GT-40/GT-40S – Multipurpose Gamma Center

User's Guide

Rev. 1.9 – June 2023

NOTE:

User's Guide Rev. 1.9 covers all firmware versions of GT-40 and GT-40S launched before version 1.17 in all features.

There is required program Geomon of version 0.6.19 or higher for access to all functions and parameters of FW 1.17 via a PC

New features added:

All versions of FW starting with 1.xx supports updated hardware revisions of GT-40 and GT-40S. All spectrometers GT-40 and GT-40S with serial numbers 140 and higher are equipped with new hardware revision.

1. GENERAL

The **GT-40/GT-40S Multipurpose Gamma Center** is a new state-of-the art among portable hand-held radiation survey instruments and radionuclide identification. Ideal for searching radioactive sources, their identification and determination of their activities - concentrations. Perfectly suits in application in geology, environment protection, waste management, industry and much more. It offers an integrated design with good weather protection, large detector, easy to use and the highest sensitivity. It was designed as a multipurpose instrument to be used in outdoor as well as in laboratory conditions.

1.1. Main Features

- **GT-40** – **3 x 3" (345 cm^3)** Sodium-Iodide detector provides High sensitivity performance due to a large crystal. Energy range from 15 keV - 3000 keV.
- **GT-40S** – **2 x 2" (103 cm^3)** BGO (Bismuth Germanate) detector provides High sensitivity performance due to the larger density of the crystal. Energy range from 15 keV - 3000 keV.
- Large Graphic Color LCD **Trans reflexive display** of size 360 x 240 dots ensures excellent readability in any outdoor conditions. The size is 3.5" diagonal. Automatic dimming.
- Simple operated with five-position **navigation joystick**. Positions of the joystick are illuminated.
- Memory able to store **2000 samples** what includes spectra, assay or identification results, GPS coordinates and voice recordings.
- New designed state-of-the art electronics with advanced CPU capability.
- Special rugged mechanical design, robust aluminum casted construction. Rubber shock absorber and internal thermal isolation.
- Well balanced, easy to hold, designed for operation in field conditions.
- **Full IP65 weatherproofing** – short term water immersion and fully dust protected.
- **Rechargeable battery Li-ion** module.
- Typical **8+ hour** battery life at 20 ^{0}C.
- Size 120 mm diameter x 415 mm Weight – 4 kg.
- Operational Temperature range **-10 to +50 ^{0}C** (display is the limit).
- Sensitivity: 386 cps above background (1 MBq of Cs-137 from 1 m).
- Modern spectrometer design. Fully digital.
- New sophisticated algorithm for evaluation of concentrations of up to 6 radioisotopes in various geometries.
- Extendable for Nuclide Identification of Gamma-ray sources.
- Full energy compensated dose rate measurement.
- Automatic energy calibration based on natural background radiation. **No external radioactive source required.**
- USB and Bluetooth and Wi-Fi connection.
- Integrated GPS.
- Integrated microphone for voice recording.
- Automatic display orientation adjustment suits for horizontal or vertical operation mode.

1.2. Description

The GT-40/GT-40S is designed as a portable handheld instrument. The design respects specifications for indoors as well as for outdoors applications in wide range of temperature and humidity conditions. The GT-40/GT-40S consists of single body proposed to be used mainly as stand up detector. Minimal diameter overlap of head of the instrument over a detector's part allows an easy use of the instrument in boreholes or to be placed in tight shielding. The instrument is self-contending there are no additional devices required for its full functionality.

The detector body is made of thin aluminum pipe shaped to harbor internal shock absorbers and temperature isolation. Internal locks fix the detector assembly in position. A head assembly is milled of two pieces of aluminum. Inside the bigger one there is located battery, electronic boards and terminals. The second piece combines bezel of main panel and handle grip for easy carrying.

The bottom of the instrument is protected with rubber boot. The boot is removable and covers bottom lid closing access to detector and collimator (GT-40S).

There are two items on backside of the head assembly. A loudspeaker is hidden behind milled grid and below it there is access to USB and power input connector's terminal. The terminal is covered with a rubber lid. The lid is removable from one side where is visible a small slot for nails. The other side of the rubber lid is permanently locked. User shall pay attention to which side is the removable one to prevent any damage of the lid. No other types of USB and power adaptor cords than delivered by manufacturer shall be used for connection with the GT-40/GT-40S. Improper connector may damage terminal.

The main panel consists of a large display, buttons joystick, holes for microphone and light sensor. A gray plastic lid under grip hides a GPS antenna. A Bluetooth antenna as well as Wi-Fi is located near display.

The joystick is made of five separate buttons. Four of them are orbiting the central OK button. All buttons are protected with transparent rubber cover. Each of the buttons is illuminated.

The instrument can be cleaned or decontaminated any time using soap water or ethyl alcohol or isopropyl alcohol may also be used. All mechanical components were designed for highest possible robustness. The most fragile elements (detection crystal and photomultiplier) are bedded in shock absorbers regardless that fact user must pay attention to how the unit is used and prevent mechanical shocks.

2. SYSTEM OPERATION

2.1. Batteries

The GT-40/GT-40S is powered from Li-ion battery pack build in the unit. The pack is not replaceable by user and must be changed by trained personal. To increase protection of any damage caused by batteries the manufacturer uses only batteries with build in protection. Full control of charging and discharging of batteries is arranged by build in circuit.

The Li-ion battery is an excellent source of power for the unit but needs an extra care. Although the most critical conditions are watched by build in computer, user is requested to care of following:

- Never charge the unit when temperature of the batteries drops below 0 °C. Preferable conditions are around 20 °C.
- Do not store the unit with fully discharged battery!
- Pay attention to warning messages of internal diagnostic.
- Access to battery back is limited and its replacement shall be done by authorized service personal only.
- Only original spare battery pack may be used.

2.2. Charging (Low batteries)

The GT-40/GT-40S has a full control of capacity of batteries. When the Battery charge is getting below 10 % of capacity an audible beep sounds prompting user to pay attention to a message on display. If the Battery icon shows very little capacity left (message **LOW**) the battery pack must be charged promptly. We recommend as prevention of any data loss by uncontrolled termination of measuring activities to switch unit off. This action ensures complete and correct data storage.

The GT-40/GT-40S has a build in battery charger. This allows the batteries to recharge the unit while operating without removing the batteries. The implemented charging controller is active during charging regardless a working status of the GT-40/GT-40S. The GT-40/GT-40S can be charged in power on as well as in power off status. Indication of charging progress is arranged by green LED light located on side of power adapter plug on rear terminal. LED light on indicates charging process. Light off means no charging and flashing light announces any error.

Only verified power adaptors delivered or approved by manufacturer can be used for charging. In case of use of a 12 V DC car outlet this has to be fused. User must prevent any direct connection to an auto battery without a fuse. Minimum fuse current shall not be less than 4 A. Any non-fused connection may cause a fire or permanent damage.

To charge connect the unit to a 12 V DC charger plugging the power connector in the hole located on rear terminal under rubber cover. Charging progress indicates an icon shown on right top corner of display. The icon has animated filling  pattern to indicate charging progress.

The Manufacturer will not be held responsible for damage to the unit caused by use of improper adaptor. Connecting a wrong type may lead to unpredictable damage on the unit and will invalidate the warranty.

The unit may operate on external power anytime. External power use is not time limited and suits for long term monitoring tasks (permanent monitoring stations).

2.3. Joystick

The GT-40/GT-40S Multipurpose Gamma Center has five control buttons associated in a PUSH-BUTTON JOYSTICK. Each button is illuminated what is used for prompting expected actions. The Joystick has four buttons on sides creating an orbit around the fifth button in the center. The orbital buttons control graphical cursor directions UP, LEFT, RIGHT and DOWN. The central button is used for confirmation and also for switching the unit ON and OFF.

Except switching ON and OFF all clicks of any button shall be performed as a short press of a finger on center of a button as long as a mechanical feedback (click) occurs. Then the finger pulls back. Any button click must be followed with any action of graphic users interface. User must pay attention to a feedback. The feedback can be a move of graphic display to different position, change of a value in editable boxes, starting on any action. To increase operability of some editable functions or spectrum browsers an auto repeat function on buttons is implemented. User shall push a button and hold as long as an expected number or cursor position occurs on screen.

2.4. Display

The Display is a backlit LC trans-reflective color display optimized for high contrast in outdoor conditions. Display backlighting is required in low light conditions to make the display readable. Backlit is controlled automatically. Ambient light is measured by sensor under main panel. The Display is used for various functions and messages. The trans-reflective feature ensures magnificent readability even on bright sunlight. Orientation of a picture on the display is controlled by accelerometers and will automatically flip when the instrument is moved from vertical to horizontal position and vice versa.

2.5. Switching ON

Press and hold the button **OK** as long as buttons illumination lights appear or for maximum three seconds. Following actions will continue. There is a message LOADING accompanied with animated progress circle hold for about five seconds. Then the display is replaced with a welcome screen consisting of manufacturer's logo, name of the instrument, serial number and firmware version number. Then the startup action continues and the unit switches after internal tests to a SURVEY mode.

2.6. Switching OFF

To switch the unit OFF, press and hold the button **OK** until the unit switches OFF. This switching off is used when it happens that the unit stops user interface function and there is no reaction on any key touch. Standard way to switch OFF the unit is to choose switch Shutdown function from Main menu and confirm Shutdown action.

2.7. Connection to devices

Transfer of Recorded data from the unit as well as major parameters modification or remote operation can be provided via three different communication channels. There is one wire and two wireless standards to connect the unit with external devices.

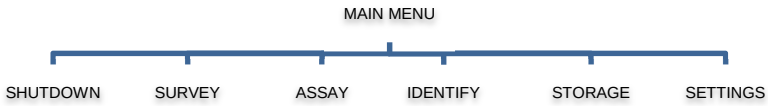
USB standard wire connection cares of all tasks between PC devices. Via USB there are accessible all measured data logged information and access to all parameters. A remote operation is also possible. A connection procedure description is a part of this User's Guide in section Supporting PC programs.

Bluetooth connection bypasses USB by wireless way in all functions and additionally there are modes for connection of special devices extending the GT-40/GT-40S functionality e.g. wireless headphones, automated loggers and more.

Wi-Fi connection is the most preferable way. It profits of worldwide use and presence of Wi-Fi devices and high speed. It is not only reserved for applications requiring direct LAN access. Beside Internet connection and far distance controlling mode this type of connection allows also creation of a network of GT-40/GT-40S, e.g. in environmental monitoring applications or fix monitoring stations.

3. Access to working modes and Main menu

The Main menu is a root of tree of action's direct calls and submenus. The direct actions are Shutdown, Survey, Identify and Assay. Shutdown call leads to switching off the unit. Survey, Identify and Assay starts measurement procedures. Activation of the two other

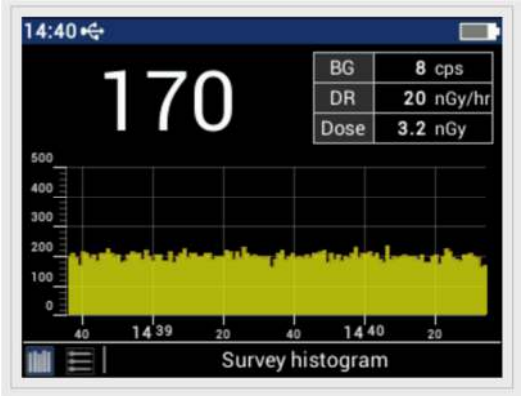


items Storage and Settings leads to opening submenus for further access to Data Logs or Parameters. Return back to Main menu from procedures or submenus is arranged through an **Action menu** where selection of the last item of this menu returns to Main menu. See appendix for detailed map of functions and menus.

After power on the GT-40/GT-40S starts immediately Survey process. The joystick button OK is designed to call a subordinate menu **Actions** from active working procedures (Survey, Identify or Assay) or to confirm selection of an item in menus. For example: To go to Main menu from Survey or to switch to any supported feature user needs to touch OK to get **Action menu**, then select **Main menu** or required feature and confirm with OK again. To reach Main menu from Identify or Assay through related Actions menu use the same way.

4. Survey

The GT-40/GT-40S unit associates two functions at a time. A sensitive gamma ray scintilometer accompanied with gamma spectrometer function working on backstage. The survey mode is rated for fast and easy sources targeting or as a stationary monitor of radioactivity. Survey is suitable for sensitive gamma ray profile logging in terrain. Carrying unit as backpack or on any suitable moving device gives excellent gamma profile information. Each reading is completed with actual position of the unit in GPS coordinates and is stored on memory. Survey mode starts automatically after power ON or can be started from Main menu calling item Survey. While the unit is ON a gamma spectrum is continuously collected on backstage. It is used for a real time gain compensation of the unit's temperature drift. In the same time also actual dose rate is evaluated and continues total dose integration since the unit is powered ON.



Indication on display is partitioned into three fields – windows. The strip field in a top is status information bar. There are various pictograms displayed in this row. See the appendix for details about icons used. Actual time of the unit occupies the left corner. The middle of the row is used for plenty of icons, like Gain stabilization, Recording, USB connection, Bluetooth connection active, GPS status and important error warning icons. Shall be more icons to be displayed then there is space available, Icons are animated and rotate from left to right like headlines. Battery status is on the right side of the bar.

The left side of the second window is reserved for Total Counts. There are up to five digits reserved for showing every second readings of recorded gamma ray incidents within last second (cps). The total counter is connected with a graphical histogram what occupies lower two thirds of display area. The histogram - recorder is used for easy orientation while searching. The recorder indicates intensities of radiation scans recorded during last 120 seconds. It allows to user fast and simple comparison of gamma-ray intensities in different positions of the unit while searching and easy determination of the most radioactive spot. The histogram's scale is auto ranging and the current amplitude is indicated with a little arrow left of the y scale. An x scale of the histogram is marked with actual time marks.

The right side of the second window is a table of most important On fly results. There are written last updated background values and current dose rate together with accumulated dose.

For a detailed inspection of the histogram user can **Pause recording**. This will happen after call of Action menu by pressing OK button followed with selection Pause and its confirmation with OK button. In this mode the screen freezes and user has time to inspect the recorded histogram. User can use UP, RIGHT, DOWN and LEFT buttons to move position of the histogram on x as well as y scale to see time or amplitude details. Return to actual mode is performed after pressing OK button and selecting of **Resume** followed by OK confirmation. It is important that during the pause the unit keeps recording of actual data on backstage and no data of search profile are lost.

4.1. Audio and voice recording

The GT-40/GT-40S has an audio loudspeaker inside the unit. The audio system is used in various modes. In the search mode the audio system is activated when the radiation level gets above a certain internally computed Audio Threshold. Once the Audio Threshold is

exceeded then the Audio frequency reflects the incoming count rate. The frequency pitch is proportional to count rate. Rules for audio threshold set up are in the next section.

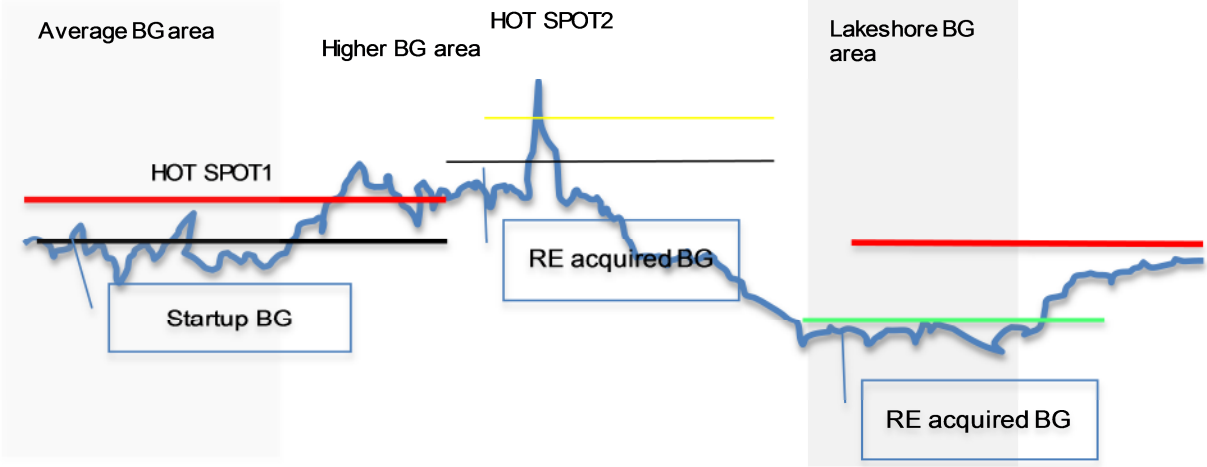
Audio system is used for recording of spoken messages/comments of user in Assay or Identification mode. Important notes about measurement can be spoken to a build-in microphone at front panel and re-played before saving. The voice in digital form is then attached to the spectrum. Voice notes are exported in wmf format and can be replayed on PC. The voice notes are editable prior storing into memory.

The audio system is also used to inform user about important statuses of the instrument. Various warnings are broadcasted.

4.2. Re-acquire Radiation Background

We use a following condition for demonstration how the audio in survey mode works. Let set the **Audio threshold** to one sigma. Immediately as the unit is powered ON and starts Survey mode (or Survey is engaged from any menu), the first 10 readings of total counts in cps are averaged and the audio threshold is computed from this average. The threshold responds to the value of the average plus one standard deviation of the averaged data. If the count level exceeds this threshold the audio starts sound as described above. However in many areas and conditions the local background may vary and it may cause threshold problems, false alarms or sensitivity failure. It is important to be able to accommodate the audio threshold to local conditions any time.

There is an example on the next page illustrating possible threshold problems. Survey starts in the area with low level local background. When the local background level is 100 cps - then at 1 Sigma, the Audio Threshold = 110 cps (100 + 1 Sigma). See the red line in Average BG area what demonstrates the threshold. So if the count rate goes above 110 cps the audio will sound. Indication of a hot spot 1 is possible.



However the local Background may increase substantially let say to 200 cps (user moved from an open space to a building e.g.) then the audio will be on continuously and the frequency pitch will not be sensitive enough to small local changes so the hot spot 2 will be missed due false alarm. Re adjustment of the threshold is essential to accept higher background condition. The new threshold is 214 cps. It may happen an opposite case. If the local background drops down, e.g. to 50 cps (Lakeshore area) then the local radiation would have to increase very substantially (above 214 cps) before the audio sounds what means that even as high source radiation as from hot spot 2 can be missed because it sits on a low background and total counts of the source will not reach the threshold. This effectively desensitizes the audio system. The new re-adjustment on Lakeshore area sets the threshold to 57 and maintains high sensitivity to hot spots.

To overcome this “problem” AT ANY TIME user can briefly touch the **OK** Button and choose the **Acquire bg** from action menu list then the system will start measuring of background

(10 seconds), re-compute the new Audio threshold, and automatically return to the Survey display.

This means user can "re-tune" the Audio Threshold at any time thus keeping the audio threshold optimized. The actual background level is indicated in the table on search display.

4.3. Actions

The GT-40/GT-40S has the joystick as noted above. To achieve the required system functions CLICK the OK button and the Action Menu appears. User navigates up and down this menu using clicks on proper buttons. To prompt user to use only sensible buttons the expected are illuminated. Highlighted icons on display move with the selection. Once the item is selected press OK and the selection is confirmed and the unit starts action.

a) **Assay** – starts a spectrum measurement and performs radio assay – see chapter ASSAY.
b) **Identify** - starts a spectrum measurement and perform Nuclide Identification - see chapter IDENTIFICATION.
c) **Acquire BG** – the unit starts new background measurement. Then a new audio threshold is computed and set up. A new actual averaged background is indicated in the table on search display.
d) **Start recording** – activation will start the recording of the count rate measured (cps) and dose rate. Data are recorded every second with actual GPS coordinates. Once selected and the units is recording readings the item Start recording in action menu is replaced by **Stop recording**. This way user can Start or Stop in flip flap mode.
e) **Pause** – leads to pausing survey histogram move. The values on display and histogram are not updated. User can user left and right button to move cursor through survey histogram bars and can take readings of past scans. While user browses the paused display the unit continues with scanning on backstage.
f) **Resume** – resume returns display to actual position of last scanned sample. The Pause function is left and histogram resumes to actual position from backstage buffer.
g) **Main Menu** – return to instrument's root menu.
h) **Continue** – activation will switch off the action menu and keeps all background values without change.

4.4. Recording to Memory

Gamma Ray intensities and dose rate accompanied with GPS coordinates can be recorded to memory. There is a huge space allocated for Survey in memory. Data are saved every second. Data stream is exportable via supporting PC programs. See section about PC tools.

Start recording is accessible from menu **Action** what appears immediately after OK button click while unit works in Mode – Survey. Next user moves highlighted cursor bar to position **Start recording** (using up or down button clicks) and activates it with OK Button press. Unit switches back into Survey. Memory storage starts promptly. Icon R in the information bar indicates process of continuing data storage. To stop recording user must revoke menu **Action.** Selecting and activating **Stop recording** user will interrupt data storage and the unit will return to basic Survey mode again.

User can read, browse recorded data and manage memory with PC support program GeoMon or browse profiles on unit screen using functions of Survey log.

4.5. On fly Assay

The On Fly Assay mode is designed for fast assay measurement while the instrument is targeting radioactive sources in survey mode. The On Fly Assay performs assay evaluation in short time intervals. Purpose of this mode is to show preliminary assay results. This

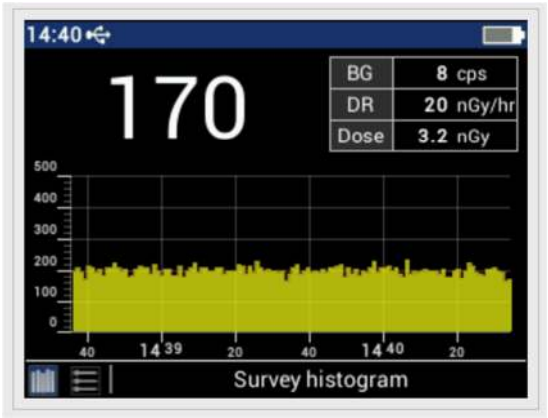
feature may help to target locations of interest much faster and then allow spending more time on proper assay in pre-selected localities. As an example there can be two different hot spots on search track, which appear similar in total counts in cps. Meanwhile the On Fly Assay indicates higher concentration of U on the first place and Th on the second. This way there is added additional information about type of the source.

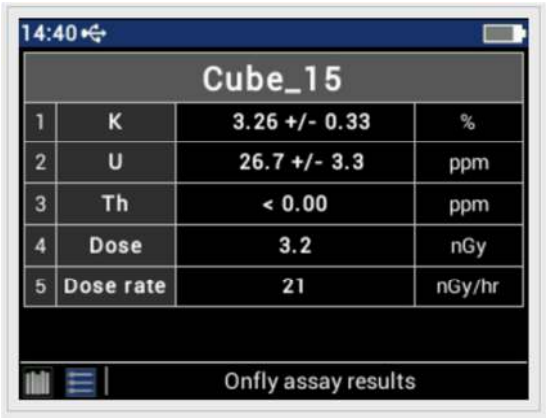
Integration and display time can be changed. There is used 300 seconds integration window and results are evaluated every 10 seconds by default. Both parameters – **Onfly_assay_buffer_length** and **Onfly_interval** are accessible via Geomon application. Evaluated results become part of data stream while recording of Survey is ON.

On Fly Assay works with every method implemented in the unit. There are evaluated and shown up to six components without any limitation. This helps to target e.g. man made sources in environment or allows fast pre scanning of drill cores. A right method is engaged the same way as for regular assay in Settings. The On Fly Assay mode is engaged/disengaged through selection of deselection of proper parameter using Geomon. Once the mode is selected it starts automatically since survey mode is active. Because every assay depends on correct energy calibration the first On Fly Assay result appears 10 seconds after successful unit gain stabilization - icon **((•))**.

It is important to know that using short integration time does not allow reaching high confidence level of results and therefore is important to pay attention also to evaluated standard deviation. Also use of 10 second moving window on 300 seconds buffer leads to suppressing of differences in time profile. Both parameters shall be tuned with profile scanning speed and then On Fly Assay brings its benefits.

Access to On Fly Assay results is via second screen in survey mode. See pictures below. Switching between survey histogram and On Fly Assay results screen is arranged by left and right button.





5. Spectrometer features

The GT-40/GT-40S Multipurpose Gamma Center is a High Sensitive Handheld Spectrometer. Build with large volume NaI/Tl detector with 1024 channel analyzer (MCA) gives a solid base for highly sophisticated algorithms for gamma spectra evaluation. A new powerful Microprocessor allows engaging complicated statistical method to be used in the unit. A unique evaluation algorithm allows determining concentration of natural radioactive elements as well as manmade radioisotopes in various applications. Beside most common application in geology the GT-40/GT-40S is perfectly suitable for tasks in waste management, environment and general monitoring. The whole assay process is fully automated and does not require special user's effort. Information about concentrations and their confidence are printed in a result table.

5.1. Warming Up

As other devices based on NaI/Tl (or BGO) scintillation detector the GT-40/GT-40S must compensate amount of lite of the detector to ambient temperature. Unlike other units the GT-40/GT-40S profits of radiation of natural background where is enough information to provide gain correction precisely. There is no requirement to use any man made radionuclide for warming up process.

Warming up and hold on correct working parameters is automated process running continuously after power on. For all the time while the unit is ON there is spectrum measurement process active (all background process) and actual gain deviations are compensated. Exposition of the unit to other than natural sources (search for unknown source and identification of radionuclides) will temporally postpone any gain correction. Recovery of the self-compensation process starts immediately as the unit is back on natural background level. Method of self-compensation uses spectral patterns of K-40, Ra-226 and Th-232 with their library templates to be compared. Any shift from ideal position leads to gain adjustment. After switch-on the unit prompts to Survey. Warming up process starts immediately on backstage – system is collecting actual spectrum. Collected spectrum is evaluated every 30 seconds and unit's gain is tuned. Evaluation progress is indicated with flashing icon **((•))** located on the information bar. Once the unit sets the gain to the correct value the icon **((•))** holds in info bar on display and the unit is fully ready to work. The gain correction process is active all the time and access to any other functions of user's interface e.g. setup menus will not interrupt it.

Because sensitivity of NaI/Tl to temperature is relatively high and unit may compensate big differences in gain, to save time it is recommended to let unit running for all the time even when assay is not needed. The unit can be powered on external power. While in idle, the unit will proportionally compensate any temperature drift and hold unit ready to go any time. Should it happen that the unit was stabilized and finally switched OFF in very different ambient temperature then other day when is switched ON again. The warm up process started next day will have to compensate a huge drift off previous last work gain setup what may take longer time, but no longer than 15 minutes. Exposing the unit to higher radioactivity than natural background will work contra productive.

In case there is no way to perform warm up process for any reason, e.g. extremely low local background typically on glaciers or on the sea, user can use maintenance function and re-stabilize the unit using an external source of Cs-137. The radioactive source Cs-137 is not delivered with the instrument. All process of warming up is logged and can be reported via supporting programs. In case of gain stabilization troubles please contact manufacturer for advice.

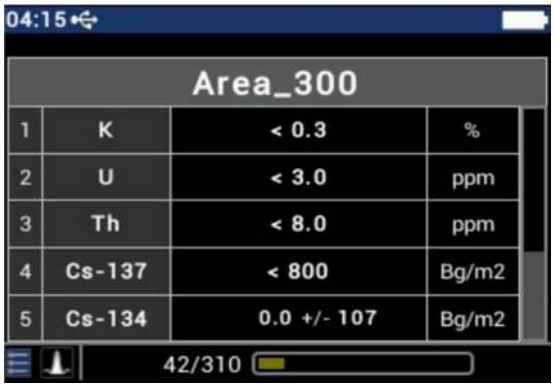
5.2. ASSAY

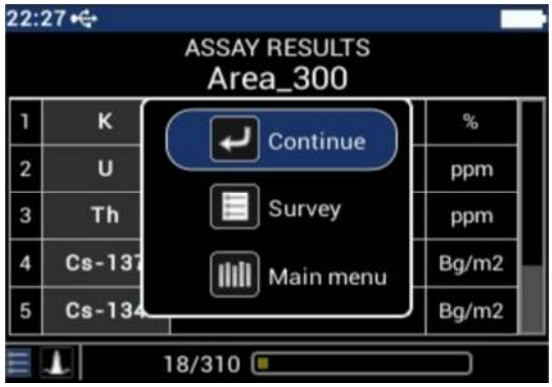
Routines for Radionuclide ASSAY feature the highest level of Gamma Ray Spectrum analyze. Process of calculation of concentration of various elements is a unique method developed by Georadis. Result is a list of determined radionuclides and their concentrations.

Let suppose that the unit has been switched ON and the warming up process has been finished. There is the icon **((•))** present in info bar on all screens. The ASSAY process can start. First **OK** button click activates menu **Action**. Then select and activate the item **Assay** by **OK**. Spectrum acquisition starts immediately and a new Assay screen will appear on the display. It consists of two screens. To extend size for spectrum displayed and offer a service for detailed spectrum view there are results of Assay printed on separate screen. User can easily switch between the screens anytime. Use left and right arrows.

5.2.1. Assay results screen

The picture below shows a screen with Assay results. Almost all area of display is occupied with table of results. Headline of the table indicates a method used for current Assay. An index number of each component assigned to the method is in the first column. There are maximum six components. Rows in the table can be scrolled up and down using UP and Down button. A name of a component is in the second column. The third column shows activities or concents of components plus their errors in units printed in the fourth column. The first results of Assay are printed after 30 seconds after spectrum acquisition starts and then every 30 seconds are updated. Information about time progress is in numeric as well as graphic form and is located down on the bottom of the screen.

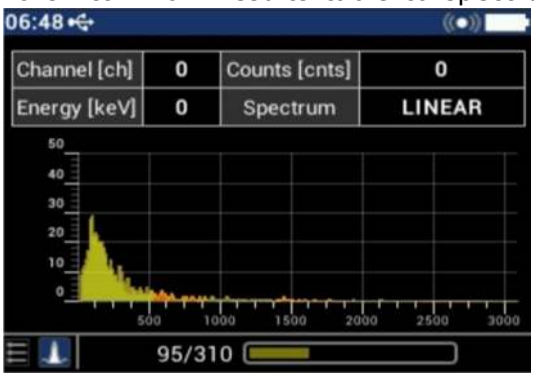




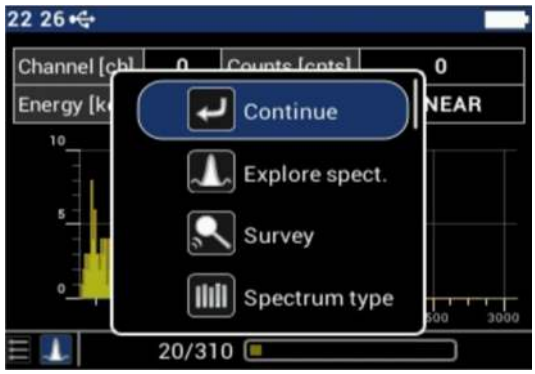
To leave the assay press OK button to activate **Actions** interface. Available services are: **Continue** what returns back to results table, **Survey** what jumps in survey or **Main menu** to return. Number of actions may vary with number of engaged services e.g. Identify, Save results, etc.

5.2.2. Spectrum display

To switch from results table to spectrum screen user must use right or left button. For indication of direction two icons are used in down left corner of the both screens. The left icon indicates table of results and the right one spectrum. Actual selection is highlighted with blue background. Beside the common objects like information bar and time progress area the spectrum screen shows table with cursor channel position, related energy and counts and plots a spectrum.



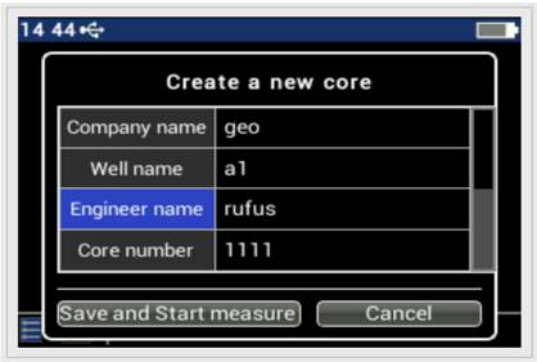
To leave the screen press **OK** button to activate **Actions** interface. Available services are: **Continue** - leads to return back to spectrum. **Explore spect.** switches SPECTRUM BROWSER ON. Item **Survey** jumps into survey mode. Selection of **Spectrum type** gives a choice to display either common LINEAR spectrum or compressed 256 channel nonlinear spectrum. Next is **Main menu** to return back.

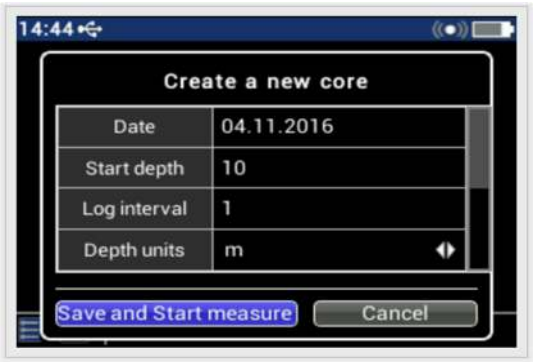


An actual measured spectrum is animated on display. Once engaged SPECTRUM BROWSER mode there are active all direction button for x and y scaling, zooming of selected regions and spectral cursor move. While pushed the arrow button the cursor moves proportionally in direction of the arrow button. Its position over particular channel is displayed in a table above spectrum. Channel position in index number, related energy in keV and actual channel counts informs about spectrum details. There are additional services supporting the browser. After OK press a list of services pops on spectrum screen. Services are **Continue** to return back again without any change, next **Zoom** to enlarge x scale for details, **Auto Scale** to rearrange spectrum proportions, **Spectrum type** and Exit **exploring.**

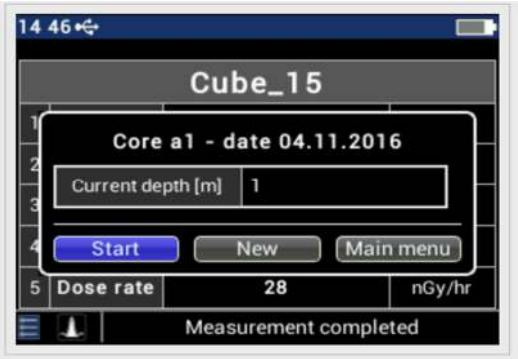
5.3. Core Logging feature

Core mode represents a repeater what adjusts automatically proper core descriptors and synchronize them with assay results. There is created a new record in database. The record consists of Name of the company, Name of a well what the cores belong to, Name of an engineer who performed measurements, core identification number, Measuring date, Starting depth, Logging interval and depth units.



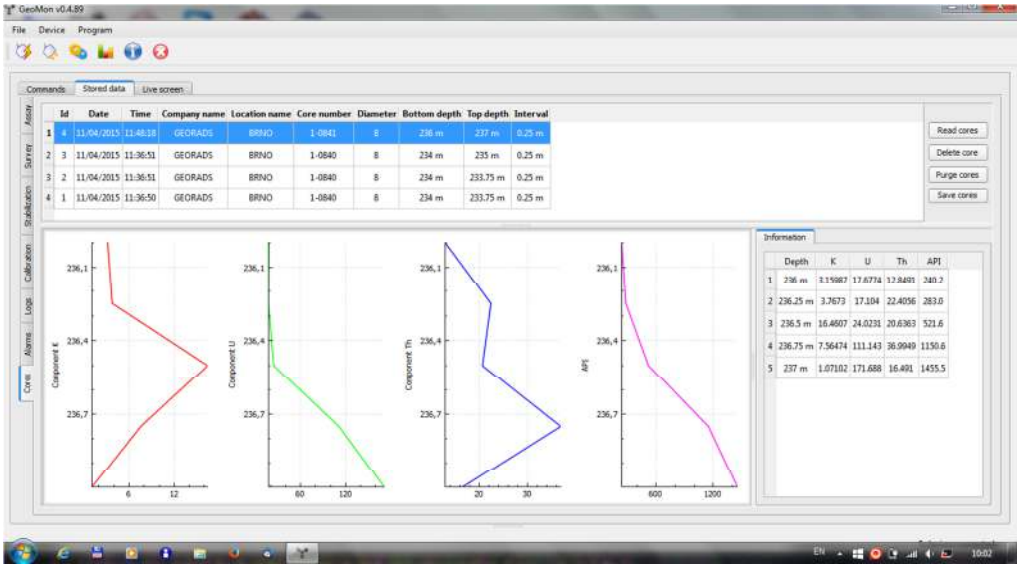


Core measurement consists of repeated assays along a core in predefined depth positions. Every assay starts with generating a new depth position. User then adjusts instrument to a new position and confirms it. Measuring process starts promptly. Assay results completed with depth position are recorded.



Once the whole core is completed a new core record can be created. Button **New** starts a process of creation of a new record and all job then repeats.

Final results are exportable in csv format. The program Geomon is extended for core data manipulation and graphical interpretation.



Core data tools are located in separate window in section Stored data. Next push on tab Core opens the window. Records are downloaded from unit after pressing button Read Cores. Internal database is organized in the way that core assays are kept separately of regular assays.

5.4. Measuring Methods

Evaluation of concentrations of various samples in different geometries.

Determination of activity or concentration using gamma spectroscopy is based on comparing of spectrum of an unknown sample with spectral response of a standard of known concentration of element in fixed geometry. The geometry factor is critical. There is no way to use one type of geometry for calibration and different one for samples. For example unit calibrated for response on a beaker of a small volume cannot give a correct result of soil contamination measurement in large area. The GT-40/GT-40S is designed to be able to build in up to six different calibrations for different geometries – called **Methods**. Methods are selectable prior measurement.

Each method consists of a complex of parameters and spectra of known standards. All this parameters are essential and any improper change will lead to degradation of result's confidence. A method can be customized by manufacturer or advanced users can create a method themselves.

How to create a method? There has to be prepared following items:

1. It has to be made a decision on list of radionuclides to be determined. Maximum number is six radionuclides. Only radionuclides emitting gamma radiation within energy range 30 keV up to 3 MeV can be used. There is no limit on a shape of spectra and number of peaks in the spectrum. A single peak emitting radionuclides are determined as good as radionuclides with multiplets.

2. The customer must decide what geometry will be used. For example, bulk or liquid samples should be measured; user must decide what containers are to be used and in which position to the detector will be measured. When measuring large objects, user chooses only the appropriate geometry. Most common geometries are for example standard beakers of 100 ml, 250 ml or 750 ml, measuring of large flat areas, measuring in tunnels (4π), borehole cores, etc.
3. For each radionuclide must be prepared a calibration standard of known concentration – activity. Preparation shall be consulted with manufacturer or with a local laboratory licensed for manipulation and manufacturing radioactive substances. Many geometries are being used worldwide already and are standardized. The manufacturer has evidence what geometries and standards have been used and may recommend and calibrate the unit during manufacturing period.
4. Concentrations of each radionuclide within one method can be computed in different units. There is possible to combine %, ppm or kBq/m^2. It means every component has its own unit and there is not any bound to other components units.
5. There must be selected ROIs – region of interest for each radionuclide in spectrum. Typically are used margins (from left to right foot) of peaks belonging to the determined radionuclide. Up to six ROIs per radionuclide may be used and combined. Any spectra overlap is allowed. For example ROI for Cs-134 can be from 520 to 690 keV and it will overlap ROI for Cs-137 from 570 to 740 keV.

The instrument is delivered with default calibration for determination of potassium, uranium, and thorium in rocks at flat infinite outcrop. The method is named as Geo_300. For calibration were used pads for K, U and Th plus background (BG).

Dimensions of Pads: 1 x 1 x 0.3 m

Concentrations of Pads:

Pad	K [%]	U [ppm]	Th [ppm]
K	7.57	1.22	1.40
U	1.07	46.93	2.75
Th	1.43	1.74	121.6
BG	1.43	0.94	2.32

Numbers in the matrix above represent concentrations (contents) of each radionuclide (component). The K, U and Th pads were made of natural materials so there is small contamination of each pad by other natural radioinuclides. Therefore there are also concentrations out of the main diagonal in the matrix.

Method creation can be done directly in the unit but due limited operability by only five buttons joystick it is recommended to use proper tool in PC supporting program – Geomon – see Chapters 9. and 15.

Once the calibration matrix is finished there can be started measurement of each standard. Time of measurement of each radioisotope is adjustable as well as time of sample measurement and background measurement. Access to the matrix is via Main menu – Settings – Measurements – Measurement method.

Then choose a method to edit (if exists) or select first not used method to create a new one.

Calibration itself starts with Main menu – Settings – Calibration – Component calibration. Then activate **Calibrate**. Next appears a table with components to be used in a method. Items are selectable using UP or DOWN key and further confirmation with OK button starts promptly measurement of a particular standard. Move the highlight pattern from item to item using up and down button and activate measurement with OK. Once the measurement is finished spectrum is stored and a check mark displayed at the item's left side. The calibration ends when all items are measured. The measured spectra can be downloaded in any PC. Suitable calibration spectra can be also uploaded back in the unit

from a file. This way can be restored older calibrations. Without measured or uploaded spectra the GT-40/GT-40S cannot evaluate concentrations. **It is highly recommended to archive calibration spectra files for future use.**

The GT-40/GT-40S can work with various calibrations for different applications. It can be selected prior a measurement.

The GT-40/GT-40S is designed to be easy extendable with a shielding for high sensitivity measurement in a laboratory. An accommodation to non-standard samples like borehole logs of different diameters is possible.

5.4.1. Selection of measuring method

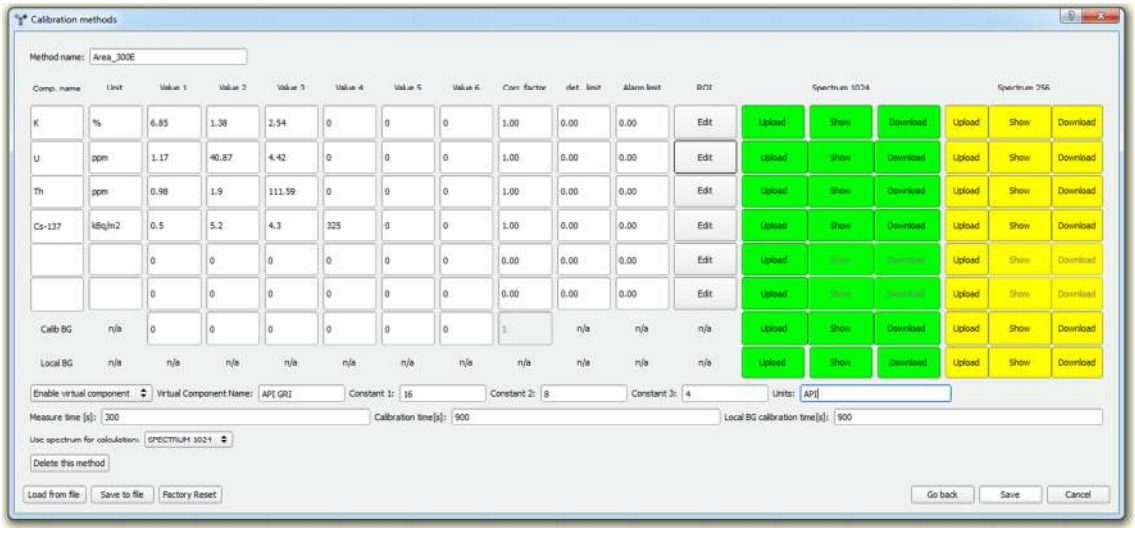
As mentioned above, there are up to six different methods available in the unit. Methods can be combined without any restrictions. To engage an appropriate method, user must change a parameter prior starting assay. To do so there is access through Main menu – Settings – Measurement – Measurement method. Using left or right button user selects a method from the list and typing **Save** activates the method for next assay.

5.4.2. Virtual components

Virtual components is a tool how to instruct the GT-40 to compute and display additional results from measured data. Typically there are required miscellaneous indexes describing properties of samples. For example there is API Gamma Ray Index, Gamma Index, Activity Index, Summary Activity, Uranium or Thorium Equivalent, etc. All this indexes have common structure. It is sum of measured components weighted by factors. As an example there is calculation of API Gamma Ray Index from measured contents of K, U and Th.

$API = 16*K_c\,[\%] + 8*U_c\,[ppm] + 4*Th_c\,[ppm]$

User can activate virtual component evaluation in related Method. Geomon's Method definition window was extended for this feature.



Virtual component formula works with readings of the first three components. There is K, U, and Th in our example. The Cs-137 is not taken in consideration. User has to select Enable Virtual Component from a switch box. Then it is necessary to input a string with name of the component. We used API GRI. Following there are three edit boxes for coefficients. The last edit box requires a string with name of the unit. The string edit boxes can be left empty. Calculated virtual component becomes a part of result data stream and is recorded together with other results.

5.5. Dose rate

Unique algorithms build in the firmware of GT-40/GT-40S is used for real time gamma dose rate evaluation from gamma spectra of NaI/Tl detector. The instrument is not targeted as dose rate measuring device and this feature is only the addendum protecting the user of unexpected exposure. The measured dose rate is within range 0.1 nSv/hr - 80 microSv/hr and matches all requirements of IEC 60846 standard. The response is fully compensated in energy range 60 keV – 1.5 MeV. The maximum dose range is sufficient enough to give an early warning on dose rate levels allowed for public.

The angle response of the detector used is very uniform there is not much limitation which way the unit shall be oriented towards coming radiation to get correct values but please be reminded that a central reference point of the unit is eight centimeters above bottom cover. The preferable direction of radiation is towards the bottom.

Dose rate and dose readings are visible during survey action and are recorded together with gamma total counts. The GT-40/GT-40S is primary calibrated in Air Kerma in units of Gy/hr. There is possible to convert and display readings in Ambient dose equivalent rate in Sv/hr. Conversion between these two quantities are made with coefficients recommended by IRPA (International Radiation Protection Agency). Access to Dose unit parameter is through Main menu – Settings – Measurement – Dose units.

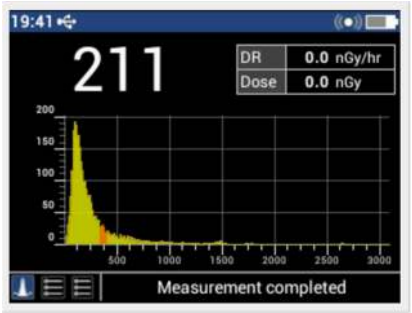
Measurement of dose rate with GT-40S model is restricted only for unit with unmounted lead collimator. In case the collimator is used the dose rate readings are incorrect.

5.6. Identify

Since firmware version 0.24 the GT-40 and GT-40S equipped with NaI/Tl type of detector there is implemented also Nuclide Identification function. An advanced peak search algorithm is called and detected peaks pattern is compared with library of nuclides. To extend flexibility for users there are two types of nuclide libraries supported. A permanently build in library consists of most common gamma emitting radionuclides and the selection was done upon twenty years of experience of cooperation with customers. This library is fixed as default and cannot be changed by user. Should be a need for library modification user may use "User nuclide library". User library is implemented as plugin file in text format and user can modify it by its own. There is recommended to contact manufacturer prior any change for detailed explanation of meanings of records and eliminate any false identification issues.

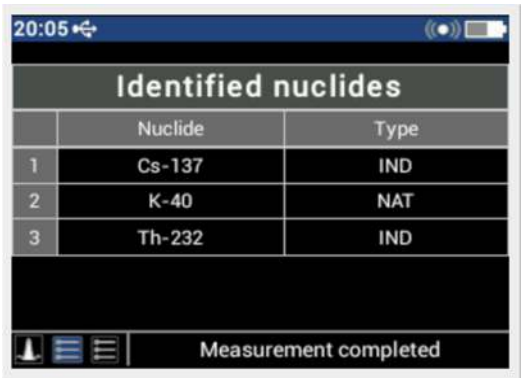
5.6.1. Starting Nuclide Identification

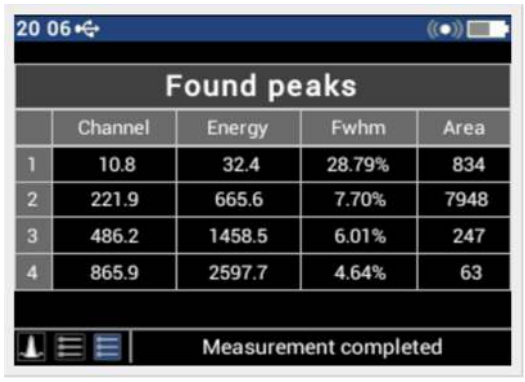
It is highly important for Nuclide Identification function that gain is set correctly and positions of peaks in spectrum are right. Let suppose that the unit has been switched on and the warming up process has been finished. There is an icon **((•))** present in info bar on all screens and Identify process can start. First click **OK** Button to activate menu **Action**. Then select and activate the item **Identify** by **OK**. Or go from Main Menu selecting **Identify** icon.



Spectrum acquisition starts immediately and a new screen will appear on the display. It consists of three screens. All functions of spectral browser are identical as described in section ASSAY. The second screen is a table of radionuclides identified and the third screen shows details about detected peaks. User may switch between screens anytime using right and left button key.

Functions arranging access to voice recorder, start a new identification or extension of measurement of previous sample are accessible from action menu. The popups menu on the screen after pressing **OK** button.





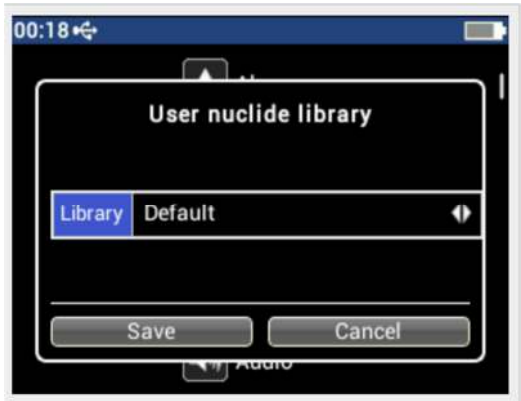
All functions and data browsers are identical as described in ASSAY section.

Prior leaving the identification section, the user is prompted to save results.

5.6.2. Selecting of Nuclide Library

Selection of active Nuclide Library used for identification can be made either on unit using proper setup function in section Settings or via PC and program Geomon. The Geomon arranges a direct access to proper parameter and user selects library from popup menu. It is important to know that user library file has to be transferred in the unit otherwise there is no other selection than Default possible.

To engage proper library in the field, user has to call function Settings from **Main Menu** and select item **Measurements** and **User nuclide library**. Using left or right button he selects expected library and confirms selection by touching button down to highlight **Save** followed pressing **OK**. User may leave menu without any change selecting Cancel.



6. DATA MEMORY

The GT-40/GT-40S controls a huge Solid State Memory. There is enough room for measured data, voice comments, information about position of the unit and there are logged all information about gain stabilization including spectra used as well as reports of internal system messages and events. Access to logs and basic browser operation is common for all types of logs.

The common access is from **Main menu – Storage**. Then select of type of log. Once selected and activated there are three action items. To let read **All records** of selected type and put on a list or to use a date **Filter** to get only logs between chosen days. Result of loading procedure is a list of logs available. For details user must select one item of the list and confirm with OK button. The last item of the list returns back to previous menu.

6.1. Identification results log

The Identification log is a database of spectra and results of nuclide identification. Identified nuclides and peaks found are included and filed. All spectrum browsing features are ready for scaling, zooming etc. Return back is arranged via **action menu** with items Continue, Reload, Graph, Results and Back to Logs.

6.2. ASSAY results log

The Assay log consists of assay results and spectra. Browsing on it is arranged the same way like in real assay function. There are two screens one for results, second one for spectra. All spectrum browsing features are used for scaling and zooming. Return back is arranged via action menu with items Continue, Reload, Graph, Results and Back to Logs.

6.3. Core log

Similar to Assay log the core log consists of spectra and results of assays made on cored. Additionally there are depth information and core descriptors.

6.4. Survey profiles log

The survey log is organized as a stream of total counts in cps, dose rates, and integrated dose values. Additionally there are linked On FLy Assay results and GPS coordinates. To check profiles there is accessible graphical histogram. All browsing features are supported to see details of the profile on time as well as counts scale. For details see section Survey.

6.5. Stabilization log

The stabilization log offers a table of most important stabilization inputs and outputs. There are in columns: Index, Date, Time of stabilization event and stabilization result. The stabilization result is OK when unit's gain is corrected or there is report about problems caused unsuccessful gain stabilization. An additional note is in the next column. The next six columns are used for detail information about peak differences of nominal peak position in channels, next there are information about high voltage adjustment before and after stabilization event. The last columns show fine gain adjustment prior and after stabilization. All that information is rated for maintenance purposes and can be requested by authorized personal in case of any gain adjustment failures.

6.6. System log

The system log is used to file all important system announcements and is organized as a simple strings output. It is used by maintainer or manufacturer for any service events.

7. PARAMETER SETUP

Warning: Change or improper set up of some parameters may have negative impact on function of the unit. Uncertain meanings of parameters shall be consulted with manufacturer.

7.1. Access to parameters

There is a structured menu user interface integrated in the unit to help user set up selected basic working parameters. Access to all parameters is possible only via remote connection from the PC. Limited set of parameters accessible from unit's user interface are described in this section. Menus are organized into function groups. To browse in menus there are used short Button clicks for step by step move or button hold to engage an auto repeat function. The **Main menu** is accessible from **Survey** after short button click or from other menus redirecting to Main menu. While in Main menu a selection of service **Settings** and its activation with OK Button press leads to root of parameter's structure. The structure consists of names of function groups and each group is entered after its selection followed by OK button confirmation.

For return from a group to previous level there is a service **Go Back** in each menu.

7.2. Date and time

Date and time setup is arranged in three sections. One for date the other for time and the third for time zone. Year, month and day or hour, minute and second are kept in separate editable window. Only one window is active for edit at a time. Selection of nearby window is arranged by right and left button. Increase or decrease the value in the window by up and down buttons.

7.3. Display

Display setup consists only from one parameter for adjustment of contrast. Values are editable by right and left button.

7.4. Audio

Audio section arranges access to three parameters. Audio volume, audio mode and sweep threshold. Audio volume allows muting or adjusting loudspeakers volume. Audio mode defines signaling after exceeding of alarm threshold. It can be chosen Silent, Frequency Sweep or Alarm. Frequency sweep activates audio indication where frequency pitch is proportional to registered number of gamma ray incidents in last second. Alarm means activation of horn signal once the threshold is crossed. The horn is on as long as the alarm message is served and confirmed. Sweep threshold is a multiplicative factor of standard deviation of averaged background. See section Survey for details.

7.5. Measurement

Measuring method. Activation of a proper calibration for measurement of a sample is here. Measurement time can be re adjusted. Dose units - selection of dose measurement quantity. Background - parameters for different type of background evaluation in Survey mode. Floating background automatically copies slow changes of background radiation during a day. It is used for permanent monitoring applications. Core mode ON/OFF switch, Factory method reset for recovery of default calibration.

7.6. Calibration

Calibration section consists of many sensitive parameters. It is recommended not to change any prior contacting a maintainer and full understanding of meanings. Next are parameters important for fast preparation of the unit for measurement.

In some unpredictable circumstances may happen that rule for gain stabilization fails. Mainly it happens due lack of presence of natural radioisotopes in local background. There are known cases where the unit was used on vessel on the sea or thick layers of ice on glaciers where high shielding efficiency of the water almost suppressed any local radiation. To resume correct working set up there is accessible Cs calibration utility.

Cs calibration

It will perform basic gain setup. To use this item user needs a weak Cs-137 source (not delivered with the unit, must be ordered as an option).

Component calibration – Calibration Method (Selection of the method) **– Local Background Spectrum**

Some methods are very sensitive to the level of radiation from local background. Mainly it is the case of high sensitive measurements in shielding. It is important to inform the unit about current level of the background radiation prior sample measurement. Measuring the Local Background Spectrum is activated here.

7.7. Accessories

7.7.1. GPS logging

GPS receiver is an integral component of the GT-40/GT-40S. The GPS antenna is located on top of the head between handle supports. For the best performance the antenna shall stay clear of metal or high conductive materials what may shield the signal from satellites. As soon as GPS service is enabled and position is fixed, following icon appears on top bar of each screen. Up to date information about GPS status, number of satellites and actual position are accessible through Settings – Maintenance – GPS status.

Once available the GPS coordinates are automatically integrated in survey records as well as in assay or identification results. The GPS receiver can be disengaged also in GPS Status screen after pushing button OK and selecting GPS Turn OFF or from Accessories menu setting parameter GPS to disable.

7.7.2. USB port

The USB port can be used and its configuration is fully automatized. There is not required any parameter settings since hardware revision 1.xx.

Wi-Fi connection

A build in Wi-Fi transmitter extends communication range of the GT-40/GT-40S to be capable to work within WLAN. This allows maintaining or operating the unit worldwide using internet or intranet networks. A discrete login information will be required for successful connection therefore any cooperation with a local IT personal is needed. For the communication is essential to connect the GT-40/GT-40S Wi-Fi with a local Wi-Fi router or Wi-Fi wireless access point. There are utilities build in the GT-40/GT-40S. Go through Main menu – Settings – Connections – Wi-Fi.

There is **Wi-Fi scan**. This starts the activity of Wi-Fi receiver and check for Wi-Fi networks in range of the unit. List of available networks is displayed then. After selecting a network using up down buttons and confirmation of selection on the list user is requested to enter a password. A graphic keyboard interface driven by UP, RIGH, DOWN, LEFT an OK key is used. This way can be typed all combinations in letters, numbers and special characters.

7.7.3. Bluetooth

Bluetooth® technology is designed to establish a wireless connection between your GT-40/GT-40S device and a Bluetooth enabled device. You must pair your GT-40/GT-40S

device with a Bluetooth® enabled device before you can connect to it. For more information about preparing the Bluetooth enabled device for pairing, see the documentation delivered with the Bluetooth enabled device.

8. Maintenance

8.1. Hardware maintenance

The GT-40/GT-40S is designed to be resistant of harsh outdoor condition. Regardless of it is important to remember it is a delicate measuring instrument calibrated for high sensitive and precise measurements. There are used very sensitive components – scintillation crystal and photomultiplier and any negative impact may change its performance and void calibration. All devices handling with low radiation levels MUST BE maintained with extra care of potential surface contamination by radioactive elements. Any extra protection using vinyl bags or similar is recommended. In case of the unit contamination there is recommended to use ethyl alcohol and soft towels for its decontamination.

The manufacturer recommends to establish a simple measuring – verification point. It may be a fixed point in building, backyards or solid sample what may be used from time to time for re measuring purposes. In case of loosing long term stability manufacturer shall be contacted for advice.

An extra attention shall be paid to battery charging. See chapter System Operation for details.

8.2. Collimator

The GT-40S is delivered with a lead collimator inserted inside the unit's body. The collimator is removable anytime. Access to the collimator is from underneath. Put the GT-40S down on side. Hold the unit's body by one hand and unscrew the rubber lid anticlockwise using your second hand. Be aware of dropping the collimator. It is made of lead and is heavy. As soon as the collimator is out of the unit put the lid back and screw clockwise. Installation of the collimator requires the same procedure.

Manufacturer's note: The collimator is made of lead. The lead's surface is coated with thin stainless steel mantel. There is no contact of a personal with heavy metals. The steel coating works also as absorber of K-alpha radiation from the lead so no additional low energy shielding is required.

8.3. Software maintenance

The core of the GT-40/GT-40S is made on powerful multicore microprocessor in embedded PC like environment. To eliminate any trouble caused by unauthorized access there is only limited set of parameters accessible and user can control only selected databases. The GT-40/GT-40S performance and features are permanently improved and any owner of the instrument may upgrade current firmware free of charge. In case of trouble related to functions or firmware updates there is a maintenance hot line established and user is encouraged to contact manufacturer. Majority of problems can be resolved remotely and due high efficient communication channels solution is fast and effective. The manufacturer also files all important data of the instrument from production setup period for system recovery.

9. CALIBRATION

Georadis has established several measuring methods.

The first (main) method is **Geo_300** for determination of potassium, uranium, and thorium in rocks at flat infinite outcrop. Calibration pads traced to IAEA standards for K, natural U and Th were used.

Dimensions of pads are 1 x 1 x 0.3 m with the Nominal Contents:

Pad	K [%]	U [ppm]	Th [ppm]
K	7.60	1.17	1.87
U	1.11	46.6	4.06
Th	0.89	1.76	129
BG	0.89	0.83	2.32

Correction for percent of infinite source was used 87 % as average.

The second method is **Area_300E** for determination of potassium, uranium, thorium, and Cs-137 contamination of soil in the Europian woods. The same calibration pads (above) were used to calibrate the unit for determination for K, U, and Th. To calibrate the unit for determination of Cs-137 contamination of soil in kBq/m^2 is not so easy. Five measuring stations were located in a forest where Cs-137 soil contamination persists after the Thernobyl disaster. All station was measured with GT-40 and GT-40S units and spectra were saved.

At each station, layers of 5 cm of a 35 x 35 cm area were removed. First layer 0 - 5 cm, then 5 - 10 cm, 10 - 15 cm, ..., the last 35 - 40 cm. Each layer was weighed, homogenized and laboratory samples were taken and weighed. Samples were dried and re-weighed and filled into measuring vessel. Specific activities of Cs-137 (Bq/kg) in samples were determined using Georadis' RT-50 Laboratory spectrometer tested and controlled each 2 years by CMI Inspectorate of Radiation, Prague, Czech Republic.

Laboratory results were then recomputed to the area activities in kBq/m^2 at all stations and spectra measured at stations were used as calibration spectra. With well calibrated unit a point Cs-137 source was measured in the distance of about 20 cm as a calibration standard for calibration all other GT-40/GT-40S units with "apparent" Cs-137 activity in kBq/m^2.

Using the above-mentioned RT-50 laboratory spectrometer, different etalons were prepared to develop methods for measuring laboratory samples, drill holes and concrete test cubes.

10. TECHNICAL DATA

Detector:
GT-40 NaI/Tl, dimensions Ø 76 x 76 mm (3“ x 3“) 345 cm^3 with bi-alkali PMT. Resolution FWHM at 661 keV typical 6.8 % max 7.2 %.

GT-40S BGO, dimensions Ø 51 x 51 mm (2“ x 2“) 103 cm^3 with bi-alkali PMT. Resolution FWHM at 661 keV typical 11.5 % max 12.5 %.

Spectrometer:
1024 channel, 40 MHz DSP, Energy Linearity Corrected, Pile Up Rejecter, 200 ns Resolution. Lifetime correction.
Energy range 15 keV – 3.0 MeV

Scintilometer:
Sampling period 20/second.
Gamma ray sensitivity (1 MBq in 1 m): Cs-137 386 cps.

Dose meter:
Dose rate measurement range: 0.1 nanoSv/hr - 80 microSv/hr
Energy compensation range: 30 keV – 1500 keV

Gain stabilization: Two steps (course with HV in range from 700 up to 900 V, fine gain digitally ± 50 %). Gain stabilized continuously in fully automated mode.

Sensitivities: Single measurement of areal soil contamination. Time of measurement 300 seconds. Sensitivities are in minimum detectable contents or activity.

Potassium: 0.3 %
Uranium: 0.9 ppm
Thorium: 1.5 ppm
Cs-137: 0.4 kBq/m^2

Spectra evaluation: Unique spectral analyze method, calibrated for different geometries and application. Measuring methods selectable. Allows measurement of activities.

Measuring modes: Single, repeated meas mode or preprogramed calendar for measurement up to one year ahead.

Display: Graphic, Colour, Trans reflective, 360 x 240 dots, 72 x 54 mm (3.5”), Sun readable.

Acoustic: Speaker, dia. 28 mm + Built-in Microphone.

Data Storage: min. 2000 Samples with full Spectra, Data position and Voice messages.

Communication: Data Transfer, Remote Control and Diagnostic by:
USB 2.0
Bluetooth 1.2 Class 2
Wi-Fi 802.11n

Power: Rechargeable Li-ion 7.2 V/6600 mAh (Panasonic GR18650CG /2S3P) – min. 10 hours of measurement. External AC adapter (12 V/3 A) for charging or measurement.

Remote control: Full remote control via USB or Bluetooth, real time data transfer.

Position: Integrated GPS receiver, GPS navigate down to –162 dBm and -148 dBm cold starts.

Date and time precision: Synchronized with GPS.

Language: English by default. Different languages easy adoptable via changing plug in file. Scripts in UNICODE.

Environmental:
Operating temperature range -10 °C to +50 °C,
Storage temperature range -20 °C to +60 °C,
RFI/EMF Shielding complies with FCC (47 CFR part 15) for Class A,
CE Certification.

Size and weight:
Diameter 120 mm x 415 mm height. Suits in bore holes. Weight 4 kg.

Package:
Plastic case,
Net power adaptor,
USB cable,
Software CD or USB memory stick,
Users guide.

Optionally:
Straps gadget for carrying,
Car power outlet adapter.

11. IMPORTANT ICONS and MEANINGS

Alarm message. Check alarm list for pended alarms

Battery status.

Bluetooth active

Warning or error message. See Status Log for details

GPS active and location fixed

GPS active and searching for satellites to get fixed

Survey recording in progress

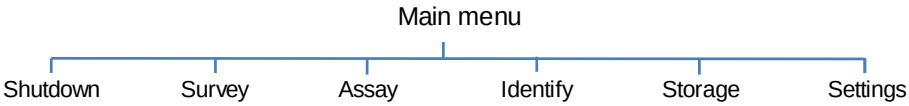
Data are being written on Solid Disc

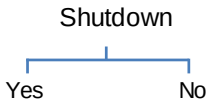
Unit stabilized

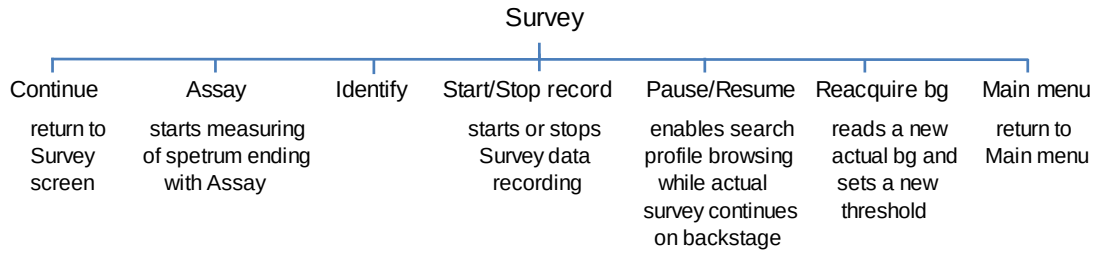
USB active

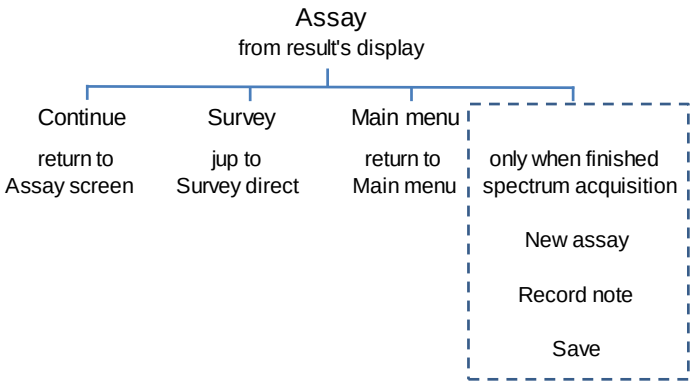
Wi-Fi active and connected

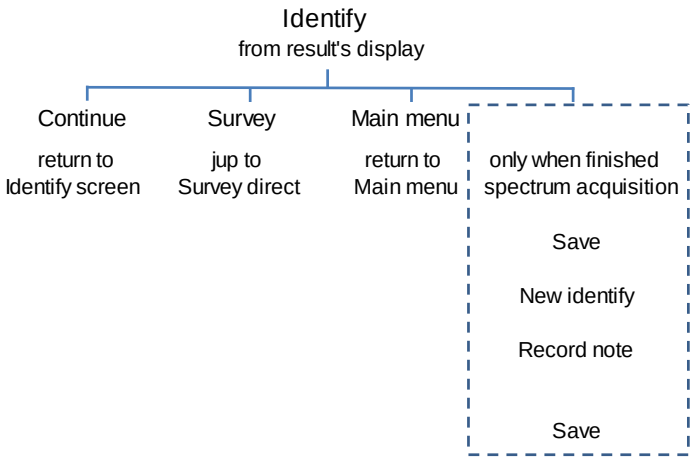
12. MAP OF ACTIONS

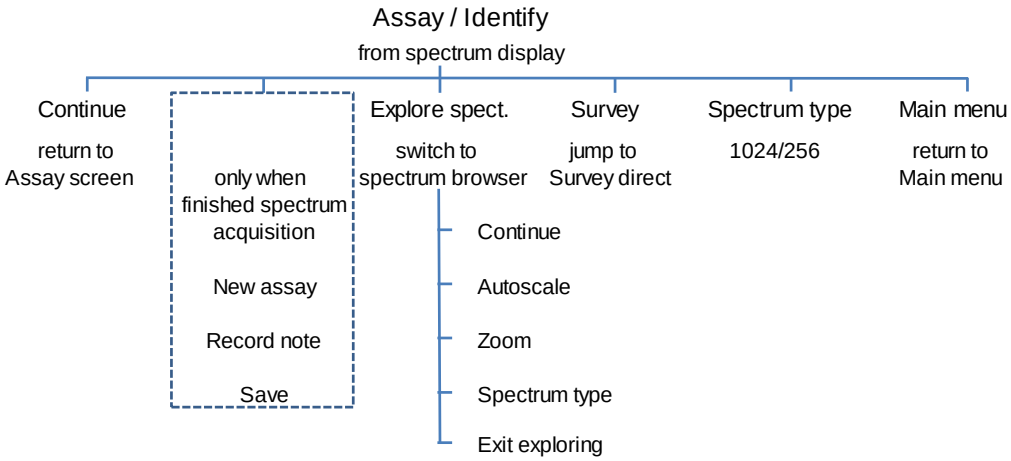


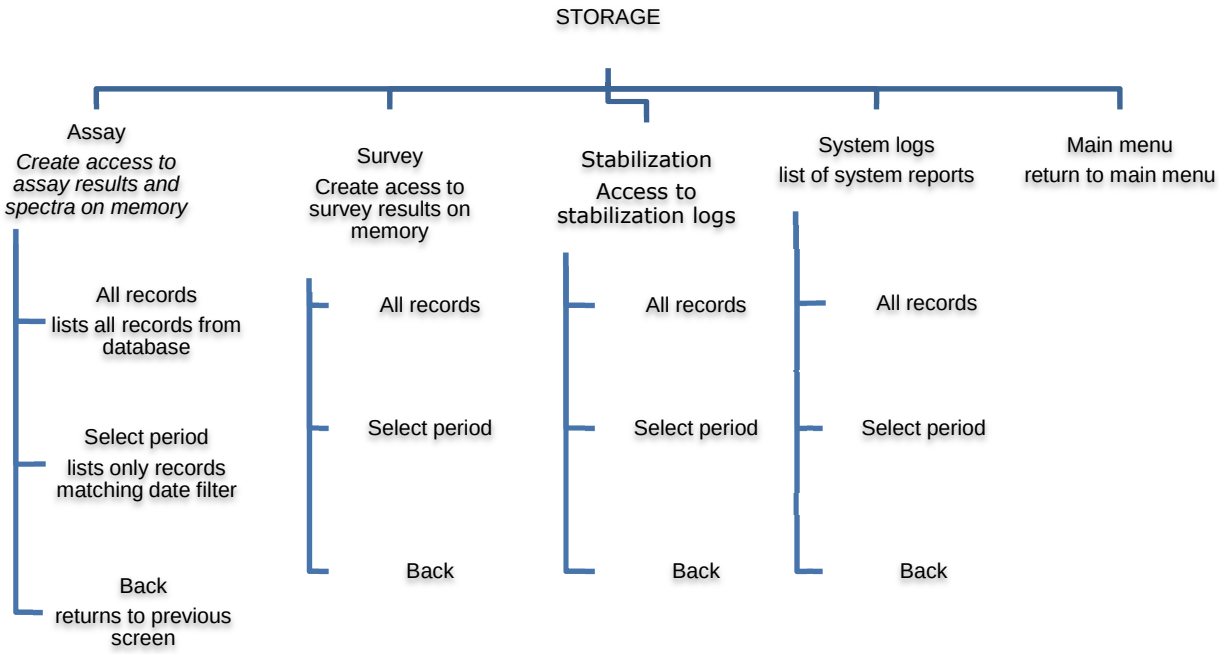


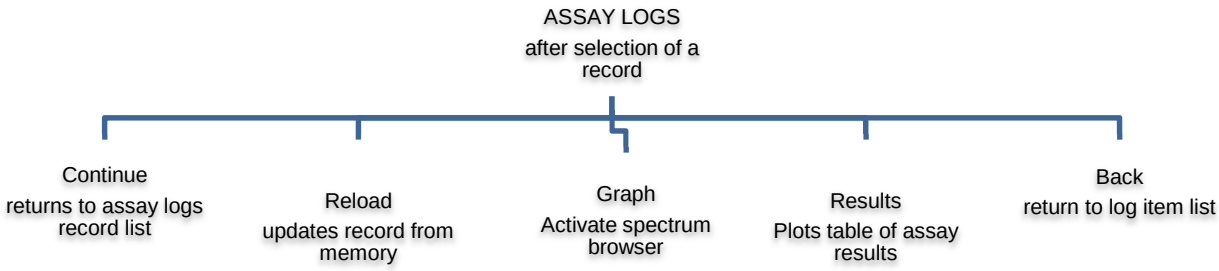




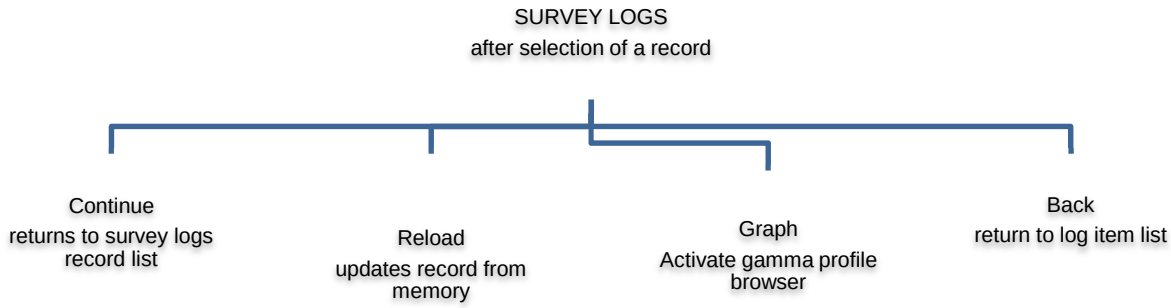

Identify
from result's display
Continue
return to
Identify screen
Survey
jup to
Survey direct
Main menu
return to
Main menu
only when finished
spectrum acquisition
Save
New identify
Record note
Save

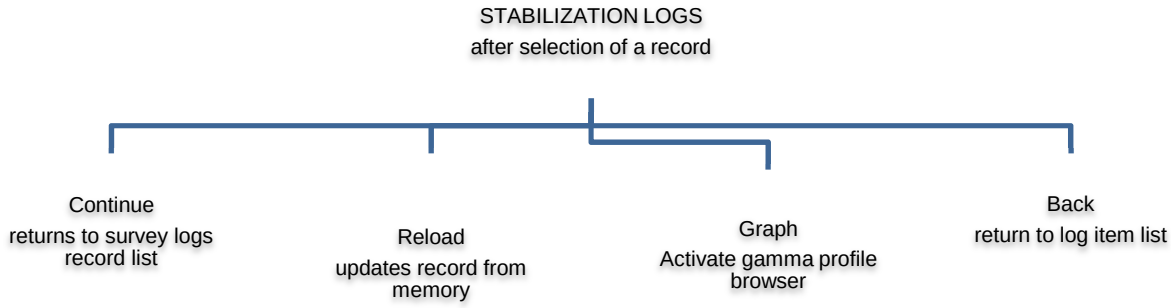

Assay / Identify
from spectrum display
Continue
return to
Assay screen
only when
finished spectrum
acquisition
New assay
Record note
Save
Explore spect.
switch to
spectrum browser
Continue
Autoscale
Zoom
Spectrum type
Exit exploring
Survey
jump to
Survey direct
Spectrum type
1024/256
Main menu
return to
Main menu

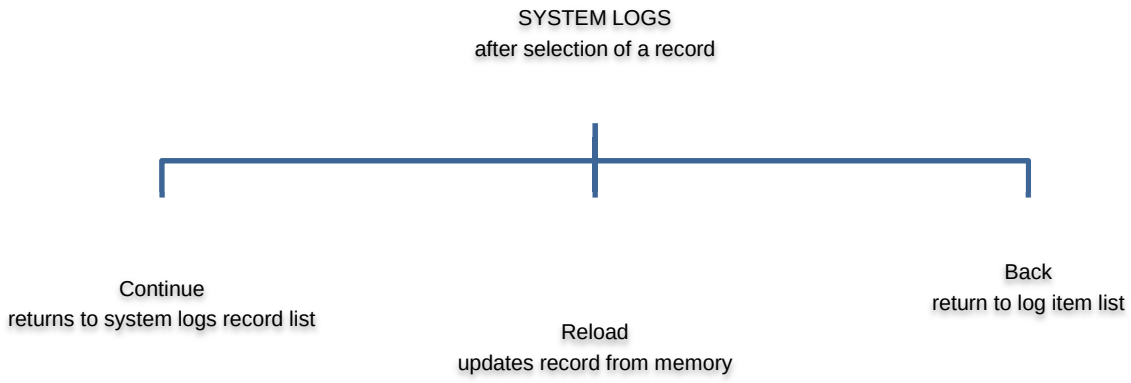


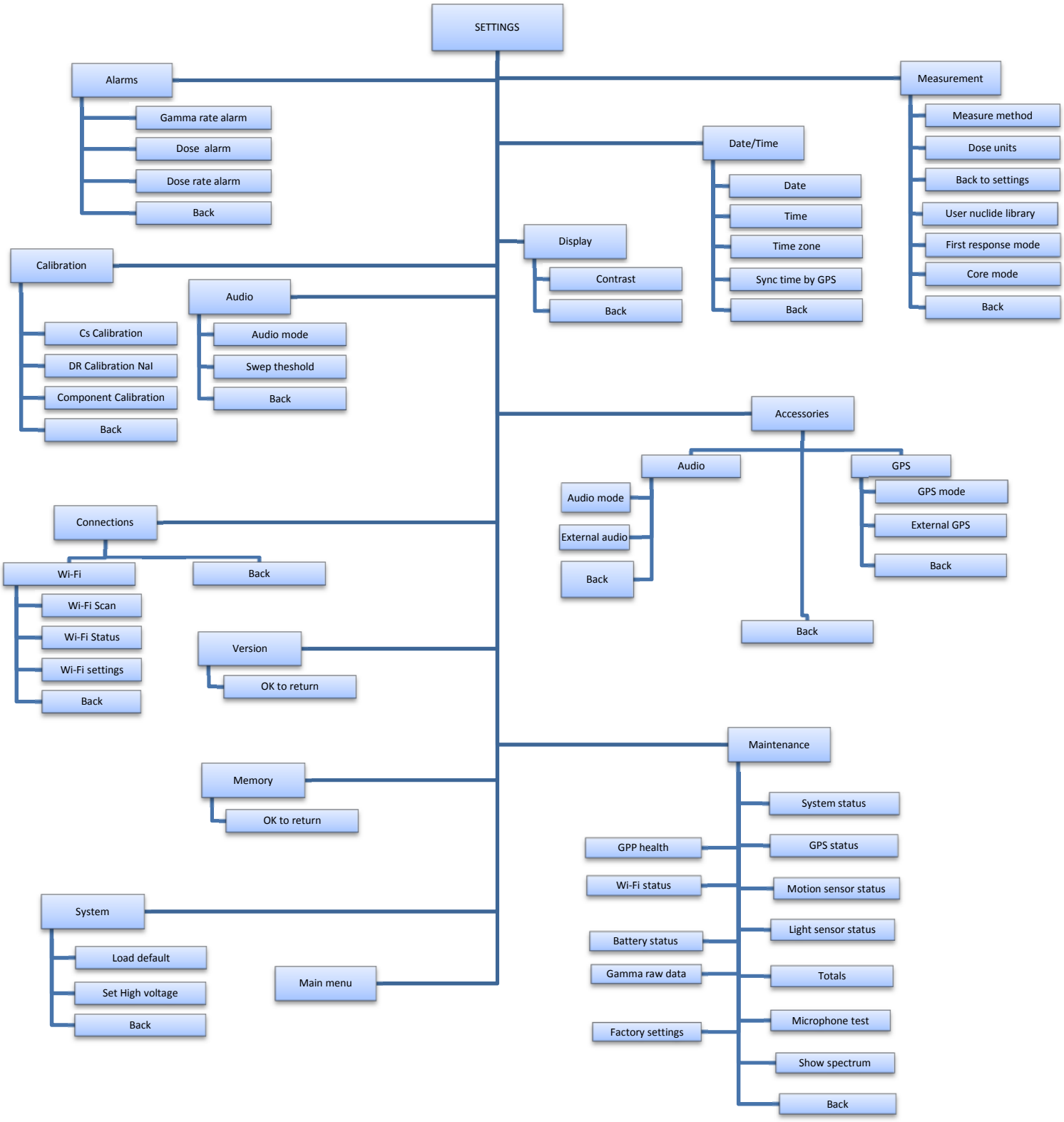


*Identify and Core logs are similar to Assay log


SURVEY LOGS
after selection of a record
Continue
returns to survey logs record list
Reload
updates record from memory
Graph
Activate gamma profile browser
Back
return to log item list


STABILIZATION LOGS
after selection of a record
Continue
returns to survey logs record list
Reload
updates record from memory
Graph
Activate gamma profile browser
Back
return to log item list


SYSTEM LOGS
after selection of a record
Continue
returns to system logs record list
Reload
updates record from memory
Back
return to log item list


SETTINGS
Alarms
Gamma rate alarm
Dose alarm
Dose rate alarm
Back
Measurement
Measure method
Dose units
Back to settings
User nuclide library
First response mode
Core mode
Back
Date/Time
Date
Time
Time zone
Sync time by GPS
Back
Display
Contrast
Back
Calibration
Cs Calibration
DR Calibration NaI
Component Calibration
Back
Audio
Audio mode
Swep theshold
Back
Accessories
Audio
Audio mode
External audio
Back
GPS
GPS mode
External GPS
Back
Back
Connections
Wi-Fi
Wi-Fi Scan
Wi-Fi Status
Wi-Fi settings
Back
Back
Version
OK to return
Memory
OK to return
Maintenance
System status
GPS status
Motion sensor status
Light sensor status
Totals
Microphone test
Show spectrum
Back
GPP health
Wi-Fi status
Battery status
Gamma raw data
Factory settings
System
Load default
Set High voltage
Back
Main menu

13. Nuclide Libraries

13.1. Default Library

There are hardwired following radionuclides:

Ra-226, Eu-152, U-235, U-233, Th-232, Pu-239, Ga-67, I-131, Ba-133, Tl- 201, Cs-137, K-40, Co-60, Tc-99m, Co-57, Am-241, Ir-192, In-111, Na-22, Kr-85, Cr-51, Cd-109, Xe-133

13.2. User Library

User library is accessible by user and list of nuclides and properties can be edited.

As an example follows library USERLIB3:

0	NU	NAT	4	5	-150.0	0.010	186.0	0.030	352.0	0.370	609.0	0.460	1120.0	0.150	1760.0	0.160	2204.0	0.050
1	Ra-226	IND	3	5	295.0	0.200	352.0	0.370	-609.0	0.460	1120.0	0.150	1760.0	0.160	2204.0	0.050	768.0	0.010
2	Eu-152	IND	3	9	40.0	0.570	121.0	0.284	245.0	0.080	344.0	0.260	778.0	0.960	867.0	0.040	964.0	0.140
3	LEU	SNM	2	4	1001.0	0.005	766.0	0.090	-185.0	0.550	93.0	0.050	143.0	0.050	60.0	0.010	0.0	0.000
4	Ag-108m	IND	3	5	79.0	0.071	434.0	0.898	-614.0	0.900	723.0	0.900	20.0	0.100	0.0	0.000	0.0	0.000
5	U-233	SNM	2	2	440.0	0.010	725.0	0.010	584.0	0.090	677.0	0.050	150.0	0.010	0.0	0.000	0.0	0.000
6	HEU	SNM	2	2	185.0	0.550	143.0	0.110	93.0	0.050	60.0	0.010	662.0	0.020	0.0	0.000	0.0	0.000
7	Th-232	IND	3	9	77.0	0.200	239.0	0.450	338.0	0.110	2615.0	0.640	911.0	0.280	583.0	0.170	967.0	0.220
8	Th-232	IND	1	1	2615.0	0.640	239.0	0.450	338.0	0.110	77.0	0.200	911.0	0.280	583.0	0.170	967.0	0.220
9	HEU	SNM	2	2	6666.0	0.000	185.0	0.050	662.0	0.020	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
10	LEU	SNM	2	2	6666.0	0.000	1120.0	0.020	142.0	0.010	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
11	Pu-239	SNM	3	6	-6666.0	0.000	59.0	0.010	662.0	0.010	380.0	0.010	722.0	0.010	340.0	0.010	0.0	0.000
12	Neut	IND	2	5	-6666.0	0.000	511.0	0.010	847.0	0.000	1238.0	0.010	2223.0	0.010	0.0	0.000	0.0	0.000
13	RGPu	SNM	3	7	59.0	0.010	380.0	0.010	210.0	0.090	96.0	0.050	418.0	0.010	340.0	0.010	662.0	0.010
14	RGPu	SNM	3	6	-59.0	0.010	380.0	0.010	119.0	0.010	418.0	0.010	210.0	0.010	340.0	0.010	148.0	0.010
15	Ga-67	MED	3	4	93.0	0.360	184.0	0.200	300.0	0.160	393.0	0.040	494.0	0.010	888.0	0.010	0.0	0.000
16	I-131	MED	2	5	-364.0	0.810	722.0	0.020	637.0	0.070	80.0	0.030	505.0	0.010	0.0	0.000	0.0	0.000
17	Ba-133	IND	2	4	81.0	0.360	302.0	0.180	-356.0	0.690	280.0	0.070	31.0	0.010	160.0	0.060	150.0	0.060
18	Np-237	SNM	3	4	87.0	0.150	-145.0	0.050	198.0	0.020	310.0	0.010	0.0	0.000	0.0	0.000	0.0	0.000
19	Tl-201	MED	2	2	70.0	0.500	167.0	1.000	135.0	0.250	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
20	Se-75	MED	2	3	-136.0	0.300	265.0	0.150	405.0	0.050	70.0	0.010	96.0	0.010	199.0	0.010	0.0	0.000
21	Mo-99	MED	3	4	-141.0	0.300	181.0	0.200	370.0	0.050	741.0	0.100	922.0	0.010	0.0	0.000	0.0	0.000
22	Sm-153	MED	2	2	-102.0	0.050	41.0	0.200	70.0	0.010	143.0	0.030	170.0	0.010	0.0	0.000	0.0	0.000
23	Cs-137	IND	1	1	662.0	0.850	32.0	1.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
24	Cs-134	IND	2	2	-605.0	0.970	796.0	0.850	570.0	0.230	475.0	0.010	0.0	0.000	0.0	0.000	0.0	0.000
25	Co-60	IND	2	2	1173.0	1.000	1332.0	1.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
26	K-40	NAT	1	1	1460.0	1.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
27	Co-57	IND	1	1	125.0	0.850	90.0	0.050	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
28	Am-241	IND	1	1	60.0	0.360	30.0	0.080	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
29	Ir-192	IND	2	2	314.0	0.830	468.0	0.480	606.0	0.080	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
30	In-111	MED	2	2	171.0	0.900	245.0	0.940	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
31	Na-22	IND	2	2	511.0	1.800	1274.0	1.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
32	Zn-65	IND	2	2	511.0	0.050	-1115.0	0.500	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
33	F-18	MED	1	1	511.0	1.400	185.0	0.050	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
34	Kr-81m	MED	2	2	514.0	1.000	446.0	0.190	185.0	0.050	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
35	Ba-133sh	IND	1	1	-356.0	0.690	302.0	0.180	280.0	0.070	383.0	0.090	81.0	0.360	31.0	0.010	0.0	0.000
36	Cd-109	IND	2	2	88.0	0.990	22.0	0.037	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
37	Xe-133	IND	2	3	-80.0	0.360	31.0	0.380	162.0	0.010	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
38	U-238sh	IND	1	1	1000.0	0.005	766.0	0.090	93.0	0.050	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
39	Tc-99m	MED	1	1	141.0	1.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
40	Cr-51m	MED	1	1	320.0	0.100	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000
41	Te-132	IND	1	1	228.0	0.880	29.0	0.520	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0	0.000

14. NOTES and WARNINGS

The GT-40/GT-40S is a delicate instrument and contains components (Crystal, Photomultiplier) very shock sensitive. **The detector assembly is not covered under warranty**.

Warranty:

Manufacturer warrants to the original purchaser of Equipment that for the Warranty period, the Equipment will be free from material defects in material and workmanship.

a) The "Warranty Period" begins on the date the Equipment is delivered and continues for 24 months.
b) Any repairs under this warranty must be conducted by an authorized Company service representative.
c) Excluded from the warranty are problems due to accidents, misuse, misapplication, storage damage, negligence, or modification to the Equipment or its components.

WARNING: Li-ion battery

Lithium-ion cells and battery packs may get hot, explode or ignite and cause serious injury if exposed to abuse conditions. Be sure to follow the safety warnings listed below:

- Do not connect the positive terminal and negative terminal of the battery to each other with any metal object (such as wire).
- Do not carry or store battery together with necklaces, hairpins or other metal objects.
- Do not pierce the battery with nails, strike the battery with a hammer, step on the battery or otherwise subject it to strong impacts or shocks.
- Do not expose battery to water or salt water, or allow the battery get wet.
- Do not place the battery in or near fire or other high temperature places.
- Do not place the battery in direct sunlight or use or store the battery inside cars in hot weather.
- Do not disassemble or modify the battery. The battery contains safety and protection devices, which, if damaged, may cause the battery to generate heat, explode or ignite.

This is a Wi-Fi® enabled device subject to restrictions of use in some member states of the European Community.

Certificate of Origin

This is to certify that GEORADIS s.r.o., Novomoravanska 41, Brno, is the only manufacturer of Radiation Detectors series GT-40/GT-40S. All instruments are designed, manufactured and assembled in the Czech Republic.

Manufacturer:

GEORADIS s.r.o.
Novomoravanska 41
619 00 Brno
Czech Republic

Phone: +420 541 422 231
e-mail: info@georadis.com

15. Supporting software tools

15.1. Geomon

The Geomon is versatile utility for basic maintenance of the GT-40/GT-40S as well as for simple data access or remote control. It is running on Windows XP and all later platforms including Windows 8. A version for Linux operating systems is also available. The geomon is distributed in form of self installation program. Follow instruction after starting installation batch file. In case of using a windows operating system it is necessary to install proper USB driver. The driver is also delivered in form of self installation package. From time to time it is necessary to update the driver for new operating systems. New USB drivers are downloadable from manufacturer's web sites.

Connection to a device

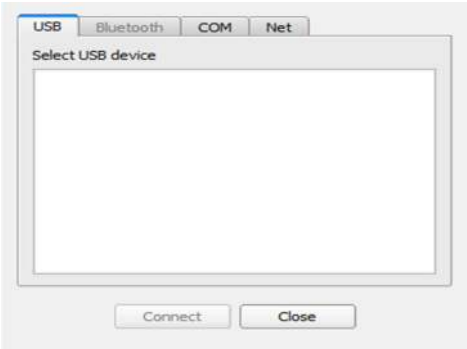
Connection to GT-40/GT-40S can be done on three different hardware platforms. The most common is to use direct USB connection of a GT-40/ GT-40S with a PC. The second solution is possible via Bluetooth port. The third possibility is to use wireless WiFi connection to a WiFi router. This way is possible to operate the unit remotely within WLAN worldwide.

15.1.1. USB and Bluetooth connection

Both types of connection require the same procedure by Geomon, difference is only in assignment of proper drivers for hardware support of USB hubs or Bluetooth transmitters. For details user shall check guidelines delivered with a PC or Bluetooth devices.

When a proper USB hub or a Bluetooth device is recognized by PC and successfully assigned to the right driver, control over communication takes over the Georadis USB Driver delivered with the GT-40/GT-40S unit. The USB driver recognizes request for connection from a GT-40/GT-40S and interacts between ports and the Geomon.

The next step is to call function Connect device accessed through Main menu and section Device or to touch Speed button Choose a device to connect below Main menu bar. A new window appears on screen. There are four tabs on top: USB, Bluetooth, COM and Net. On behalf of successful assignment of a GT-40/GT-40S to the proper hardware device driver a serial number of the GT-40/GT-40S connected appears in a window. It meas when a USB connected the serial number of the unit is printed in window on tab USB. Bluetooth connection belongs to the Bluetooth tab window, etc. To complete connection user must select the serial number of requested instrument (there can be more instrument supported in the same time) and confirm button Connect.



After that the main screen of the Geomon will switch to allow access to all supported features of the GT-40/GT-40S.

15.1.2. WiFi connection

Like other devices with Wi-Fi connection support the GT-40/GT-40S requires to pass a login and authorization process for a local Wi-Fi network. Therefore cooperation with a local IP personal is required. Once the GT-40/GT-40S and a PC are connected to a network user can specify and type GT-40/GT-40S internal IP address in edit box. The internal IP address of GT-40/GT-40S may be changed. The change must be done directly on the unit. There are supported IP standards for 4 and also 6 bytes addresses. User can also edit gateways. Services for IP modification are in Main menu – Connections – WiFi – WiFi Settings.

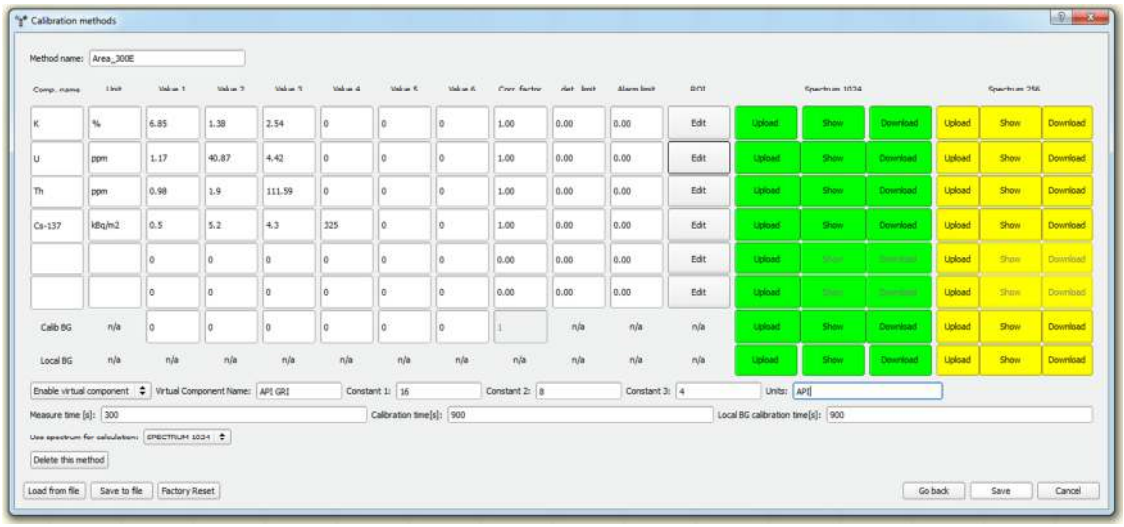
For reason of complexity and many local LAN limitations the manufacturer cannot offer an easy guide for Wi-Fi connection. In case of trouble user is welcome to contact manufacturer to get specific support.

15.2. Commands

15.2.1. Method calibration

Method calibration is a section what allows to implement in the GT-40/GT-40S variety of measuring methods for measuring activities or concentrations of different radionuclides in many geometries or conditions. To be able to implement a new measuring method in the unit is necessary to have suitable calibration standards or at least their spectra measured with the unit.

Within one measuring method there is possible to determine six independent radioisotopes. To enter to edit screen for method calibration touch button Method calibration from screen tabbed commands. Selection list of six different methods available is displayed now. Select the method to be modified in case if exists any, or select closest not defined method by touching a button with appropriate name on. The Calibration methods screen appears next. There are following edit boxes and their meanings:



Method name is a string value keeping identification name for the method. There are no limits for words to be used but the total size is limited to 16 characters. The name of the method will appear in the unit as a button. User can select expected method activation the button. For example there is used name Area_300. It is a method calibrated for infinite area measurement with time of measurement 300 seconds.

Comp. Name. In the method, each determined element is called component. The component may be the name of radionuclide or its abbreviation or any other description. It is only a string what is plot on the list of results.

Unit. There is no limit on use of various units to be evaluated by the GT-40/GT-40S. There is only condition that used unit has to be related to values (concentrations) of calibration standards. This way user can input almost unlimited number of different measuring geometries to obtain activities or concentrations of elements.

Value 1 – value 6. Creates a vector of the calibration matrix. An activity of a component (element or radionuclide) is evaluated a way that there is compared a spectrum of measured unknown sample against combination of all calibrated spectra of standards. This process is repeated as long as the combined spectrum is identical to unknown spectrum. Ratios of standards' spectra give then a measure of concentrations of components in the spectra of unknown sample.

It is possible and some applications often that a calibration standard of one component can be contaminated by other components. Therefore there is vector for each component and each position in the vector defines how much is the conctent of other component.

Example # one: There is a calibration method for measuring concentrations in rocks. There will be used a method that a sample will be filled in a beaker of volume one liter and the GT-40/GT-40S will be placed on the beaker. There is expected a presence of three natural components K, natural Uranium and Thorium. Three different calibration standards will be made. To keep the same density of each standard there will be used a low radioactive concrete. There was determined that the concrete base of each standard contained e.g. 0.5 % K, 2.3 ppm Uranium and 1.6 ppm Thorium. These values have to be subtracted of the additives and create a background calibration standard. Concentrations of additives will be 10 % of K (it will be mixed in K standard), 30 ppm of U natural and 60 ppm Th.

The real vectors for three components will be:

Comp. Name	Unit	Value1	Value2	Value3
K	%	10	2.3	1.6
U	ppm	0.5	30	1.6
Th	ppm	0.5	2.3	60
The BG vector is then		0.5	2.3	1.6

There is evident that within the matrix of values on main diagonal of the matrix represent additives in the calibration standards and values off the main diagonal are contaminations by other components. There is a system that for the first component is related value 1 as concentration of the component. Value 2 in the same row is contamination of the standard of the first component with component number 2. The Value 3 in the same row is a contamination of the standard with a third component, etc.

Example # two: How to change units used for concentration (activities). Let take the values of example # one. The unit calibrated like that will display results in % for K and ppm for other two components. There is a requirement to have a different method for the same samples but to display results in Bq/kg. The concentrations of (components) elements are K, U and Th = 10 %, 30 ppm and 60 ppm. Concentrations of components contaminating the other standards are K, U, Th = 0.5 %, 2.3 ppm and 1.6 ppm. To change to units in Bq/kg there is necessary to recompute concentrations from % or ppm to Bq/kg. There are common factors used: K 1 % = 317 Bq/kg, U 1 ppm = 12.35 Bq/kg and Th 1 ppm = 4.3 Bq/kg. Then the calibration matrix using the same calibration standards, but different units is:

Comp. Name	Unit	Value1	Value2	Value3
K	Bq/kg	3170	28.41	6.88
U	Bq/kg	158.5	370.5	6.88
Th	Bq/kg	158.5	28.41	258
The BG vector is then		158.5	28.41	6.88

This way the method is modified to compute results in Bq/kg.

Example # three: How to extend measurement of natural radioisotopes for man-made radioisotopes (case of artificial accidental contamination). The values for K, U and Th will be the same as in example two in Bq/kg. Additionally there are two new radioisotopes Cs-134 and Cs-137 present. There were used following activities of Cs-134 and Cs-137 for standards. There are Cs-134 = 1609 Bq/kg and Cs-137 = 1360 Bq/kg. Radiation background does not contain any Cs radioisotopes. The calibration matrix is:

Comp. Name	Unit	Value1	Value2	Value3	Value4	Value5
K	Bq/kg	3170	28.41	6.88	0	0
U	Bq/kg	158.5	370.5	6.88	0	0
Th	Bq/kg	158.5	28.4	258	0	0
Cs-134	Bq/kg	0	0	0	1609	0
Cs-137	Bq/kg	0	0	0	0	1360
The BG vector is then		158.5	28.41	6.88	0	0

Example # four: There is a requirement to list results of area contamination in % and ppm in case of natural radioisotopes and in Bq/m^2 for man made radionuclides. Calibration will be performed on concrete pads. The thickness of K, U, Th and BG pad will be 50 cm what is a thickness when self absorption of material for photons emitted by K, U and Th is more than 95 percent and any influence of radiation from deeper layers is negligible.

A penetration of Cs-134 and Cs-137 radioisotopes is expected only to the surface layer. Let the depth of layer is 5 mm. Calibration of Cs-134 and Cs-137 will be provided on BG pad used as a base with layer of Cs-134 or Cs-137 contaminated substance. If there is used the same activity of a Cs-134 and Cs-137 in substance we have to compute activity per square meter. There is obvious that volume of a layer of one by one meter and thickness of 5 mm is 5 liters. The substance used for standard has density 1 gram/cm^3. Use of 5 liters of substance then gives 1609 Bq/kg x 5 = 8044 Bq/m^2 of Cs-134, and analogically 1360 Bq/kg x 5 = 6800 Bq/m^2 of Cs-137. The final matrix is:

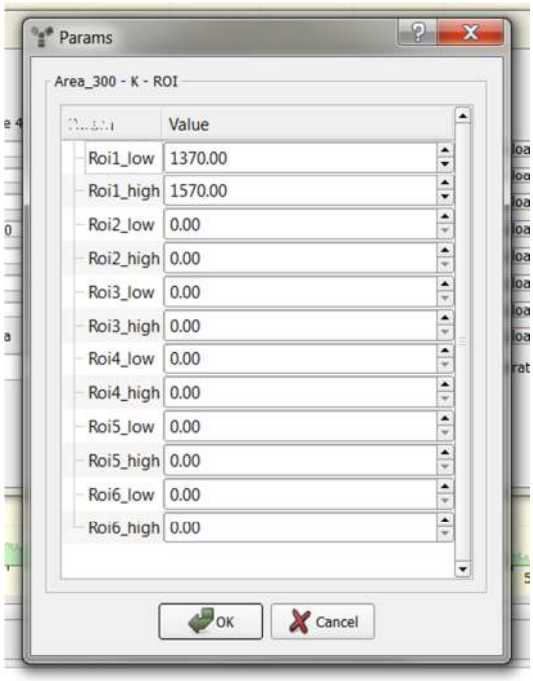
Comp. Name	Unit	Value1	Value2	Value3	Value4	Value5
K	%	10	2.3	1.6	0	0
U	ppm	0.5	30	1.6	0	0
Th	ppm	0.5	2.3	60	0	0
Cs-134	Bq/m2	0	0	0	8044	0
Cs-137	Bq/m2	0	0	0	0	6800
The BG vector is then		0.5	2.3	1.6	0	0

Corr. Factor. It is a universal correction factor used for correction of the concentrations within the calibration vector. As an example - there is used a correction factor 1.15 for K calibration standard in Area_300 table. The factor is used to compensate difference of reading of K on calibration standard (a block of concrete 1 x 1 m) and a reading of the same element in a real infinite area. The compensation is 15 % so there is used the factor 1.15. Use of this factor is not limited only to correction of geometry but may be used also for corrections of densities of standards to real samples densities, etc.

Det. Limit. Detection limit. It is a number preventing a display of not reliable results on display. Results what are below detection limit will be displayed as "< det limit". There is used 800 Bq/m^2 for Cs-137. All results below this limit are displayed as <800.

Alarm limit. An alarm limit is a value to trigger any action in case that its value is crossed. May be used to trigger a horn signal, etc., to warn user that a concentration in a sample is above limit.

ROI. Region of Interest. It is a definition of intervals in a spectrum where are expected information about presence of a components.



As an example we use K component in the Area_300 method. K-40 is emmiting gamma photons with nominal energy 1460 keV. There is expected a peak from K-40 in spectrum within 1370 through 1570 keV. Many components have more then one gamma peak so there is possible to enter up to 6 ROIs for each component. The ROIs may have an overlap. Wide of the ROI is restricted only number of channels in keV it means no energies below 15 keV and above 3072 keV. Every component must have at least one ROI defined.

Spectrum 1024 or Spectrum 256. Spectra of calibration standards can be measured directly by the GT-40/GT-40S prior finishing calibration process or can be uploaded from a file made from any previous measurement. It is important that the spectrum uploaded or measured MUST represent spectrum of calibration standard of the component. Any swap of components will lead to wrong evaluation of concentrations/activities. Once the calibration spectrum is in the unit (uploaded from a file or measured directly with GT-40/GT-40S) also the buttons Show and Download will be available. The Show button serves only to show actual assigned calibration spectrum for visual control. The Download button allows downloading measured calibration spectrum to be saved on file on a PC for a future use. The GT-40/GT-40S may work in 1024 channels linear spectrum mode or in 256 channels square root spectrum mode. For each type of spectrum there is restricted set of buttons. There is not allowed to combine spectrum modes within one method. What spectrum mode is used for calculation can be selected on compo box called Use spectrum for calculation. Both types of spectra are measured and stored every time.

Virtual component Enable/Disable engages/disengages evaluation and display additional quantity computed from values of first three components in the method. Virtual component is identified by a name and unit entered in edit boxes. Three multiplicative coefficients are editable in factor windows.

Measure time. Time of measurement defined for a method. Measuring time can be changed if it is required, but too short measuring time is not recommended and will lead to results loaded with big error. Shorter measuring time is possible as long as the concentrations in samples are rather high.

Calibration time and BG calibration time. Time requested for measuring of each calibration standard is called Calibration time. For the measurement of background sample there is recommended to use two time longer time then for a calibration standard with active component.

Load from File is a button what creates an access to file containing all parameter of the selected calibration methods list.

Save to file is a button to store all data from Calibration methods table in a file for a future use.

Go Back button closes actual Table of Calibration methods and goes back to selection list of methods. It is used when more then one method is created to switch between tables of methods.

Save button starts transfer and update of content of the table in the GT-40/GT-40S.

Cancel terminated the table without any data change and return to main screen.

15.2.2. Parameters

There is arranged a limited access to working parameters. Only parameters related to measuring modes units may be changed by user and their improper change will not lead to instrument's malfunction. Parameters are called by names and there is an edit box for each of them.

Parameters:

Params.active_meas_method = 1
Selection of 1 of 6 possible methods of measurement

Params.audio_mode = 1
Audio mode

Params.audio_sweep_threshold = 3

Params.audio_volume = 50
Loudness in percentage 0 - OFF

Params.bg_acquire = 10
Number of readings for background reaquirement

Params.bg_const = 90
Time interval for floating background

Params.bg_floating = 0
Enables floating background (system automatically copies slow background variations) or uses fix background

Params.calib_check = 0

Params.contrast = 0
Display contract parameter

Params.dose_alarm_status = 0
Dose alarm mode

Params.dose_alarm_threshold_l1 = 4

Params.dose_alarm_threshold_l2 = 5

Params.dose_alarm_threshold_l3 = 6

Params.dose_alarm_threshold_l4 = 7

Params.dose_alarm_unit = 0

Params.dose_rate_alarm_status = 0

Params.dose_rate_alarm_threshold_count = 3

Params.dose_rate_alarm_threshold_l1 = 4

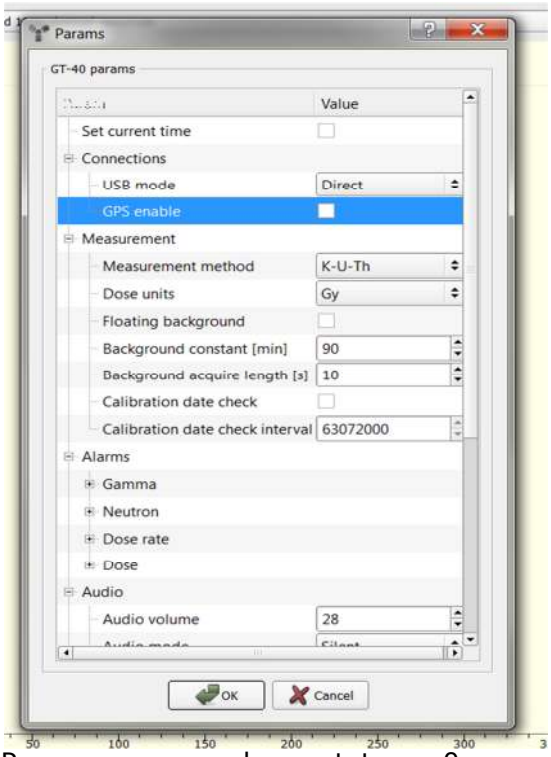
Params.dose_rate_alarm_threshold_l2 = 5

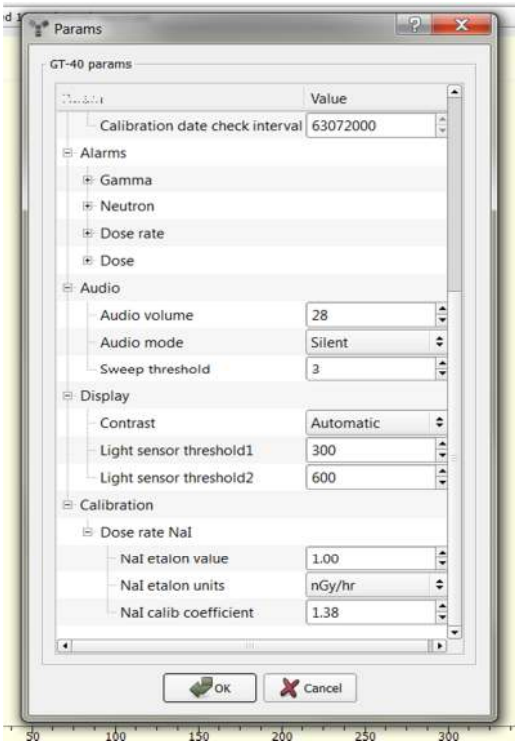
Params.dose_rate_alarm_threshold_l3 = 6

Params.dose_rate_alarm_threshold_l4 = 7

Params.dose_rate_alarm_unit = 0

Params.dose_units = 1
Dose-rate units: 0 – Gy/hr, 1 – Sv/hr





Params.gamma_alarm_status = 0

Params.gamma_alarm_threshold_count = 3

Params.gamma_alarm_threshold_l1 = 3

Params.gamma_alarm_threshold_l2 = 4

Params.gamma_alarm_threshold_l3 = 5

Params.gamma_alarm_threshold_l4 = 6

Params.gps_enable = 0
GPS ON / OFF: 1 / 0

Params.nai_dr_calib = 1.23
Dose-rate calibration factor

Params.nai_dr_nominal = 626

Params.nai_dr_units = 0

Params.usb_mode = 0
USB working mode – Direct – Ethernet – Com

Manufacturer can change all other parameters only. There are two ways how to do it.

1. Upload of a parameter set file verified by manufacturer. For that there are implemented function Upload parameters.
2. Remote connection to manufacturer where all maintenance is performed by manufacturer in real time.

15.2.3. Upload Firmware

The GT-40/GT-40S is a complex instrument and a new features supporting variety of new applications are being implemented continuously. From time to time it is recommended to check manufacturer's web for a new software revisions. Firmware uploading process is then required.

Firmware upload is a delicate process where any unpredictable action may lead to system damage and complications with system recovery. There are implemented policy rules to minimize failure rate but still remains few items what has to be arranged by the user:

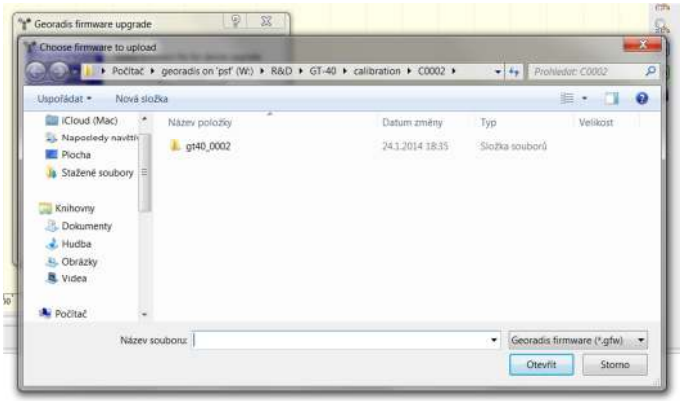
1. Prior firmware upload check battery status. The GT-40/GT-40S MAY NOT switch off during firmware update due lack of battery power. The upgrade can be done with battery charger ON.
2. In no circumstances the unit may be switched OFF by user while transferring files into PC or updating.
3. Do not unplug USB cable.
4. Do not switch OFF the PC before the process of upgrade is finished.

Before starting upgrade process user must know where to get a new firmware package. One of the sources is direct access to manufacturer's FTP. The access is arranged through a link sent by manufacturer. User must download the firmware file using a web browser and save the file in a local folder on his PC. The second possibility is to let download the file directly by Geomon. There is an alternative for locations with very poor internet connection: User gets new firmware on a solid memory medium like CD, DVD or memory stick.

Firmware upload procedure:

1. Download a new gfw file and save in a local file folder.
2. Start Geomon.
3. Switch On the GT-40/GT-40S.
4. Connect USB cable.
5. On Geomon connect device.
6. Activate button Upload firmware.
7. Check manual selection of a gfw file.

8. Use Browse button to select gfw file.



9. Touch Next to start update process

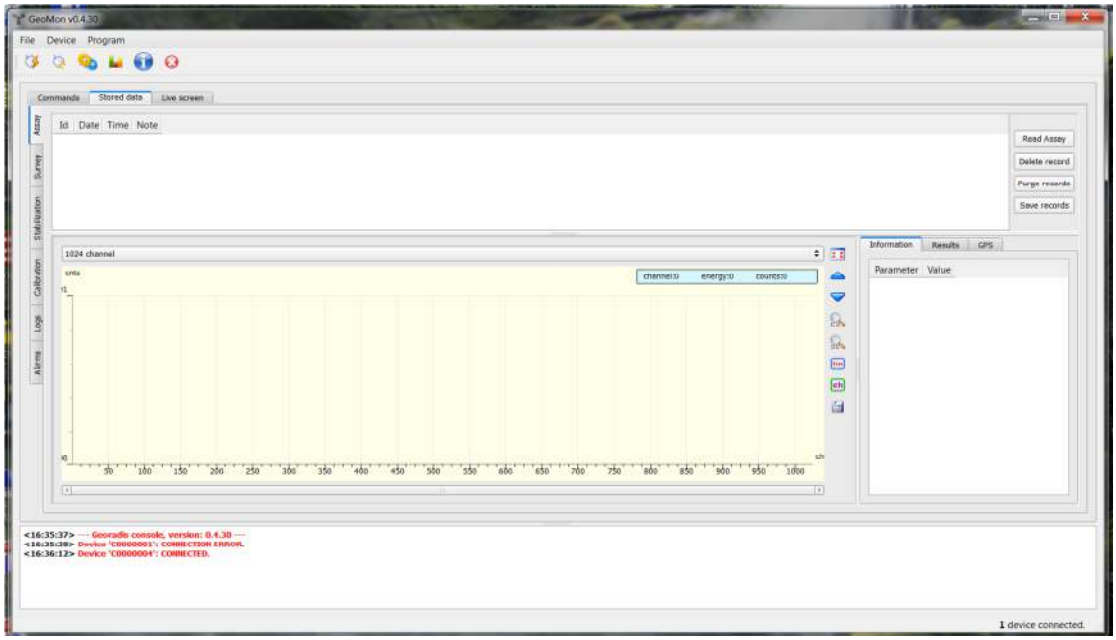
The update routines will check completeness of the new fgw file and will transfer it in the GT-40/GT-40S. Once finished a process of re-writing of the old firmware is started. It is critical to interfere somehow with the unit during re writing. Once the process is completed the GT-40/GT-40S will restart and a new firmware version is in charge.

Any unpredictable behaving must be consulted with manufacturer. This may prevent complication of damaging file system of the unit. In case user is not fit enough to do upgrade itself manufacturer can do an upgrade using a remote access to the unit.

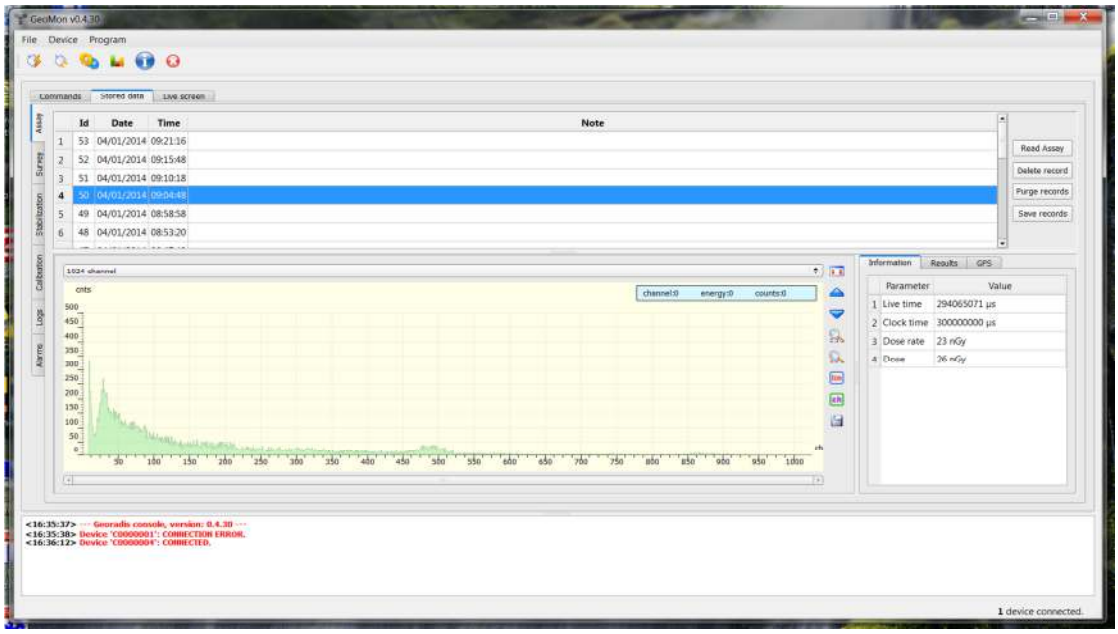
15.3. Stored data

15.3.1. Assay, Identification, Core and Survey data

Geomon is to be used for measured data download from the GT-40/GT-40S and converting in a data files. GT-40/GT-40S data structures are complex and results of different work modes are filed separately. For easy orientation the Geomon groups each working mode on designated list. Vertical tabs on left side of each list arrange switching between lists. There are tabs for ASSAY, IDENT, SURVEY, CORES, STABILIZATION, CALIBRATION, LOGS and ALARMS. There are arranged following functions on each of the list.

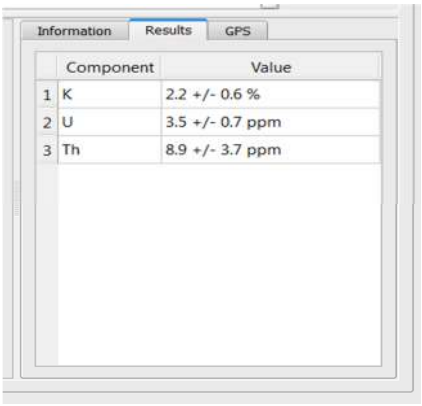


Read ... - (e.g. Read Assay) transfers all records from the GT-40/GT-40S.



List of records with identification number ID, date and time respectively note are listed in table on the left of function buttons. User may browse the list up or down and select record. All other properties of a record are shown in other two windows. Spectrum of an assay or survey profile record is plotted in window in the middle of the screen. User can browse plot in details using UP or DOWN arrow button to change y-scale, to extend x-scale for zooming details. A partial spectrum can be exported in a text file format after activation of diskette labeled button.

Computed results and all information related with measurement are accessible in right window. User can be informed about measuring time, dead time, and concentrations and also GPS coordinates of the place of measurement.



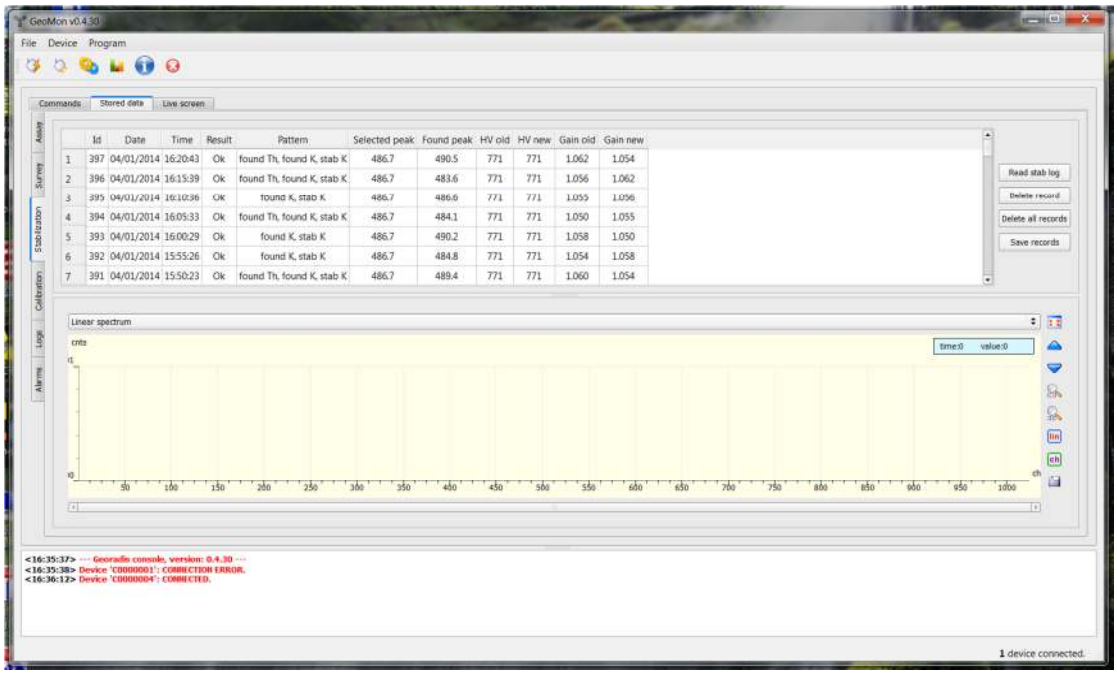
Delete record - Records in the GT-40/GT-40S can be maintained using Geomon application. A single record highlighted can be deleted from GT-40/GT-40S database after pressing button **Delete record**. To delete all records in the unit user touch button **Purge records**.

Save records leads to opening a folder structure on user's PC and storing all records within the structure.

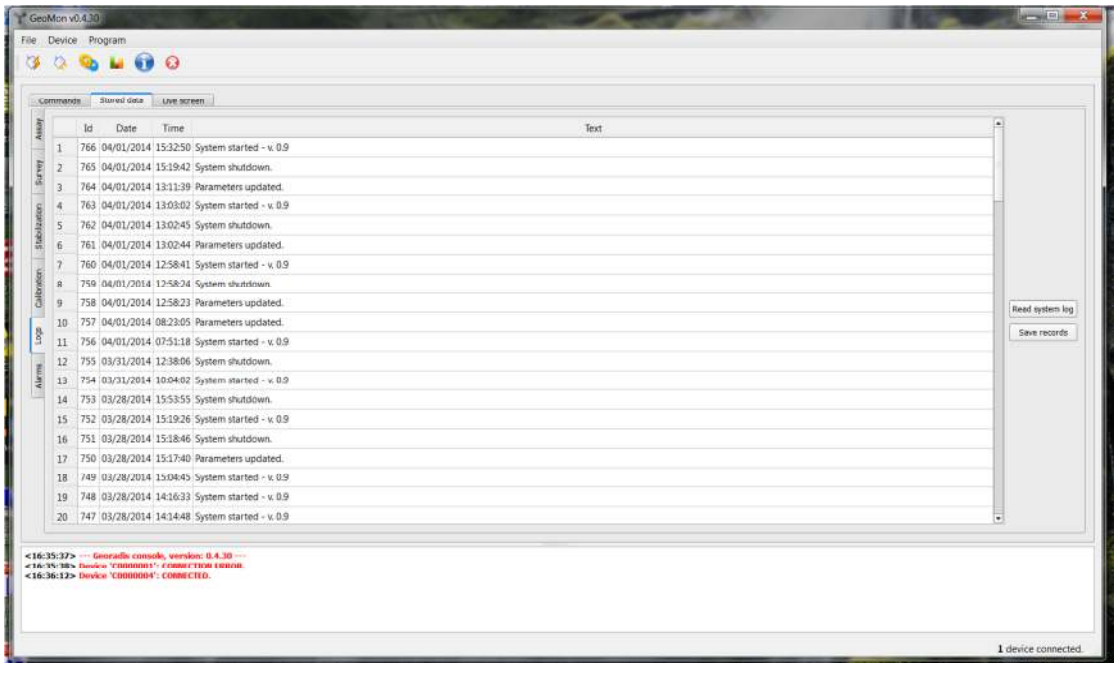
15.3.2. Stabilization LOG

Stabilization log is one of the most important sources of information about long-term performance of the instrument and its condition. While the GT-40/GT-40S is ON a continuous gain stabilization process is active. A background spectrum is accumulated and every 30 seconds analyzed for peaks present. List of peaks found gives a pattern what has to be matched with pattern of energy nominal of natural radioactive elements. Results of these iterations together with spectra are then logged.

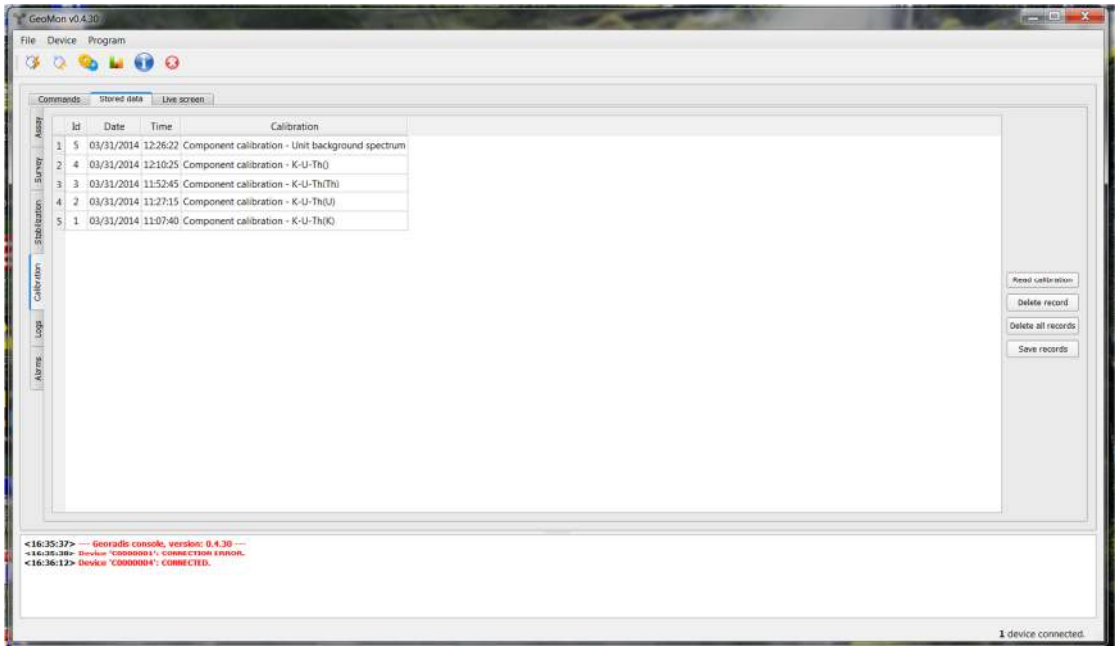
Operation with data is similar to assay or survey records. Following are meanings of texts in columns. ID is a record identification number. The number is important and spectra files are named with this unique number. Date and Time have standard meaning. Result reports if the stabilization was accepted as valid and gain adjusted is correct or if unit is still not warmed up. Pattern informs about nuclides found and used for stabilization. There is important information for experts about quality of local background and also about confidence level of gain stabilization. The least confidence level has K only stabilization because there is only single K-40 peak used. The more elements are identified the higher is the confidence.



Manufacturer asks from time to time user to send stabilization log in case of any trouble. A next source of information about health of the instrument is System log. There are written all important system messages. Both logs are very important for remote maintenance. User cannot delete the system log.



Last part of logged information is a list of calibration attempts. The log may help to user in case of uncertainty about proper calibration spectra used or their date and time.



15.4. Remote operations

Wide connectivity of GT-40/GT-40S predestines it to be used as a remote measuring point. A remote operation is supported on all levels of connection – it means USB, Bluetooth or Wi-Fi and with using WLAN there is no distance limit for it. A simple application integrated in Geomon emulates GT-40/GT-40S display and five buttons for instrument operating. Using remote there is no limit on any function of the instrument. In case of slow connections on far distance there is selectable a refreshing period of signals. During work the remote can be interrupted anytime due data transfer or setup.