User Manual

MyRIAM

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Content

MyRIAM

The Myriam (**My R**adioactivity **I**n **A**ir **M**onitor) is a personal dosimeter to determine dose obtained by long living radioactive dust (LLRD) within the breathed air. Both, alpha and beta radiation will be detected simultaneously. The instrument was designed to warn persons immediately in case of accidents or disasters as well as to provide routinely radiation protection

How to apply the Myriam

At the begin of an observation period (e.g. at the begin of each month)
- Inserting a new filter
- Checking the pump flow rate
- Setting the integration interval with respect to the required detection limit and response time

If the person enters the controlled area
- Starting the measurement using the „Sampling Mode".
- The instrument has to be worn with open face sampling aperture (for example at the belt)
- In case of increased exposure the instrument will give an optical as well as an audible signal

If the person leaves the controlled area
- Stopping the measurement and reading/saving the acquired data
- Recharging the internal batteries if necessary

At the end of an observation period
- Starting the measurement using the „Filter Analysis Mode" to determine the exposure/dose as exactly as required
- Stopping the measurement and reading/saving the acquired data
- Data analysis and archiving of the filter for preservation of evidence.

Theory of operation

The air is sucked through a filter by an internal pump whereby the radioactive aerosols will be collected at surface of the filter. A semiconductor detector is placed directly above the filter to determine simultaneously the collected activity.

The short living Radon daughter products within the air will be separated by alpha spectroscopy to be not included in the exposure/dose calculation.

Because the exposure period is much less than the half life of the collected LLRD, a direct proportionality between the filter activity and the exposure/dose is given.

The dose can be calculated by the exposure using the nuclide specific dose coefficients and the breathing rate of the person under control.

Dose = Exposure * Breathing Rate * Dose Coefficient

The basic interval to determine the filter activity is fixed to one Minute to realise an immediate alert in case of very high exposure. In addition, the user may set a second integration interval in the range of 1 to 255 Minutes. The integration interval defines the point to point distance within the stored time distribution. A longer integration interval causes a decreased detection limit which allows to detect a lower exposure.

If the calculated dose exceeds the user defined alert level, a audible as well as an optical signal is activated.

Beside the online observation of the person an exact dose calculation can be performed by a subsequent filter analysis.

The Myriam offers a special operation mode where the pump remains switched off during the measurement. The influence of the Radon daughters will become negligible and the detection limit may decreased as required by increasing the measurement period.

The following table gives a short overview about the detection limits with respect to the operation conditions (assumed breathing rate of 8100 m³/a).

	1 Minute basic interval			60 Minutes integration interval			Filter analysis 12 hours
Concentration of Po-218 [Bq/m³]	10	100	1000	10	100	1000	0
Pu-238/239 [mSv]	2.28	3.31	6.15	0.09	0.19	0.49	0.0024
U-234/238 [mSv]	0.42	0.61	1.13	0.016	0.035	0.090	0.00044
Sr-90/Y-90 [mSv]	0.020	0.043	0.109	0.0015	0.0040	0.0116	0.00001

*) The mean value of the indoor Po-218 concentration is less than 10 Bq/m³. Under special geological conditions the level can reach 100 Bq/m³. Concentration values up to 1000 Bq/m³ are observed only inside mines, caves and sealed water supplies.

Instrument control

Starting and stopping a measurement

After switching on the instrument by the push button the display will show:

```
   Welcome
Please push
   button
```

or, if the button has been locked by the PC software:

```
   WELCOME
Please
   check in
```

It is possible to start a sample either by PC software or by pressing the push button if the button is unlocked. Otherwise the sample can be started by software only.
During the measurement, the push button toggles the display pages even if the button is locked.
The measurement can be stopped either by software or (if the button is unlocked) by pressing the button for at least five Seconds. If the Myriam is turned on again the data can be read via the infrared interface. Pressing the button for a second time will start a new sample and the old data are lost. Therefore, the button should be locked during routinely operation. The measurement will be cancelled automatically if the battery voltage drops below the switch off level.

Display of the results

The results are shown on three different display pages which can be toggled by pressing the push button. The dose values as calculated by the adjusted dose coefficient and breathing rate for both, alpha and beta radiation are displayed on the first two pages. The second line shows the value based on the last 1 minute while the third line contains the values based on the last finished storage interval.

```
ALPHA
`         0uSv
I         0uSv
```

or

```
BETA
`         7uSv
I         5usV
```

The physical unit of the dose value can be switched over by software between µSv and mrem.

Another display page shows the total alpha and beta count rate including the natural occurring Radon daughter products in the unit CPM (counts per minute). Because Radon daughters are always present these values indicate a error-free operation of the instrument.

```
TIME: 643min
ALPHA:  3cpm
BETA:   6cpm
```

If the count rate becomes higher than 999 / 9999 cpm for the Alpha/Beta activity, the displayed value remains at 999/9999 cpm and the phrase „HIGH COUNT" appears in the upper display line instead of the elapsed time.

Alert situations

If the dose exceeds the user pre-set alert level, either by a 1 Minute OR an interval based calculation, the display automatically switches over to the related dose display page and a blinking symbol of a bell appears in the upper line. The LED starts to blink and the buzzer starts to sound for approximately 15 Seconds. The alert must be acknowledged by pressing the button, otherwise buzzer and LED will be activated once Minute.
If the alert situation is still pending after finishing a storage interval, a new alert will be generated.
The alerts are re-set if the calculated dose value drops below the adjusted limit. This situation can take place if the alert has been initiated by a high Gamma radiation or by a strong mechanical shock or continuous mechanical vibrations (see also chapter "Gamma interference, high count rates and shock rejection").

Gamma interference, high count rates and shock rejection

The detector of the MyRIAM is unable to distinguish between conversion electrons generated by Gamma radiation and electrons emitted by the collected aerosols. That means, in case of high Gamma exposures, a beta inhalation dose is displayed without a true contribution of the filter activity. In that case the dose value will decrease if the radiation field has been left. In case of a true inhalation dose, the activity of the LLRD at the filter remains stable.

The Alpha channel is not affected. But, it has to be attended that the detector dead time is increased in presence of conversion electrons resulting in an increased Alpha detection limit as well.

The detector is sensitive against strong mechanical shock or vibrations. The built-in electronic signal analysis suppresses the noise very efficiently but continued shock or vibration results also in an increased detector dead time.

If the count rate exceeds 1000 cpm, the shock rejection procedure is switched off automatically to minimise the dead time. Normally, the contribution of mechanical shock becomes negligible in that case.

If the count rate is higher than 50000 cpm, the instrument will show "OVERLOAD" and the dose values are not longer displayed. The dead time is approximately 35 % at this activity level. The measurement is still continued and the results can be assessed later on (after downloading the data to a PC).

Dead time ratios higher than 10 % are displayed on the display (upper line of the dose display)

Data transfer

The communication between the Myriam and the PC is realised by an infrared data link. The

infrared interface has to be connected to any USB port of the PC using the USB adapter cable. If the infrared interface is connected for the first time, a driver has to be installed (see software manual).

The Myriam has to be placed in the middle of the interface unit in that way that the charge receptacle at the instruments bottom panel fits into the hole of the plate. The instrument has to be switched on. Each data transfer is initiated by the PC software (remote control).

The stored time distribution, set-up parameters as well as the recent display values can be read even if the measurement is running. To change set-up parameters, the measurement must be stopped before.

Battery and Charger

The Myriam is powered by internal NiMH batteries. Using the "Sampling Mode" (running pump), an operation period of more than 20 hours is guaranteed. The battery recharge takes

about two hours. A charger is included in the delivery.

If the battery voltage drops below a critical level while the instrument is in the stand by mode, "BATT. LOW" will .

A less or more filled battery symbol on the display shows the battery voltage and can be used to estimate the remaining operation time. Please note that the battery capacity depends on the temperature.

Take care for a completely charged battery at the begin of a longer mission.

If the voltage drops below a warn level, the sounder signalises the critical state by a short beep. The measurement can still be continued for a few hours until the battery becomes completely discharged. Then, the instrument switches off automatically. In this case, please recharge the Myriam before switching on again and downloading the data.

If the instrument is not in use for a longer period, the batteries have to be discharged and recharged each 2 to 3 month. The Myriam must not be charged during a sample with running pump. The charging during a filter analysis is possible. Please note that the charger is no continuous power supply. After finishing the recharge process the charger disconnects the

power from its output. To force another recharging the connector to the Myriam has to be removed and inserted again.

Filter replacement

Important note: Use only filters of the specified type. The filter material affects directly the quality of the alpha spectroscopy. Wrong filter material causes malfunction.
To replace the filter, loose the small screw on the back of the pivot mounted arm. Swivel away the arm towards the front panel for free filter access. Unscrew the filter nut anti-clockwise and remove the old filter. Do not touch the surface of the semiconductor detector! Start a sample to make the pump running. The new filter can be placed now very easily because the pressure of the pump fixes the filter on the air inlet. Take care for the filter material because it is very sensitive against bending. Do not use any sharp-edged tool. Fix the filter nut slightly using two fingers. Too strong fixing may damage the filter as well.

Maintenance

The Myriam contains a high quality membrane pump to collect the aerosols on the filter. This ensures a long life time and a very stable flow rate during the operation. Like all moved mechanical part also the pump still undergoes an abrasion process. Therefore the proper function should be checked periodically. If the Myiam is permanently used, the check can be carried out monthly after the filter replacement. It is sufficient to do that once per year if the instrument is only used from time to time (e.g. during calibration).

If the flow rate drops below 10% of the value stated in the calibration certificate, the pump must be replaced because the flow rate affects the sensitivity (linear relationship).
A calorimetric mass flow sensor should be used for the flow measurement because those types offer a very low flow resistance. Insert a new filter for the measurement.

To determine the flow rate, the detector head must be pivoted. Then a special adapter with elastomere sealing (available from SARAD) can be pressed tightly at the filter nut to suck the air through the air flow sensor.

Please check the Myriam for loose parts (detector head, pivot arm, filter nut).

Technical Data

Power Supply	Internal batteries for approx. 24 hours operation, recharge time approx. 1 hour
Operation	1 Button (lock function) Display with back-light (3 x 12 characters)
Alarm	optical (red bright LED at the top of the detector head) acoustical (sounder 85 dB at 2,3 kHz)
Dimensions/Weight	138 mm x 57 mm x 32 mm / 300g
Interface	Infrared (Reader unit for PC, connection via USB)
Memory	240 Data records and Alpha spectrum
Integration Interval	1 ... 255 Minutes (one Minute steps)
Detector	150 mm² ion-implanted silicon detector
Pump	0.25 L/min
Filter	0.8 µm PTFE, operable > 1 Month at „normal" dust exposure
Alpha Spectroscopy	2.8 ... 10 MeV
Energy Window for LLRD Alpha radiation	2.8 ... 5.5 MeV
Lower Beta Cut Off	200 keV
Gamma interference of the Beta channel	approx. 15 cpm / µSv/h
Maximum count rate	100 000 counts per Minute (cpm) Instrument display max. 999/9999 cpm (Alpha/Beta) Dose value displayed only for less than 50000 cpm
Detection Limits/Thresholds	refer following text
Software	Instrument-setup, data download, graphic display of acquired data (exposure, dose, concentration), ASCII Export (EXCEL compatible text file)

Detection thresholds and detection limits

The stated detection thresholds and detection limits are based on exposures meaning the product of activity concentration an exposure times. All values are related to a confidence interval of 3σ.

For the correction of the Radon daughters an Equilibrium Factor F of 1.0 is assumed which is the worst case condition.

The limits are given for the most radio-toxic nuclides Pu-239 and Sr-90 (without Y-90). The dose coefficients (e50) of those nuclides are derived from the ICRP68 standard for inhalation (4,7E-5 Sv/Bq (Pu-239) and 1,5E-7 Sv/Bq (Sr-90)).

We assume the breathing rate for adults defined by the EURATOM guidelines.

To calculate the detection limit/Threshold for other nuclides, following expression may be used:

$$\textbf{H = e(50) * Breathing Rate * Exposure.}$$

Independent on the set integration interval, a one Minute basic interval is applied to analyse the filter with respect to dangerous exposures:
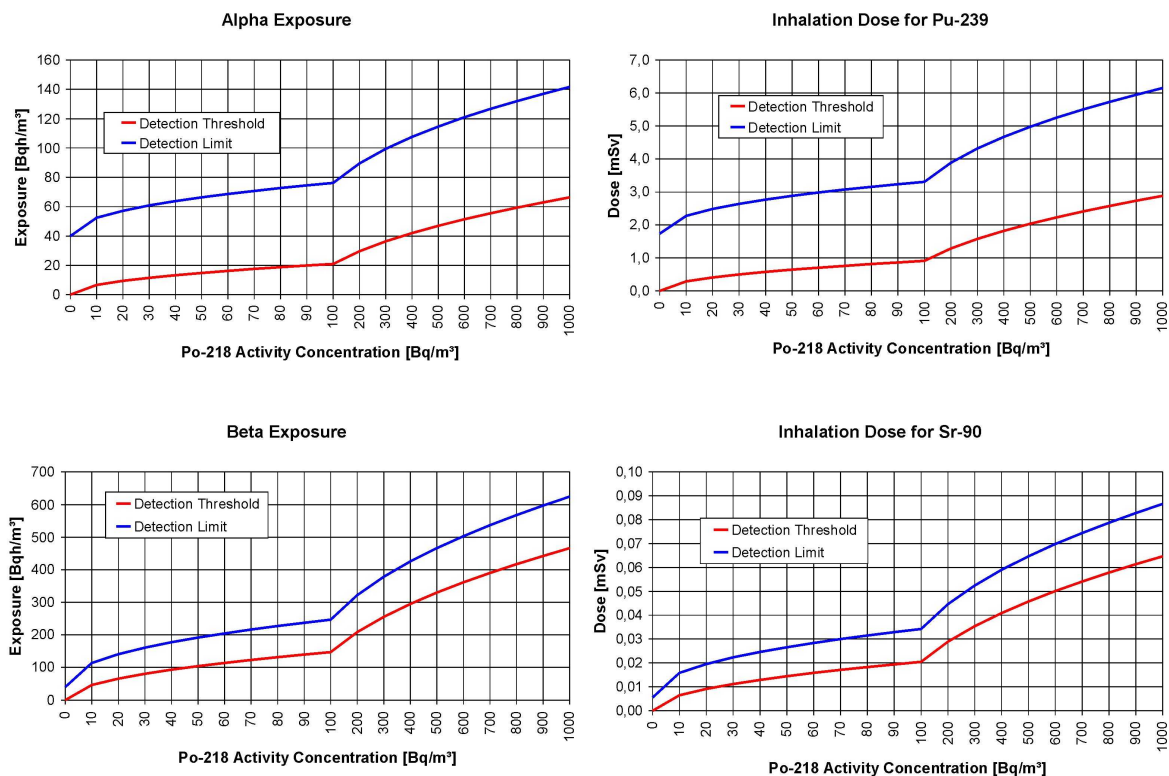

Fig. 1 Detection Limit/Threshold (3σ) for T_i = 1 min

For example, choosing an integration interval of one hour results in strongly reduced detection limits and gives still a good possibility for a chronological (and therefor also local) assignment of dose contributions.

The immediate alert function (1-Minute basic interval) is not affected by any setting of the integration interval. The resulting limits for a 60 Minutes integration interval are stated below:
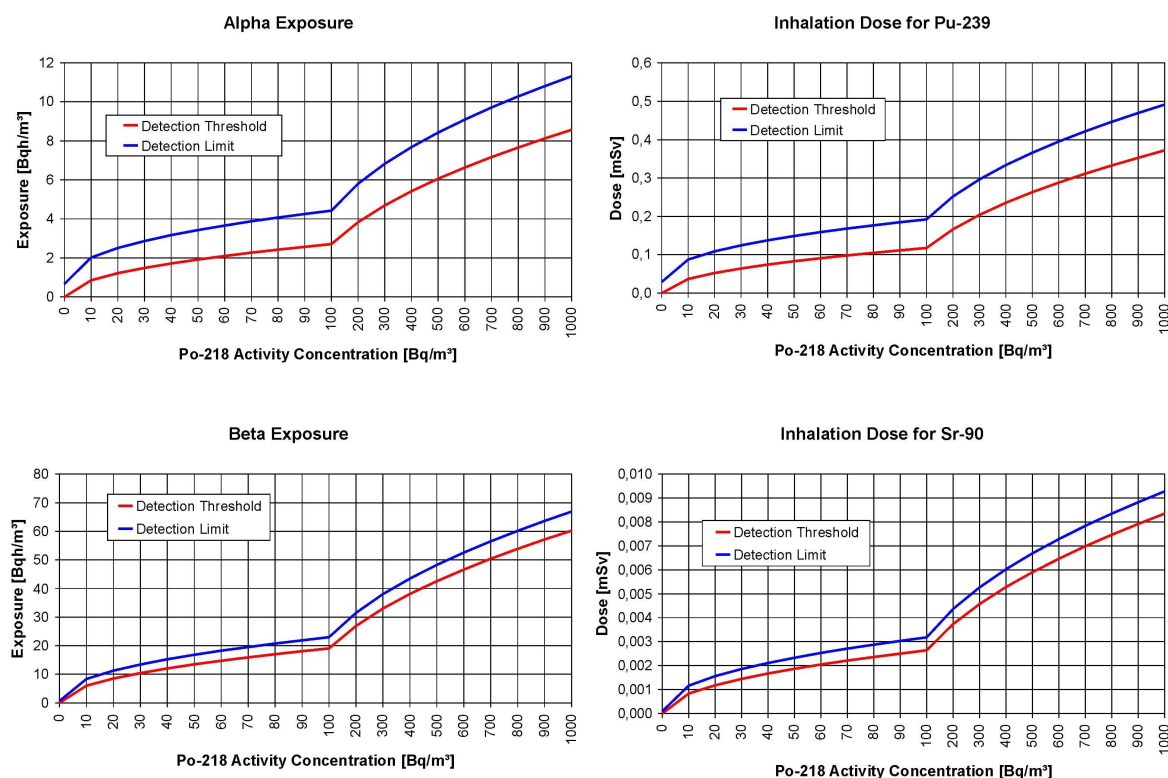
Fig. 2 Detection Limit/Threshold (3σ) for T_i = 60 min

After finishing the observation period (e.g. one month), the inhalation dose for the whole period can be determined by using the filter analysis mode. Because the pump is not running, the influence of Radon daughters becomes negligible and the collected activity is stable over the analysis period.

Channel	ALPHA		BETA	
Analysis Period	Exposure [Bqh/m³]	Dose (Pu-239) [mSv]	Exposure [Bqh/m³]	Dose (Sr-90) [mSv]
8 hours	0,083	0,0036	0,083	0,000012
12 hours	0,056	0,0024	0,056	0,000008
24 hours	0,028	0,0012	0,028	0,000004

Tab. 1 Detection Limits (3σ) for filter analysis mode

Software
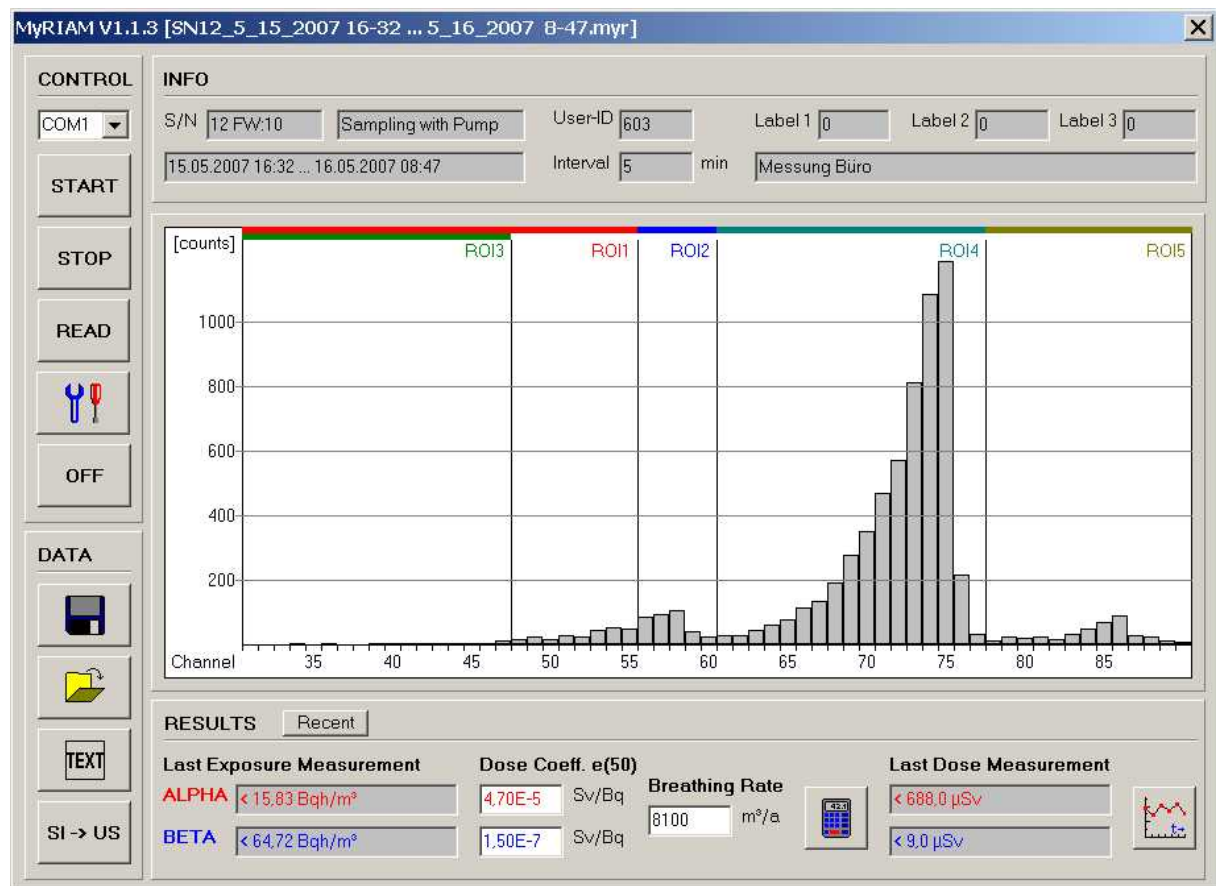
System requirements

- Windows 2000, XP, Vista
- Intel Pentium processor 600 MHz or better
- Graphic 800 x 600 Pixels, 256 colours
- mouse or touch pad
- USB port

Connecting the Myriam

The Myriam communicates with the PC via an infrared data link. The data link unit has to be connected to any USB port of the PC by the cable included in the delivery. When connecting the unit for the first time, the Windows system detects the "new hardware" and starts the installation assistant. The installation assistant will ask for a sufficient driver which is available on the Myriam installation disc within the subdirectory "DRIVER". The installation process will be passed through for two times, one time for the USB link and a second time for the virtual COM port which is used by the PC software to access the infrared data link.

The port selection is realised by a list box in the left upper edge of the program window. If the list was opened all available COM ports are shown. A port is available if it is physical present

at the PC and if it is not occupied by another software. Port numbers above COM9 are not accessible. Normally, virtual COM ports are linked to port numbers higher than COM2. If required, the COM port number can be reassigned by the Windows system control panel.

Accessing the instrument (panel „CONTROL")

START
Clears all old measurement data and starts a new sample with or without pump depending on the selected operation mode (either „Sampling Mode" or „Filter Analysis"). If the button has not been locked, the sample can be started also by pressing the button.

STOP
Stops the running sample (if not yet stopped) and loads the acquired data and the instrument information from the Myriam to the PC. During the data transfer, the number of received messages will be displayed.

READ
Reads the stored data from the instrument without stopping the sample. To get the recent display data, press the button "RECENT" within the "RESULTS" panel.

Opens the dialog window for the instrument set-up. The actual parameters can be read even if a measurement is in progress. However, it is necessary to stop the measurement if the parameter shall be changed.

Switches off the Myriam. To switch on the instrument again the push button has to be used. It is not possible to switch on the unit by software

Set-up

The set-up dialog allows the user to select the different operation modes and to change the parameters required for online dose calculation. If the dialog is opened by the SETUP button of the main window, all actual parameters are read from the Myriam (if accessible) and will appear inside the edit lines.

The four upper fields are used for the personal and local assignment of the acquired data later on. The "User ID" is the primary key for the storage of the data at the hard disk and should be distributed as a fixed personal number. The range of the "User ID" is 0 to 65535.

The items "Label 1", "Label 2" and "Label 3" can be used to specify the location where the instrument was operated. The range for these values is 0 to 255.

The radio buttons "Pump Mode" define how the instrument is operated, either using "Sampling Mode" with running pump or using the "Filter Analysis" mode without pump.

Using the radio button group "Push Button" locks and unlocks the push button of the Myriam. The edit fields in the lower part are important for the dose calculation and the alert check. The alert level is valid for both, alpha and beta channel. The maximum value is 20000 µSv or 2000 mrem.

The meaning of the dose coefficients "ALPHA e(50)" and "BETA e(50)" is explained in detail within the chapter "Data output".

The item "Beta detection rate" needs to be considered more in detail. To achieve the beta exposure, the total beta activity on the filter above an energy level of 200 keV is determined. Because the part of emitted beta particles above this level is depending on the nuclide of origin, the measured activity has to be corrected by a nuclide specific factor. Using the energy spectrum of a beta emitter the factor "Beta Detection Rate" can be calculated by the following expression: number of emitted particles with an energy above 200 keV multiplied by 100 and divided by the total number of emitted particles. Multiplying the quotient by the factor

100 is necessary to get the result as a percentage. In practice the Myriam beta sensitivity will be calibrated by a test source which gives the correct value for the used nuclide.

The "Sample Interval" defines the integration interval for the measurement. After completion of each sequential interval a data record will be stored into the internal data logger.

If the check box "Beep" is marked, the internal buzzer will sound for each keystroke.

Sets the real time clock of the Myriam to the actual PC time.

Loads the actual set-up information from the Myriam into the edit fields of the set-up dialog.

Transfers the content of the edit fields to the Myriam. After transfer, the Myriam will show the dose values using the units as actually selected.

Data handling (panel „DATA")

Saves the data received from the instrument as a binary file on the hard disk. To keep the data integrity, the folders and file names are generated automatically. The data subdirectory will be created in the same folder where the program file "Myriam.exe" has been installed. The "DATA" directory contains subdirectories assigned to each used User ID. (e.g. USER_ID_XYZ). The file name contains the serial number of the instrument as well as the begin and end of the sampling period. It is possible to add a comment to the file. The text has to be written in the edit field right down of the "INFO" panel before saving the data.

Activates the standard Windows „Open file" dialog. Only binary files with the extension „*.myr" are accepted.

Exports the binary data file to an Excel compatible ASCII text file. The file name can be chosen without restrictions. The text file contains beside the measurement results all relevant system parameter and the name of the original binary file. The items within the text file are separated by tabulator stops, so that the file can be opened by the Excel "File open" menu directly.

SI -> US

Toggles between SI- and US units. The units used within the set-up dialog and the graphic window are the same like selected in the main window before – independent on the recent settings of the instrument. If the parameters have been transmitted to the instrument, the display of the Myriam will show the units as used within the PC software.

Data output

The „INFO" panel

The text fields within this panel show the operation mode, the serial number, the user identification, the local assignments, sample interval and the period of the measurement
The fields will be filled after data download from the instrument or opening a binary data file. Only the right lower field is editable to add a comment. The field accepts a maximum of 255 chars.
If a comment has been added before saving data to the hard disc, the text will appear again in the edit field after loading the file.

The spectrum view

A summary spectrum is stored for each measurement series shown in the centre of the program window. The energy limits for the single regions of interest (ROI) are marked by lines and coloured bars. The ROI1 (3000 … 5600 keV) contains the LLRD activity as well as a part of the Po-218 while the ROI2 (5600 … 6100 keV) contains remaining Po-218 only. The ROI2 is used to estimate the Po-218 counts within ROI1 which have to be subtracted from the LLRD activity. The ROI3 is set in that way to cover the energy range of the natural LLRD (3000 … 4700 keV). The software does not distinguish between natural and artificial

radiation but this additional information may be helpful for subsequent considerations. ROI4 and ROI5 cover the natural Radon/Thoron daughters Po-214 and Po-212.

The „RESULTS" panel

The basic value of each dose calculation is the measured exposure. The exposure will be determined for alpha and beta radiation separately. Right beside the exposure values, the dose coefficients and the breathing rate [m³/annum] are stated. The fields contain the values read from the instrument during data download or, if a binary file was opened, the originally saved values.
The content of these fields may be replaced by the user to recalculate the dose with different

dose coefficients and breathing rate. After the input of the new values, the button has to be pressed. The dose coefficients for inhalation are given by the ICRP68 for each nuclide while the age depending breathing rates are stated by the EURATOM guidelines as following:

Age	< 1 year	1 - 2 years	2 - 7 years	7 - 12 years	12 - 17 years	> 17 years
Breathing rate [m³/a]	1100	1900	3200	5640	7300	8100

The resulting dose values are related to the calculated value of the last completed storage (integration) interval. Due to the statistical variations (especially at low exposures and short integration intervals), the true value may be lower or higher than the displayed one. It is strictly recommended to take a look at the acquired time distribution.
If no LLRD activity has been detected, the fields exposure and dose will contain the 3σ detection limits estimated by the Po-218 concentration with a prefaced "<" sign.

This button opens a window to display the time distribution of a measurement. One data point is assigned to each integration interval. The viewed value can be selected by the list box below the graphic area. Exposure, dose value, average activity concentration as well as the total number of counts within the interval can be displayed. To show the 1σ error bars mark the check box "Show Error Bars". The 3σ detection limit appears as a grey shaded area in the background of the diagram.
If the mouse pointer (red line) is moved across the graphic area, the results related to the selected data point are shown below the graphic. The "Life Time" label gives the percentage of the valid measurement time. Values below 100% indicate shocks, vibrations etc. during the sample interval.
In case that the data have been acquired using the operation mode "Filter Analysis", it is not possible to select the concentration distribution because there is no defined relation to the pumping time used for the activity collection. The curves for exposure and dose will show a continuously decreasing error.