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COSMIC-RAY INDUCED BACKGROUND OF SHIELDED HPGe DETECTOR

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INTRODUCTION

In order to achieve reliable interpretation of data, it is necessary to understand and properly analyze background of the HPGe spectrum. One way to investigate background of the HPGe spectrum is to use Monte Carlo simulation. In this paper, GEANT4 software package is used to perform simulation of HPGe detector system, consisting of detector relative efficiency of 100%. Muon and neutron components were simulated separately in order to achieve simpler separation of obtained data. Simulated spectra were merged and compared with experimental one. Furthermore, cosmic-ray induced processes in the Ge crystal itself, were investigated and spectra corresponding to certain processes induced from cosmic muons and neutrons were obtained.

EXPERIMENTAL SETUP AND MONTE CARLO SIMULATIONS

- The experimental spectrum shown in **Fig. 1** was acquired by Canberra GX10021 ultra-low background, 380 cm3 active volume germanium spectrometer with 100% relative efficiency. The experiment was performed in surface-based laboratory at the Department of Physics building in Novi Sad (45° 14′ 42.27″ N, 19° 51′ 06.35″ E), at 80 m above sea level.
- A quite detailed model of the detector was used, consisting of the end cap with the window, protective cover, internal housing with support rings, thermal shield, contact pin, bullet-shaped Ge crystal with hole. The most important dimensions were taken from the original manufacturer's specifications. Model of the detector is show in **Fig. 2**.
- Cosmic muons and neutrons were emitted toward the detector from the circular flat area positioned above the detector with 0.5 m and 0.3 m radius, respectively, using the General Particle Source model.
- Energy distribution of emitted muons was represented by Gauss distribution with a mean value of 2 GeV and standard deviation of 1 GeV, while neutron energies were taken directly from CRY distribution.
- The spatial distribution of emitted muons was vertical beam with Gauss angular distribution and standard deviation of 20 deg relative to the vertical axis, neutrons were emitted vertically toward the detector.

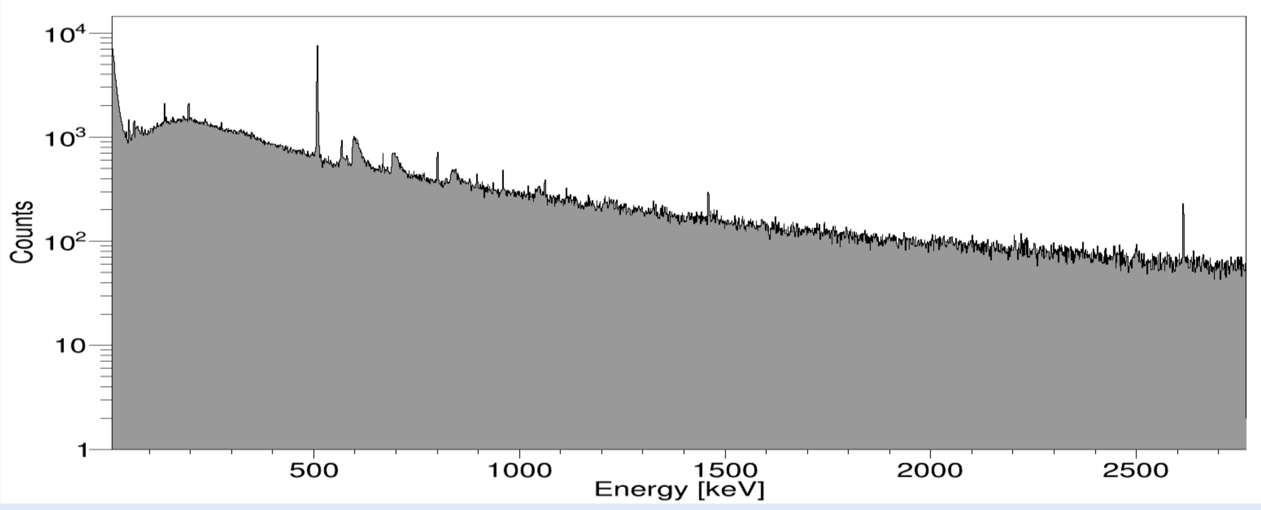
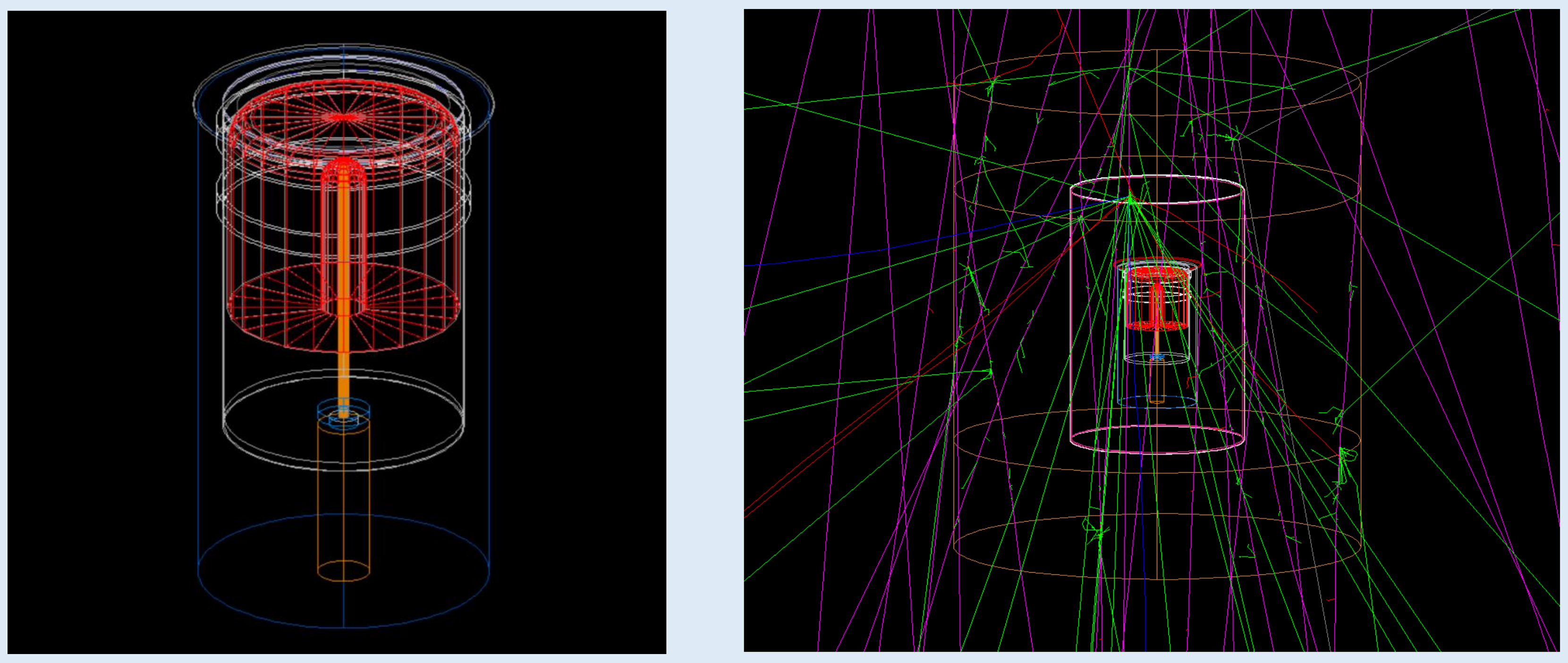


Fig 1. Experimental background spectrum acquired by HPGe detector.

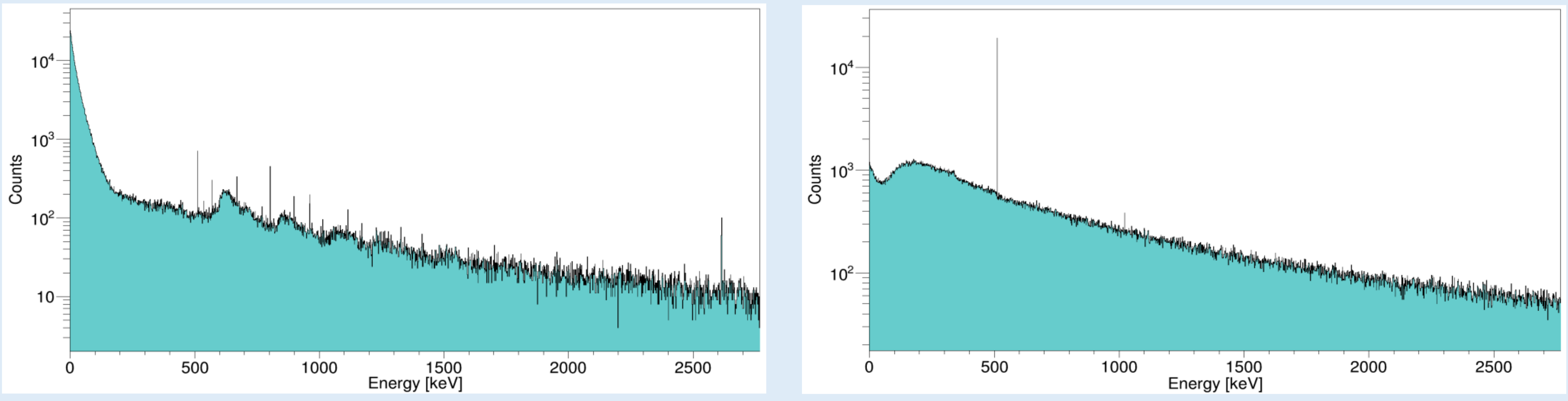


(a) (b)

Fig 2. Model of the HPGe detector used in simulations (a) and HPGe detector positioned inside of the cylindrically shaped shield with muons (purple) interacting with lead shielding (b).

RESULTS

- In order to normalize the spectra, the equivalent time (for both simulated components) was calculated using cosmic-ray muon flux at sea level of 167 muons/s*m^2 and neutron flux of 34 neutrons/s*m^2. Normalized spectra are shown in **Fig 3**.



(a) (b)

Fig 3. Spectra obtained from simulations of Pb shielded HPGe detector originating from cosmic neutrons (a) and cosmic muons (b)

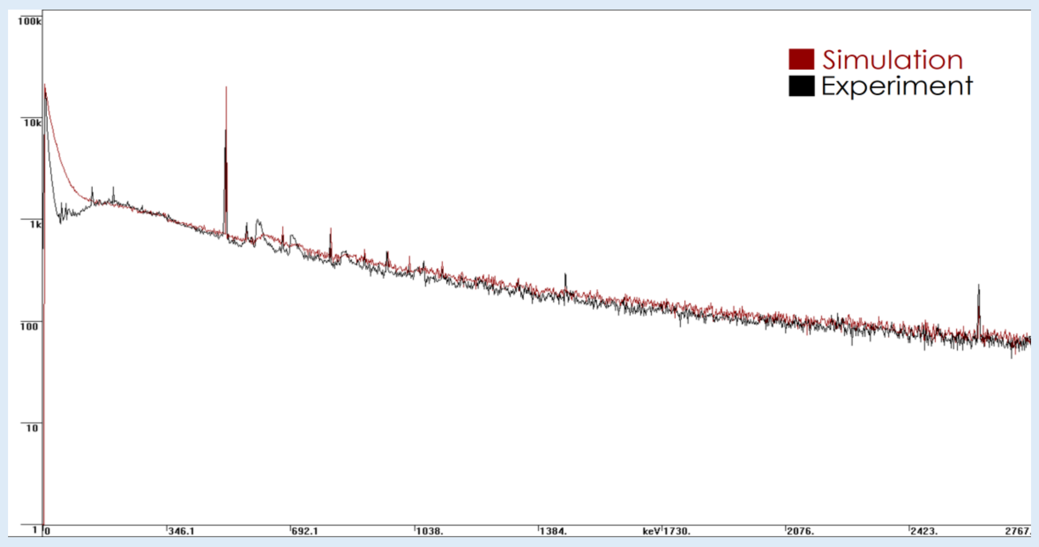


Fig 4. The comparison between experimental and simulated spectrum

Table 1. Gross count for different energy regions in experimental and simulated spectrum

Energy range [keV]	Gross count (experiment)	Gross count (simulation)	Δ [%]
30 - 300	261 566	360 710	-38
150 - 500	281 384	298 222	-6
50 - 2700	732 344	820 178	-12

- In addition to simple energy deposit, cosmic-ray induced processes in Ge crystal were investigated. Table 2. shows the number of events corresponding to the type of process that took place inside the Ge crystal depending on the simulated component.

Table 2. Hadronic processes induced inside Ge crystal

Type of process	Neutron component	Muon component
hadElastic	1 312 162	22 162
nCapture	31 423	523
neutronInelastic	541 423	5372

nCapture (muon component)	
Ge71	44
gamma	430
Ge74	14
Ge73	24
Ge77	2
Ge75	9

nCapture (neutron component)	
Ge71	2028
gamma	25756
Ge74	1036
Ge73	1595
Ge77	94
Ge75	914

CONCLUSION

- Relatively good agreement between simulated and experimental results is observed
- It is evident that neutron models in Geant4 give big discrepancy in low energy region (30-300 keV), where most of the energy is deposited as the result of a nucleus recoil.
- Although cosmic muons do produce some neutrons in their interaction with Pb shield it is evident that the most hadronic components inside the crystal originate form cosmic neutrons.

ACKNOWLEDGEMENTS

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