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PEAKTOR: A Gamma-Ray Data Display and Analysis Software

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Abstract

PEAKTOR is an offline gamma-ray spectrum analysis software program developed by using the programming language of JavaFX. Using the powerful JavaFX programming language, PEAKTOR was designed and compiled to work under modern personal computers. It is designed to serve all modern operating systems including; Linux, Linux Mint, and UBUNTU. PEAKTOR calculates the energy calibration, area, centroid, FWHM and background. It can be used for important applications such as environmental studies, low-level monitoring, neutron activation analysis, nuclear analytical techniques based on accelerator and several medical applications. In this work, an evaluation will be carried out in an automatic mode between the PEAKTOR and others recent software for gamma spectroscopy such as GENIE-2000, GAMMA VISION and APTEC. Based on the comparison between Genei-2000 software and PEAKTOR the test spectra results were in good agreement for spectra analysis. While the peak area and peak integer have been seen, the automatic mode has more tendencies to low understated values.

Keywords

PEAKTOR; Gamma-Ray spectrum analysis; Gamma Spectroscopy; JavaFX

Introduction

Gamma rays are used in science to discover the secrets of the nucleus, the development of reactors, nuclear accelerators, and scientific experiments. It is also used as an aid to the neutron activation technology to determine the elemental composition of substances quantitatively and qualitatively. Gamma rays are used in medicine to kill cancer cells and to keep them from growing. In industry, gamma-ray technology is used to examine petroleum pipelines and detect weaknesses. Gamma-ray spectrometry is also one of the most important methods of screening the safety of environmental radiation, which is used by most nuclear organizations to monitor and report the environmental contaminations radioactive to conclude the safe and hazardous radiation levels. Therefore, techniques based on gamma-ray spectrum measurement were given special attention in the methods of results analyzing their measurements as analytical tools to characterize the different types of materials for their different fields of applications. The IAEA assists member states in developing their capacity to use these technologies for scientific research and technological applications.

The gamma spectra are continuous and consist of discrete photo-peaks with a very small width (called resolution), so it is necessary to describe the shape of the spectrum, the background in the peak region, and the peaks themselves. The description of gamma spectra is available in several books for detailed coverage. In particular, books by Gordon R. Gilmore and Alcocer Giovanni [1, 2] are extremely comprehensive.

Scientists have been thinking about finding more programs that work more easily and more efficiently, due to technological advances and recent discoveries. A large number of programs have therefore been proposed, such as Genie 2000 [3], Gamma version [4], Hypermet PC [5], SAANI [6], IDeFix [7], and some other recent codes [8-18]. Included in the Genie 2000 Gamma Analysis Software package was an advanced analytical algorithm for further processing of the gamma-ray spectrum acquired through the basic spectroscopy software Genie 2000. These algorithms have provided complete gamma-ray spectra analysis which can be obtained from any type of gamma detector. The software has been proven on-time methodologies with a long history of acceptance and refinements and includes patented, groundbreaking analysis and techniques of calibration.

A new PEAKTOR program for gamma-ray spectrum analysis will be implemented in this work. PEAKTOR is multiuser software written using the versatile language of JavaFX. Genie 2000 software and some programs [3,4,19] were used to test the PEAKTOR program for its performance. Some of the principles used in the proposed revision of the ANSI specification will be used in Canberra and Nuclear Data software packages, such as Genie 2000, to test peak search and area estimation algorithms currently in use. As a function of peak separation and peak height ratio, the test selected in this study requires the software capability to locate and calculate the photo-peak near an adjacent second peak.

PEAKTOR Description

Figure 1 explains the flow chart of the PEAKTOR software calculation. The flow chart shows step by step the modes of data processing and the sequence of analysis. The Spectrum Data source is opened in ASCII format and then changed to be in ten rows to fit the software interface format. The process of analysis can be defined as; the program that applies the predetermined calibration of energy. In pre-determined regions of interest, the program then looks for photo- peaks that have been selected and match those peaks, based on a calibrations response. The photo-peak strength can be automated by this method, after that, the nuclides presented in the analyzed range, are defined as a feature of energy (from a previous calibration). Finally, the radioactivity concentration of the analyzed sample ordered and displayed in a text document form is represented by an output report. It is further presumed that a peak analysis, including optional background subtraction, was conducted on the spectrum.

Material and Methods

In this research, we will use mathematical techniques and software programs to analyze gamma-ray spectra resulting from neutron

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activation and measurements of natural samples and to find fast and automatic detailed results of these experiments. To make this software program, we will use the JavaFX programming language [20]. The new JavaFX is a pure Java language programming interface (API). The aim of JavaFX is to be used in many types of devices, including embedded devices, tablets, TVs, tablet computers, and desktops. So it is perfect for our plan. Thirty test spectra were used to qualify PEAKTOR software's spectrum analysis has been taken from reference [21]. They were prepared using a spectrum of 15.5 percent relative efficiency of a mixed gamma-ray standard filter paper measured on a 1.96 keV resolution n-type HPGe detector. To a peak-free random background spectrum, a peak from this spectrum was added. In Table 1, the energy calibration of the test spectra was summarized. For all test spectra, the count time is 240000 seconds. PEAKTOR will open spectra data in DAT format, so it is simpler than Genie 2000, where the Genie 2000 edition available only saves spectra in the proprietary CNF format that cannot be opened in any of the other software, the spectra have been converted to CHN format using the Cambio program [22]

PEAKTOR Program Features

PEAKTOR draws a chart that is a link between counts and channels. In a wide drawing window, it can display the peak profile. The view, expand and peak selection windows, shown in Figures [2-5], consists of the Title Bar, the Menu Bar, and the Display Status. It is possible to clarify these properties as follows:

Title Bar: The Title Bar often means the spectrum's name.

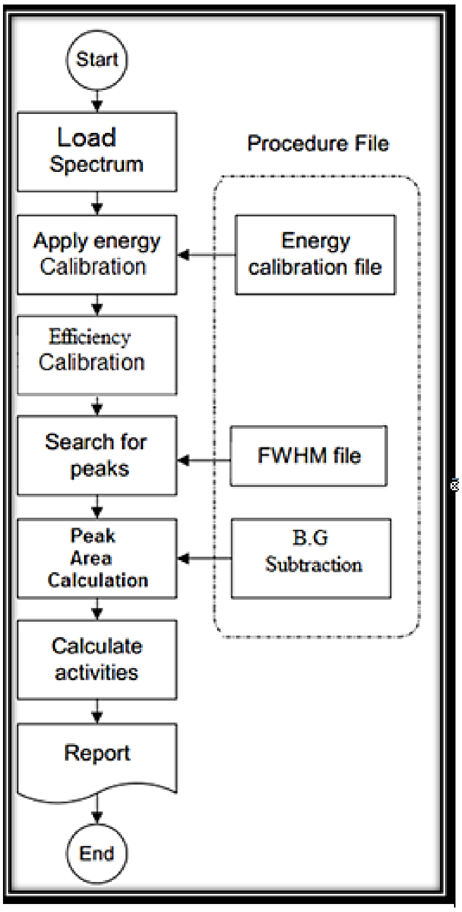

Figure 1: Flowchart for identification analysis.

Menu Bar: The Menu Bar appears at the top and offers you a choice of energy calibration, efficiency calibration, and a summary menu of various menu functions.

Display Status Line: The Display Status Line shows the current spectrum information, such as the current position of the cursor, in

Table 1: Reference date for Energy calibration. (Count time for 6000 seconds) [21].

Isotope	Gamma Energy	Half-Life	Gamma-Rays Per Second
Cd-109	88	463.9 Days	46.4
Co-57	122	272.4 Days	39.3
Ce-139	166	137.7 Days	16
Sn-113	392	115.0 Days	34
Cs-137	662	30.0 Years	315
Y-88	898	106.66 Days	78
Co-60	1173	5.271 Years	379
Co-60	1332	5.271 Years	380
Y-88	1836	106.66 Days	82

Figure 2: PEAKTOR program main interactive analysis window.

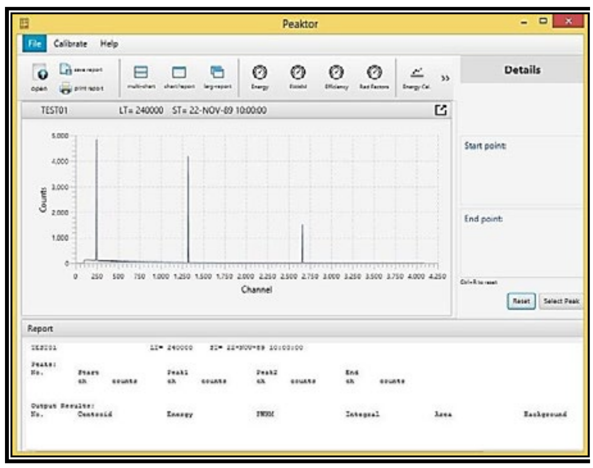

Figure 3: The chart of the spectrum.

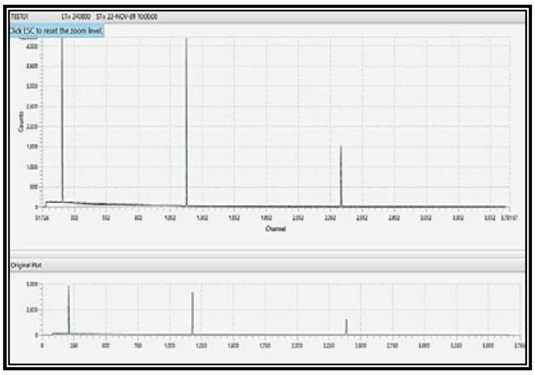

Figure 4: PEAKTOR program main spectrum display and expand menu.

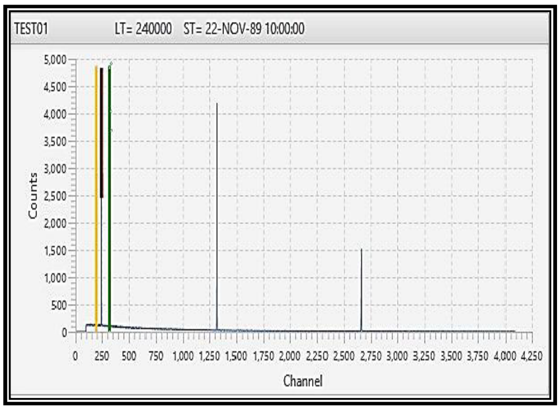

Figure 5: The Peak selection routine.

terms of channel and energy, the total counts at that point, and the preset and elapsed preset time values.

Description of Test Spectra

In this evaluation, two types of test spectra are used.

The Sanderson test spectra: Colin Sanderson, of the US Energy Department [23], created these spectra as ASCII text files in 1990. A variety of spectrum analysis systems studied some years earlier were used to reevaluate these research spectra. They were prepared using a spectrum of 15 percent relative efficiency of a mixed gamma-ray standard filter paper measured on a 1.96 keV resolution n-type HPGe detector. Peaks from this spectrum were added to a peak-free random background spectrum. After evaluating the actual background level in the real spectrum, this background was developed. Spectra had concocted to test peak search, doublet resolution with equal and asymmetric peak ratios, and an efficiency test [23, 24]. These test spectra are used in the comparison between PEAKTOR and both GAMMA VISION and APTEC in an automatic mode.

IAEA test spectra: The G-1 inter-comparison test spectra were established by the International Atomic Energy Agency (IAEA) from genuine gamma-ray spectra via numerical control so that the relative positions and intensities of all peaks were precisely known [25]. These test spectra are used in the comparison between PEAKTOR and GENIE-2000 in an automatic mode. The IAEA test spectra consisted of nine spectra as follows:

- G1100: It is a regular spectrum of 20 single peaks of typically impressive control statistics from which the peaks have been inferred in all other spectra.
- G1200: There are 22 small peaks in the spectrum, closed to and below the limit of detection.
- G1300-G1305: Six duplicated spectra; 22 single peaks of varying sizes were included in each spectrum. A sample measured six

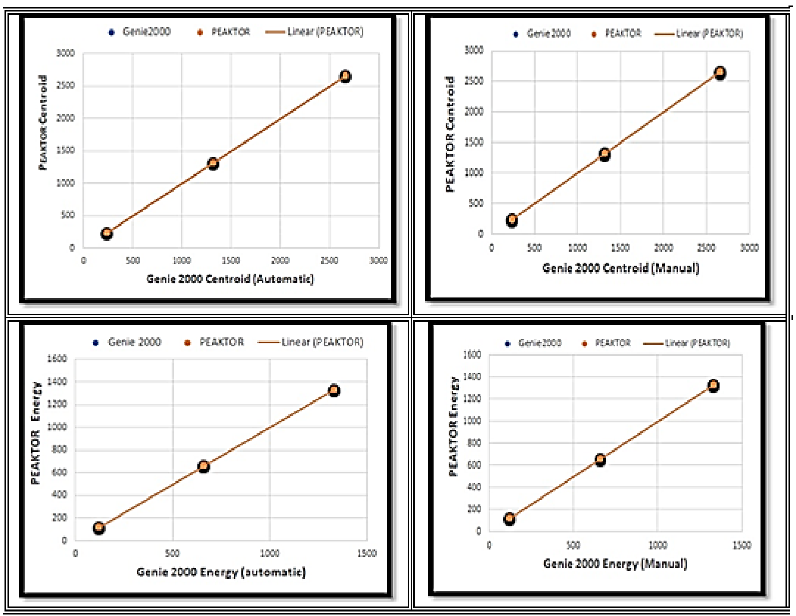

Figure 6: Comparison between PEAKTOR& Genie 2000 centroid and energy calibrations.

times and served to assess the precision and consistency of the peak area calculations was represented by the spectra.

- G1400: It comprises nine double peaks with various degrees of overlap component and relative strength.

Results

PEAKTOR comparison with Genie 2000 software

The performance analysis of the PEAKTOR program using 30 test spectra [21], was summarized and compared with the Genie 2000 software. The peak centroid, peak area, peak integer, FWHM, and energy calibration comparison figures are shown in figures (6-8). The peak areas were calculated following calibration by analyzing each of the single peak test spectra. As shown in figure 6, the peak centroid and peak energy observed were compared by taking a simple Genie 2000 ratio and providing the most accurate PEAKTOR results. For FWHM, figure 7 shows that there is a disagreement in the relation comparison between PEAKTOR and Genie 2000 results. PEAKTOR and Genie 2000 in Figure 8 seem to have a tendency to strongly overestimate the area in the automatic mode for peak area and the integral area determination, whereas the manual mode provides results agreement

PEAKTOR comparison with Aptec code

A wide comparison of the outcomes is given in Table 2. The gamma energy is given in (keV) units for 30 test spectra, the calculation for non-resolving peaks was done and the Aptec code was given for automatic run modes. A good agreement in the energy calculations was achieved as shown in Table 2 and Figure 9. Some error values, more than 50%, in Aptec area calculations may due to the that it treats any investigated peak as a single peak and no resolving factors are taken into account [19].

PEAKTOR comparison with Gamma Vision code

Table 3 provides a broad comparison of the final results, for the measurement of 30 test spectra for non-resolving peaks provided for automatic Gamma Vision code run modes. The Gamma Vision's centroid, energy, and integer (growth area) measurements are in good agreement with PEAKTOR. There are some high error values in Gamma Vision area measurements since it considers any investigated peak as a single peak and no resolving factors are taken into account [4]. All these details are illustrated in Figure 10. The similarities in the measurements of the area are extremely fluctuating. Typically, it is

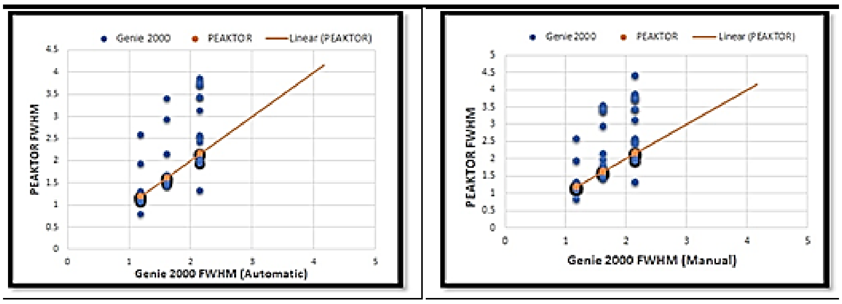

Figure 7: Comparison between PEAKTOR & Genie 2000 FWHM.

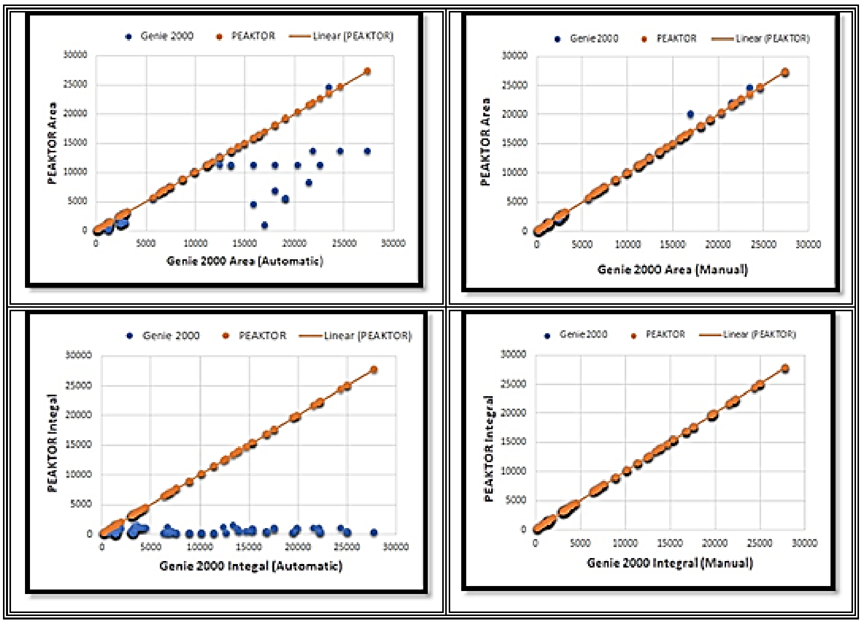

Figure 8: Comparison between PEAKTOR& Genie 2000 peak area and integral.

Table 2: PEAKTOR output comparison with Aptec program automatic run mode.

Spectrum	PEAKTOR Energy (keV)	Aptec Energy (keV)	Energy error %	PEAKTOR Area	Aptec Area	Area error %
Test 01	122.65	122.02	0.0051	11365	11340	0.0022
	662.02	661.46	0.0008	13724	13660	0.0047
	1333.17	1332.62	0.0004	6307	6265	0.0067
Test 02	122.68	122.02	0.0054	5727	5703	0.0042
	662.01	661.46	0.0008	6878	6818	0.0087
	1333.16	1332.62	0.0004	3185	3128	0.0179
Test 03	122.51	122	0.0042	1305	1191	0.087
	661.94	661.46	0.0007	1468	1342	0.0858
	1333.1	1332.62	0.0004	678	621	0.0842
Test 04	122.48	121.96	0.0042	752	485	0.3547
	661.89	661.46	0.0006	783	642	0.1803
	1333.04	1332.62	0.0003	361	316	0.1258
Test 10	122.39	121.75	0.0052	2321	2319	0.0006
	661.75	661.17	0.0009	2838	2712	0.0444
	1332.91	1332.42	0.0004	1303	1246	0.0437
Test 11	122.05	121.51	0.0044	2343	2198	0.0617
	661.53	660.92	0.0009	2837	2703	0.0472
	1332.67	1332.17	0.0004	1313	1237	0.0579
Test 12	121.79	121.27	0.0043	2471	2253	0.0882
	661.29	660.71	0.0009	2774	2702	0.026
	1332.4	1331.87	0.0004	1231	1237	0.0049
Test 13	121.63	121.99	0.003	2457	2292	0.0672
	661.03	660.46	0.0009	2830	2703	0.0447
	1332.15	1331.63	0.0004	1214	1237	0.0189
Test 14	121.05	122	0.0078	2514	1263	0.4976
	660.81	661.45	0.001	2815	1386	0.5076
	1331.84	1331.39	0.0003	1290	1238	0.0399
Test 15	121.01	122	0.0082	2519	1218	0.5164
	660.44	661.46	0.0015	2801	1396	0.5015
	1331.6	1332.59	0.0007	1355	1231	0.0915
Test 16	120.76	122	0.0103	2514	1194	0.5251
	660.18	661.46	0.0019	2798	1333	0.5236
	1331.37	1329.11	0.0017	1378	1231	0.1064
Test 17	120.51	122	0.0124	2497	1083	0.5662
	659.94	661.46	0.0023	2859	1346	0.5292
	1331.15	1328.61	0.0019	1379	1232	0.1063
Test 18	120.11	122	0.0157	2431	1090	0.5516
	659.73	661.46	0.0026	2858	1337	0.5322
	1330.93	1332.62	0.0013	1381	625	0.5476
Test 19	119.71	122	0.0191	2523	1177	0.5334
	659.45	661.46	0.003	2894	1331	0.54
	1330.72	1332.62	0.0014	1380	6173	3.4748
Test 20	121.6	122.01	0.0034	22630	22590	0.0018
	661.02	660.46	0.0008	27393	27380	0.0005
	1332.18	1331.62	0.0004	12463	12520	0.0046
Test 21	121.7	122.01	0.0025	20374	20330	0.0022
	661.13	660.65	0.0007	24656	24650	0.0002
	1332.29	1331.84	0.0003	11211	11260	0.0044
Test 22	121.82	122.02	0.0016	18118	18080	0.0021
	661.27	661.34	0.0001	21917	21910	0.0003
	1332.43	1332.04	0.0003	10073	10010	0.0063
Test 23	121.98	122.02	0.0003	15865	15830	0.0022
	661.45	661.38	0.0001	19180	19170	0.0005
	1332.61	1332.42	0.0001	8754	8763	0.0011
Test 24	122.18	122.02	0.0013	13608	13570	0.0028
	661.68	661.45	0.0003	16442	16430	0.0007
	1332.84	1332.57	0.0002	7526	7510	0.0021

Test 25	122.41	122.02	0.0032	12467	12440	0.0022
	661.84	661.45	0.0006	14977	15020	0.0029
	1332.99	1332.59	0.0003	6917	6883	0.0049
Test 26	122.45	122.02	0.0035	11752	11880	0.0109
	661.92	661.46	0.0007	14351	14340	0.0008
	1333.08	1332.61	0.0004	6611	6568	0.0064
Test 27	121.57	122.01	0.0036	17007	20330	0.1954
	660.92	660.26	0.001	23531	24650	0.0476
	1332.08	1331.45	0.0005	11168	11260	0.0082
Test 28	121.37	122.01	0.0053	18120	18080	0.0022
	660.76	659.61	0.0017	21531	21910	0.0176
	1331.92	1331.19	0.0005	9927	10010	0.0084
Test 29	121.21	120.02	0.0098	15864	15820	0.0028
	660.61	659.49	0.0017	19178	19170	0.0004
	1331.74	1330.81	0.0007	8756	8756	0.0001
Test 30	121.01	120.02	0.0082	13609	13570	0.0029
	660.39	659.47	0.0014	16444	16430	0.0009
	1331.5	1330.66	0.0006	7406	7502	0.013

Table 3: PEAKTOR output comparison with Gamma Vision program automatic run mode.

Spectrum	PEAKTOR Centroid	G.V Centroid	Centroid Error %	PEAKTOR Energy (keV)	G.V Energy (keV)	Energy Error %	PEAKTOR FWHM (keV)	G.V FWHM (keV)	FWHM Error %	PEAKTOR Integral	G.V Integral	Integral Error %	PEAKTOR Area	G.V Area	Area Error %	PEAKTOR Background
Test 01	242.99	241.93	0.0044	122.65	122.03	0.0051	1.19	1.15	0.0336	12427	12790	0.0292	11365	11213	0.0134	1062
	1321.29	1320.29	0.0008	662.02	661.44	0.0009	1.62	1.53	0.0556	14053	14053	0	13724	13673	0.0037	329
	2663.06	2662.09	0.0004	1333.17	1332.63	0.0004	2.16	1.93	0.1065	6426	6418	0.0012	6307	6271	0.0057	119
Test 02	243.04	241.92	0.0046	122.68	122.03	0.0053	1.19	1.16	0.0252	6789	7152	0.0535	5727	5575	0.0265	1062
	1321.29	1320.29	0.0008	662.01	661.44	0.0009	1.62	1.53	0.0556	7207	7207	0	6878	6837	0.006	329
	2663.05	2662.08	0.0004	1333.16	1332.62	0.0004	2.16	1.94	0.1019	3275	3281	0.0018	3185	3145	0.0126	90
Test 03	242.72	241.84	0.0036	122.52	121.99	0.0043	1.19	1.15	0.0336	2015	2640	0.3102	1305	1063	0.1851	711
	1321.15	1320.3	0.0006	661.94	661.45	0.0007	1.62	1.52	0.0617	1702	1731	0.017	1468	1368	0.0681	234
	2662.93	2662.06	0.0003	1333.1	1332.61	0.0004	2.16	1.98	0.0833	768	774	0.0078	678	649	0.0428	90
Test 04	242.65	241.77	0.0036	122.48	121.95	0.0043	1.19	1.17	0.0168	1452	2077	0.4304	752	500	0.3351	700
	1321.04	1320.3	0.0006	661.89	661.44	0.0007	1.62	1.51	0.0679	1017	1046	0.0285	783	686	0.1239	234
	2662.81	2662.06	0.0003	1333.04	1332.61	0.0003	2.16	2.06	0.0463	451	457	0.0133	361	335	0.072	90
Test 10	242.47	241.36	0.0046	122.39	121.75	0.0052	1.19	1.28	0.0756	3378	3734	0.1054	2321	2237	0.036	1058
	1320.77	1319.8	0.0007	661.75	661.2	0.0008	1.62	1.65	0.0185	3072	3101	0.0094	2838	2733	0.037	234
	2662.55	2661.61	0.0004	1332.91	1332.39	0.0004	2.16	2.04	0.0556	1393	1399	0.0043	1303	1269	0.0261	90
Test 11	241.79	240.97	0.0034	122.05	121.55	0.0041	1.19	1.7	0.4286	3602	3735	0.0369	2343	2231	0.0476	1260
	1320.32	1319.29	0.0008	661.53	660.94	0.0009	1.62	2.07	0.2778	3071	3101	0.0098	2837	2718	0.0419	234
	2662.05	2661.08	0.0004	1332.67	1332.12	0.0004	2.16	2.38	0.1019	1401	1401	0	1313	1242	0.0541	88
Test 12	241.28	239.71	0.0065	121.79	120.92	0.0071	1.19	0.29	0.7563	3471	3735	0.0761	2471	1612	0.3476	1000
	1319.72	1318.83	0.0007	661.23	660.71	0.0008	1.62	2.73	0.6852	3103	3103	0	2774	2600	0.0627	329
	2661.53	2660.62	0.0003	1332.4	1331.89	0.0004	2.16	2.99	0.3843	1407	1401	0.0043	1231	1220	0.0089	176
Test 13	240.95	237.91	0.0126	121.63	120.02	0.0132	1.19	0.44	0.6303	3472	3739	0.0769	2457	597	0.757	1015
	1319.32	1316.45	0.0022	661.03	659.52	0.0023	1.62	1.26	0.2222	3122	3100	0.007	2830	1252	0.5575	293
	2661.02	2659.27	0.0007	1332.15	1331.21	0.0007	2.16	2.61	0.2083	1418	1398	0.0141	1214	936	0.229	204
Test 14	239.79	236.9	0.0121	121.05	2121	16.5217	1.19	1.05	0.1176	3942	4338	0.1005	2514	2121	0.1563	1428
	1318.88	1315.34	0.0027	660.81	2721	3.1177	1.62	1.52	0.0617	3122	3231	0.0349	2815	2721	0.0332	308
	2660.41	2659.77	0.0002	1331.84	1272	0.0449	2.16	4.62	1.1389	1447	1441	0.0041	1290	1272	0.0136	158

Test 15	239.71	235.86	0.0161	121.01	119	0.0166	1.19	1.15	0.0336	3838	4445	0.1582	2519	2197	0.1277	1320
	1318.15	1320.28	0.0016	660.44	661.44	0.0015	1.62	1.54	0.0494	3228	3257	0.009	2801	2714	0.0309	428
	2659.92	2661.91	0.0007	1331.6	1332.53	0.0007	2.16	2.26	0.0463	1454	1454	0	1355	1274	0.0598	99
Test 16	239.22	234.8	0.0185	120.76	118.47	0.019	1.19	1.15	0.0336	3942	4577	0.1611	2514	2114	0.1591	1428
	1317.63	1320.3	0.002	660.18	661.44	0.0019	1.62	1.52	0.0617	3258	3287	0.0089	2798	2741	0.0204	460
	2659.46	2662.06	0.001	1331.37	1332.61	0.0009	2.16	2.01	0.0694	1458	1460	0.0014	1378	1264	0.0824	81
Test 17	238.72	233.88	0.0203	120.51	118	0.0208	1.19	1.02	0.1429	4049	4697	0.16	2497	2054	0.1772	1553
	1317.14	1312.29	0.0037	659.94	657.44	0.0038	1.62	1.52	0.0617	3279	3308	0.0088	2859	2733	0.0441	420
	2659.02	2662.06	0.0011	1331.15	1332.61	0.0011	2.16	1.98	0.0833	1459	1465	0.0041	1379	1282	0.07	81
Test 18	237.92	232.95	0.0209	120.11	117.54	0.0214	1.19	1.02	0.1429	4301	4829	0.1228	2431	1969	0.19	1870
	1316.72	1320.3	0.0027	659.73	661.66	0.0029	1.62	1.52	0.0617	3278	3328	0.0153	2858	2752	0.0371	420
	2658.59	2662.05	0.0013	1330.93	1332.61	0.0013	2.16	1.99	0.0787	1461	1472	0.0075	1381	1312	0.0496	81
Test 19	237.11	232.01	0.0215	119.71	117.07	0.0221	1.19	1.14	0.042	4546	4942	0.0871	2523	2025	0.1972	2024
	1316.16	1310.3	0.0045	659.45	656.45	0.0045	1.62	1.56	0.037	3319	3348	0.0087	2894	2785	0.0375	426
	2658.16	2662.05	0.0015	1330.72	1332.61	0.0014	2.15	1.99	0.0744	1460	1477	0.0116	1380	1310	0.0504	81
Test 20	240.89	237.97	0.0121	121.6	120.05	0.0127	1.19	0.16	0.8571	24400	23995	0.0166	22630	6079	0.7314	1770
	1319.31	1318.51	0.0006	661.02	660.55	0.0007	1.62	3.57	1.2037	27793	27881	0.0032	27393	27361	0.0012	400
	2661.08	2659.14	0.0007	1332.18	1331.15	0.0008	2.16	1.7	0.213	12709	12666	0.0034	12463	9161	0.2649	247
Test 21	241.09	237.91	0.0132	121.7	120.02	0.0138	1.19	0.06	0.9496	22144	21739	0.0183	20374	3823	0.8124	1770
	1319.53	1318.61	0.0007	661.13	660.6	0.0008	1.62	3.67	1.2654	25056	25144	0.0035	24656	24624	0.0013	400
	2661.3	2659.23	0.0008	1332.29	1331.19	0.0008	2.16	0.28	0.8704	11443	11411	0.0028	11211	7912	0.2943	232
Test 22	241.34	237.51	0.0159	121.82	119.82	0.0164	1.19	0.22	0.8151	19888	19483	0.0204	18118	1567	0.9135	1770
	1319.8	1320.02	0.0002	661.27	661.31	0.0001	1.62	1.89	0.1667	22317	22405	0.0039	21917	21885	0.0015	400
	2661.58	2660.91	0.0003	1332.43	1332.04	0.0003	2.16	3.68	0.7037	10192	10217	0.0025	10073	10074	0.0001	119
Test 23	241.65	242.04	0.0016	121.98	122.09	0.0009	1.19	0.46	0.6134	17635	17288	0.0197	15865	8465	0.4664	1770
	1320.15	1320.17	0	661.45	661.38	0.0001	1.62	1.64	0.0123	19580	19522	0.003	19180	15572	0.1881	400
	2661.95	2661.68	0.0001	1332.61	1332.5	0.0001	2.16	2.51	0.162	8932	8917	0.0017	8754	7619	0.1296	179
Test 24	242.05	241.94	0.0005	122.18	122.03	0.0012	1.19	1.01	0.1513	15378	15038	0.0221	13608	9840	0.2769	1770
	1320.62	1320.23	0.0003	661.68	661.41	0.0004	1.62	1.58	0.0247	16842	16788	0.0032	16442	14623	0.1106	400
	2662.41	2661.91	0.0002	1332.84	1332.53	0.0002	2.16	2.15	0.0046	7679	7667	0.0016	7526	6944	0.0773	153
Test 25	242.52	241.91	0.0025	122.41	122.02	0.0032	1.19	1.08	0.0924	13883	13914	0.0022	12467	10525	0.1558	1416
	1320.94	1320.26	0.0005	661.84	661.43	0.0006	1.62	1.56	0.037	15418	15418	0	14977	14145	0.0556	441
	2662.71	2662.03	0.0003	1332.99	1332.59	0.0003	2.16	1.97	0.088	7053	7043	0.0014	6917	6607	0.0448	136
Test 26	242.59	241.9	0.0028	122.45	122.02	0.0035	1.19	1.1	0.0756	13448	13352	0.0071	11752	10869	0.0751	1697
	1321.11	1320.28	0.0006	661.92	661.44	0.0007	1.62	1.55	0.0432	14736	14736	0	14351	13908	0.0309	385
	2662.88	2662.06	0.0003	1333.08	1332.61	0.0004	2.16	1.95	0.0972	6738	6729	0.0013	6611	6437	0.0262	128
Test 27	240.83	237.99	0.0118	121.57	120.06	0.0124	1.19	0.29	0.7563	21643	21749	0.0049	17007	7115	0.5816	4637
	1319.11	1318.2	0.0007	660.92	660.4	0.0008	1.62	3.57	1.2037	24987	25143	0.0062	23531	24623	0.0464	1456
	2660.88	2659.06	0.0007	1332.08	1331.11	0.0007	2.16	0.2	0.9074	11440	11416	0.0021	11168	8583	0.2315	272
Test 28	240.43	237.9	0.0105	121.37	120.01	0.0112	1.19	0.86	0.2773	19890	19504	0.0194	18120	8153	0.5501	1770
	1318.79	1316.37	0.0018	660.76	659.48	0.0019	1.62	1.43	0.1173	22266	22220	0.0021	21531	13047	0.394	735
	2660.57	2659.17	0.0005	1331.92	1331.17	0.0006	2.16	3.37	0.5602	10183	10166	0.0017	9927	8004	0.1937	256

Test 29	240.12	237.89	0.0093	121.21	120.01	0.0099	1.19	0.98	0.1765	17634	17258	0.0213	15864	17258	0.0879	1770
	1318.48	1316.34	0.0016	660.61	659.47	0.0017	1.62	1.47	0.0926	19578	19499	0.004	19178	19499	0.0167	400
	2660.21	2658.49	0.0006	1331.74	1330.82	0.0007	2.16	2.38	0.1019	8934	8917	0.0019	8756	8917	0.0184	179
Test 30	239.7	237.89	0.0076	121.01	120.01	0.0083	1.19	1.06	0.1092	15379	15012	0.0239	13609	10228	0.2484	1770
	1318.04	1316.32	0.0013	660.39	659.45	0.0014	1.62	1.51	0.0679	16869	16779	0.0053	16444	13451	0.182	425
	2659.72	2658.28	0.0005	1331.5	1330.72	0.0006	2.16	2.11	0.0231	7678	7669	0.0012	7406	6847	0.0755	272

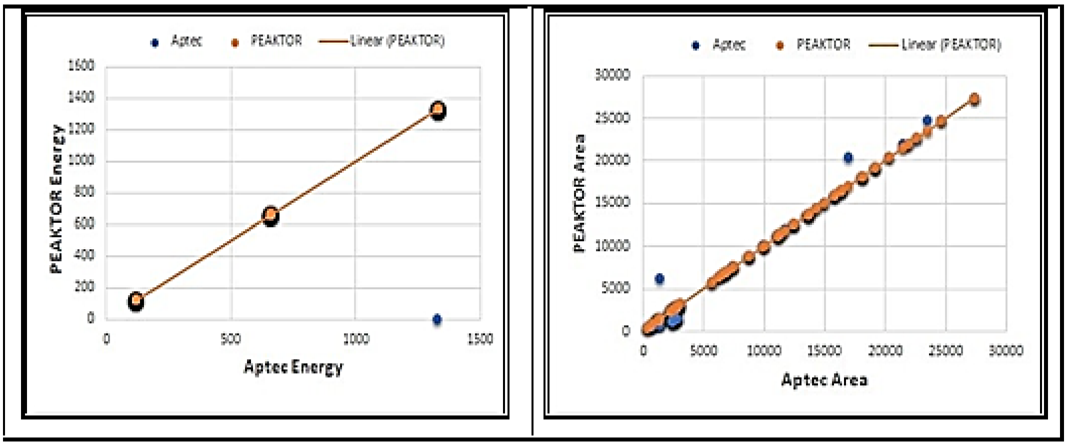

Figure 9: Comparison between PEAKTOR& Aptec, energy and area, calculations in automatic run mode.

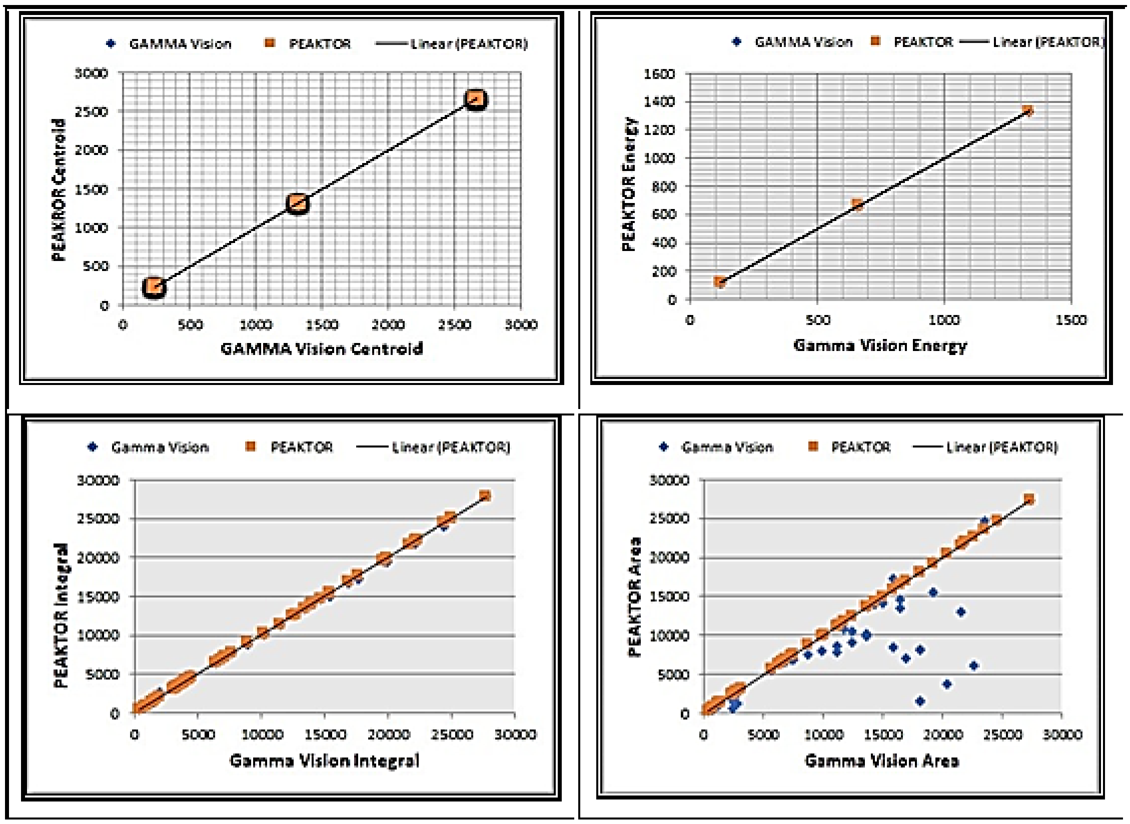

Figure 10: Comparison between PEAKTOR& Gamma Vision Photo peak in automatic mode.

smaller than the estimated values.

Conclusion

In this research, the test data were taken from standard international measured spectra, the JavaFX language was used, the net area was calculated using peak analysis and thus this PEAKTOR program calculates the spectroscopic factors of all important analysis. Also, the PEAKTOR program provides many essential features such as running with any operating system including Windows and real-time remote control with any spectrum analyzer. For energy calibration, performance calibration, radioactivity, and radiological protection factors, the code consists of routines provided. As shown in the automatic mode, the results of test spectra in the comparison between different software and PEAKTOR were in good agreement for spectrum analysis. Usually, under comparison between Genie-2000 software and PEAKTOR, the results of test spectra were in good agreement for spectra analysis as seen in the manual mode. Although the peak area and peak integer outcomes have been seen, there are more tendencies to underestimate low values in the automatic mode.

Finally, PEAKTOR provides all the qualitative and quantitative spectrum analysis options requirements; Spectrum display and a widescreen view with multi-expand modes, FWHM functions specified from calculated peaks, Linear and non-linear energy calibration mode, Intrinsic function efficiency or fitting polynomials, background subtractions and interferences consideration.

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