the first step towards the development of more integrated systems capable of **identifying alpha-emitting radionuclides.**

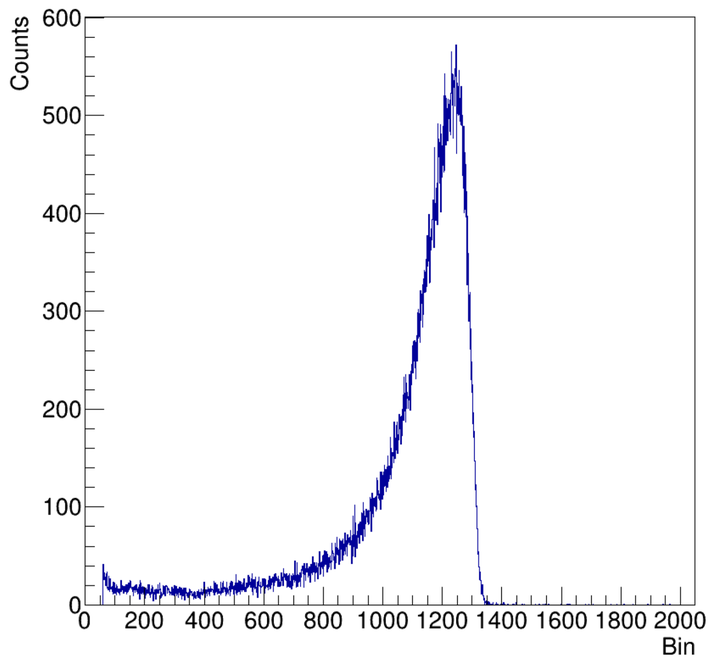

Fig. 3. Energy spectrum of the alpha particles emitted by the ^{241}Am source

References

[1] http://www.micronsemiconductor.co.uk/product/w1/

[2] DS72233 – A1444 Preamplifier Data Sheet

[3] UM3148 – N1068 User Manual

[4] UM7493 – N6741 User Manual

[5] AN8422 – Position Sensing with silicon strip detector and CAEN acquisition chain

[6] C.Altomare et al. “*A high efficiency fast response gamma detector with mrad pointing capabilities*” , Nuclear Inst. And Methods in Physics Research A, 125 (2022)

[7] https://www.caen.it/subfamilies/fers-5200/