Evaluation of a Small Field of View Personal Gamma Spectrometer Under ^{137}Cs Irradiation Conditions

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Nuclear energy

- ✓ Raise of the usage of nuclear energy in various scientific sectors.

✓More often nuclear accidents or leakages.

✓Need for measurement of radioactivity in everyday life increased.

Personal Radiation Spectrometer Detectors

- A gadget that may interest more and more people over the years.

- Characteristics
  - ✓ Isotope identification
  - ✓ Compactness
  - ✓ Portability (size, weight, etc)
  - ✓ High Sensitivity
  - ✓ Angular response

Materials I

- ^{137}Cs radio source of 0.87μCi

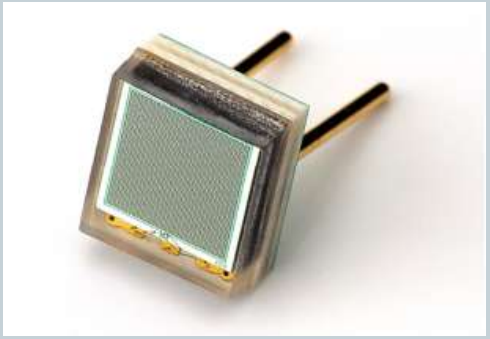
- GAGG:Ce inorganic scintillator crystals

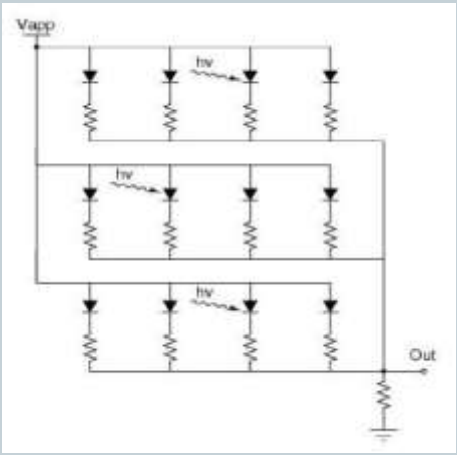
Furukawa Co., LTD	Epic Crystal
3x3x4 mm^3	3x3x5 mm^3
up to 3x3x20 mm^3 (7 samples)	3x3x10 mm^3

- with all crystal surfaces polished.

Materials II

SiPM characteristics	
Company name	KETEK
Model	PM3350 trench design
Pixel size	3 x 3 mm^2
Cell size	50 µm
Cells per pixel	3600
Bias Voltage	+30.5 V
Gain	10^6
Dark rate	< 300 kHz/mm^2
Photon Detection Efficiency at 520nm	27 %

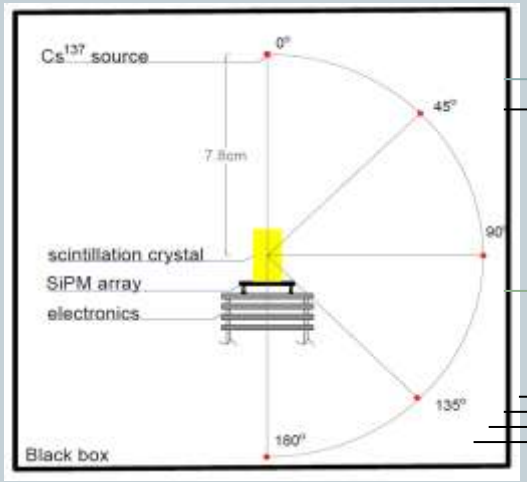




Materials III

- DT5720 Caen digitizer
  - Desktop waveform digitizer
  - 4 channels
  - 12-bit 250 MS/s
  - 2 Vpp single ended input dynamics
  - Adjustable DC offset via 16-bit DAC on each channel in the ±1 V range
- Digital pulse processing for charge integration (DPP-CI) Control Software

Experimental Setup I



±5V

ground

Power supply

+30.5 Vbias

Power supply

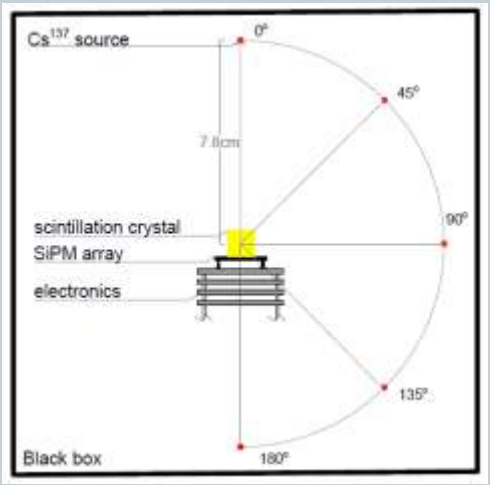
usb connection

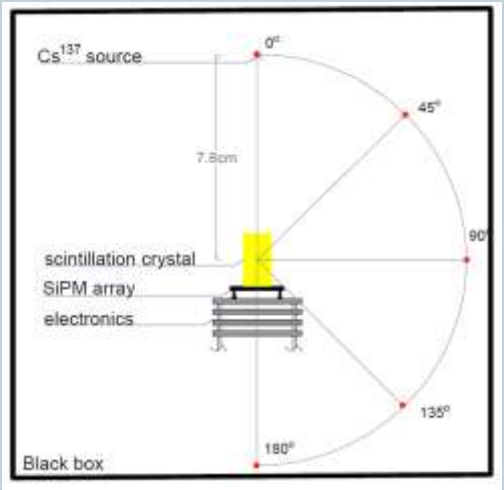
Experimental Setup II

- Angular detection response in 5 positions, **0, 45, 90, 135 & 180** degrees.

- **30'** measurement at each angle position.

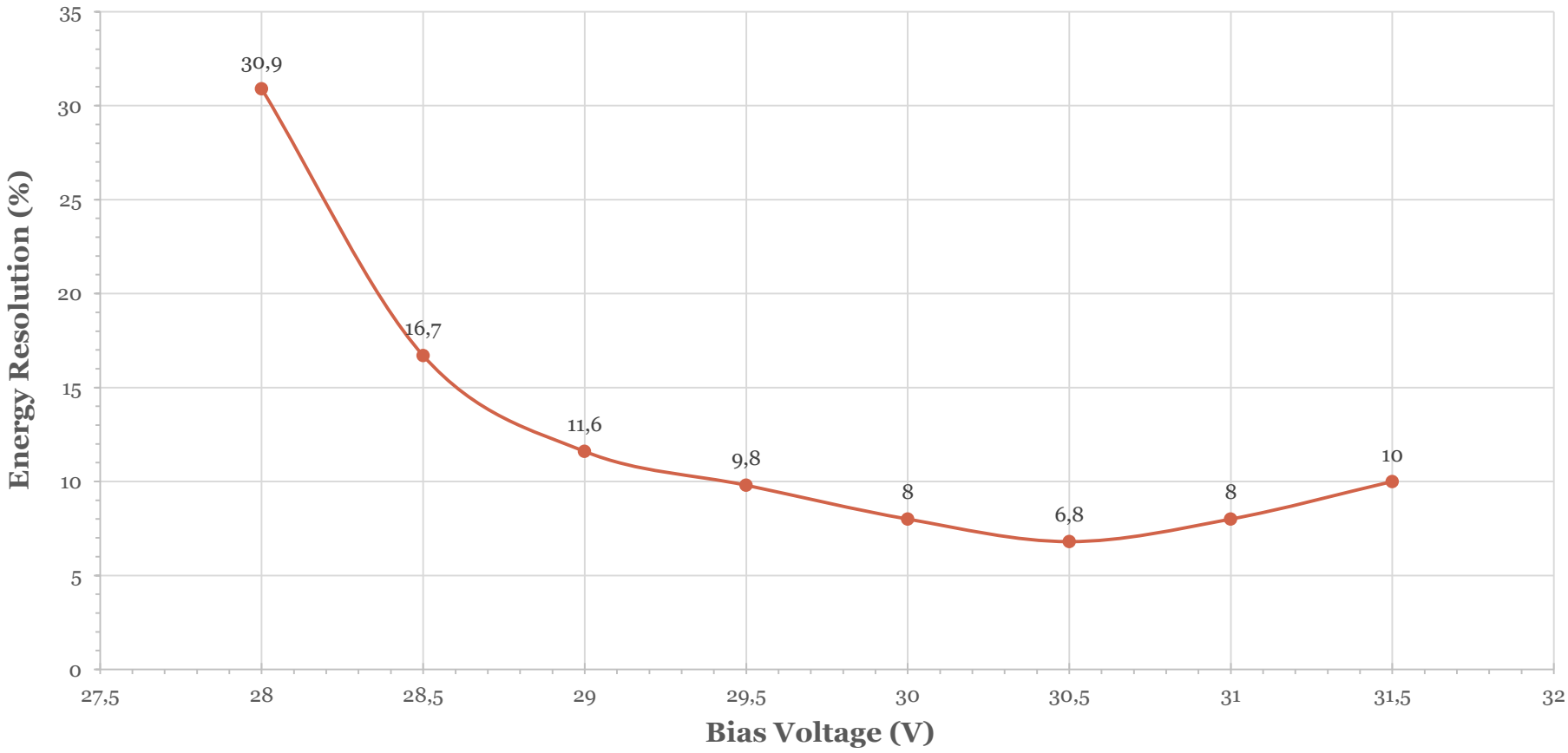
The 2 experimental setups for GAGG 3x3x5mm^3 & GAGG:Ce 3x3x10mm^3





Results and Discussion I

30.5 V bias was chosen, as the one that provides the lowest energy resolution values.



Results and Discussion II

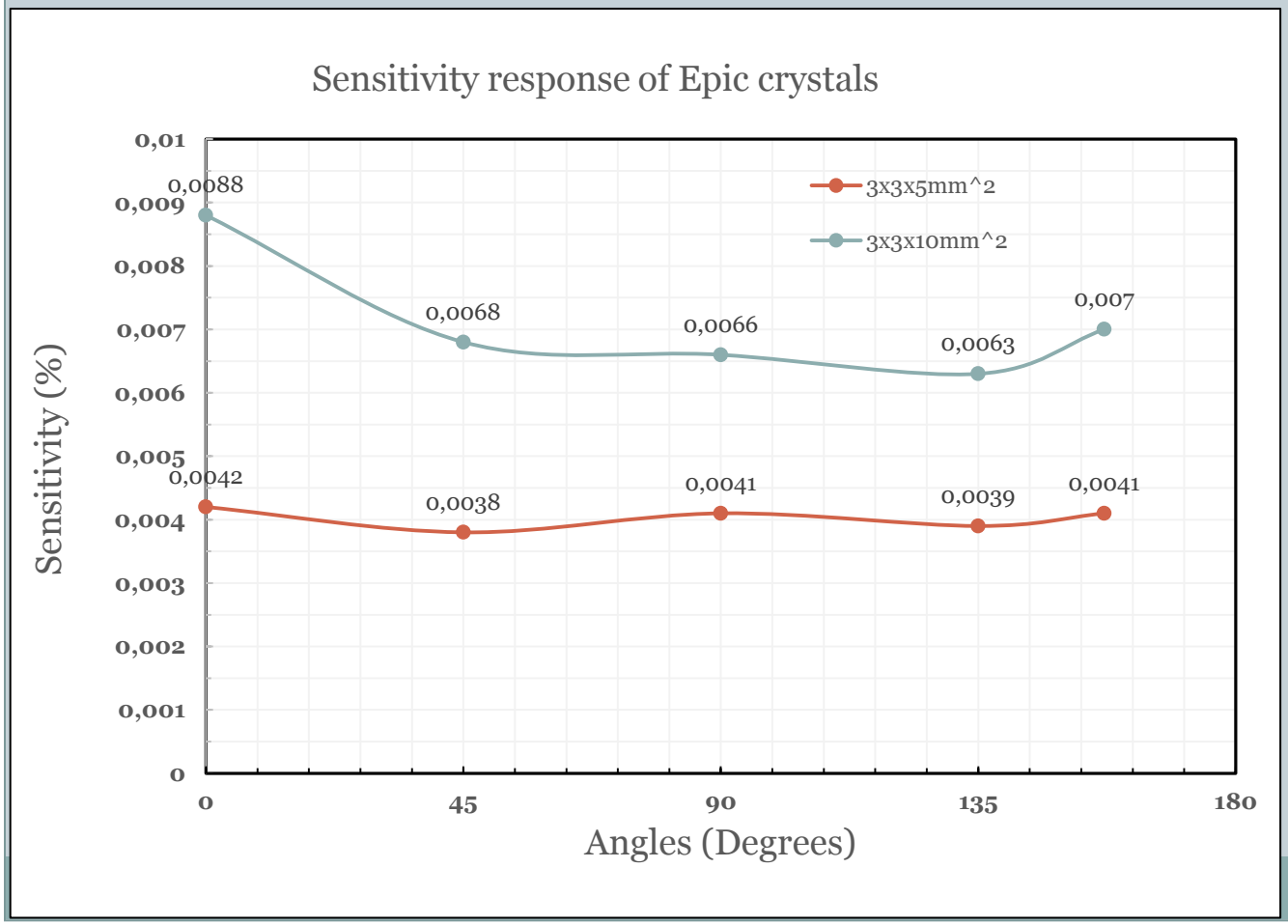
Comparison between Furukawa & Epic Crystals irradiated with ^{137}Cs for 30 min. The source was placed just upon the crystal for the excitation.

Crystal Thickness (mm)	Furukawa Crystals	Epic Crystals
	R (%)	R (%)
4	7.2	-
5	6.8	5.8
6	8.9	-
8	9.4	-
10	10.4	9.5
15	6	-
20	10.2	-

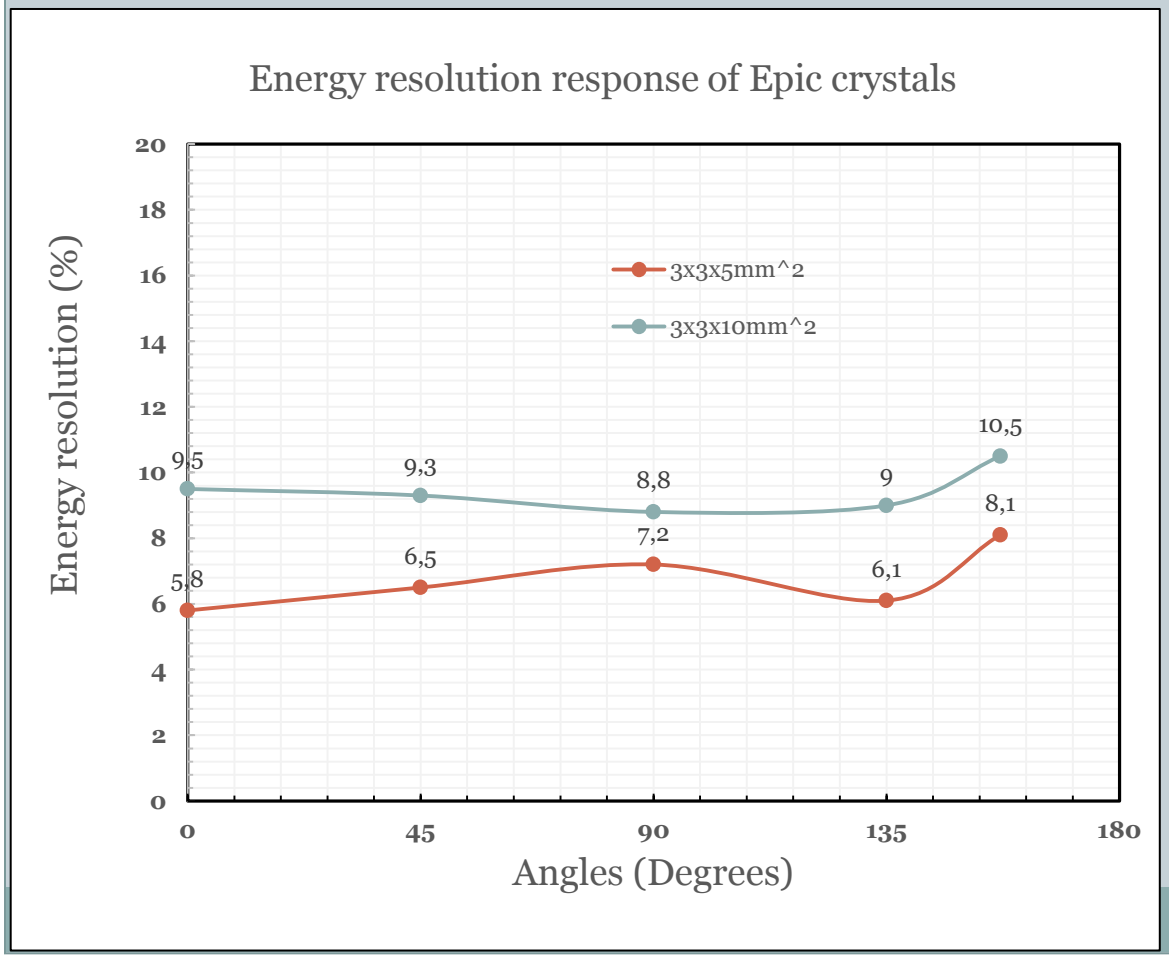
Sensitivity

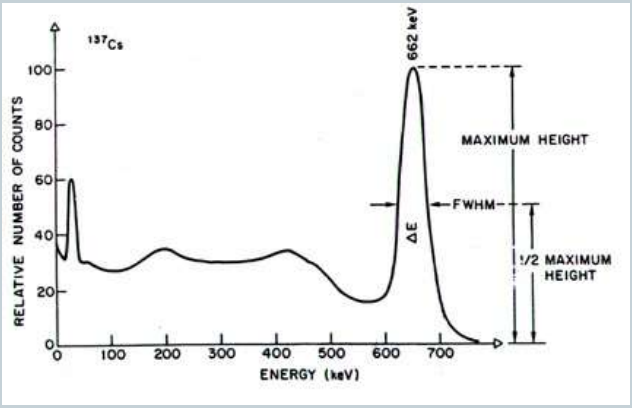
Higher sensitivity for the bigger crystal

$$Sensitivity = \frac{total\ counts}{emitted\ photons}$$



Energy Resolution (ER)





MEAN VALUES

@5mm =6.7%

@10mm =9.4%.

Photo percentage

$$PP = \frac{662keV\ photopeak\ counts}{total\ recorded\ counts} \times 100\%$$

Angles (degrees)	Photofraction (%)	
	$3x3x5mm^3$	$3x3x10mm^3$
0	10.3	14.4
45	12.8	15.4
90	10.6	14.8
135	11.3	15.1
157	11.8	16.1

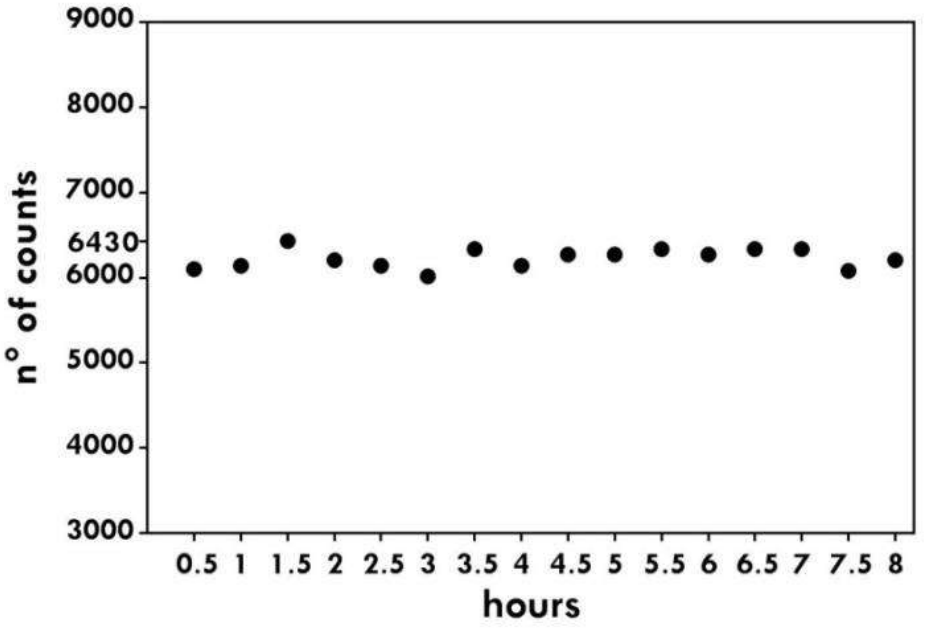
MEAN VALUES for ^{137}Cs

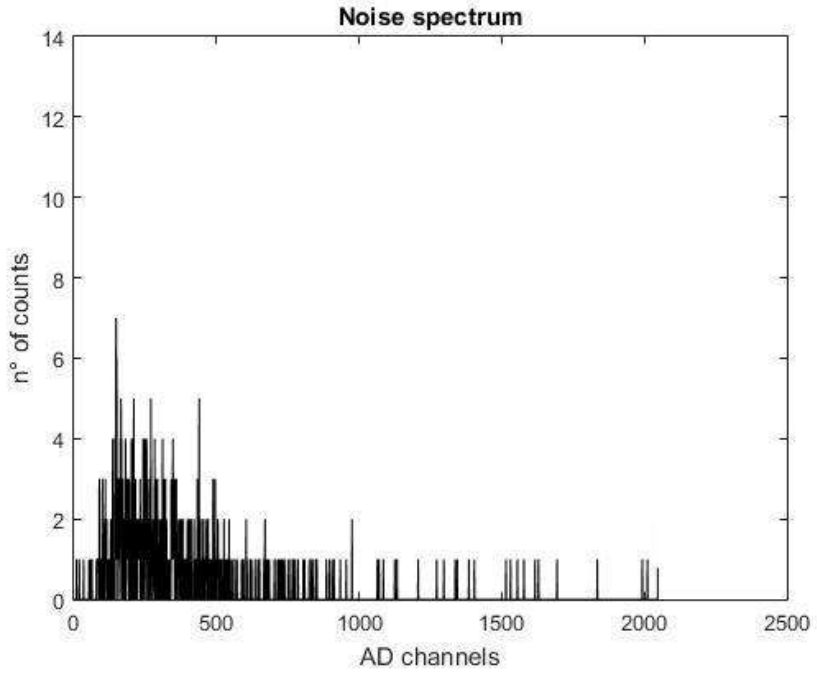
- 11.2% -5mm thick
- 15.1% -10mm thick

MEAN VALUES for ^{22}Na

- 13% -5mm thick
- 17% -10mm thick

Stability-in-time & Dark counts measurements





Future work….

- Additional features, such as
  1. detector response to other gamma energies,
  2. possible ability to construct a new DAC in order to communicate via WiFi with mobile devices via web browser,
  3. construct smaller electronics to have the ability to take place in a miniature device.

can also be implemented to improve this device.

Acknowledgement

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