Efficiency

Utility for registration efficiency
calculation Efficiency.
User's manual.

2015

Contacts:
Baltic Scientific Instruments, Ltd.
Ganibu dambis 26, Riga, Latvia. LV-1005
WWW: *http://www.bsi.lv*
Tel/Fax: +371 67383947; +371 67382620
E-mail: *office@bsi.lv*

The following conventions are used in this manual:
- **bold text** denotes the names of menus, buttons, or other interface elements.
- *italic* text denotes references to other documents, sections, or main terms, used in this manual.
- ***bold italic*** text denotes notes or warnings.
- sign * denotes interface elements, which are not in use now.

Contents

1 Introduction

Efficiency software is designed for registration efficiency calculation and efficiency curve construction.

This manual contains the following parts:

- *Main functions of Efficiency software* – description of the main functions of the software and methods of their usage.
- *Description of the file formats* – description of formats of service files.
- *Appendix I List of pictures* – the list of used in the manual pictures,
- *Appendix II References* – the list of used in the manual documents,
- *Appendix III Support* – contacts.

2   Main functions of Efficiency software

Calculation of registration efficiency can be realized after peaks search procedure in SpectraLine software (look through [1]). In this case the first parameter of the command line, that is launching executable file of Efficiency utility, is the path to LSRM.ini file, containing general settings of the program including interface language, and the second parameter is the path to result.txt file, containing the results of peaks search.

Efficiency utility can be launched directly from SpectraLine software as well as in autonomous mode. If the utility is launched from SpectraLine, there is created service file TempData.tmp containing the data from the spectrum file and the configuration file necessary for the calculation. If Efficiency is working in autonomous mode, the results of peaks search are not sent to the utility, and it works in the limited functionality mode.

If the procedure of peaks research has not been executed, message **Empty result.txt file** will be displayed and the utility will work in autonomous mode.

The main window of Efficiency utility (look through picture _The main window of the utility for registration efficiency calculation_) contains several regions:

- File of etalon sources;
- Results of registration efficiency calculation;
- Area of registration efficiency visualization;
- Panel of registration efficiency filtration.

The functionality of Efficiency utility:
- Calculation of registration efficiency by absolute and relative methods;
- Calculation of registration efficiency for a selected file of sources;
- Visualization of the calculated data;
- Construction of an approximating curve for registration efficiency;
- Filtration of the calculation results.
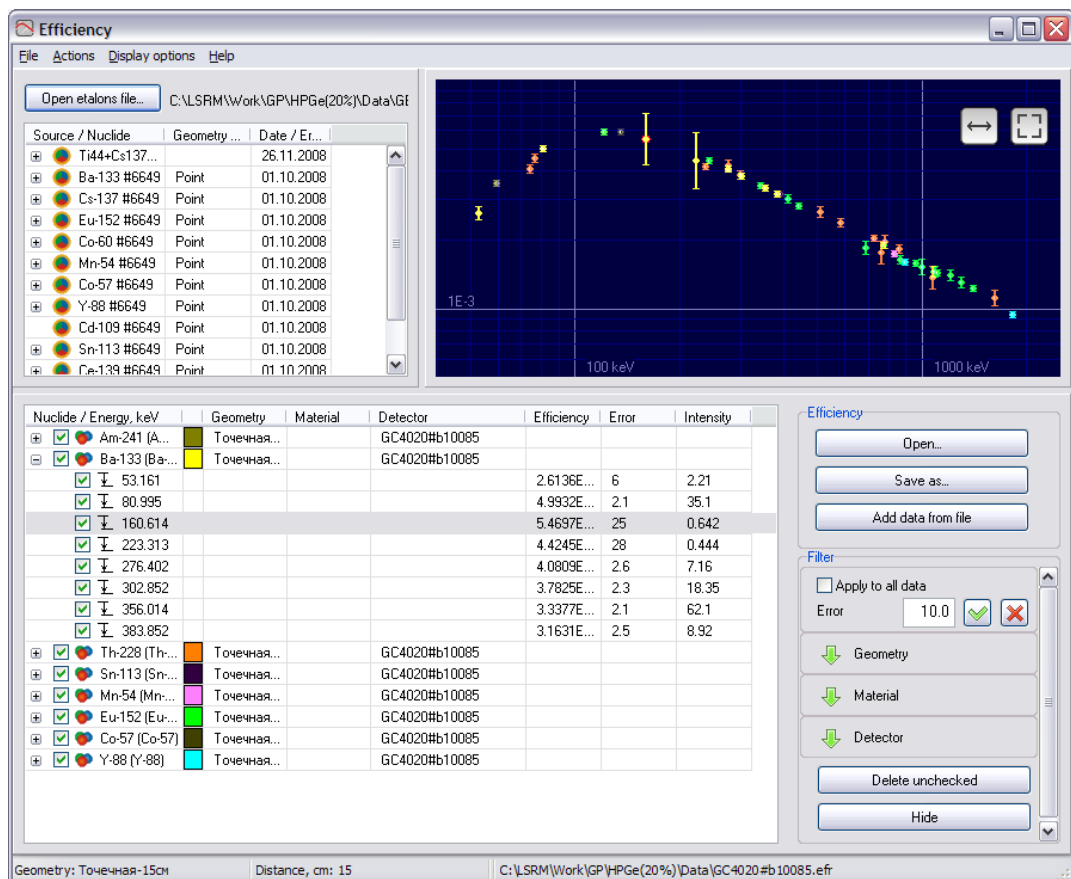
Picture 2-1 The main window of the utility for registration efficiency calculation

2.1 Calculation of registration efficiency by absolute and relative methods

Registration efficiency can be calculated by two methods: *absolute* and *relative*.

Absolute method lies in registration efficiency calculation in the case of reliable value of activity of the nuclides. In this case the .src file of etalon sources is to contain the value of precision of the activity. Calculated with this method values of registration efficiency are named *absolute*.

Relative method is used if the activity of one or several nuclides for a source from the calibration set is unknown. In this case any value of activity is set in etalon sources file for such nuclides, and the precision of activity is not specified. Calculated with this method values of registration efficiency are named *relative*. This method is called *relative* because it is necessary to normalize relative values by a constant factor for finding the real (*absolute*) values of registration efficiency.

If it is necessary, the relative method can be used for efficiency of any nuclide calculation. For that it is necessary to set the efficiency checkbox to the proper position (look through picture *Selection of the efficiency*) and execute the procedure of data sewing (look through picture *Data sewing*).
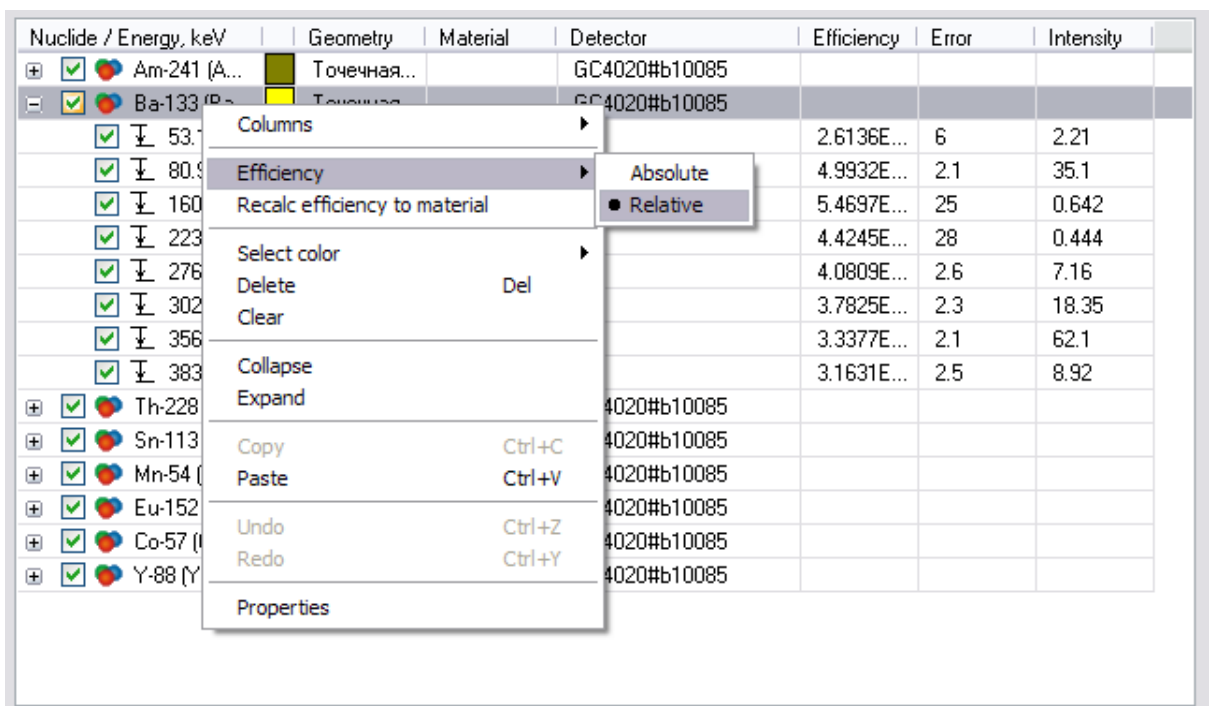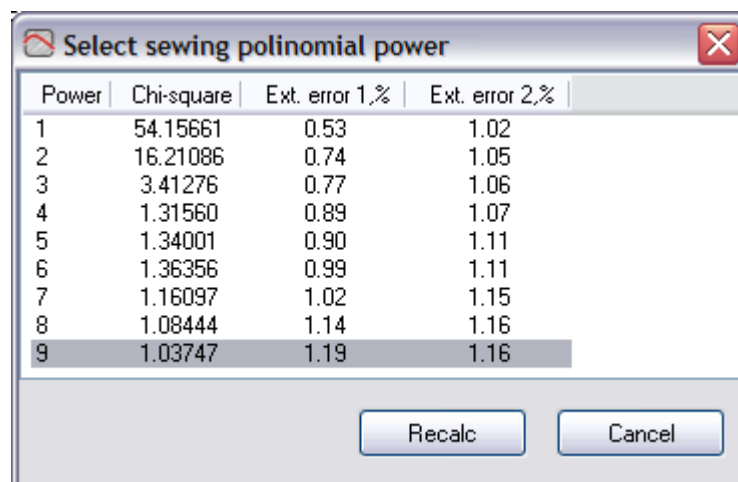

Picture 2-2 Selection of the efficiency
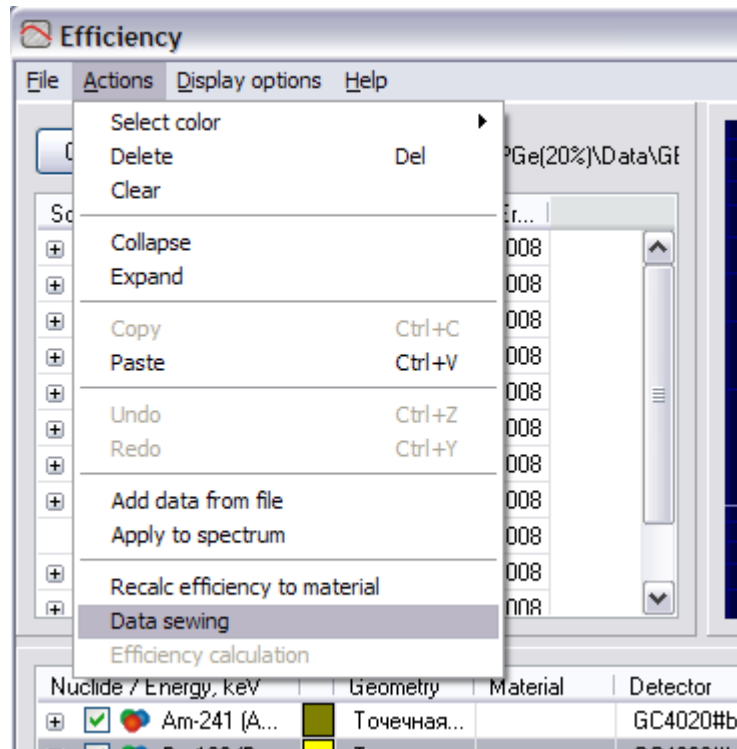
Picture 2-3 Data sewing

In the appeared window (look through picture *Selection of degree of the sewing polynomial*) choose the degree of sewing polynomial from the table where degree of the polynomial (column **Power**), corresponding value of $\chi2$ functional (column **Chi-square**) as well as relative precision of sewing in percentage (columns **Ext. error N,%**) for the curve of absolute values and all curves calculated by relative method are specified. While selecting the degree of the polynomial you should follow the fact that the value in **Chi-square** column should be ≈1.

Picture 2-4 Selection of degree of the sewing polynomial

2.2   Calculation of registration efficiency for the selected file of sources

By default after starting the utility works with the file of etalon sources that is set in configuration parameters (look through *[1]*). If the utility is launched from SpectraLine software, the path to it is taken from service file TempData.tmp. Otherwise it is taken from the configuration file, path to which is specified in result.txt.

To change the file of etalon sources choose command **File → Open etalons file...** of the main menu or press button **Open etalons file...**, then with the use of standard dialog window for files selecting open the necessary passport.

After that the following data for etalon sources containing in this file is displayed as a table:

- Code of the source in column **Source**;
- Code of the geometry in column **Geometry**;
- Date of the source measuring in column **Date**;
- Set of the source in column **Source set.**

Any column of the table can be hidden or displayed by selecting the corresponding checkmark in the popup menu.

Near every code in column **Source** there is a pointer in the form of sign **+**, after pressing which the list of nuclides containing in the source is displayed. At the same time for each nuclide its name (column **Nuclide**), activity (column **Activity**) and relative precision of activity in percentage (column **Error**) are represented.

After selecting one of the sources with left mouse button, the results of identification of lines of nuclides containing in this source with the library of radionuclides and identification window as well as registration efficiency with precision (look through picture *The main window of the utility for registration efficiency calculation*) are represented in the central table in the following columns:

- The name of the nuclide containing in the source to which this line belongs and library energy of the line in keV in column **Nuclide/Energy, keV**;
- The name of the geometry of the set to which the nuclide belongs in column **Geometry;**
- The name of the material of the set to which the nuclide belongs in column **Material;**
- The name of the detector in column **Detector;**
- Registration efficiency in column **Efficiency**;
- Relative precision of registration efficiency in percentage in column **Error**;
- Peak area from result.txt file in column **Area**;
- Absolute precision of the peak area from result.txt file in column **Error**;
- Library intensity of the line in column **Intensity**;
- Color of the line in visualization area in column **Color**.

If a line was identified ambiguously (in other words, was identified as belonging to two or more nuclides), it is eliminated from further calculations.

If the file of etalon sources has assigned specific activity (Bq/kg or Bq/litre in field **Activity unit**), then the activity is multiplied by mass of the source from spectrum file or by volume of the source from etalon sources file during the calculation.

If the calculation is conducted with taking into consideration of true summation correction of intensity of gamma radiation (the corresponding option, that further is saved to the configuration file or to service file TempData.tmp, is set in SpectraLine software, look through *[1]*), the library of radionuclides is corrected with the use of file of library of corrections, and only after that registration efficiency is calculated.

2.3   Filtration of the results of calculation of registration efficiency

Filtration of the calculation results can be executed by several parameters: precision, geometry, material, detector. For filtration by precision it is necessary to set maximum possible value of precision in field **Error** and apply the filter by pressing button ![checkmark button]. To cancel the filtration by precision press button ![cancel button]. Filtration by precision can be applied to a definite nuclide or to all nuclides containing in registration efficiency area depending on the state of checkbox **Apply to all data.**

Filtration by geometry is realized by setting the checkboxes in the list of all geometries of this file to proper states. Access to the list can be obtained by pressing button ![arrow button].

Necessary materials and detectors can be selected similarly.

2.4 Construction of an approximating curve

To construct an approximating curve for registration efficiency select command **Add zone** of the popup menu of visualization area. After that the energy range and the degree of the curve are selected automatically and the curve is constructed (look through picture 2.5).
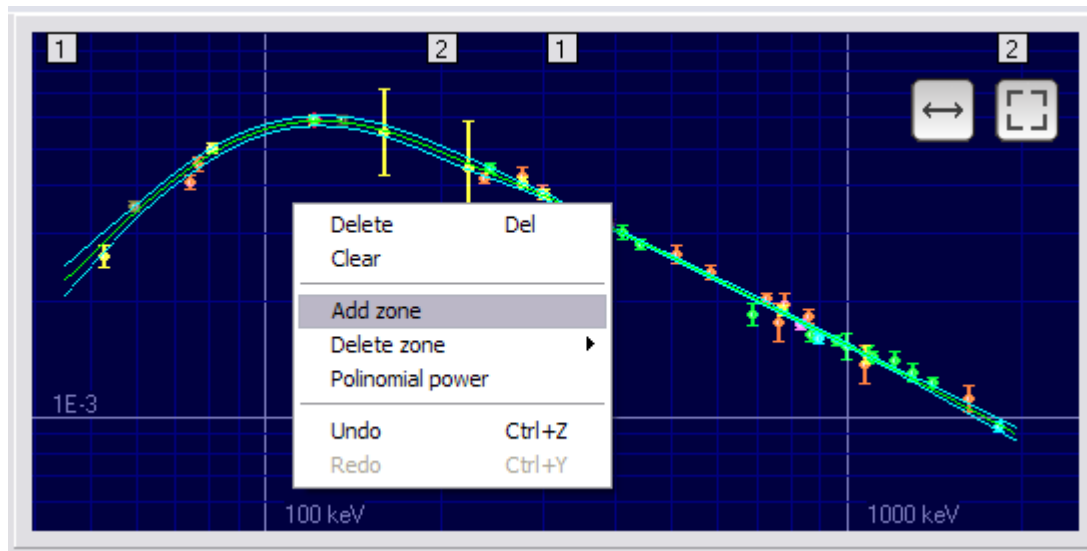
Picture 2-5 Approximating curve

Utility Efficiency allows approximation applying several energy ranges. For that it is necessary to execute command **Add zone** again.

If it is necessary it is possible to change the degree of the approximating curve as well as the bounds of energy ranges. Changing of the degree is realized in window **Polynomial power** (look through picture 2-6). Changing of the bounds of energy ranges is realized by moving the corresponding marks situated at the top of the area of data visualization.
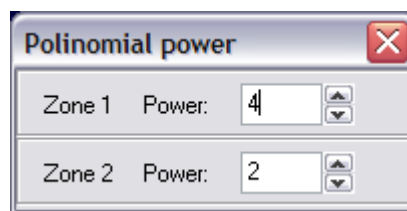
Picture 2-6 The degree of the approximating curve

For ease of visual information perception there is provided the possibility of color scheme of lines displaying adjustment in the program. To change colors of background, scale, approximating curve and precision corridor select command **Display options** of the main menu. Selecting the color of nuclides can be realized by several ways: with the use of the main menu, command **Actions ➔ Select color**, with the use of the popup menu, command **Select color.**

An approximating curve can be saved to .efa files. To save the results select command **File ➔ Save calibration file as...** of the main menu, if the parameters of the spectrum differ from the parameters of the sections saved to the .efr file or the .efr file contains several sections with different parameters, then window **Properties** (Picture 2-7), where it is necessary to set the parameters with which the calibration file is to be saved, will appear. Then with the use of the standard dialog window set the file name and its location at the disk.
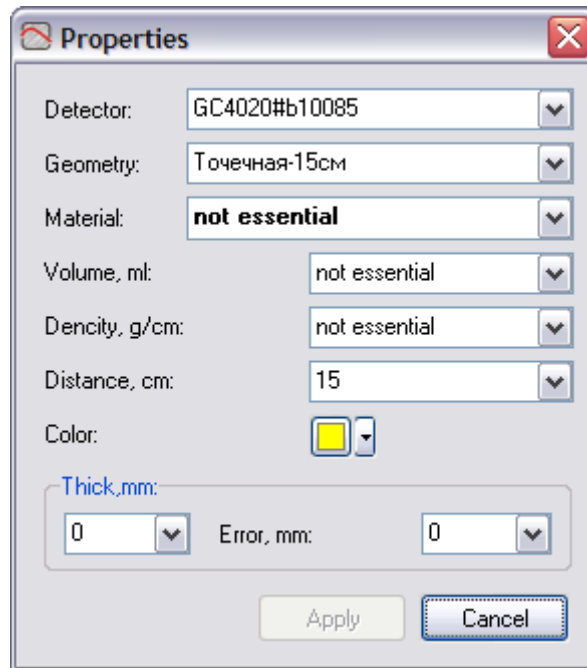
Picture 2-7 Parameters of a calibration file

2.5 Registration efficiency recalculation on density of the material

Efficiency utility provides to a user the possibility of registration efficiency recalculation on density of any material. For that it is necessary to select the required material from the list in dialog window of materials choice (look through picture Picture 2-8 Efficiency recalculation on density of the material), that can be called with command **Actions → Recalc efficiency to material** of the main menu of with command **Recalc efficiency to material** of the popup menu.
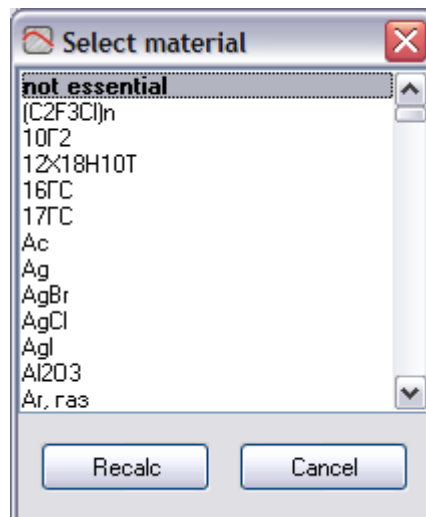
Picture 2-8 Efficiency recalculation on density of the material

2.6 Applying a registration efficiency to a spectrum

To apply a calculated registration efficiency to a spectrum it is necessary to use command **Actions → Apply to spectrum.** At that if there is no active spectra or SpectraLine software is not running, the corresponding message will be displayed.

3   Additional possibilities of Efficiency software

3.1   Additional possibilities of the visualization window

The visualization window contains a set of additional functions:

- The possibility of visualization window extension at the width of the application window;

It is executed by pressing button [↔].

- Zooming in the visualization area;

It is executed by selecting a part of the visualization area with a "square box". Restoring the initial size is realized by pressing button [⌐⌐].

- Adjustment of color scheme of the visualization area;

It is executed with menu **Display options** (look through picture _Display options_)
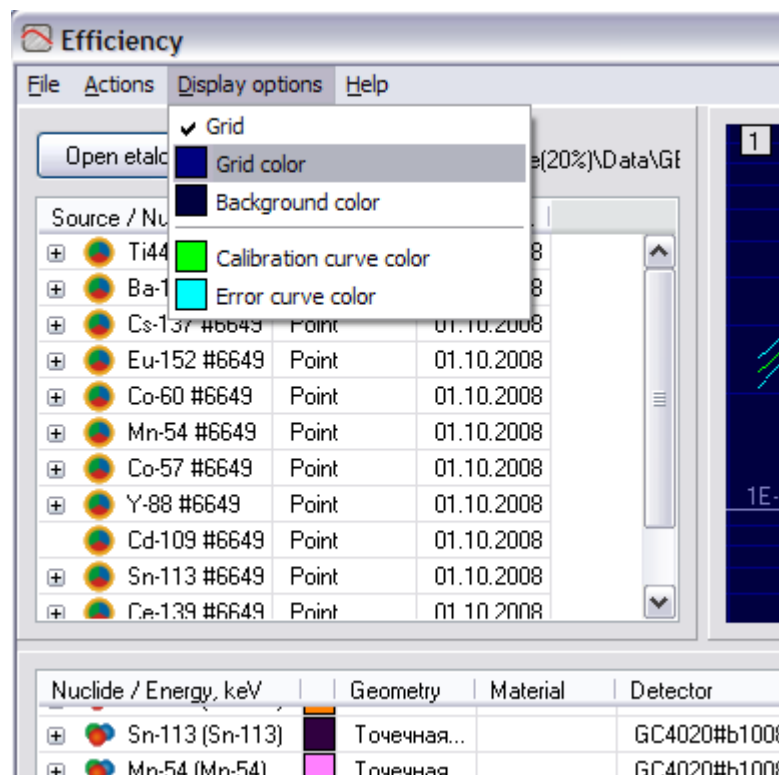
Picture 3-1 Display options

3.2   Efficiency calculation

The window of efficiency calculation can be called by command **Actions → Efficiency calculation** of the main menu. In this window user can select bounds of the calculation area as well as the interval with which the calculation will be performed. Calculated results will be represented in a table, also they can be saved to a .txt file, for that it is necessary to press button **Save as** and enter the name of the saved file.

If it is necessary it is possible to calculate the efficiency for a particular point. For that enter energy value in field **Energy, keV** in area **Point calculation** and press button **Calculate**.

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Option of efficiency calculation becomes active only after the procedure of approximation curve construction is performed.
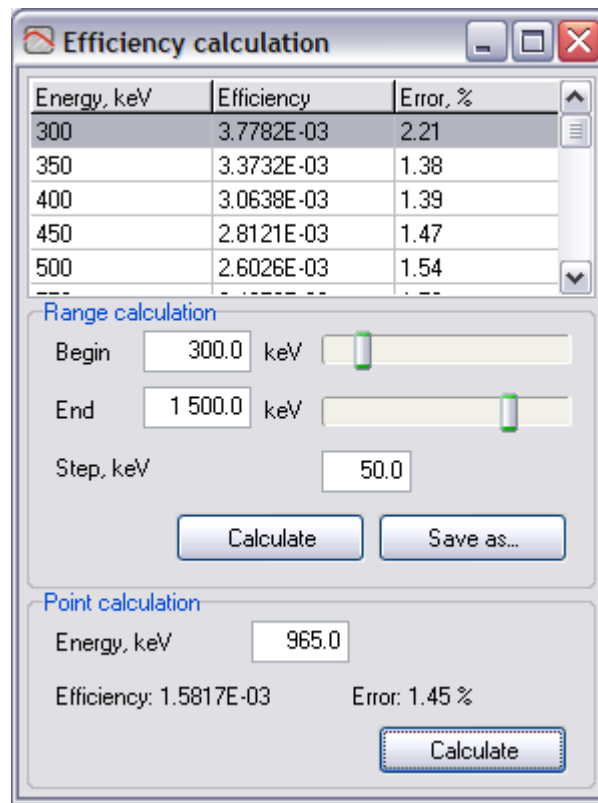
Picture 3-2 The window of efficiency calculation

3.3 Approximation curves files viewing

To view the approximation curve saved to a file select command **File → Open calibration file…** of the main menu. After that registration efficiency curve with precision corridor will be drawn in the visualization area.

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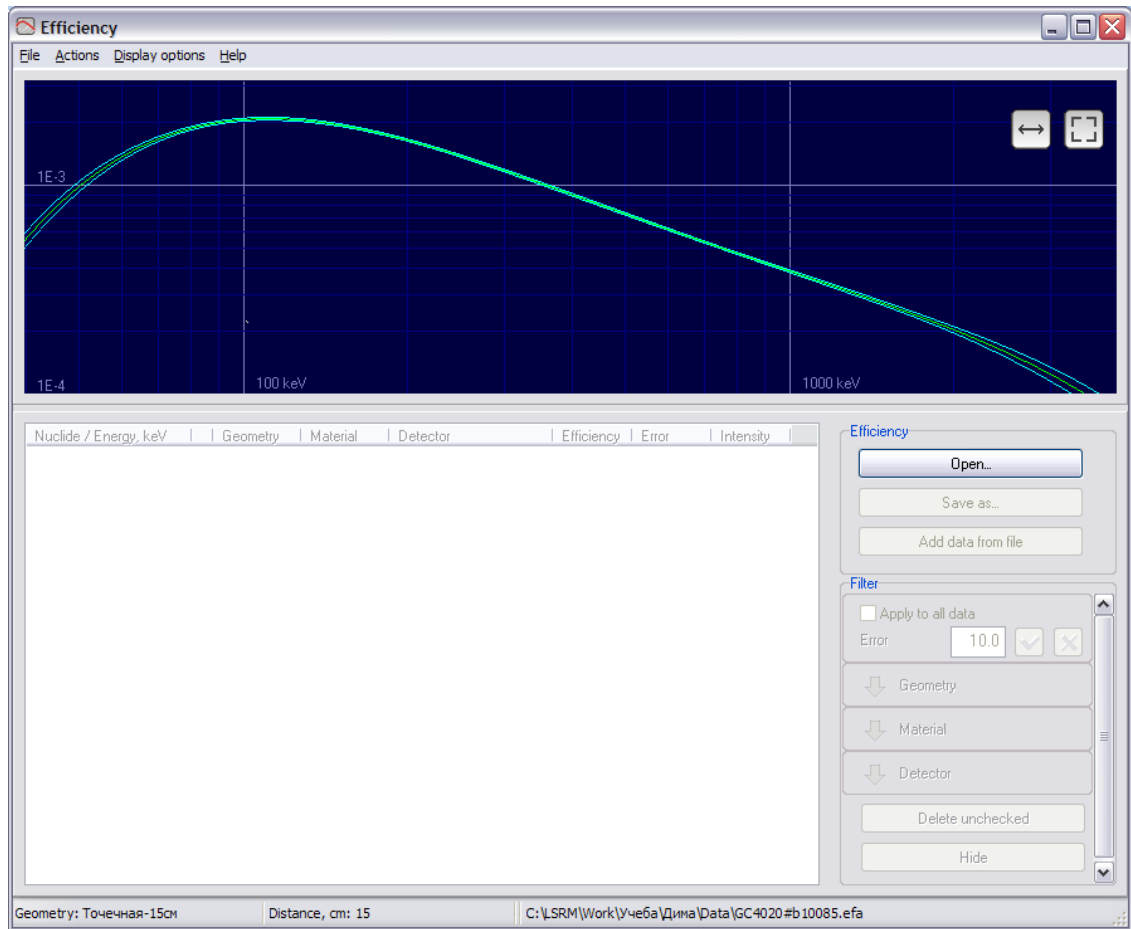
Picture 3-3 Approximating curve representing

3.4 Information about the software

Display of the information about the software is executed with the use of command **Help → About** of the main menu. The appeared window **About** contains the name of the program and its version.

Picture 3-4 Information about the program

4   Description of the file formats

4.1   Etalon sources file

This file with .src extension contains the following data:

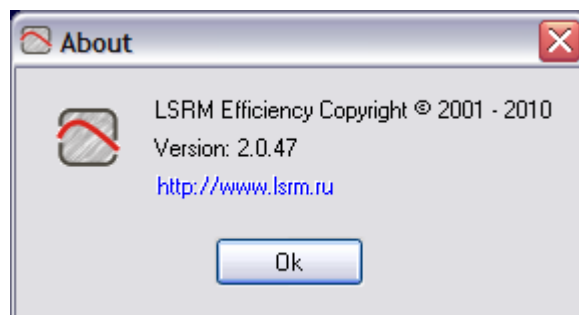1. Section Sets contains the name of the sets, information about which is contained in the file.

2. Sections <name of the set> contain

- The name of the measuring geometry in field Geometry.
- The mass of the source, g, in field Mass,g.
- The volume of the source, ml, in field Volume,ml.
- The material of the source in field Material.
- The date of measuring in field Date.
- Unit of activity measurement in field поле Activity unit (Бк, Бк/кг, Бк/л in Russian or Bq, Bq/l, Bq/kg in English).
- Efficient thickness of the source, mm, and after a comma, the absolute precision of the thickness in field Thick,mm.

3. Sections <name of the set>, structure contain the names of the sources belonging to the set.

4.Sections <name of the set>, <name of the source>, Act contain

- Activity and after a comma the relative precision of the activity, %, for the nuclide belonging to the source in field <name of the nuclide>. In the case of lack of data about the precision of the activity, calculation of the registration efficiency is conducted with the use of relative method.

Fields Mass,g, Volume,ml can contain expression *not essential* if the values are not defined.

If the efficient thickness of the source is null, then the value of the precision is not specified in field Thick,mm.

Below there is given an example of a .src file:

[Sets]
ОСГИ №765=
ОСГИ №250=

[ОСГИ №765]
Geometry=точечная
Mass,g=20
Volume,ml=10
Material=
Date= 30-09-2005
Activity unit=Бк
Thick,mm=2,1
[ОСГИ №765,structure]
Натрий-22=
[ОСГИ №765,Натрий-22,Act]
Na-22=19000,3

[ОСГИ №250]
Geometry=точечная
Mass,g=0
Volume,ml=
Material=
Date= 02.04.2004
Activity unit=Бк
Thick,mm=00
[ОСГИ №250,structure]
Марганец-54=
Кобальт-57=
Титан-44=
Кадмий-109=

[ОСГИ №250,Марганец-54,Act]
Mn-54=50000,3
[ОСГИ №250,Кобальт-57,Act]
Co-57=66500,3
[ОСГИ №250,Титан-44,Act]
Ti-44=10000,3
[ОСГИ №250,Кадмий-109,Act]
Cd-109=185000,3

4.2   Registration efficiency file

A registration efficiency file has .efr extension and consists of the following sections: <name of the detector>;<name of the geometry>;<name of the source>. Each section contains the following data:
1. The name of the detector from the spectrum in field Detector.
2. Entered during the file saving name of the measurement geometry in field Geometry (look through part *Error! Reference source not found.*).
3. The volume of the selected source, mm, or expression *not essential* from the etalon sources file in field Volume,ml. Expression *not essential* also is in this field if the efficient thickness of the source is null.
4. The density as ratio of the mass of the source from the file of the processed spectrum to the volume of the selected source from etalon sources file in field Density,g/cm3. Expression *not essential* contains in this field, if this ratio is not defined or the efficient thickness of the source is null.
5. The material of the selected source from the etalon sources file in field Material or expression *not essential* if the efficient thickness is null.
6. The efficient thickness, mm, of the selected source in field Thick,mm.
7. The absolute precision of the efficient thickness, mm, in field DThick,mm.
8. Entered during the saving of the file distance from the source to the detector (mm) in field Distance,mm.
9. Path to the .tc file of the correction library for the procedure of correction of intensity of gamma radiation in the library of radionuclides in field CorrectionFile. If the calculation of the efficiency is conducted without the correction, this field contains an empty string.
10. The list of the nuclides whose lines are identified in the set of records of the following format:
<name of the nuclide>=<activity from the sources file >,<relative precision of activity in percentage from the etalon sources file >,< feature >.
Field <feature> contains 1 if the absolute method of efficiency calculation is used, for the relative method it contains 2, 3 and so on depending on the amount of processed with this method (look through part *2.1*).
11. The results of identification of lines of the nuclides and the results of registration efficiency calculation (look through part *2.2*) in the set of records in the following format:
<E>=<Eff>,<DEff>,<Nuclide>,<Area>,<DArea>,<Intensity>, where
<E> is library energy of the line, keV,
<Eff> is registration efficiency,
<DEff> is relative precision of registration efficiency, %,
<Nuclide> is the name of the nuclide,
<Area> is the area of the peak,
<DArea> is absolute precision of the area,
<Intensity> is library intensity.

4.3   File of efficiency curve .efa

File with .efa extension consists of sections <name of the detector>; <name of the geometry>. Each of them contains information about measurement geometry, detector, source, efficiency curve and lines on the base of which it has been constructed in the following format:
1. Name of the detector in field Detector.
2. Name of the geometry in field Geometry.
3. Volume of the source, ml, or expression *not essential* in field Volume,ml.
4. Density of the source or expression *not essential* in field Density,g/cm3.

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5. Material of the source or expression *not essential* in field Material.

6. Efficient thickness, mm, in field Thick,mm.

7. Absolute precision of the efficient thickness, mm, in field DThick,mm.

8. Distance from the source to the detector, mm, in field Distance,mm.

9. Path to .tc file of corrections library for the procedure of correction of intensity of gamma radiation in the library of radionuclides in field CorrectionFile. If values of efficiency have been calculated without correction, this field contains an empty string.

10. List of lines on the base of that the efficiency curve has been constructed in the following format:
<E>=<Eff>,<DEff>,<Nuclide>,<Area>,<DArea>,<Intensity>, where
 <E> - energy of the line, keV,
 <Eff> - registration efficiency,
 <DEff> - relative precision of the efficiency, %
 <Nuclide> - name of the nuclide to which this line belongs,
 <Area> - area of the line,
 <DArea> - absolute precision of the area,
 <Intensity> - intensity of the line.

11. General number of energy zones, on the base of which the efficiency curve has been constructed, in field Zones.

12. Information about energy zone <number of the zone> in field Zone_<number of the zone> in format
<Degree>,<BegZone>,<EndZone>,<Deviation>, where
 <Degree> - degree of the curve,
 <BegZone> - decimal logarithm of low bound of the zone,
 <EndZone> - decimal logarithm of top bound of the zone,
 <Deviation> - dispersion of experimental points.

13. Information about the efficiency curve in the form of a system of orthogonal polynomials in fields Curve_<number of the zone>_<number of the polynomial>, where all polynomial coefficients are listed in a comma.

14. Information about this efficiency curve in the form of an ordinary polynomial in field Curve_<number of zone>, where polynomial coefficients are listed in a comma.

Information in1-8 is taken from .eff, .efr efficiency files. As the peak area, its absolute precision and intensity do not contain in a file of .eff format, there will be written a spacing character instead of number values.

Below there is given an example of .efa file:

```
[BSI-10%;точечная]
Detector=BSI-10%
Geometry=точечная
Volume,ml=not essential
Density,g/cm3=not essential
Material= not essential
Thick,mm=0
DThick,mm=0
Distance,mm=2
CorrectionFile=
121.782=0.045669,3.485,Eu-152,2302037,7155,28.397
244.699=0.029665,3.437,Eu-152,391674,1791,7.438
344.281=0.020962,3.328,Eu-152,979631,3280,26.328
411.118=0.016136,4.425,Eu-152,63843,639,2.229
443.985=0.015317,4.163,Eu-152,82899,794,3.049
564.03=0.011598,10.076,Eu-152,10520,407,0.511
586.26=0.012246,9.747,Eu-152,8847,468,0.407
688.68=0.010328,7.327,Eu-152,15455,398,0.843
778.906=0.008648,3.53,Eu-152,194840,1056,12.693
867.379=0.007755,4.681,Eu-152,54195,663,3.937
Zones=2
Zone_1=2,2.0855831021,2.64736829776,0.00912087442
Curve_1_1=.100000000E+1
Curve_1_2=.487563506E+1,-.118442068E+2
Curve_1_3=.320981661E+2,-.151124216E+3,.176348688E+3
```

Curve_1=-.160495414E+1,-.171494923E+0,-.290362078E-1
Zone_2=2,2.61396649193,2.93820890329,0.00831119517
Curve_2_1=.100000000E+1
Curve_2_2=.768548251E+1,-.213855025E+2
Curve_2_3=.123952844E+3,-.686902450E+3,.949526420E+3
Curve_2=-.195243515E+1,-.128862373E+0,-.530109528E-2

Fields 121.782, 244.699, … , 867.379 contain the list of lines, on the base of which the efficiency curve has been constructed. For example, for the line of Eu-152 with energy of 121.782 keV registration efficiency is 0.045669, relative precision of the efficiency is 3.485%, peak area is 2302037, absolute precision of the area is 7155, intensity of the line is 28.88.

Decimal logarithms of low and top bounds of the first energy range accordingly are equal to 2.0855831021 and 2.64736829776, degree of the curve is 2, deviation of experimental points is 0.00912087442. This data contains in field Zone_1, where 1 is the number of this energy range.

Fields Curve_1_1, Curve_1_2 and Curve_1_3 contain coefficients of orthogonal polynomials with degree 1, 2 and 3 for the efficiency curve in the first energy range. These polynomials are mathematically written in the following way:

.100000000E+1

.487563506E+1 + (-.118442068E+2) * E

.320981661E+2 + (-.151124216E+3) * E + .176348688E+3 * E^2

Coefficients of the ordinary polynomial for this efficiency curve contain in section Curve_1. Mathematically it is written in the following way:

-.160495414E+1 + (-.171494923E+0) * E + (-.290362078E-1) * E^2

Appendix I. List of pictures

Appendix II.   References

[1] SpectraLine_User's manual

[1] SpectraLine_User's manual

Appendix III. Support

Baltic Scientific Instruments Ltd,
Ganibu dambis 26, Riga, Latvia. LV-1005
WWW: *www.bsi.lv*
E-mail: *service@bsi.lv*
Tel/Fax: +371 67383947; +371 67382620