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Identification of radionuclides using energy spectra of xenon gamma-ray spectrometer

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Abstract. Software tool for identification of radionuclides using energy spectra of xenon gamma-ray spectrometer was developed. Software tool includes the build-in gamma-ray library and allows to perform the qualitative and quantitative isotopes analysis of gamma-ray spectra.

1. Introduction

Software tool “Acquisition and processing of gamma-ray spectra” was designed to control the operation of xenon gamma-ray spectrometer and has a number of built-in functions of gamma-ray spectrum nuclide analysis and identification of radionuclides [1, 2].

Software tool was developed in the CodeGear™ RAD Studio 2007 [3] using the programming language DELPHI. Software tool is a set of interactive windows which allow making the nuclide list from build-in radionuclides library, analyzing a gamma-ray spectra using this list of isotopes, visualizing and saving on disk PC the results of nuclide analysis. This article will review the software tool functions for nuclide analysis of gamma-ray spectra and the method of identification of radionuclides.

The program contains a built-in library of radionuclides with information about isotopes and their gamma-lines.

2. The software tool functions for the nuclides analysis of gamma-ray spectra

The software tool “Acquisition and processing of gamma-ray spectra” is composed of a main window, window of spectra and auxiliaries windows for determine processing and analyzing options of the spectrum. Software tool supports multiple-window acquisition, visualization, processing, calibration and analyzing of the spectra.

The software tool has the following functions of gamma-ray spectrum nuclides analysis:

- selection of analyzed radioactive source type: a point source or a volume with a three-dimensional source (container), source parameter input;
- processing of containers with a three-dimensional radioactive source: reading from and saving to a disk PC, editing and making some other operations with a containers list;
- analyzing of gamma-ray spectrum for determination of composition and activity of a radioactive source by Gauss's method;



- analyzing of gamma-ray spectrum for determination of composition and activity of a radioactive source by iteration method;
- express-analysis of isotopes activity using the work list of nuclides;
- preparing, viewing, and saving to a disk PC a protocol with information about nuclides in a radioactive source;
- viewing of a build-in radionuclides library, list of isotopes, their gamma-lines with energies and intensities;
- creating a work list of nuclides. Saving to and loading from the disk PC a list of nuclides;
- creating a list of radioactive isotopes for carry out a full calibration of xenon gamma-ray spectrometer XGS.

3. The nuclides analysis of gamma-ray spectrum

3.1. The algorithm of the gamma-ray spectrum analysis

Figure 1 presented the algorithm of gamma-ray spectra analysis, measured by xenon gamma-ray spectrometer (XGS).

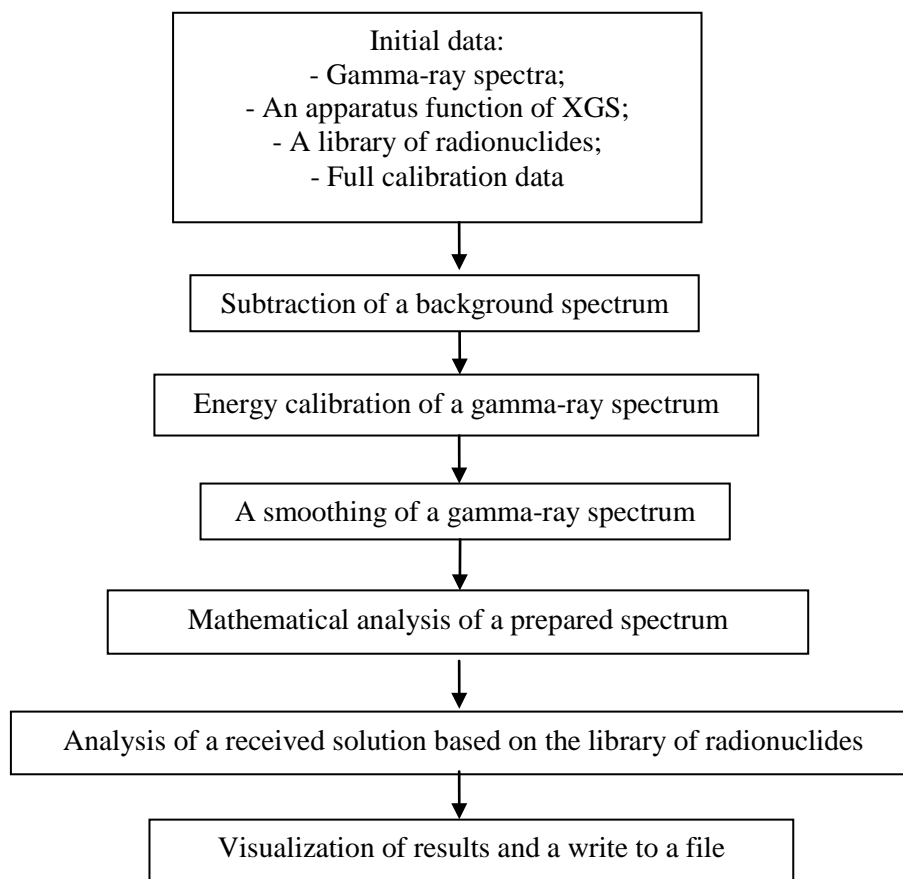


Figure 1. A flowchart of an algorithm of XGS gamma-ray spectra nuclide analysis and identification.

3.2. Parameters of the gamma-ray spectrum analysis

The software tool allows to varying and adjusting the parameters of gamma-ray spectrum nuclide analysis. Software tool has the following possibilities of adjustment of analysis parameters:

- the smoothing of a gamma-ray spectrum by Savitzky-Golay method [4] can be carried out using 5, 7, 9 and 11 points;
- the analysis procedure can be carried out by three different methods – Gauss's method [5], Muller's method [6] and express-analysis by the nuclides list. Gauss's method is a method of numerical solution of an algebraic equations system using special features of the XGS response matrix. The Muller method is an iteration method of equation system solution requiring a longer time for gamma-ray spectrum reconstruction than Gauss's method. For the Muller's method the number of iterations and a type of response matrix must be specified. Express-analysis by the nuclides list evaluates and processes the shape of a spectrum in the neighborhood of each nuclide gamma-line and gives the results without mathematical analysis. Express-analysis requires the setting of the following parameters – smoothing points, the range of the analysis area, the threshold nuclides activity and the minimum relative gamma-lines sensitivity;
- the range of the analysis area allows specifying the left and the right limit of the analysis area in energies unit. The maximum range of the analysis area is defined by the operating range of XGS and its spectrometric electronic tract;
- the sensitivity threshold, the gate width, the distance from XGS to a radioactive source, the minimum relative intensity of a line and the threshold activity are necessary to carry out the spectrum analysis and computation of nuclides activities. The parameter “Sensitivity threshold” indicates the level of an event (in percent) relatively to a line with maximum intensity below which the lines are not taking onto account. By default the sensitivity threshold is equal to 10% of the level of a line with maximum intensity. The parameter “The gate width” indicates the half-interval of a coincidence of the position of calculated gamma-line maximum with the position of isotope line maximum. By default the gate width is equal to 3 keV, which means the complete interval of a coincidence is equal to 6 keV. The parameter “Distance to a radioactive source” is used during the computation of isotopes activities. If distance to a source is specified in the file with a gamma-ray spectrum that is processed, its value puts in the field “Distance to a radioactive source” and it is used in calculations. The parameter “Minimum relative intensity of a line” indicates a minimum relative isotope line intensity level under which the lines do not take part in analysis. By default minimum relative intensity of a line is equal to 1%. The parameter “Threshold activity” specifies the level of a radioactive source activity for determination of a source as radioactive or not radioactive. Determination is made by excess of area under a spectrum over a background spectrum area or over mentioned activity level in Bq.

3.3. Nuclide spectrum analysis

After the setting of analysis parameters a procedure of mathematical processing and analysis of energy calibrated gamma-ray spectrum can be run. Figure 2 presents the results of nuclide analysis of gamma-ray spectrum from ^{137}Cs isotope.

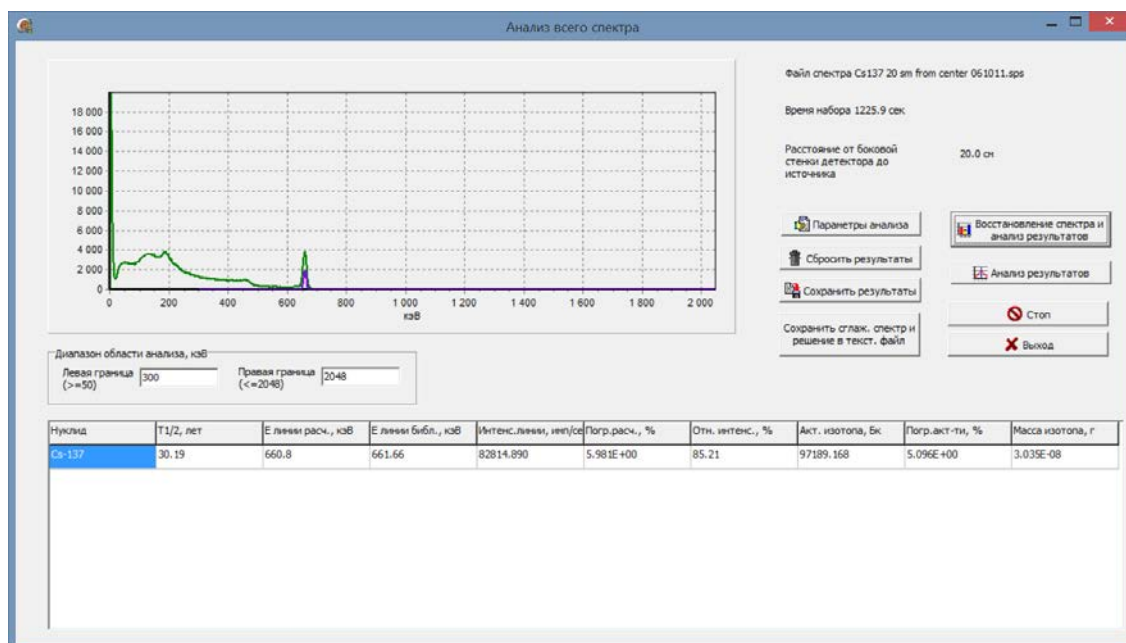


Figure 2. Results of nuclide analysis of the gamma-ray spectrum from ^{137}Cs isotope.

In the left part of a window the graph displays a smoothed original gamma-ray spectrum (green color) and a result of gamma-lines reconstruction using a XGS response matrix (violet color). The following information about gamma-lines is presented in the table in the bottom part of a window: the nuclide name, the isotope half-life time, the calculated gamma-line energy, the corresponding gamma-line energy from the build-in nuclides library, the calculated gamma-line intensity, the error of intensity, the relative intensity of a corresponding line from a library (% per decay), calculated nuclide activity in Bq, error of activity and nuclide mass in grams. The results obtained can be saving to a disk PC in *.html or *.txt format using a standard file saving dialog.

References

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