Development of a submillimeter portable gamma-ray imaging detector, based on a GAGG:Ce - silicon photomultiplier array

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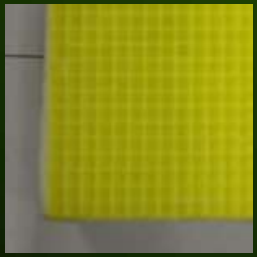
Purpose

- The aim of this study is to investigate the behavior of the ArraySL-4 (4x4 array) SiPM coupled to a $1mm^2$ GAGG:Ce pixellated scintillator array for possible applications in small-animal PET scanner dedicated to mouse brain.

- Evaluation was carried out with ^{22}Na & ^{137}Cs radioactive sources and results regarding intrinsic spatial resolution, energy resolution and peak to valley ratio are presented.

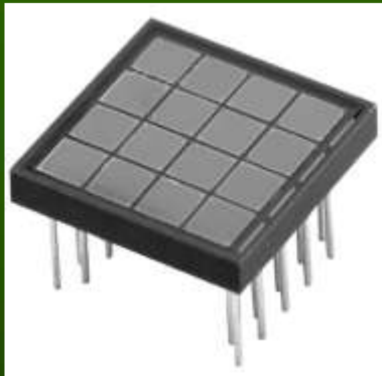
Introduction

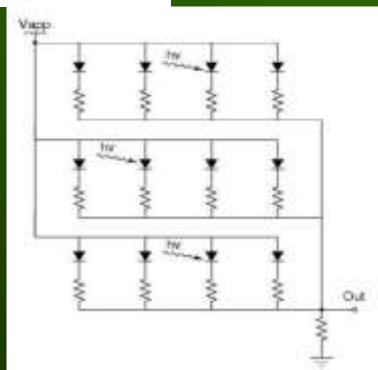
- GAGG:Ce scintillator crystal has high density of 6.63 g/cm^3, high light output (~46000 ph/MeV) and fast scintillation decay time (~80 ns).
- SiPM arrays are very flexible and can be used in the design of a dedicated mice PET head detectors.





Materials and Methods I



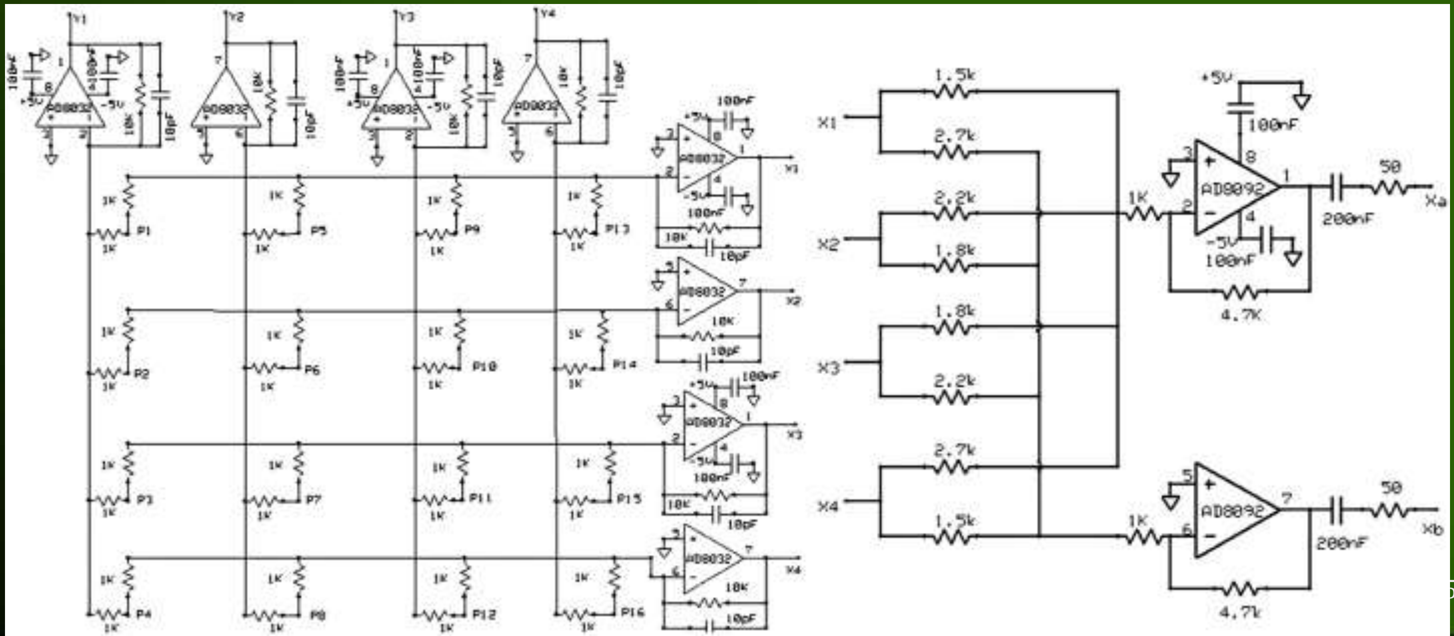


SiPM characteristics	
Company name	SensL
Model	ArraySL-4
Number of pixels	16
Active area	13.4 mm^2
Pixel size	3 x 3 mm^2
Cell size	35 μm
Cells per pixel	4774
Bias Voltage	+29.5V
Gain	10^6
Photon Detection Efficiency at 520nm	15 %

- GAGG:Ce 12x12 scintillator array, with 1x1x10mm^3 crystal size elements.
- The array has pitch 1.1mm with 0.1mm thickness of $BaSO_4$ reflector material. The coupling material used was optical grease (BC-630).

Materials and Methods II

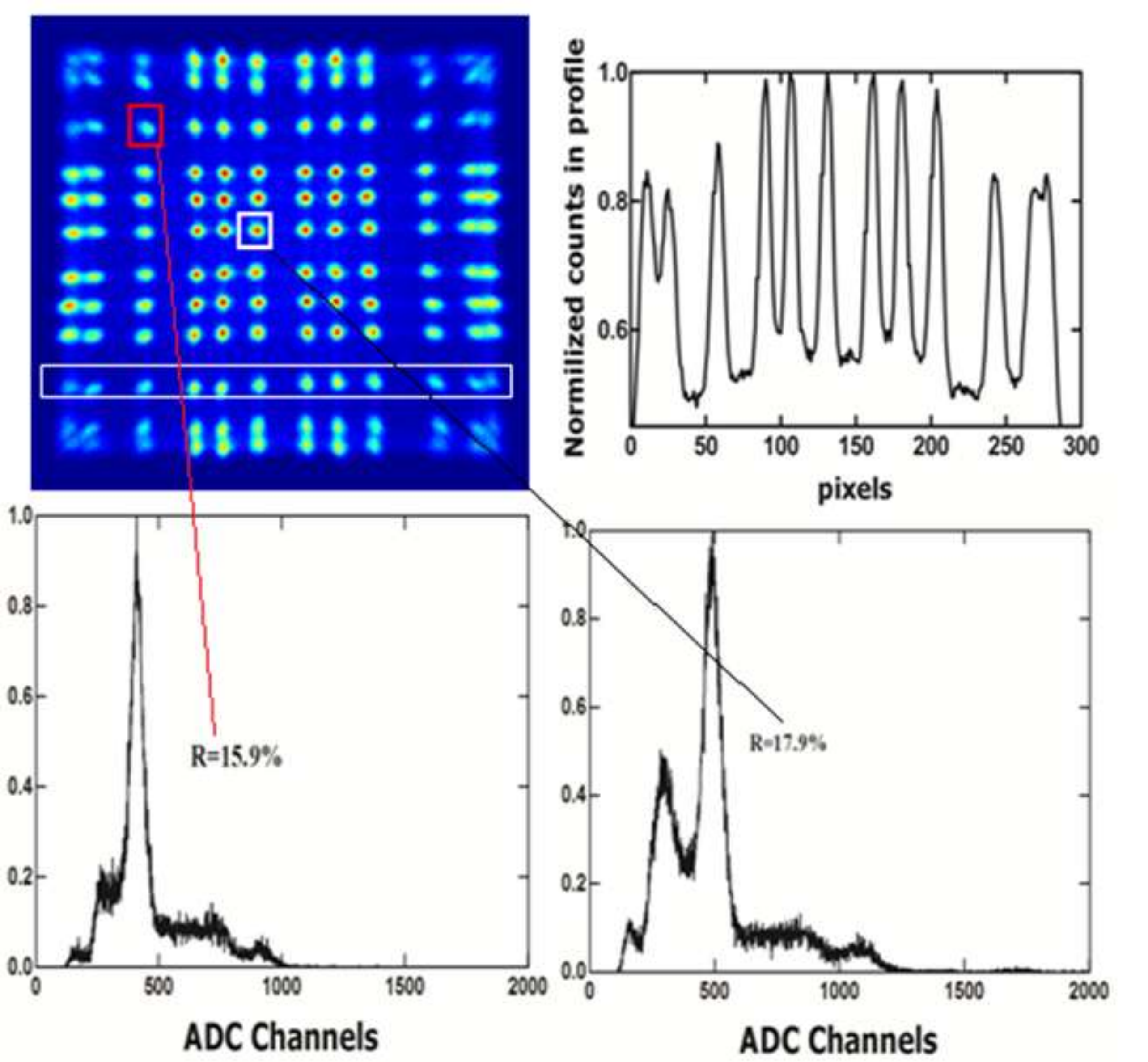
- A symmetric resistive charge division circuit reduces the 16 pixel outputs to 4 position signals
  1. a two-stage charge division resistor circuit reduces the 16 output channels of SiPM at 8 by equally splitting them in a resistive matrix (4 rows-X, 4 columns-Y),
  2. into 4 position signals (Xa, Xb, Ya, Yb) by a division network of weighting resistors.



Materials and Methods III

- The 4 position signals were amplified and digitized using free running ADCs (50MHz sampling rate).
- An FPGA (Spartan 6 LX150T) was used for triggering and signal processing of the pulses.
- Trigger signal was produced when the sum of the four in coming samples exceeded a given digital threshold (150mV).
- All the experiments conducted inside a black box under room temperature conditions.

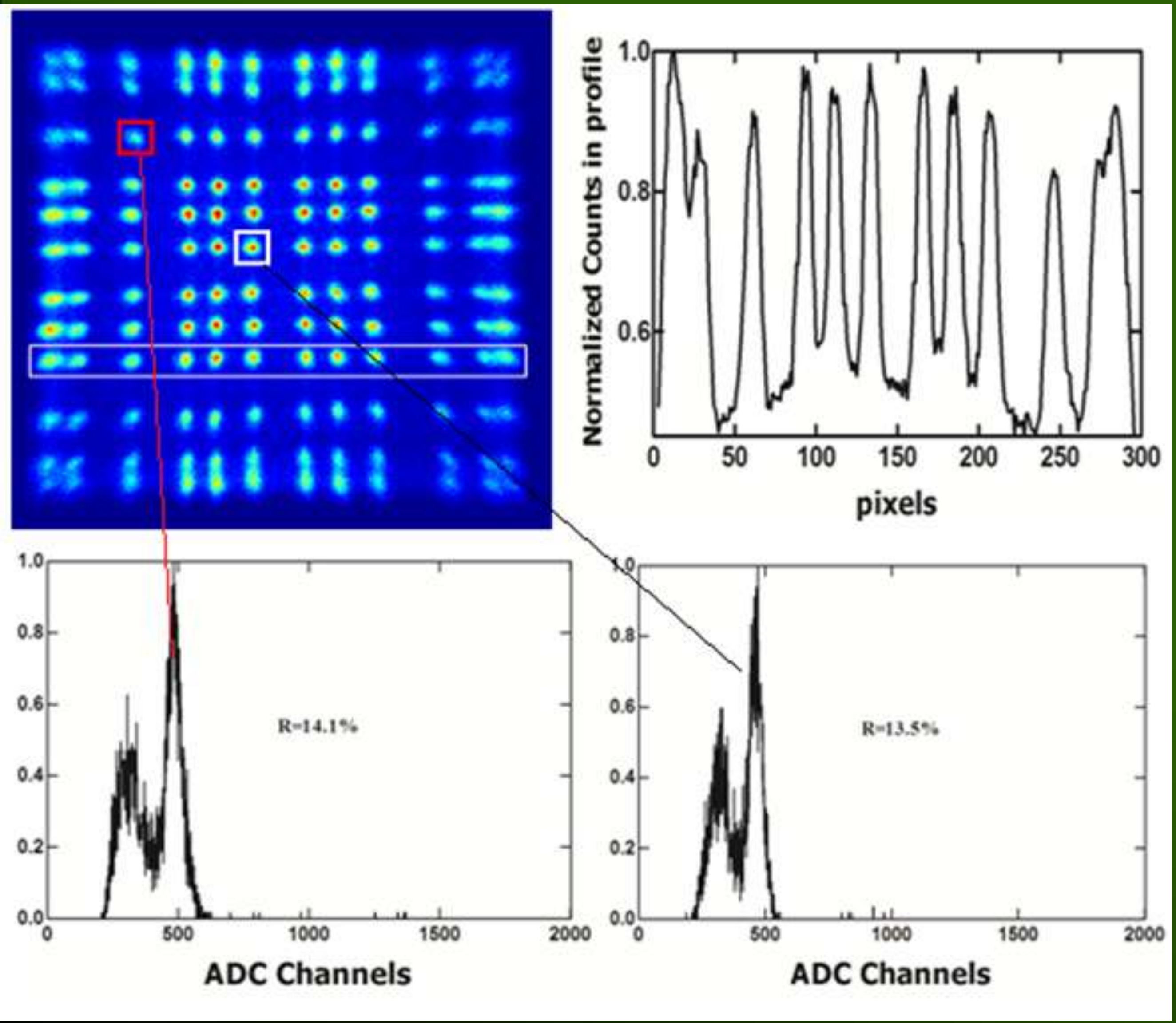
Results under ^{22}Na excitation



Top: Raw image of the 12x12 GAGG:Ce scintillator array and a horizontal line profile of the scintillator elements under ^{22}Na excitation;

Bottom: Energy spectra of the two 2 pixels.

Results under ^{137}Cs excitation



Top: Raw image of the 12x12 GAGG:Ce scintillator array and a horizontal line profile of the scintillator elements under ^{137}Cs excitation;

Bottom: Energy spectra of 2 pixels.

Conclusions

Pixel size of GAGG:Ce array	R%@ 511keV	PV ratio	Sp. R in mm	R %@ 662keV	PV ratio	Sp. R in mm
1x1x10 mm^3	16.9	1.75	0.81	14	1.85	0.77

- The acquired raw images of the GAGG:Ce crystal array show a visualization of all (12x12=144) discrete scintillator elements under ^{22}Na and ^{137}Cs irradiation.
- The mean energy resolution was measured equal to 16.9 and 14 for ^{22}Na and ^{137}Cs respectively.
- The mean peak to valley ratio of the profiles on the image was measured equal to 1.75 and 1.85 for ^{22}Na and ^{137}Cs.
- The intrinsic spatial resolution was calculated in vertical and horizontal lines equal to 0.81mm and 0.77mm for ^{22}Na and ^{137}Cs respectively.

Acknowledgement

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