SiPM-Based Gamma Spectrometer for Nuclear Spectroscopy

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Gamma-Alpha spectroscopy

The importance of gamma spectroscopy in various fields of the science

- Radiation Safety: Detecting Radiation in the Environment
- Identification of radioactive isotopes
- To understand the decay pathways of nuclides
- Providing accurate measurements of energy spectra in spectroscopy fields

The importance of alpha spectroscopy in various fields of the science

- In the development of smoke detectors
- Ion beam therapy in medicine
- Industrial quality control of materials
- The inherent versatility of SiPM scintillation detectors makes them suitable for alpha and gamma spectroscopy research.

Worldwide SiPM manufacturers

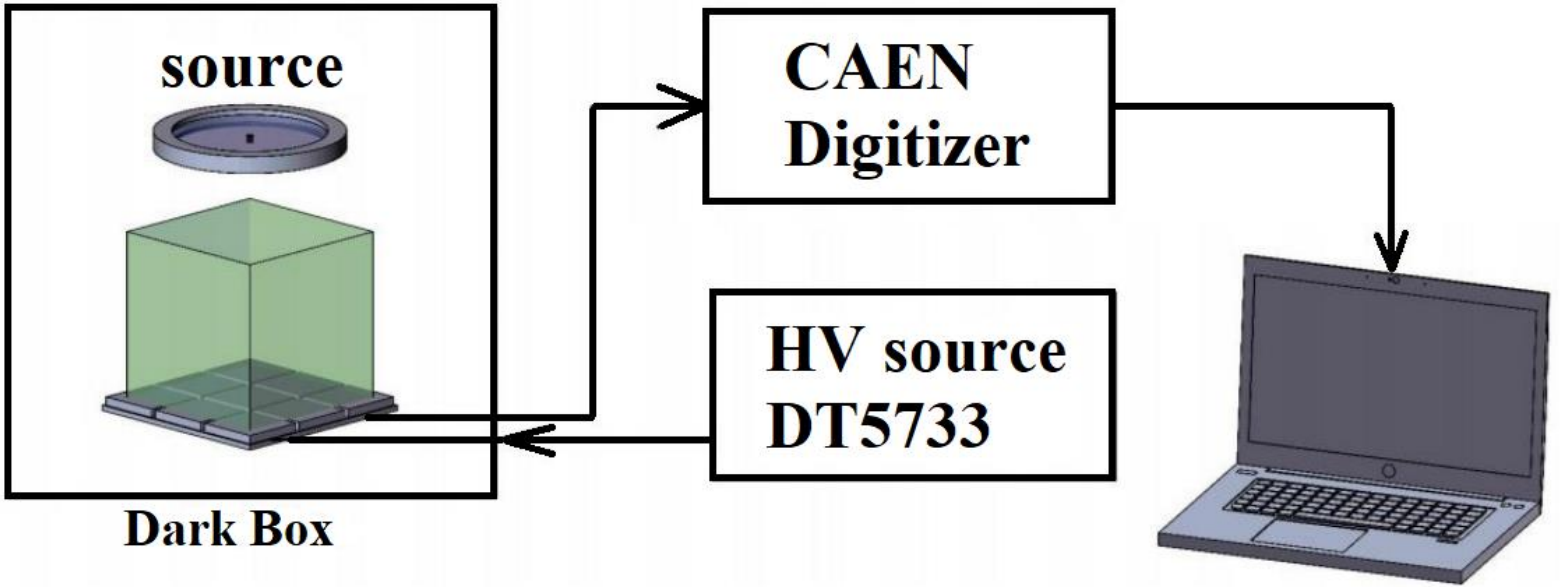
Developed MAPDs by JINR

	MAPD 3B	MAPD 3N	MAPD 3NK0	MAPD 3NM-I	MAPD 3NM-II
Piksel density pix/mm^2	40000	15000	10000	10000	6000
Active area ,mm^2	3x3	3x3	3.7x3.7	3.7x3.7	3.7x3.7
PDE , % (420-550 nm)	~12	~28	~30	~34	~40
Gain -10^4	1	2	5	8	30
Operation Voltage	~70	~90	~90	~70	~55

SiPM application areas

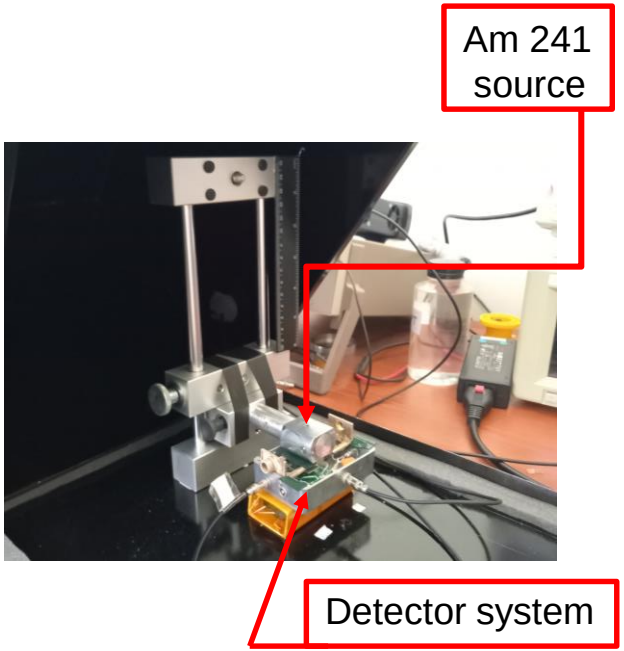
- Industrial equipment.
- Analytical equipment.
- Optical communication.
- Automotive.
- Consumer electronics.
- Industrial X-ray NDT inspection.
- Radiation detection.
- Quantum technologies.
- Spectroscopy

Experimental Scheme of a Gamma and Alpha spectroscopy detector based on SiPM



MAPD - silicon photomultiplier array parameters

SiPM	**MAPD-3NM-II array**
Active area (mm^2)	**289**
Total numbers of Pixel	**974 728**
Pixel pitch	**15**
Gain	**~$3*10^5$**
Operation Voltage	**55V**



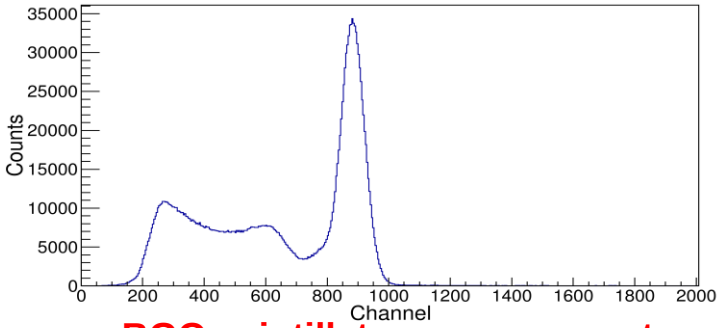
16 photodiodes matrix with 14mm * 14mm active area

Scintillators

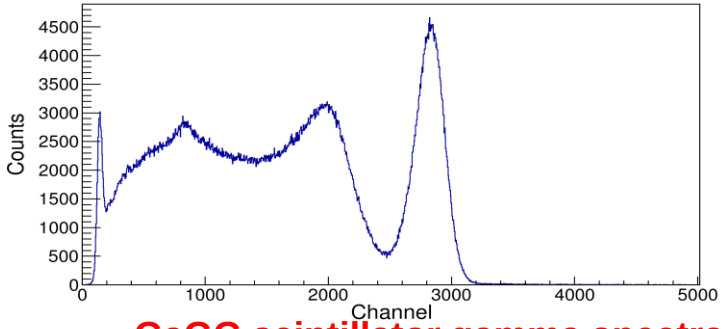
Crystal	BGO	GAGG	YSO
Density	7,13	6,6	4,4
Light Output	8500	42000	18000
Wavelength of Emission Peak	480	520	410
Decay Constant	317	90	62

Main parameters of the used scintillators BGO, GaGG and YSO.

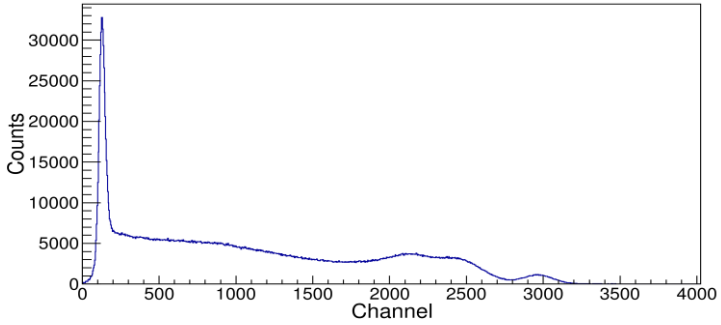
Cs-137 gamma spectra from BGO, GAGG and YSO scintillators



BGO scintillator gamma spectra

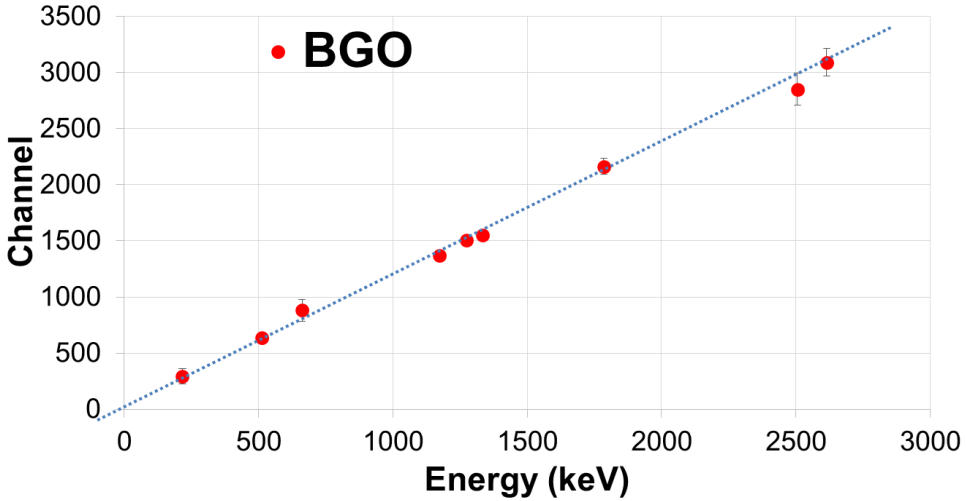


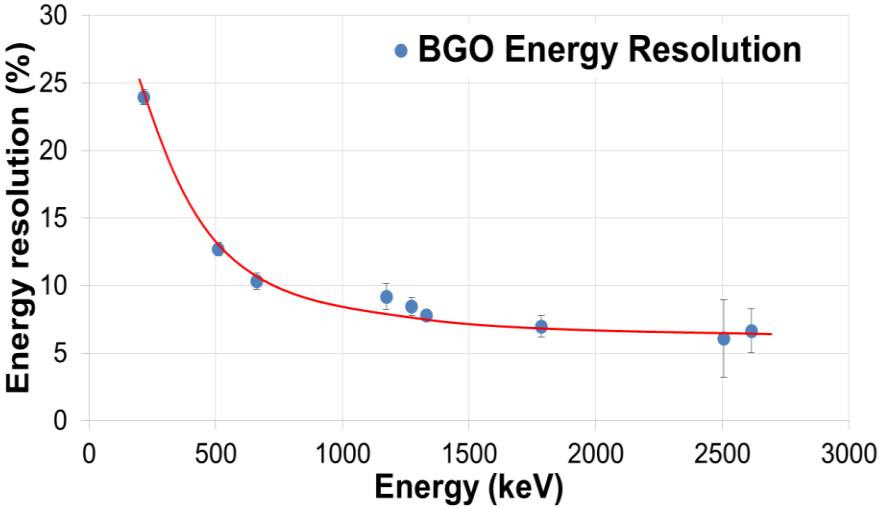
GaGG scintillator gamma spectra



YSO scintillator gamma spectra

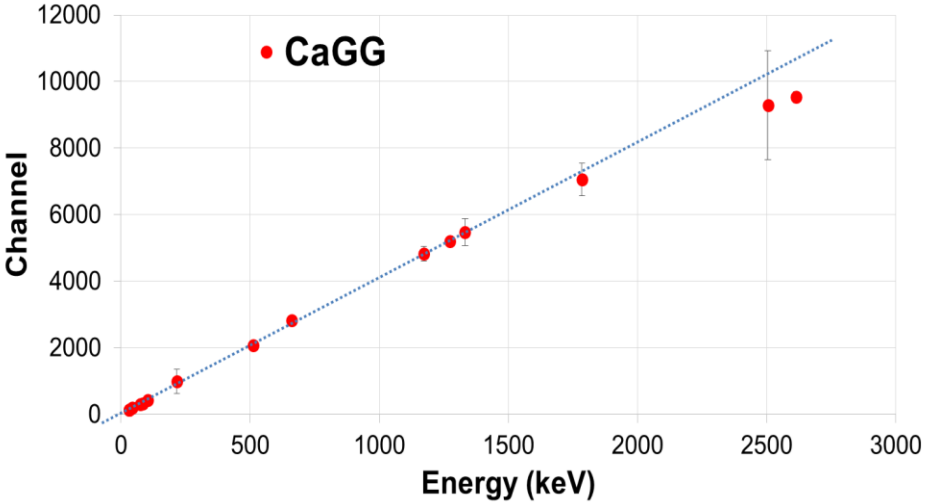
Dependence of linearity and resolution on gamma energy for the BGO scintillator

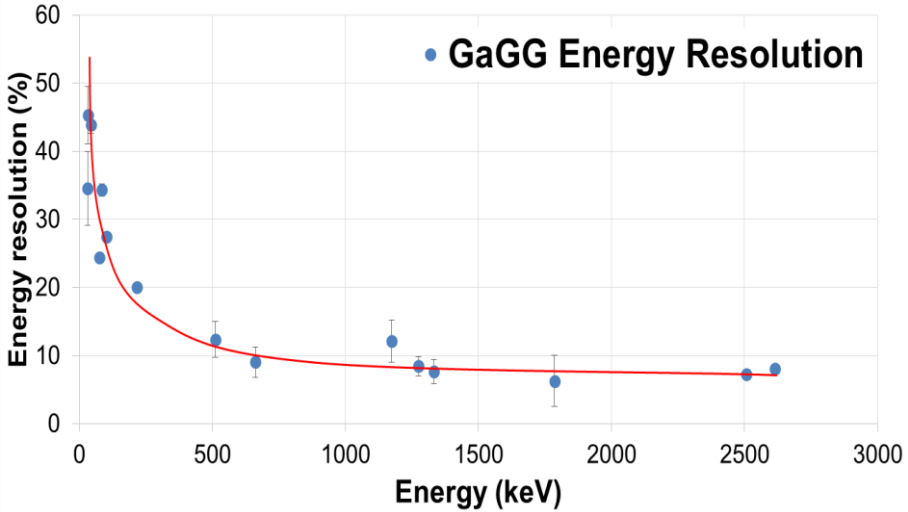




The detector's gamma ray detection performance has been tested using various radioactive point sources. The characteristics of gamma radiation registration in the energy range from 32 keV to 2700 keV were studied.

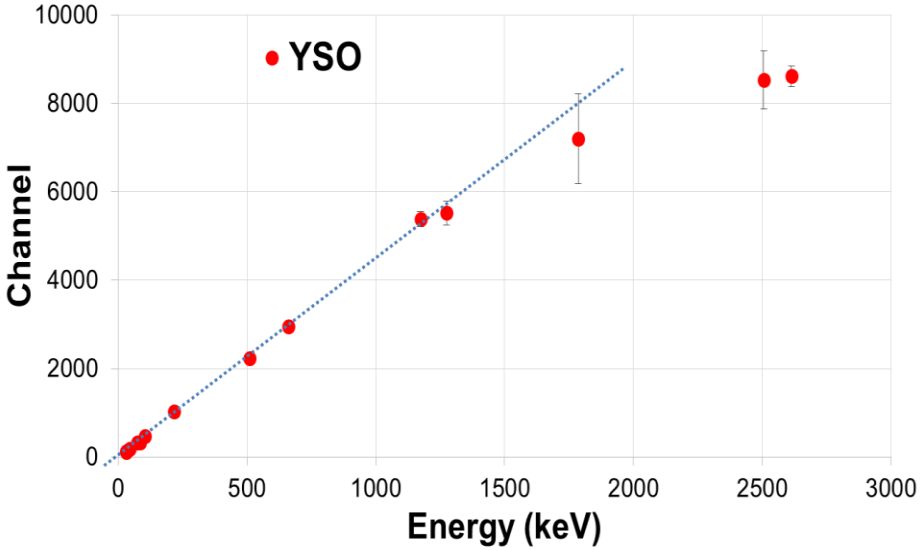
Dependence of linearity and resolution on gamma energy for the GAGG scintillator

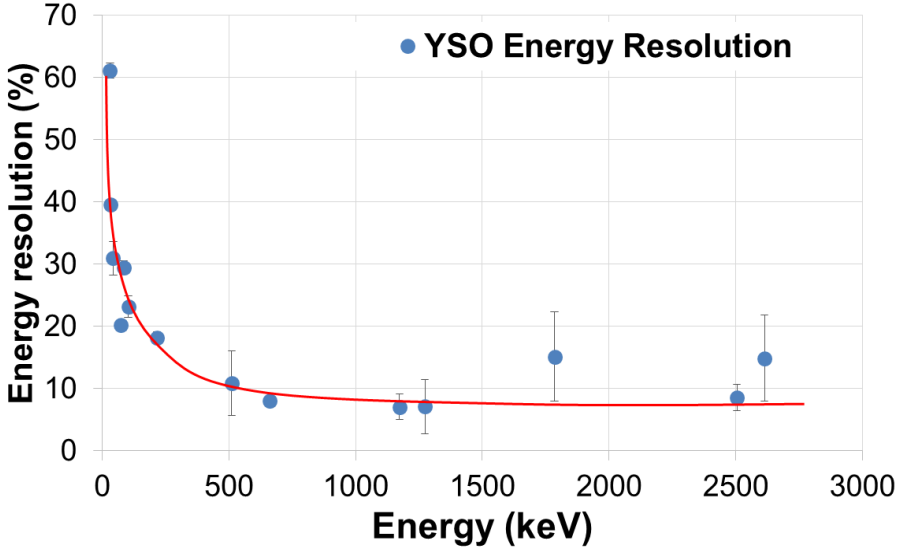




The results obtained showed that the developed SiPM detector based on GaGG scintillator demonstrated good energy resolution and linearity in the energy range of 30- 2000keV.

Dependence of linearity and resolution on gamma energy for the YSO scintillator



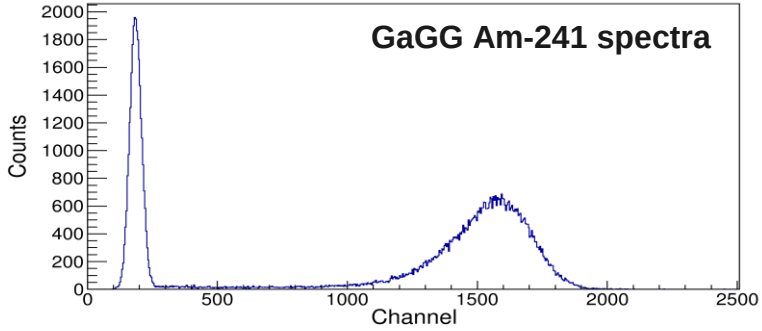


Compared to YSO and GAGG scintillators, BGO shows linear results in the range of 30-2000 keV.

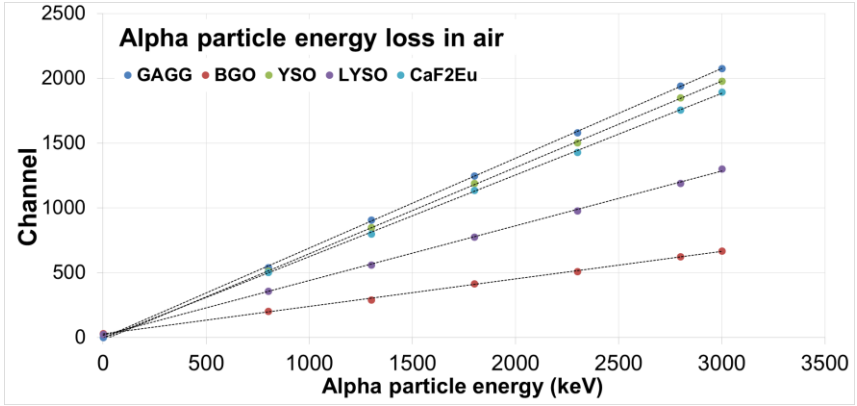
Energy resolution of 661 keV gamma-ray peak from a 137-Cs point source with different scintillators

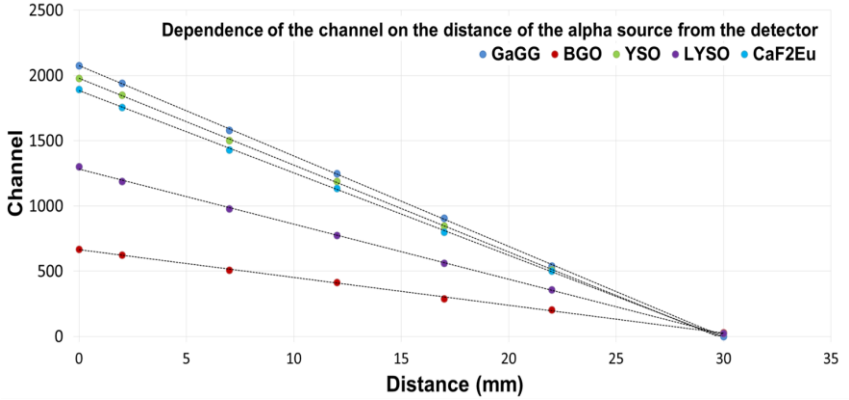
Scintillators	Energy resolution (%)
BGO	10.21
GaGG	9.07
YSO	8.15

Am-241 alpha spectra from BGO, GAGG and YSO scintillators



Scintillator	Light output ratio of gamma to alpha
BGO	6.1
GaGG	5.8
YSO	6.8





Results

- The results obtained with different types of scintillation show that the array used is well suited as a light detector.
- The assembled detectors allow to be used them as a spectrometer and a counter for alpha particles and gamma rays.
- The alpha and gamma ray detection characteristics of BGO, GaGG, YSO in combination with the SiPM array make possible to use these types of detectors in nuclear physics, public safety, industry and space experiments.