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Gamma-ray Spectrum Analysis (GSA v2) Software Manual

edited by

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I - Introduction

The manual was created to simplify and clarify the gamma spectrum analysis (GSA) software. It shares all the information necessary for the user to better understand the graphical interface. All functions and options are presented. Each option has been uniquely explained. Currently, the main functionality of GSA is to locate peaks, calculate the region of interest, identify and **quantify** radionuclides.

II - Complete graphical interface of the program.

The first boot program interface is shown in Figure 1. There is still a hidden space under the gray program panel. To appear it, he must double-click on the position marked in figure 2, then slide down. Figure 3 shows the hidden space.

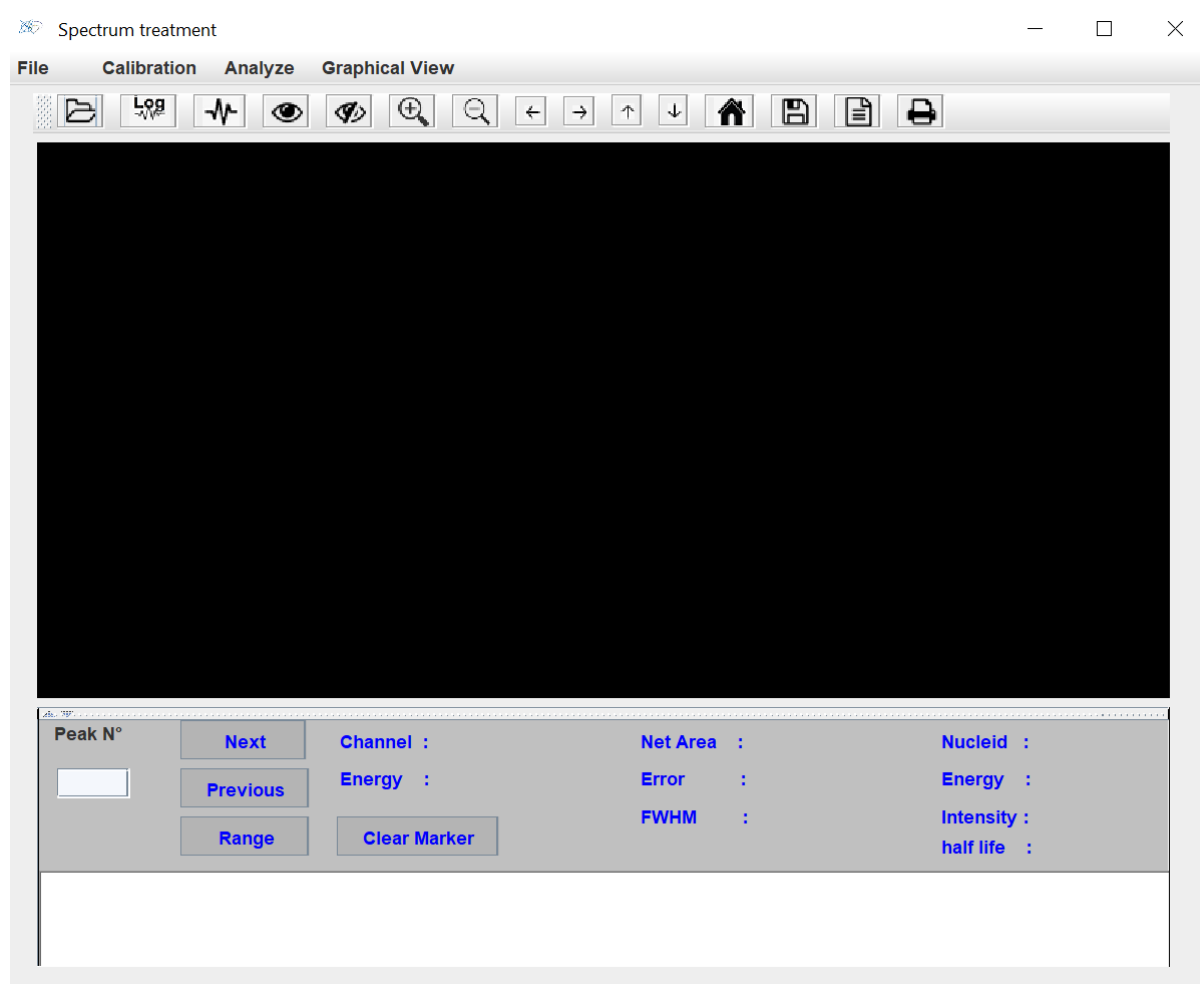


Figure 1 The graphical interface when the program starts for the first time.



Figure 2 show hidden space.

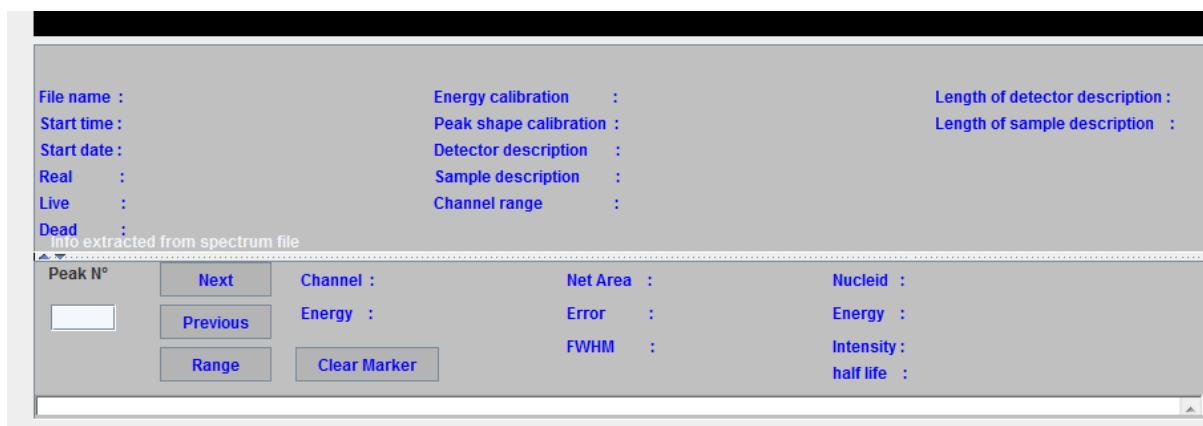


Figure 3 The hidden space (before results).

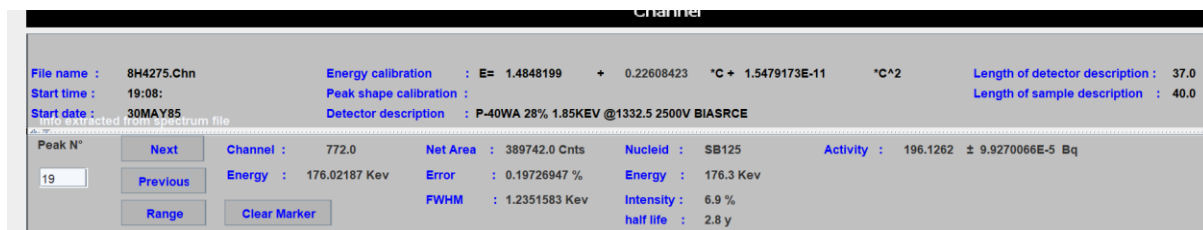


Figure 4 The hidden space (after results).

III- Software presentation

To simplify this guide, the graphical interface has been divided into the following six parts (see fig. 5):

- 1- Menu bar
- 2- Icon bar
- 3- Space of graph
- 4- Space of info extracted from file
- 5- Space for markers and analysis info.
- 6- Space of results

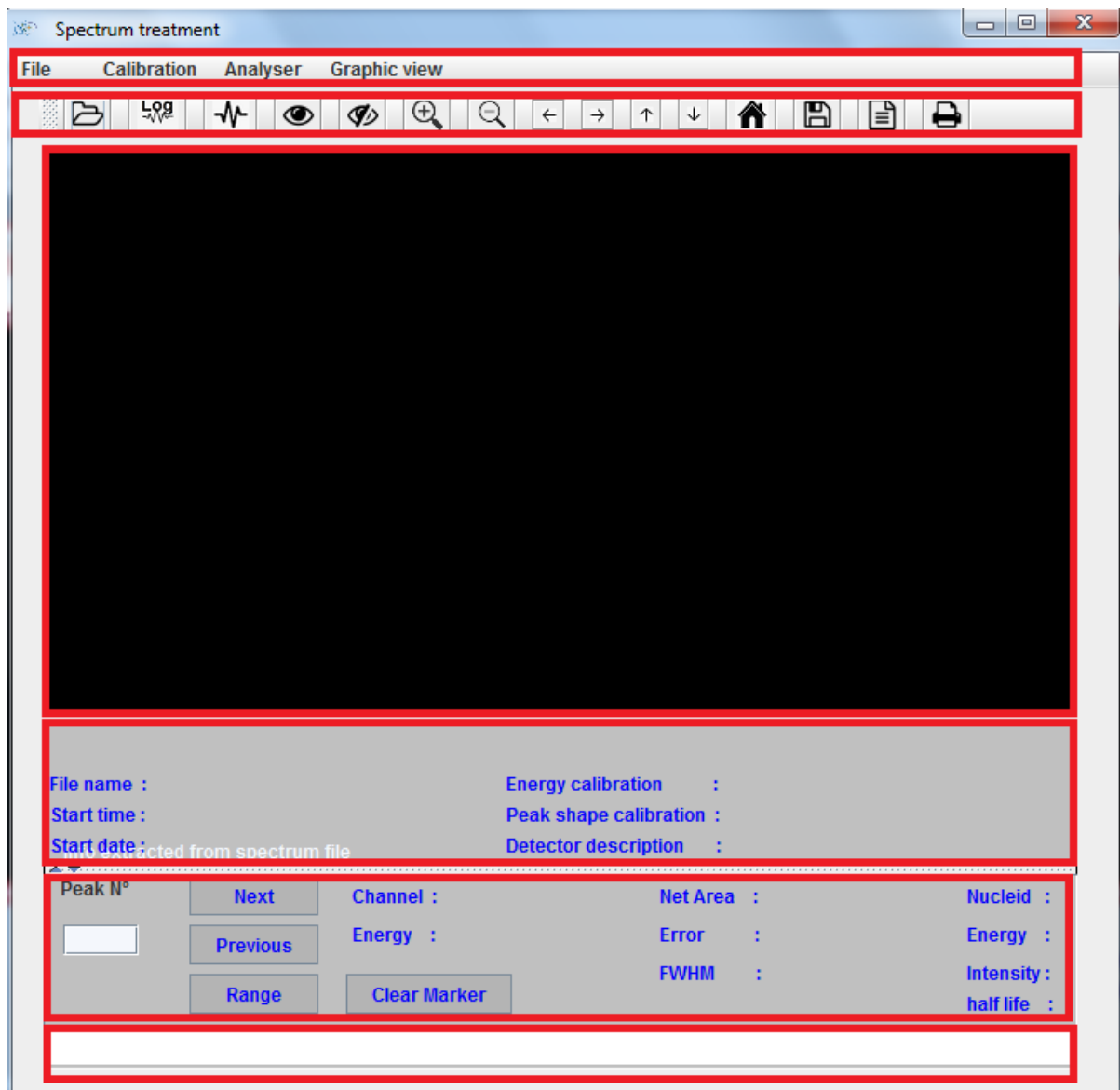


Figure 5 Six parts of software.

III.1 Menu bar

It generally has four menus: File, Calibration, Analysis and Graph view (Fig. 6).

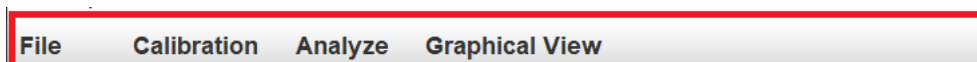


Figure 6 Toolbar.

III.1.1 File

File is the first menu the user must start in in order to continue their analyzes (or the Folder icon). It contains the options shown in Figure 7. Each option is explained below.

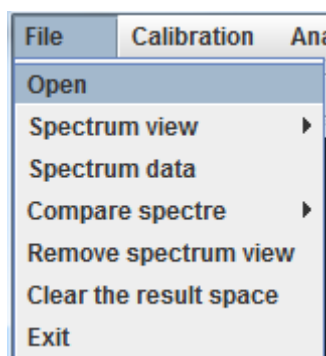


Figure 7 The File menu options.

Open : To open the file (only .chn format, the others not yet).

Spectrum view: To see the graph. Logarithm scale and normal scale are available. The graph appears on the graph space.

Note: File info automatically appears in the info space (fig.8).

File name :	m0375sc1.Chn	Energy calibration :	E= -44.55694 + 0.3239517 *C + -2.02589E-7 *C^2	Length of detector description :	13.0
Start time :	12:00:37	Peak shape calibration :		Length of sample description :	0.0
Start date :	09Mar11	Detector description :	3.102 Compton		
Real :	609.52	Sample description :			
Live :	600.0	Channel range :	From 0 to 8192		
Dead :	1.5618879 %				
Info extracted from spectrum file					

Figure 8 The appearance of info extracted from file.

Spectrum data: Appearance of “Channel” numbers and “counts” values in the results space.

Channel	Counts
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

Figure 9 The channel numbers and the corresponding “counts” values.

Compare spectrum: To compare two spectra in the same graph. Two scales are also available.

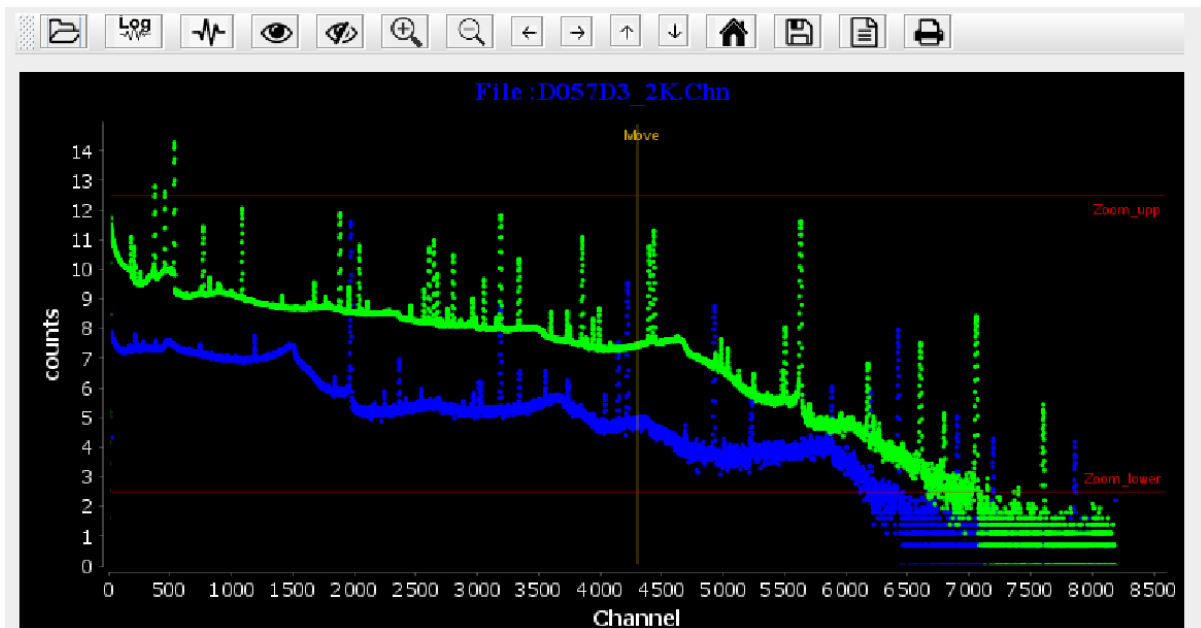


Figure 10 Comparison of spectra.

Remove spectrum view : To remove the graph displayed on the graph space.

Clear the result space : To delete the content of the last part.

Exit : To close the program.

1.1.2 Calibration

The calibration menu has three options: Energy Calibration, Full Width at Half Maximum Calibration (FWHM), and Tail Calibration.

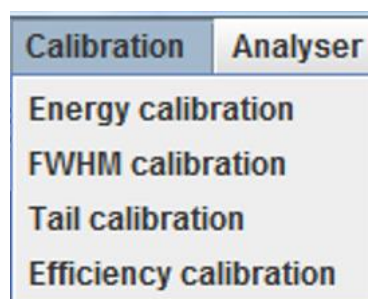
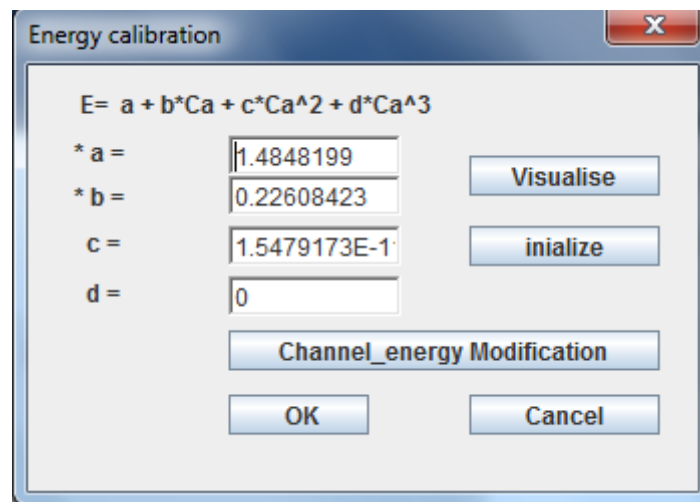


Figure 11 Calibration options.

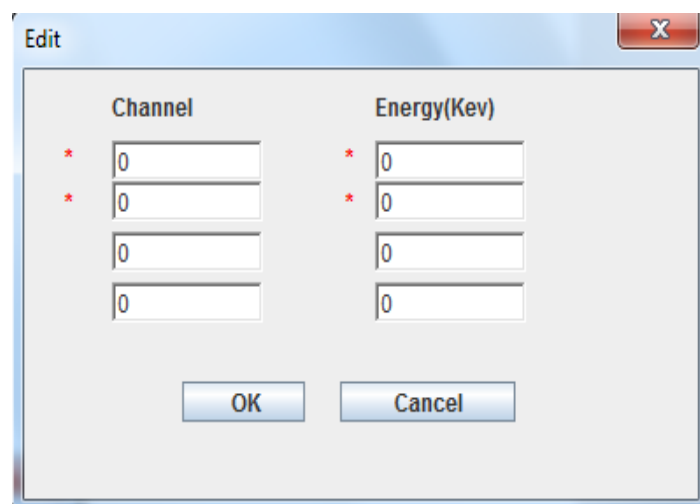
Energy calibration: The program automatically reads the calibration parameters from the .chn file. Including the possibility of modifying the coefficients in three ways, either

manually modifying the coefficients (Fig. 12), or manually entering the energies corresponding to each count (Fig. 13), or graphically (see part of the graph space below).



The 'Energy calibration' dialog box features a title bar with a close button (X). The main area displays the equation $E = a + b \cdot Ca + c \cdot Ca^2 + d \cdot Ca^3$. Below this, four input fields are provided for coefficients: a (1.4848199), b (0.22608423), c (1.5479173E-1), and d (0). To the right of these fields are two buttons: 'Visualise' and 'inialize'. A 'Channel_energy Modification' button is centered below the input fields. At the bottom are 'OK' and 'Cancel' buttons.

Figure 12 The coefficients of the energy calibration.



The 'Edit' dialog box has a title bar with a close button (X). It contains two columns of input fields. The left column is labeled 'Channel' and the right column is labeled 'Energy(Kev)'. Each column has four input fields, each preceded by a red asterisk (*). All input fields currently contain the value '0'. At the bottom are 'OK' and 'Cancel' buttons.

Figure 13 Calibration by Channel and corresponding energy.

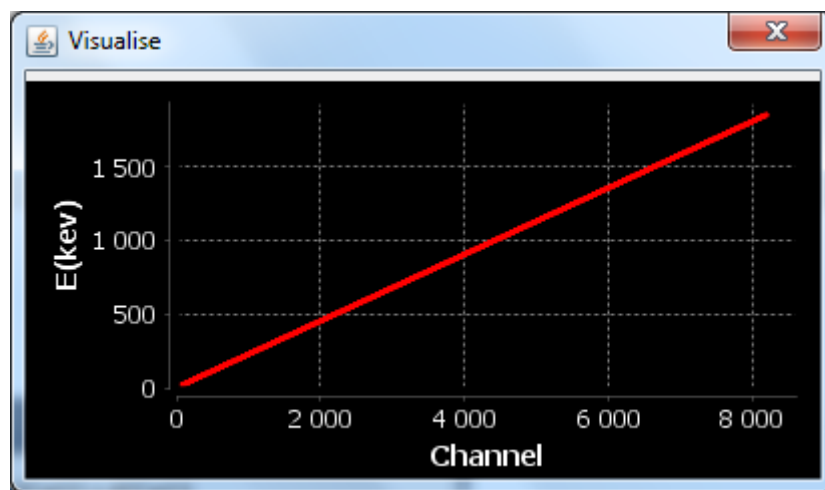


Figure 14 The energy calibration graph.

FWHM calibration: Two coefficients a and b can be modified.

A dialog box titled 'FWHM calibration' with a close button (X) in the top right corner. The window contains the formula $FWHM = a + b \cdot E^{1/2}$. Below the formula, there are two input fields: 'a =' with the value '0.731' and 'b =' with the value '0.038'. At the bottom of the window, there are two buttons: 'OK' and 'Cancel'.

Figure 15 FWHM calibration window.

Tail calibration: To correct the peak shape.

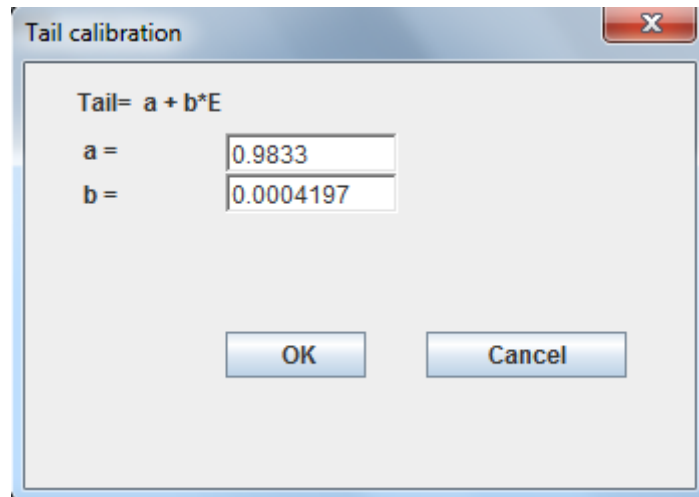


Figure 16 Peak tail calibration window.

Efficiency Calibration: This section covers calibrating the detector efficiency to obtain accurate results. As illustrated in the following figure, the equation used for this calibration is:

$$\ln(\text{efficiency}) = a + b \times \ln(E) + c \times \ln(E)^2 + \dots + f \times \ln(E)^n \quad (n = 1, 2, 3, 4 \text{ or } 5)$$

$$\text{efficiency} = a + E^{-b}$$

$$\text{efficiency} = a + b \times E + c \times E^2 + \dots + f \times E^n \quad (n = 1, 2, 3, 4 \text{ or } 5)$$

$$\text{efficiency} = \text{Exp}(a + b \times E + c \times E^2)$$

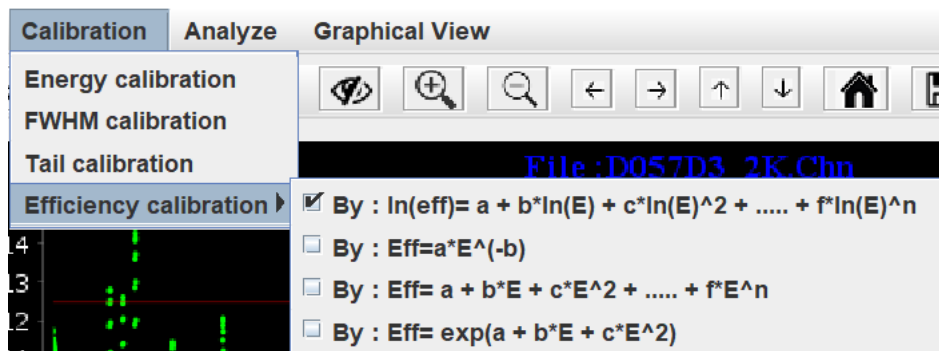


Figure 17 Efficiency Calibration

Efficiency calibration

Det01(Cal1)

Det01(Cal2)

Det01(Cal3)

Det01(Cal4)

Det01(Cal4)

sample name :

position :

x= ... y= ... z= ...

Other info :

source sample : ...

Centre name : ...

Laboratory name : ...

Detector name : ...

...

...

...

...

Select the calibration nuclides

Degree of the equation n = 4

$$\ln(\text{eff}) = a + b \cdot \ln(E) + c \cdot \ln(E)^2 + \dots + f \cdot \ln(E)^n$$

a = -251.4355

b = 162.7302

c = -39.00950

d = 4.077086

e = -0.157907

f = 0.0

Efficiency

0,12

0,10

0,08

0,06

0,04

0,02

0,00

0

500

1 000

1 500

E (keV)

80.54Wm

226Ra

137Ba

60Co

137Cs

40K

Zoom_top

Zoom_low

OK

Cancel

inialize

Figure 18 window to calibrate efficiency

12

efficiency table			
Nuclide	Energy (keV)	EmissionProbability(%)	Efficiency (effl)
137Cs	121.78	85.1	0.1315287711
60Co	244.0	99.9	0.06221250025
54Mn	344.28	100.0	0.06716867823
40K	411.0	10.7	0.02775032853
226Ra	443.96	100.0	0.02425373938
137Ba	778.9	85.5	0.0153877396
60Co	964.0	99.9	0.01240755308
113Sn	1112.07	100.0	0.01161158858
40K	1408.0	11.1	0.0092600542
<div> Add Delete Save </div>			

Figure 19 example of a nuclide table with energies and efficiencies to calibrate efficiency

III .1. 3 Analysis

The analysis menu contains eight options. These are usually options in which the user improves their analyzes.

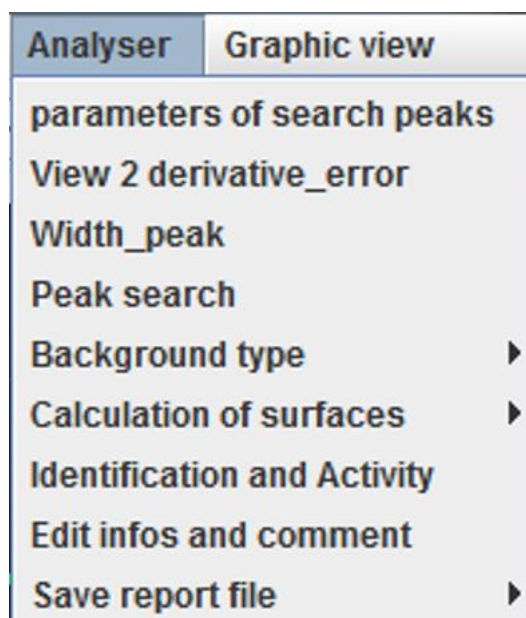


Figure 20 Analysis menu.

Parameters of search peaks: These are parameters to analyze the spectrum.

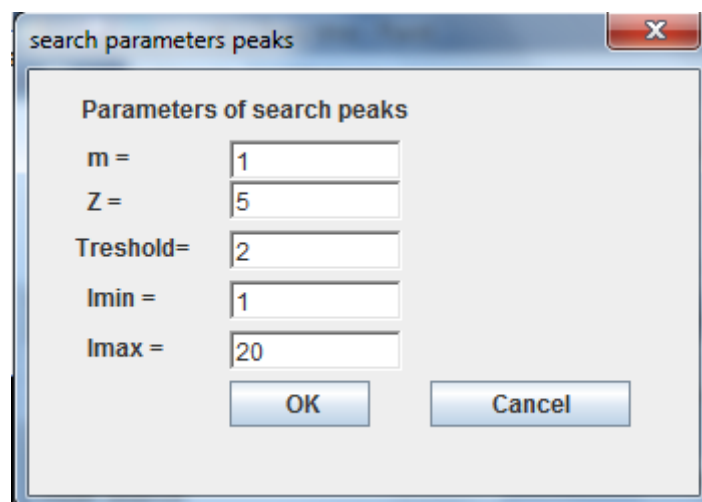


Figure 21 Analysis parameters.

m and **z** are coefficients to smooth the spectrum.

Threshold is the peak acceptance threshold.

lmin and **lmax** are the minimum and maximum number of negative points of the smoothed second derivative to accept peaks.

View 2 derivative_error: It has been integrated to best choose the values of **lmin** and **lmax**.

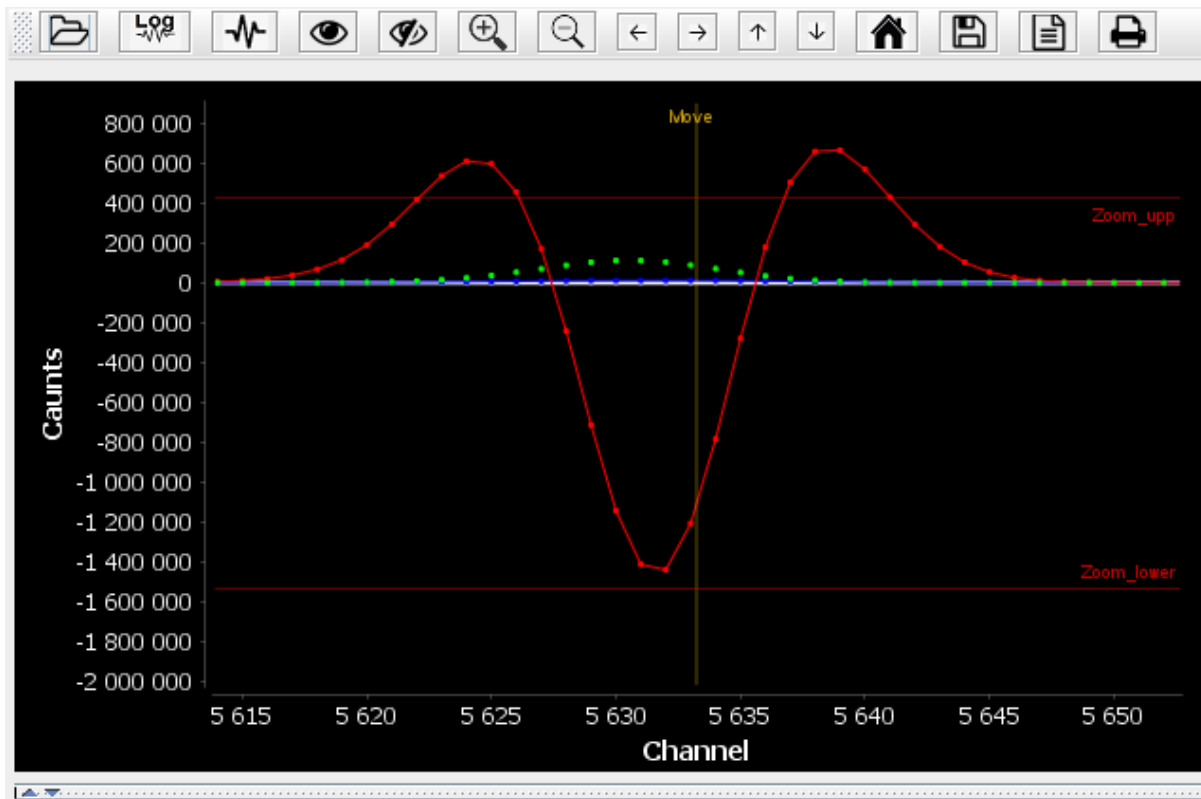


Figure 22 Graph of the smoothed second derivative and its error.

Width_peak: the sub-peak width in which the program starts to calculate the area.

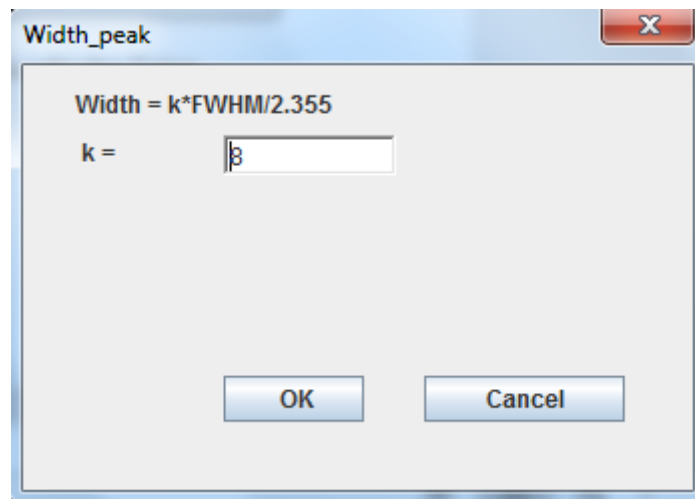


Figure 23 Window of the width value below peak.

Peak search: The program searches for peaks, then displays them in the result space (Fig.23). The peak markers are also displayed on the graph (Fig.22). The scale previously chosen by user.

A "Clear Marker" button in the marker and info space allows to delete all markers.

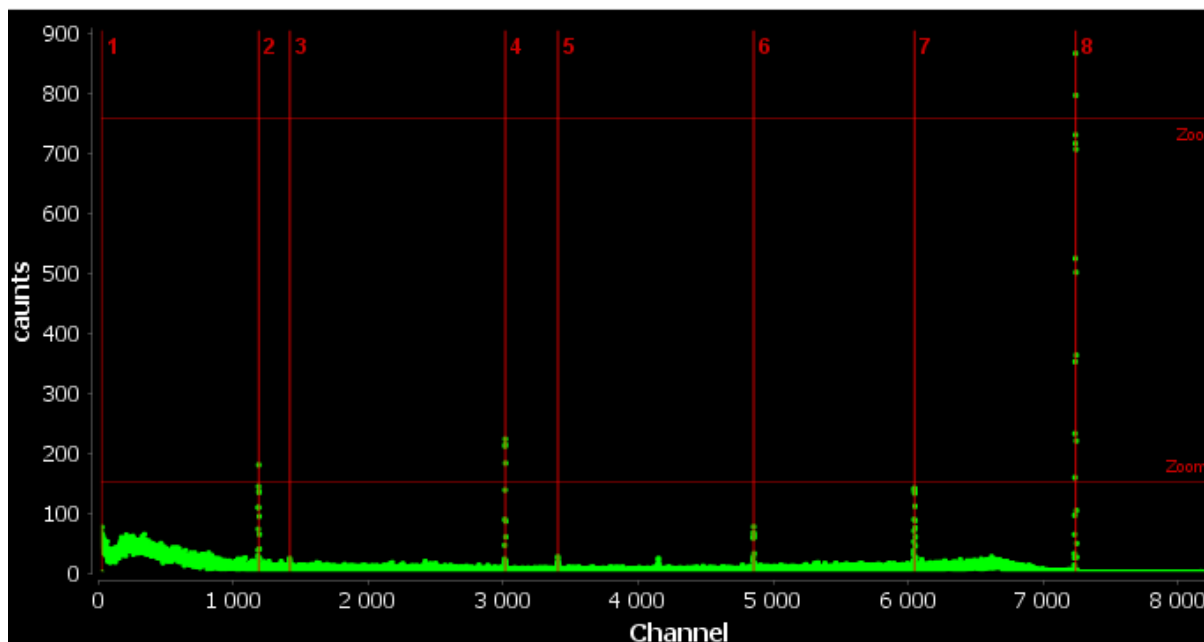


Figure 24 The markers corresponding to each peak.

N° peak	Centroid_Channel	Energy_kev
001	0026	0013,22
002	1191	0512,07
003	1421	0610,56
004	3016	1293,53
005	3406	1460,53
006	4855	2080,99
007	6046	2590,98
008	7239	3101,82

Figure 25 The results of the peaks found in the results space.

Background type: three types of background can be used: “Straight line background”, “stepped background” and “parabolic background”. Currently, Straight line background is working. The others haven't yet.

Calculation of surfaces: Finding peaks and calculating the area of each peak. Two scales are available. The results of the analysis appear automatically in the graph space (Fig. 24) and the results space (Fig. 25). Peak regions are stained red, the tails of each peak are stained blue, and deconvolved peaks are stained red and light blue.

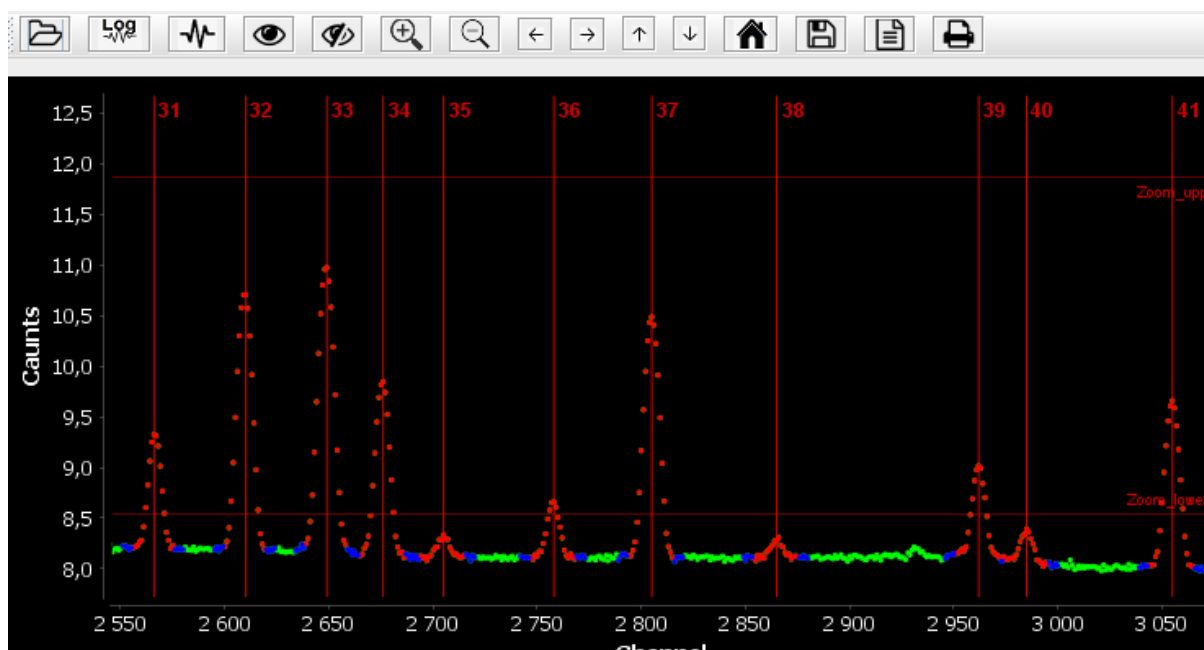


Figure 26 Graph of peaks in case of calculating peak areas.

Channel	Energy	FWHM	Net area	Background	Error (%)
001M 15,00E00	48,76E-01	81,49E-02	20,92E04	19,64E04	37,05
002M 22,00E00	64,59E-01	82,76E-02	74,97E03	50,06E04	13,84
003S 15,40E01	36,30E00	96,00E-02	35,21E02	25,05E04	20,67
004M 18,60E01	43,54E00	98,17E-02	11,38E04	24,24E04	67,96
005M 19,70E01	46,02E00	98,88E-02	16,43E02	21,20E04	39,71
006M 21,10E01	49,19E00	99,75E-02	79,64E03	18,72E04	84,61
007M 21,80E01	50,77E00	10,02E-01	21,51E03	20,51E04	30,51

Figure 27 Results of the analysis in case of calculating peak areas.

Identification: Here to identify the radionuclides. A standard library selected by default. The user has the option of selecting the desired library. If the user would like to create his own library, the file must have five columns, which are the radionuclide name, energy, intensity, half-life and its unit.

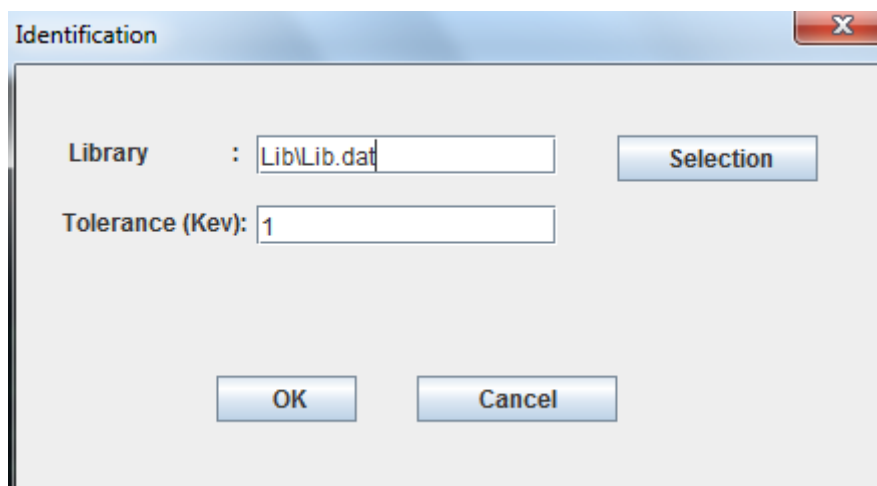


Figure 28 The library selection of radionuclides.

Identification and Activity: This section was added in this second version. Its main functionality is to identify and calculate the activity of each nuclide in a radioactive sample.

Edit infos and comment: The operator can fill this window. Each Edit will appear in the report file.

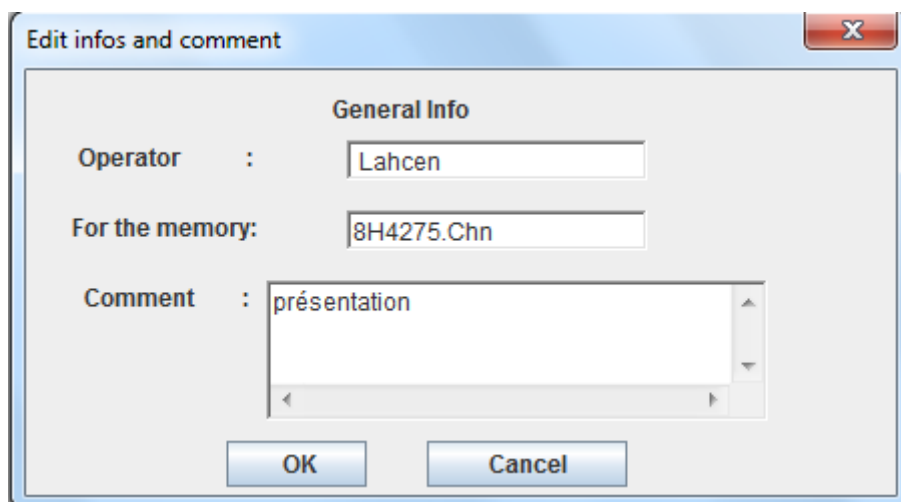


Figure 29 Edit info and comment window.

Save report file: A file created contains Edit info and the results of the analysis.

Operator	: Lahcen					
Date	:Tue Jul 20 18:16:13 CEST 2021					
Name of the analyzed file	: 8H4275.Chn					
Comment	: présentation					
	Channel	Energy	FWHM	Net area	Background	
001M	15,00E00	48,76E-01	81,49E-02	20,92E04	19,64E04	37,
002M	22,00E00	64,59E-01	82,76E-02	74,97E03	50,06E04	13,
003S	15,40E01	36,30E00	96,00E-02	35,21E02	25,05E04	20,
004M	18,60E01	43,54E00	98,17E-02	11,38E04	24,24E04	67,
005M	19,70E01	46,02E00	98,88E-02	16,43E02	21,20E04	39,
006M	21,10E01	49,19E00	99,75E-02	79,64E03	18,72E04	84,
007M	21,80E01	50,77E00	10,02E-01	21,51E03	20,51E04	30

Figure 30 Report file created.

III .1. 4 Graphic view

The options under the "Graphic view" menu have been set so that the user has the ability to hide or show certain graph curves. Each option has two possibilities, either view or hidden.

Note: he must click on "Calculation of surfaces" again to display the graph with new option.

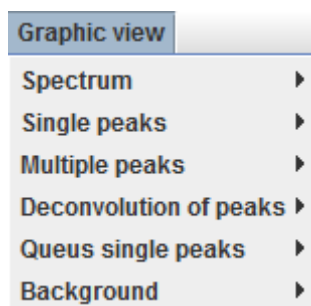


Figure 31 The "Graphic view" menu options.

Spectrum: hidden case. The data spectrum is not showing. On the other hand, the detected peaks appear in the graph space.

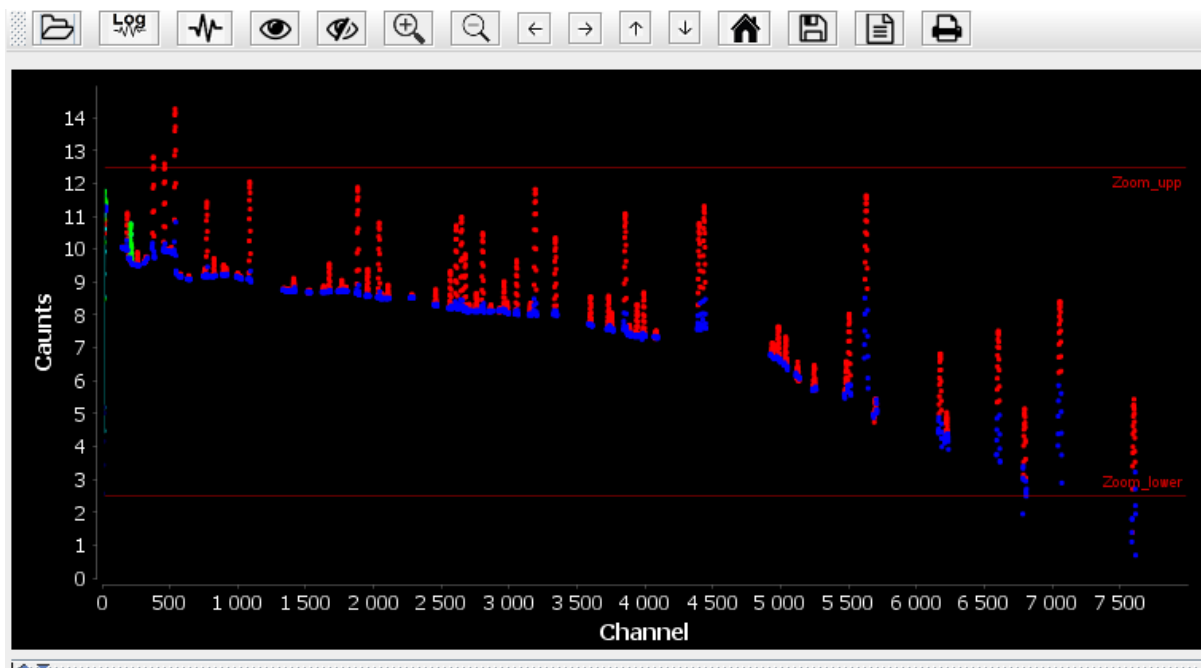


Figure 32 Case of spectrum data is hidden

Single peaks: hidden case. Singles peaks no longer stay colored.

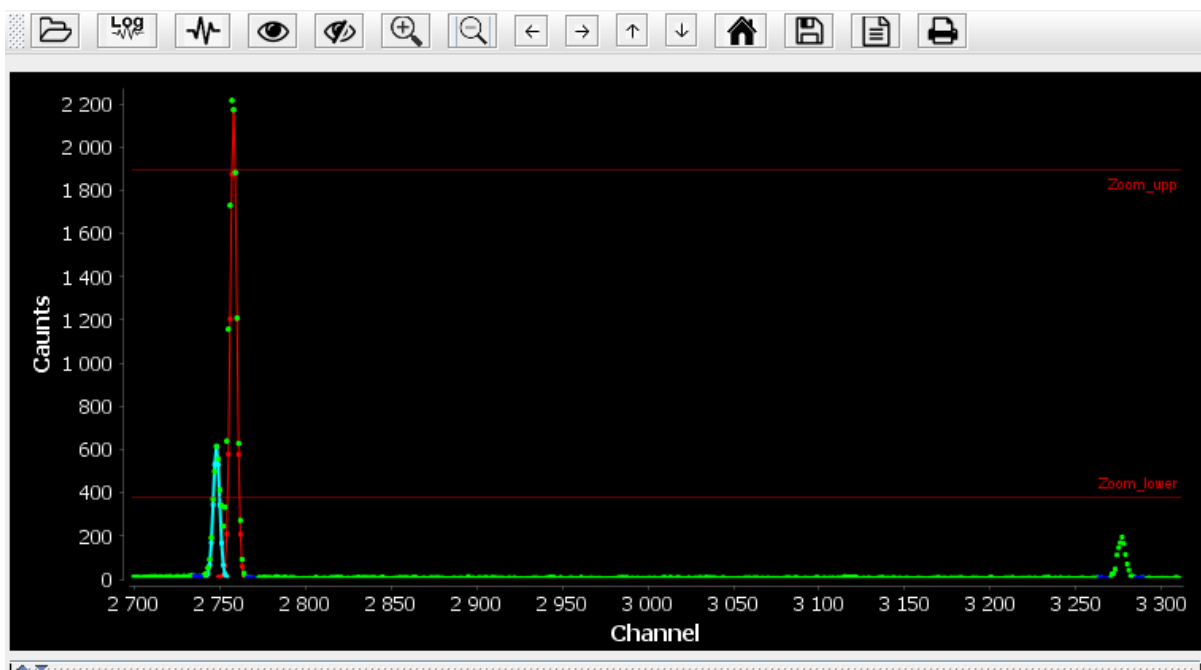


Figure 33 Case of singles peaks are hidden

Deconvolution of peaks: hidden case. Gaussian peaks no longer remain visible.

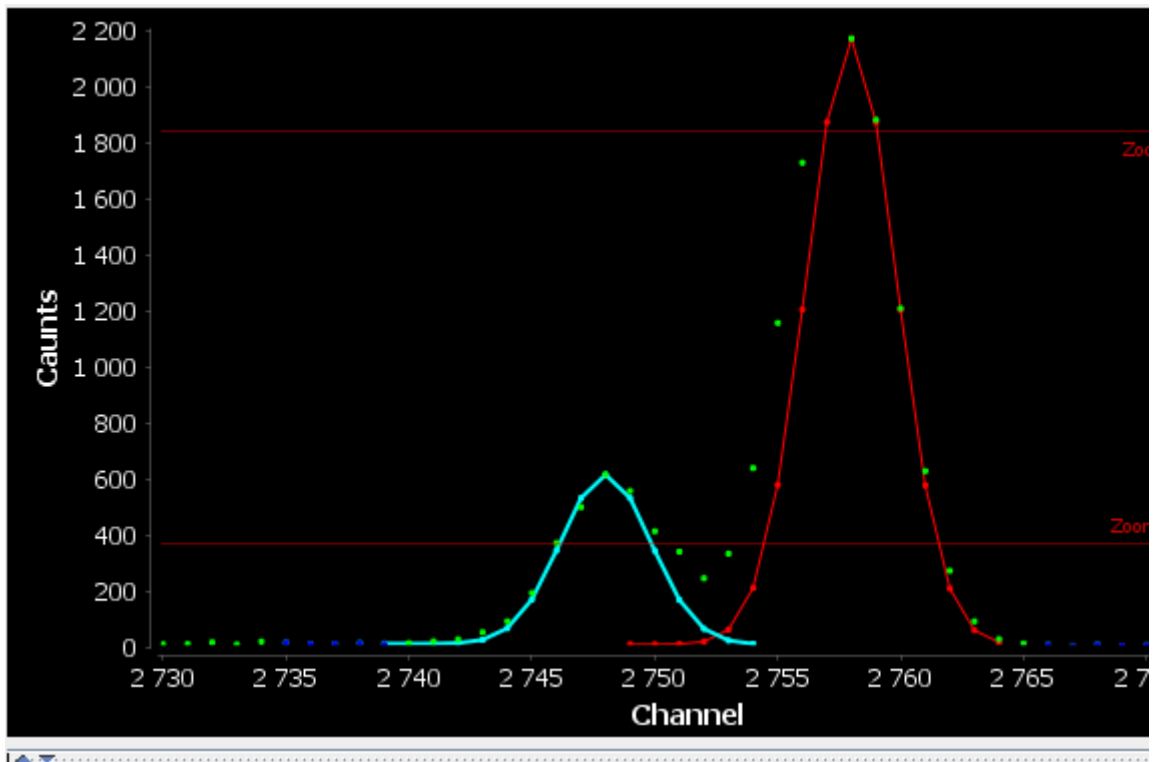


Figure 34 Case of multiple peaks are visible.

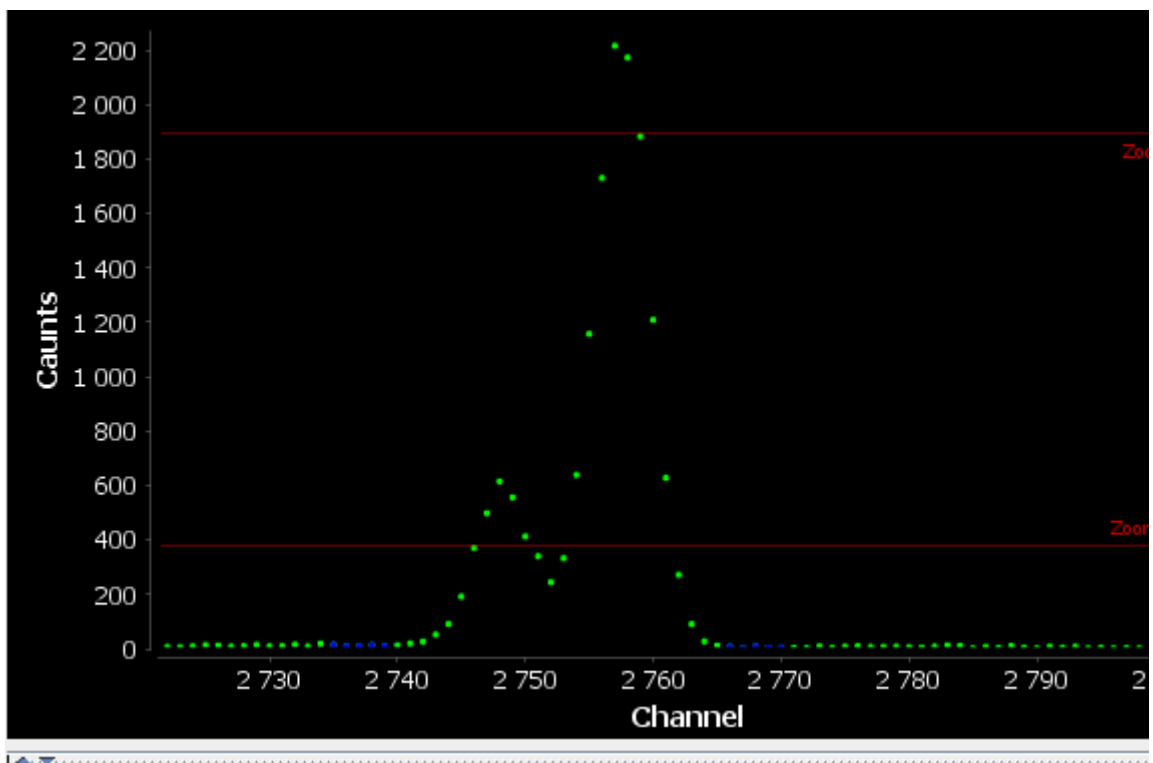


Figure 35 Case of multiple peaks are hidden.

The same goes for the rest.

III.2 Icon bar

The icon bar has fifteen icons. Each icon has a different functionality to the other. Usually these are shortcuts of menu bar. Including options for zooming and moving graphics.

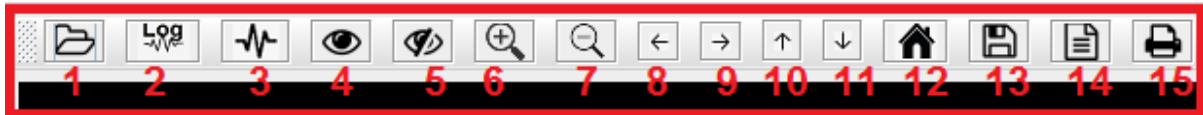


Figure 36 Icons bar.

- 1: the input file
- 2: display of the spectrum graph in logarithmic scale.
- 3: display of the spectrum graph in normal scale.
- 4: display of data in the results space.
- 5: erasing the content of the graph space and the results space.
- 6: zoom (+).
- 7: zoom (-).
- 8: graph movement to the left.
- 9: movement of the graph to the right.
- 10: zoom up.
- 11: zoom down.
- 12: return the graph to the initial state.
- 13: not yet
- 14: creation of a report file.
- 15: not yet.

Note: The icons six to twelve are also available by using the mouse (Fig. 25).

III.3 Graph space

From menu options, mouse, icons and buttons, the user could see graphs in this space. Currently, this is the only space in which the user could view their graphs.

As soon as the graph is displayed, two options are available to control it. Either by icons or by the mouse. Figure 38 explains how to control the graph with the mouse.



Figure 37 Graph space.

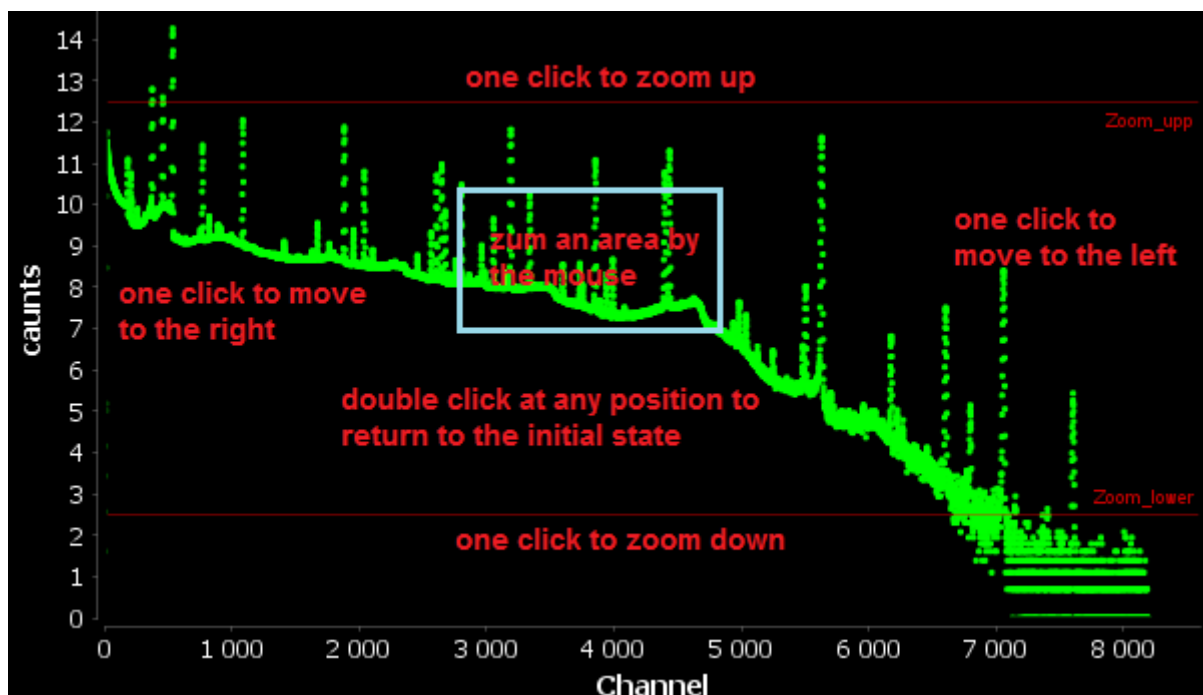


Figure 38 Use of the mouse on the graph.

Another graphical energy calibration option is available in this part. Right click, then choose the last option (Fig. 37). When the user enters the energy value corresponding to the value of Channel (Fig. 38), the calibration coefficients will automatically change.

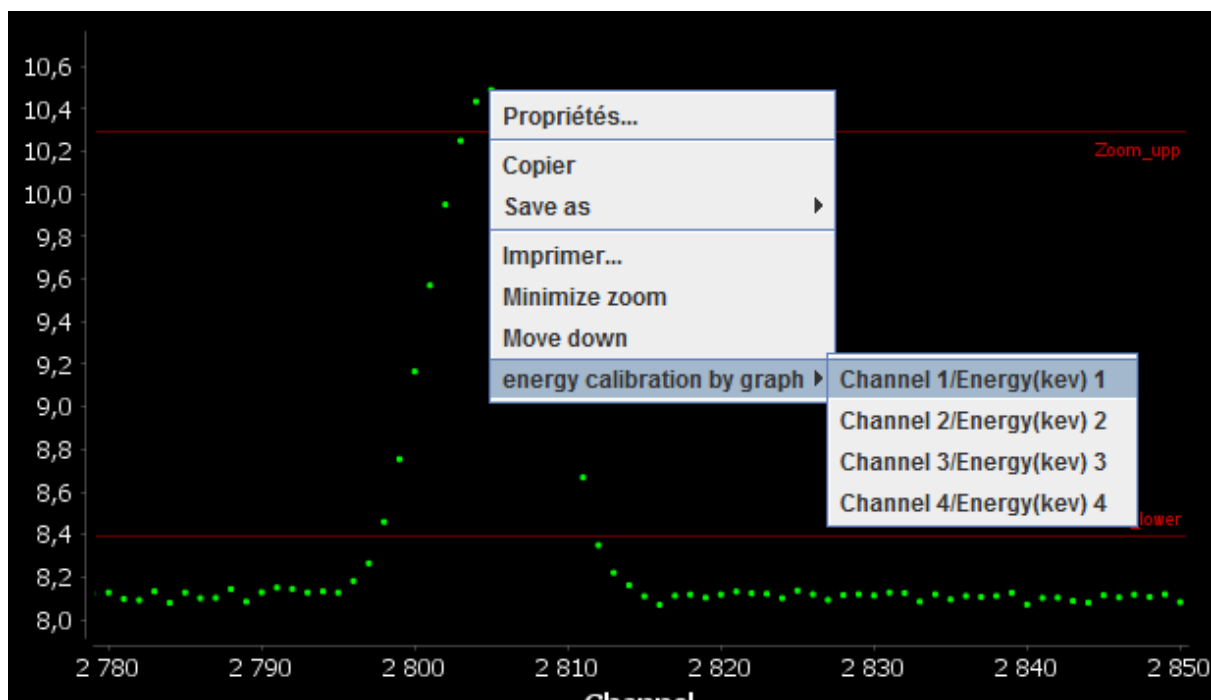


Figure 39 Graphical energy calibration option.

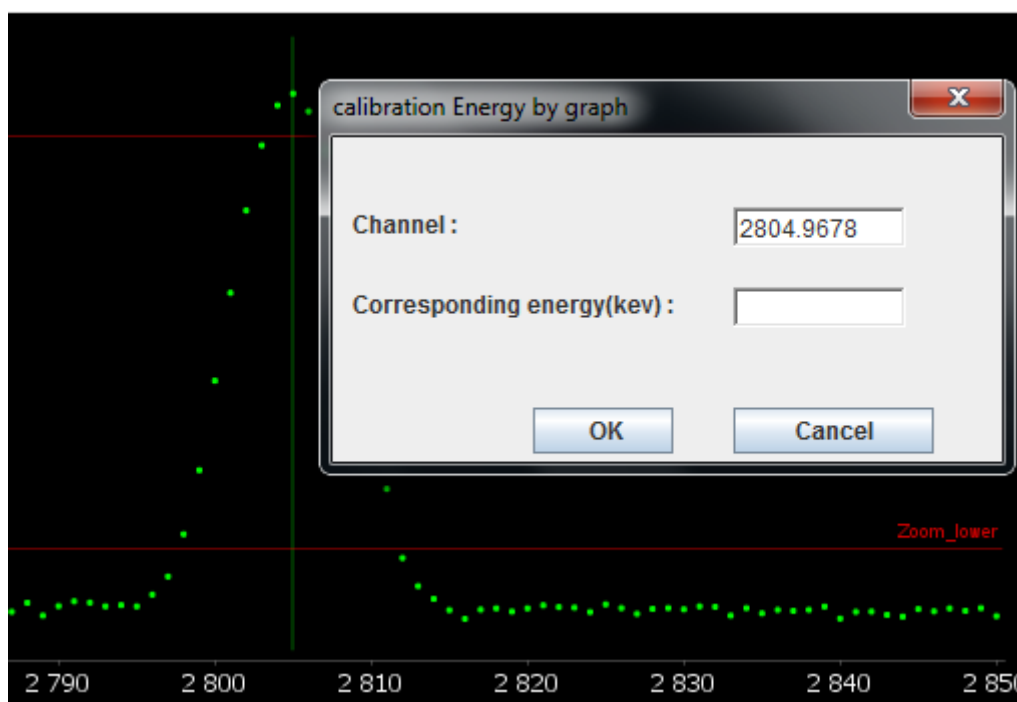


Figure 40 Window to enter the energy value corresponding to the Channel.

III .4 Space of Information extracted from file

Before entering the spectrum file, the space of information extracted from file was empty as shown in figure 39. As soon as the file opened in the program, the information is extracted from the file and then automatically displayed in this space (Fig. 40).

File name :	Energy calibration :	Length of detector description :
Start time :	Peak shape calibration :	Length of sample description :
Start date :	Detector description :	
Real :	Sample description :	
Live :	Channel range :	
Dead :		

Info extracted from spectrum file

Figure 41 Space of Info extracted from file.

File name :	m0375sc1.Chn	Energy calibration :	E= -44.55694 + 0.3239517 *C + -2.02589E-7 *C^2	Length of detector description :	13.0
Start time :	12:00:37	Peak shape calibration :		Length of sample description :	0.0
Start date :	09Mar11	Detector description :	3.102 Compton		
Real :	609.52	Sample description :			
Live :	600.0	Channel range :	From 0 to 8192		
Dead :	1.5618879 %				

Info extracted from spectrum file

Figure 42 The info extracted after putting the spectrum file.

III .5 Space for markers and analysis information

This space is useful after finding peaks or calculating areas. It has two functions. The first is to display the information for each peak found. The second is to clarify and simplify the vision of the peaks.

Four buttons manage these two functions (Fig. 41). If the user has not yet searched peaks or calculated areas, a dialog box will appear asking the user to search peaks first (Fig. 42).

Peak N°	Next	Channel :	Net Area :	Nucleid :	Activity :
	Previous	Energy :	Error :	Energy :	
	Range		FWHM :	Intensity :	
	Clear Marker			half life :	

Figure 43 Space for markers and analysis info.

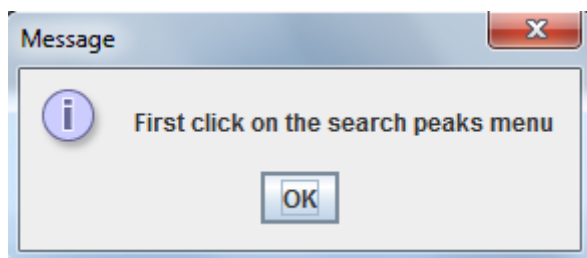


Figure 44 Dialog box.

After searching for peaks or calculating areas, the following four buttons are ready:

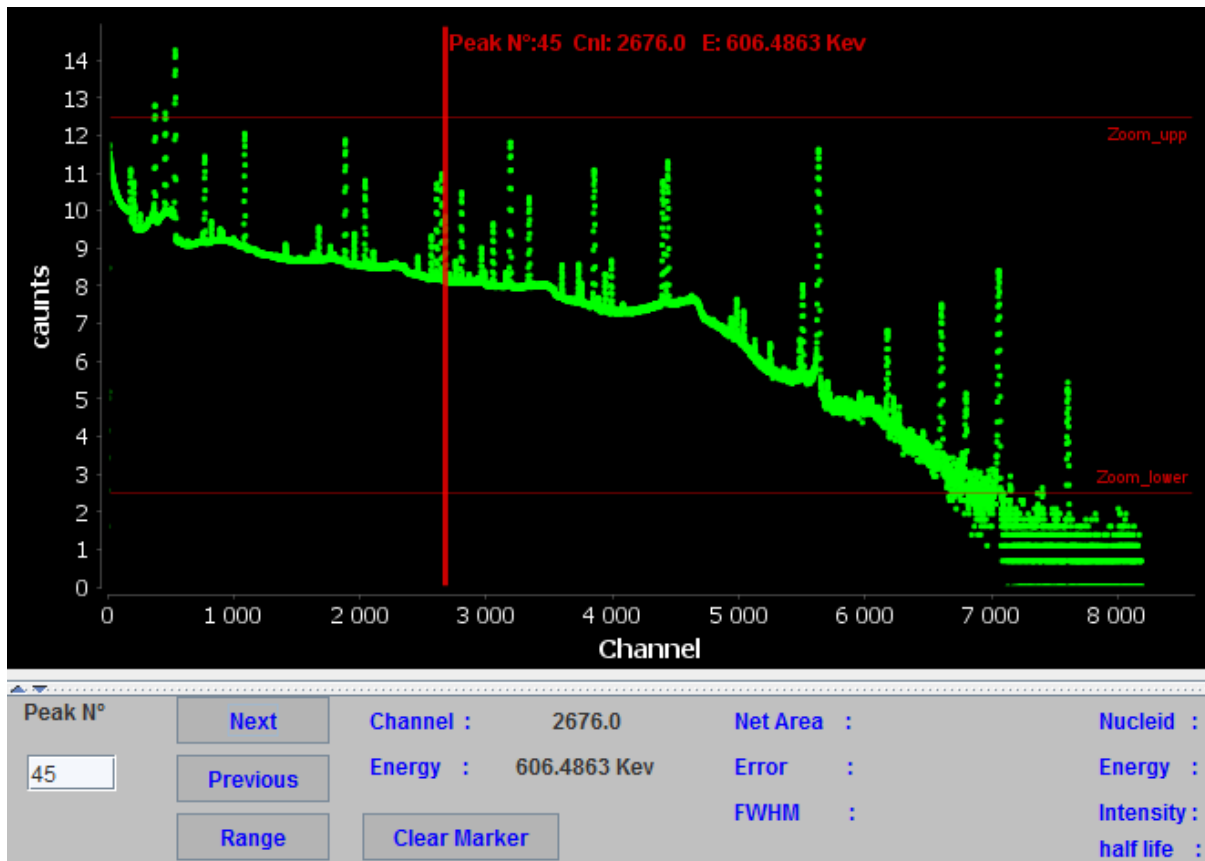


Figure 46 Marker in the "Range" option before having calculated the areas of the peaks.

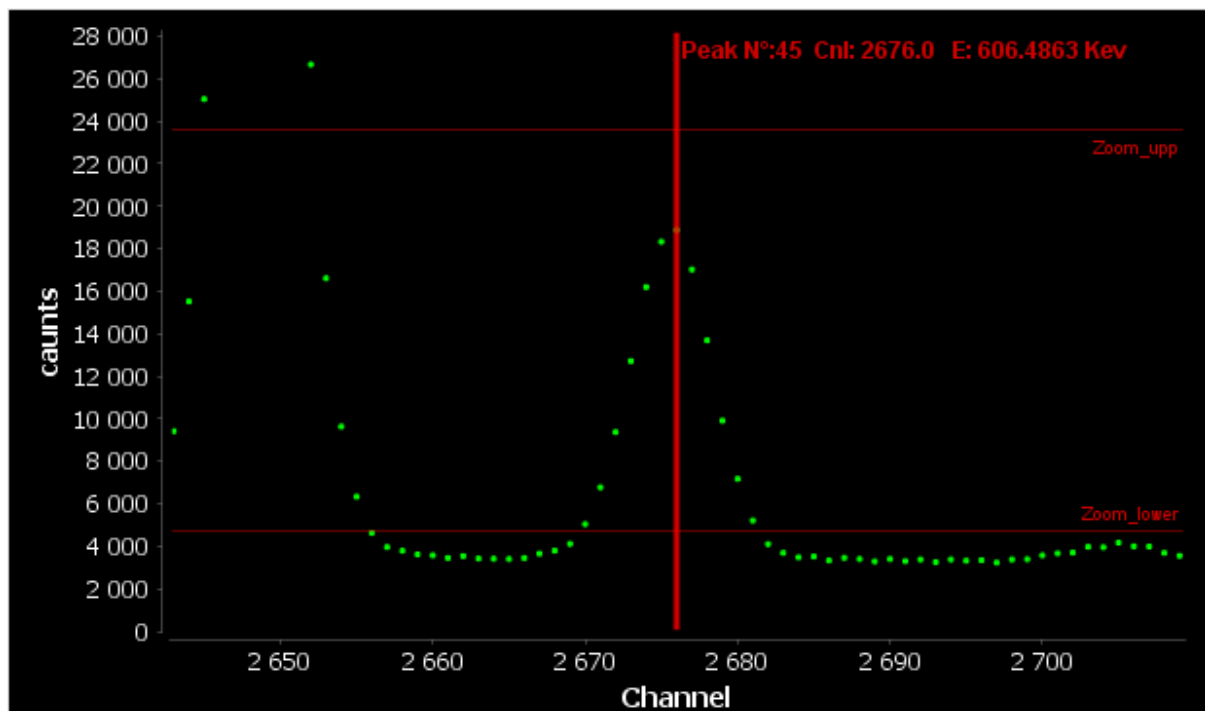


Figure 47 Marker in the "Not Range" option before having calculated the areas of the peaks.

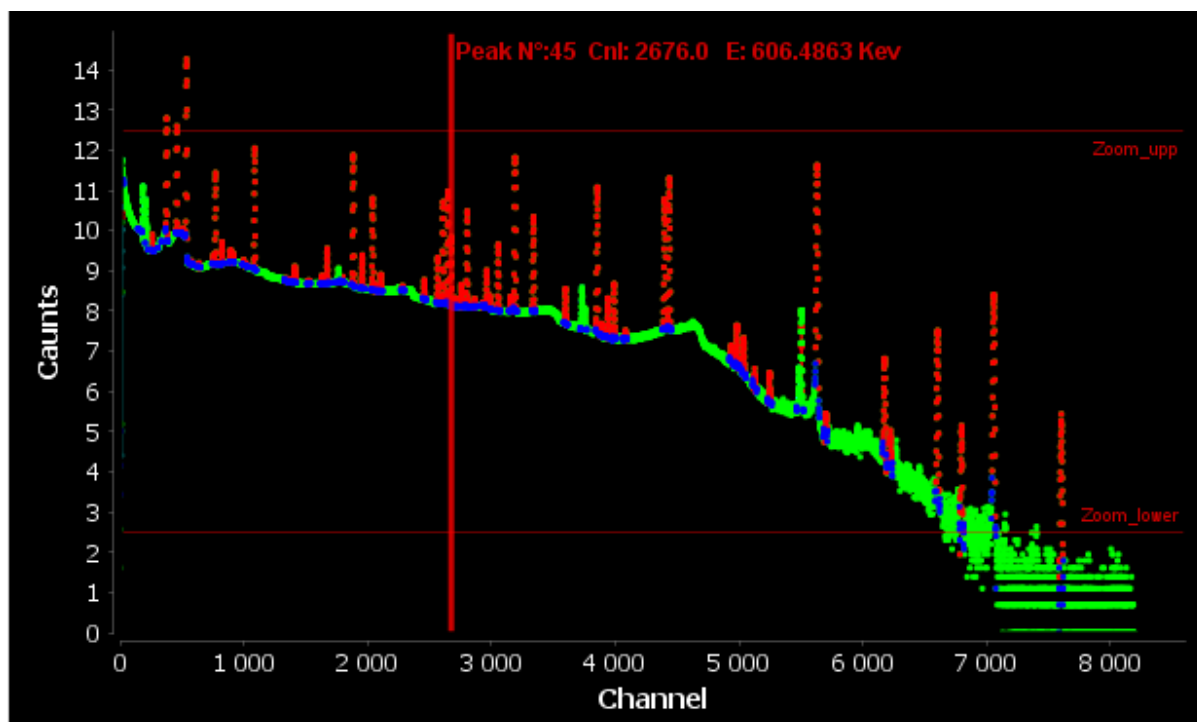


Figure 48 Marker in case of choosing the "Range" option after having calculated the areas of the peaks.

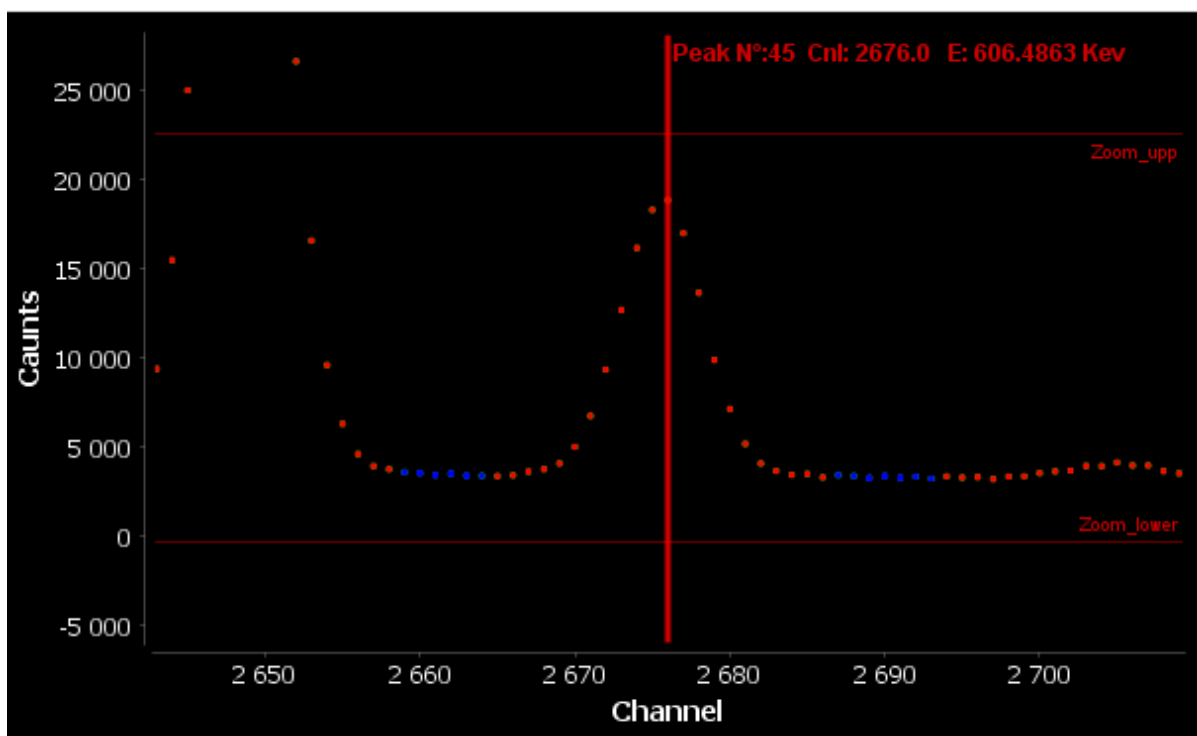


Figure 49 Marker in case of choosing the "Not Range" option after having calculated the areas of the peaks.

III .6 Space of results

It is a display space. It is possible to see in this space: spectrum data, the peaks found and the results of the analysis. The copy and cut options are still working. Including, the modification.



Figure 50 Results space.