Software tool for gamma-ray spectra analysis

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Abstract. Software tool for gamma-ray spectra analysis was developed. Software tool has the possibilities for visualization of gamma-ray spectra, background and shadow spectrum, analysing of gamma-lines by Gaussian distribution, calculation of gamma-lines characteristics, manipulation with background and shadow spectrum.

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 visualization, processing, calibration and analyzing functions [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 acquisition, visualization, carrying out an energy calibration and processing of gamma-ray spectra. This article will review the software tool functions for processing, calibration and analyzing of gamma-ray spectra.

2. Software tool for the gamma-ray spectrum processing and analysis
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.

Software tool has the following functions for visualization and processing of gamma-ray spectra:
- visualization of a spectrum with a various scaling;
- energy calibration of spectra, saving and loading calibration parameters from the disk PC;
- full calibration of gamma-ray spectrometer, saving and loading full calibration parameters from the disk PC;
- loading a shadow spectrum, display it simultaneously with a working spectrum, normalizing it in a different parameters, adding the shadow spectrum statistics to the main one;
- loading, normalizing and visualization of a background spectrum, subtracting it from the main spectrum;
- setting, removing and editing of processing area of a spectrum, searching and determination of spectrum parameters in the mentioned area;
- processing of the single and double gamma-lines;
- determination of the full width in the half maximum (FWHM) of the gamma-lines and its position on the spectrum;
• determination of total intensity in the gamma-lines, full gamma-ray spectrum and the background spectrum.

3. Gamma-ray spectrum processing

3.1. Spectrum visualization

To visualize a gamma-ray spectrum it is necessary to call the command "Load the spectrum" through the "File" main menu or the corresponding toolbar button and using of a standard dialog box choose a file with spectrum in "sps" format on a disc PC and open it (Figure 1).

![Figure 1. A child window with a gamma-ray spectrum.](image)

The gamma-ray spectrum is visualized in the form of the graph with the vertical axis as counts statistics and the horizontal axis as gamma-quanta energy. The units of axes in the graph can be changed at the following types: a linear or logarithmic scale type for the vertical axis and channel or gamma-quanta energy for the horizontal axis. If energy calibration parameters in the opened file with gamma-ray spectrum are different from zero, the spectrum is automatically calibrated. The child window with a spectrum also contains fields with information about the cursor position on a spectrum, time of acquisition and area under a spectrum. The child window also provides possibilities to scaling, energy calibration and processing gamma-lines of the spectrum and to the operation with a background spectrum and shadow spectrum.

3.2. Energy calibration of a spectrum

File with spectrum contains the information about energy calibration parameters – a channel-energy matching values. The spectrum is automatically calibrated and then visualized in energy units (keV), if the calibration parameters are not equal to zero. In the other case the spectrum is visualized in channels units. To carry out the energy calibration it is necessary to specify a channel-energy matching values for two points of the spectrum in a special window "Calibration". The energy calibration parameters can be loading from a file or saving to a file on a disk PC using a standard dialog box. The current energy calibration parameters can be used as the basic for all loaded spectra, if the "Use this calibration as basic" checkbox in a special window "Calibration" is checked on. In the other case the current calibration is used only for one active spectrum. The calibration parameters are saving to the file along with calibrated spectrum on a disk PC.
3.3. Processing of a spectrum

The software tool has a possibility to processing the gamma-lines using a Gaussian distribution. Figure 2 shows a location of a panel with characteristics and parameters of processing areas selected in a spectrum. It consists of following parts:

- boundaries of processing areas (the left and right one);
- parameters of the left or right gamma-lines if the area is processed by double Gauss;
- characteristics of processing area;
- statistics in maximum of the gamma-line.

![The information panel with characteristics of the gamma-lines.](image1)

![The processing area and a gamma-lines approximated by double Gauss.](image2)

**Figure 2.** The processing area and a gamma-lines approximated by double Gauss.

Using the command "Approximate by Gauss" in the pop-up menu software tool automatically defines the processing area of fixed width in channels (keV), specified it by the green vertical dotted line on the graph (Figure 2), then searches the peak and approximate it by Gauss distribution. This processing method allows to determine most accurately the full width in the half maximum (FWHM) of the gamma-line, its maximum and position, the background and the number of events under the peak. The information panel shows boundaries of processing areas, the position of the gamma-line maximum, the number of events under the peak and within selected area.

Software tool allows to process double gamma-lines by the Gauss approximation. It is necessary to move a cursor between of two close lying peaks and click "Two peaks" in the pop-up menu. The selected area is being approximated by double Gauss distribution, the button "Double peak" becomes available and allows to switch between corresponding characteristics of the left and right peak.

3.4. A shadow spectrum

Sometimes one need to compare of two spectra in one graph and carry out some operations with both spectrum simultaneously. For implementation of this comparison a concept of a shadow spectrum is introduced. Software tool allows loading an additional (shadow) spectrum at the same time with basic spectrum. A special command panel "Shadow spectrum" is designed to loading and visualization of a shadow spectrum and a panel "Operation basic-shadow spectrum" – to normalization of shadow spectrum relatively basic spectrum. In the graph one can show a pure shadow spectrum, a sum of the shadow and basic, shadow and basic difference. The software tool provides a possibility of normalization of a shadow spectrum relative to a basic spectrum live or real time and other basic spectrum characteristics.
3.5. *A background spectrum*

A background spectrum can be selected and loaded at the presence of basic one as well as without it. In the latter case information about the background spectrum is stored in the memory and can be displayed in a graph only after loading a basic gamma-ray spectrum. The background spectrum can be loaded as global, i.e. available to everyone opened basic spectra or local, i.e. available only to current active basic spectrum. If the background spectrum is loaded in the absence of opened basic spectrum, it is used as global by default. There is a possibility to simultaneous loading and using several background spectra, if one is defined as global, but the other defined as local. Using the switch "Global/Local" one can determine what spectrum of the available to use in this active window as a background spectrum.

**References**

[1] Novikov A S et al. 2014 Xenon detector with high energy resolution for gamma-ray line emission registration *Proc. SPIE 9213 Hard X-Ray, Gamma-Ray and Neutron Detector Physics XVI* 921318

[2] Novikov A S et al. 2014 New modification of xenon gamma-ray detector with high-energy resolution *Optical Engineering J.* 53 021108

[3] http://cc.embarcadero.com/item/25015