

# Manual

---

# Lab Scout

Gamma Identifier/Quantifier for soil, material and food samples with integrated scale and lead shielding

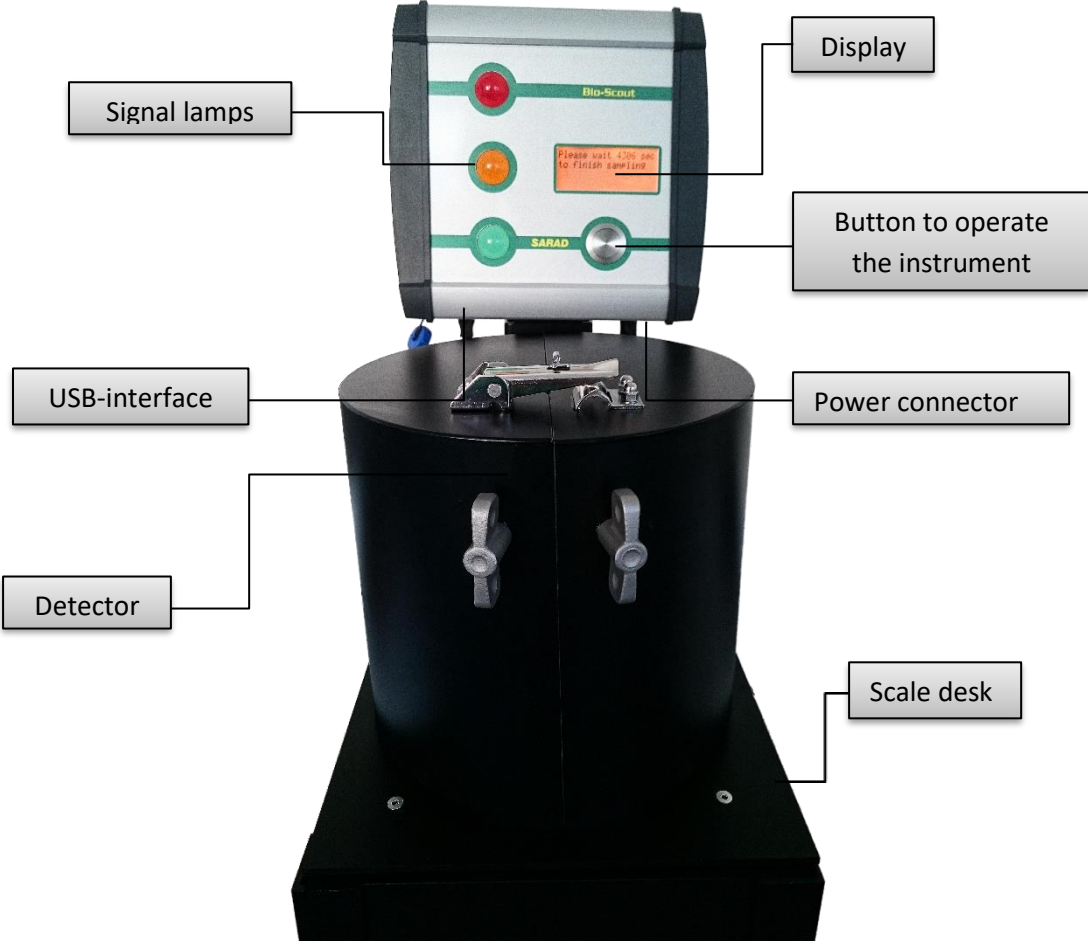
Version 01.2022

## Referenced documents

*Video clip "Instrument assembling with lead shield"*



SARAD GmbH  
Wiesbadener Straße 10  
01159 Dresden  
GERMANY  
[www.sarad.de](http://www.sarad.de)  
[info@sarad.de](mailto:info@sarad.de)



---

## Content

General .....	4
Lab Scout operation .....	4
Placing the Lab Scout on the right location.....	4
Scale taring .....	4
Menu operation .....	4
Selecting the sampling interval .....	4
Start of a measurement .....	5
End of the measurement and result presentation.....	5
Saving the recent sampling results.....	5
Background Subtraction .....	5
Configuration of the instrument .....	6
Nal Gamma probe .....	7
General hints for operation.....	7
Lab Scout Works.....	7
Software installation and communication with the instrument.....	7
How to operate the software.....	7
Working with background subtraction.....	8
Loading the sample data from the instrument .....	8
Analysis and calculation of the measuring results .....	10
Selection of suitable emission lines and the analysis method for a sample type.....	10
Calibration .....	12
Calculation of the nuclide-specific activity.....	13
Selection of the analysis method with Lab Scout works.....	13
Subsequent analysis with modified calibrations and nuclide lists .....	14
Management and specification of the measurement uncertainties .....	14
Definition of the nuclide list .....	15
Detector Calibration .....	16
Energy calibration and peak width calibration.....	16
Efficiency calibration .....	19
Protocol print .....	21
Definition of nuclide specific alert thresholds, Editing of library files .....	22
Lead shielding.....	22
Service instructions .....	23

## General

The typical application for the Lab-Scout is the quantitative analysis of samples with a known nuclide mixture, such as:

- Uranium, radium, thorium and potassium **in soil and rock samples**
- Cs-137 content in natural samples (**earth, building material, ash, biomass, etc.**).
- Monitoring of material samples (**fertilizers, cement, etc.**)

A sensitive and high-resolution 2 "x 2" NaI crystal is used as a detector, which in conjunction with the implemented spectroscopic analysis enables to determine the activity of individual nuclides. Thanks to the integrated balance, the results can be shown directly in Bq / kg, which is relevant for the limit values. The device can also be operated by less qualified personnel with just a single button. The ergonomic design allows a high sample throughput with minimal space requirements. The Lab Scout has a lead shield to reduce the natural ambient radiation. The Lab-Scout Works operating software enables the analysis to be optimally adapted to each sample type, so that the Lab-Scout can replace in many cases an expensive and time-consuming laboratory analysis.

## Lab Scout operation

### Placing the Lab Scout on the right location

The unit should be placed at a location with low Gamma background radiation. Direct exposure to sunlight or other heat sources must be avoided, to prevent the detector against heating up. For the device with lead shielding, it is essential to ensure that the contact surface is stable. The base plate has four holes at the corners, with which it has to be screwed firmly to the table. The manufacturer rejects any responsibility for injury or damaging by dropping of heavy parts. To operate the Lab-Scout, only a mains power outlet is required.

### Scale taring

For an accurate determination of the sample weight, the weight of the container (e.g. Marinelli beaker) must be taken in account. Therefore an empty container needs to be placed on the scale plate before powering up the instrument (connecting the AC/DC adapter). The weight will be measured during the short initialization period. Do not touch the scale plate or sample container to ensure an exact reading.

### Menu operation

There is just a single push button to operate the instrument. A short touch is used to toggle the various menu items and to select the displayed sampling results. To choose a menu option the button must be kept pressed until a short beep will sound. The long touch will also lead back to the parent menu and confirms alerts and messages.

### Selecting the sampling interval

The main menu option can be toggled until the option "... change pre-set sample interval" appears on the display. A long touch will open the menu to change the sampling interval. Now, the desired interval

can be selected by repeated short touches. The selection must be confirmed by a long touch and finally, a short touch returns to the main menu.

### **Start of a measurement**

Place the sample container (Marinelli beaker) on the scale plate. If a lead shielding is available, close it completely. Select the option "...start a new measurement" from the main menu. Press the button longer to start the acquisition. If no sample has been placed on the plate (weight is less than 50 grams), a message will appear on the screen. In that case the acquisition will not be started. After confirming the message by a long touch and correct sample placement, the procedure can be repeated. If the message still appears, check the taring of the scale. While the data acquisition is running, the remaining sampling time is shown on the display. The measurement data of the completed measurement can also be loaded by the PC (with Lab-Scout Works)

### **End of the measurement and result presentation**

If the acquisition will be finished after the pre-set time period (signalized by a short beep), the peak verification algorithm checks the spectrum for each position which is related to an emission line within the used peak list. If a peak with the expected shape has been detected, the net counts are determined. Now, the weight related activity for the nuclides can be calculated from the count rates including the sample weight, the detector efficiency and the branch probability of the emission lines.

After the results are available, the instrument will check if any measured activity exceeds the adjusted alert levels. In this case, the alert will become active (sounder, red signal lamp blinks) and a list with nuclides generating the alerts will appear. A short button touch will turn off the sounder. Another long button touch will cancel the list view and switch back to the result display. Press button shortly to toggle the results of the single emission lines. The signal lamps will light red, yellow or green, dependent on the alert status of that line. A green light means that no activity has been detected while yellow light indicates a measured activity below the defined alert level. Red light signalizes an alert. In addition, an empty or filled bell-symbol is shown in the display in front of the verified nuclide. To turn back to the main menu, the button must be pressed long. The results may be shown again by choosing the menu option "...show recent sampling results" (available until the next measurement has been finished).

### **Saving the recent sampling results**

The instrument has an internal non-volatile memory (SD card) to store the measured data. The data can be read by the PC software Lab-Scot Works later on for further processing. To save sample data, the menu option "...store this sample" is available. A unique sample identifier (ID number) will be assigned automatically. This ID is also part of the file name generated during download.

### **Background Subtraction**

The instrument provides the online subtraction of the natural radiation background to decrease the reachable detection limits. The menu option "carry out & save a new background measurement" allows the acquisition and the storage of a so-called background spectrum. If the function "Subtract background spectrum" has been activated by the instrument setup (Lab-Scout works), the previous stored background spectrum will be subtracted from the recently acquired sample spectrum. This will be done prior the all further calculation, resulting in a net-spectrum nuclide analysis. This setting is recommended for stand-alone operation of the Lab-Scout. If the instrument is permanent connected to a PC that function may be disabled and the background subtraction can be performed more flexible

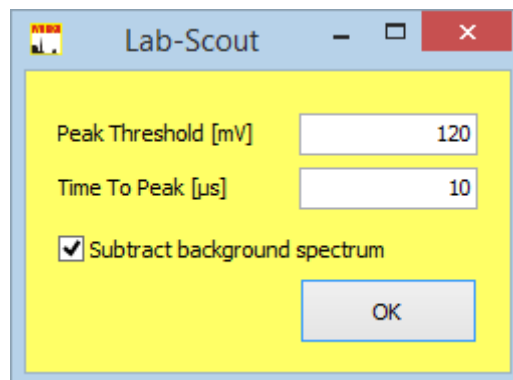
by Lab-Scout Works. In that case the background and original sample spectrum can be loaded separately for processing (offers the possibility to compare results with/without subtraction and to acquire the background spectrum after the sample spectrum). Please note that only net spectra will be stored and transferred in case of enabled online background subtraction.

The background spectrum is stored in the non-volatile memory and will be present even after power interruption. Please pay attention to the hints given in the chapter “Working with background subtraction” in that manual.

### Configuration of the instrument

The configuration includes calibration functions for energy, peak width and detector efficiency as well as the peak list used for the analysis. Lab Scout Works offers easy to use features to carry out the calibration procedures and to edit the peak list content. If all necessary changes have been done, the new settings can be transferred to the Lab Scout. The peak list can be checked by choosing the menu option "...show peak list and peak parameter". The display shows the emission energy, the channel number within the spectrum, the peak width, the branch probability and the detector efficiency for each line.

The menu “Lab-Scout → Spectrometer Configuration” offers the possibility to change the detector related settings as well as the spectrometer operation mode.



Following parameters can be adjusted:

**Peak Threshold:** defines the voltage threshold (Millivolt) for incoming pulses generated by the detector. Only pulses higher than this level will appear in the spectrum. Increasing of the value cuts off the left edge of the spectrum while decreasing can result in the appearance of detector noise in the low energy region.

**Time To Peak:** defines the sampling point for the pulse height measurement in Microseconds, starting if the signal exceeds the peak threshold level. The sampling point needs to set after the pulse signal reaches its maximum. This parameter depends on the electronic signal processing of the probe.

**Subtract background spectrum:** defines if the background spectrum will be subtracted by the instrument prior analysis or not (see also related chapters in that manual).

The pre-set values are optimized for the built-in 2" x 2" detector and should not be changed.

## Nal Gamma probe

### General hints for operation

The gamma probe contains a 2" x 2" NaI(Tl) detector, a photo-multiplier, a high voltage supply and the electronic circuits for signal conditioning. The probe is shielded against magnetic fields and compensated against temperature variations.

Photo-multipliers and Scintillation crystal should not be exposed to any mechanical shocks. Mechanical loads are also caused by strong and rapid changes in temperature. Make sure that the temperature gradient is less than 3 ° C per hour.

### Lab Scout Works

Lab Scout Works is an easy to use software tool to configure and analyse with the Lab Scout. The software includes:

- Management of editable nuclide library and peak lists
- Easy to use automatic energy, peak width and efficiency calibration based on reference samples
- Extended analysis from Lab Scout charged spectra

### Software installation and communication with the instrument

The software Lab Scout Works requires a Windows (XP...Win10) platform with a graphic interface with a minimum of 1280 x 720 pixels. After running the "setup\_LabScoutWorks.exe" (CD or SARAD website) all program components will be installed in the selected folder ("C:\SARAD\Lab Scout Works"). Within this folder the subfolders "Library" and "Calibration" are automatically created. These folders contain the pre-defined libraries and efficiency calibrations. The software should not be installed into the application program folders offered by Windows because later write accesses will require administrator rights.

The communication with the Lab Scout is done by a USB interface. This interface requires a special software driver that is available on the program CD or in the internet too. Please install the driver before starting Lab Scout Works. After starting the software, the port can be selected from the list box "Connect" just left below the main menu. Please note that the COM port number must be below COM50 otherwise it will not be visible. If Windows has already assigned too much ports for other devices, the Lab Scout port number must be re-directed by the Windows device manager to a number in the range of 1 to 50.

### How to operate the software

After starting the software, a sample file can be opened, imported or loaded from the Lab Scout. These options are available in the "Sample" menu. The file contains in addition to the spectrum all information required for analysis (calibration, peak list, sample weight etc.).

The spectrum is shown in the upper graphic area. The check box "Log. View" above the graphic toggles between linear and logarithmic spectrum display. A cursor line appears as soon as the mouse is moved across the spectrum. The related energy and the spectrum channel are shown in a box above.

A vertical line is drawn in the spectrum for each peak defined in the used peak list. If a peak will be selected by a click onto its name in the peak list box (bottom centre), the related and pre-processed spectrum region (ROI) is shown in the graphic space left beside the box. Within the spectrum, the selected line is highlighted by red colour.

Activities of all lines that could be verified by the algorithm are shown in the result box to the right of the peak list. With a tick in the "Detailed Results" check box, additional information about the undetected lines is displayed.

### Working with background subtraction

To decrease the detection limit, in some cases it makes sense to subtract the background radiation which has been measured before. This can be done either directly by the instrument itself or later in Lab-Scout Works after loading background and sample spectra from the Lab-Scout. Please note: if the check box "Subtract background spectrum" has been enabled by the menu "Lab-Scout → Spectrometer Configuration", the background spectrum will be subtracted from the sample before any analysis. Furthermore, all stored and transferred spectra (except the background spectrum) will contain the net counts of each channel. The background subtraction must not be performed a second time by Lab-Scout Works. A more flexible way is offered if the online subtraction will be disabled and the analysis will be done by Lab Scout Works. Then, the background spectrum either can be loaded directly from the instrument (menu: Lab-Scout → read background) if this has been acquired as such ("Carry out & save new background measurement"), or the spectrum of any sample previously saved on the hard disk is declared as the background.

The sample must be opened like a sample spectrum ("Sample → Open") and in a next step it can be defined as background measurement by the menu option "Sample → Use as background". The background spectrum is displayed below the spectrum to be analyzed. The sample data to be analyzed can now be opened or loaded from the device. With the check box "Backgr. Subtraction" you can switch between analysis with and without background subtraction. Is the checkmark set, the result of the subtraction is displayed in the spectrum area.

The sampling interval used for a background measurement should be at least ten times longer than the one used for later sample analysis. It should be performed with a similar sample (density, geometry) without activity. The measurement has to be done at the same place like the later analysis. The time span from taking the last background measurement should be as short as possible. Take care that no radioactive samples are stored in the surrounding of the instrument.

Please note: Only if these hints are strictly considered, the detection limit can be reduced and the measuring result will be more precise.

### Loading the sample data from the instrument

The Lab Scout is equipped by an internal non-volatile memory which allows to store all sample data while stand-alone operation. The data contains in addition to the spectrum all relevant information like calibration functions and the used peak list. Each measurement can be identified by a unique sequential ID number (incremented and assigned by the instrument). To load the data from the Lab Scout, the menu option "Lab Scout → ReadMemory" must be chosen. After calling this function, a file name has to be assigned, performing the base of the automatically generated file name. Each sample will be stored as a separate file under the name which will be created as follows: Base name + serial



number + sample ID + Index of transmission (for example: Test\_SN2\_ID25\_2.bsb). These files can be opened by the "Sample → Open" menu option.

To avoid long transmission periods because of a large number of stored samples, the instrument memory should be cleared after the download. The read data function will load generally all stored samples. To clear the memory, use the menu option "Lab Scout → Clear memory".

The software allows also setting the unique sample ID to zero. After this operation, the indexes are counted from zero again. This option should only be used, if the sample files are generally stored manually under unique file names. The menu option "Lab Scout → Set sample ID to zero" forces the ID reset.

## Analysis and calculation of the measuring results

### Selection of suitable emission lines and the analysis method for a sample type

In order to analyse a sample and to achieve the best possible result (lowest detection limit, lowest measurement uncertainty), suitable emission lines of the potentially present nuclides and the analysis method suitable for each emission line must be selected. To understand the selection, the term peak width must be explained.

#### Peak Width

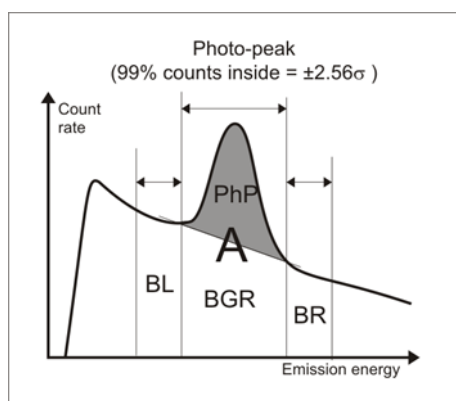
The activity of a nuclide is determined on the basis of the detected photons with complete energy transfer to the detector. These photons form a Gaussian peak (photo peak) in the spectrum. The position of the maximum on the X-axis (energy axis) corresponds to the emission energy of the respective line. The Gaussian shape results from statistical processes during the conversion of the radiant energy into a measurable signal. The width of a Gaussian peak is described by the parameter sigma. The energy range of  $\pm 2.5$  sigma related to the maximum of an emission line contains approx. 99% of the detected photons with full energy transfer. The number of these photons is called the peak area, the energy range is called the ROI (Region Of Interest).

The peak width depends on the photon emission energy and the material of the scintillation crystal and is therefore usually given as a percentage of the emission energy. For NaI detectors the parameter sigma is about 3.4% of the emission energy. For the 662 keV emission line from Cs-137, Sigma would be therefore  $662 \text{ keV} \cdot 3.4 / 100 = 22.5 \text{ keV}$ .

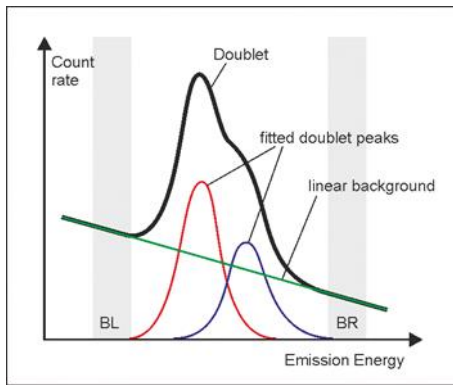
The photons of all emission lines contained in the spectrum, in which there is no complete energy transfer, lead to a more or less linear "base" spectrum distributed over the entire energy range. The measured spectrum thus always shows the superposition of the "base" and the peaks of the emission lines.

#### Analysis Methods

In order to clearly determine a peak area on the basis of the measured spectrum, three different methods can be used, which are subject to different statistical uncertainties and require different requirements.

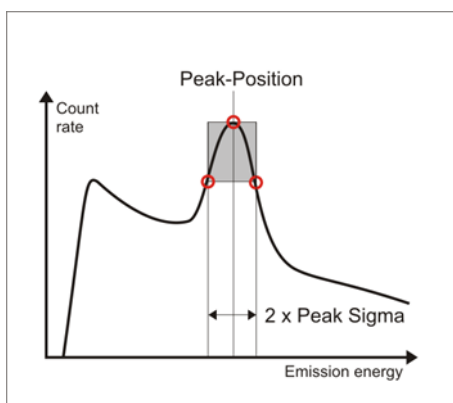


The so-called **trapezoidal method** offers the lowest statistical uncertainty. The base contribution in the area of the peak (ROI) is determined and subtracted from the total number of photons in the ROI. The base contribution (BGR) is determined by linear interpolation of the base height to the left and right of the ROI (BL / BR). A prerequisite is therefore a linear background (no overlay by another emission line or Compton edges) in the energy range of  $\pm 3.5$  sigma. This criterion can usually only be met with a few emission lines or less complex spectra.



Often two peaks overlap, i.e. the distance between the emission lines is less than about 4 sigma. In this case, the trapezoidal method is expanded to include the so-called **doublet unfolding**. The base contribution is determined in the area of the two peaks in a similar way to the trapezoidal method, but the total number of photons is proportionally assigned to both peaks. This is done by repeatedly varying the proportions of both lines until the best possible match between the measured spectrum and the spectrum modeled on the basis of the variation is achieved. The prerequisite here

is a linear background in the range of minus or plus 4 sigma in relation to the lower or higher-energy line of the doublet.



The two methods described above require a relatively wide linear base area, which is often not the case in complex spectra. The so-called **PSV (Peak Shape Verification)** analysis enables the energy range used for the analysis to be halved. The peak area (number of photons of an emission line) is determined from the distance between the inflection points (this corresponds to 1 sigma) and the elevation of the maximum with respect to the inflection points (Fig. Left). This eliminates the need to determine the base, so that only a linear base range of approximately  $\pm 2$  sigma is required. It is

also checked whether a peak is actually present in the energy range of the peak. The trapezoidal method and doublet unfolding also provide a measured value for any concave spectral shape (e.g. Compton edges). The uncertainty of the measurement is increased compared to the other two methods.

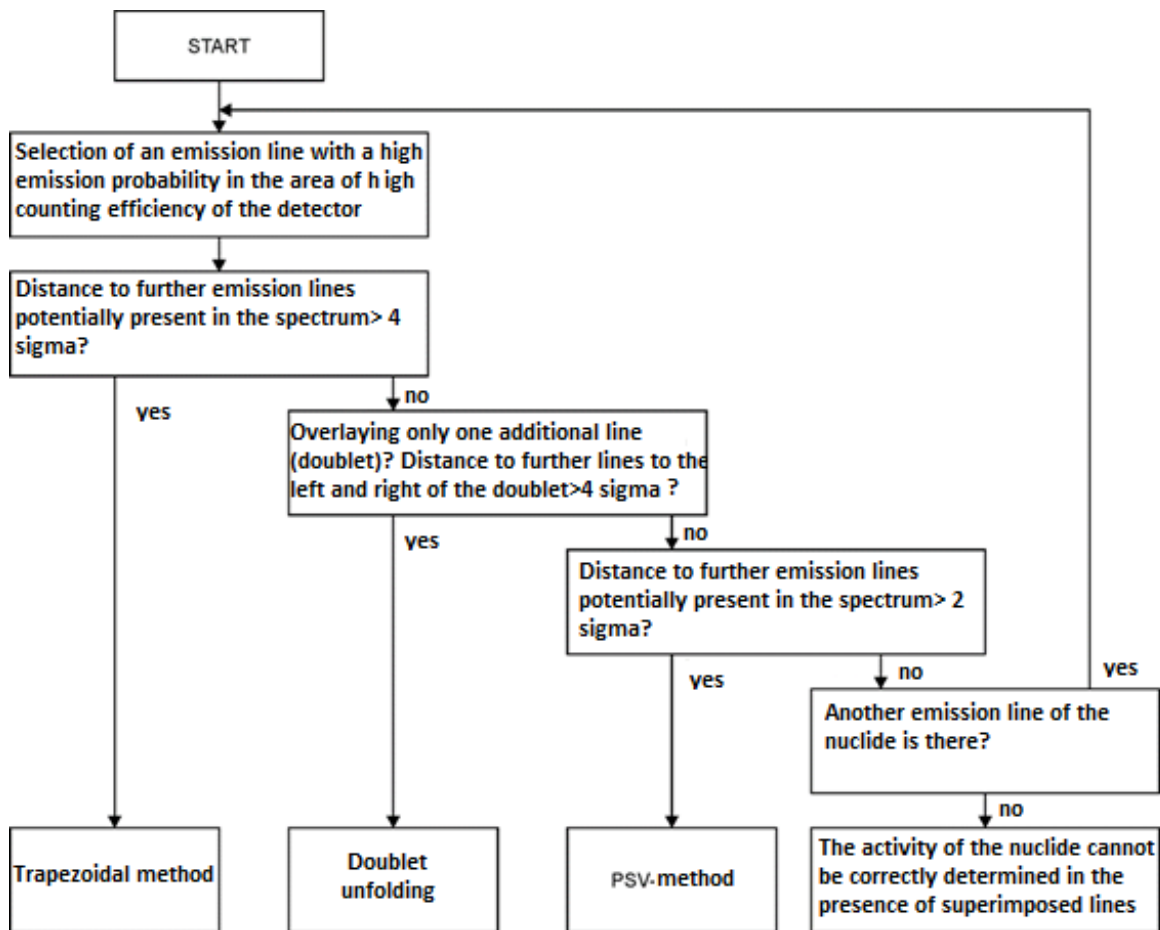
### Selection procedure

Lab-Scout Works can use an individual analysis method for each emission line. The following scheme shows the recommended selection process. Basically, however, the PSV method is first used to check whether an emission line actually forms a peak in the spectrum. In the Lab-Scout itself, only the PSV method is used. Trapezoidal method and doublet unfolding offer an opportunity to reduce the measurement uncertainty if the emission lines are selected properly.

Further general principles apply for the selection of the lines to minimize the detection limits and the statistical measurement uncertainty:

- Use of lines that are as isolated as possible (large distance to neighboring emission lines)
- High transition probability (selection according to the nuclide data)
- Use of lines in the area of high detector counting efficiency (decreases in the direction of higher energy)

Due to the different optimization parameters, the best possible compromise in terms of line selection and analysis method must be found in practice. The selection procedure to be used is shown in the following diagram.



*What to do, if there is no adequate nuclid line?*

Many samples do not contain potentially interfering nuclides or contain negligible amounts in relation to the nuclide to be analyzed. If this can be assumed (e.g. checking for the absence of further lines of a nuclide), the line selection must be carried out again without considering the interfering nuclides. An assessment in this regard should always be carried out by a specialist in gamma spectroscopy.

**Calibration**

Careful calibration of the Lab-Scout is required to obtain a reliable measurement result. The general procedure is described in the corresponding chapters of the manual. However, it makes sense to adapt the calibration to a specific sample type. For energy and peak width calibration, spectra with as few emission lines as possible should always be used in the energy range that is relevant for the subsequent sample (emission lines of the calibration emitter correspond to or are very close to the energy of the nuclides to be analyzed). The base spectrum below the emission lines will be linear. Any test source can be used for energy and peak width calibration, and the calibration can be carried out on the basis of several spectra. Cs-137, K-40 or Thorium (Th-208) radiation sources are particularly suitable. The efficient calibration must be carried out with reference emitters which correspond to the geometry (vessels used, filling quantity, material density) of the subsequent samples. The emission lines used for efficient calibration should be close to the lines used for sample analysis. The analysis method used later for the sample should always be used for calibration.

Note: Using a few, well-chosen emission lines often provide a more precise calibration than using many lines within a complex spectrum.

---

### Calculation of the nuclide-specific activity

In order to be able to determine the activity of a nuclide within a sample, in addition to the net pulse number (N) in the photo peak are required: the measuring time (T), the transition probability of the emission line selected (P), the sample weight (G) and the counting yield (efficiency  $\eta$ ) of the detector. The transition probability is a constituent of the peak information of an entry in the peak list. The efficiency must be determined by a previous calibration. It contains both the energy-dependent response curve of the detector and the geometry effects and absorption effects of the sample or between detector and sample, resp. The activity of a nuclide can be calculated as follows:

$$A = \frac{N}{T * P * G * \eta}$$

### Selection of the analysis method with Lab Scout works

The Lab-Scout always uses the PSV method to display the measured values on the device. Further analyzes are only possible with the Lab-Scout Works software. If a spectrum is loaded from the device or a saved spectrum is opened, the results of the PSV method are output first. The "Tools" menu offers the choice of the trapezoidal method and the doublet unfolding.

If the trapezoidal method is selected, each emission line contained in the nuclide list used can be marked for this analysis method within a selection list. By calling up "Tools -> Trapezoid" again, you can change the selection or reset the analysis for all lines to PSV.

Selecting "Tools -> Doublet solver" opens a window with a list of all potential doublets detected using the nuclide list used. The calculation is carried out automatically and the results are accepted with the "Use Doublet Solver Results" button. To reset the analysis method to PSV, select the "Discard Doublet Solver Results" button.

The trapezoidal method has the highest priority for the output of results. This means that if a line has been marked for the trapezoid analysis, the result of this method will always appear, regardless of whether the line is part of a doublet. The results of the doublet unfolding overwrite the results of the PSV method after calling the doublet solver. The PSV results are output for all emission lines that have not been marked for the trapezoidal method or are part of a doublet.

The ROI window to the left of the calculated measured values always shows the relevant graphic for the respective analysis method. In the results list, the lines whose results were calculated using the trapezoidal method or Doublet unfolding are marked accordingly. The same applies to the printed protocol.

## Subsequent analysis with modified calibrations and nuclide lists

After loading a measurement from the device or opening a saved measurement, the calibrations and nuclide lists stored in the device or the file are used for the analysis. If other nuclides are to be analyzed or, for example, another efficiency or energy calibration is to be used, these can be loaded from the correspondingly generated files (see chapter Definition of the nuclide list and detector calibration). The origin of the respective information is displayed under the output fields for the measurement results. The analysis method is reset to PSV after the new information has been loaded. The doublet unfolding or the trapezoidal method must then be used again.

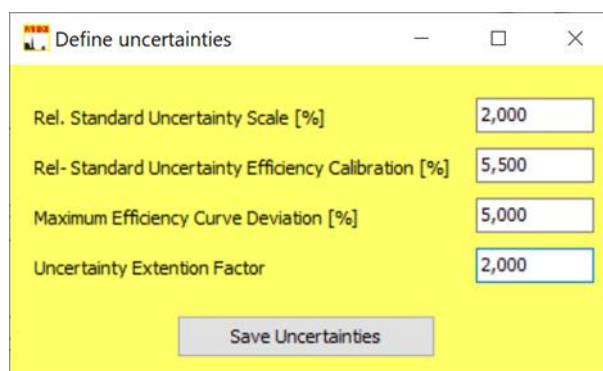
The current settings can also be adopted and used later for further measurements. All you have to do is select the menu option "Tools → Clip analysis setup". The following settings are cached:

- Energy and peak width calibration
- Efficiency calibration
- List of nuclides used
- Activated doublet unfolding
- Selection of the peaks to be analyzed with the trapezoidal method

After loading another measurement data file or reading a measurement from the device, the temporarily saved settings can be called up with the menu option "Tools → Use clipped analysis setup". The analysis is then carried out immediately accordingly. It is not necessary to call the doublet unfolding or the trapezoid method again.

## Management and specification of the measurement uncertainties

The total uncertainty of an analysis result results from the statistical uncertainty of the activity determination, the uncertainty in the determination of the sample weight and the uncertainty of the efficiency calibration (tracing back to a standard). The statistical uncertainty of the activity determination is derived from the counting statistics of the acquired spectrum, while the remaining uncertainties are derived from previous calibration processes. These uncertainty contributions are also managed by Lab-Scout Works. The menu option "Calibration → Uncertainties" is available for this and opens the following dialog window:

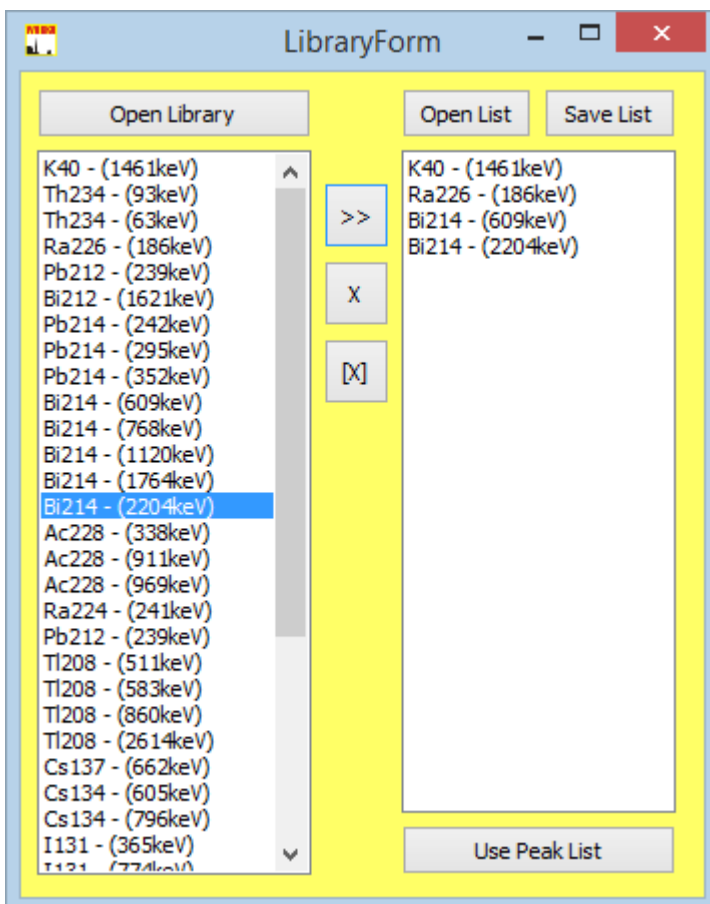


The values shown here correspond to the standard calibration procedure for deliveries and can of course be adapted by the customer if their own calibrations are carried out. The current settings are managed in the "UncertaintySettings.usf" file, which is located in the Lab-Scout Works program directory. Any changes are accepted with "Save Uncertainties". The file is loaded when the program starts. If the file does not exist, a request appears to create it using a dialog window. The standard uncertainty of the influencing variables must always be used when entering data.

When specifying the measurement uncertainties, the total uncertainty is given. This represents the Gesat standard uncertainty of the measurement result expanded with the Uncertainty Extension Factor. According to DIN 17025, a factor of 2 must be used in order to achieve an acceptance probability of 95% for the total uncertainty. The statistical uncertainty of the activity determination is given in brackets in the program window.

## Definition of the nuclide list

By means of the nuclide list (also called peak list) you will determine what emission lines shall be identified and quantified. The nuclide list contains a selection of sixteen emission lines at a maximum which will be displayed later as measured values and stored, respectively. Due to the flexible handling of the list the different peak lists can be used on an acquired spectrum. The selection of the emission lines will be performed by the help of a library (such as "Gamma\_Library\_DecimalByDot.txt" or "Gamma\_Library\_DecimalByComma.txt" which will be part of the delivery volume of the operating software the contents of which can be edited by the user. Please note: the library file must be selected with respect to the used Windows localisation schema (dot or comma as decimal separator). Otherwise, the library will be loaded incompletely.



Each line of the file contains the name of the nuclide the emission energy as well as the transition probability of the photo peak. These entries are separated by tab stops. By means of the Windows Editor you can add any nuclides. But note, that the names of the nuclides shall have only five characters at a maximum, the emission energy shall be entered as an integer value in the unit "keV" and the transition probability in percentage (here are floating point numbers allowed).

The software offers an easy possibility to edit the nuclide list. These can be called by the menu option "Library -> Edit". It will open a dialog window that contains at the right side a list box for the nuclide library, and at the right side a further list box with selected emission lines.

First of all, by means of the switch area „Open Library“, a library must be loaded.

The buttons between both lists perform the following manipulations:

- [x] will delete all entries from the nuclide list
- X will delete the selected entry from the nuclide list
- >> will take over the entry into the nuclide list as selected in the library

At a maximum, sixteen nuclides can be assigned to the nuclide list. Therefore, possibly, you should remove that photo lines not needed any longer, before you will add new lines.

By means of the switch areas „Open List“ and „Save List“ you can store the nuclide lists made out or you can load them. By means of the switch area “Use Peak List” the new list will be taken over. The transfer to the instrument shall be done by clicking the menu option „Library -> Transfer“. Precondition for it is an opened connection to the instrument.

The changes of the peak list will directly affect the results derived from the displayed spectrum but it will not affect the settings of the instrument.

## Detector Calibration

Several calibrations are required for the identification and quantification of radiation sources.

### Energy calibration

is used for the positional determination of a peak within the spectrum (assignment of the ADC channels to the emission energy)

### Peak-Width calibration

It delivers the anticipated comparison value to the actually measured peak width.

### Efficiency calibration

compensates the energy-dependent response curve of the detector as well as the absorption in the probe or between probe and detector, resp.

The instrument will be delivered with being completely calibrated. There are, on your choice, different efficiency calibrations for common standard applications. But in case of special applications, a new calibration might be required.

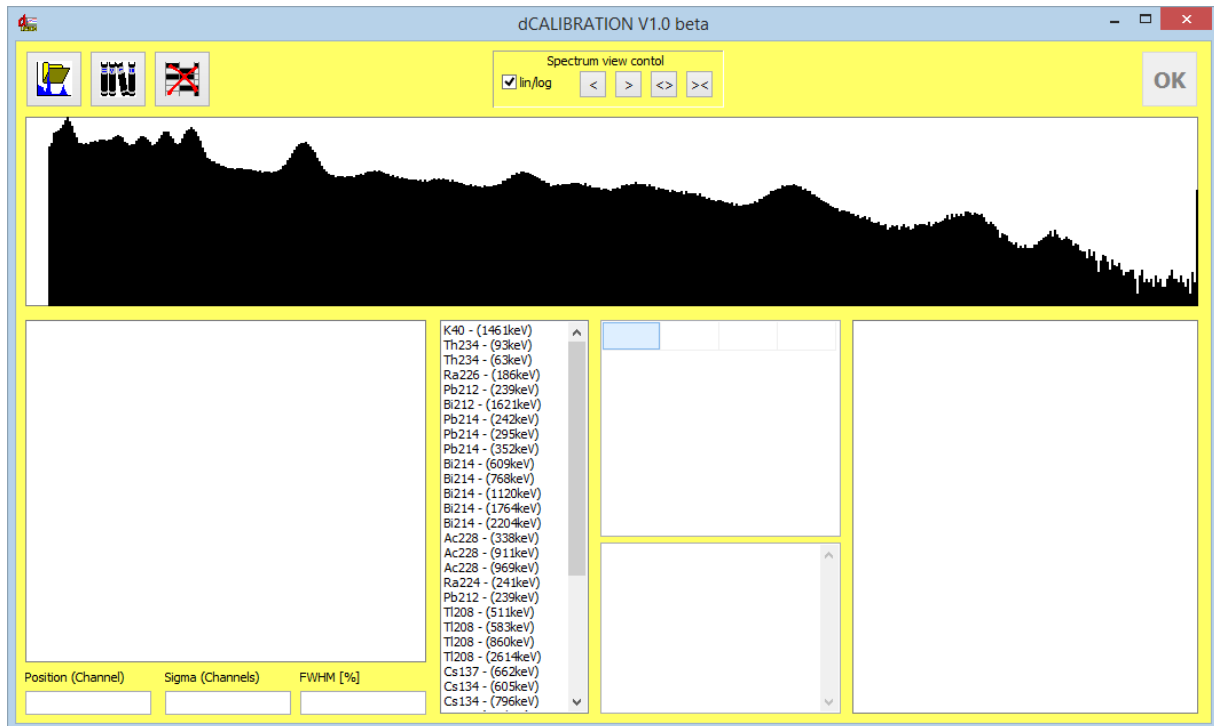
The calibrating functions are accessible by the main menu item “Calibration”. The various functions will be explained in detail in the following paragraphs.

### **Energy calibration and peak width calibration**

The calibration of energy and peak width will be performed in one single step. At the beginning, a calibrating spectrum will be taken by means of the instrument that should contain isolated photo lines as many as possible in the whole energy range. We recommend to use a solid radium or thorium test source. The measuring time shall be selected in such a manner that the statistical fluctuations of the single counting channels will not result in a falsification of the Gaussian profile of the peaks. Now, the acquired data can be opened or loaded from the instrument to display the calibrating spectrum. The menu option “Calibration -> Energy/Peak Width -> Calibrate” will open an interactive dialog window that already will contain the calibrating spectrum. The following steps shall be carried out:

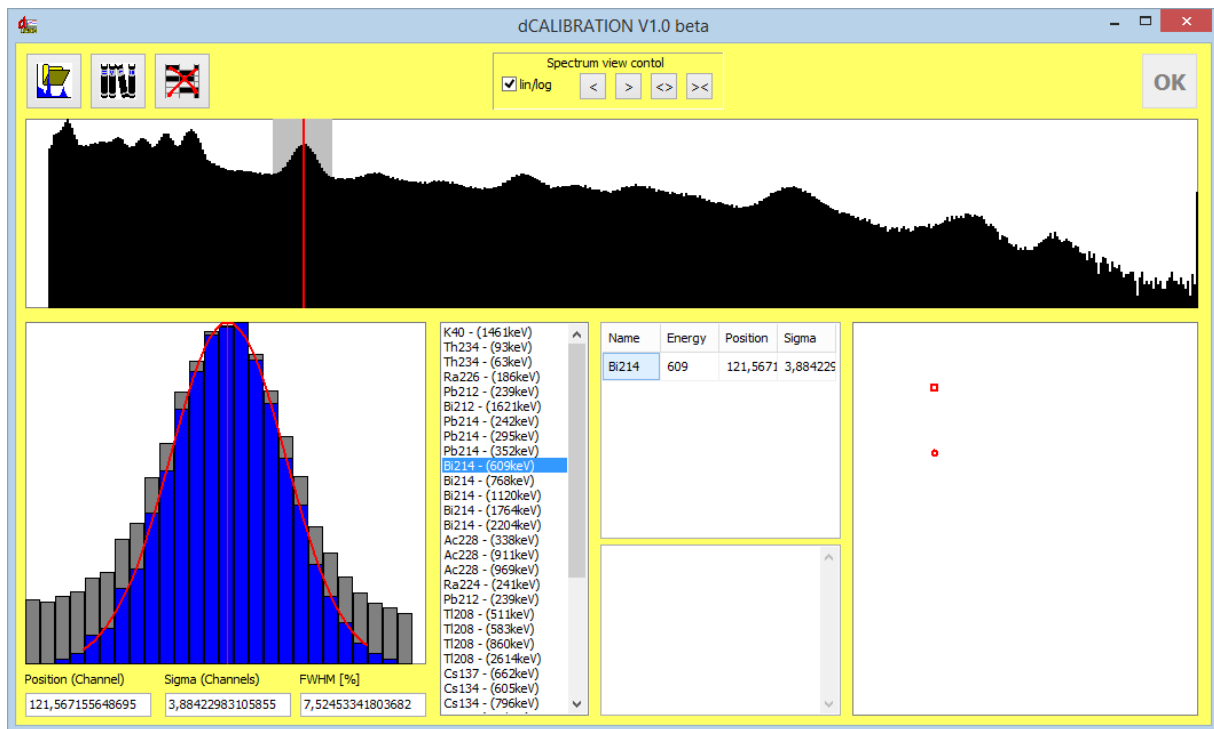
1. Open a nuclide library. This text file must contain that photo lines as used for calibration. The Installation of the software contains the standard library file “Gamma-Library.txt” in the program folder (subfolder Library).





2. Mark the limits of the first peak that is intended to be used for calibration. In order to set the markings you should click – by means of the right mouse key at the right side, by means of the left mouse key at the left side – beside the peak. The peak range is highlighted in grey colour in the spectrum and appears separately in the graphic box under the spectrum. The limits shall be set in such a manner that the whole peak will be contained. The ROI selection can be fine-tuned with the navigation buttons above the spectrum. The boundary channels are used for linear background subtraction. The blue bars show the net peak after this subtraction. With sufficient statistics and correct range selection, the net peak should appear symmetrical. The program superimposes a Gaussian curve, which represents the modeled peak, with the parameters expected value ( $\mu$ ) and standard deviation ( $\sigma$ ) determined from the real spectrum. These parameters and the resulting peak width (FWHM) are output in the text fields below.

A double-click on to the nuclide in the library that corresponds with the selected peak will add its pieces of peak information to the list of calibrating points (right-hand side beside the nuclide library). The graphic box at the right down side will display the first data points for energy and FWHM.

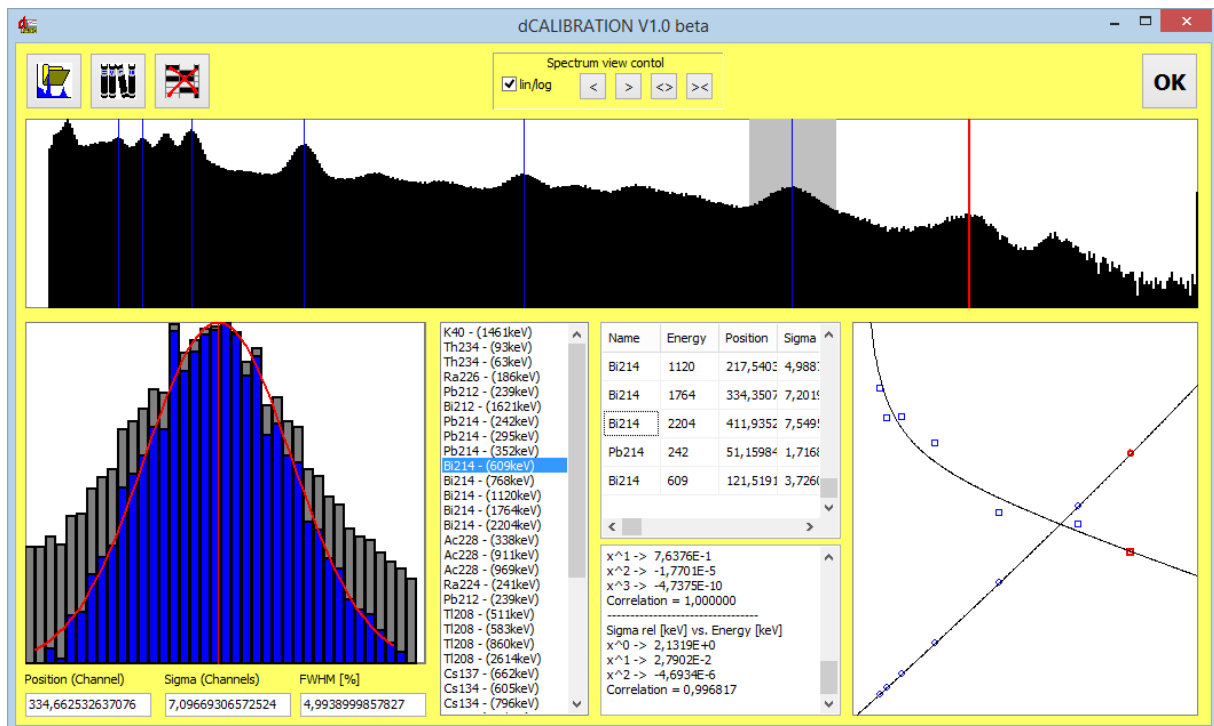


3. Repeat that steps as given under point 2 for the next peaks. Already with adding the second data point the calibrating curves will be calculated. But you should consider that a polynomial of third order will be expected as a calibrating curve. Therefore, four data points at a minimum should be used. At a maximum, nine data points can be used. At the same time, the peak width calibration will be performed by using the Sigma calculated of the single peaks. This will be described by a polynomial of second order.

In order to remove a peak from the list it will be sufficient to double-click in the corresponding line of the calibration point list. The text field beneath it contains the calculated coefficients of the polynomial for various instrument-specific definitions of the calibrating function.

It is possible to carry out the calibration using different spectra (eg with different sources). To do this, the calibration window must be closed and another spectrum opened or loaded for viewing. Now the window for energy calibration can be opened again. The calibration points off the previously used spectrum are still available.

The graphic box at the bottom right now shows the qualitative course of the calibration curves. These should increase monotonically (energy calibration) or decrease (peak width). The deviation of the calibration points from the curve should be as small as possible. The correlation coefficient acts as a measure of these deviations. This is indicated next to the polynomial coefficients in the text box. Correlation coefficients greater than 0.99 indicate a good calibration.



The calculated coefficients will be taken over by means of the button „OK“. The calibrating parameters can be entered into the instrument by the menu item “Calibration -> Energy/Peak Width ->Transfer” (precondition is an opened connection to the instrument).

The changes of the energy/peak width calibration will directly affect the results derived from the displayed spectrum but it will not affect the settings of the instrument.

### Efficiency calibration

In order to correctly calculate the activity of a nuclide, in addition to the knowledge of the emission probability of the used photo peak, the energy-dependent counting yield of the detector must be taken in account. On the one hand, it is dependent on the detector sensitivity and, on the other hand, on the absorption in the sample or the shielding between sample and detector, resp. In case of nearly homogeneous samples and emission lines greater than 80...100 keV ( $E_{cut}$ ) the efficiency can be described very well by means of a potential function of the following equation:

$$\eta(E) = \frac{R(E)}{Z} = A * E^B$$

with:

$\eta(E)$  Detector efficiency for the photo peak with the emission energy E

$R(E)$  energy-dependent counting rate of the detector

Z decay rate of the relevant photo line of the emission energy E

E emission energy

A, B equation parameters of the approximation function

The range below  $E_{cut}$  will be approximated by a linear function, which is tied to the potential curve the energy defined by  $E_{cut}$ . The parameter m sets the slope of the linear function and may be entered by the user. If one or more calibration points are available for that range, the linear function will be approximated too. In practice, a very low number of utilizable emission lines are located in that region.

Therefore, in the most calibration and sampling situations this range is not used and the values  $m = 0$  and  $E_{\text{cut}} = 80\text{keV}$  can be used.

From this, an easy and quick possibility is given for efficiency calibration by means of a reference sample. Geometry and density of the reference sample should correspond at a good approximation with those of the samples to be analysed. Generally, only two emission lines will be required. Due to the function course one line should be below 300 keV, another line above a 1,000 keV. The calibration will be very easy if all the required lines are existent in one spectrum.

Precondition for the efficiency calibration is an energy and peak width calibration of the instrument already performed. Firstly, a measurement of the reference sample shall be performed. The measuring time should be taken in such a manner that the expected statistical error of the achieved counting sums can be neglected in the photo peaks that are used for calibration.

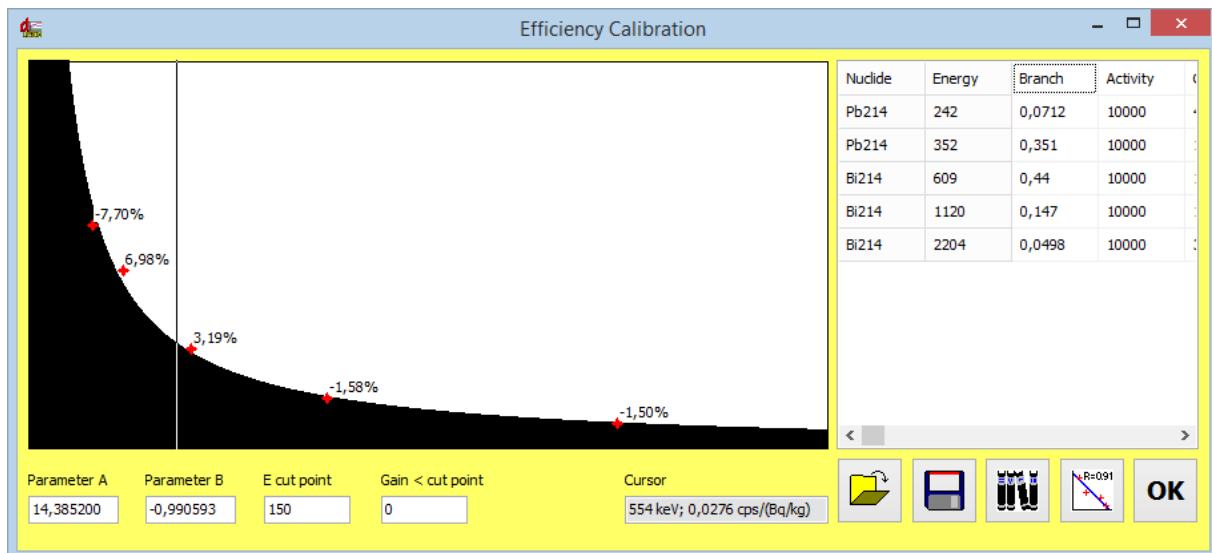
At first, the calibration spectrum must be loaded or opened. In order to simplify the calibration, first of all, the peak list should be adjusted in such a way that all the emission lines needed for calibration are contained. (Refer to section "Definition of the peak list"). With a correct energy calibration and sufficient counting statistics, corresponding net counting pulses (peak area) will appear for the selected peaks in the result box of the tool window. They will be taken over jointly with the parameters of the selected peaks for the efficiency calibration.

By clicking onto menu item "Calibration -> Efficiency -> Calibrate" the calibrating window will be opened. Before, a query to enter the activity of the reference sample will appear. This value is used as a pre-setting for all the peaks included in the calibration. If all the peaks of a nuclide or a decay series are in a radioactive equilibrium so there will be no need of more entries later. Here likewise, we recommend e.g. radium or thorium samples.

The calibrating window, at the left side, contains a graphic range to display the relevant efficiency calibration function. Below the graphic range, energy and efficiency will be given for the relevant cursor position. Small red crosses will mark the calibrating points determined from the available reference measurement and the activity pre-setting.

The table in the right window range contains all the emission lines needed for calibration. The fields for activity and counting rate can be edited. This allows entering the true values for all nuclides their activities do not fit with the previously input. Furthermore, the peak list can be increased (or reduced) in order to include calibrating points from other samples (with manual input of activity and count rate).

A click on the button „ SELECT “opens the selection dialogue. Of course, for these emission lines both the counting rate and the reference activity needs to be entered later.



If you now click on the button „CALIBRATE“, the program will calculate the approximation best possible of the before-described function for all the calibrating points used. The resulting deviation of the single markings from the functional value should amount some percentages at a maximum, otherwise the reference activities assigned to the lines shall be checked and possibly changed in the table right beside the graphic. If greater deviations remain existent in spite of correct entries, one or several lines might be unsuitable for calibration, e.g. by superimposing of another line or insufficient counting statistics. Use the button “APPLY” to return to the spectrum and applying the new calibration curve. Menu options to store and load of efficiency calibrations are at your disposal (“Calibration -> Efficiency -> Transfer”). The options “Open” and “Save” are still available so that calibrated sample geometries can be saved and reloaded later.

The changes of the efficiency calibration will directly affect the results derived from the displayed spectrum but it will not affect the settings of the instrument.

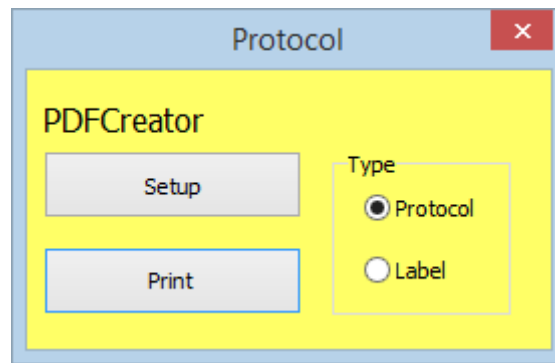
## Protocol print

The results of an analysis can be printed in protocol style. The software distinguishes between standard protocol and label print. While the protocol style has been optimized for standard A4 printer, the label format was implemented for special label printers. We recommend the usage of the model Brother QL-1050 or compatible. The list below shows the types of labels which can be used:

- DK-22205 endless label 62mm; paper
- DK-22113 endless label 62mm; transparent film waterproof, tear-resistant
- DK-22212 endless label 62mm; white film waterproof, tear-resistant
- DK-22606 endless label 62mm; yellow film waterproof, tear-resistant
- DK-11241 Shipping label 102mm x 152mm; white paper

Choose the menu option “Sample → Print protocol” to open the control dialogue for the print process.

A control dialog opens for selecting and setting the desired printer. The name of the selected printer is displayed above the buttons.



Clicking onto the button "Setup" opens the Windows printer dialog to choose the printer and to adjust print parameters, such as page orientation and paper size. Select either "Protocol" or "Label" to define the correct print format of your selected printer. When printing a protocol, the ROIs for all nuclides contained in the peak list are displayed graphically in addition to the spectrum and the analysis results. Printing is started by pressing the "Print" button.

## Definition of nuclide specific alert thresholds, Editing of library files

An individual alert threshold can be defined for each emission line of a nuclide. This is done by editing of a nuclide library. The nuclide library is a text file which performs the base of the nuclide list generation within LabScout Works. The structure of the file is very simple: Each line contains one emission line of a nuclide. The first item is the nuclide name (max. 5 chars) followed by the emission energy in keV, the branch probability in percent, and the alert threshold in Bq/kg. All items within the line need to be separated by tabulators – spaces must not be used. The alert threshold item is not obliged. If no value was present in the line, only the yellow lamp goes active in case of verified activity. It is recommended to use one of the delivered library files as base for individual changes. It is necessary to use the decimal separator within the library file with respect to the selected language scheme in LabScout Works (e.g. dots for English).

## Lead shielding

The instrument is equipped with a lead shielding covering the whole probe as well as the sample containment completely. The effective thickness of the wall is at least two centimetres. The function of the integrated scale is not affected. To avoid transportation damages, the unit comes disassembled. It needs just a few steps to assemble the instrument on site. Thus, the Lab Scout can be relocated easily if required.

The delivery contains following units:

- Instrument body with scale
- Electronic unit
- Detector unit with lead shield
- Two half shells to shield the sample containment
- Lead ring to shield the scale desk

The assembling procedure is shown in various video clips available at [SARAD's homepage](#) in the internet.

During sampling the both shells must be kept closed using the lock on the top of the shells. Take care that the scale desk can move between the lead shells and instrument body.

## Service instructions

We offer a comprehensive repair, maintenance and calibration service for all our products.

Please fill out the form on our homepage (<https://sarad.de/service.php>) **BEFORE SENDING A DEVICE** and send it to us. We need the device type and serial number as well as a short description of the error that occurred or the expected service. You will then receive an initial cost estimate from us as well as information on how to proceed.

The device check and the preparation of the cost estimate for repairs after the warranty has expired are subject to a fee.

To use the calibration service, please also go to our homepage ([https://sarad.de/product-detail.php?lang=en\\_US&cat\\_ID=1&p\\_ID=109](https://sarad.de/product-detail.php?lang=en_US&cat_ID=1&p_ID=109)) and fill out the appropriate form.

## Technical data

Detector	Natrium-Jodid (NaI(Tl)) with integrated PMT and high voltage power supply; scintillation crystal 2" x 2"; energy area: 25 keV – 3MeV; resolution < 7.5% (7% typ.) @ 662keV
Efficiency	net count rate: approx. 1100 cps / (μSv/h) based on Cs-137
Max. count rate	100.000 cps
Measuring range NaI-Detector	0 ... 15 μSv/h based on Cs-137
Spectrum	1024 channels
Measurement / Analysis	<ul style="list-style-type: none"> <li>• identification of up to 16 peaks (nuclide list)</li> <li>• creating various nuclide lists from an editable library or from predefined lists can be loaded</li> <li>• Determination of the nuclide-specific, weight-related net activity through variably applicable efficiency calibrations</li> </ul>
Stabilization	electronic stabilization of temperature; Peak-Pickup by PSV algorithm
Scale	0 ... 2,5 kg
Measuring times	1min, 5min, 15min, ½h, 1h, 4h, 12h
Data storage	2 GB-SD-card for more than 780.000 records
Operation / Display	Display 4x20, 1 button, signal lights (red,yellow,green)
Acoustical signal	80dB
Interface / Software	USB, Lab Scout Works (Analysis, Calibration, Configuration)
Environment	5 ... 35°C, 0 ... 95%
Power supply	Mains adapter 15V/250mA
Dimensions / weight	20cm /22cm/52cm (B/T/H); approx. 5.5 kg without lead shielding; with lead shielding approx. 68 kg