A LabVIEW solution for coupling an automated gamma-ray counter and software for spectra analysis

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A simple approach to transfer data from a PerkinElmer® Wizard2® automatic gamma-ray counter to Canberra® Genie 2000® software for spectra analysis has been developed. The LabVIEW® graphical programming language has been utilized to collect data for automated ASCII file generation based on optical character recognition of information displayed by the Wizard^2. The results have been checked using spectra collected from an ^{88}Zr source. The system substantially increases the speed at which spectra can be analyzed while providing more flexibility to the user.

1. INTRODUCTION

Automation of any routine process allows one to manage time and efficiency more optimally. Radiochemical investigations often consist of numerous experiments in which scientists must check their hypothesis by varying one parameter at a time in a systematic way. This approach leads to large amounts of samples to be analyzed, and the most common and relatively simple means to treat samples with radioactive material is a gamma-ray detector. Compared to alpha detectors, gamma-ray detectors have substantially lower sample preparation requirements, but this comes at the expense of reduced detection efficiency. Long analysis times are typically required, but an automated gamma-ray detector helps to maximize throughput by allowing for sample set measurements to continue at night and on weekends. This implementation also helps to reduce dose rates on personal [1-3]. Thus, safety and speed of certain processes might be significantly enhanced. Also automation is very valuable in particular for radioimmunoassay [4-6], analysis of art objects [3,7], and environmental applications [8]. This explains the rise of the automatic γ-counters market worldwide [9-13].

Several years ago, PerkinElmer® designed and developed the Wizard2® automatic gamma-counter [14], which is actively used for radiometric detection in clinical and academic research labs around the world. These units are equipped with sodium iodide (NaI) gamma-ray detectors that have poor peak resolution (tens of keV FHWM) but very high efficiency (up to ~80%). Additionally, these units can be loaded with up to 1,000 samples, and options are available for up to 10 detectors. The Wizard^2 has built-in software to acquire and analyze spectra and to save summary information to a file. Although there are models that can track up to six energy regions of interest, usually a radionuclide has several emitted gamma-ray energies that would be useful to analyze. This problem is exacerbated if multiple radionuclides are studied simultaneously, such as when an element is present as multiple isotopes. Also, the unit does not allow the user to save a spectrum to a text file in order to store and analyze it independently.

In order to create a user-friendly device, the automated system is usually equipped with software to monitor parameters and control the process. Among numerous programming languages, LabVIEW® is one of the most popular and reliable. This National Instruments® product is a very well-known graphical medium for scientific and technical tasks. It has been widely used for instrument communication, data visualization and analysis, for example in food inspections, wind turbine applications, spectrometry, optical character recognition, and many other fields [1,7,15-22].

As was mentioned above, the automation helps not only to physically replace samples on the counter, but also in data acquisition and analysis. Thus, the goal of the current work was to use LabVIEW® virtual instruments (VIs) from National Instruments® to save the raw spectrum data from a PerkinElmer® Wizard^2 automatic gamma-counter to a text file and then automatically analyze it using the Genie 2000 program from Canberra® [23], which is used worldwide for sophisticated analyses of gamma-ray spectra. The Wizard^2 model has a built-in computer with the Windows® operating system, so the LabVIEW program will be focused on calling Windows' functions for the reading the spectrum data. Thus, this procedure could be applied to any software capable of displaying spectra.

2. EQUIPMENT AND SOFTWARE

We used the PerkinElmer Wizard^2 automatic gamma-counter, model 2480 [24]. It has the capability to count vials or tubes of any shape up to 20 mL in volume and up to 95 mm in height (including cap). The maximum capacity is 1,000 tubes (up to 13 mm diameter) or 270 tubes (up to 28 mm diameter). The detector consists of a thallium-activated, NaI crystal with an end-well design. There are up to 6 simultaneous counting regions and its energy range is up to ~2,000 keV (2,048 channels). LabVIEW 2010 and Genie 2000 version 3.0 were used.

3. METHODS

Fig. 1 shows the Wizard^2 touchscreen when the system is collecting data from a sample of radioactive ^{88}Zr. (The radioactive decay daughter ^{88}Y is also present). The display resolution is 800 pixels x 600 pixels but the number of spectrum channels is 2,048, so simply digitizing the spectrum image will lead to errors because two neighboring channels cannot be distinguished. For convenience, the program has a moveable vertical marker, and the number of counts in the selected channel is displayed, so controlling the marker position and recording the associated marker counts was necessary. A subtask was to save the display information to a file, change the marker position, and repeat. This was accomplished using automated mouse control and the computer's "Print Screen" function.

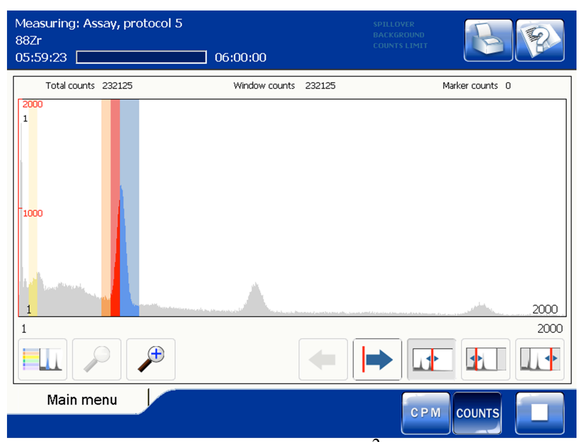

FIG. 1. Screenshot of the Wizard^2 display while the ^{88}Zr/^{88}Y sample was measured.

The final executable file must access an image stored to the clipboard, so these tasks were realized via a .NET method. Fig. 2 shows an adapted code [25] that acquires image data and saves it to a PNG file. In order to synchronize our code with the beginning of the measurement, we use the Wizard^2 software principle that enables/disables buttons on the control panel during the measurement and when samples are being changed, respectively. For example, in Fig. 1 one can see a number of active (colored) and inactive (grey) buttons underneath the spectrum.

The marker is moved by the user clicking the left or right arrow buttons on the touchscreen (see Fig. 1). Programmatically, this is accomplished by calling Windows' functions from the User32.dll library using a "Call Library Function Node" [26]. If the two approaches described here are combined together, then one can easily scan the entire spectrum by moving the marker from one side to another and saving the screenshots. In practice, this takes approximately 560 s, so the program must start approximately 10 min prior to the end of measurement. Usually energy lines of interest are in the first half of the spectrum (up to 1,000 keV), so the spectrum is scanned from right to left to get better statistics for the low-energy peaks. The data from each channel is recorded after a different counting time, so the data is normalized using the timestamps recorded by the "Get Date/Time In Seconds" function (Fig. 2, top left corner). This correction is trivial as long as the half-life of the nuclide(s) is/are long compared to the count time; this criterion is satisfied in the current work. The correction will be less with increased measurement time, so we recommend to measure each sample for at least 100 min in order to minimize error associated with the normalization.

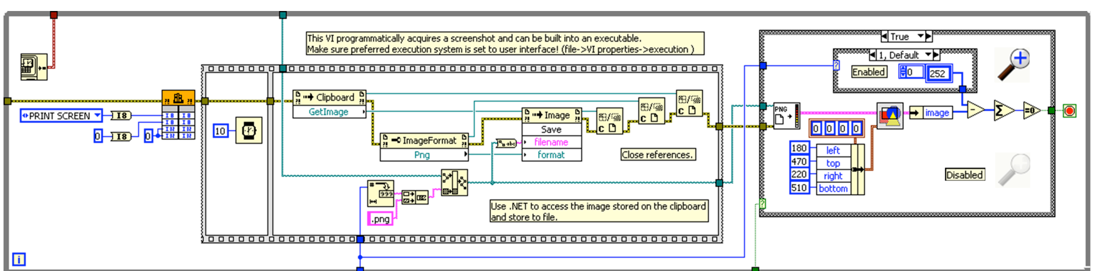

FIG. 2. .NET method to save screen images to PNG files with attention to the Wizard^2 touchscreen and the Print Screen button activities.

Implementation of the full code (shown in Fig. 3) results in ~2,000 screenshots collected with a different marker position for each PNG file, and the number of counts in the marker channel is shown on the top right of each screenshot. The timestamps can be used to correlate with the marker position on the screen.

Fig. 4 represents a code to read these data. A two dimensional array is a "library" of digits that has been created based on screenshots. A While Loop was implemented to identify all of the characters associated with marker counts and a positional notation method [27] has been applied afterwards. The one dimensional array near the top is the RGB background color we have used to determine if there is one more digit in the line. The accuracy of this procedure is 100%.

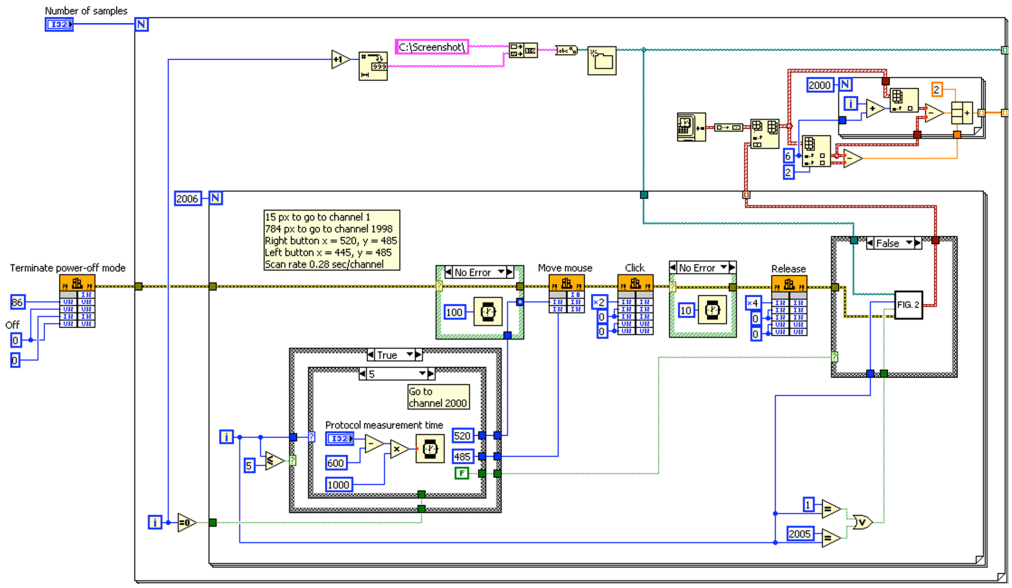

FIG. 3. Block-diagram to control the mouse position using left button clicks. SubVI in the False Case Structure represents the diagram shown in Fig. 2.

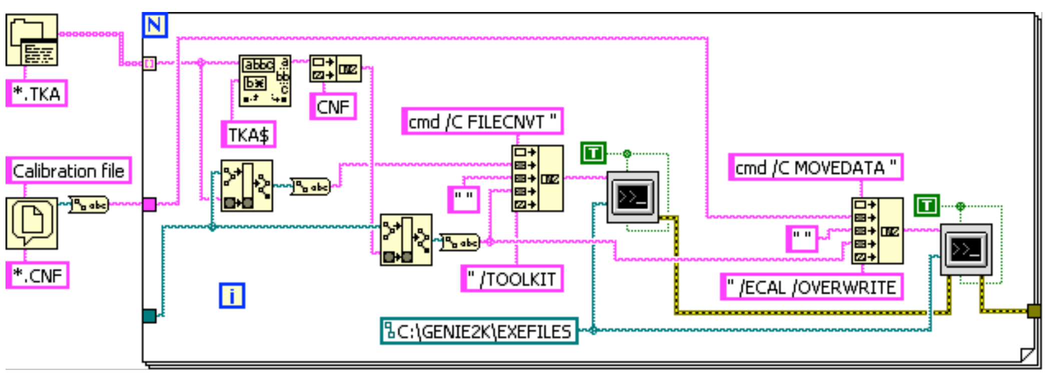

FIG. 4. Diagram to convert text files to Genie 2000 native formats with energy calibration.

The Wizard[2] automatic gamma-ray counter can handle up to 1,000 samples, so it is desirable to have all of the spectra analyzed automatically using Genie 2000 due to its sophisticated scripting and analysis capabilities. The ability to calibrate if needed and independently analyze the data provides substantial flexibility. The process consists of converting each spectrum's text file to a CNF file (a file format supported by Genie 2000), analyzing the

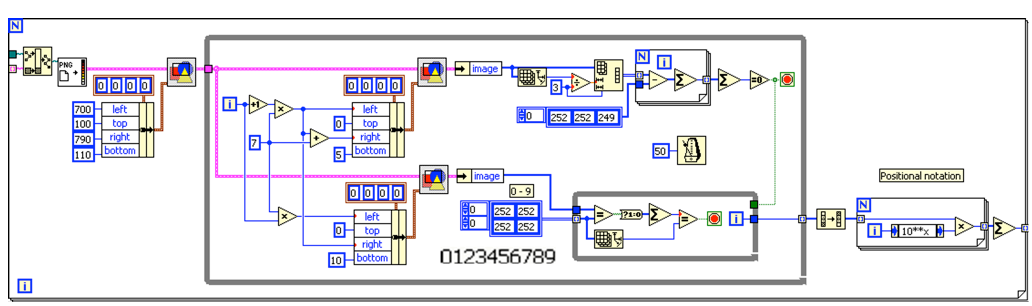

FIG. 5. Marker counts character recognition diagram.

spectrum, and extracting the data from "report" files. In order to run Genie 2000 via LabVIEW, we used commands one can find in the "S561 Batch Tools Support" and "Genie 2000 Customization Tools" PDF manuals co-installed by default with the software. Fig. 5 shows the code to convert each text file (file with a TKA extension) to a native Genie 2000 format (FILECNVT command with a TOOLKIT qualifier). It should be noted that TKA files do not contain energy calibration information. In order to calibrate the newly converted file, one should transfer such data from another CNF file prepared in advance by using the MOVEDATA command with the ECAL and OVERWRITE qualifiers. Thus, a set of energy-calibrated CNF files can be prepared.

Spectrum analysis is accomplished using the code shown in Fig. 6. A peak search command is required with established qualifiers such as threshold and number of channels. The PEAK_STD command performs an unidentified second difference peak locate followed by a pure

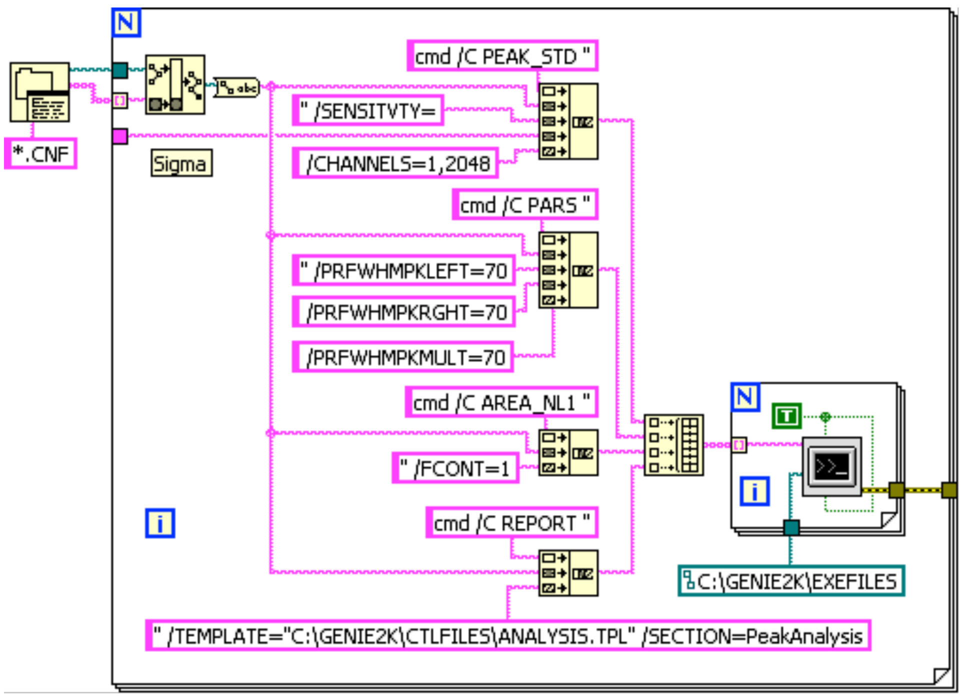

FIG. 6. Genie 2000 spectra analysis code.

gaussian peak fit phase of analysis on the specified datasource. The AREA_NL1 command is used to set the appropriate summation region, and the PARS command is used to modify the expected peak width to match the resolution of the detector. The Genie 2000 software has some analysis templates with access to a specific section. This is what has been used by the REPORT command and reference to a Peak Analysis section to save information generated to a report (RPT) file.

Genie 2000 produces one RPT file per spectrum, so the next step is to extract the data

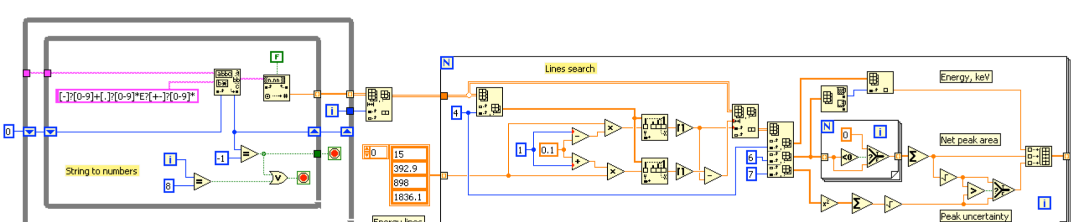

FIG. 7. Diagram to search for peaks of interest in Genie 2000 report files.

about the peaks of interest from all of the report files and combine these data together. The “Read From Spreadsheet File” virtual instrument can be easily used to open up report files if their extensions were previously changed from RPT to TXT. The report file contains a table, and the proper rows must be selected in order to keep track of the net peak area and associated uncertainty. Fig. 7 shows how report files can be treated in LabVIEW. The Match Pattern function with a corresponding regular expression has been used to create an array of numbers. Then, the search for energy lines of interest is performed using a For Loop. Genie 2000 works better with relatively small FWHM peaks, but the Wizard^2 peaks are very wide. To make the analysis procedure suitable for NaI detector data, a very small threshold for the peak search has been applied at a level of 0.5σ. This results in a large number of peaks, and summation of those that are close in energy to the known gamma-ray energy is required. A limit of 10% deviation from the known energy was chosen.

4. RESULTS AND DISCUSSION

Fig. 8 shows the spectrum extracted from the screenshot in Fig. 1, and qualitatively the two agree very well. In order to be sure that both methods (default and LabVIEW-based) give similar results, the Wizard^2 standard output file data (sum of counts in the desired range of channels) were compared to the results from the LabVIEW code. Table I gives the measurement time, ^{88}Zr gross peak area, and associated uncertainties obtained by each method. One can see that gross area values are close to each other. Despite the fact that all the corrections and background subtraction in the Wizard^2 software were disabled, the corresponding gross peak area number is not an integer, which suggests that some internal corrections were done. An interesting observation is that the relative uncertainties are significantly different; the Wizard^2 software overestimates the uncertainty by a factor of $t^{1/2}$, where t is the duration of the measurement in minutes. The statistical uncertainty in the net number of counts is

$$r = \frac{\sqrt{N}}{N} \cdot 100\% , \qquad (1)$$

where r is the relative uncertainty and N is the number of counts.

Table I. ^{88}Zr 392.87 keV gross peak area analysis.

Data source	Measurement Time (sec)	Gross Peak Area (counts)	Relative Uncertainty (%)
Wizard^2	21599.89	50532.26	8.44
LabVIEW	21600.00	50536.30	0.44

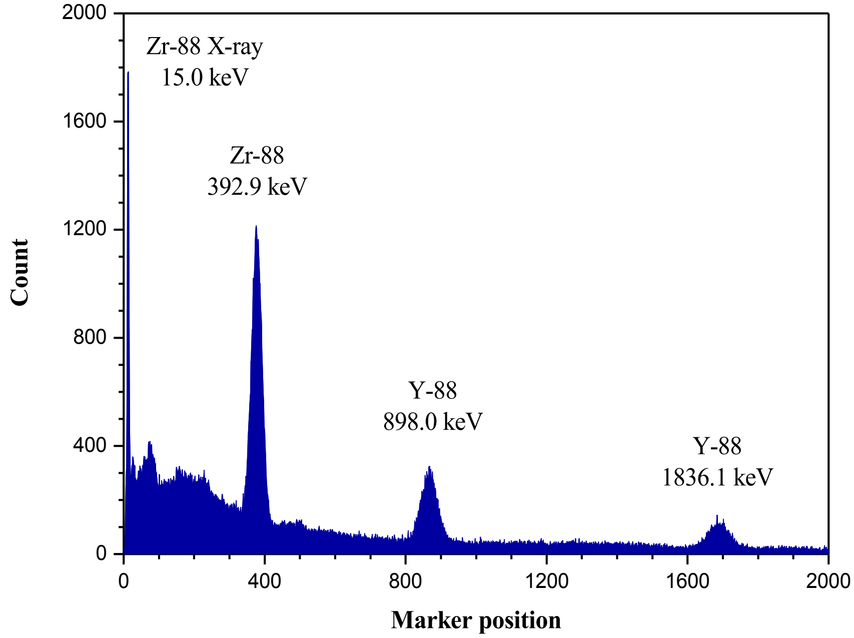

FIG. 8. Reconstituted spectrum from the Wizard[2] based on Fig. 1.

A section of the Genie 2000 report file for the spectrum shown in Fig. 8 is presented in Table II.

Table II. Selected lines from the Genie 2000 report file with an energy near the 392.87-keV gamma-ray from ^{88}Zr. The spectrum is shown in Fig. 8.

Peak No.	Peak Centroid (channels)	Energy (keV)	Net Peak Area (counts)	Net Area Uncertainty (counts)	Continuum (counts)
24	321.41	334.91	2.63E+002	58.58	1.54E+003
25	341.51	355.53	7.15E+002	61.69	1.52E+003
26	377.88	392.78	1.28E+004	359.37	1.34E+003
27	384.64	399.69	1.19E+004	335.75	1.28E+003
28	392.12	407.34	8.88E+003	253.50	1.22E+003
29	403.77	419.25	3.21E+003	107.78	1.16E+003
30	411.84	427.49	1.10E+003	64.55	1.14E+003
31	423.01	438.90	1.45E+002	54.05	1.23E+003

Peaks that can be attributed to the ^{88}Zr gamma-ray with energy of 392.87 keV [28] lie in the range from 353.6 to 432.2 keV (lines 25 – 30 in Table II). Summing the net peak area from these lines and dividing the result by the measurement time gives the output shown in Table III. Finally, Table III gives the count rates of the four main peaks from the spectrum shown in Fig. 1 after applying the analysis described above.

Table III. Analysis of the spectrum shown in Fig. 1. Literature data are taken from [28].

Isotope	Measured Energy (keV)	Literature Energy (keV)	Counts per second
Zr X-ray	14.46	14.958	0.653 ± 0.022
^{88}Zr	392.78	392.87	1.787 ± 0.026
^{88}Y	897.01	898.042	0.677 ± 0.011
	1835.39	1836.063	0.343 ± 0.011

5. CONCLUSION

A LabVIEW-based system has been developed to save data form the Wizard^2 automated gamma-ray detector to a text file, convert them to a Genie 2000 native format spectrum, and automatically analyze that spectrum. LabVIEW was used to control a computer mouse and Print Screen button activity to move the Wizard^2 marker channel by channel and save a screenshot for each marker position. Optical character recognition was used on consecutive images in order to reconstitute the spectrum. Genie 2000 was chosen to work with spectra and a LabVIEW code helps with software communication and automated information extraction. This provides experimentalists significant flexibility in terms of independently analyzing the available data.

[1] K.H. Chung, H. Kim, J.M. Lim, Y.Y. Ji, G.S. Choi, and M.J. Kang, "Rapid determination of radiostrontium in milk using automated radionuclides separator and liquid scintillation counter," *Journal of Radioanalytical and Nuclear Chemistry*, vol. **304**, no. 1, pp. 293-300, April 2015.

[2] R. Marques, F. Bernardoni, S. Pollack, and R. Helmy, "Development of an automated system for preparation of liquid scintillation counting samples for radiolabeled pharmaceuticals," *Journal of Labelled Compounds and Radiopharmaceuticals*, vol. **57**, no. 3, pp. 121-124, March 2014.

[3] C.R. Johnson, D.H. Johnson, N. Hamashima, H.S. Yang, and E. Hendriks, "On the utility of spectral-maximum-based automated thread counting from X-radiographs of paintings on canvas," *Studies in Conservation*, vol. **56**, no. 2, pp. 104-114, February 2011.

[4] V. Dvorak, T. Vasek, K. Broj, and P. Temml, "Multidetector scintillation detection unit for the measurement of ^{125}I in an automatic gamma counter," *Isotopenpraxis*, vol. **2**6, no. 2, pp. 54-56, February 1990.

[5] I.S. Anand and R. Benzing, "A simple automatic gamma counter based upon the IAEA radioimmunoassay instrument," *Applied Radiation and Isotopes*, vol. **40**, no. 1, pp. 89-90, February 1989.

[6] M. Regener, "Automated gamma-counters," *Proc. of the Conf. Antibiotics and Chemotheraphy*, vol. **26**, pp. 61-66, 1979.

[7] V. Desnica and M. Schreiner, "A LabVIEW-controlled portable X-ray fluorescence spectrometer for the analysis of art objects," *X-Ray Spectrometry*, vol. **35**, no. 5, pp. 280-286, August 2006.

[8] M.J. O'Hara, S.R. Burge, and J.W. Grate, "Automated radioanalytical system for the determination of ^{90}Sr in environmental water samples by ^{90}Y Cherenkov radiation counting," *Analytical Chemistry*, vol. **81**, no. 3, pp. 1228-1237, February 2009.
[9] Berthold Technologies, www.berthold.com.
[10] Hidex, www.hidex.com.
[11] Laboratory Technologies Inc, www.labtechinc.com.
[12] Long Island Scientific, www.liscientific.com.
[13] PerkinElmer, www.perkinelmer.com.
[14] PerkinElmer automatic gamma counters, http://www.perkinelmer.com/catalog/family/id/wizard2%20automatic%20gamma%20counter.
[15] Zh. Ding, R. Zhang, and Z. Kan, "Quality and safety inspection of food and agricultural products by LabVIEW IMAQ vision," *Food Analytical Methods*, vol. **8**, no. 2, pp. 290-301, February 2015.
[16] B. Lin, L. Xiaofeng, and H. Xingxi, "Measurement system for wind turbines noises assessment based on LabVIEW," *Measurement*, vol. **44**, no. 2, pp. 445-453, February 2011.
[17] S. Mu, D. Chen, H. Tang, J. Yang, and M. Huang, "Spectrum measurement network based on Labview," *Applied Mechanics and Materials*, vol. **239-240**, pp. 1356-1359, December 2012.
[18] P. Novak, J. Navarik, J. Pechousek, V. Prochazka, L. Machala, and J. Tucek, "Development of fast pulse processing algorithm for nuclear detectors and its utilization in LabVIEW-based Mössbauer spectrometer," *Journal of Instrumentation*, vol. **9**, pp. T01001, January 2014.
[19] N.C. Sahoo, A.S. Satpathy, N.K. Koshore, and B. Venkatesh, "D.C. motor-based wind turbine emulator using LabVIEW for wind energy conversion system laboratory setup," *International Journal of Electrical Engineering Education*, vol. **50**, no. 2, pp. 111-126, April 2013.
[20] S.K. Singla and R.K. Yadav, "Optical character recognition based speech synthesis system using LabVIEW," *Journal of Applied Research and Technology*, vol. **12**, no. 5, pp. 919-926, October 2014.
[21] P. Wrobel *et al.*, "LabVIEW control software for scanning micro-beam X-ray fluorescence spectrometer," *Talanta*, vol. **93**, pp. 186-192, May 2012.
[22] F. Yuan, Y.Z. Li, and L.Y. Xie, "Design of gamma energy spectrometer based on the technology of LabVIEW and Bluetooth," *Advanced Material Research*, vol. 113-116, pp. 720-724, June 2010.
[23] Canberra, Genie 2000 software, http://www.canberra.com/products/radiochemistry_lab/genie-2000-software.asp.
[24] PerkinElmer, 2480 WIZARD^2, http://www.perkinelmer.com/catalog/product/id/2480-0010.
[25] National Instruments, *Programmatically acquiring a screenshot in a LabVIEW executable*, http://digital.ni.com/public.nsf/allkb/5AFA0CA7D031B05086257CC300430C28.
[26] National Instruments, *How can I programmatically simulate a mouse click?* http://digital.ni.com/public.nsf/allkb/0CC5602FE23E86DA86257350004E1B6A.
[27] D.E. Knuth, *The art of computer programming*, Addison-Wesley, Reading, 1985.
[28] NNDC, Chart of the nuclides: basic properties of atomic nuclei, http://www.nndc.bnl.gov.