MultiSpect Analysis

User Manual

For software version 17.1.194 (November 2015)

The information in this manual describes the product at the time of writing and is subject to change without notice. Kromek frequently releases new software and hardware revisions and this manual may differ from what is seen.

Functionality within the software is controlled by licence. Which features are accessible will depend on the licence type applied by the user.

The Kromek logo, KSpect, MultiSpect, MultiSpect Analysis, D3, DS3, SIGMA, TN15, K102, GR1, Quant for GR1, and RayMon are registered trademarks of Kromek Limited.

Windows is a registered trademark of Microsoft Corporation in the US and other countries.

Contents

Introduction

MultiSpect Analysis is designed for Kromek's range of USB radiation detectors giving easy connection and setup, and analysis functions tailored to the detectors and their applications. **MultiSpect Analysis** *Premium* adds advanced functions for the quantitative analysis of activity which are not present in standard **MultiSpect Analysis.**

KSpect is a free version of the software with capabilities for data acquisition from one gamma and one neutron detector at a time, and basic peak region of interest analysis, without the advanced features of **MultiSpect Analysis**.

In order to use **MultiSpect Analysis** a licence is required that is supplied by Kromek which enables either the standard or the premium features. Without a valid licence, or after a trial licence has expired, **MultiSpect Analysis** will run with only the **KSpect** features available.

Software Installation

KSpect and **MultiSpect Analysis** are compatible with *Windows 7* and *8.*

To install the software double click the *setup.exe* file.

Microsoft SQL Server is installed alongside **KSpect** and **MultiSpect Analysis**. The installer will prompt the user if additional downloads are required from *Microsoft* during the installation process.

Software Updates

The software will check for updates periodically. If an update is found on the server the user is notified and given the option to download and install the update. The user can make the software check whether an update is available by selecting 'Check for Updates' from the 'Help' menu. If there is no internet connection on the computer running **KSpect** or **MultiSpect Analysis** installer files can be downloaded from the Kromek website. If the current licence will not work with the updated software the user cannot download the update. Notifications for updates which require a licence upgrade can be turned off by clicking 'File', followed by 'Preferences', and then clicking the checkbox for hide incompatible updates.

Licensing

When MultiSpect Analysis is run for the first time it will ask the user to enter a licence. The licence controls which features are available to the user. A new licence can be applied at a later time by selecting 'Enter New Licence' from the 'Help' menu.

Activating a licence

A licence can be activated in one of three ways:

1. Over the internet using a licence key
2. Via another computer that has an internet connection using a licence key (if you have no internet connection on the computer where the software is installed)
3. Using a file if you have been supplied with a licence file instead of a key

Please select the appropriate option and follow the on-screen instructions.

Moving a licence

To move your software licence to another machine please contact Kromek to have your licence reset. Moving your licence is free provided the licence is still valid.

Upgrading your licence

To upgrade your licence please contact Kromek for a new licence key. The new licence can then be applied by selecting 'Enter New Licence' from the 'Help' menu.

Main Screen Overview

When first loading **KSpect** or **MultiSpect Analysis** the main window is displayed:
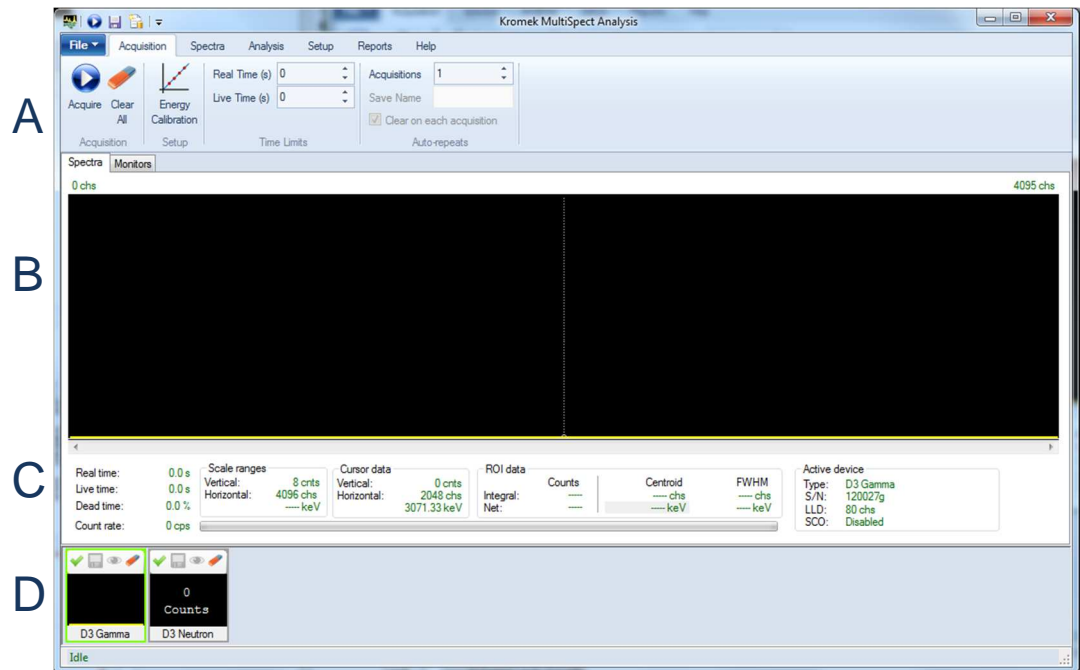
A. The menus at the top of the screen contain controls for starting an acquisition, viewing the data and choosing the analysis that is performed on the measured data. Double clicking the menu headings allows it to be hidden giving more space for the display of data. Shortcut buttons on the top title bar always give convenient access to the most important functions regardless of which menu tab is displayed. These can be configured from the drop down menu to the right of the shortcuts.

B. The plot area shows the data acquired from the detectors. When the 'Spectra' tab is selected the energy spectra from the detectors are displayed, and when the 'Monitors' tab is selected the count rate against time is plotted for the detectors. Note that only spectra are visible in **KSpect**.

C. When on the 'Spectra' tab a spectrum data box gives information on the active measurement and detector.

D. Every detector connected to MultiSpect, and every loaded measurement, is given a thumbnail. The thumbnail gives controls over just that single set of data. Clicking the thumbnail makes it active, shown by a green border, and all analysis is performed on the active measurement.

Connecting Detectors

Connect a compatible detector to the computer using a USB cable. The software will recognize the hardware and indicate that the device is connected in the status bar at the bottom of the window.

The software displays a dialog listing the newly-connected detector, asking you to enter or confirm the serial number of the detector:
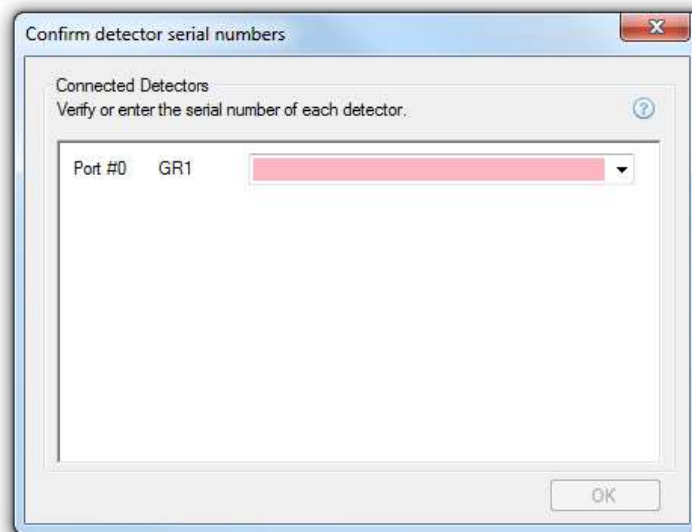
Enter the serial number of the detector and click *OK*.

The device is now ready to start acquiring data.

Detector serial numbers

KSpect and *MultiSpect Analysis* allow you to enter calibration data and other device settings for each detector and save this information for future use when the same detector is connected again. It is important to use the same serial number for the detector each time you connect that detector so the correct stored values are used.

You must give each detector a unique serial number. The serial number can be any text, but we suggest you use the serial number printed on the detector if possible. If you have more than one detector connected, you can see which is which by checking the Port names in the dialog. The Port names identify the USB ports you have connected the detectors to, and will be the same when you connect the detectors again.

When you re-connect a detector on the same USB port, KSpect/MultiSpect assumes that this is probably the same detector you last connected to that port, and puts the

serial number of that detector in the serial numbers dialog. So if you always use the same detectors in the same USB ports, all you have to do after the first time is check that the serial numbers in the dialog are correct, and click 'OK' or press the [Enter] key.

The software remembers each serial number you have used. So if you change which detector is connected to which port, you can simply select the correct serial number from the drop-list of serial numbers beside each detector.

If you choose the wrong serial number, and you only realize this after you have closed the dialog, just disconnect the detector and re-connect it - The software will display the dialog again so you can select the correct serial number.

Known detectors can be managed by selecting 'Manage Detectors' from the 'Setup' menu allowing editing of device information and records of old detectors that are no longer used to be removed.
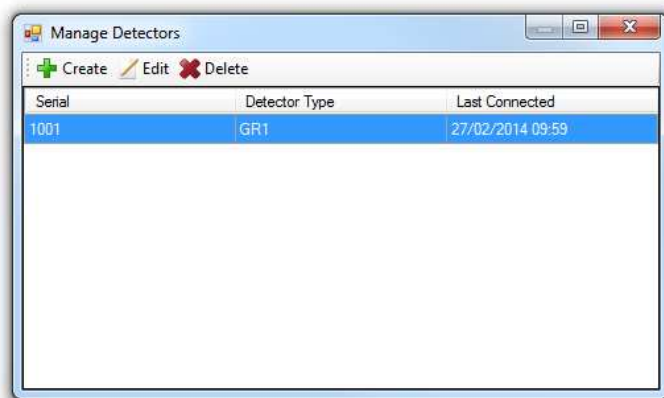
- **Create** can be used to add a new detector.
- **Edit** will allow the serial number or the device type to be changed.
- **Delete** removes the detector and all associated calibrations.

Selecting detectors in KSpect

KSpect is limited to only acquiring from one gamma ray detector and one neutron detector at any one time. If multiple detectors are connected the active detector can be selected from the 'Setup' menu.

Acquiring Data

MultiSpect Analysis can acquire from all connected detectors simultaneously. *KSpect* supports acquisition from one single gamma ray detector and one neutron detector at a time. The active detector can be selected from the *Setup* menu.

Starting data acquisition

Pressing the 'Acquire' button located either on the 'Acquisition' menu or shortcut menu at the top, or pressing [F1], will begin collecting data from all the enabled detectors.

When detectors are first connected they are enabled for data collection by default. If multiple detectors are connected it is possible to disable an individual detector to stop data being recorded during acquisition using the button on the detector thumbnail (see page 12).

Clearing acquired data

MultiSpect Analysis can simultaneously display results from multiple detectors and loaded measurements. At any one time there is one selected or "active" measurement, which is chosen by clicking on a thumbnail, and is highlighted by a coloured border around the thumbnail. After selecting the thumbnail showing the data to be cleared press the 'Erase' button, or the [F2] key, to clear the data.

Acquisition time limits

The acquisition of data can be stopped automatically after a user specified time limit has elapsed. Two different time limits are available: real time and live time. Real time is the total duration of the measurement. Live time is the total time the detector has been active and able to record data. The values of these limits are set using the '*Real time'* and '*Live time' limits* controls located on the 'Acquisition' menu.

A limit of zero will be ignored and allow acquisition to continue indefinitely. If both limits are set to non-zero values, the one that is reached first will stop the acquisition. If both limits are zero, the acquisition will not stop until the 'Stop' button, or the [F1] key, is pressed. The limits can only be adjusted when the acquisition is not active.

Performing auto-repeats

Repeated acquisitions of a fixed duration can be saved into the database automatically. They are configured from the 'Acquisitions' menu. All enabled detectors will be included in the repeat measurements.

To perform repeated acquisitions:

1. Set the number of measurement to perform in the 'Acquisitions' field. Set this value to '1' to disable repeated acquisitions.
2. Provide a 'Save Name' that will be used for the measurements in the database. This 'Save Name' will have the number of the repeat appended when saved. The 'Same Name' will be used for measurements from all detectors in the acquisition.
3. To clear the data before each repeat tick the 'Clear on each acquisition' check box.
4. Provide a 'Live Time' and/or 'Real Time' limit for each repeat.
5. Enable/disable the detectors you wish to include/exclude from the acquisitions using the controls on the detectors' thumbnails.
6. Start the acquisitions by clicking the 'Acquire' button.
7. Repeat acquisitions can be cancelled at any time by clicking the 'Stop' button. All completed acquisitions up to that point will have been saved into the measurement database.

Overflow bin suppression

The highest channel of a spectroscopic detector is used to collect all counts that are higher than the upper range of the detector. This can result in a spike appearing at high energies depending on the type of detector being used. To avoid this spike the overflow counts can be suppressed. This suppression is configured under 'File' and 'Preferences'. Suppression is enabled by default when the software is first installed.

Spectrum Cursor

A vertical dashed line in the plotting area of the 'Spectra' tab forms a cursor allowing data to be read from the graph and several different operations such as region of interest (ROI) selection, energy calibration, and lower level discrimination (LLD) adjustment.

The position of the cursor can be shifted by a single channel using the [Left] or [Right] arrow keys on the keyboard. Larger steps in the cursor position are obtained by pressing the [Page Down] or [Page Up] keys. Left-clicking the mouse anywhere on the spectrum plot will also move the cursor to that channel in the spectrum.

The 'Cursor data' section of the spectrum data box gives the spectrum information at the position of the cursor.

Detector and Measurement Thumbnails

Below the data plots section are the thumbnails. Each thumbnail shows a miniature representation of the data from the detector. The source of the data is shown underneath and there is a toolbar of buttons to manage the data at the top. Hovering

the mouse over the thumbnail will display the serial number or measurement name of the thumbnail.

The buttons on the toolbar save the data (if it has changed since the last save), hide or show the data in the main plot, and clear or close the measurement. There is also an 'enable/disable acquisition' button; when acquisition is started, only those detectors that are enabled will acquire data. The input spectra to an aggregate can also be configured from the thumbnail. During acquisition, the enable and disable acquisition buttons are disabled.
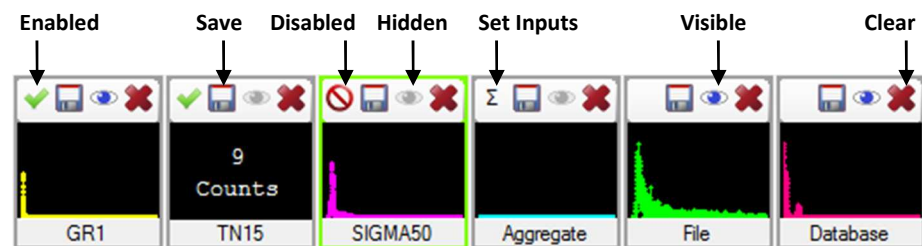
Additional functions are available by right clicking the thumbnail. For example, data can be copied to a new thumbnail by right clicking the existing thumbnail and selecting "Copy". This is particularly useful for preserving acquired data and using it for comparison.

After loading a measurement, the information on the measurement can be seen by right clicking the thumbnail and selecting 'Measurement Information'. A window is displayed showing information including any associated neutron measurements. This window also allows some of the data to be edited.
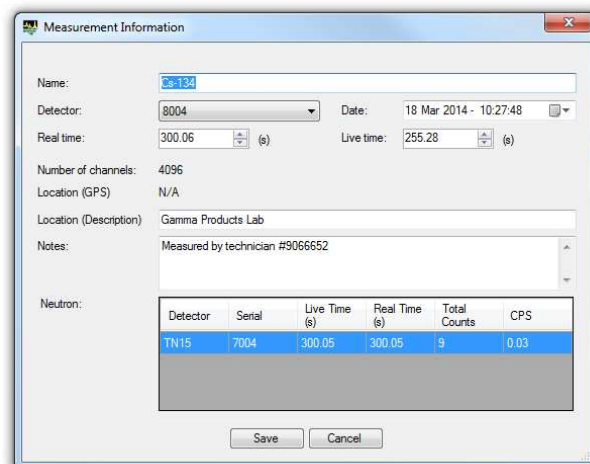
Spectrum Display Settings

Spectrum display settings can be found on the 'Spectra' menu. The menu will only be visible when the 'Spectra' view is shown.

Zooming

Pressing 'Zoom in' at the top, or pressing the [F4] key, zooms in at the position of the cursor. The plot area is split into two sections, the top showing the full range spectrum and the lower the zoomed in region. Pressing 'Zoom in' again increases the level of magnification. Zooming can also be achieved with the mouse wheel after clicking on the spectrum.

Clicking at a different point on the top spectrum changes the region shown in the zoomed in section of the display. Directly beneath the plot area is a scroll bar that can also be used to change the view area when the horizontal scale has been zoomed in. Additionally, right-clicking the mouse when the pointer is over the spectrum display will bring up a context menu with selections for zooming.

The spectrum can be returned to full scale by repeatedly pressing 'Zoom Out' / [F5] or pressing 'Full Scale' / [F6].

Vertical scale

The vertical axis of the spectrum plot is in units of counts. The maximum displayed value can be changed using the *Vertical scale* controls located on the 'Spectra' menu. Pressing the [Up]/[Down] arrow key will also move the axis maximum counts stepping up/down through the available values.

This maximum counts value can be set to a fixed value, or to automatically adjust to the maximum value of the data being plotted. You can choose whether auto-scaling adjusts to accommodate all spectra or just the active spectrum in the program 'Preferences' from the 'File' menu.

Channels or energy on horizontal axis

Note: This functionality is not present in *KSpect*

Spectral data from a detector can be plotted by raw channel number where the counts have been detected. If an energy calibration exists for the detector, providing the conversion of channel to energy, the spectrum can also be plotted on an energy scale. To enter an energy calibration see the calibration section. The 'Energy mode' button located on the 'Spectra' and 'Analysis' menus allow the user to switch between displaying the spectrum in channel and energy modes:
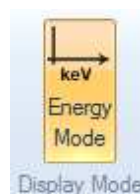
When multiple detectors are connected their spectra may not be directly comparable because of differences in the energy calibrations. **MultiSpect Analysis** transforms the channel counts into energy bins using an interpolation algorithm to reassign event counts from the detector channels to the normalized energy channels, maintaining the total counts from the detector. The user can select the energy interval using the 'interval' drop down box. In this energy display mode the spectra from different detectors are directly comparable and operations can be performed to combine detectors.

Visible spectra

Any number of spectra can be loaded into memory and displayed with **MultiSpect Analysis**. **KSpect** is limited to 5 spectra at a time. Each spectrum can be made visible or hidden by clicking on the show/hide button in the toolbar of the spectrum's thumbnail. The currently active spectrum must be visible and therefore its visibility button is disabled.

Spectrum colour

The colour used to display the spectrum can be changed by right clicking the thumbnail and selecting 'Colour'.

Energy Calibration

Each spectral detector has its own energy calibration for converting the channel number to the energy of that channel. Using a suitable radiation calibration source the energy of particular channels can be measured. When two or more data points for the calibration are entered the energy calibration will automatically be calculated. The energy calibration is determined through a fit of the channel-keV conversion data points to a straight line.

To enter a calibration right click the detector thumbnail and select 'Energy calibration'. This can also be done by selecting the thumbnail and clicking 'Energy calibration' located on the 'Acquisition' menu. A data grid will be displayed allowing pairs of channel and energy values to be entered:
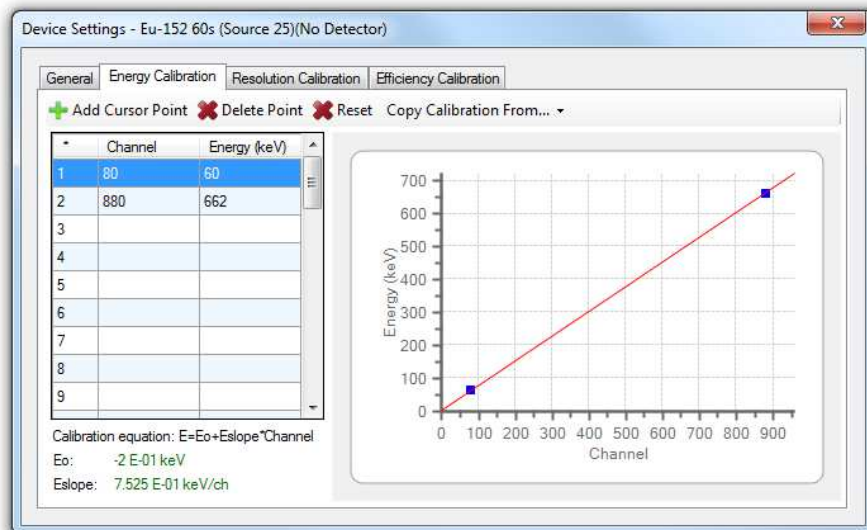
Using this window, data points can be directly entered into the data grid. The 'Add Cursor Point' button will set the channel cell in the current spreadsheet row (the row where the spreadsheet cursor is positioned) to the channel value of the spectrum cursor.

A shortcut for entering calibration points is to position the cursor on the active spectrum and enter the keV value in the text box in either the 'cursor data' or in the 'centroid' of the 'ROI data' of the data box below the spectrum.

The 'Delete Point' button will delete the data contained in the current spreadsheet row. Deleting a data point can also be accomplished by selecting and deleting the energy value associated with the point in the spreadsheet. Finally, pressing the 'Reset' button deletes all the data points clearing the calibration.

The calibration for the active spectrum can be copied from that of another spectrum loaded in memory by selecting 'Copy Calibration From' and then selecting the source spectrum from the drop-down list.

When modification of the calibration is finished, the calibration window can be closed using the standard widow close button located at the upper right corner of the widow.
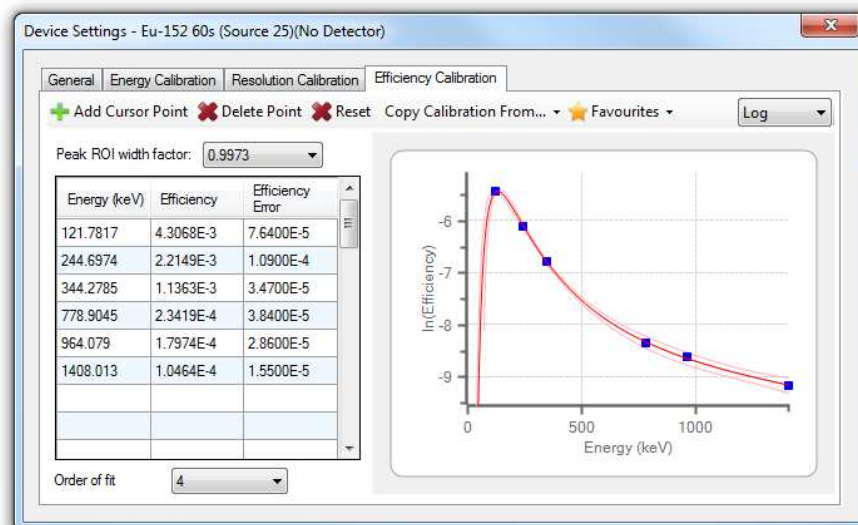
Efficiency Calibration

Note: This functionality is only present in **_MultiSpect Analysis Premium_**

Where the detector and radioactive sources are used in a fixed geometry an efficiency calibration of the system can be used, together with the measured count rates in spectrum peaks, in calculating source activity. Tools are provided allowing the user to determine the efficiency of their system using a calibration source of known activity. The detector must have an energy calibration and a resolution calibration before an efficiency calibration can be entered, and the spectrum must be displayed in 'Energy Mode' with an energy horizontal axis (see page 14).

Defining the calibration

The efficiency calibration is defined in the "Detector Settings" window which can be opened from the "Setup" ribbon menu, or by right-clicking the measurement/detector thumbnail. The "Efficiency Calibration" tab shows the calibration, the fit to the data and the 1 standard deviation confidence limits on the fit to the data. The graph can be viewed on either a linear or log scale by changing the option in the dropdown box above the graph.

Each efficiency point, ε, in the efficiency calibration is defined from:

$$\varepsilon = \frac{R}{SP_\gamma}$$

Where:
R is the measured photopeak net count rate,
S is the activity of the source on the measurement date, and
P_γ is the probability of emission of the gamma rays being measured.

All efficiency calibration points must be made with the same the peak region of interest width factor setting for analysing the net counts in the peak.

The error on the data point is calculated from the errors on the net count rate and the source activity.

After recording a spectrum from a calibration source of known activity place the cursor on a photopeak and press the 'Add cursor point' button. An efficiency calculation window is displayed allowing the efficiency and error to be determined for the selected peak.
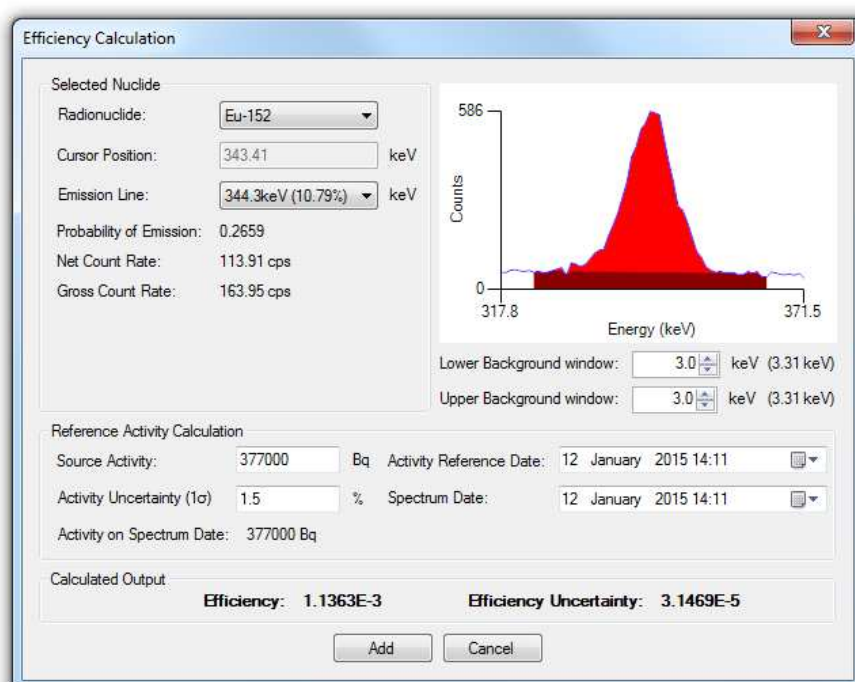
Choose the radionuclide and emission line for the selected peak. MultiSpect will measure the net counts in the peak. The number of bins used on each side of the peak for determining the background to be subtracted can be adjusted with the 'upper' and 'lower' window controls under the display of the peak.

Enter the calibrated activity of the source and the one standard deviation uncertainty in the activity for the reference date when the source was calibrated. MultiSpect uses the half-life of the radionuclide for calculating the activity on the spectrum measurement date.

The calculated efficiency and error are displayed at the bottom of the screen. To add this as a data point to the efficiency curve press 'Add'.

Fit to the efficiency data

MultiSpect fits the efficiency data points with the following curve:

$$\ln(\varepsilon) = a_0 + a_1 \ln(E) + a_2 \ln(E)^2 + \cdots + a_n \ln(E)^n$$

Where:

ε is the efficiency,

E the energy,

a_i are fitted coefficients,

and the order of fit, n, is between 3 and 7.

The user must select the order of fit most suitable for their data from the control on the 'Efficiency Calibration' tab. The ±1σ errors on the fitted line are shown with pale pink lines on the calibration curve. It is important to inspect these errors to identify if the chosen curve is a realistic fit to the data.

Note that the validity of the fit outside the region where data points lie falls rapidly and causes large errors on the extrapolated values. A wide range of data points should be included in the calibration.

Managing efficiency calibrations

Saving and loading efficiency calibrations

After an efficiency calibration has been entered it can be saved for future use by the 'favourites' menu. This allows several efficiency curves to be stored for different geometries. The same menu allows a stored calibration to be loaded to the detector. Only one efficiency calibration can be loaded at a time and this is the one used for analysis.

When a measurement is saved in the database the efficiency calibration is saved with that measurement for future use.

Copy calibration from another measurement or detector

The efficiency curve can be copied from another live detector or loaded measurement to another by using the 'copy calibration from…' option on the 'efficiency calibration' tab of the 'detector settings' window.

Exporting/Importing efficiency calibrations

Efficiency calibrations can be exported and imported from the star menu to move them to other computers which use the same detector or where analysis will be continued.

Other Device Settings

Depending on the particular type of detector that is connected additional settings may be available. These are all displayed in the "Device Settings" window from the "Setup" menu or from right clicking the thumbnail. These operations are described below. They relate to the active thumbnail and clicking between thumbnails will show the settings for the chosen detector or measurement.

Lower level discriminator (LLD) adjustment

The LLD is a setting of the attached detector. This setting is a channel value corresponding to a pulse height below which the spectrometer should ignore all pulses. To adjust the LLD, click 'Set LLD' from the 'General tab' of device settings. The spectrum cursor will change to one labelled Set LLD and will appear at the location of the current LLD setting. The LLD setting is then adjusted by moving the cursor. The cursor can be moved with the arrow keys, with the [page up]/[page down] keys, by left-clicking with the mouse anywhere along the spectrum, or by left-clicking on the cursor and dragging with the mouse. The LLD is typically set to cut out the noise counts at the low energy side of the spectrum. After the desired LLD is set, select 'Set LLD' again to exit the set LLD mode.

Software cut off

In addition to the hardware LLD a software cut off can be applied. This is purely in the software and is specified in channels relative to the hardware LLD position. To set this cut off first enable the cut off with the checkbox and then enter the number of channels offset on the 'General' tab of 'Device Settings'.

Dead time factor

KSpect and *MultiSpect Analysis* calculate dead time in the detectors based on a single dead time factor which is set on the 'General' tab of the 'Device Settings' window. Total dead time, D, is calculated from: $D = \tau MT$, where τ is the dead time constant, M is the measured count rate, and T is the real time. The live time, L, is then calculated from: $L = T(1 - \tau M)$.

Polarity adjustment

When connected to a Multi-Channel Analyser (MCA) the polarity of the incoming pulses to the MCA must be set. This is done from the 'General' tab by selecting either positive or negative from the polarity section.

Resolution calibration

The variation of the resolution of the detector with respect to channel is shown in the Resolution Calibration tab. This is used in the peak analysis functions within *MultiSpect Analysis*.

Save neutron counts in gamma spectrum

If a neutron detector is connected that only measures neutron counts, not a spectrum, there is an option within the neutron detector device settings to save the neutron data within gamma-ray measurements of all gamma-ray detectors connected at the same time. This enables the neutron field to be measured and recorded alongside the gamma-ray data for future analysis. This is available in both *KSpect* and *MultiSpect Analysis*.

Spectrum Data Box

On the 'Spectra' tab below the spectra is a pane containing data associated with the spectrum acquisition, spectrum plot scales, cursor, and current region of interest.

Spectrum acquisition data

Real time is the total time that has elapsed during the acquisition of pulse height data. Live time is the length of time that the pulse processing hardware has actually been active and able to detect pulses during the data acquisition. In other words, live time is the real time reduced by the total time that the hardware has been inactive as a result of pulse processing activities. Dead time is the instantaneous percentage of time that the hardware is inactive as a result of pulse processing activities rather than being able to detect pulses.

Count rate is the number of events detected per second shown both as a number and via a horizontal graphical bar. Rates displayed are not corrected for dead time in the detector and show the instantaneous rate, not the average rate over the total acquisition time.

Scale ranges

The next data group from the left, scale ranges, lists the maximum number of counts used for the vertical axis of the spectrum plot and the number of channels that the horizontal axis currently spans. If the active spectrum has been calibrated in energy, the horizontal axis range is also given in keV.

Cursor position

The next data group from the left, cursor data, lists the current cursor location on the active spectrum in counts, channels, and keV (if calibrated).

The text box displaying the horizontal location in keV may also be used as a data entry box to assign an energy value to the current cursor location in the energy calibration. The data entry mode is entered by clicking the keV text box. The desired energy can then be entered, and, after [Enter] has been pressed, the energy calibration will be updated by adding the new channel-keV data point to the existing energy calibration.

Region of interest (ROI)

When the spectrum cursor is positioned in a defined ROI the measurements of the ROI will be displayed in the ROI data group below the spectrum. See the region of interest operation section (see page 26). The information includes the summed counts, centroid, and full-width-at-half-maximum (FWHM) of the peak. Whether a background is subtracted or not from the ROI is controlled from the Spectra tab of the ribbon menu at the top of the screen.

The text box listing the Centroid in keV may also be used as a data entry box to assign an energy value to the current centroid channel location in the energy calibration, in a similar way to using the cursor position text box. Left click the keV text box and the desired energy can then be entered, and, after [Enter] has been pressed, the energy calibration will be updated by adding the new channel-keV data point to the existing energy calibration.

Active device

For the active device or measurement thumbnail the active device box shows the type of the detector used to record the data, the serial number of that device, the Lower Level Discriminator (LLD) setting, and the setting of the Software Cut-Off (SCO).

Monitor Traces

Note: This functionality is not present in *KSpect*

When the 'Monitors' tab is clicked above the plot area the count rate monitor traces are displayed for all the connected detectors. Each trace allows changes in the count rate recorded from the detector to be seen over time. Monitor traces are only updated during acquisition and are not dead time corrected. Press the 'Acquire' button located on the 'Acquisition' menu to begin acquisition. Moving the mouse pointer over the monitor trace displays a cursor and an information box showing the count rate and the time at that point on the trace.

Note: *MultiSpect Analysis* reads data from the detectors via USB. Depending on the computer being used to run *MultiSpect Analysi*s buffering of USB data can cause delays in receiving data from the detector and add noise on monitor traces with short aggregation times. This will become more pronounced if the computer is running many processor heavy tasks or has insufficient free resources.

By default each detector has one monitor showing the total count rate from all energy channels, although different energy ranges can be configured manually. This is useful for monitoring the count rate in one particular gamma ray peak for example. Monitors for neutron detectors only show the total counts detected. Monitor traces are automatically saved against each detector serial number so the next time the detector is connected the previously configured monitor traces are displayed again.
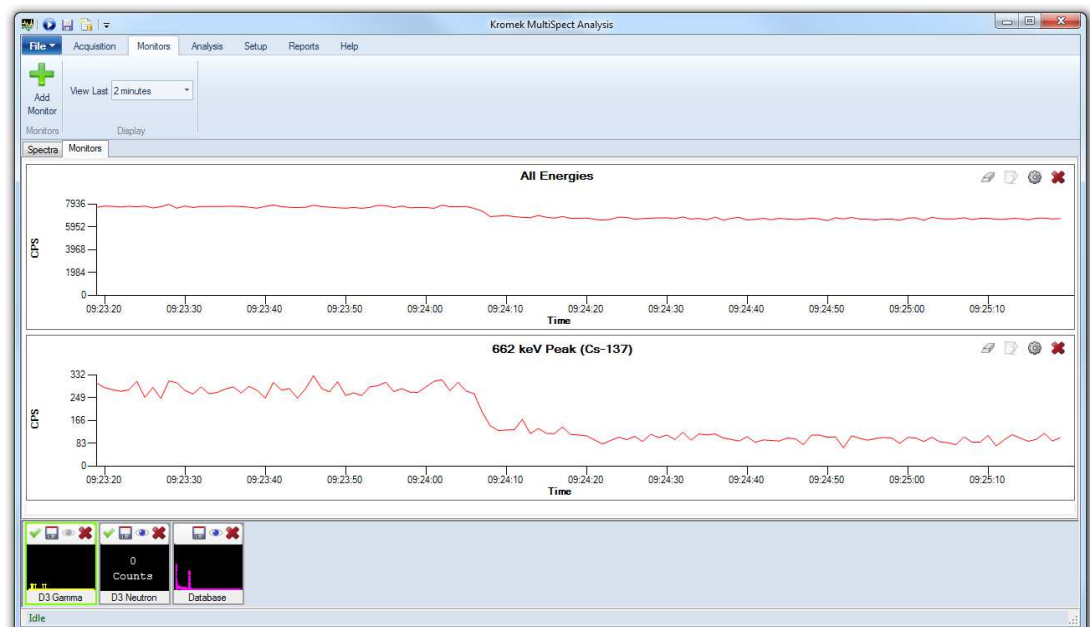

The time period being viewed can be chosen by using the drop down menu located on the 'Monitors' menu. For each time period 121 data points are shown. The time periods available are:

Time Period Shown	Data aggregated over
2 minutes	1 second
30 minutes	15 seconds
1 hour	30 seconds
4 hours	2 minutes
12 hours	6 minutes
1 day	12 minutes

Individual monitor traces can be removed by using the red cross on each trace. All monitors from a detector can be hidden by clicking on the 'hide' icon on the detector thumbnail which also hides the spectra on the 'Spectra' tab.

Adding a new monitor

New monitor traces can be added by first selecting the detector thumbnail and then clicking the 'Add monitor' button located on the 'Monitors' menu. This will bring up the 'Rate Monitor Settings' window
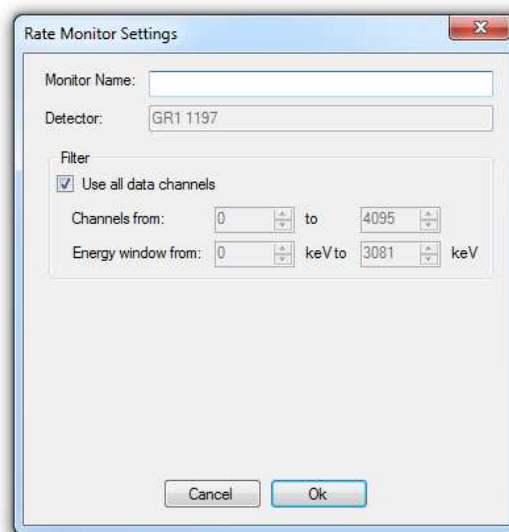
A name should be given for the monitor for identification. The filters can be used so that only the aggregated counts from a particular region of the spectrum are plotted in the monitor trace.

Editing the monitor settings

The settings for a particular monitor trace can be viewed and edited by clicking the 'settings' button on the monitor trace, or by right clicking on the trace and choosing 'settings' from the menu. The 'Rate Monitor Settings' dialog is displayed from which the name can be changed and the energy range or channel range used in the monitor

can be edited. Changes made to the monitor take effect from then on; old data is not recalculated to show it on the same basis.

Saving and exporting the monitor data

Monitor data cannot be saved in the measurement database. It can be exported to a .csv file to preserve a record of the data. Press the export button on the monitor trace to save the data for the time period being viewed.

Exported data has a header section showing the settings for the monitor. The data is in rows with a row for each time period. Each row has a time stamp, the total counts recorded in that period, and the total real time the detector was acquiring data during that time period. The count rate can be recalculated by dividing the total counts by the real time.

Clearing the monitor data

All the data for a particular monitor can be cleared by pressing the 'clear' button on the monitor trace, or from the right-click menu. This will permanently erase the data.

File Operations

Spectrum load

Opening a spectrum directly from a file can be done from the "File" menu by choosing "Open a file", or by dragging and dropping a spectrum file into the main window.

Spectrum save

Complete measurements comprising the spectrum, energy calibration and all analysis are saved in a database of measurements, from where they can be exported if required. A measurement can be saved to the database by first selecting the thumbnail and then either selecting "Save measurement" from the "File" menu, by pressing the save icon on the thumbnail, or by pressing the [F3] key. On first saving the measurement the user will be asked to provide details including a name and notes that are needed for finding the measurement in the database. These can be edited later if required. For details of working with the database please see the database section of this help file.

Copy spectrum

Spectrum data can be copied to a new thumbnail by right clicking the existing thumbnail and selecting "Copy". This is particularly useful for storing acquired data and using it for comparison.

Reports

The spectrum and analysis results can be presented together in a convenient report. This is exported in *.pdf* format for ease of sharing. The 'Generate Report' button is located on the 'Reports' menu. The report options will be displayed for choosing which information should be shown on the report.

The units of measurement used in the report can be configured between SI and US standard units from the 'Preferences' screen which is accessible from the 'File' menu.

Printing

A snapshot of the *KSpect or MultiSpect Analysis* window can be printed by selecting 'Print' from the 'File' menu. This then brings up a standard Windows print dialog from which a specific printer along with its associated properties can be selected. After this selection has been made, the snapshot of the window can be sent to the printer by clicking on the 'OK' or 'Print' button of this print dialog window. Prior to printing, the print settings can be adjusted by selecting 'Print settings'. The snapshot can also be previewed by selecting 'Print preview'.

Region of Interest (ROI) Operations

When a ROI is defined about a peak in a spectrum, and the cursor is placed within this ROI, the ROI data in the spectrum data box displayed beneath the spectrum provides the counts, centroid, and FWHM values associated with the peak.

The integral counts value is simply the sum of all the counts within the ROI, whereas the net counts number is this same sum reduced by the background counts. The background is assumed to be a line determined based on the data points at the start and end of the ROI. If the background subtraction has been turned off from the 'Spectra' tab of the ribbon menu the integral and net counts will be the same. The centroid and FWHM values are given in number of channels and, if a valid energy calibration exists in keV. The centroid and FWHM calculation is performed on the net counts if background subtraction is turned on, or the integral counts if it is turned off.

Each spectrum has its own set of defined ROIs and only those of the active spectrum will be displayed. A ROI is indicated on a spectrum using colour shading. ROIs are only displayed when the ROIs are turned on. This state is toggled between on and off by

the 'ROI show/hide' button. This state can also be toggled by right-clicking the mouse when the pointer is over the spectrum display and then selecting 'ROI on/off' from the menu. The display of ROIs is also turned on if a ROI definition is started.

Defining a region of interest (ROI)

ROIs can be defined using several different methods, but each of the methods makes use of the spectrum cursor to specify the start and stop channel of the ROI. The function key buttons 'ROI start', 'ROI stop', and 'ROI clear' can be used to define or remove a ROI. With the cursor positioned at the start channel of the desired ROI, clicking on 'ROI start' or pressing the [F8] function key starts the ROI definition. The text of the button then changes to 'ROI stop'. The ROI definition is then completed by moving the cursor to the end channel of the ROI and then clicking on 'ROI stop' or pressing the [F8] function key again. A ROI can be removed by positioning the cursor within the ROI and then clicking on 'ROI clear' or pressing [F9]. Similarly, ROI definition and clearing operations can be accessed through the menu that is activated by right-clicking the mouse when the pointer is over the spectrum display. A quick method to define ROIs is to hold down the shift key while left-clicking with the mouse on the start channel of the ROI. The ROI definition is completed by again holding down the shift key while clicking on the stop channel of the ROI.

Region of interest calculations

The *Integral Counts* value is simply the sum of all the counts within the ROI and is calculated as follows:

$$\text{Integral Counts} = \sum_{n=\text{ROIstart}}^{\text{ROIstop}} C_n$$

Where C_n is the number of counts in channel number n, and *ROIstart* and *ROIstop* are the channel number limits of the ROI.

The *Net Counts* number is the *Integral Counts* less the *Background Counts*. The background B_n is assumed to be a straight line determined from the data points at the start and end of the ROI.

The *Net Counts* values are calculated as follows:

$$\text{Net Counts} = \sum_{n=\text{ROIstart}}^{\text{ROIstop}} (C_n - B_n)$$

The **Centroid** in units of channel number is calculated from the background-subtracted count data using the equation:

$$\text{Centroid} = \frac{\sum_{n=\text{ROIstart}}^{\text{ROIstop}} n(C_n - B_n)}{\sum_{n=\text{ROIstart}}^{\text{ROIstop}} (C_n - B_n)}$$

The **FWHM** in units of channel number is determined using the following procedure:

(1) The background is subtracted from the count data.
(2) The channel containing the maximum counts, C_{max}, is determined through a simple search.
(3) Starting from this maximum-counts channel, the lower channel numbers are searched for a pair of adjacent channels whose counts straddle a counts value of $C_{max}/2$.
(4) The lower half-maximum channel value is then calculated from these two straddle points through linear interpolation.
(5) In a similar manner, the upper half-maximum channel value is determined through a search of the higher channel numbers starting at the maximum-counts channel followed by a linear interpolation calculation using the data points that straddle a counts value of $C_{max}/2$.
(6) Finally, the *FWHM* is calculated by subtracting the lower half-maximum channel value from the upper half-maximum one.

If an energy calibration has been completed for the active spectrum, the *Centroid* and *FWHM* values in channels are converted to energy in keV using the energy calibration.

Summing Spectra

**Note:** This functionality is not present in *KSpect*

Summing multiple spectra

MultiSpect Analysis provides a sum function that can sum the channel events counts from multiple spectra. The results of the sum are displayed in an additional spectrum, known as an aggregate spectrum.

This is only available in energy display mode (see page 14) where only spectra with valid energy calibrations are displayed and available for aggregation. Aggregate spectra are not displayed in channels display mode.

You can create a new aggregate spectrum by clicking on the 'Create' button $\boxed{\Sigma}$ located on the 'Analysis' menu. MultiSpect creates a new aggregate spectrum thumbnail, distinguished by a 'sum' symbol (sigma character) in the left-most button on the thumbnail:

To select the spectra to be summed, click on the 'sum' button $\boxed{\Sigma}$ in the thumbnail toolbar. This displays a window showing all the spectra that can be summed. Valid spectra include detector and file spectra with valid energy calibrations. Tick the checkboxes next to the spectra you want to sum:
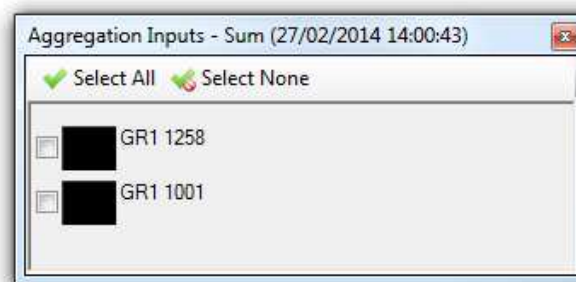
If you reset the calibration of a spectrum that is being used as the input to a sum, that spectrum is automatically removed from the sum because only calibrated spectra can be summed.

Saving an aggregate spectrum

An aggregate spectrum can be saved just like any other spectrum. When an aggregate spectrum is saved, a copy of each input spectrum is also saved.

Loading an aggregate spectrum

When an aggregate spectrum is loaded from a file, a spectrum is also created for each of the spectra that were inputs to the aggregation when the aggregate spectrum was saved. Clicking on the "sum" button on the thumbnail's toolbar opens a tool window that allows you to select which spectra act as inputs to the sum in the aggregate spectrum.

Measurement Database

To allow a spectrum to be saved with the analysis and other associated data such as locations, *KSpect* and *MultiSpect Analysis* use a database for storing complete measurements. This provides a single location for organizing measurements and all measurements can be backed up collectively. All users logging on to a particular PC share the same database with all measurements accessible to everyone.

The database can be opened from the 'File' menu by selecting 'Measurement Database', or from the shortcut at the top.
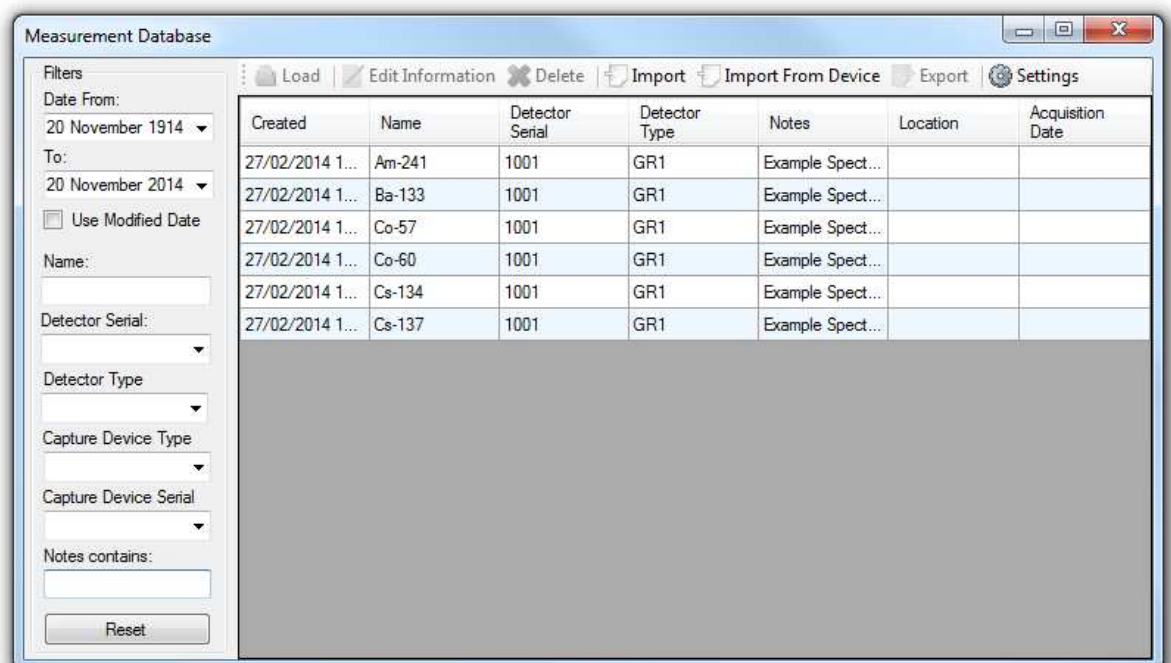
Loading a measurement

Select the measurement in the database window and press the 'Load' button.

Saving a measurement

After selecting a spectrum thumbnail the measurement can be saved to the database either from the 'File' menu by selecting 'Save Measurement', by pressing the save icon on the thumbnail, or by right clicking the thumbnail and selecting 'Save measurement'. On first saving the measurement the user will be asked to provide details including a name and notes which are needed for finding the measurement in the database. These can be edited later if required.

Importing spectra to the database

Pressing the import button allows existing *.spe* spectrum files to be imported to the database. Many *.spe* files can be imported at the same time by selecting multiple files in the file browser dialog box.

Editing measurement information

Measurement information can be edited by first selecting the measurement and then selecting 'Edit information' from the toolbar buttons at the top.

Importing measurements from a Kromek device

Note: This functionality is not present in *KSpect*

MultiSpect Analysis can synchronize data with some Kromek devices, such as the RayMon handheld radiation monitor. Connect the Kromek device to the PC running MultiSpect Analysis with a USB cable.

The first time the device is connected drivers will be downloaded and installed from the internet. If you do not have an internet connection on the PC running MultiSpect Analysis please download the following software and drivers from the Microsoft website on another PC and install them on the PC running MultiSpect Analysis. When the software drivers are successfully installed the Kromek device will appear in Windows Explorer under the 'Computer' heading.

- Windows XP users: Microsoft ActiveSync 4.5 or later
- Windows 7 and 8 users: Windows Mobile Device Centre 6.1 or later

After connecting the device press 'Import From Device' at the top of the 'Measurement Database' window to display the 'Device Import' window listing all the measurements stored on the device.
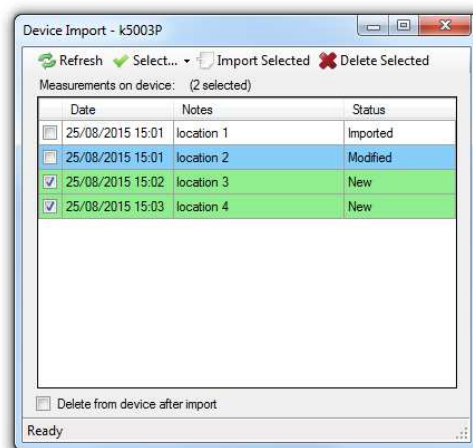
Select the measurements to import by ticking the checkboxes next to the measurements.

Pressing 'Import selected' imports all the selected measurements.

The 'Select' menu at the top of the window allows different selections to be made:

- Select all measurements on the device
- Clear all the selections so none are selected
- Select all new measurements not previously imported (shaded green)
- Select measurements that have been modified on the device since they were last imported (shaded blue)
- Select all new and modified measurements

To delete the selected measurements from the device after import tick the checkbox 'delete from device after import'.

To delete measurements from the device without importing select the measurements and click 'Delete Selected'.

Finding measurements

The filters on the left of the measurements database window allow searching for particular spectra within the database. These allow searching by:

- Date spectrum recorded
- Date measurement was last edited
- Name
- Detector serial number
- Detector Type
- The device type used to capture the data from the detector, e.g. a PC
- The serial number of the capture device
- Contents of the notes associated with the spectrum

Completing any of the filters automatically filters out all the non-matching measurements in the database. To return the filters to their default values press the 'Reset' button.

Exporting Data

Gamma ray spectra can be exported to *.spe*, *.n42* or *.txt* file by selecting the measurement and pressing the 'Export' button.

Neutron data can be exported to a *.neutron* file by selecting the measurement and pressing the 'Export' button.

Settings

The settings button brings up a menu allowing the default time period for displayed measurements when the database is first viewed to be configured. This value should be reduced if the database is slow to load. Which columns are visible can also be configured from this menu.
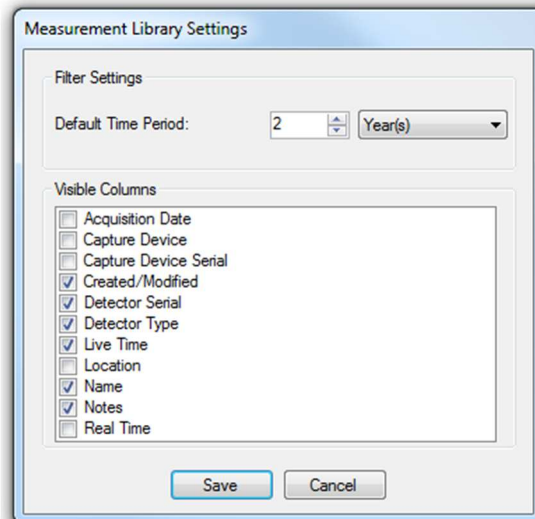
Backup

The complete database of measurements can be backed up to a single file from the 'File' menu by selecting 'Backup database'.

Restore

To restore a database select 'Restore Database' from the 'File' menu and choose which backup file to restore. All data in the existing database will be lost when a previous database is restored. Administrator privileges are required for restoring the database. If the user is not an administrator they will be prompted to enter the username and password of an administrator.

Reset

The database can be reset to a blank default database from the 'Database Settings' dialogue window. This is opened from 'File' → 'Database' → 'DB Settings' and the reset option is found on the 'Admin' menu. Administrator privileges are required for the reset; if the user is not an administrator they will be prompted to enter the username and password of an administrator.

Spectrum Peak Analysis

MultiSpect Analysis has powerful features built in to automatically analyse peaks from radiation source energy lines. **Note:** these features are not available in *KSpect*.

After selecting which radiation sources may be in the spectrum and *MultiSpect Analysis* automatically analyses a suitable region of interest around each energy line and tells you whether a significant peak exists at each energy.

Note: analysis is only available in energy display mode. The analysis features operate on the active spectrum. The analysis updates automatically while data is being acquired.

Enabling peak analysis

Peak Analysis is only available after moving to energy mode. Click the 'Energy Mode' button on the analysis toolbar.
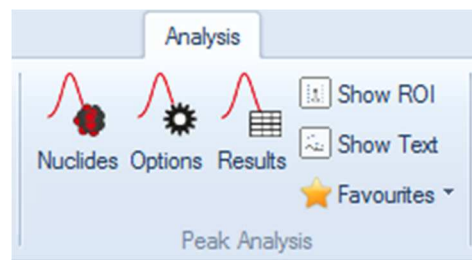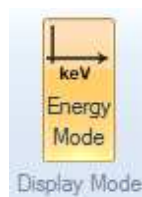
Configuring peak analysis

Analysis is configured in the 'Peak Analysis Nuclides' and 'Peak Analysis Options' windows. In these windows you can:

1. Select which radiation sources you expect may be present in the spectrum
2. Filter the energy lines of the radiation sources so only the important energy lines are analysed
3. Create your own categories and add radiation sources to them, so that you can find and include your 'favourite' sources quickly
4. Change the analysis parameters
5. Look up radiation source energy lines by energy and relative intensity

The peak analysis nuclides window
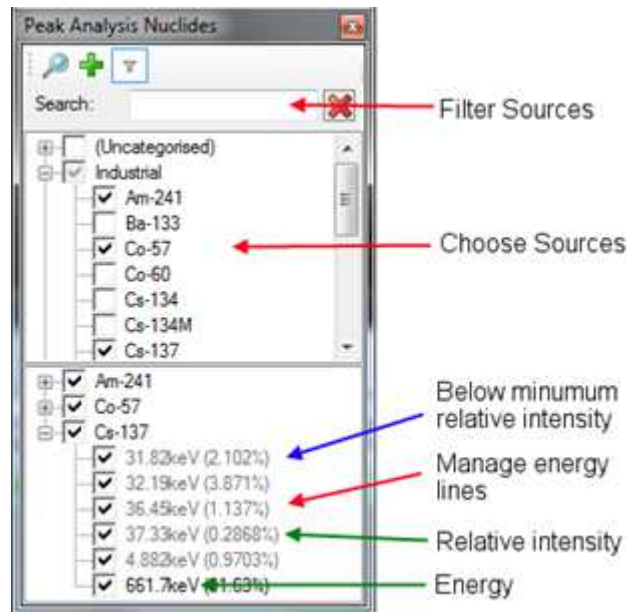
Choosing radiation sources

MultiSpect Analysis has a library of all the common radiation sources and their significant energy lines. The upper tree shows the radiation sources grouped by ANSI category. The less common sources do not belong to an ANSI category, and are grouped under the '(Uncategorised)' heading. A few sources belong to more than one ANSI category, and so appear more than once in the tree.

The 'Search' box makes it easy to find a radiation source. Enter the full nuclide name, such as 'Co-60', or just the first few characters of the name. Clear the search box and get back to the full tree by clicking on the ✖ button.

Click on the checkbox beside the name of the radiation source to add it to the analysis. Click on the checkbox again to remove the radiation source from the analysis.

Choosing energy lines

The lower tree shows the selected radiation sources, each with its energy lines. Each energy line has a relative intensity. This shows the intensity of the energy line relative to the other energy lines of the same radiation source, such that the sum of the relative intensities of all the included energy lines of a radiation source is 100%.

Note: some energy lines may not appear in the list. Energy lines outside a configurable energy window, or below a specified minimum relative intensity, are hidden when the filter button at the top of the window is enabled, and displayed in grey when the filter is disabled. The energy window and minimum relative intensity are set in the analysis configuration options window.

**User-defined radiation source categories**

Custom categories can be created and radionuclides added to them. This makes it easy to find the radiation sources frequently used. Unlike the other information in the analysis configuration form, which is saved in an analysis configuration file, the user-defined categories are saved in the *MultiSpect Analysis* application preferences and apply to all analysis configurations.

To create a new category, either click on the ➕ button or right-click on any existing category to display the context menu and then click on 'Add new category...'. The new category is added to the tree. Enter a name for the category. The name must be different from the existing categories. Rename or delete the category by right-clicking on it and choosing 'Rename' or 'Delete' from the context menu. **Note:** you can't rename or delete the default ANSI categories.

To add a radiation source to a user-defined category, right-click on the radiation source in the tree. The context menu shows the list of user-defined categories, with a tick beside each one that the radiation source already belongs to. Click on a category in the context menu to add the radiation source to or remove it from the category.

Peak analysis configuration options
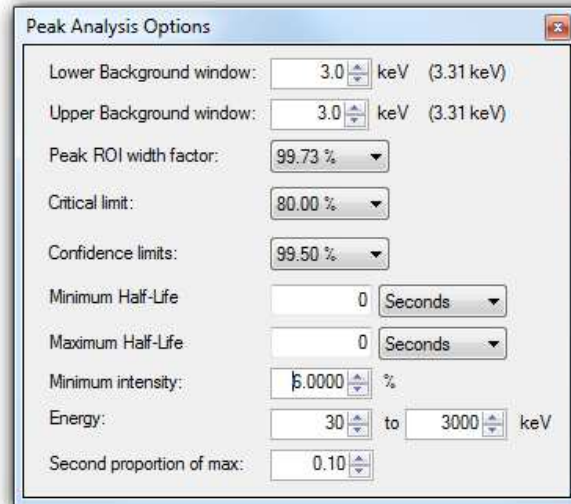
Minimum intensity: energy lines with a relative intensity less than this level can be hidden using filter buttons on other windows.

Energy: energy lines with an energy outside this range can be hidden using filter buttons on other windows.

Upper and lower background window: the energy span outside either end of the peak-region that is sampled for the background. The background is calculated by fitting a straight line through the background channels. Where data is not in 1keV bins the number shown in brackets displays the actual energy range being used.

Second proportion of max: the analysis results table shows the full-width at half-maximum (FWHM) for each detected peak, and another full-width at this proportion of maximum. For example, if this value is set to 0.1, the second full-width is the full-width at one-tenth of maximum. The full-width ratio shown in the analysis results table is this width divided by the full-width at half-maximum.

Peak ROI width factor: defines the percentage of peak events that are covered by the region of interest based on the resolution function of the detector with respect to energy.

Critical limit: the analysis uses a Critical Limit test to determine whether a significant peak exists at the energy. This value sets the confidence level for the Critical Limit calculation.

Confidence limits: the analysis calculates upper and lower confidence limits for the net counts in a peak, and, if an efficiency calibration is present, the source activities. This value sets the confidence level for the confidence limit calculation.

Minimum and maximum half-life: A range of half-lives can be specified and only energy lines from radiation sources that fall within this window are analysed.

Peak area and FWHM analysis results

The 'Peak Analysis Table' is displayed when the "Results" menu button is clicked. View the 'Peak Area' tab to see the measurements of peak areas and full widths at half maxima (FWHM).

The analysis results are colour coded for ease of interpretation as follows:

- **Green**: the spectrum has a peak in the same energy region above the level of statistical confidence specified in the analysis configuration options; the critical limit test has been passed.
- **Blue**: the spectrum fails the critical limit test in this region.
- **Red**: lines that have been excluded from analysis because they fall outside the conditions specified in the analysis configuration options

The shading within each colour indicates the relative intensity of the line. For example a dark blue is a line with a high relative intensity where the critical limit test has been failed.

The table shows a list of all the energy lines included in the analysis. Column headings can be clicked to sort the data.

- **Source**: the radiation source of the energy line.
- **Energy**: the energy of the energy line in keV.
- **Centroid**: the centroid of the region in keV. If a background line could be determined, this is the centroid of the net count, else of the gross count.
- **Gross count**: the total of all counts in the region of interest.
- **Net count**: the gross counts less the counts below the straight line connecting the average counts in the left-hand background window of the region of interest with the average counts in the right-hand background window.
- **Upper and lower confidence**: the Confidence Limits for the net count in the peak, to the configured confidence level (see above). This defines the range containing the true (rather than measured) number of events due to the energy line, to the configured level of confidence.
- **FWHM**: full-width at half of maximum in keV. The width of the peak (net counts only) at half the maximum net counts in the peak.
- **FWnM**: full-width at *n* of maximum in keV. The width of the peak (net counts only) at the configured "second full width proportion of maximum" of the maximum net counts in the peak.
- **FW ratio**: the ratio of FWnM to FWHM.

The buttons on the top bar perform the following operations:

Filter energy lines above the critical limit and associated nuclide lines: with is enabled the analysis table only shows radionuclides where at least one line has passed the critical limit test.

Filter relative intensity: when enabled emission lines that fall below the specified minimum intensity are hidden from the analysis results table.

Filter energy range: when enabled emission lines that fall outside the specified energy window are hidden from the results table.

Filter half-life: If enabled emission lines from radionuclides with half lives outside the specified range are hidden from the results table.

Analysis results can be exported by selecting 'Export…' from the top of the Peak Analysis Table. The exported data contains additional columns, such as the critical limit used to test for the presence of a peak.

Activity from peak areas

Note: This functionality is only present in *MultiSpect Analysis Premium*

After determining the efficiency calibration curve of the system, see the calibration section on page 17, the activity of a source of can be measured from the net counts in its spectrum peaks. The sample must be positioned in the geometry matching the efficiency curve, and the Peak ROI width factor for the analysis must be the same.

Simply acquire a spectrum from the source in the geometry of the efficiency curve and perform a Spectrum Peak Analysis (see page 34) to measure the photo-peaks in

the spectrum. On the 'Peak Analysis Table' click the 'Peak Activity' tab to view the results of the analysis in terms of activity using the efficiency curve loaded in 'Detector Settings'. Only peaks that have passed the critical limit test where a net count rate has been measured are analysed for activity. The units of measurement can be changed between SI and US Standard from the 'Preferences' screen accessed from the main 'File' menu.

The efficiency curve can be viewed by pressing 'View Efficiency Calibration…' above the results table, and a new calibration loaded if necessary. If no efficiency curve is present no results will be displayed.

Each emission line analysed gives a separate measure of the activity of the sample. The upper and lower confidence values are calculated using the error from the fit to the efficiency calibration points, the error in the net counts measured from the spectrum, and the 'confidence limits' chosen by the user in 'Peak Analysis Options', e.g. 1σ/68%.

Activity results can be included in .pdf reports (see page 26). They can also be exported to a .csv file by using the 'export…' button above the results table. When the measurement is saved in the database the complete configuration is saved with the measurement allowing the same analysis to be recalled at a later date.

Graphical display of analysis
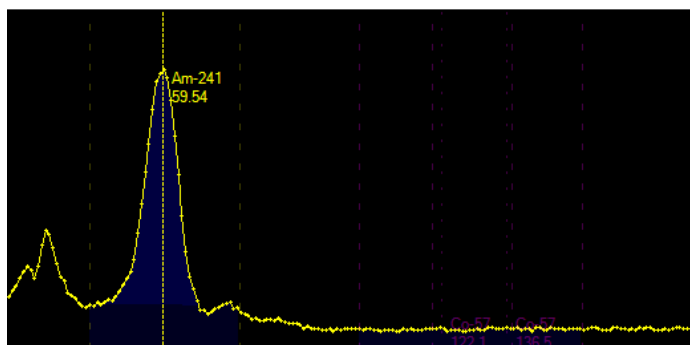
When analysis is enabled, the graphical display shows the regions of interest of the peaks being analysed. Each energy line in the analysis is shown with:

- A vertical dotted line at the energy of the energy line. This line is strongly dashed if a peak was detected. Otherwise it is lightly dotted.
- Text beside the peak, with the nuclide name, energy line energy and user-entered comment.
- Vertical dashed lines at the right and left boundaries of the region of interest.
- Shading of the region of interest under the spectrum trace.
- Darker shading below the background level in the region of interest.

All the energy lines of a radiation source are shown in one colour. The energy lines of different radiation sources are shown in different colours.

If a peak was detected in the region of interest, the graphical display of the energy line is shown brightly. Otherwise it is shown dimly, unless you hover the mouse over an element of the energy line (the centre energy line, a region of interest bounds line, or the text).

The filters on the "Analysis" menu bar can be used to control what analysis information is displayed on the graph.

Show/hide all ROI lines: pressing this shows/hides the dashed lines marking the limits of the region of interest for each radionuclide line from the graph.

Show/hide all text: pressing this shows/hides text labels on the graph. They are still displayed when the mouse is hovered over the peak centre markers.

User-entered comments

Comments can be added or edited by right-clicking on the energy line in the graphical spectrum display and choosing 'Edit text' in the menu.

Saving and loading the analysis configuration

The analysis configuration will be saved with the spectrum in the database and recalled the next time the measurement is opened.

If the analysis configuration will be used frequently it can be added to the list of favourite configurations allowing it to be quickly applied to any spectrum.
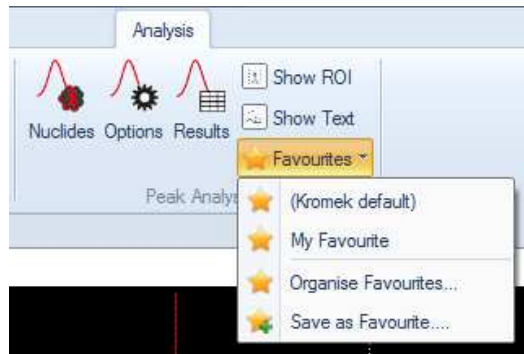
- **Save favourite configuration:** After setting up the analysis click on 'Save as favourite...' in the favourites menu above the radionuclide selection tree and name the configuration to add it to the list of favourites.
- **Apply favourite configuration:** An existing favourite can be applied to a spectrum by selecting it from the drop down list above the radionuclide tree.
- **Organise Favourites:** Favourite configurations can be managed by selecting "Organise favourites..."
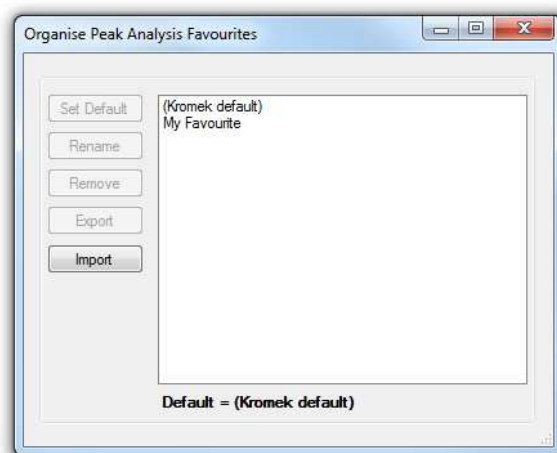
- **Choose default favourite configuration:** After selecting a favourite select 'Set Default' to make this the default configuration for future measurements.
- **Rename favourite configuration:** The name of the favourite can be changed by selecting it and pressing 'Rename'.
- **Delete favourite configuration:** To remove a favourite configuration select it and click the 'Remove' button.
- **Export/Import favourite configuration:** A favourite configuration can be exported to a *.msa* file so it can be saved and transferred to other *MultiSpect Analysis* installations. To export select the configuration and click the 'Export' button. To import a *.msa* file click 'Import' and navigate to the file.

Simplified Activity Analysis in MultiSpect

Note: *Quant for GR1* users need to apply an enhanced *MultiSpect Analysis Premium* software licence to enable these activity features.

Activity analysis quantifies the radioactivity of a sample from its gamma ray spectrum which must be recorded in a pre-defined geometry using the *Quant for GR1* accessories. The efficiency values used for the analysis are provided in the software, removing the need for the user to characterise the system. If required, the efficiency values can be updated by the user after calibration.

After selecting which radiation sources may be present and sample type in the measurement, *MultiSpect Analysis* calculates the quantity of each radionuclide. The analysis features operate on the selected spectrum and the analysis updates automatically while data is being acquired. Activity analysis is only available in energy display mode.

Disclaimer: When using the provided efficiency values the activity results will be compromised if the sample or geometry deviates from the ideal case. The user is responsible for qualifying the system and ensuring the results are appropriate for their needs.
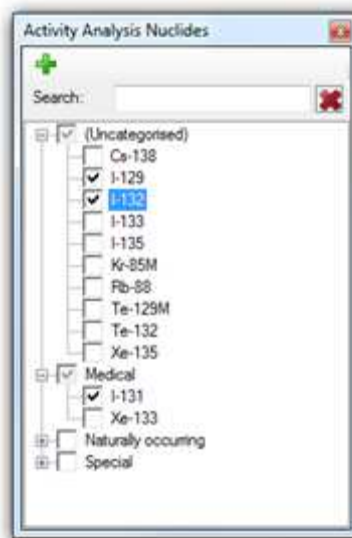
Starting activity analysis
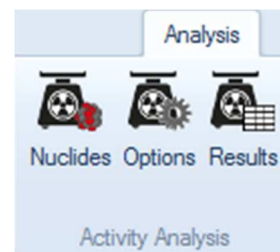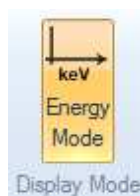
After or while acquiring a spectrum switch to energy mode by clicking on the 'Energy mode'.

Configuring activity analysis

Activity analysis is configured from the 'Activity Analysis Options' window and the 'Activity Analysis Nuclides' window. The units of measurement can be changed between SI and US Standard from the 'Preferences' screen which can be accessed from the main 'File' menu.

Choosing radiation sources

MultiSpect Analysis will analyse the sample for common radiation sources. The 'Activity Analysis Nuclides' tree shows the radiation sources grouped by ANSI category that are available for analysis. Click on the checkbox beside the name of the radiation source to add it to the analysis. Click on the checkbox again to remove the radiation source from the analysis. The 'Search' box makes it easy to find a radiation source. Enter the full nuclide name, such as 'Co-60', or just the first few characters of the name. Clear the search box and get back to the full tree by clicking on the ✖ button.

User-defined radiation source categories

Custom categories can be created and radionuclides added to them. This makes it easy to find the radiation sources frequently used. Unlike the other information in the analysis configuration form, which is saved in an analysis configuration file, the user-defined categories are saved in the *MultiSpect Analysis* application preferences and apply to all analysis configurations.

To create a new category, either click on the ✚ button or right-click on any existing category to display the context menu and then click on 'Add new category...'. The new category is added to the tree. Enter a name for the category. The name must be different from the existing categories. Rename or delete the category by right-clicking on it and choosing 'Rename' or 'Delete' from the context menu. **Note:** you can't rename or delete the default ANSI categories.

To add a radiation source to a user-defined category, right-click on the radiation source in the tree. The context menu shows the list of user-defined categories, with a tick beside each one that the radiation source already belongs to. Click on a category in the context menu to add the radiation source to or remove it from the category.

Analysis configuration options
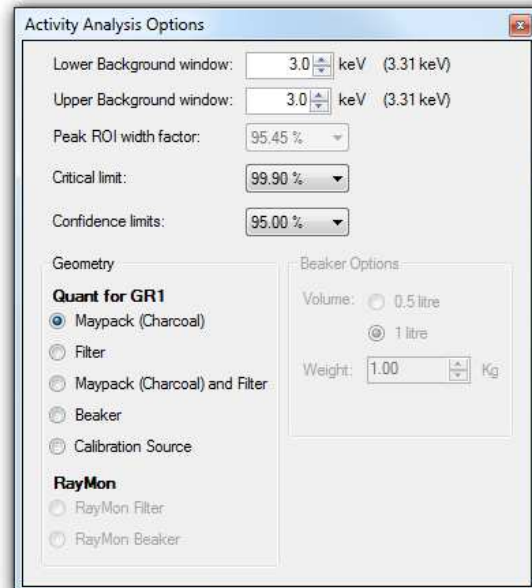
These parameters configure the analysis:

- **Upper and lower background windows:** The background under a peak in the spectrum has to be removed before activity can be calculated. The background is calculated from the counts just outside the peak region; these settings change the energy range used in this calculation.

- **Peak ROI width factor:** This defines the percentage of the peak area that is included in the calculations. A wider region of interest will give a more accurate result, but will be more susceptible to interference from radionuclides with peaks in a similar region of the spectrum.

- **Confidence level for critical limit:** The analysis uses a critical limit test to determine whether a significant peak exists or not. This value sets the confidence level for this critical limit test calculation.

- **Confidence level for quoted uncertainty:** the analysis calculates the uncertainty in the calculated activity. This value sets the confidence level used in calculating the uncertainty.

- **Sample type:** The type of sample being analysed affects the geometry of the measurement and needs to be taken into account in the calculation of the activity. Select one of the options for the type of sample being measured:
  - **Maypack (Charcoal)** for standard Maypack charcoal filters
  - **Filter** for filter papers
  - **Maypack (Charcoal) and Filter** for a combined measurement of Maypack charcoal and filter paper
  - **Beaker** is for a standardised beaker filled with material. If this option is selected additional parameters are required for the volume and weight. The material is assumed to be uniformly distributed in the beaker, with a density matching water, and with negligible self-absorption of radiation.
  - **Calibration Source** is for use with the standard calibration source. Calibration source = QCRB19952 NG3 mix from HTSL (High Technology Sources Ltd)
  - **Raymon Filter** for analysis of data imported from a RayMon handheld detector using the RayMon Quant accessories.
  - **Raymon Beaker** for analysis of data imported from a RayMon handheld detector using the RayMon Quant accessories.

Results

Source	Energy (keV)	Result (Bq)	Uncertainty (Bq)	MDA (Bq)
I-129	33.6893	125326	1361	3190
I-132	1398.57	Activity < 16962		57335
I-131	364.489	Activity < 4642		7055

The 'Activity analysis table' shows the results of the activity analysis. Column headings can be clicked to sort the data. The 'Export' button allows the results to be saved in *.csv* format.

Columns show:

- **Source:** The radionuclide that has been analysed
- **Result:** The calculated activity of the radionuclide
- **Uncertainty:** The uncertainty in calculated activity
- **MDA:** The minimum detectable activity for the radionuclide in the measurement. This provides an upper limit on the activity where it has not been possible to quantify the radionuclide.

Saving and loading the analysis configuration

The analysis configuration will be saved with the spectrum in the database and recalled the next time the measurement is opened.

If the analysis configuration will be used frequently it can be added to the list of favourite configurations allowing it to be quickly applied to any spectrum.

- **Save a favourite configuration:** After setting up the analysis click on 'Save as Favourite' in the favourites menu above the radionuclide selection tree and name the configuration to add it to the list of favourites.
- **Apply favourite configuration:** An existing favourite can be applied to a spectrum by selecting it from the top of the drop down list above the radionuclide tree.
- **Organise Favourites:** Favourite configurations can be managed by selecting 'Organise Favourites'.
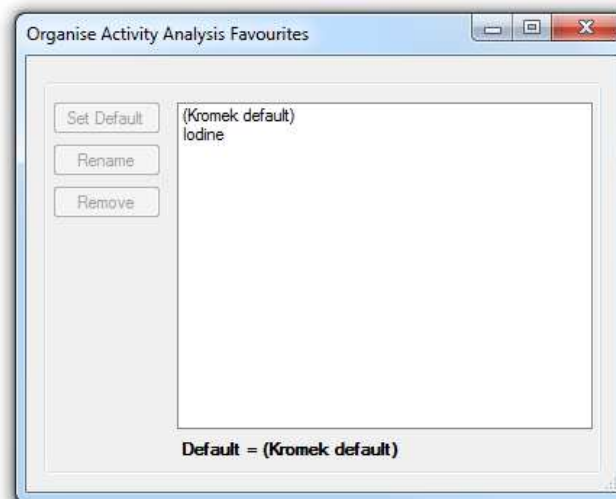
- **Choose default favourite configuration:** After selecting a favourite select 'Default' to make this the default configuration for future measurements.
- **Rename favourite configuration:** The name of the favourite can be changed by selecting it and pressing 'Rename'.

- **Delete favourite configuration:** To remove a favourite configuration select it and click the 'Delete' button.

Calibration of simplified activity

Specific efficiency values, k_e, used in this simplified activity analysis for each radionuclide can be updated from user acquired absolute efficiency curves. These must already have been recorded with a "Peak ROI Width Factor" of 95.45%. Please see page 17 for creating this calibration curve.

From the 'Setup menu' select 'Radionuclide Efficiency Values'.

This will open a window allowing the values used in the efficiency analysis to be updated. First select the geometry and then select the efficiency curve to use for calculating the new values. Calculated k_e values, which are the efficiency values adjusted for the probability of emission of the radionuclide emission line, are displayed in the table. To accept these new values press the 'Apply' button.
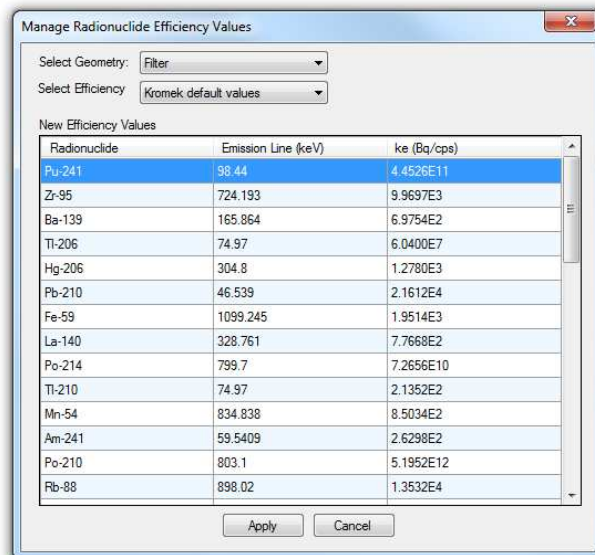
To revert back to the pre-determined values from Kromek select the 'Kromek Default Values' in the efficiency drop down box. Changes to these k_e values will affect all measurements, including historic measurements in the database. Note that in this simplified activity calculation the errors on the fit to the efficiency curve are not taken into account in calculating the errors on the final activity.

Scripting

KSpect and **MultiSpect Analysis** provide the ability to automate various operations through a scripting system. This scripting capability is accessed by selecting 'Script Window' under the 'File' menu. From this window, scripts can be loaded, edited, saved, compiled, and executed. The scripts must be written in the C# language (Microsoft Visual C# 2005) and must follow the form given in the examples below.

Control of the software is provided through the properties and methods described in the help on the scripting window of **KSpect** and **MultiSpect Analysis**. Please refer to this help file for the full list of properties and methods.

Example: repeat measurements with a single detector

```csharp
namespace USBSpect{
  public class Script : ScriptInterfaces.IScriptScript
  {
    ScriptInterfaces.IScriptHost pspect;

    public void InitializeScript(ScriptInterfaces.IScriptHost hostObject)
    {
      pspect=hostObject;
    }

    public void PSpectScript()
    {
      // Number of times to repeat acquisition
      const int totalPasses = 10;

      // Choose a file name stem which will be appended by the repeat number
      const string saveFileStem = "Measurement";

      //Set measurement live time in seconds
      pspect.setLiveTime(30);

      for (int p = 0; p < totalPasses; ++p)
        {
                pspect.eraseActiveSpectrum();
                pspect.startAcquisition();
                pspect.waitForAcquisitionStop();
                string fileName = string.Format("{0}_{1}", saveFileStem, p + 1);
                pspect.saveActiveSpectrum(fileName);
        }
    }
  }
}
```

Example: repeat measurements with multiple detectors

```csharp
namespace USBSpect{
  public class Script : ScriptInterfaces.IScriptScript
  {
    ScriptInterfaces.IScriptHost pspect;

    public void InitializeScript(ScriptInterfaces.IScriptHost hostObject)
    {
      pspect=hostObject;
    }

    public void PSpectScript()
    {
      // The serial numbers of each of the detectors
      string[] detectorSerialNumbers = new string[] {"Serial  1", "Serial 2"};

      // Number of times to repeat acquisition
      const int totalPasses = 5;

      // Choose a file name stem which will be appended by the repeat number
      const string saveFileStem = "Measurement";

      // Set measurement live time in seconds
      pspect.setLiveTime(60);

      for (int p = 0; p < totalPasses; ++p)
      {
        foreach (string det in detectorSerialNumbers)
        {
                pspect.setActiveSpectrum(det);
                pspect.eraseActiveSpectrum();
        }

        pspect.startAcquisition();
        pspect.waitForAcquisitionStop();

        foreach (string det in detectorSerialNumbers)
        {
                pspect.setActiveSpectrum(det);
                string fileName = string.Format("{0}_{1}", saveFileStem, p + 1);
                pspect.saveActiveSpectrum(fileName);
        }
      }
    }
  }
}
```

Execution at start up

A script can be run automatically when the software is started by adding the script file specification as a command line argument when executing the application. For example, the following will run KSpect/MultiSpect and then load and run the script ExampleKSpectScript.cs located in the root directory of the C: drive.

1. Select *Run* from the *Start* menu.
2. At the *Open:* prompt enter (include the quotation marks): "C:\Program Files\Kromek\Multispect\Multi-spect.exe" "C:\ExampleKSpectScript.cs"
3. Click the *OK* button to run the command.

Index

Medical imaging

Nuclear detection

Security screening

detect   image   identify

**For after-sales and customer service enquiries
please use the following contacts:**

**T: +44 (0) 1740 626060   F: +44 (0) 1740 626061
E: service@kromek.com   W: www.kromek.com**