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Influence of Cell Phone Waves on the Performance of HPGe Detector

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Abstract:* Hand phone mobile waves search systems, constructed with high resolution germanium (HPGe) detectors, are currently being installed at locations world-wide. This reflects a general desire for improved performance and a reduction in the time to make a good decision in interdiction cases. An integrated gamma-ray spectrometer, incorporating a mechanically-cooled HPGe detector, digital signal processing electronics, MCA, and communications has been developed to meet the detection and environmental needs of these systems. The HPGe detectors are designed to have good low- and medium-energy detection efficiency and excellent spectral peak resolution in order to eliminate peak overlaps and thereby remove problems by common industrial and medical radionuclides found in all types of hand phone mobile. Systems using detectors with inferior resolution, regardless of efficiency, are unable to separate the radiation signals from NORM and illicit nuclides. The absolute full-energy peak efficiency of the detector and background count-rate in the peak energy region determine the signal-to-noise ratio. Measurements presented show the impact of shielding and masking on the performance of the hand phone mobile. The results illustrate applicability of the design to a variety of monitoring situations for the detection of illicit material. In the present work we studied the effects of different types of hand phone waves on the performance of 70% HPGe X and Gamma-ray detector. The detected interference has an energy range 30-100 keV. A correction battues was estimated as a function of time verses cell phone type. The measurement quality of the measurer gamma-spectra can be corrected at low X-ray region. The effect of these waves was also studied on the performance of the main detector amplifier. The results were obtained for Etesalat, Vodafone and Mobinile stations. The introduced method can be simulated for other devices having the same interference effect.

***Keywords:* radioisotope; integrated systems; germanium detectors; HPGe; mobile waves system; illicit materials**.

I. INTRODUCTION

The increasing use of mobile phones in recent years has caused concerns about the effects of electromagnetic waves of mobile phones on the Performance of HPGe Detector [1, 2]. This study was conducted in order to survey the effects of mobile electromagnetic waves on HPGe detector, digital signal processing electronics, MCA, and communications has been developed to meet the detection and environmental needs of these systems [4].

The spectrum of electromagnetic waves has an extensive frequency range from 300 MHz to 300 GHZ and their wave lengths vary from 1 mm to 1 m. Waves emitted by mobile phones with an average frequency of 900 MHz. Mobile Phone and Electrocardiogram to 1 GHz are also in this frequency range [5]. The developing and increasing use of mobile phones which produce electromagnetic waves and several reports during the recent years on autogenic effects of these waves on different growth processes have caused concerns about human health [6,7]. Extensive increase of microwave producing devices such as mobile phones have drawn biological researchers' attention to study their effects on human health and on the performance of HPGe Detector. The results of some studies revealed that mobile waves with a power density lower than (1mv/ cm2) can cause signs such as headache, heat sense [8]. In this study, after ten years follow up, the results in the United State of America and 5 European countries indicated that constant mobile phone users are not in a higher risk of brain tumor compared to the people who never or rarely use mobile phones. Considering the findings of previous studies on the harmful effects of mobile phone waves on one hand and the inevitable need to use mobile phones in daily life on the other hand, this research was conducted to study the effects of mobile phone waves on electrocardiogram in healthy young people [9]. This research was this study was aimed to find out the effects of mobile electromagnetic waves on the performance of HPGe Detector.

The performance of portal monitors for the detection of illicit radioactive materials is of great importance in determining the efficacy of these devices in stopping trafficking of nuclear materials. In response to the need for high performance, ORTEC has developed a monitor based on HPGe detectors. The high resolution of HPGe detectors is necessary for reliable detection and identification in real-world situations [10, 11].

Hand phones or cell phones are radio transmitters emitting electromagnetic radiation. Once the connection is made the cell phones encode packages of information representing your voice or text data. When the call is received through a processor in the phone the digital information signal is converted into an analog signal so a voice can be heard. All this occurs in an average time of five seconds depending on the wave intensity and the distance from the tower. In the present experiments we studied the effects the durations of different type of cell phone signals, commonly used in Egypt, to the gamma-ray system during the dialing and alarm mode. The

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germanium detector [1] was exposed to each type of cell phone radiation in the forward and backward directions.

The effect of different communications, Etesalat, Vodafone and Mobinile, Vis the detector performance and its BG were also investigated. The effect of cell phones radiation intensities, at the same exposure durations, and the performance of HPGe are shown and investigated in the study.

II. EXPERIMENTAL RESULTS AND DISCUSSION

A. Detection system

Single gamma-ray measurements were achieved, using a high resolution ORTEC hyper-pure germanium (HPGe) detector of efficiency 70 %. A cylindrical lead-shield of five cm thickness, which contains inner concentric thin cylinder of Cu with a thickness of 5 mm, was used to shield the detector and to reduce the effect of background. Standard gamma sources, of ^{241}Am, ^{22}Na, ^{60}Co, ^{133}Ba, ^{137}Cs and ^{152}Eu, were used for both energy and efficiency calibrations of the system.

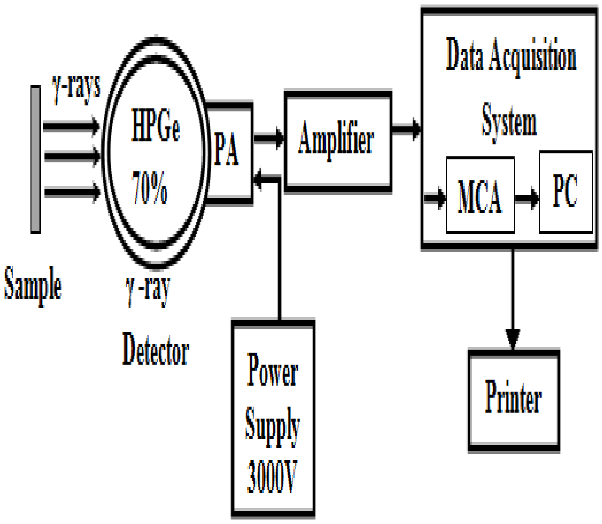

Fig.1: Blocked diagram of HPGe γ-ray spectrometer system.

Each cell phone was measured several times during receiving the dialing signal and the gamma spectra were analyzed, using different tables (3-5) and computer programs. The noise level was estimated, using the different gamma transitions of each peak area and the average value is given.

III. EXPERIMENTAL DESIGN

Ten types of mobile phones were used in this investigation. The cell phone was located in every experiment at the top of the detector plastic cover (3mm distance from the beryllium window). The noise level was measured for the following cases:

i) In the forward direction.
ii) In the backward direction.
iii) For the 3 common companies located in the Egyptian market.
iv) With and without charger mode.

IV. RESULTS AND DISCUSSION

Nowadays cell phones are often used at any place without any restrictions [12,13,and 14]. The effective noise range, generated from hand phones, on the performance of HPGe (70% efficiency) were detected. Figure 1 represents the measured spectra of different hand phone types in the forward mode.

In several studies [15,16,17], some noise parameters were detected in the region of surrounding the cell phones. No one detect and fix with its influence during any nuclear measurements. In this study, as new results, we have measured the noise levels during the performance of HPGe 70% detector with a good heat angry and efficiency calibration and the intensity level of each were summarized in figure 1. It is a useful parameter for correcting the influence of noise generated during the calling mode [18,19,and 20].

All type of cell phones produce high signals that can cause a huge noise affecting the performance of HPGe detector [21,22,23,and 24]. The quality of gamma-ray measurements can be modified by taking into account this study. The measured spectra indicate that the noise range fall in X-ray region and the user can works in safe mode at high energy region. The results show also the radiation intensities difference generated for different hand phone types and its communication companies. We must inform that, in the case of far distance from towers the noising signal has its maximum value [25,26].

One of the correction method can be used too is fitting of the gained spectrum and assumed it as BG. Equation (1) represents the fitting for the XY tel mobile cell used with Vodafone line and in the front mode.

$$Y = (A+CLNX + E(LNX)^2 + G(LNX)^3 + I(LNX)^4)/ (1+BLNX+D(LNX)^2 + F(LNX)^3 + H(LNX)^4 + J(LNX)^5 \quad (1)$$

Where; X represents the energy in keV, Y the corresponding counts and

A = 0.140122545;
B = -1.020509969
C=-0.118993748;
D = 0.416446044
E = 0.037894359;
F = -0.084943593
G = -0.005363377;
H = 0.008660219
I = 0.000284658
J = -0.000353052

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Table (1.a): Presents the noise Energy E (keV), Intensity I and the corresponding interfering nucleus A*. The cell phone was located in forward direction to the detector face.

Nokia 3410								
Vodafone			Etesalat			Mobinile		
E (keV)	I	A*	E (keV)	I	A*	E (keV)	I	A*
64	2	^{169}Yb	89	38	^{153}Eu	94	21	^{91}Rb
133	3	^{181}Hf	109	3	^{164}Dy	227	2	^{83}Se
168	4	^{164}Tb	173	3	^{177m}Lu	355	7	^{175}Hf
210	7	^{102}Mo	357	9	^{133}Ba	555	12	^{104m}Rh
325	4	^{157}Dy	403	6	^{87}Kr	875	30	^{154}Eu
511	3	Ann.	422	7	^{140}Ba	974	13	^{94}Tc
745	42	^{244}Am	557	18	^{104m}Rh	1240	100	--
805	6	^{140}Xe	635	13	^{165}Dy	1256	66	^{56}Co
915	93	^{125}Sn	661	17	^{137}Cs			
1128	68	^{90}Nb	790	69	^{130}Sb			
1151	100	^{156}Eu	897	61	^{89m}Y			
			940	100	^{131}Sb			

Table (1.b): Presents the noise Energy E (keV), Intensity I and the corresponding interfering nucleus A*. The cell phone was located in backward direction to the detector face.

Nokia 3410								
Vodafone			Etesalat			Mobinile		
E(keV)	I	A*	E(keV)	I	A*	E(keV)	I	A*
145	13	^{141}Ce	64	100	^{189}Pt	170	24	^{164}Tb
160	2	^{123m}Sn	94	27	^{91}Rb	266	21	^{206}Tl
170	4	^{182m}Ta	236	10	^{232}Th	415	18	^{184}Ta
227	6	^{83}Se	373	14	^{131}Ba	655	67	--
263	2	^{184}Ir	434	45	^{108}Rh	923	43	--
353	3	175Hf	505	92	^{121}Te	1120	100	^{214}Bi
390	1	^{163}Tb	531	45	^{147}Nd			
640	2	^{142}La						
1209	100	--						
1318	44	^{82}Br						

Table (1.c): Presents the noise Energy E (keV), Intensity I and the corresponding interfering nucleus measured during the charging process.

Nokia 3410 with Vodafone line					
Forwarded			Backward		
E (keV)	I	A*	E (keV)	I	A*
64	9	^{181}Bt	64	100	^{181}Pt
286	4	^{75}Br	444	1	^{128}Cs
314	1	^{147}Pr	605	12	^{134}CS
449	6	^{180}W	699	18	--
479	6	^{7}Be	940	19	--
708	6	^{94}Nb	1090	70	--
770	6	^{131m}Te			
1009	5	--			
1077	100	^{68}Cu			

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Table (2) : Presents the noise Energy E (keV), Intensity I and the corresponding interfering nucleus A*. The cell phone was located in forward direction to the detector face.

Nokia E65								
Forwarded						Backward		
Vodafone			Mobinil			Mobinil		
E (keV)	I	A*	E (keV)	I	A*	E (keV)	I	A*
125	14	^{52}Ti	120	78	^{152}Eu	64	100	^{181}Pt
143	37	^{105}Tc	184	11	^{67}Cu	183	23	^{129m}Ba
181	30	^{129m}Ba	367	9	^{200}Au	266	23	^{210m}Bi
244	38	^{111}In	655	35	^{110}In	419	3	^{77}Ge
289	33	^{75}Br	1034	100	--	514	1	Ann
387	35	^{71m}Zn				757	6	^{95}Zr
463	26	--				985	21	^{238}Nb
625	100	--						
809	73	^{58}Co						

E65 both Etesalat (Top and bottom) and Vodafone bottom are BG.

Table (3a): Presents the noise Energy E (keV), Intensity I and the corresponding interfering nucleus A*.

YX tel Top								
Vodafone			Etesalat			Mobinile		
E(keV)	I	A*	E(keV)	I	A*	E(keV)	I	A*
70	97	^{199}Tl	169	100	^{164}Tb	108	100	^{131m}Ba
96	100	^{153}Gd				152	97	^{85m}Kr
138	71	^{184}Hf				219	52	^{89}Kr
222	4	^{89}Kr				450	53	^{180}W
231	12	^{85}mSr						

Table (3b) : Presents the noise Energy E (keV), Intensity I and the corresponding interfering nucleus A*.The cell phone was located in backward direction to the detector face.

YX tel								
Vodafone			Etesalat			Mobinile		
E(keV)	I	A*	E(keV)	I	A*	E(keV)	I	A*
116	30	^{151}Nd	142	8	^{46m}Sc	188	7	^{109m}Pb
134	100	^{132m}La	152	100	^{85m}Kr	219	7	^{139}Xe
190	13	^{141}Ba	203	2	^{109}In	276	87	^{177m}Hf
274	6	^{117}Gd	217	11	--	320	95	^{51}Ti
360	13	^{161}Gd	296	14	^{214}Rb	643	69	^{119}Te
473	12	^{24}Ne	319	33	^{51}Ti	718	100	^{83}Se
539	33	^{100}Rh	573	47	^{121}Te			
			640	73	^{142}La			
			661	68	^{137}Cs			

Table (4): Presents the noise Energy E (keV), Intensity I and the corresponding interfering nucleus A*.

Black Berrry Vodafone					
Forwarded			Backward		
E(keV)	I	A*	E(keV)	I	A*
254	3	^{151}Ld	146	21	^{141}Ce
601	3	^{137}I	190	13	^{141}Ba
695	5	^{129}Te	230	7	^{115}Ag
1120	1	^{214}Bi	271	4	^{134m}I
2608	100	--	454	3	^{146}Pm

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2737	95	--	571	3	^{121}Te
			700	6	--
			802	6	^{206}Bi
			1083	7	^{177}Yb
			1130	17	^{135}I
			1388	19	--
			1459	19	^{40}K
			1982	100	--

Figure (1): Represents the measured spectra of different hand phone types in the forward mode.

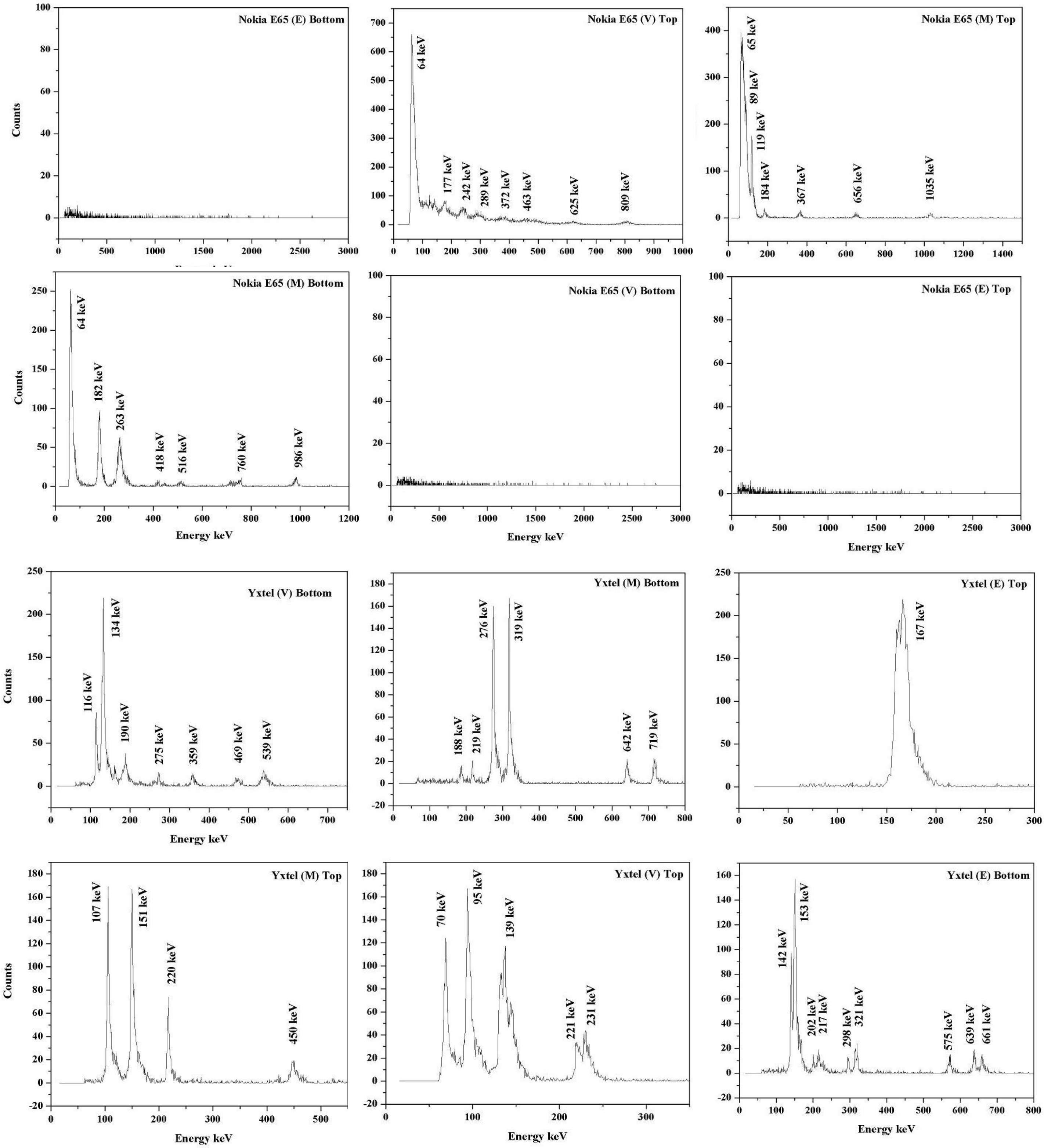

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Figure (2): Represents the measured spectra of different hand phone t
Backward mode

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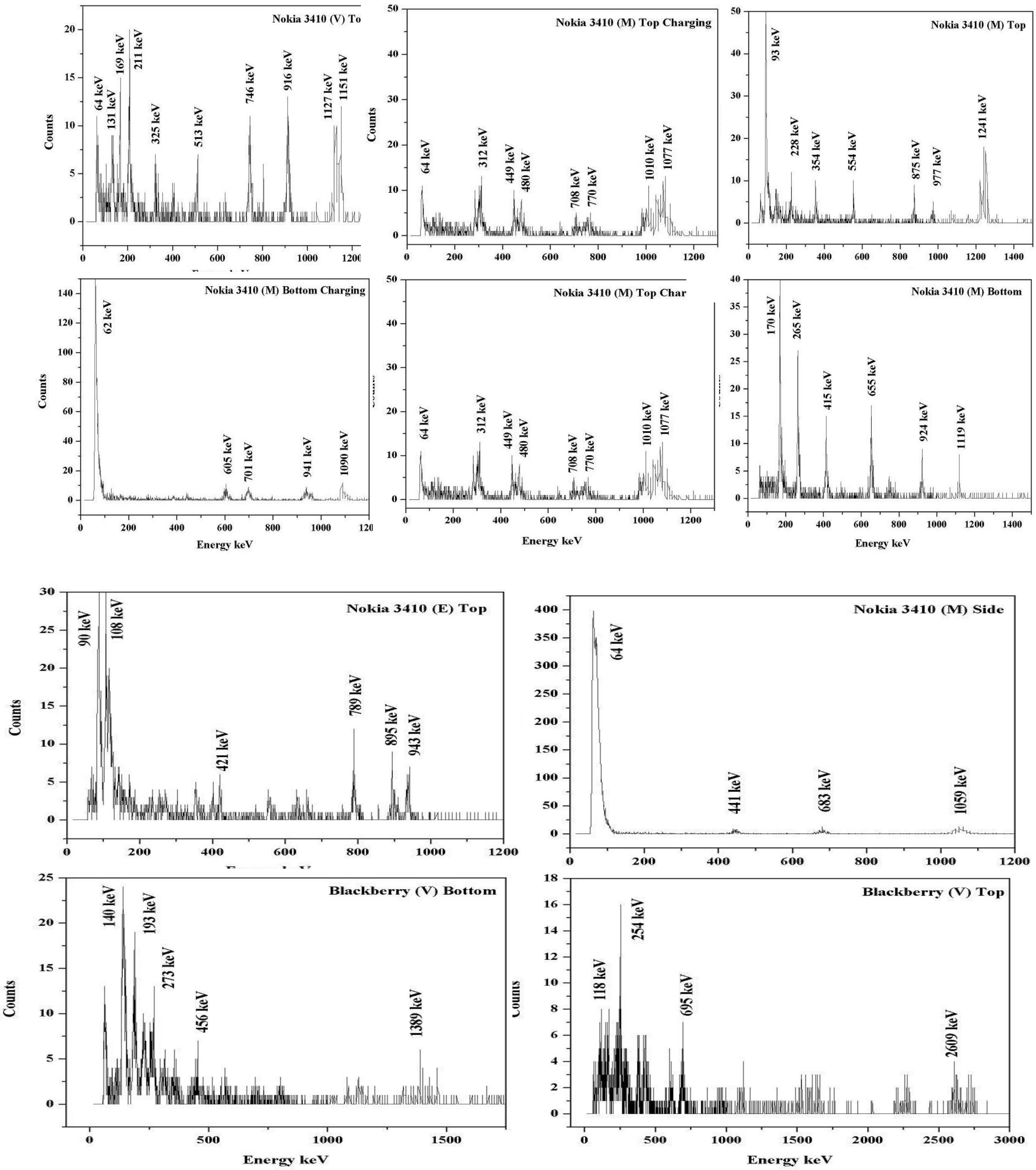

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VI. CONCLUSIONS

All type of cell phones produces high signals that can cause a huge noise affecting the performance of HPGe detector. The quality of gamma-ray measurements can be modified by taking into account this study. The measured spectra indicate that the noise range fall in X-ray region and the user can works in safe mode at high energy region.

The results show also the radiation intensities difference generated for different hand phone types and its communication companies. I must inform that, in the case of far distance from towers the noising signal has its maximum value.

It should be mentioned that; for mobile cell type Nokia E65, used with Etesalat line, the measured photon spectra was in the order of the BG level and can be safety used in the gamma spectroscopy labs.

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