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Introduction

Silicon detectors started to play a central role in the field of applied nuclear physics, thanks to the possibility to realize thinner active areas with high detector channel density, and their almost 100% detection efficiency. In particular, silicon strip detectors are nowadays widely used for both nuclear structure and dynamics studies. Their segmented active area makes them a suitable choice for many kinds of position sensing experiments, but also for coincidence measurements between two or more particles, when it is necessary to fully characterize the final state of a system. Silicon strip detectors principle of operation is fairly straightforward, each strip is connected to a different readout channel and the radiation position is revealed by the location of the strip showing the signal. Furthermore, it is possible to obtain 2D spatial resolution by adding a second set of strips on the detector backside, orthogonal to the ones on the front. This particular type of detectors is called double sided silicon strip detector (DSSSD) and in this application note we evaluate the performances of a DSSSD in conjunction with CAEN readout technology. The goal is to determine the possibility of performing a reliable position sensing measurement.

Experimental Set up

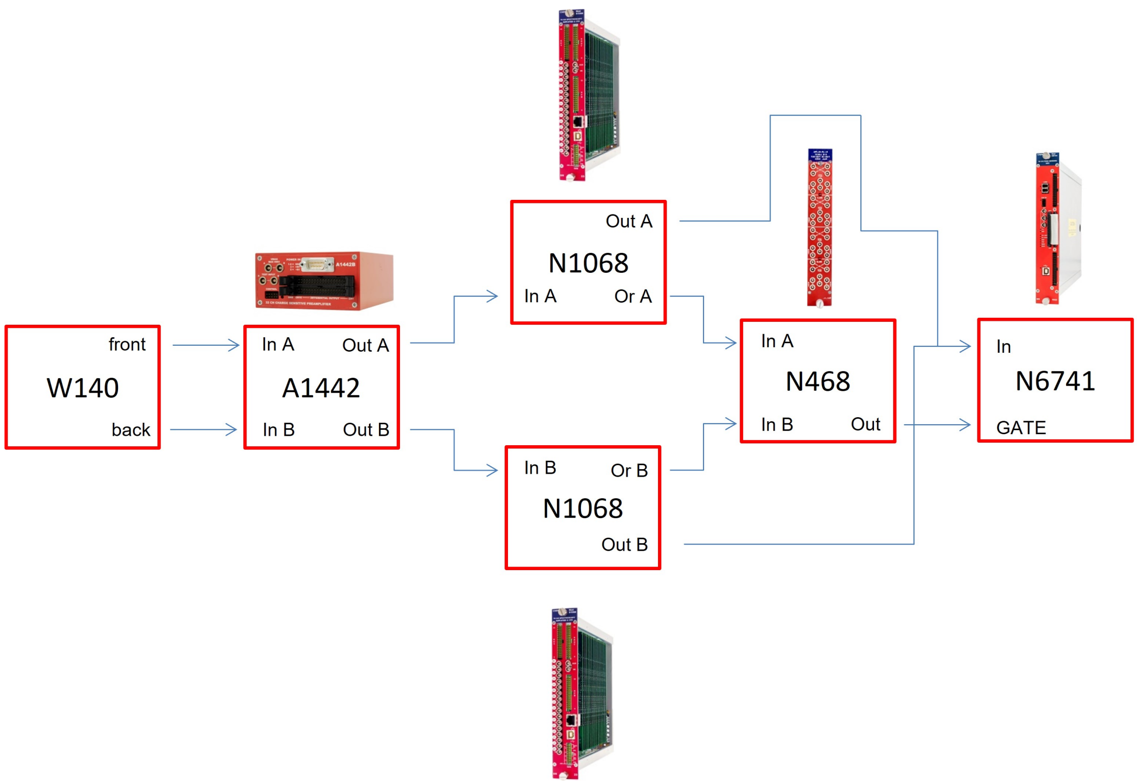

Fig. 1: Setup scheme

The experimental set up (**Fig. 1**) consists of:

- radioactive source: ^{241}Am
- detector: W1-140 supplied by Micron Semiconductor[**1**]
- preamplifier: A1442 [**2**]
- shaping amplifiers: two N1068D [**3**]
- fan-in/fan-out: N454 [**4**]
- peak sensing ADC: N6741 [**5**]

The W1-140 is a 140 µm thick DSSSD composed by a total of thirty two 3x50 mm strips, sixteen on the front and sixteen on the back. The signal from each strip is preamplified by the A1442, a thirty two channels preamplifier divided in two independent groups, one for the detector front side and the other for its back side. The preamplified signals were then shaped into gaussians by two sixteen channels N1068D shaping amplifiers, again one for the front and the other for the DSSSD backside.

For a successful measurement, it is important to correctly set the parameters of the two shaping amplifiers and the N6741. As one would expect, settings like shaping time, coarse gain and pole zero should have the same values for each strip (**Tab. 1**), however it is necessary to set threshold and time offset individually for each channel (**Tab.2**).

To find the correct threshold values, we suggest to check the MUX timing signal and the OR signal at the oscilloscope (one channel at a time). First, it is convenient to compensate for any offset in the timing signal and then adjust the threshold until there is only one OR for each signal, later the threshold can be more finely tuned by looking at the histograms. More details can be found in **[6]**.

Finally, the energy spectra are built for all the strips by the N6741, a thirty two channels peak sensing ADC. The N6741 is used in gate mode, where the gate starting point is given by the OR signals of the two shaping amplifiers. Since the peak sensing has one gate input only, we connected in output the two OR ports with the N454 fan-in/fan-out, and then we sent the resulting signal to the peak sensing. Here it may be important to point out that since the OR signals coming from each channel are all summed and sent to the peak sensing ADC, the N6741 may fire the gate for a channel even when the strip do not show a signal, introducing noise in the energy spectra. It is necessary then to properly set the ZS_THRESHOLD in the peak sensing configuration file, in our case we used a value of 100 LSB for each of the seven groups (the settings used for the N6741 configuration file are listed in **Tab. 3**).

For more information on how to set the N1068D and the N6741 peak sensing ADC please check references [**3**] and [**5**].

Parameter	Value
Bias Voltage	10 V
Shape time	0.5 µs
Coarse Gain	64
PZero Adj	255
Tgain	4X
Tint	80 ns
TDiff	500 ns

Tab. 1: Shaping amplifiers parameter values used in the acquisition.

	Front		Rear	
Channel	T Offset	Threshold	T Offset	Threshold
Ch0	700	30	600	25
Ch1	250	20	320	20
Ch2	600	20	550	20
Ch3	400	19	400	19
Ch4	200	21	300	21
Ch5	400	25	350	25
Ch6	800	15	700	10
Ch7	400	15	300	26
Ch8	900	26	1000	26
Ch9	600	24	700	24
Ch10	700	13	700	13
Ch11	000	18	100	4
Ch12	1200	18	900	25
Ch13	900	15	1000	30
Ch14	900	19	900	20
Ch15	400	19	400	30

Tab. 2: T Offset and threshold values (LSB) of the two shaping amplifiers connected to the detector front and rear sides.

Parameter	Value
INPUT_RANGE	8V
SLSCALE_ENABLE	YES
SPECTRUM_CHANNEL	4K
GATE_WIDTH	6 µs
ZS_THRESHOLD	100 LSB

Tab. 3: Peak sensing N6741 parameter values used in the acquisition.

Results

We measured the position of an ^{241}Am alpha source when placed at a distance of approximately 2 cm from the detector in three different positions. As already mentioned the alpha particles position is revealed by the strip that senses the radiation, here the maps have been obtained by considering as a ”pixel” [1] the intersection between two orthogonal strips and by summing the counts in the strips forming the ”pixel”. The maps obtained in this way seem to be in agreement with the expectations, as all the three contour plots show the correct radioactive source position (**Fig. 2** and **3**). Furthermore the spot diameter in the plots is of five pixels, which is a reasonable result considering that the strips are 3 mm wide and the source (uncollimated) had a 16 mm diameter.

Finally, **Fig. 4** shows an example of an energy spectra collected by a single strip, 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, due to the fact that we performed our measurement in air, which scatters and absorbs alpha within 2 to 5 cm.

[1] A known issue with DSSSD is the ambiguity in the particle position reconstruction when more particle hits the detector together **[7]**. This issue may be critical especially in vertex tracking detectors. Two close hits could produce two ghost hits besides the two real one. The ambiguity area is proportional to the sine of the relative angle (so the maximum ambiguity is for orthogonal strips) and the precision in the second coordinate reconstruction goes as $\propto \sin^{-1}$ of the strip relative angle. To resolve the ambiguity, in some cases additional information may be useful, if available:

- charge correlation when the signals for the two angles were produced by the same ionization process;
- a nearby detector with yet different angles (having next a detector with the same angles does not help because then also the ghost hits correlates)

This ambiguity is in any case not treated within the present Application Note.

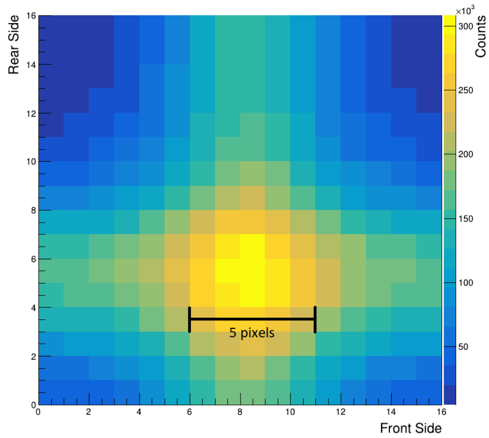

Fig. 2: Alpha radiation map with the source in a central position respect to the detector.

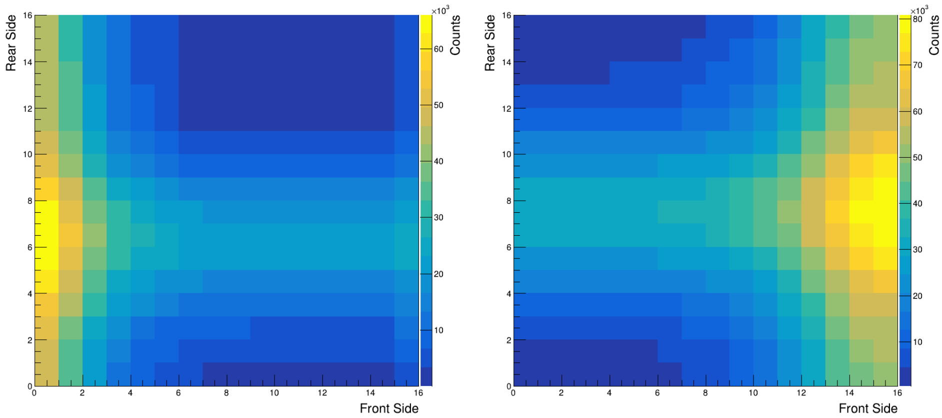

Fig. 3: Alpha radiation map with the source on the right and on the left of the detector.

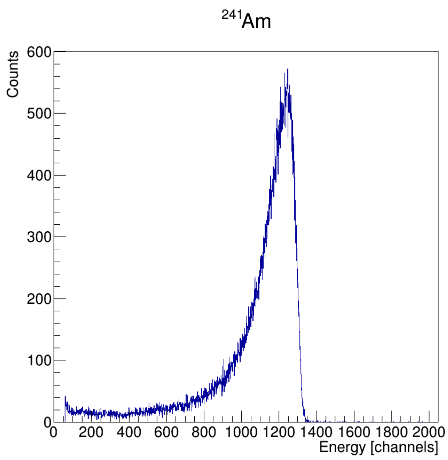

Fig. 4: Energy spectrum of the alpha radiation emitted by the ^{241}Am source.

Conclusions

We tested the possibility to perform position sensing measurements using a readout system composed by an A1442, two N1068D and a N6741. We performed measurements in three different source positions and we were always able to accurately map the alpha radiation emitted, as well as the energy even in the not ideal condition of performing a measurement in air.

References

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

[**2**] DS72233 – A1444 Preamplifier Data Sheet.

[**3**] UM3148 – N1068 User Manual.

[**4**] Technical Information Manual Mod. N454.

[**5**] UM7493 – N6741 User Manual.

[**6**] AN7498 – Performances of the analog system N1068 Shaping Amplifier and N6741 Peak Sensing ADC.

[**7**] Sally Seidel. "Silicon strip and pixel detectors for particle physics experiments". In: *Physics Reports* (2019). URL: `www.sciencedirect.com/science/article/abs/pii/S0370157319302923`.

CAEN Tools for Discovery

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