Version: V20250700

GammaSense
Spectrum Acquisition and Analysis Software
User Manual

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1 Introduction

GammaSense is a commercial γ spectrum acquisition and analysis software developed by our company, which is compatible with all our Multi-channel analyzers (MCAs or called devices below). The software integrates functions such as spectrometer control, measurement setup, spectrum acquisition and display, spectrum zooming, region of interest operations, peak analysis, energy calibration, efficiency calibration, nuclide library, activity calculation and report export, and user management.

The software is equipped with high-performance spectrum analysis algorithms, capable of supporting various γ spectroscopy spectrum analyses and applications. It includes multiple spectrum analysis engines, suitable for spectrum analysis of γ spectrometers such as NaI, $LaBr_3$, HPGe, CdZnTe, etc.

2 Software Installation

After unzipping the software installation package, double-click to run the setup.exe program, as shown in Fig.1, click the ‘GammaSense’ button, and the GammaSense installation interface as shown in Fig.2 will pop up. This interface allows you to change the installation path (it is best to choose a path where adding or modifying files does not require administrator privileges. If GammaSense is already installed on the PC, it will prompt that the installation path cannot be changed). Click the ‘Installation’ button, and in the installation interface shown in Fig.3, click the ‘Next’ button to proceed with the installation. If you click ‘Language’ in the upper right corner of Fig.1, you can switch between Chinese and English display.

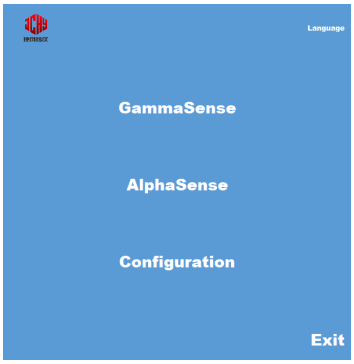


Fig.1: Installation Start Screen

Fig.2: GammaSense Installation Interface

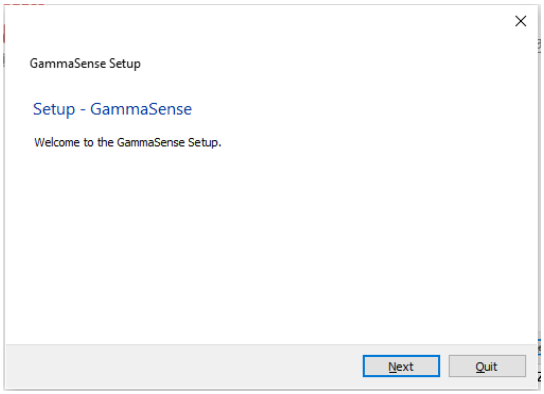


Fig.3: GammaSense Installation Wizard Interface

If the software is already installed, a prompt dialog window will pop up asking whether to update the nuclide library, as shown in Fig.4.

Clicking ‘No’ will automatically uninstall the current version first, and after the uninstallation is complete, the installation interface shown in Fig.3 will pop up.

Clicking ‘Yes’ will prompt whether to back up the nuclide library, as shown in Fig.5. Clicking ‘Yes’ will terminate the installation, allowing the user to back up the original nuclide library. Clicking ‘No’ will automatically uninstall the current version first, and after the uninstallation is complete, the installation interface shown in Fig.3 will pop up.

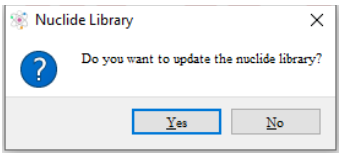


Fig.4: Prompt whether to update the nuclide library.

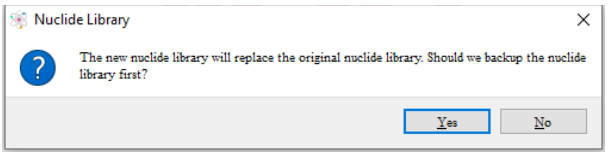


Fig.5: Prompt whether to back up the nuclide library.

After the installation is complete, a ‘GammaSense’ shortcut will be generated on the desktop. If the ‘Open software after installation’ is checked at the bottom right corner of Fig.2, the software main interface will automatically open, as shown in Fig.6. If the ‘Open software after installation’ is not checked, you can double-click to run the software.

3 Main Interface

The main interface of the spectrum acquisition and analysis software - GammaSense is shown in Fig.6:

The main interface of the software consists of the menu bar, toolbar, spectrum window area, measurement information bar, and status bar.

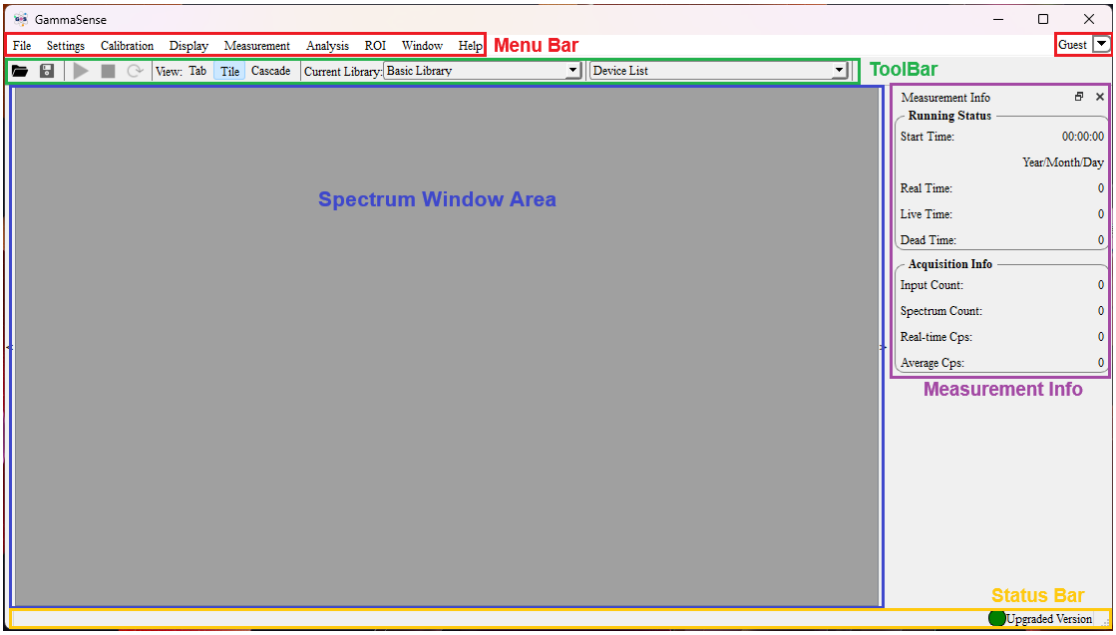


Fig.6: GammaSense Main Interface

4 Menu Bar

The menu bar is as shown in Fig.7 below.

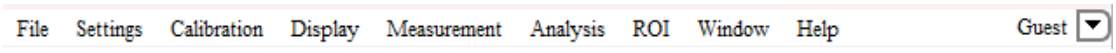


Fig.7: Menu Bar

4.1 File

The File menu is shown in Fig.8 below:

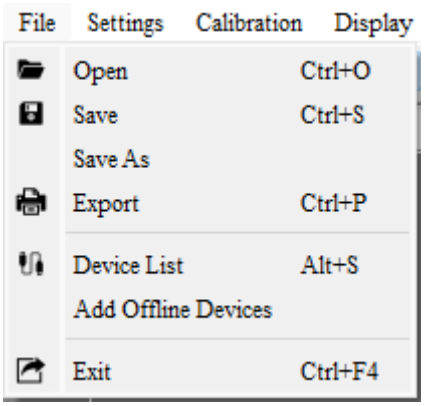


Fig.8: File

4.1.1 Open

As shown in Fig.9, it is used to open spectrum stored on the hard drive, including formats such as .Spe, .mca, .Chn, etc., allowing multiple files to be selected and opened at the same time.

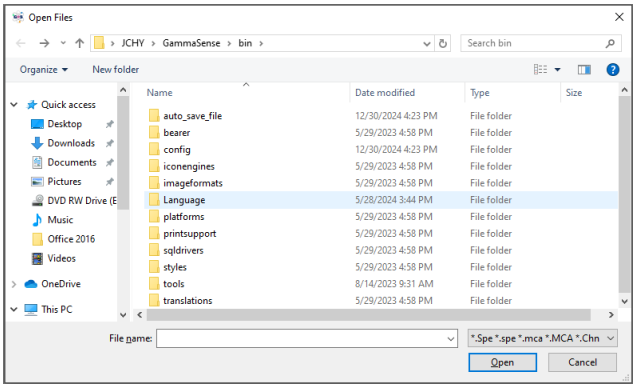


Fig.9: Open Files window

4.1.2 Save

If the currently displayed spectrum is opened from the hard drive, clicking the ‘Save’ button will save the modified information to the opened spectrum file. If the currently spectrum is measured by a MCA, clicking the ‘Save’ button will pop up the save file window as shown in Fig.10, where you can select the save path, fill in the file name, choose the save type, and then click the save button to complete the saving process.

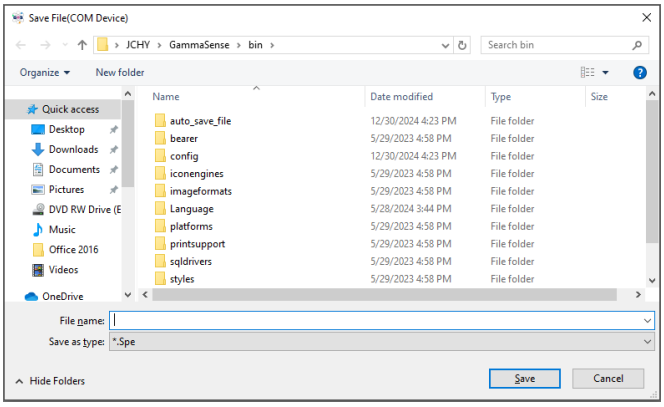


Fig.10: Save File window

4.1.3 Save As

The currently displayed spectrum information (including the spectrum opened from the hard drive and the spectrum measured by the MCA) can be saved to a different path folder, and it can also be saved in other spectrum file formats.

4.1.4 Save the original data in List mode

This is only valid for online MCAs that support the List mode. After selection, the interface shown in Fig.11 will pop up. Select the save path, fill in the file name, choose the save type, and click the save button. The software will save the List data read from the current device afterwards. As shown in Fig.12, the

first column is the channel number, the second column is the timestamp, the third column is the channel address, and the fourth column is the PSD value.

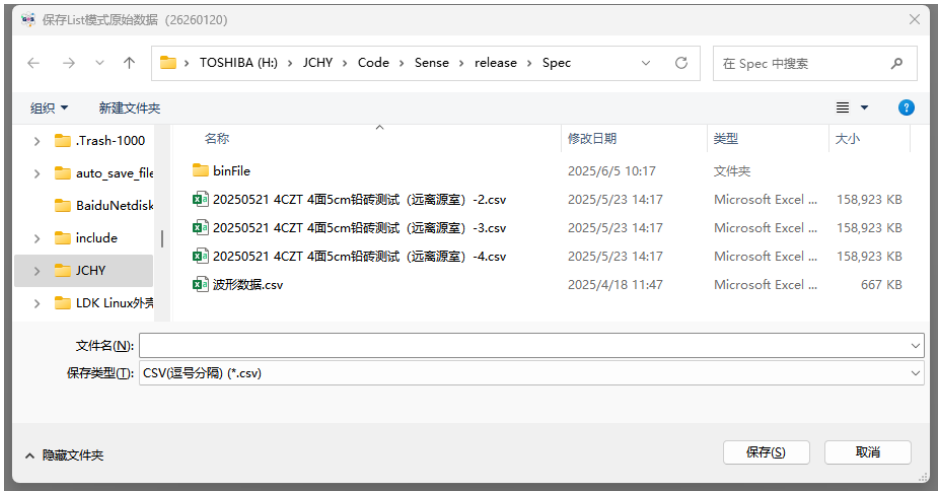


Fig.11: Save original data in List mode - Select save path

Channel	Timestamp	Energy	PSD
0	0	24163	24
1	0	24163	24
2	0	24163	24
3	0	24163	24
0	0	24164	24
1	0	24164	24
2	0	24164	24
3	0	24164	24
0	0	24165	24
1	0	24165	24
2	0	24165	24
3	0	24165	24
0	0	24166	24
1	0	24166	24
2	0	24166	24
3	0	24166	24
0	0	24167	24
1	0	24167	24
2	0	24167	24
3	0	24167	24

Fig.12: Save the original data in List mode - CSV file

4.1.5 Save the original data of the waveform pattern

This is only valid for online devices that support the waveform mode. After selection, the interface shown in Fig.13 will pop up. Select the save path, fill in the file name, choose the save type, and click the save button. The software will save the List data read from the current device afterwards. As shown in Fig.14, the first column is the channel number, the second column is the timestamp, and the third column and subsequent columns are the waveform data.

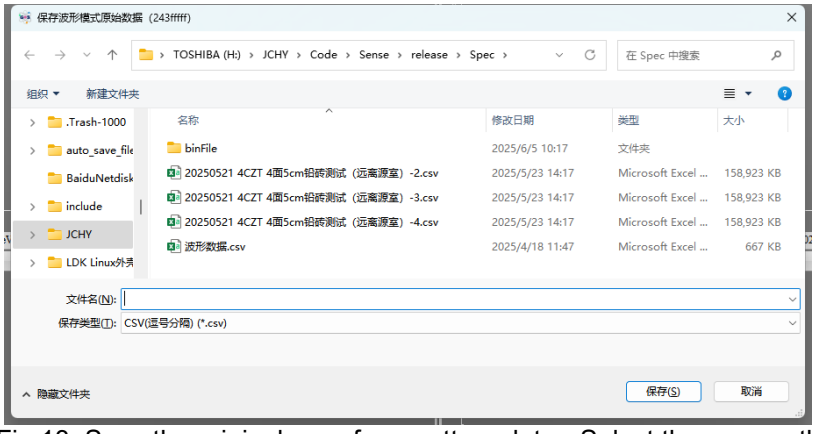


Fig.13: Save the original waveform pattern data - Select the save path

Channel	Timestamp	Energy										
0	6.2425E+11	159	131	183	115	131	199	63	191	163	123	175
1	6.2425E+11	151	103	163	159	115	199	95	135	183	83	163
2	6.2426E+11	157	149	153	93	165	153	157	153	133	125	161
3	6.2426E+11	123	119	127	139	147	115	151	119	127	203	143
0	6.2428E+11	151	147	151	159	139	159	159	151	131	123	171
1	6.2428E+11	163	139	119	131	147	123	127	147	167	151	191
2	6.2429E+11	173	145	137	149	173	141	157	141	141	145	125
3	6.2429E+11	111	143	135	183	151	147	163	135	159	131	131
0	6.243E+11	131	135	131	135	135	111	139	139	119	147	163
1	6.243E+11	143	171	119	147	167	131	127	155	143	139	167
3	6.2431E+11	163	159	135	131	147	207	163	111	175	131	195
2	6.2431E+11	133	145	129	125	157	153	109	145	209	109	193
0	6.2433E+11	163	115	147	107	135	151	159	155	151	127	163
1	6.2433E+11	171	143	119	167	155	131	155	139	119	175	79
2	6.2434E+11	169	181	209	145	121	149	169	145	129	173	161
3	6.2434E+11	159	147	175	171	119	203	119	147	147	143	159
0	6.2435E+11	175	143	135	135	119	175	135	155	171	139	111

Fig.14: Save the original data of the waveform pattern - CSV file

4.1.6 Export

Click the Export button to pop up the window as shown in Fig.15. This function allows you to export the currently spectrum and information to Print, export to Print-PDF, or export to Picture.

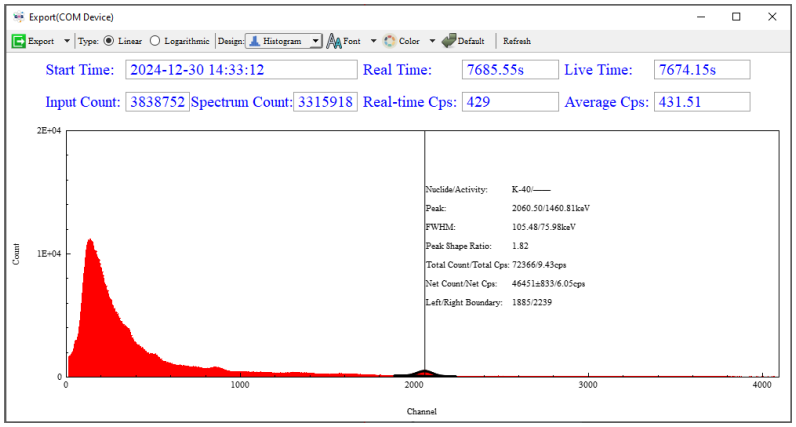


Fig.15: Export window

Toolbar function buttons in Fig.15:

1. **Export：** Including Print and Picture.

   ① Print - A preview window as shown in Fig.16 will pop up. Clicking print will bring up the print window as shown in Fig.17. If a printer is connected, you can directly select the printer to print it out. Or you can choose to Print to PDF, and clicking the print button will

pop up the save path window as shown in Fig.18.

② Picture - A window will pop up as shown in Fig.19, where you can select the format, name, and path for saving the Picture.

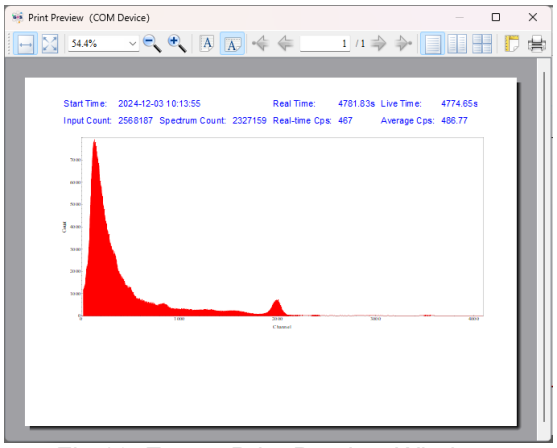


Fig.16: Export-Print Preview Window

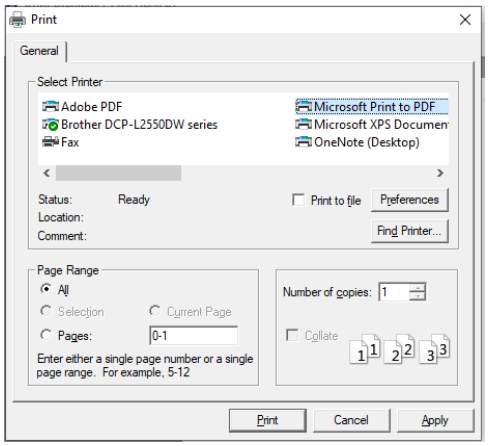


Fig.17: Print Window

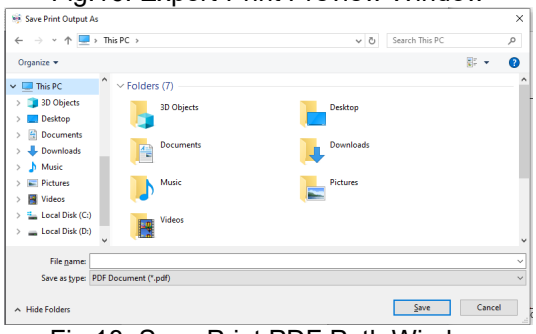


Fig.18: Save Print PDF Path Window

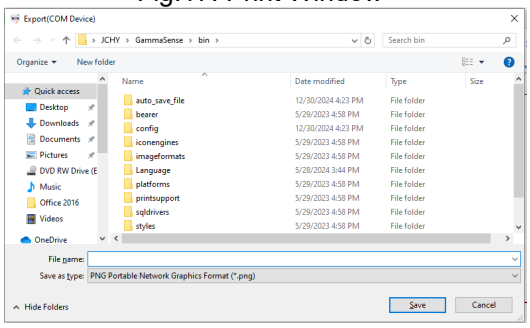


Fig.19: Save Export-Image Path Window

2. Type： Choose to display the spectrum Y-axis in linear or logarithmic.

3. Design：

① The spectrum can be displayed as a histogram, scatter plot, or line chart.

② Font - You can set the font for measurement information and the spectrum, including font format, font style, size, underline, strikethrough, and font color, as shown in Fig.20.

③ Color - You can set the spectrum color, background color, and others. In others, you can set the pen style, pen width, and pen color for the spectrum border, marker line, fitting lines, etc., as shown in Fig.21.

④ Default - Restore the design to default.

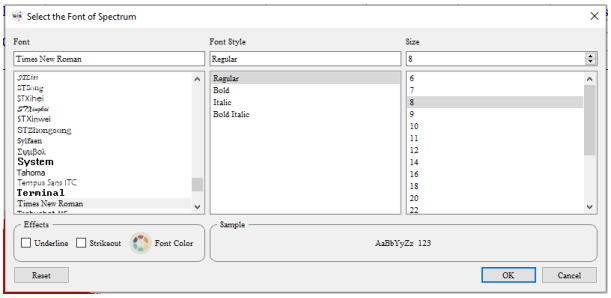


Fig.20: Font Settings Interface

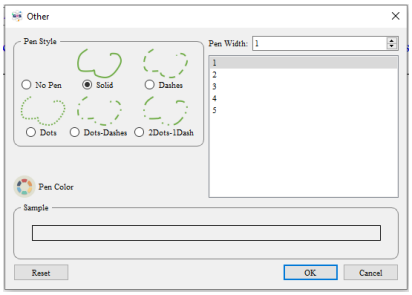


Fig.21: Color-Other Settings Interface

4. **Refresh:** Refresh the spectrum information.

4.1.7 Device List

When the PC connects to a multi-channel device, you need to select the devices and add it to the added devices to open the MCA's spectrum window, and then set up and collect the spectrum from the MCA.

The Device List window is shown in Fig.22:

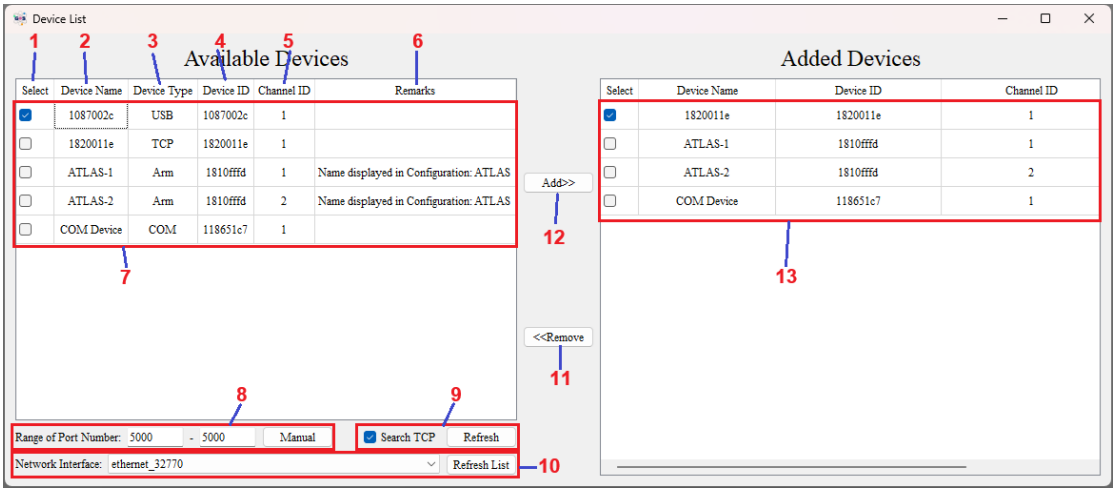


Fig.22: Device List window

The description of this interface is as follows:

① Selection: Check/Uncheck a device.

② Device Name: Displays the device name. The device name can be modified in the 'Configuration' software. For the latest MAC (October 2024 and later) from our company, the modified name will be written into the MCA. After changing the PC or reinstalling the software and connecting to the MCA, the name displayed will be the last modified name.

③ Device Type: This displays the communication type of the device, including COM, USB, TCP, and Arm. COM represents serial communication devices (referred to as COM devices below), USB

represents USB communication devices (referred to as USB devices below), TCP represents network communication devices (referred to as TCP devices below), and Arm represents MCA with embedded systems, which use USB communication.

④ Device ID: The serial number of the MCA.

⑤ Channel ID: Displays the channels. If the device is single-channel, it will be '1'. If the device is dual-channel, it will have two channels '1' and '2'. If the device is triple-channel, it will have three channels '1', '2', and '3', and so on. When modifying the name for a device with 2 or more channels, suffixes '-1', '-2', etc., will be automatically added.

⑥ Remarks: Prompts the status of the device. If the device name does not match the one in Configuration, there will be a prompt here.

⑦ Displays the devices connected to this computer.

⑧ Sets the port number based on the device network information. You can also click 'Add Manually' to input the corresponding IP and port to manually add a network port device.

⑨ Refresh: When communication is interrupted but the device is still connected to the computer, click 'Refresh' to make the computer re-connect to the device (including COM devices, USB devices). you can also check 'Search TCP' to search for TCP devices while refreshing.

⑩ When selecting network communication, you need to choose the corresponding network card. If the network card changes, or the drop-down menu does not display the corresponding network card information, click 'Refresh Network Card'.

⑪ Remove: Used to remove devices that has already been added.

⑫ Add: Used to add devices to the list of added devices.

⑬ Displays devices that have been added.

4.1.8 Select Offline Devices

It is only valid after at least one offline device has been added to the software, as shown in Fig.23.

Fig.23: Dialog box for selecting offline devices

① Selection: Check and uncheck, used for device addition or removal.

② Device Name: Displays the custom name of the offline device, which is also the unique device identifier of this offline device. It cannot be the same as the device number of any device in the device list in Fig.22.

③ Number of Channels: Displays the set number of channels of the offline device.

④ Add: Add the checked devices in the left device list to the added device list and display them on the main interface.

⑤ Remove: Remove the checked devices in the right added device list from the added device list and remove them from the main interface.

4.1.9 Add Offline Devices

Select one or more List data files saved through 4.1.4. As shown in Fig.24, the configuration file interface as shown in Fig.25 will pop up. Adjust the file reading order by moving up/down, and select whether to perform proportional scaling when reading the file according to the description below Fig.25. After pressing the OK button:

① If no offline device has been added to the software, the new device configuration interface as shown in Fig.26 will pop up. Fill in or select the device name, number of channels, number of channel addresses, and time accuracy in sequence, and click the OK button. The software can then start reading data from the selected List data files.

② If an offline device has been added to the software, the offline device

selection interface as shown in Fig.27 will pop up. Select "Yes". If there is only 1 offline device in the software currently (Fig.27(a)), directly add the selected file to this offline device (if the offline device already contains this file, do not add it). If there are more than 1 offline device in the software currently (Fig.27(b)), the offline device selection interface as shown in Fig.28 will pop up. Select an offline device and press the OK button, then add the selected file to the selected offline device (if the selected offline device already contains this file, do not add it). Select "No", which is the same as ①. Select "Cancel" to abandon the addition of the offline device this time.

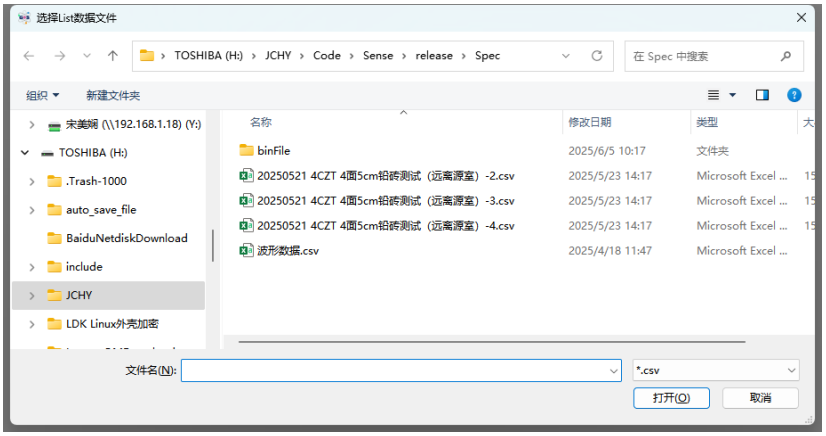


Fig.24: Select List data file

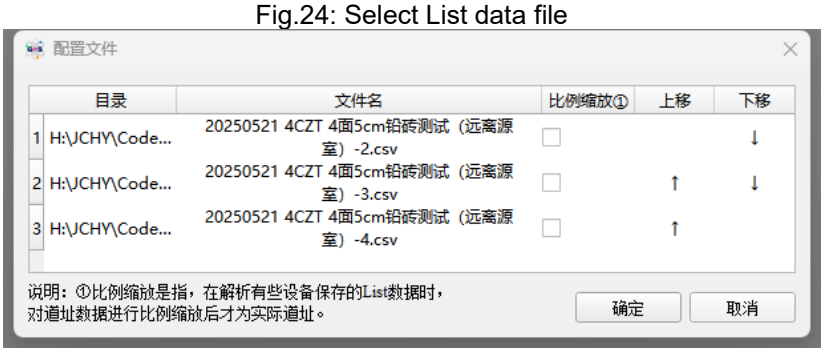


Fig.25: Configuration file

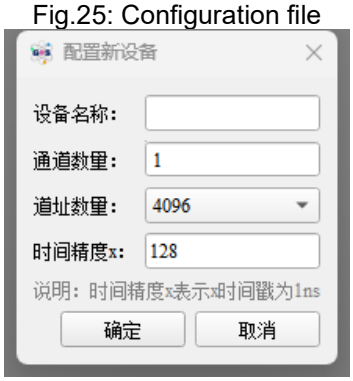
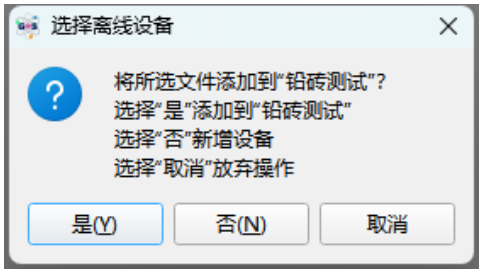
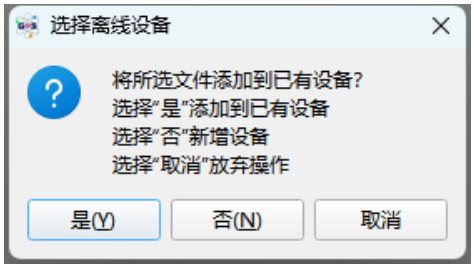


Fig.26: Configuration interface for new devices



(a) There is only 1 offline device.



(b) There are multiple offline devices

Fig.27: Select Offline Device Interface 1

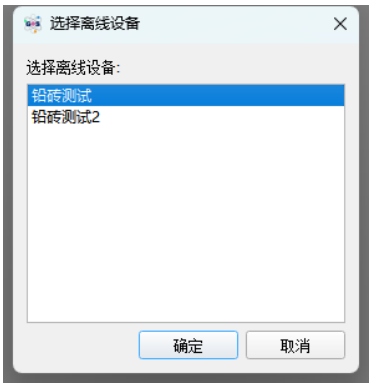


Fig.28: Select Offline Device Interface 2

4.1.10 Exit

Exit the software.

4.2 Settings

The Settings menu is shown in Fig.29 below:

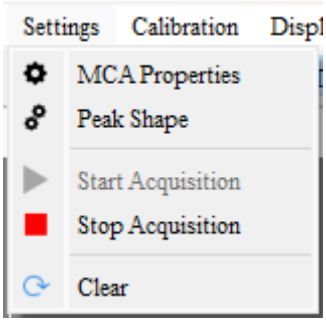


Fig.29: Settings Menu

4.2.1 MCA Properties

The MCA Properties interface is used to provide parameter settings for the MCA. The MCA Properties interface and parameter items may vary for different MCA models. Please refer to the user manual of the respective MCA for the specific MCA Properties.

MCA Properties will include the Device Info page, Mode Settings page, MCA Settings page, Input/Output Settings page, Coincidence Settings page, Condition For Stopping Acquisition Settings page, and Administrator Settings page.

Note: Different MAC models will have different pages.

4.2.1.1 Device Info

The Device Info page allows for the adjustment of high voltage and displays device information, including the device ID, set high voltage value, actual high voltage value, device temperature (if there is a temperature monitoring module), maximum channel, baud rate, etc.

In the high voltage settings, you can choose positive high voltage or negative high voltage (some devices do not require selection, such as AVATAR Digital MCA), high voltage protection mode selection (only for MCA connected to HPGe detector), and HV(high voltage) modification. To modify the HV value, first click the lock icon '🔒' on the right side of the number, so that it is in the unlocked '🔓' state, then enter the voltage value you need to set in the input box, and press the 'Enter' button on the keyboard to modify it successfully. After that, click the 'Turn on' button to turn on the high voltage.

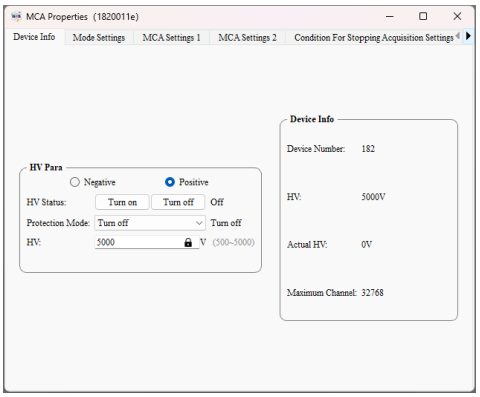


Fig.30: Device Info Page (ARES-32T Digital MCA)

Note: The display and settings of this interface may vary for different devices. For detailed operation instructions, please refer to the user manual of the respective MCA.

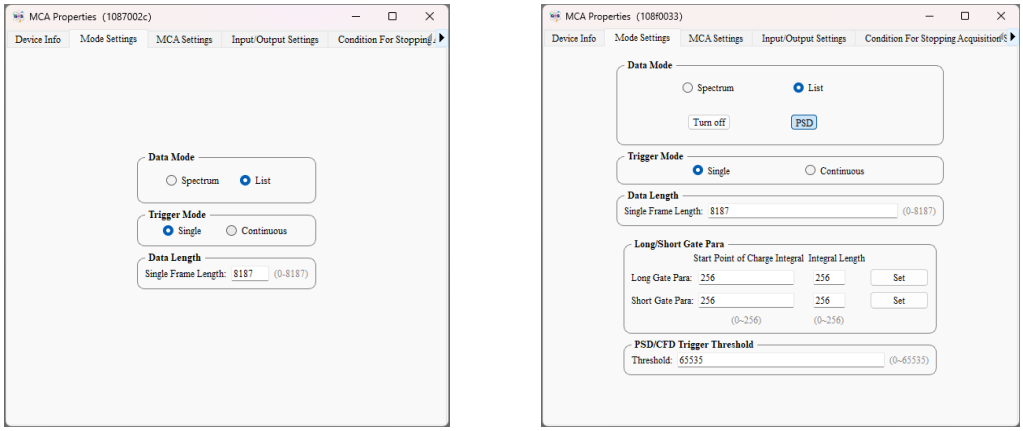
4.2.1.2 Mode Settings

Devices that support List mode will display the Mode Settings page, on which the Spectrum or List can be selected. The Spectrum mode only contains the amplitude information of particle events, used for collecting energy spectra and analysis. The List mode includes informations such as the time, amplitude, and detector ID of particle events, which can be used for applications like signal coincidence and anticoincidence.

When selecting List mode, the trigger mode needs to be set, with options

for single and continuous. Single trigger means the computer sends a command to the MCA, and the MCA then sends a data packet to the computer. Continuous trigger means the MCA continuously sends data packets to the computer. Additionally, the length of a single frame of data needs to be set, typically ranging from 0 to 8187. Enter the desired length number and then press the 'Enter' key on the keyboard to successfully set it.

Some devices' List mode has a Pulse Shape Discrimination (PSD) function. In addition to setting the trigger mode and data length, it is also necessary to set the long/short gate parameters and the PSD/CFD trigger threshold.



a. List Model b. Pulse Shape Discrimination (PSD) Model

Fig.31 Mode Settings Page

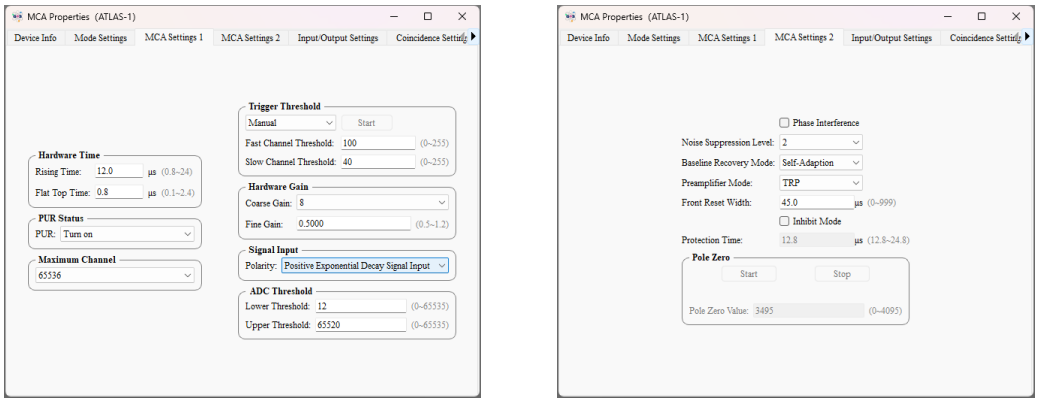
Note: The display and settings of this interface may vary for different devices. For detailed operation instructions, please refer to the user manual of the respective MCA.

4.2.1.3 MCA Settings

MCA Settings page allows for the configuration of some important parameters of MCA. Depending on the connected MCA, some may display only one page of MCA settings (such as the AVATAR series MCA), others may show two pages of MCA settings (such as the ARES-32T and ATLAS Digital MCA).

The first page of MCA settings generally includes hardware-related items such as rise time and flat top time, pile-up rejection (PUR) status, maximum channel, GATE mode (only for ARES-32T MCA), fast and slow channel threshold, coarse/fine gain, polarity adjustment for signal input, and ADC upper/lower threshold. The second page of settings generally includes phase interference, noise suppression level, baseline recovery mode, preamplifier model and Front reset width (for TRP preamplifier type), Inhibit mode and

protection time, and pole-zero.



a. MCA Settings 1 b. MCA Settings 2

Fig.32: MCA Settings Page (ATLAS Digital MCA)

Note: The display and settings of this interface may vary for different devices. For detailed operation instructions, please refer to the user manual of the respective MCA.

4.2.1.4 Input/Output Settings

The page will be displayed if the multi-channel device has an integrated input/output interface and supports input/output settings.

The input mode can be set to START mode, trigger mode, or off. START mode is: the device starts acquisition upon receiving a high-level signal at the input interface and pauses upon receiving another high-level signal. Trigger mode is: the device starts acquisition upon receiving a high-level signal at the input interface and then automatically pauses according to the set trigger mode duration.

The output mode can be set to ICR mode, SCA mode, Pause TTL Output mode, Coincidence Pulse Output mode, or off.

ICR mode: after setting the delay and window to be greater than 0, the MCA quickly triggers a TTL level output.

SCA mode: after setting the delay and window to be greater than 0, the MCA triggers a TTL level output based on the SCA upper and lower threshold range.

Pause TTL Output mode: after enabling this mode, the device starts acquisition and then pauses, with the output interface emitting a TTL level signal.

Coincidence Pulse Output: after setting the delay and window to be greater than 0, a TTL level output is triggered by a coincidence pulse, used for coincidence pulse counting (this mode is currently only used for the ATLAS

digital MCA).

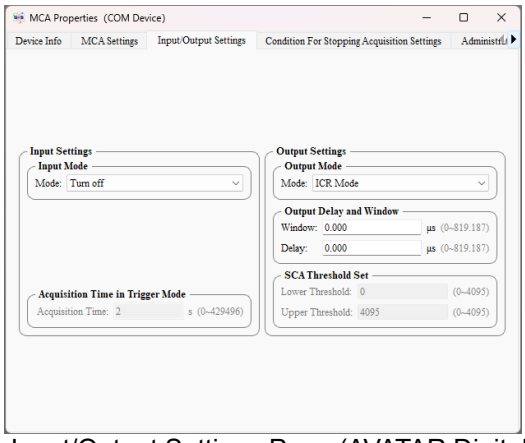


Fig.33: Input/Output Settings Page (AVATAR Digital MCA)

Note: The display and settings of this interface may vary for different devices. For detailed operation instructions, please refer to the user manual of the respective MCA.

4.2.1.5 Coincidence Settings

This page is currently only open to the ATLAS digital MCA.

In this interface, the spectrum output mode can be set (including original spectrum, coincidence spectrum, anti-coincidence spectrum, and any combination of two), GATE delay and window, coincidence delay and window, and the input port count rate and GATE port count rate can be viewed.

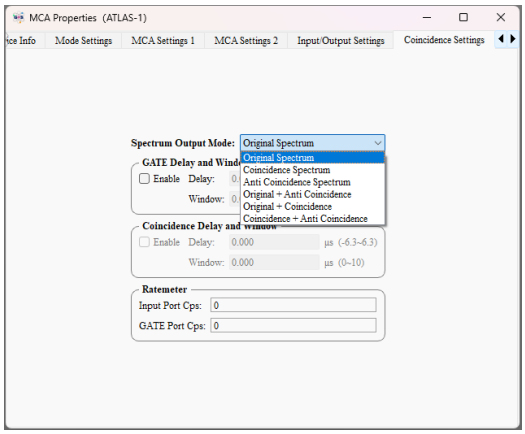


Fig.34: Coincidence Settings (ATLAS Digital MCA)

There are roughly two methods for coincidence: 1) Set the Delay and window of the coincidence/anti-coincidence detector signals and perform coincidence with the main detector signals. 2) Set the Delay and window of the main detector signals and perform coincidence with the coincidence/anti-coincidence detector signals.

When using the first type of coincidence method, only check the box to enable GATE delay and window. Adjusting the GATE delay and window is

equivalent to adjusting the delay and window of the coincidence/anti-coincidence detector signals for coincidence with the main detector signals. Adjust the delay and window times and monitor the coincidence count rate in real-time (i.e., the input port count rate, with the output port of the channel connected to the input port, and the output mode configured as coincidence pulse output) to find the optimal delay and window times.

When using the second type of coincidence method, it is necessary to check both the ‘Enable GATE Delay and window’ and the ‘Enable Coincidence Delay and window’ options. Adjusting the coincidence delay and Enable times is equivalent to adjusting the delay and stretch of the main detector's fast shaping signal for coincidence with the coincidence/anti-coincidence detector signals. When a coincidence occurs, a GATE signal is immediately generated, which is used to pick up the slow shaping signal that follows the fast shaping signal of the main detector. These slow shaping signals picked up by the GATE are used to form coincidence or anti-coincidence spectra. Therefore, the GATE delay and window are set according to the shaping time of the main detector's slow shaping signal (rise time and flat-top time), ensuring that the set GATE delay and window can fully encompass the flat-top of the slow shaping. Adjust the coincidence delay and window times and monitor the coincidence count rate in real-time (i.e., the input port count rate, with the output port of the channel connected to the input port, and the output mode configured as coincidence pulse output) to find the optimal delay and window times.

Note: For detailed operation instructions, please refer to the user manual of ATLAS Digital MCA.

4.2.1.6 Condition For Stopping Acquisition Settings

This page can set four types of measurement stop conditions, including real-time, live-time, peak count of ROI, and total count of ROI. It is applicable to all digital MCA produced by our company.

Real time: The system stops measuring when the system's real time equals the set value.

Live time: The system stops measuring when the system's live time equals the set value.

Peak count of ROI: The system stops measuring when the count of a

specific channel between the ROI low channel address and the ROI high channel address reaches the set value.

Total count of ROI: The system stops measuring when the sum of counts across all channels between the ROI low channel address and the ROI high channel address reaches the set value.

To modify, enter the corresponding number and then press the ‘Enter’ key to successfully input. If you do not wish to set a measurement stop condition, please enter ‘0’ and then press the ‘Enter’ key on the keyboard.

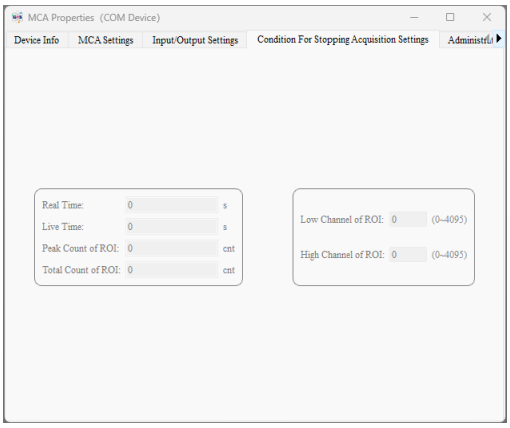


Fig.35: Condition For Stopping Acquisition Settings Page

4.2.1.7 Administrator Settings

By entering the password on the Administrator Settings page, you can access the Administrator mode to set the parameters as they were at the factory. This mode is not open to users. Note: If unauthorized by the manufacturer, the operator enters and modifies parameters, leading to system errors or damage, the manufacturer will not be responsible for warranty coverage. Please contact our company if there are any issues.

Depending on the connected MCA, if the MCA supports a virtual oscilloscope (such as AVATAR-HCT/LAN, ARES-23T, ATLAS, etc.) and status window (such as ATLAS), the ‘Virtual Oscilloscope’ and ‘Status window’ buttons will also be displayed.

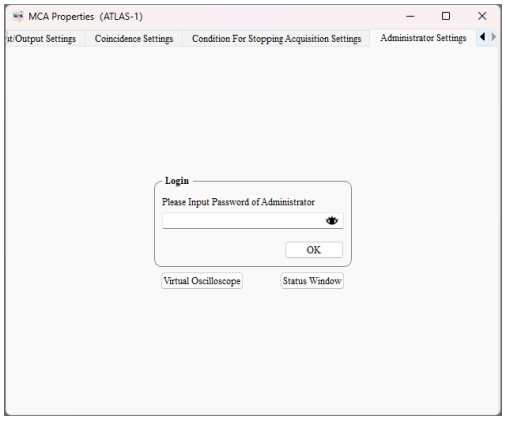


Fig.36: Administrator Para Settings Page

4.2.1.7.1 Virtual Oscilloscope

Clicking the 'Virtual Oscilloscope' button will display the interface as shown in Fig.37, where the waveform display area will show waves refreshing in real-time. The sidebar on the right allows for the setting of the signal type of channels, baseline offset, sampling frequency, sampling depth, trigger signal source, and trigger threshold.

You can check or uncheck the single trigger option. If single trigger is checked, the waveform display area will only refresh when the single trigger is clicked, and if it is unchecked, the waveform will refresh in real-time.

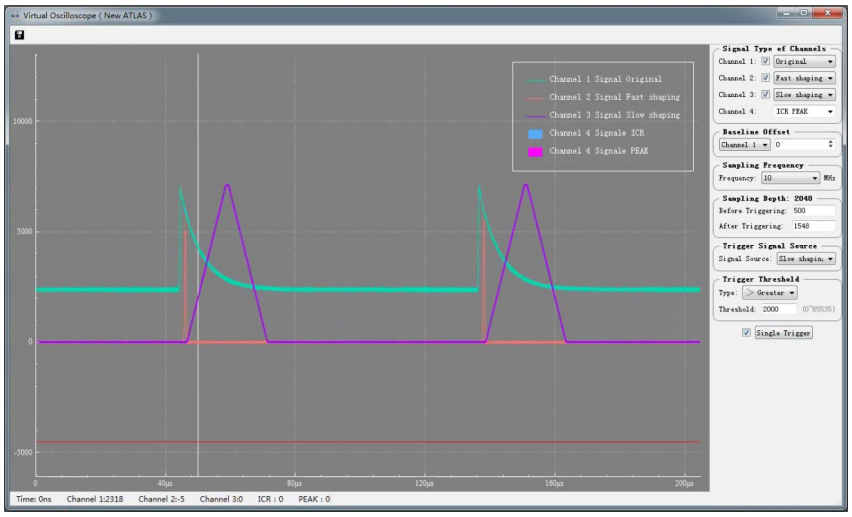


Fig.37: Virtual Oscilloscope Interface

The horizontal axis of the waveform display area represents time information, and the vertical axis represents amplitude information. Clicking the left mouse button in the waveform display area will display a red crosshair, which can be used as a reference point. The mouse wheel controls the zoom in and out of the vertical axis, and Ctrl + mouse wheel controls the zoom in and out of the horizontal axis. Clicking the × in the upper right corner of the page

will close the virtual oscilloscope.

4.2.1.7.2 Status Window

Clicking the Status Window will display the interface as shown in Fig.38. It monitors the low-voltage power supply (±12V, ±24V) status in real-time.

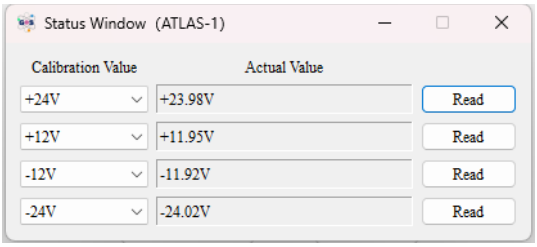


Fig.38: Status Window (ATLAS Digital MCA)

4.2.2 Peak Shape

As shown in Fig.39, it is used to set the X value for 1/X height width, with a default of 10. After modifying the value, press 'Enter' to complete the setting, or click the 'OK' button to finish. This value is used to calculate the peak shape, which is the ratio of 1/X height width to full width at half maximum.

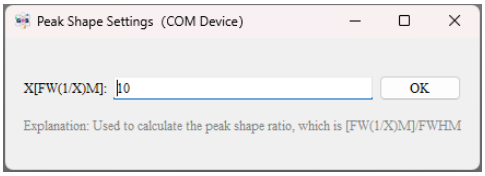


Fig.39: Properties of Peak Shape Interface

4.2.3 Start Acquisition

Issue a start acquisition command to the device to start collecting the spectrum.

4.2.4 Stop Acquisition

Issue a stop acquisition command to the device to stop collecting the spectrum.

4.2.5 Clear

Send a clear command to the device to clear the spectrum.

Note: When clearing the spectrum, the spectrum will automatically be saved to 'My Documents (the specific path depends on the computer used)\GammaSense\temp' to prevent accidental clearing operations.

4.3 Calibration

The calibration menu is shown in Fig.40 below:

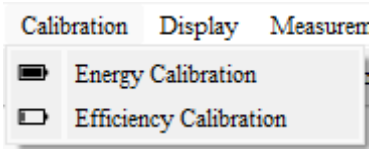


Fig.40: Calibration Menu

4.3.1 Energy Calibration

Energy calibration involves correlating the channel address with energy levels based on a specific formula to obtain accurate characteristic peak energy information. Correct energy calibration is necessary when first using a MCA to collect energy spectra and when analyzing spectrum data.

Click the ‘Calibration → Energy Calibration’ option in the menu bar to enter the energy calibration interface, as shown in Fig.41. For energy spectra that have not been energy-calibrated, the default channel address value is equal to the energy value. Linear energy calibration and polynomial energy calibration are supported. The calibration coefficients can be saved or loaded, corresponding to the ‘Save’ button and the ‘Load’ button, respectively.

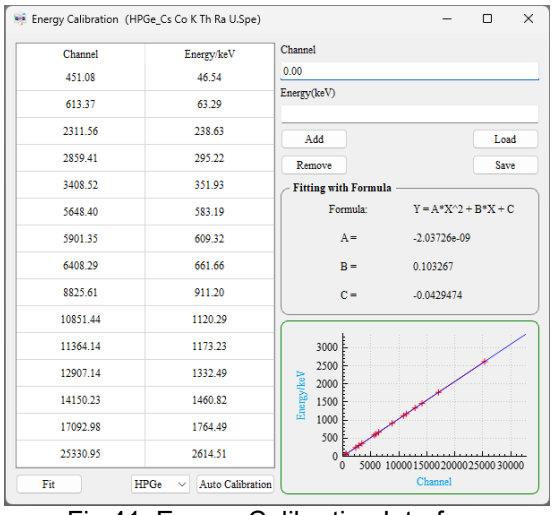


Fig.41: Energy Calibration Interface

If you do not want to use certain rows of data in the list, after selecting the rows to be deleted (you can hold down the Ctrl key and click with the left mouse button to select multiple rows. You can use the left mouse button + Shift key to select multiple rows continuously. You can press the left mouse button on a row and drag the mouse up or down to select multiple rows continuously), click the ‘Delete’ button. To fit the remaining data in the list, click the ‘Fit’ button again.

Click the ‘Load’ button to load the energy calibration coefficient file and use the coefficient. Click the ‘Save’ button to save the current energy calibration coefficients to a file.

In addition to reading the coefficient file for energy calibration, it can also be performed manually or automatically.

4.3.1.1 Manual Energy Calibration

The main steps for manual energy calibration are: enter the channel and corresponding energy, click the ‘Add’ button to add the channel and energy to the list on the left. After adding the required ‘channel-energy’ pairs one by one, click the ‘Fit’ button to complete the energy calibration.

Note:

- The channel bar allows for manual entry or automatic filling.
- When the left mouse button clicks anywhere on the spectrum, a vertical marker line will appear at that position, and the channel value at that position will automatically fill into the bar.
- If the ‘Count Info’ or ‘Peak Fit’ mode is enabled on the spectrum by right-clicking the mouse, and then the left mouse button is used to click on the energy peak within the selected region of interest (ROI), the central channel value of that peak (if Count Info mode is enabled, the central channel address is the channel value at the maximum counts within the ROI. If Peak Fit mode is enabled, the central channel address is the channel value at the maximum point of the fitted peak within the ROI) will automatically fill into the channel bar.

4.3.1.2 Automatic Energy Calibration

The automatic energy calibration function can save the determination of ‘channel-energy’ pairs, input of channel addresses and energies, as well as the steps of adding and fitting, as these steps are completed entirely by the program automatically.

Note:

- Before using automatic energy calibration, you need to mark the main peaks in the spectrum with ROI (there are various ways to mark ROI, see 9.4.1 Mark the Region of Interest (ROI)).
- At least two ROI must be selected in the spectrum to apply the automatic calibration. Otherwise, a prompt saying ‘Please mark at least two ROI’ will appear, as shown in Fig.42.

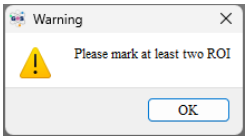


Fig.42: If fewer than 2 ROIs are marked during automatic calibration, a prompt will pop up.

- It is recommended that at least 3 ROI be marked in the spectrum. If only 2 ROI are marked, automatic calibration can still be performed, but the program may incorrectly determine ‘channel-energy’ pairs.
- Before automatic calibration, you can choose 'Auto' or select a specific detector type's spectrum from the dropdown, as shown in Fig.43. It is recommended to choose a specific detector type because the software is not intelligent enough to identify the type of detector spectrum.

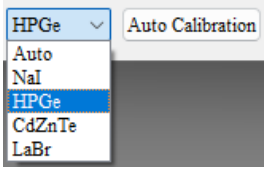


Fig.43: Select the detector type dropdown box.

- For HPGe spectra, automatic energy calibration is applicable to spectra generated from measuring single and multi-energy calibration radioactive sources recommended in part or all of Appendix A of GB/T 16145-2022, as well as natural environmental backgrounds. The specific radioisotopes included are: Pb-210, Am-241, Cd-109, Co-57, Ce-141, Cr-51, Cs-137, Mn-54, Na-22, Y-88, Co-60, Eu-152, K-40, and the major nuclides in the Th-232 decay chain and the major nuclides in the Ra-226 decay chain.
- For non-HPGe spectra, automatic energy calibration is applicable to energy spectra generated from measuring some or all of Am-241, Cs-137, Co-60, Eu-152, K-40, and the major nuclides in the natural environmental background.

4.3.2 Efficiency Calibration

The detection efficiency at a specific characteristic energy is determined using the standard source test method or the passive efficiency calibration method. By inputting the detection efficiency and the corresponding characteristic energy into the efficiency calibration interface and fitting, the detector's efficiency calibration curve can be obtained, which can then be used to calculate the radioactivity of the measured sample.

Click on ‘Calibration → Efficiency Calibration’ in the menu bar to enter the

efficiency calibration interface, as shown in Fig.44. The default efficiency for spectrum that have not been efficiency-calibrated is 1. Calibration files can be stored or loaded, corresponding to the ‘Load’ button and the ‘Save’ button, respectively.

Note: This feature is an upgraded version and requires the use of an SuperDog key.

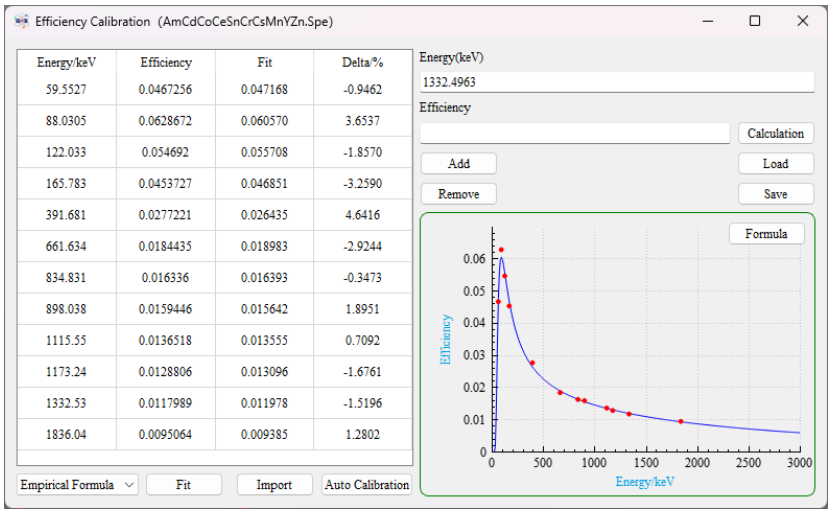


Fig.44: Efficiency Calibration Interface

If you do not want to use certain rows of data in the list, after selecting the rows to be deleted (you can hold down the Ctrl key and click with the left mouse button to select multiple rows. You can use the left mouse button + Shift key to select multiple rows continuously. You can press the left mouse button on a row and drag the mouse up or down to select multiple rows continuously), click the ‘Delete’ button. To fit the remaining data in the list, click the ‘Fit’ button again.

The efficiency can be fitted according to the "Empirical formula" and "Quadratic polynomial formula". Click the "formula" button to display the efficiency calibration fitting formula, as shown in Fig.45 below. At the same time, the efficiency fitting values and deviations at each energy point will be given. The deviation calculation formula is:$\frac{Efficiency\ value - Fit\ value}{Efficiency\ value} \times 100\%$.

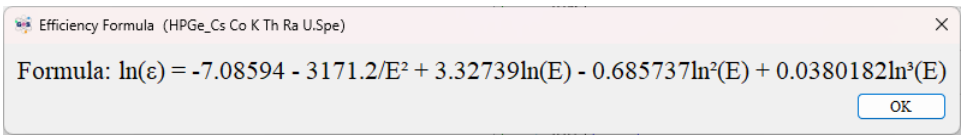


Fig.45 Efficiency calibration fitting formula (Empirical formula)

Click the ‘Load’ button to load the efficiency calibration coefficient file and use the coefficient. Click the ‘Save’ button to save the current efficiency calibration coefficients to a file.

In addition to performing efficiency calibration by reading the efficiency

calibration file, it can also be done manually or automatically.

4.3.2.1 Manual Efficiency Calibration

There are two methods for manual efficiency calibration:

Method One: Enter the energy and efficiency, click the ‘Add’ button to add the energy and efficiency to the list on the left. After adding the required ‘energy-efficiency’ pairs one by one, select the fitting formula (empirical formula or quadratic formula), click the fitting button to complete the efficiency calibration.

The efficiency values for each peak can be calculated using the efficiency calculation feature. Click the ‘Calculation’ button to enter the interface shown in Fig.46, confirm the acquisition information and nuclide, then fill in the calibration date, time, and activity of calibration source. Click ‘Efficiency Calculation’ to obtain the efficiency values. Click the ‘OK' button to add the calculated efficiency values to the efficiency column.

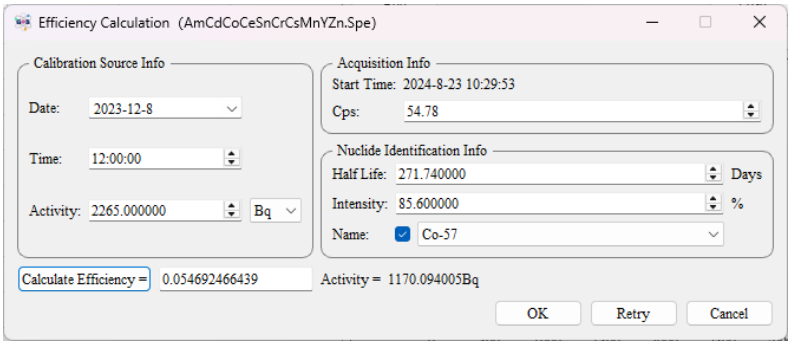


Fig.46: Efficiency Calculation Interface

Note:

- The energy bar can manually input, or automatically fill in.
- When you click on any part of the spectrum with the left mouse button, a vertical marker line will appear at that position, and the energy at that position will automatically fill into the bar.
- If the ‘Count Info’ or ‘Peak Fit’ mode is enabled on the spectrum by right-clicking the mouse, and then the left mouse button is used to click on the energy peak within the selected region of interest (ROI), the central channel value of that peak (if Count Info mode is enabled, the central channel address is the channel value at the maximum counts within the ROI. If Peak Fit mode is enabled, the central channel address is the channel value at the maximum point of the fitted peak within the ROI) will automatically fill into the energy bar.

Method Two: Click the ‘Import’ button, as shown in Fig.44, to add an

edited .csv file (containing two columns of data, the first column for energy values and the second for efficiency values, as shown in Fig.47), after adding, select the fitting formula (empirical formula or quadratic formula), and click the 'Fit' button to complete the efficiency Calibration.

	A	B
1	59.5527	0.0467256
2	88.0305	0.0628672
3	122.033	0.054692
4	165.783	0.0453727
5	391.681	0.0277221
6	661.634	0.0184435
7	834.831	0.016336
8	898.038	0.0159446
9	1115.55	0.0136518
10	1173.24	0.0128806
11	1332.53	0.0117989
12	1836.04	0.0095064

Fig.47: Efficiency Calibration - Example of Data Imported from CSV File

4.3.2.2 Automatic Efficiency Calibration

Click the 'Automatic Calibration' in Fig.44, and the interface shown in Fig.48 will pop up. This interface is used for inputting or importing calibration source information.

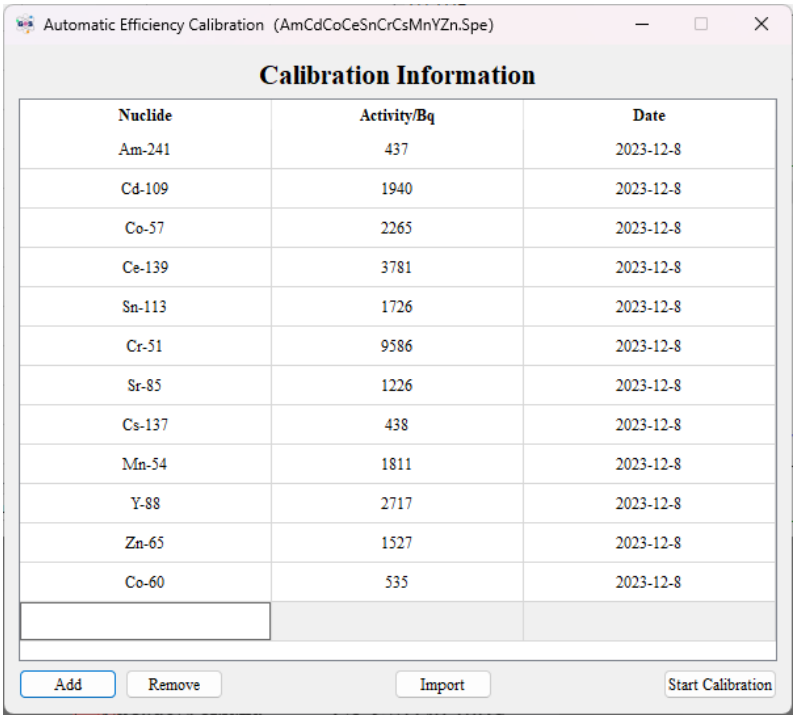


Fig.48: Automatic Efficiency Calibration - Calibration Information Interface

Click the 'Add' button to insert a blank line, and double-click on a column in the blank line to enter relevant information (such as nuclide, calibration activity, and calibration date).

Click the 'Remove' button to delete the selected row.

Click the 'Import' button to add a pre-edited .csv file (which contains three

columns of data: the first column for isotope names, the second for calibration activities, and the third for calibration dates as shown in Fig.49 below), and import the data from the csv file into the calibration information list.

	A	B	C
1	Am-241	437	2023/12/8
2	Cd-109	1940	2023/12/8
3	Co-57	2265	2023/12/8
4	Ce-139	3781	2023/12/8
5	Sn-113	1726	2023/12/8
6	Cr-51	9586	2023/12/8
7	Sr-85	1226	2023/12/8
8	Cs-137	438	2023/12/8
9	Mn-54	1811	2023/12/8
10	Y-88	2717	2023/12/8
11	Zn-65	1527	2023/12/8
12	Co-60	535	2023/12/8

Fig.49: Calibration Information Interface Import CSV File Data Example

Click ‘Start Calibration’, the program automatically calculates the ROI efficiency value for each identified nuclide based on the calibration source activity information and enters it, automatically fitting the efficiency calibration with empirical formula, as shown in Fig.50 below.

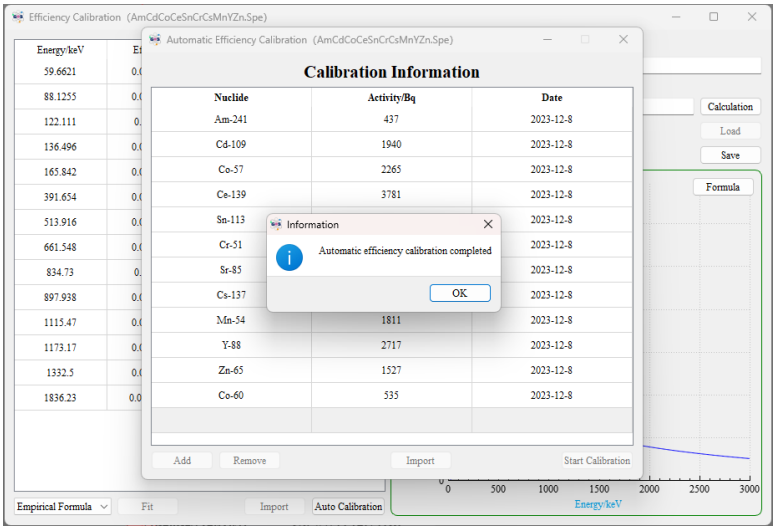


Fig.50: Automatic efficiency calibration completion

Note:

- When using the automatic efficiency calibration function, it is necessary to edit the applicable nuclide library and apply it.
- The column name for ‘Nuclide’ in the calibration information interface should be consistent with the names of nuclide in the applied library.
- The application's nuclide library must include all nuclides entered/imported in the calibration information interface.

When the ‘Nuclide’ column name in the calibration information interface should be consistent with the nuclide name in the applied nuclide library, or if the applied nuclide library does not fully contain all the nuclides

entered/imported in the calibration information interface, clicking the ‘Start Calibration’ button will pop up a prompt as shown in Fig.51 below. It is necessary to correctly modify the nuclide library or calibration information. Otherwise, the automatic efficiency calibration cannot be carried out.

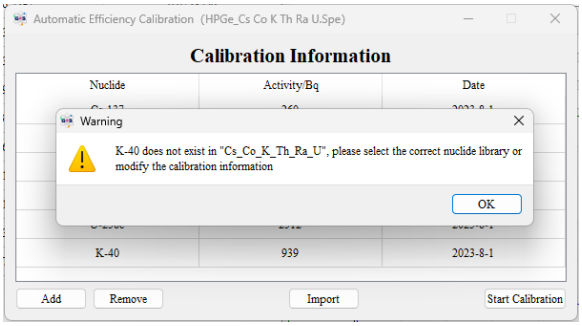


Fig.51: Clicking the ‘Start Ranging’ button may trigger a pop-up prompt.

4.4 Display

The menu is displayed as shown in Fig.52 below:

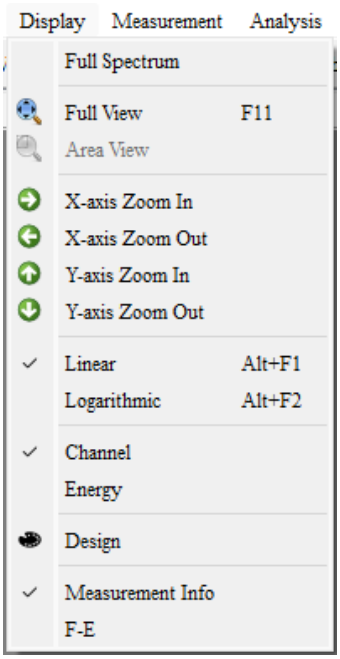
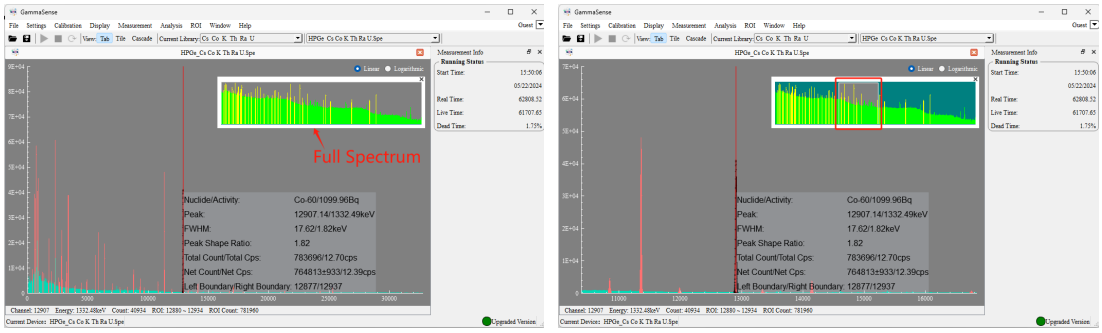


Fig.52: Display menu

4.4.1 Full Spectrum

Used to control whether to display a thumbnail of the spectrum at the upper right position of the spectrum window, as shown in Fig.53 below, the default is not to display.



a b

Fig.53: Full Spectrum Window

Hold the left mouse button on the upper edge of the full spectrum window to drag.

Hold the left mouse button on the edge of the full spectrum to zoom in or out on the full spectrum window.

Click the left mouse button on any position in the full spectrum window, and the marker line in the spectrum window will appear at the corresponding position in the spectrum.

When zoom in the spectrum, the spectrum area displayed in the spectrum window will also be highlighted with a light-colored frame in the full spectrum graph, selecting the corresponding spectrum area, as shown in Fig.53b.

Clicking the ☒ button in the top right corner can close the window.

4.4.2 Full View / Area View

Full View: The current spectrum window scales the spectrum to the minimum display, with the shortcut key F11.

Area View: When you select an area with the left mouse button (by pressing + dragging + releasing the left mouse button), choosing this option will enlarge the spectrum window to display the spectrum of the selected area.

4.4.3 X/Y-axis Zoom In/Out

X-axis Zoom In: Centered on the vertical marker line in the current spectrum window, the X-axis display range is enlarged (equivalent to the keyboard '→' key).

X-axis Zoom Out: Centered on the vertical marker line in the current spectrum window, the X-axis display range is narrowed (equivalent to the keyboard '←' key).

Y-axis Zoom In: The current spectrum window displays an enlarged range

on the Y-axis of the spectrum (equivalent to the keyboard ‘ ↑ ’ key).

Y-axis Zoom Out: The current spectrum window narrows the display range of the Y-axis of the spectrum (equivalent to the keyboard ‘ ↓ ’ key).

In addition to the aforementioned methods for spectrum scaling, the spectrum can also be scaled by scrolling the mouse wheel. When scrolling the wheel, the spectrum X-axis will be scaled with the cursor at the center, while the Y-axis will be automatically scaled proportionally to the height of the spectrum window. By holding down the Ctrl key and scrolling the mouse wheel, the spectrum can be scaled individually in the Y-axis direction.

4.4.4 Linear/Logarithmic

Linear: The current spectrum displays the Y-axis in linear scale, with the shortcut key being Alt+F2.

Logarithmic: The current spectrum displays the Y-axis in logarithmic scale, with the shortcut key being Alt+F2.

4.4.5 Channel / Energy

Channel: The abscissa of the spectrum diagram is displayed as the channel value.

Energy: The abscissa of the spectrum diagram is displayed as the energy value, provided that the energy is calibrated correctly.

4.4.6 Design

Click on the ‘Display-Design’ option in the menu bar to open the design interface (i.e., Properties of Plot Area interface) as shown in Fig.54 below.

The interface allows for the setting of chart types, point size for scatter and line charts, background color, background color of full-spectrum, marker line color, ROI color, fitting line color, full spectrum ROI color, spectrum color, full spectrum color, and comparison spectrum colors 1/2/3, as well as font and color.

The meaning of chart types is shown in Fig.55 below. When the scatter or line chart type is set, the point size can be set, with a range of 2 to 20.

The meanings represented by each color and font are shown in Fig.56.

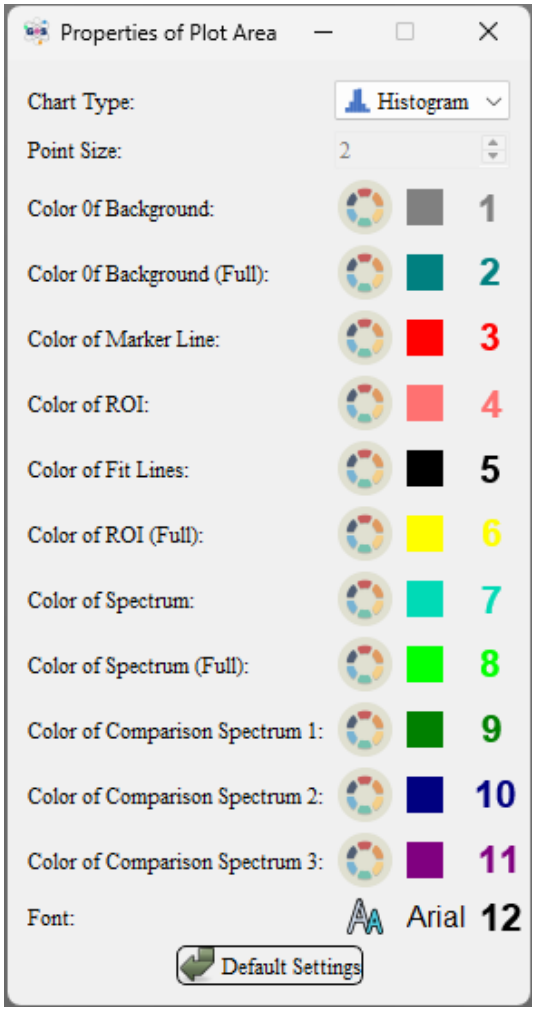
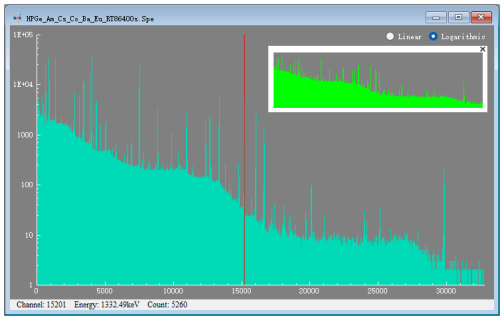
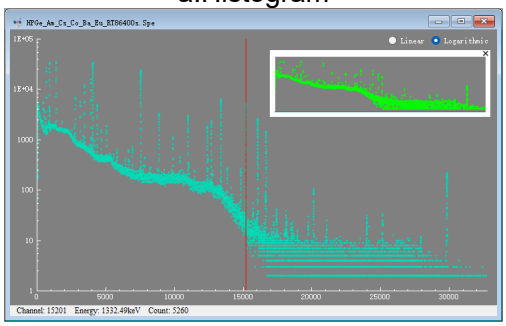


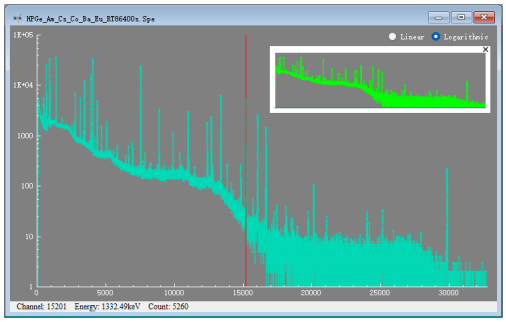
Fig.54: Properties of Plot Area Interface



a.Histogram



b.Scatter



c.Line

Fig.55: Chart Type

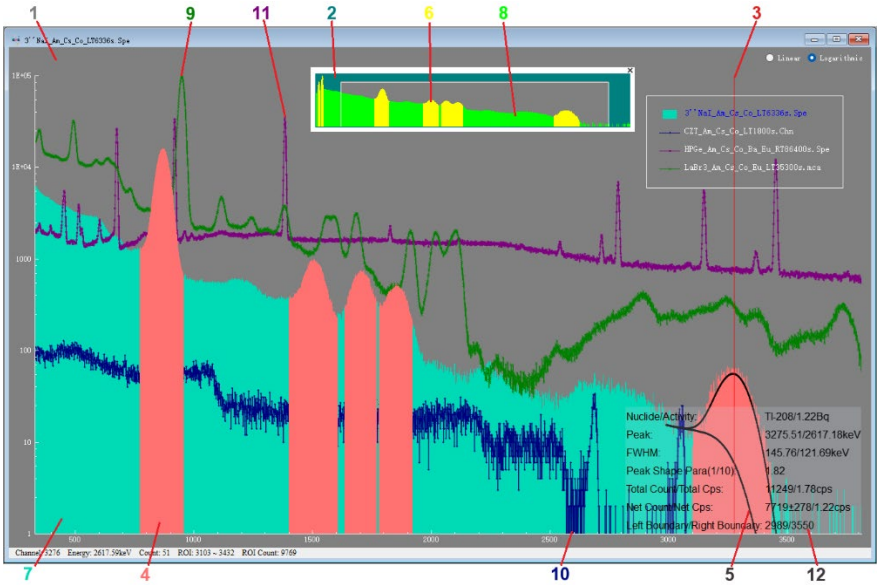
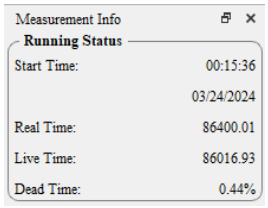


Fig.56: Meanings of various colors and fonts

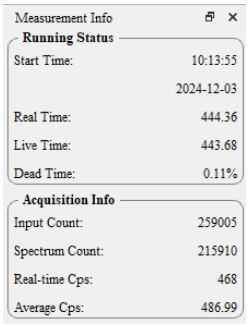
4.4.7 Measurement Info

This option is used to turn on/off the measurement information bar on the

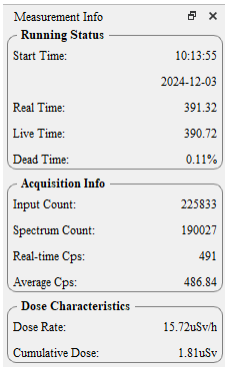
right side of the spectrum window, as shown in Fig.57. The measurement information bar of the opened spectrum file is different from that during the device's spectrum acquisition process, as the latter includes acquisition information, specifically including input count, spectrum count, real-time count rate, and average count rate. When dose measurement is enabled during the device's spectrum acquisition process (for details, see Section 4.5.3), dose characteristics will also be displayed, specifically including dose rate and cumulative dose.



a. Measurement information of the opened spectrum file from hard drive



b. Measurement information in the spectrum collected by the MCA.

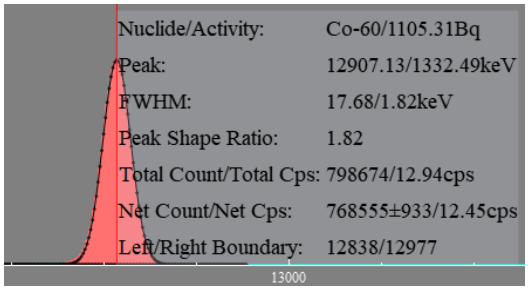


c. Measurement information in the spectrum collected by the MCA, when dose measurement is enabled.

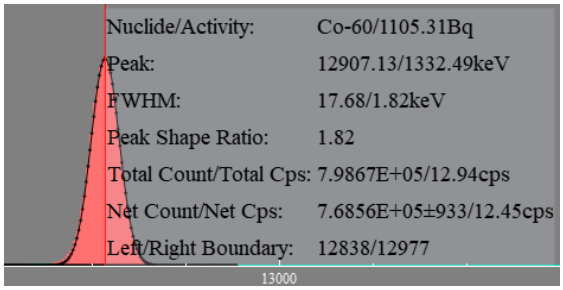
Fig.57: Measurement Information Bar

4.4.8 F-E(scientific notation)

Display the information in the measurement information columns in scientific notation, as shown in Figure 58.



(a) Default



(b) F-E(scientific notation)

Fig.58 Default and scientific notation display

4.5 Measure

The Measurement Menu is shown in Fig.59 as follows:

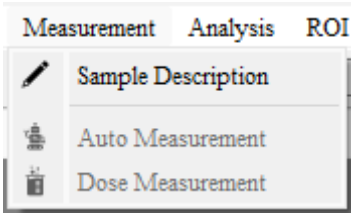


Fig.59: Measurement Menu

4.5.1 Sample Description

Clicking on this option opens the window shown in Fig.60 below. The content in the '( )' at the top of the window is the device name or the name of the opened spectrum file.

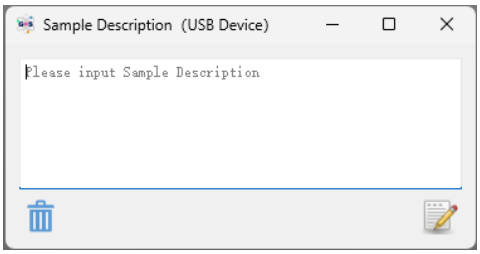


Fig.60: Sample Description Window

This window allows for the display or input of descriptions and notes for the spectrum currently shown in the window (including the spectrum collected by the device and the opened spectrum files).

Click '🗑' to clear the description, click '📝' to save the description. Descriptions can be saved along with the spectrum files.

4.5.2 Auto Measurement

This option interface includes continuous scheduled save and single scheduled save.

4.5.2.1 Continuous scheduled save

Continuous scheduled save interface is shown in Fig.61 below:

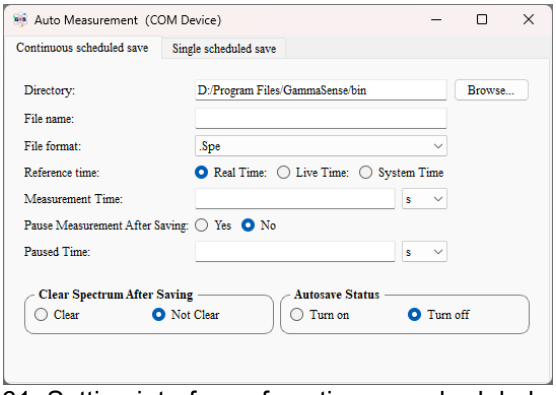


Fig.61: Setting interface of continuous scheduled save

The interface requires selecting a save directory, entering a file name, choosing a file format and reference time, entering the measurement time,

selecting whether to pause for a while after each save, if yes, entering the paused time, choosing whether to clear the spectrum after each save. After setting the parameters, click the ‘Turn on’ under the Autosave status bar to start continuous scheduled measurement saving.

Note:

① File names cannot contain any of the characters ‘\ / : * ? ‘ < > |’ and must not be empty.

② The names of the automatically saved spectrum files will be based on the entered file name, with a numerical suffix automatically added thereafter, such as ‘_1’, ‘_2’, ‘_3’....

③ If ‘Real/Live time’ is selected, the filled time must be greater than the current Real/Live time of MCA.

④ If "System time" is selected, the automatic measurement will be carried out according to the system time of the PC, and it will not be affected by the current real/live time of MCA.

⑤ If the option to save and pause measurement is selected, the pause time must be filled in and must be greater than 0 seconds.

4.5.2.2 Single scheduled save

The single scheduled save interface is shown in Fig.62 below:

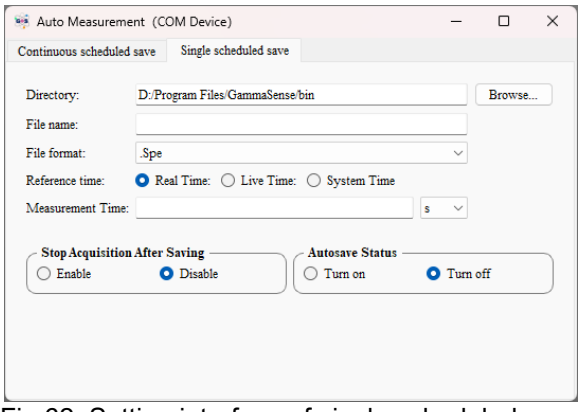


Fig.62: Setting interface of single scheduled save

The interface requires selecting a save directory, entering a save file name, choosing a save file format and reference time, filling in the measurement time, selecting whether to stop acquisition after saving, and after parameter settings are completed, clicking the ‘Turn on’ under the auto-save status bar will start single scheduled measurement saving.

Note:

① File names cannot contain any of the characters '\ / : * ? ' < > |' and must not be empty.

② The names of the automatically saved spectrum files will be based on the entered file name, with a numerical suffix automatically added thereafter, such as '_1', '_2', '_3'....

③ If 'Real/Live time' is selected, the filled time must be greater than the current Real/Live time of MCA.

④ If "System time" is selected, the automatic measurement will be carried out according to the system time of the PC, and it will not be affected by the current real/live time of MCA.

4.5.3 Dose Measurement

The option interface is shown in Fig.63 below. This interface can display the dose rate information measured by the device and can also be used to calibrate the GE function value of the device under a standard dose field.

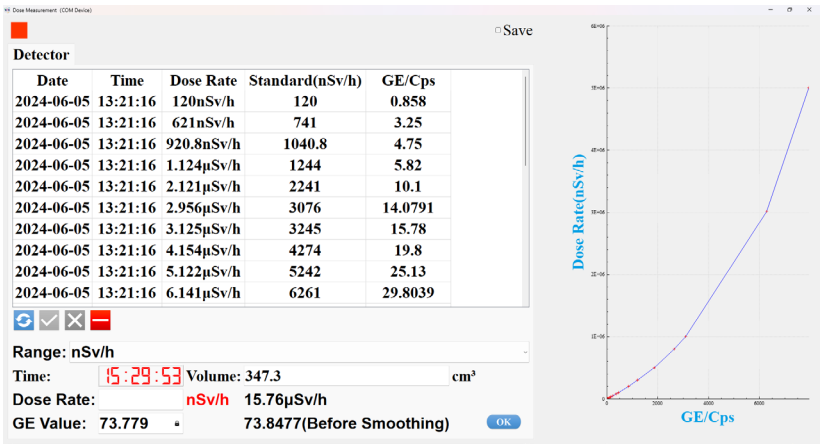


Fig.63: Dose Measurement Interface

① Click the top left ▶/■ to start/stop dose rate measurement. When starting dose rate measurement, the measurement information bar displays the dose rate and accumulated dose (as shown in Fig.57c). When stopping dose rate measurement, the measurement information bar hides dose characteristic information.

② Enter the dose rate and GE value, click the OK button to add information to the dose rate list, and refit the 'dose rate-GE value' curve on the right. Since the device will continuously refresh the value in the GE value input box when collecting spectrum, you can stop the collection first, input or modify the value in the input box, and then

press the OK button.

③ Each time the device collects a spectrum, it will automatically update the GE value and dose rate in real time.

④ Click to return to the state when the dose rate list was last saved. Click the button to confirm changes and save the dose rate list. Click the button to cancel changes and return to the state when the dose rate list was last saved. Click the button to delete the selected row in the dose rate list.

⑤ The calculation of dose rate can be corrected by modifying the volume value of the detector connected to the MCA, with the default volume value being 347.3cm³.

Note: Dose rate measurement is only available when the device is in spectrum mode. In other modes (such as List mode), the software automatically disables dose rate measurement, and the measurement information bar hides dose characteristic information. The button in the upper left corner changes from ▶/■to⏻, and clicking this button at this time will not enable dose rate measurement.

4.6 Analysis

The analysis menu is shown in Fig.64 below:

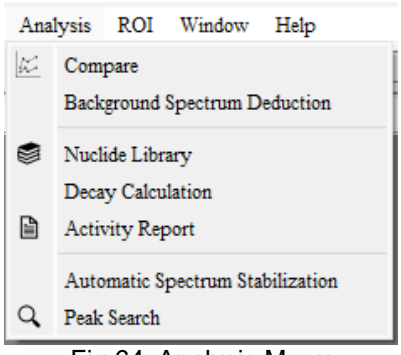


Fig.64: Analysis Menu

4.6.1 Compare

Add a comparison spectrum to the current spectrum and display them together. As shown in Fig.65. When adding a comparison spectrum, the file names of the main spectrum and the added comparison spectrum will be displayed in the upper right corner of the spectrum window, with the main spectrum file name displayed on the first line. '■' is the main display icon (a rectangular block shape, which can also be the color of the added comparison

spectrum), ‘  ’, ‘  ’, and ‘  ’ are comparison display icons. You can click on ‘  ’, ‘  ’, or ‘  ’ to switch that comparison spectrum to the main display spectrum, its icon will become a rectangular block, and the icon color remains unchanged. ROI operations and peak information viewing (right-click with the mouse - Count Info or Peak Fit) can be performed on the main display spectrum.

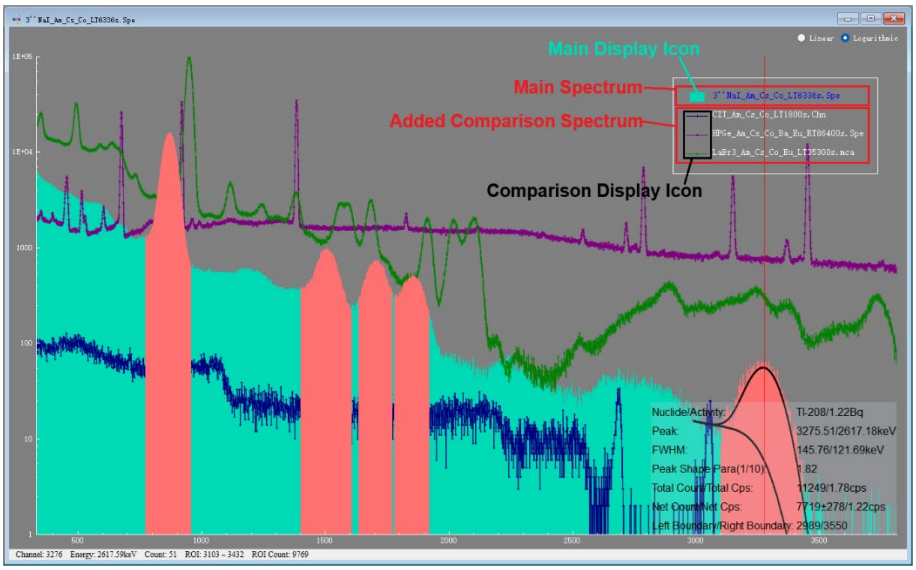
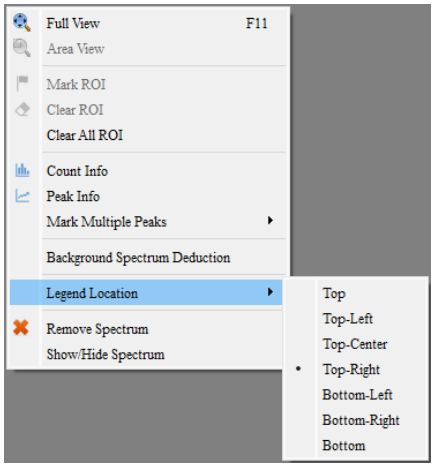


Fig.65: Spectra comparison

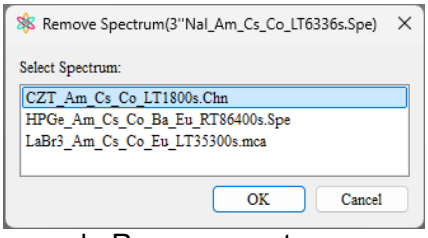
Note:

- The channels of the comparison spectrum must not be less than the channels of the current spectrum.
- The energy calibration coefficient and the efficiency calibration coefficient both use the coefficient of the primary spectrum.
- Add up to 3 spectra. If 3 spectra have already been added, a window will pop up asking whether to replace one of them.

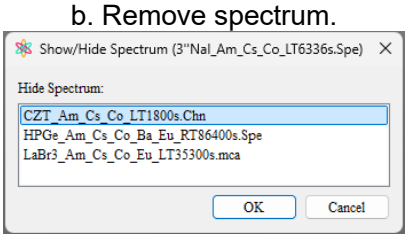
After adding the comparison spectrum, the mouse right-click menu will include additional options for ‘Legend Location’, ‘Remove Spectrum’ and ‘Show/Hide Spectrum’ as shown in Fig.66.



a. Legend Position



b. Remove spectrum.



c. Show/Hide Spectrum

Fig.66: Right-click context menu: Additional Options

Legend Location: Used to adjust the display position of the file names for the main spectrum and the added comparative spectra, with the default position being the upper right part of the spectrum window.

Remove Spectrum: Used for removing comparison spectra.

Show/Hide Spectrum: Used for hiding/showing comparative spectra.

4.6.2 Background Spectrum Deduction

Clicking this option will open a window for selecting a spectrum to be used as the background spectrum. Once selected and opened, it will add the background spectrum to the current spectrum (either the spectrum opened from the hard drive or the one being measured), and the software will display a subtracted spectrum, where the counts for each channel as follows:

$$N_c - \frac{N_b}{T_b} \times T_c$$

Where, N_c are channel counts of current spectrum. N_b are corresponding channel counts of background spectrum. T_b is live time of background spectrum. T_c is live time of current spectrum.

This function is for plotting display only and is not used for subsequent analysis and calculation.

Note: The number of channels in the background spectrum must not be less than the number of channels in the current spectrum.

4.6.3 Nuclide library

The nuclide library consists of three types of libraries: 1. Isotope Library, which is a built-in library, includes all x/γ energy information emitted by all known

radioactive isotopes, and cannot be edited or deleted. 2. Basic Library, Natural Library, Industrial Library, Medical Library, and User Library, which are built-in libraries, allow editing, deletion, export, and import of isotopes in the library. 3. Newly created libraries, which allow editing, deletion, export, and import of both the library and the isotopes within it.

Clicking on the ‘Analysis- Nuclide Library’ option in the menu bar will open the nuclide library interface. The first time you open the isotope library interface, it will look like Fig.67 shown below:

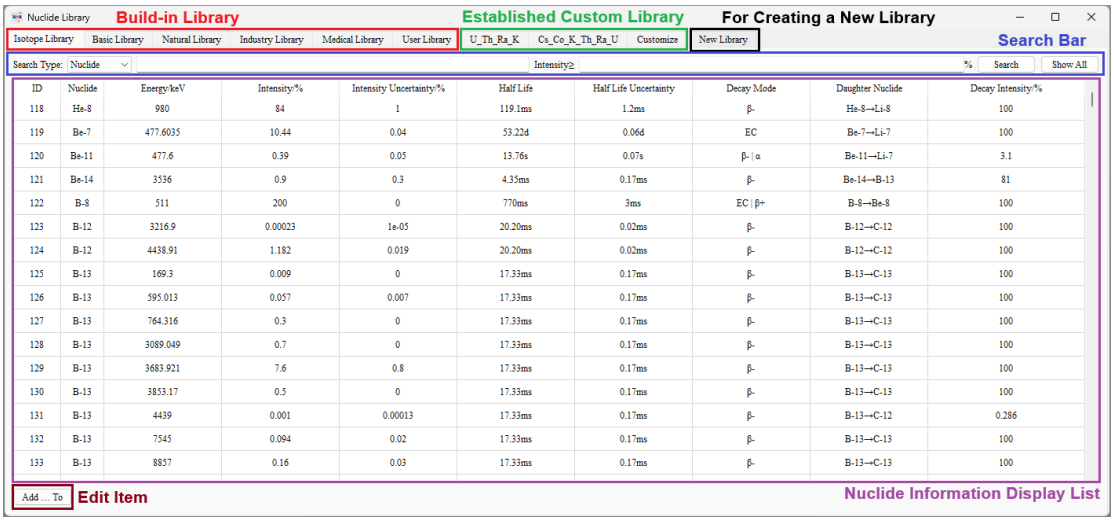


Fig.67: First-time opening of the nuclide library interface (Isotope Library interfaces)

The nuclide library interface mainly includes:

Nuclide library selection option: for selecting the display of nuclide libraries, and also for creating new libraries, mainly including built-in nuclide libraries and established custom libraries.

Search bar: to search for nuclide information based on nuclide, energy, branching ratio, and half-life.

Nuclide information display list: for displaying nuclide information, including nuclide, energy, intensity and its uncertainty, half-life and its uncertainty, decay type, decay nuclide, decay intensity.

Editing option: for editing libraries and nuclide information. different nuclide libraries will have different editing options.

Add nuclide: for manually adding nuclides. Note: all isotope library interfaces are not visible.

4.6.3.1 Isotope Library

The interface is shown in Fig.67.

Isotope Library: As the built-in nuclide library, this library cannot be deleted, the library name cannot be edited, and the nuclide information cannot be edited. It contains all the x/γ energy information emitted by all known radioactive isotopes (over 3000 types) in the IAEA nuclear database.

Search Bar: The default search type is ‘Nuclide’. By clicking the downward triangle next to ‘Nuclide’, it can be switched to the ‘Energy/keV’ type, as shown in Fig.68. When switched to energy, the search bar will add energy search window and half-life search condition, as shown in Fig.69.

Search can be conducted individually for nuclide. Combined search can be performed for nuclide and intensity. Individual search can be conducted for energy ± search window. Combined search can be performed for energy ± window, intensity, and half-life.

Click the ‘Search’ button to retrieve the set search conditions and display them in the nuclide information display list. Click the ‘Display All’ button to ignore search conditions, and the isotope information list displays all isotope information in the database.

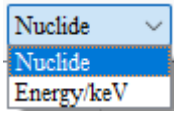


Fig.68: Search Type Selection

Fig.69: Search bar for energy type

Nuclide Information Display List: Including nuclide, energy, intensity and its uncertainty, half-life and its uncertainty, decay type, decay nuclide, and decay intensity information. When double-clicking on a line of nuclide information with the left mouse button, the vertical marker line in the spectrum window will position to the corresponding energy in the spectrum based on the energy value of the nuclide (provided that the nuclide energy value is within the energy range of the spectrum). When double-clicking on a cell of a nuclide in other nuclide library interfaces, the marker line will position to the corresponding energy in the spectrum, and the cell will enter the edit state for modification. Therefore, when using double-click to position the marker line to the corresponding energy location, it is recommended to double-click on the ID column.

Add to: Is editing items, more editing items will appear when switching to other nuclide libraries. This button is used to add selected nuclides to other libraries, with specific operations as follows: select a row or multiple rows of

nuclide information (hold the Ctrl key, left-click with the mouse to select multiple rows. Select multiple rows continuously with the mouse left-click + Shift key. Press the mouse left-click on a row and drag the mouse up/down to select multiple rows continuously), click this button, a window as shown in Fig.70 will pop up, select the library and click 'OK' to add the selected nuclide information to other nuclide library.

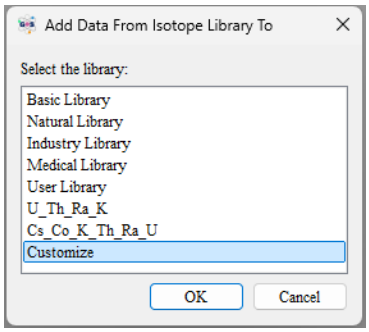


Fig.70: Window for selecting the addition of nuclide information to other libraries.

4.6.3.1 Basic Library, Natural Library, Industrial Library, Medical Library, and User Library

The interfaces of the basic library, natural library, industrial library, medical library and user library differ from the interface of isotope library, mainly by adding some editing items and the option to add nuclide at the bottom of the nuclide information display list, as shown in Fig.71 (using the basic library interface as an example). The basic library, natural library, industrial library, medical library, and user library cannot be deleted or renamed, but the nuclides within them are editable.

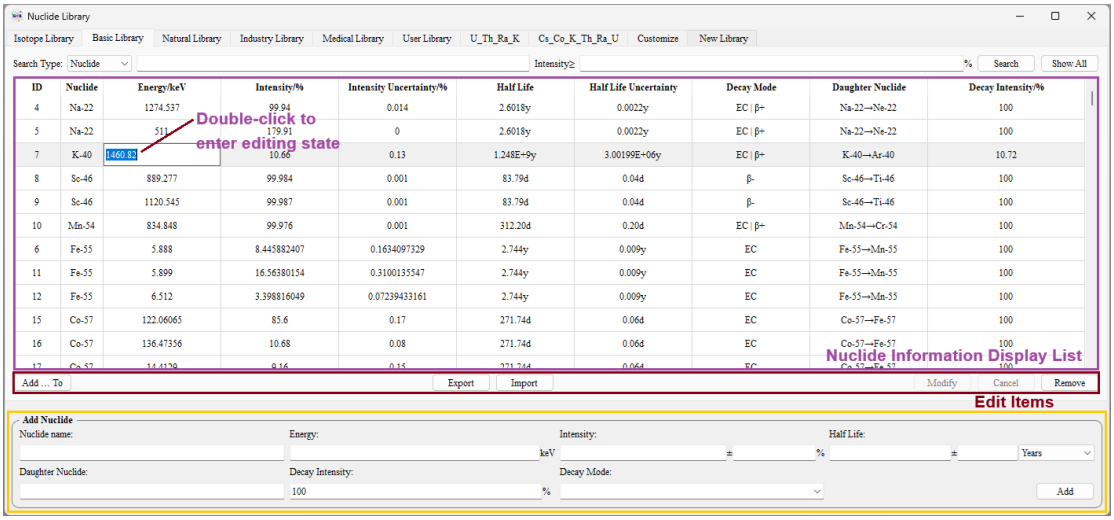


Fig.71: Basic Library, Natural Library, Industrial Library, Medical Library, and User Library interfaces (using the Basic Library interface as an example)

Basic Library: This is the built-in nuclide library, which is the default library

used by the software. It cannot be deleted, and the library name cannot be edited. The nuclide information can be edited. This library is a collection of natural, industrial, and medical libraries.

Natural Library: A built-in nuclide library that cannot be deleted, with non-editable library name and editable nuclide information, containing most of the natural radioactive isotope information found in nature.

Industrial Library: A built-in nuclide library that cannot be deleted, with non-editable library name and editable nuclide information, containing most commonly used artificial radioactive isotope information.

Medical Library: A built-in isotope library that cannot be deleted, with non-editable library name and editable nuclide information. It contains information on most commonly used medical radioactive isotopes.

User Library: A built-in nuclide library, which cannot be deleted, the library name cannot be edited, and the nuclide information can be edited. This library is empty by default.

Nuclide information display list: Its display and functionality are consistent with the list in isotope library interfaces. Double-clicking on a cell (not the ID column) enters the edit state to modify the nuclide information, click ‘Modify’ at the bottom right of the list to confirm the modification, and ‘Cancel’ to cancel the modification. Since double-clicking enters the edit state, it is recommended to double-click on the ID column when using the double-click function to position marker line in the spectrum.

Edit items: In addition to the ‘Add to’ button, add some other edit items, such as ‘Export’, ‘Import’, ‘Modify’, ‘Cancel’, and ‘Remove’ buttons.

Add to: See the previous section for details.

Export: The library nuclide information can be exported as a .lib file for use by GammaSense software on other computers.

Import: Import .lib files to quickly import nuclide information.

Modify: Confirm the modifications to the information in the nuclide list.

Cancel: Undo changes to the information in the nuclide list.

Remove: Used to delete the selected nuclide information in the list (hold the Ctrl key, left-click with the mouse to select multiple lines. Select multiple lines continuously with the left mouse button + Shift key. Press the left mouse button on a line and drag the mouse up/down to select multiple lines

continuously.).

Add Nuclide: Used to add nuclide information not present in the isotope library. Required inputs include nuclide **name**, **energy**, **intensity** and its uncertainty, **half-life** and its uncertainty, decay type, decay isotope, and decay intensity (Note: Bold items are required fields). In the decay isotope column, only the daughter isotope needs to be entered, and 'Parent isotope name →' will be automatically added.

4.6.3.2 Established Custom Libraries

Click on any established custom library, and its interface is shown in Fig.72, taking the U_Th_Ra_K library as an example. The interface is roughly the same as that of the basic library, natural library, industrial library, medical library, and user library, except that two edit buttons—'Remove Library' and 'Rename'—are added in the edit items, and the position of the 'Add to' button is adjusted. You can edit the established custom library and the nuclides in the library.

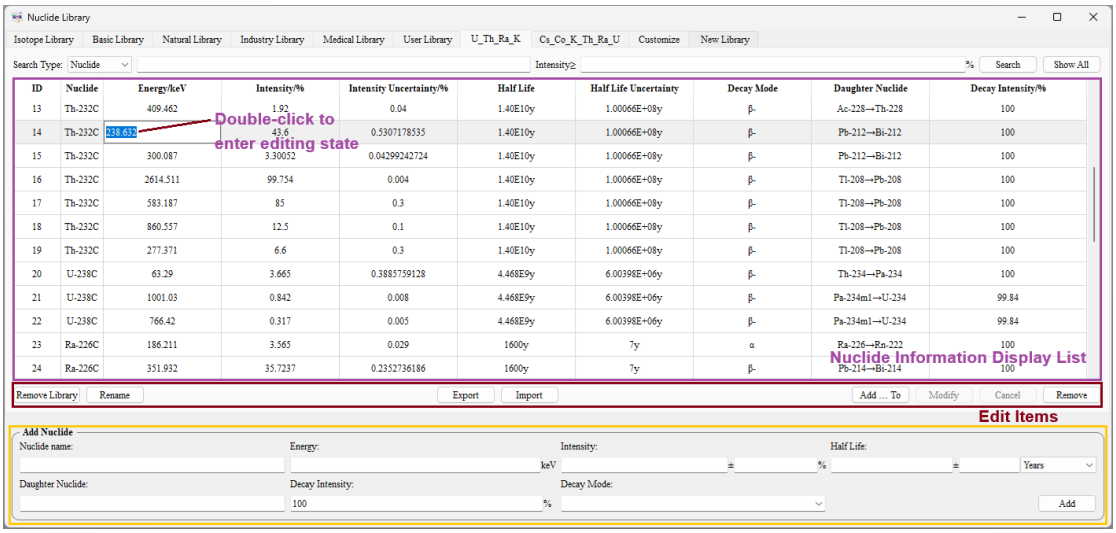


Fig.72: Established Custom Library Interface(Taking the U_Th_Ra_K Library as an Example)

Nuclide Information Display List: The display content and functions are the same as those in the basic library, natural library, industrial library, medical library, and user library, as described in the previous section. Since double-clicking enters the edit state, it is recommended to double-click on the ID column when using the double-click function for positioning marked line in the spectrum.

In the editing options, 'Remove Library' and 'Rename' buttons have been added, and the position of the 'Add To' button has been adjusted.

Remove Library: Remove the currently displayed nuclide library.

Rename: Rename the currently displayed nuclide library.

Export, Import, Add to, Modify, Cancel, Remove operations and their meanings are found in the relevant content of the previous section.

4.6.3.3 New Library

The ‘New Library’ is used to create a custom nuclide library. Clicking on this option will pop up a window as shown in Fig.73, which is used to input the name of the nuclide library. After clicking ‘Confirm’, an empty custom nuclide library will be established.

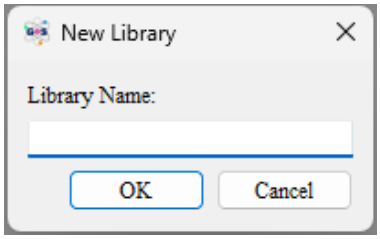
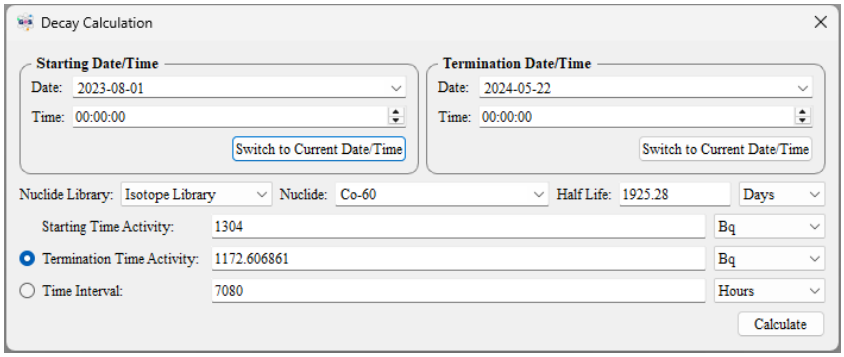


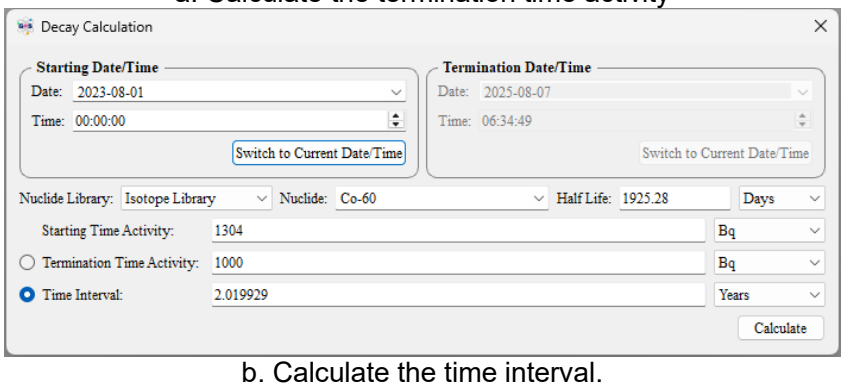
Fig.73: New Library - Enter Library Name Interface

4.6.4 Decay Calculation

Clicking this option will open the dialog box as shown in Fig.74 below.



a. Calculate the termination time activity



b. Calculate the time interval.

Fig.74: Decay Calculation Interface

On the interface, users can calculate the activity at the termination time based on the input start date and time, end date and time, nuclide and half-life, and start time activity. They can also calculate the decay time interval based on the start time activity, end time activity, nuclide, and half-life.

In the nuclide input field, users can manually enter the nuclide name. When manually entering the nuclide name, the software will automatically search and display related nuclides, at which point the input can be selected from the drop-down menu, or the manually entered nuclide name can be used.

In the half-life input field, if the nuclide name entered by the user exists in the nuclide library, the half-life information will be automatically filled in. Otherwise, it needs to be entered manually.

The time unit and activity unit can both be selected and set.

4.6.5 Activity Report

Selecting this option will open the interface as shown in Fig.75. It is used to provide peak information and activity values for marked ROIs, and can be exported to other format files.

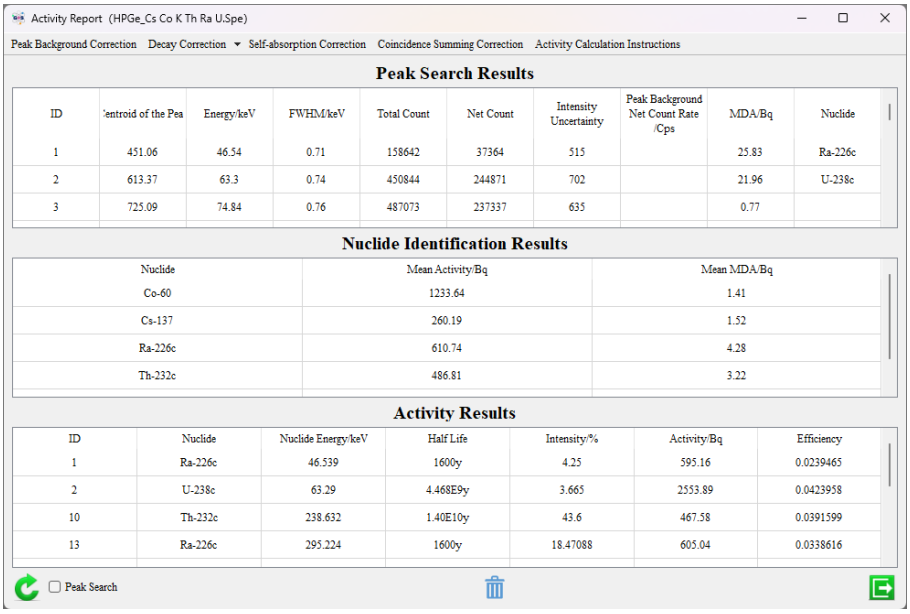


Fig.75: Activity Report Interface

In this interface's menu bar, background subtraction, decay correction, self-absorption correction, and coincidence addition correction can be applied, and the activity calculation instructions can be viewed.

There are three lists in the middle of the interface, which give the peak search results, nuclide identification results, and activity results, respectively.

The bottom operation buttons include the following:

/: Provide peak information and calculate the activity of the marked ROI based on the applied nuclide library.

： Clear the list.

：Export list information to other files, including .txt, .xlsx, .xls, and .pdf formats.

Peak Search: If checked, when clicking ‘ / ’, the software will automatically search for peaks across the entire spectrum and then provide peak information and calculate the activity. For more information on this feature, see ‘4.6.7 Peak Search’.

Note: This feature is an upgraded version and requires the use of an SuperDog key.

4.6.5.1 Background Deduction

Click the "Peak Background Correction" button to open the dialog box shown in Fig.76 below:

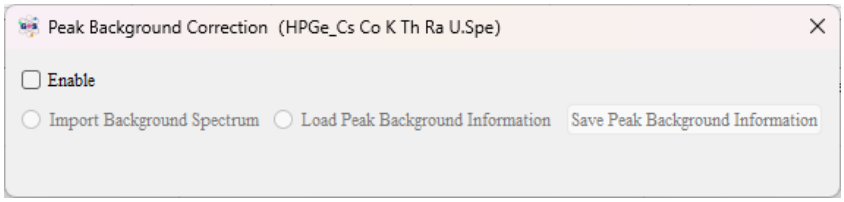


Fig.76: Background Deduction Drop-down Menu

Checking the checkbox before "Enable" will enable the "Peak Background Correction" function; not checking it will not enable the function.

Import Background Spectrum: A dialog box will open for selecting the background spectrum to perform peak background correction on the sample spectrum.

Note: The background spectrum must be measured with the same detector under the same conditions (such as the same shielding geometry, detection geometry, using the same matrix, and the same fine gain, etc.). When clicking ‘ / ’ to analyze, the same nuclide library, ROI, and energy calibration coefficients as the analyzed sample spectrum are used to search for peak in each ROI of the background spectrum. If a peak is identified and attributed to a nuclide, peak background information will be established, including: nuclide, energy, net counts, live time, uncertainty. At the same time, when calculating the activity, the peak net count rate will be subtracted by the peak background net count rate.

Call Peak Background Information: A dialog box will open for selecting the peak background information saved on the hard drive.

Save Peak Background Information: This button will be activated after

importing the background spectrum and clicking '/' to analyze. During this process, the software will establish peak background information and save it to the hard drive. The peak background information includes: nuclide, energy, net counts, live time, and uncertainty.

Cancel Background Subtraction: This button is activated when importing a background spectrum or using peak background information, and is used to cancel the background subtraction correction.

4.6.5.2 Decay Correction

Click the '' to the right of Decay Correction to open the drop-down menu, as shown in Fig.77 below.

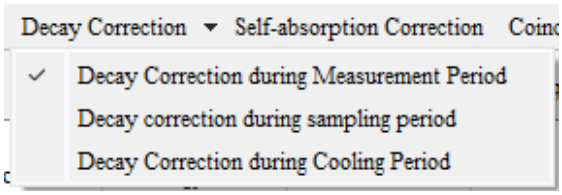


Fig.77: Decay Correction Drop-down Menu

Decay Correction During Measurement Period: This correction is enabled by default. It is for the decay correction of short-lived nuclides during the measurement period. If the half-life of the nuclide being analyzed is greater than 100 times the sample measurement time, the correction factor can be taken as 1. The formula for the correction factor is:

$$\frac{\lambda T_c}{1 - e^{-\lambda T_c}}$$

Where, λ is Decay Constant. T_c is Real Time of Measurement. e is Natural Constant.

Decay correction during sampling: The decay correction factor for short-lived radionuclides during the sampling period. It is assumed that the concentration of radionuclides in the air and during the sampling process is constant, which is applicable to aerosol samples. The formula for this correction factor is: $\frac{\lambda T_S}{1-e^{-\lambda T_S}}$. Click this option, and a dialog box as shown in Fig.78 will pop up, which is used to set the start and end sampling dates and times. First, check the checkbox in front of "Enable", then set the time and date. When analyzing, that is, when pressing the '/' button as shown in Fig.75, the decay correction during the sampling period will be automatically applied.

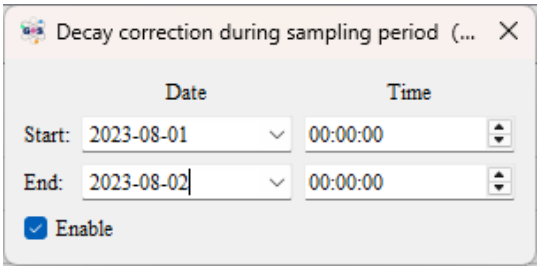


Fig.78: Set the start and end dates and times for sampling

Decay Correction During Cooling Period: The decay correction coefficient during the sample cooling period, which is the decay correction for the time interval from the start of sampling to the start of measurement. The correction coefficient formula is: $e^{-\lambda\Delta t}$. Click this option, and a dialog box as shown in Fig.79 will pop up, which is used to set the sampling time and date. First, check the checkbox before "Enable", and then set the time and date. When analyzing, that is, when pressing the '/' button as shown in Fig.75, the decay correction during the cooling period will be automatically applied.

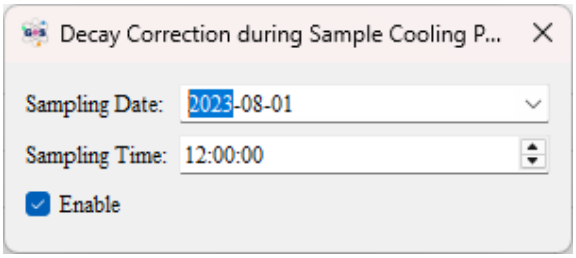


Fig.79: Set Sampling Date and Time Dialog Box

4.6.5.3 Self-absorption Correction

Self-absorption correction refers to the sample's self-absorption correction coefficient relative to the efficiency calibration source. If the sample density is the same or similar to the density of the efficiency calibration source, the self-absorption correction coefficient can be set to 1. Clicking this option will pop up a dialog box as shown in Fig.80: Self-absorption Correction Dialog Box below.

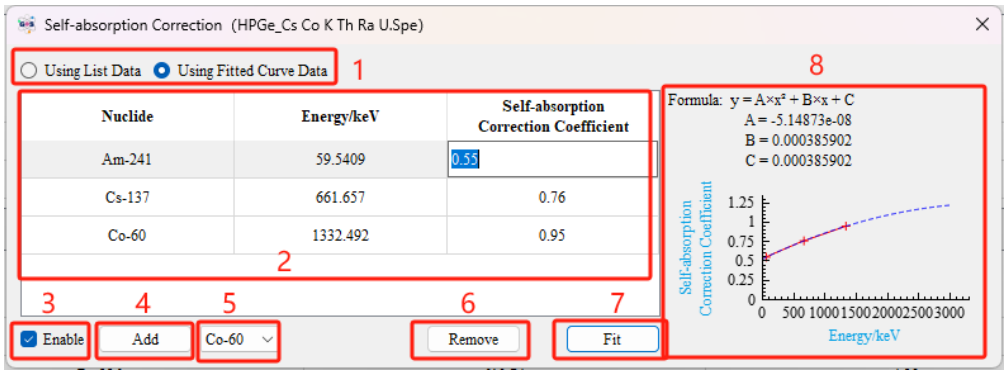


Fig.80: Self-absorption Correction Dialog Box

① Users can choose to perform self-absorption correction using list data or by using fitted curve data. Regardless of the method, it is necessary

to input the nuclide, energy, and corresponding self-absorption correction coefficient information.

② Display the nuclide information that requires self-absorption correction, including nuclides, energies, and the corresponding self-absorption correction coefficients. Double-clicking on the self-absorption correction coefficient column with the mouse enters the edit state.

③ Used to enable or disable the Self-absorption Correction. Note you can only edit this interface after checking the checkbox.

④ Add: Add the selected nuclide and energy to the list.

⑤ Used to select the nuclides and energies in the current applied nuclide library.

⑥ Remove: Used to delete the selected nuclide information in the list.

⑦ Fit: Based on the information in the list, use a quadratic polynomial fitting curve.

⑧ Display the quadratic polynomial formula and curve for fitting.

4.6.5.4 Coincidence Summing Correction

For nuclides emitting single-energy rays, or when the corresponding correction coefficient for the analyzed rays is not significant, the correction coefficient can be taken as 1. Otherwise, the coincidence summing correction coefficient should be estimated. Clicking this option will pop up the dialog box as shown in Fig.81 below.

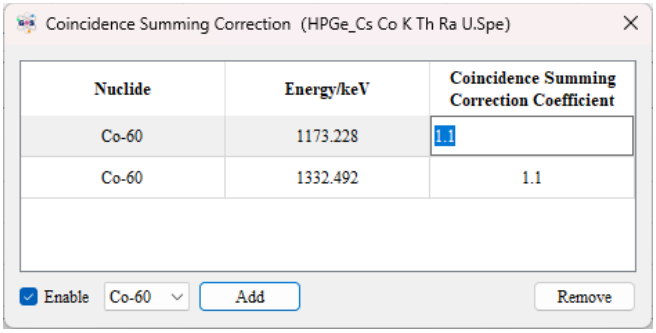


Fig.81: Coincidence Summing Correction Dialog Box

The middle list on this interface displays the nuclide information that requires coincidence summing correction, including: nuclide, energy, and the corresponding coincidence summing correction coefficients.

Check the checkbox in the lower left corner to enable this correction. The interface can only be edited when the checkbox is checked.

The sidebar in the right of 'Enable' display nuclide information in the nuclide

library, which is used to select nuclides and energies from the currently applied nuclide library.

Add: Add the selected nuclide and energy to the list.

Remove: Used to delete the selected nuclide information from the list.

4.6.5.5 Activity Calculation Instructions

Clicking this option will pop up the activity calculation instructions as shown in Fig.82 below. Also shown in APPENDIX A.

Activity Calculation Formula:

$$A = \frac{(N_s/T_s - N_b/T_b) \times F_{MP} \times F_{Sam} \times F_{CS}}{F_{SA} \times \varepsilon \times P \times F_{CP}}$$

In the above formula:

A: The activity of nuclides in the sample, the unit is *Bq*.

N_s: Net count of the full-energy peak in the sample measurement.

T_s: Live time of sample measurement, the unit is *s*.

N_b: Net count of background peak.

T_b: Live time of background measurement, the unit is *s*.

F_{MP}: The decay correction factor for short-lived nuclides during the measurement period. If the half-life of the nuclide being analyzed is greater than 100 times the sample measurement time, F_{MP} can be set to 1. $F_{MP} = \frac{\lambda T_c}{1-e^{-\lambda T_c}}$.

F_{Sam}: The decay correction factor for short-lived radionuclides during the sampling period, assuming that the concentration of the radionuclides in the air and during the sampling process is constant. $F_{Sam} = \frac{\lambda T_S}{1-e^{-\lambda T_S}}$. Suitable for aerosol samples.

F_{CS}: The coincidence summing correction coefficient. For nuclides emitting single-energy rays, or when the corresponding correction coefficient for the analyzed rays is not significant, the F_{CS} can be taken as 1. Otherwise, the F_C should be estimated.

F_{SA}: The self-absorption correction coefficient for the sample with respect to the efficiency calibration source. If the density of the sample is the same or similar to the density of the efficiency calibration source, the F_{SA} is taken as 1.

ε: The detection efficiency of the full-energy peak for the corresponding energy γ-ray.

P: The emission branching ratio of the corresponding energy γ-ray.

F_{CP}: The decay correction coefficient during sample cooling period, which is the decay correction for the time interval from the start of sampling to the start of sample measurement. $F_{CP} = e^{-\lambda \Delta t}$.

In the calculation formula for F_{MP}, F_{Sam} and F_{CP}:

λ: Decay constant, the unit is s^{-1}. $\lambda = \frac{ln2}{T_{1/2}}$, $T_{1/2}$ is half-life，the unit is *s*.

T_c: The real-time duration for sample measurement, in seconds (s).

T_S: The duration of the sampling period, which is the time interval from the start of sampling to the end of sampling, measured in seconds (s).

Δt: The decay time for the nuclide, which is the time interval from the start of sampling to the start of sample measurement, the unit is *s*. For aerosol samples, it refers to the time interval between the end of sampling and the beginning of measurement.

e: The natural constant.

Fig.82: Activity Calculation Instructions

4.6.6 Automatic Spectrum Stabilization

Clicking this option displays the automatic spectrum stabilization settings window as shown in Fig.83.

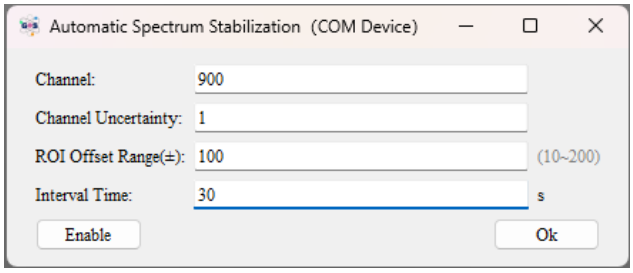


Fig.83: Automatic spectrum stabilization setting window

Channel: Stabilize the peak center position at a certain channel.

Channel Uncertainty: Due to the inability to completely stabilize the peak center at a specific Channel, a window range is required to stabilize the peak center within the channel ± window range, and this window range is the channel uncertainty.

ROI Offset Range (±): The set value range here is 10 to 200, meaning the region of interest ROI is the set channel ± the set value range.

Interval Time: The minimum setting is 30 seconds, meaning that every set interval, the software will automatically adjust the fine gain for a stable spectrum.

As shown in Fig.83 for parameter settings, click ‘OK’ and ‘Open’ to stabilize the spectrum. The software will automatically set the channel range of 900±100 as the region of interest (ROI), automatically identify the peak center channel within this ROI, and stabilize the identified peak center channel within the range of 900±1. The fine gain will be adjusted for spectrum stabilization every 30 seconds.

4.6.7 Peak Search

The peak search interface is shown in Fig.84 below. After setting the sensitivity, full-spectrum peak search can be performed, and the detected peaks will be automatically marked as ROIs.

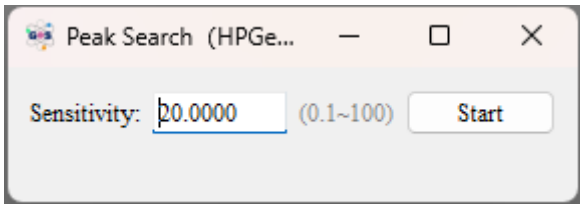


Fig.84: Peak Search Interface

Note: This feature is an upgraded version and requires the use of an

SuperDog key.

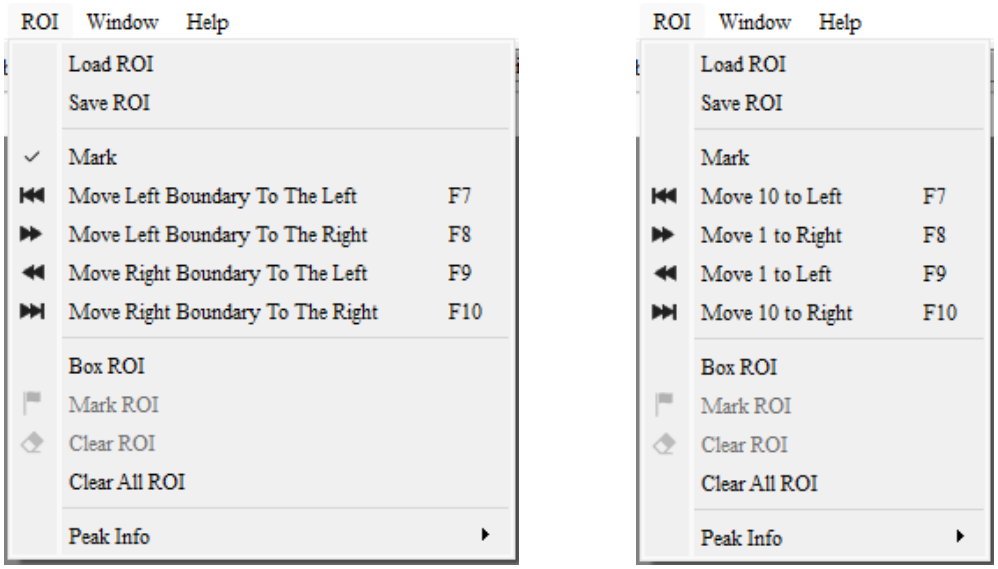
The smaller the sensitivity value, the more minor peaks will be detected, meaning the peak detection is more sensitive, but there is a risk of misidentifying non-peaks as peaks. Conversely, the larger the sensitivity value, the opposite is true.

For energy spectra with high energy resolution, almost no pile-up peaks, and no peak tailing, peak search will be very effective. Otherwise, it will be very poor. For example, peak search is more effective for HPGe spectra. Whereas, it is less effective for NaI spectra.

Even if the peak search sensitivity is set very high (i.e., a small value), there will still be instances where peaks are not detected. In such cases, the peak does not meet the peak detection criteria, such as the FWHM determination.

4.7 ROI

The menu for the region of interest (ROI) is shown in Fig.85 below:



a b

Fig.85: Region of Interest Menu

4.7.1 Load/Save ROI

Load ROI: Load the ROI (i.e., .R file) from the hard disk to the current spectrum.

Save ROI: Save the current ROI to the hard disk in .R file format.

4.7.2 Mark/Move Left Border To The Left/ Move Left Border To The Right / Move Right Border To The Left / Move Right Border To The Right

Mark: for switching between ROI adjustment and Vertical marker line

movement.

Move Left Border To The Left/ Move Left Border To The Right / Move Right Border To The Left / Move Right Border To The Right: When the mark is selected, ‘Move Left Border To The Left/ Move Left Border To The Right / Move Right Border To The Left / Move Right Border To The Right’ will move boundary by 1 channel to adjust the ROI. When unselected, ‘Move Left Border To The Left/ Move Left Border To The Right / Move Right Border To The Left / Move Right Border To The Right’ become ‘Move 10 to Left / Move 1 to Right / Move 1 to Left / Move 10 to Right’, used for moving the vertical marker line left and right.

You can use shortcut keys F7 to F10 to quickly mark ROIs or move the vertical marker line in the spectrum.

4.7.3 Box ROI/Mark ROI/Clear ROI/Clear All ROI

Box ROI: Clicking on this option will pop up a dialog box as shown in Fig.86. After entering the left boundary channel and the right boundary channel, click the ‘OK’ button to select the corresponding channel range for ROI.

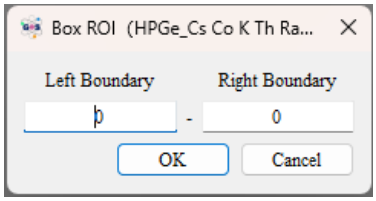


Fig.86: Box ROI dialog

Mark ROI: When the left mouse button selects an area in the current spectrum window, clicking this option can mark the channel range of the area as ROI.

Clear ROI: When selecting an area in the current spectrum window with the left mouse button, clicking this option will clear the ROI within this area.

Clear All ROI: Click this option to clear all ROI for the current spectrum.

4.7.4 Peak Info

Peak Info includes ‘Count Info’, ‘Peak Fitting’ and ‘Mark Multiple Peaks’, as shown in Fig.87 below.

Fig.87: Peak Info Menu

4.7.4.1 Count Info

Clicking this option will enable/disable the count information for ROI.

When enable, the vertical marker line is located within a ROI (the position of the vertical marker line can be selected with the left mouse button), and the count information of that ROI will be displayed, as shown in Fig.88 below. Otherwise, it will not be displayed.

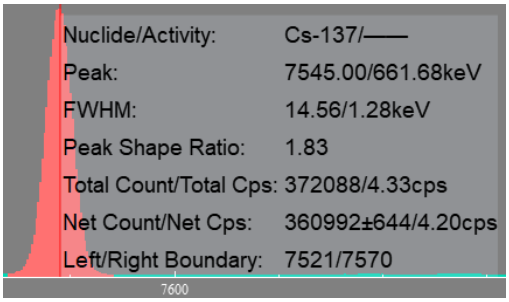


Fig.88: Count Information

4.7.4.2 Peak Fit

Clicking this option will enable/disable the peak fitting for ROI.

When enable, the vertical marker line in the spectrum is located within a ROI (the position of the vertical marker line can be selected by clicking the left mouse button), and the peak fitting information of that ROI will be displayed, as shown in Fig.89. Otherwise, it will not be displayed.

This software uses net count of peak fitting when calculating activity.

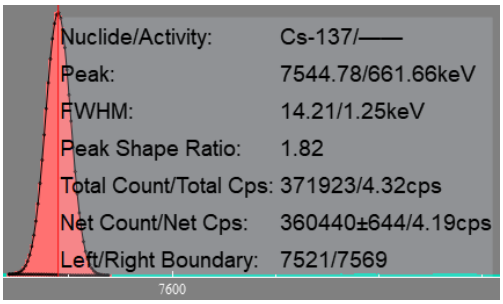
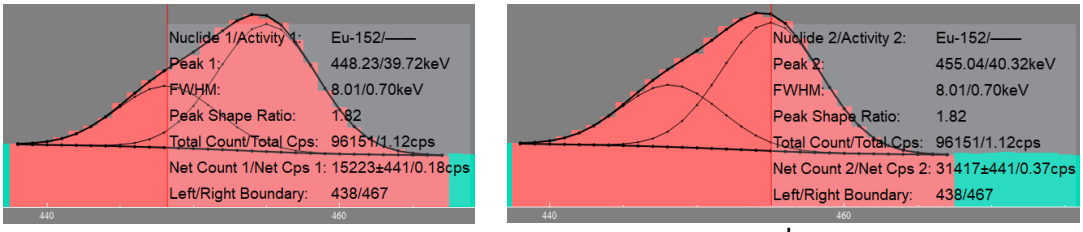


Fig.89: Peak Fit

4.7.4.3 Mark Multiple Peaks

When the vertical marker line is located within a ROI, that option will be displayed. Currently, clicking on this option can mark the ROI as doble peaks. Mark triple peaks and more peaks are under development. After marking an ROI as doble peaks, the program will automatically fit the ROI as doble peaks according to the peak fit mode, as shown in Fig.90.

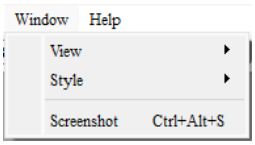


a b

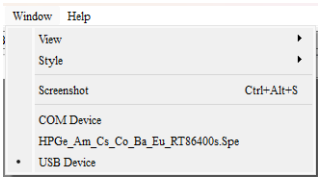
Fig.90: Multi-peak fitting (peak fit model)

4.8 Window

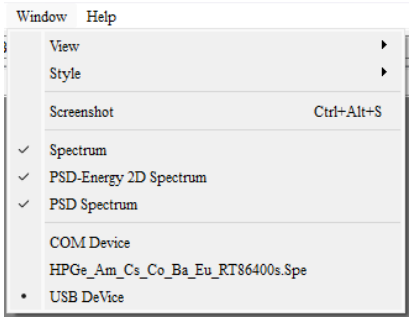
The window menu is shown in Fig.91 as follows:



a. No devices connected and no spectrum opened in the hard drive.



b. Connected the devices and opened the spectrum in the hard drive.



c. Connected the device with PSD functionality and opened the spectrum in the hard drive.

Fig.91: Window Menu

When the software connects to MCAs or opens a spectrum from the hard drive, options for the device name or spectrum name will be added to the 'Window' menu, as shown in the above Fig.91b. When a MCA with PSD functionality is connected, options for Spectrum/PSD-Energy 2D Spectrum/PSD Spectrum will be added, as shown in the above Fig.91c. The '·' indicates that the current spectrum display area is showing the window for that device or spectrum.

4.8.1 View

This option is further divided into three sub-options: 'Tile', 'Tab', and 'Cascade' as shown in Fig.92. The '·' represents the application view. This menu option is the same as the view in the toolbar.

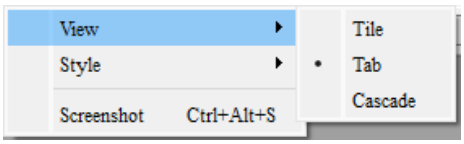


Fig.92: View

Tile: Display each spectrum window in a tiled format, as shown in Fig.93 below:

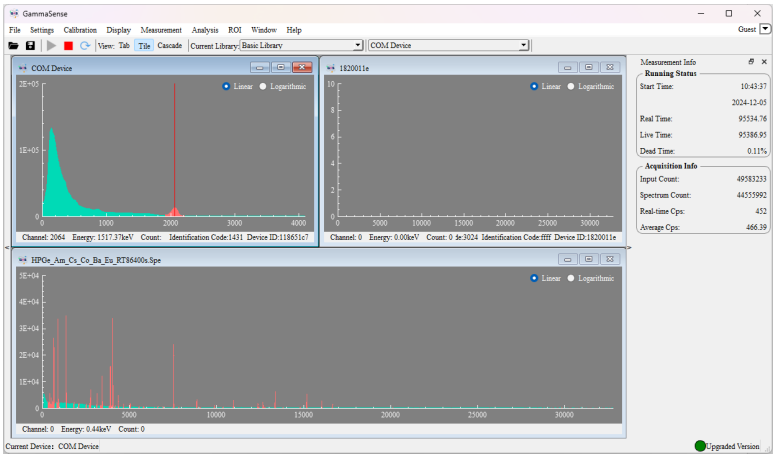


Fig.93: View - Tile

Tab: Display each spectrum window as tab format, as shown in Fig.94:

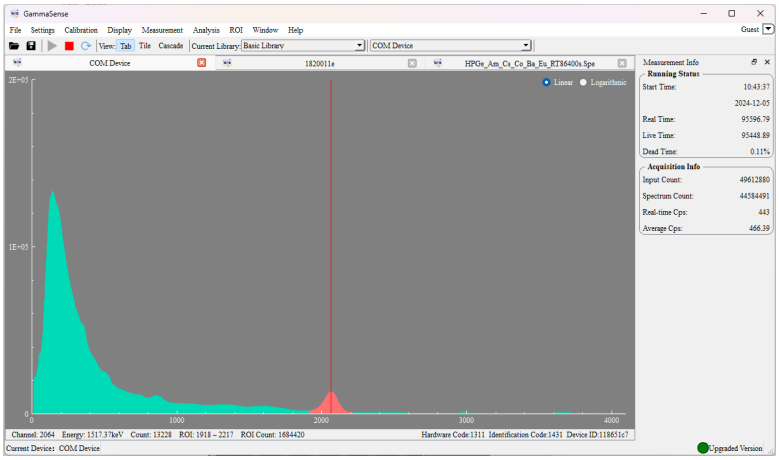


Fig.94: View - Tab

Cascade: Display each spectrum window as cascade format, as shown in Fig.95:

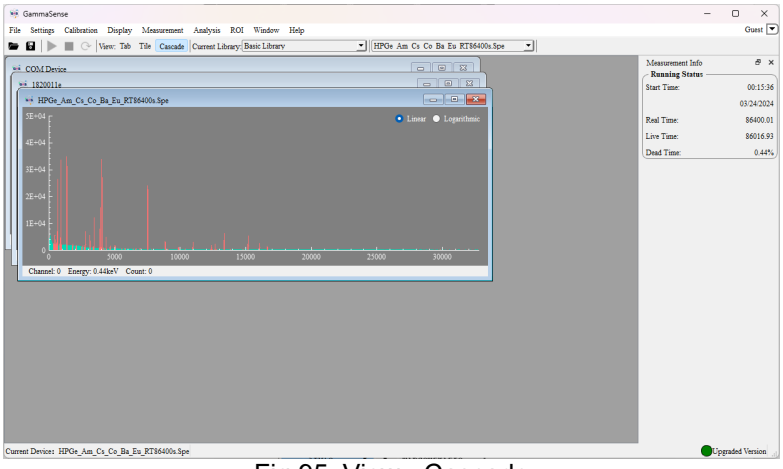


Fig.95: View - Cascade

4.8.2 Style

This option is further divided into three sub-options: ‘WindowsVista’, ‘Windows’, and ‘Fusion’ as shown in Fig.96 below. The ‘·’ represents the application window style.

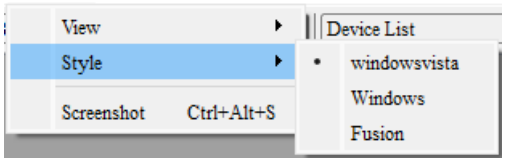


Fig.96: Style

The window display style can be switched (the number of styles supported depends on the PC being used), and the change takes effect immediately after each switch.

Note: If you need to switch the window style, it is recommended to do so right after turning on software, as the more windows that are opened subsequently, the longer the switch will take (the specific duration depends on the PC being used), which may cause the software to lag.

4.8.3 Screenshot

Clicking this option will freeze the current screen display. The left mouse button can be used to drag and select the desired screenshot area, as shown in Fig.97. Clicking the '  ' at the bottom right of the area allows you to draw a red rectangle frame. Clicking '  ' saves the screenshot to the hard drive. Clicking '  ' cancels the screenshot. Clicking '  ' confirms the screenshot of the area and temporarily stores it in the clipboard. The shortcut key for this function is Ctrl+Alt+S.

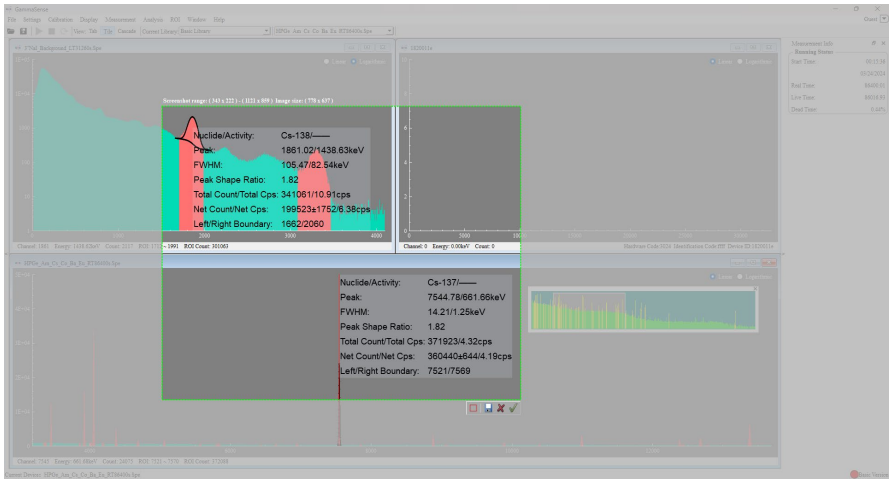


Fig.97: Screenshot

4.9 Help

The Help menu is shown in Fig.98 below:

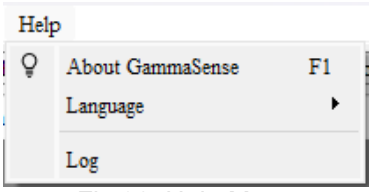


Fig.98: Help Menu

4.9.1 About GammaSense

Selecting this option will pop up a dialog box displaying the software version number, release date, company name, and website information, as shown in Fig.99 below:

Fig.99: About GammaSense Dialog Box

4.9.2 Language

This option includes ‘Chinese (Simplified)’ and ‘English [English]’, as shown in Fig.100 below:

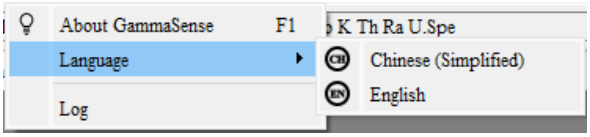


Fig.100: Language

When switching language, a prompt will pop up: Please restart the application to change the language. As shown in Fig.101 below:

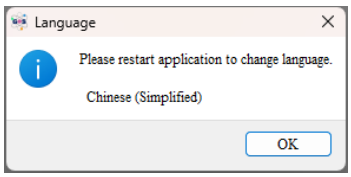


Fig.101: Language Prompt Window

4.9.3 Log

Log are used to record a series of operations by the user during software usage. Only administrator and auditor users can open the log interface and view it. The log interface is shown in Fig.102 below:

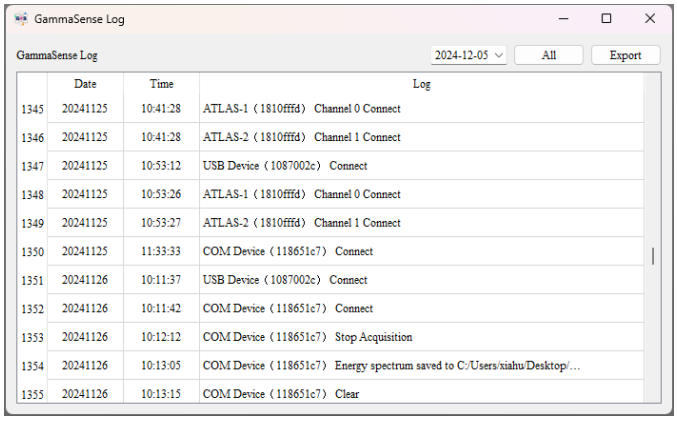


Fig.102: Log Interface

The date bar in the upper right corner of the interface is used for selecting the year, month, and day. Once the date is set, the interface will display the operation records for that date. Clicking the ‘All’ button will show all logs. Clicking ‘Export’ can export the logs to a PDF file or an Excel file.

4.10 User

At the far right of the menu bar (the top right corner of the software interface), the currently logged-in user is displayed. When the software is opened, the default is a guest login.

There are three levels of user permissions:

Administrator: Can view logs, add users (including regular users and auditor users), modify user permissions, and delete users.

Auditor: Can view logs, cannot add users, cannot modify user permissions, and cannot delete users.

Regular user: Cannot view logs, cannot add users, cannot modify user permissions, and cannot delete users. Guest is considered regular user.

The User Menu is shown in Fig.103 below:

a. Guest b. Admin

Fig.103: User Menu

Add User: Can add regular users and auditor users, available only to administrator. Clicking ‘Add User’ or ‘Add Auditor’ will pop up a dialog box for entering the username and password, as shown in Fig.104 below:

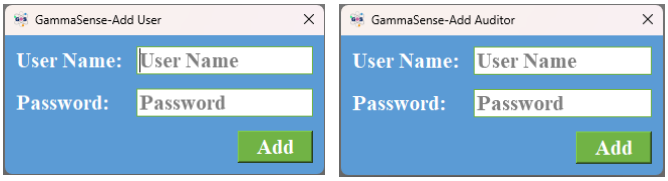


Fig.104: Add User Dialog Box

Switch User: Used to log in as an administrator or a user that has been added. Clicking this option will pop up a dialog box as shown in Fig.105. The default administrator username and password are ‘Admin’, for password modification, please contact our technical support.

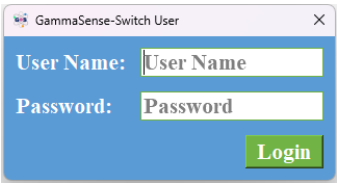


Fig.105: Switch User Dialog Box

User Management: Used to modify user permissions (available only to administrator), clicking this option will pop up a dialog box as shown in Fig.106. Click ‘Modify Permissions’ to change the selected user's permissions to ‘Auditor User’ or ‘General User’. Click ‘Delete User’ to delete the selected user.

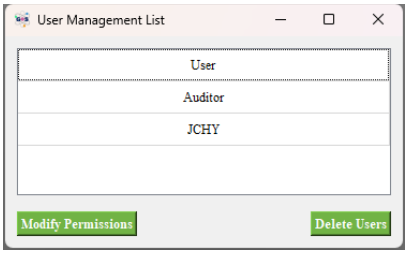


Fig.106: User Management List

Logout: Log out the user and switch to ‘Guest’ login for the software.

5 Toolbar

The toolbar is shown in Fig.107 below:

Fig.107: Toolbar

: Open File.

: Save Spectrum File.

: Start Acquisition.

: Stop Acquisition.

: Clear Current Spectrum. Note: When clearing the spectrum, the spectrum data will automatically be saved to ‘My Documents (the specific path depends on the computer used)\GammaSense\temp’ to prevent accidental clearing operations.

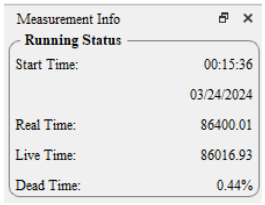
View: Display spectrum windows in tab, tile, or cascade modes, see the 'Window – View' in the menu bar for details, refer to the '4.8.1View' section.

Current Library: Select the nuclide library to refer to for nuclide identification with the current spectrum.

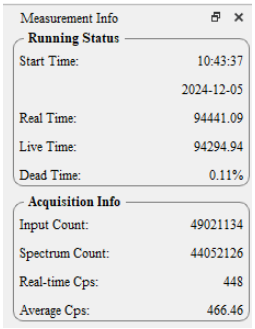
Device List: Switch between the spectrum windows of connected devices or open spectrum files.

6 6 Measurement Information

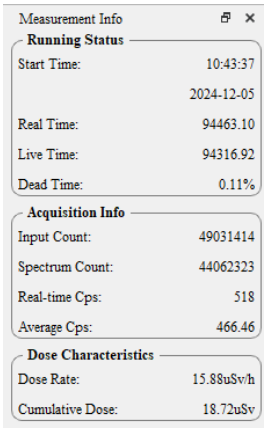
The Measurement Information is located on the right side of the software interface by default and is a draggable window that can be displayed in front of the spectrum window as shown in Fig.108. The Measurement Information for opening spectrum files differs from that during the device acquiring spectrum, with the latter including additional acquisition information such as input count, spectrum count, real-time count rate of spectrum, and average count rate of spectrum. If dose measurement is enabled during the device acquiring spectrum (see ③ for details on dose measurement), it will also display dose characteristics, including dose rate and cumulative dose.



a. Measurement Info of opened Spectrum File



b. Measurement Info of Device is Acquiring Spectrum



c. Measurement Info when Device is Acquiring Spectrum and dose measurement is enabled

Fig.108: Measurement Information

7 Spectrum Window Area

The energy spectrum window area is used to display the energy spectrum window. This chapter will introduce the spectrum window, ROI information box, and mouse functions.

7.1 Spectrum Window

The spectrum window is primarily used for displaying the spectrum

(including the real-time refresh display of the spectrum of the connected device during measurement), acquiring key information of the spectrum, and providing various operations on the spectrum.

The spectrum window can be displayed as tab, tile, or cascade. When the mouse is placed between the spectrum window area and the measurement information bar, and the mouse cursor changes to ⇹, holding down the left mouse button and dragging left or right can adjust the display width of the main window and the information bar.

Each spectrum window can switch between linear and logarithmic display. The full spectrum and ROI information of each spectrum can be displayed on the spectrum.

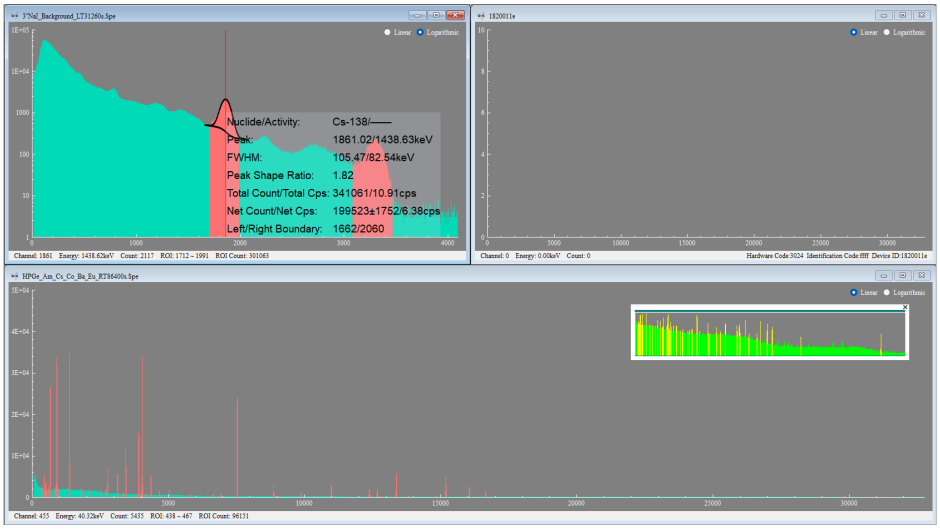


Fig.109: Three spectrum windows displayed in tiled format.

When dual-spectrum mode is enabled (in the '4.2.1.5 Coincidence Settings' spectrum output mode settings), the spectrum window will also display two spectrum modes, as shown in Fig.110. When the mouse is placed over the middle and the style changes to ⇳, dragging the mouse up and down with the left button can adjust the height of the dual spectrum.

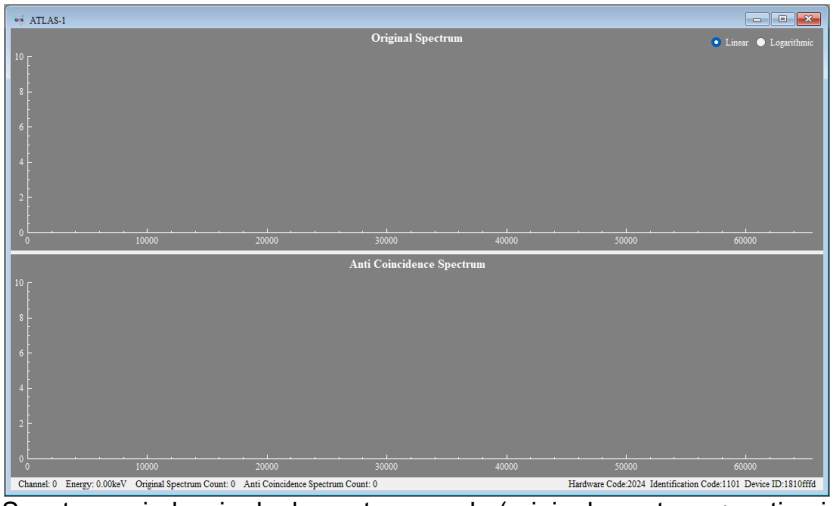


Fig.110: Spectrum window in dual-spectrum mode (original spectrum + anti-coincidence spectrum).

The information bar at the bottom of each spectrum window can display the channel of the vertical marker line, energy, count, ROI left and right boundary information, and ROI count information. For the spectrum window of a connected device, it can also display the device's hardware code, identification code, and device number. As shown in Fig.109 and Fig.110.

If the connected MCA supports spectrum mode / List mode, the applied mode will be displayed on the far right of the toolbar, such as spectrum mode (as shown in Fig.107) or List mode (as shown in the following Fig.111).

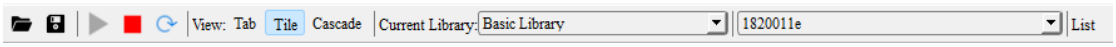


Fig.111: The ‘List’ mode is displayed on the far right of the toolbar.

Some digital MCAs will have pulse shape discrimination (PSD) functionality, and as a result, the window menu will have additional options for Spectrum, PSD-Energy 2D Spectrum, and PSD Spectrum, as shown in Fig.91c. By clicking the ‘Spectrum/PSD - Energy 2D Spectrum/PSD Spectrum’ button, you can choose whether to display the corresponding spectrum. As shown in Fig.112. When the mouse is placed between any two graphs and the style changes to ⇼, holding down the left mouse button and dragging left or right can adjust the display width of these two graphs.

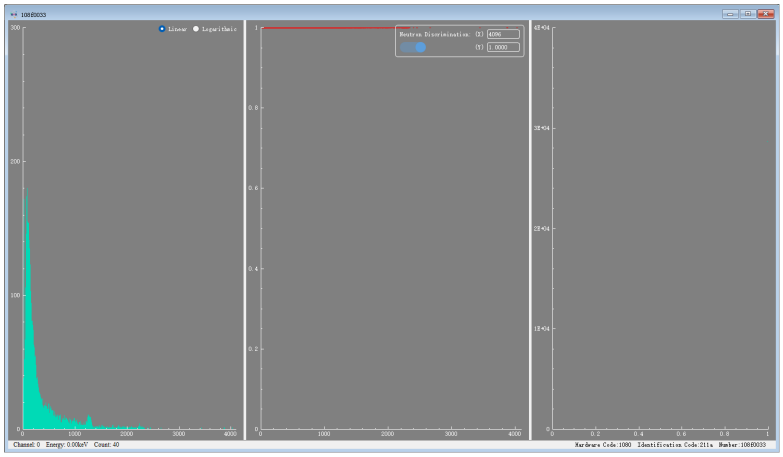
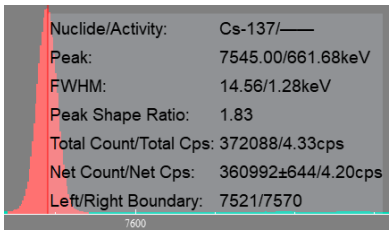


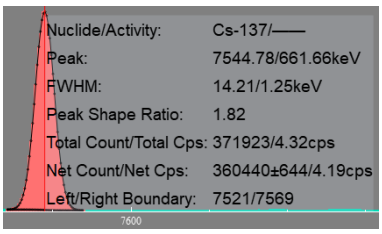
Fig.112: Spectrum window with PSD functionality (from left to right: Spectrum, PSD-Energy 2D Spectrum, PSD Spectrum)

7.2 ROI Information Box

When Count Info or Peak Fit is enabled, left-clicking on a certain ROI will automatically position the marker line to the channel address with the highest count of that ROI or the fitted channel with the highest count, and simultaneously display the information box to the right of the adjacent vertical marker line, as shown in the following Fig.113:



a. Count Info



b. Peak Fit

Fig.113: The information box for the same ROI.

Nuclide/Activity: Displays the identified nuclide for the ROI peak and the calculated activity value of the peak. Note: The calculated activity is only displayed in the upgraded version of the software, the basic version displays '——'. If no nuclide is identified, '——' will be displayed.

Peak: Displays the channel / energy value at the maximum counts of the ROI, or the channel / energy value at the maximum count after peak fitting.

Peak Shape Para: Also known as the peak shape ratio. If it is 1/10, it displays the FWTM/FWHM value (full width at ten percent of the maximum height / full width at half maximum). If it is 1/50, it displays the FWFM/FWHM value (full width at fifty percent of the maximum height / full width at half maximum).

Total Count/Total Cps: Displays the total count/total count rate of the ROI (count info). Or the total count/total count rate of the fitted peak (peak fit).

Net Count/Net Cps: Automatic background subtraction. Displays the net count/net count rate of the ROI (count info). Or the net count/net count rate of the fitted peak (peak fit).

Left Boundary/Right Boundary: Displays the left boundary/right boundary of the ROI (count info). Or the left boundary/right boundary of the fitted peak (peak fit).

Note: The software uses the counts in 'Peak fit' mode for activity analysis and calculation.

7.3 Mouse Functions

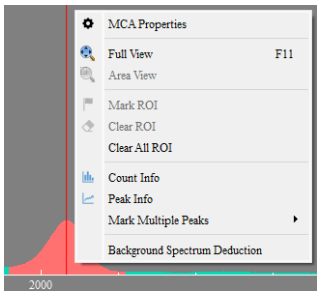
7.3.1 Left Button Functions

Click: Used for selecting. A left-click in the spectrum moves the vertical marker line to the position of the mouse. Holding down the left mouse button in the spectrum and dragging the mouse left or right creates a rectangular box for ROI operations.

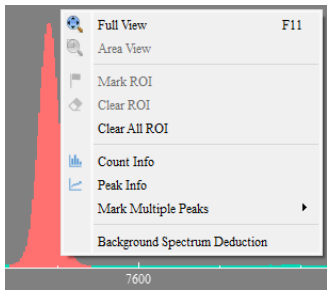
Double-click: Double-clicking on the top bar of a window will zoom in/restore the window. When the mouse double-clicks on a peak in the spectrum, it will automatically locate the single peak and select the ROI.

7.3.2 Right Button Functions

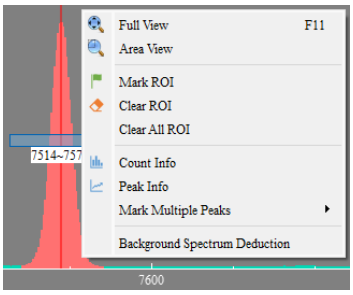
The right mouse button can be used to open the right-click menu, which may vary depending on the context, as shown in Fig.114:



a. Open the Spectrum Window for Connected MCA, and the Right-click Menu for ROI



b. Open the spectrum from the hard drive, right-click menu for ROI



c. Open the spectrum from the hard drive, right-click menu for the rectangular window drawn with the left mouse button.

Fig.114: Right-click Menu

MCA Properties**:** Parameters for connected MCAs can be set. See the section '4.2.1 MCA Properties' for details. This menu is only activated and displayed when a MCA is connected, as shown in Fig.114a.

Full View: Zoom the spectrum to the minimum (X-axis).

Area View: Zoom in on the spectrum range within the rectangle box drawn with the left mouse button to the maximum display. This menu can only be activated after dragging with the left mouse button, as shown in Fig.114c.

Mark ROI: Hold down the left mouse button on the spectrum, drag out a rectangular box, and then release the left mouse button. Switch to the right mouse button, and in the popped-up dialog box, select ‘Mark ROI’. The selected ROI will then be filled in red (default color, which can be changed in the Display - Design menu). If you need to mark more ROIs, repeat the above steps.

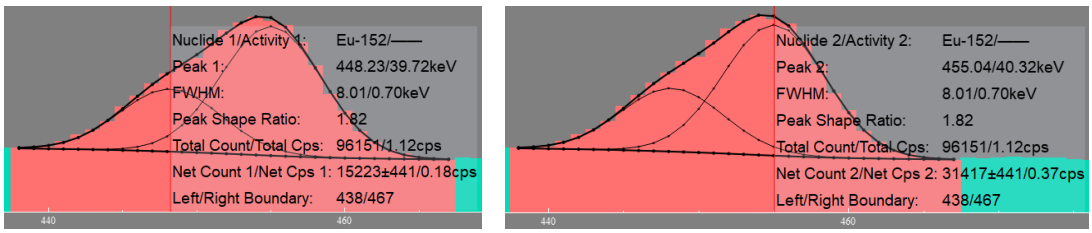
Clear ROI: Hold down the left mouse button, drag out a rectangle, and then release the left mouse button. Switch to the right mouse button, and in the popped-up dialog box, select ‘Clear ROI’ to remove the ROI in the rectangle box, as shown in Fig.114c.

Clear All ROI: Clear all ROIs in the spectrum with one click.

Count Info**:** Select the ROI with the left mouse button, right-click on the ROI and select ‘Count Info’, the ROI Information Box will pop up on the right side of the marker line.

Peak Fit**:** Select the ROI with the left mouse button, right-click on the ROI and choose ‘Peak Fit’. The software will then automatically fit the ROI, and the ROI Information Box will pop up on the right side of the marker line.

Mark Multiple Peaks**:** This option will only be displayed when the vertical marker line is within a certain ROI. Currently, clicking this option will mark the ROI as a double peak. Triple peaks and more are under development. After marking an ROI as a double peak, the program will automatically fit the ROI as a double peak in the Peak Fit mode, as shown in Fig.115.



a b

Fig.115: Double Peak Fitting

Background Spectrum Deduction**:** Clicking this option will open a window for selecting a spectrum to be used as the background spectrum. Once selected and opened, it will add the background spectrum to the current spectrum (either the spectrum opened from the hard drive or the one being measured), and the

software will display a subtracted spectrum, where the counts for each channel as follows:

$$N_c - \frac{N_b}{T_b} \times T_c$$

Where, N_c are channel counts of current spectrum. N_b are corresponding channel counts of background spectrum. T_b is live time of background spectrum. T_c is live time of current spectrum.

This function is for plotting display only and is not used for subsequent analysis and calculation.

Note: The number of channels in the background spectrum must not be less than the number of channels in the current spectrum.

7.3.3 Scroll Wheel Function

Scroll the scroll wheel to zoom in and out on the spectrum along the X-axis based on the mouse position, with the Y-axis automatically scaling proportionally.

Ctrl + scroll wheel to zoom in/out on the spectrum along the Y-axis.

Press the scroll wheel and move the mouse left or right to move the spectrum along the X-axis.

8 Status Bar

The status bar is located at the bottom of the software interface, as shown inFig.116 below. The left side displays the current device name or the opened spectrum name, and the right side indicates Basic / Upgrade version, with the Upgrade version requiring the use of an SuperDog key.

Fig.116: Status Bar

9 Common Operations

9.1 Communication Connection

The digital MCAs use serial communication, USB communication, or network port communication. It can only be configured and spectrum collected after the MCA is added in the GammaSense software.

9.1.1 Serial Communication Connection

Applicable to serial communication devices, the main operating steps are:

① Hardware connection, the device is connected to the computer via a communication cable; ② Open the Configuration software, click ‘Search COM’ in the toolbar (this button function is triggered automatically when a COM device is connected, usually no need to click), when a COM device appears in the software interface list, it indicates successful communication, and the device's available status is noted in the remarks column; ③ Open the GammaSense software, click ‘File – Device List’, and add the COM device to the list of Added Devices.

Note: If the communication cable is accidentally pulled out and reconnected, it will generally connect automatically after a short wait, which is to automatically open the spectrum window of the device. If it does not connect automatically, repeat steps ② and ③. If the communication is still not possible or the remarks column shows "Device Unavailable," restart the Configuration software or check the cable connection.

9.1.2 USB Communication Connection

Applicable to USB communication devices, the main operating steps are: ① Hardware connection, the device is connected to the computer via a communication cable; ② Open the Configuration software, click ‘Search USB’ in the toolbar (this button function is automatically triggered when a USB device is connected, usually no need to click), when a USB device appears in the software interface list, it indicates successful communication, and the device's available status is noted in the remarks column; ③ Open the GammaSense software, click ‘File - Device List’, and add the USB device to the list of Added Devices.

Note: If the communication cable is accidentally pulled out and reconnected, it will generally connect automatically after a short wait, which is to automatically open the spectrum window of the device. If it does not connect automatically, repeat steps ② and ③. If normal communication is still not possible or the remarks column shows ‘Device Unavailable’, restart the Configuration software or check the cable connection.

9.1.3 Network Communication Connection

9.1.3.1 Wired Network Communication Connection

When using wired network communication, there are mainly two connection methods between the device and the computer: ① The device is directly connected to the computer using a network cable; ② The device is connected to the computer through a local area network, with IP obtained automatically/manually.

Note: If the network communication is unexpectedly disconnected and then reconnected, you need to confirm the network card being used in the GammaSense software under ‘File – Device List’ and click the "Refresh" button again to reconnect the device. If it is not successful, check the communication cable connection or restart the software.

9.1.3.1.1 Direct Connection via Ethernet Cable

The main operational steps are: ① Operate the computer, open the Ethernet status interface, and click the "Properties" button; ②Double-click to open Internet Protocol Version 4 (TCP/IPv4), select ‘Use the following IP address’, set the IP address, making sure it is within the same IP segment, the subnet mask can be left as default, then click ‘OK’ – ‘OK’; ④ In the GammaSense software, on the ‘File – Device List’ interface, enter the device port number, check ‘Search TCP’, confirm the network card in use, and click "Refresh" to see the connected TCP device.

9.1.3.1.2 Connection via Local Area Network (LAN)

The main operational steps are as follows: ① Before connecting, confirm the IP address segment of the local area network, such as the 192.168.1.XXX segment; ② Connect the digital MCA to the local area network via an Ethernet cable and turn it on; ③ If the digital MCA can have its IP address set, then set the IP address. If the digital multi-channel uses a fixed IP address, skip to the next step without setting the IP; ④ The computer connects to the local area network via a wired or wireless connection. Its IPv4 address is obtained automatically and does not require separate settings. Or apply for a fixed IP

address within the local area network and set this IP address in the computer's Internet Protocol Version 4 (TCP/IPv4); ⑤ In the ‘File – Device List’ interface of the GammaSense software, enter the device port number, check ‘Search TCP’, confirm the network card being used, click ‘Refresh’, and you will see the connected TCP devices.

9.1.3.2 WiFi Network Communication Connection

Currently, WiFi network communication is only applicable to the ATLAS digital multi-channel analyzer with a WiFi version. The main operational steps are as follows: ① Power on the ATLAS device, operate the ATLAS embedded system screen, click on the settings in the embedded GammaSense main interface, then click the WiFi icon in the bottom right corner to enter the WiFi connection interface; ② In this interface, connect to the WiFi network and then return to the settings interface; ③ The computer connects to the same WiFi network (LAN) via wired or WiFi, and the computer's IPV4 can be automatically obtained without the need for separate settings. Or apply for a fixed IP address within the LAN and set this IP address to the computer's IPV4; ④ In the ‘File-Device List’ interface of the GammaSense software, fill in the device port number (as seen in the embedded system settings interface), check ‘Search TCP’ confirm the network card being used, and click ‘Refresh’ to see the connected TCP devices.

9.2 MCA Settings

After the digital multi-channel analyzer is added to the GammaSense, the MCA can be set up, which is done in the ‘Settings – MCA Properties’. For MCA connecting scintillator detectors, it generally includes high voltage setting, hardware timing setting, pile-up rejection status setting, maximum channel setting, trigger threshold setting, and hardware gain setting. For MCA connecting semiconductor detector, it generally includes high voltage setting, hardware timing setting, pile-up rejection status setting, maximum channel setting, trigger threshold setting, hardware gain setting, signal input polarity setting, preamplifier type setting, and pole-zero settings.

Note: Different MCAs may have different setting options.

High Voltage Setting: Confirm and select the high voltage type, input and

set the high voltage value in the HV bar according to the recommended high voltage value or range of the detector. To modify the high voltage value, first click the lock icon ‘🔒’ on the right side of the number to unlock it ‘🔓’, then enter the desired voltage value in the input box, and press the "Enter" button on the keyboard to modify the high voltage setting. Click the Turn on button to activate the high voltage. Once the high voltage is on, you can control the MCA to acquire spectrum.

Hardware Time: Also known as slow shaping time, it is divided into rising time and flat-top time. Set appropriate rising and flat-top times based on the detector signal decay characteristics. For HPGe detectors, a rising time of 12μs and a flat-top time of 0.8μs are generally set. When the count rate is very low, the rise time can be increased to obtain better resolution; when the count rate is high, the rise time can be reduced to increase the Throughput rate, but the resolution will worsen.

Pile-up rejector(PUR) state: When the circuit detects a pileup pulse signal, whether to suppress the piled-up pulses can be chosen to be enabled or disabled. It is recommended to enable this feature when conducting quantitative measurements.

Maximum Channel: You can select to set the maximum channel for the spectrum. It is recommended to choose a higher channel, as this will result in more details on spectrum.

Trigger Threshold: The fast channel threshold and slow channel threshold can be set. For MCA without an automatic trigger threshold function, first set the slow channel threshold as small as possible to ensure there is no obvious noise count at the leftmost end of the collected spectrum, then adjust the fast channel threshold so that the input count in ‘Measurement Info - Acquisition Info" is about 10% higher than the spectrum count, the closer the better. For MCA with an automatic trigger threshold function, select ‘Auto’ and click the start button. If setting an extremely small fast channel threshold will increase the system dead time, leading to inaccurate energy spectrum counts.

Hardware Gain: Coarse gain and fine gain can be set to adjust the spectrum display of the expected energy range. Typically, the energy range displayed in the spectrum is 0-3 MeV. Use a calibration source with one or two characteristic energies to collect a spectrum, and adjust the combination of

coarse/fine gain so that the characteristic peak center channel is at channel C, with the calculation formula for C as follows:

$$C = \frac{Maximum\ Channel}{Maximum\ Energy\ of\ Spectrum} \times Characteristic\ Energy$$

Signal Input: Set according to the signal type, including positive exponential decay signal and negative exponential decay signal.

Preamplifier Model: Set according to the preamp type of the detector, including Transistor Reset Preamp (TRP) and Resistor Feedback Preamp (RC).

Pole-zero Setting: It is recommended to use automatic pole-zero. Click the "Start" button to automatically calculate. After some time, the pole-zero setting will be completed automatically. The automatic pole-zero function can only be activated when the real-time count rate of the energy spectrum is at least about 900 cps. Otherwise, the 'Start' button will be grayed out, and manual input followed by pressing the "Enter" key will be required to complete the setting. If the rising/top-flat time is changed, the pole-zero setting must be performed again.

All these settings are saved in the MCA and will be reloaded from the connected MCA when GammaSense is started.

Once the settings are complete, you can acquire the sample spectrum, calibrate, and analyze the spectral data.

9.3 Spectrum scaling/movement

The spectrum can be scaled using the mouse wheel, and also through keyboard shortcuts.

Scroll the mouse wheel to scale the spectrum along the X-axis based on the mouse position, with the Y-axis automatically scaling proportionally. Ctrl + scroll the mouse wheel to zoom in/out the spectrum along the Y-axis.

Press the keyboard ←/→ keys to scale the spectrum along the X-axis based on the vertical marker line, with the Y-axis automatically scaling proportionally. Press the keyboard ↑/↓ keys to zoom in/out the spectrum along the Y-axis.

Press the scroll wheel button and move the mouse left or right to translate the spectrum along the X-axis.

9.4 Region of Interest (ROI) Operations

9.4.1 Mark the Region of Interest (ROI)

The software provides 4 ways to mark ROIs:

① Drag a rectangle with the left mouse button, then mark the ROI with the right mouse button.

② Double-click the left mouse button on an peak in the spectrum, and the program will automatically locate the single peak and mark the ROI (this function is available after energy calibration).

③ Click ‘ROI - Box ROI’ in the menu bar to pop up a marking ROI dialog box, enter the channel for the left and right boundaries, click OK, and mark the ROI based on the input channel range.

Note: You can use the left mouse button to control the vertical marker line to confirm the specific channel.

④ Click ‘Analysis - Peak Search’ in the menu bar, and the program will automatically search for peaks across the full spectrum and mark the ROI. Note: This function is an upgraded feature and requires the use of an SuperDog key.

9.4.2 Adjustment of Region of Interest (ROI) Boundaries

The software provides two methods for adjusting ROI boundaries:

① Near the ROI boundary, drag a rectangle with the left mouse button, then mark/clear the ROI with the right mouse button.

② Ensure that ‘ROI- Mark’ is enabled in the menu bar, and use the shortcut keys F7 (move left boundary 1 channel to the left), F8 (move left boundary 1 channel to the right), F9 (move right boundary 1 channel to the left), and F10 (move right boundary 1 channel to the right) to quickly adjust the ROI boundary.

9.4.3 Clear ROI

Drag a rectangle with the left mouse button, then right-click to clear the ROI, which will remove the ROI contained within the rectangle.

Right-click to clear all ROI, which will remove all ROIs from the spectrum.

9.5 Nuclide Library

9.5.1 Nuclide Information Search

The steps to search for nuclide information are as follows:

① Click on the search type bar in the Isotope Library to confirm whether to search by 'Nuclide' or 'Energy' and enter the nuclide or energy to be searched.

② Confirm whether to apply the intensity (branching ratio) and half-life search conditions, and enter the relevant values.

③ Click the 'Search' button, and the nuclide information list will display the nuclide information that meets the search criteria. To display all nuclide information in the library, click the 'Display All' button.

9.5.2 Create/Delete Custom Library

The steps to create a custom library are as follows:

① Click on 'Analysis - Nuclide Library' in the menu bar to open the nuclide library interface.

② Click 'New Library', enter a name, and click OK. At this point, a blank custom nuclide library is established.

The steps to delete a custom library are as follows:

① Click on the nuclide library to be deleted.

② Click the 'Remove Library' button below the nuclide information list, and then click OK.

9.5.3 Add/Delete Nuclides

Two methods are provided to add nuclide information to the custom library:

Select nuclide information from the Isotope Library to add to the custom library, the main operational steps are as follows:

① Click on 'Isotope Library', use the search bar to find the required nuclide, and click to select it.

② Click the 'Add To' button below the nuclide information list.

③ Select the nuclide library you want to add to, and click OK.

Add nuclides through the 'Add Nuclide' input bar below the custom library:

① Enter the nuclide **name, energy, intensity (branching ratio)** and its uncertainty, **half-life** and its uncertainty, decay nuclide, decay intensity, and decay type (**Note: Bolded items are required**).

② Click the ‘Add’ button.

The steps to delete nuclide information are as follows:

① Click on the nuclide to be deleted.

② Click the ‘Remove’ button below the nuclide information list, and then click Confirm.

9.5.4 Edit Nuclide Information

The steps to edit nuclide information are as follows:

① Double-click the cell to enter edit mode.

② Enter the new value.

③ Click the ‘Modify’ button below the nuclide information list to complete the modification of the nuclide information. To cancel the modification, click the ‘Cancel’ button.

Note: nuclide information in Isotope Library cannot be edited.

9.5.5 Import/Export Nuclide Library

The steps to import a nuclide library are as follows:

① Click the ‘Import’ button below the nuclide information list to pop up a window for selecting the nuclide library file (.lib).

② Select the nuclide library file to be imported and click Open.

The steps to export a nuclide library are as follows:

① Click the ‘Export’ button below the nuclide information list to pop up the save path window.

② Enter the ‘File name’, click Save, and it will be saved as a .lib file.

9.6 Energy Calibration

The software provides manual energy calibration and automatic energy calibration.

9.6.1 Manual Energy Calibration

The steps for manual energy calibration are as follows:

① Manually confirm the peaks and their corresponding energies in the spectrum.

② Mark ROI on the peaks with known energy in the spectrum.

③ Enable the Count Info mode or Peak Fit mode (Peak Fit is recommended).

④ Click ‘Calibration - Energy Calibration’ in the menu bar to open the energy calibration dialog box.

⑤ Click the channel input bar, then click the ROI on the spectrum. The center channel of the ROI will automatically fill into the channel input bar.

⑥ Click the energy input bar, enter the corresponding energy, and then click Add.

⑦ Repeat steps ⑤ and ⑥ until all required ‘channel – energy’ pairs are added.

⑧ Click ‘Fit’ to complete the energy calibration.

9.6.2 Automatic Energy Calibration

The steps for automatic energy calibration are as follows:

① Mark ROI for the main peaks in the spectrum.

② Click ‘Calibration - Energy Calibration’ in the menu bar to open the energy calibration dialog box.

③ Click the dropdown menu to the left of ‘Automatic Calibration’ and select the spectrum for the corresponding detector.

④ Click ‘Automatic Calibration’ and wait for the energy calibration to complete.

For precautions on using automatic energy calibration, see ‘4.3.1.2 Automatic Energy Calibration’.

9.7 Efficiency Calibration

Note: This feature is an upgraded version and requires the use of SuperDog key.

The software provides manual efficiency calibration and automatic efficiency calibration.

9.7.1 Manual Efficiency Calibration

The software provides two methods for manual efficiency calibration. The steps for the first method of manual efficiency calibration are as follows:

① Edit the applicable nuclide library and apply it.

② Open the spectrum to which the efficiency calibration is to be applied, and mark ROI on the peaks for efficiency calculation.

③ Enable the Count Info mode or Peak Fit mode (Peak Fit is recommended).

④ Click ‘Calibration - Efficiency Calibration’ in the menu bar to open the efficiency calibration dialog box.

⑤ Click the energy input field, then click the ROI on the spectrum, and the center energy of the ROI will automatically fill into the energy input field.

⑥ Click the efficiency input bar, enter the corresponding efficiency value, and add it. If the efficiency value is unknown, you can apply the ‘Calculation’ function. The steps to calculate efficiency using ‘Calculation’ are as follows:

a) Click the ‘Calculation’ button to open the ‘Efficiency Calculation Worksheet’

b) Confirm the nuclide identification information and the count rate information in the acquisition info. If incorrect, make corresponding modifications.

c) Enter the date, time, and activity of calibration source.

d) Click the ‘Calculation Efficiency’ button to obtain the efficiency value, then click ‘OK’ to automatically fill the efficiency value into the efficiency input field.

⑦ Repeat steps ⑤ and ⑥ until all the required ‘energy-efficiency’ pairs are added.

⑧ Confirm the formula type, click ‘Fit’ and complete the efficiency calibration.

The steps for the second method of manual efficiency calibration are as follows:

① Click ‘Calibration - Efficiency Calibration’ in the menu bar to open the efficiency calibration dialog box.

② Click the ‘Import’ button to add an already edited .csv file (which contains two columns of data, the first column being energy and the second column being efficiency, as shown in Fig.47).

③ Confirm the formula type, click ‘Fit’ and complete the efficiency calibration.

9.7.2 Automatic Efficiency Calibration

The steps for automatic efficiency calibration are as follows:

① Edit the applicable nuclide library and apply it.

② Open the spectrum to which the efficiency calibration is to be applied, and mark ROI on the peaks for efficiency calculation.

③ Enable the Count Info mode or Peak Fit mode (Peak Fit is recommended).

④ Click ‘Calibration - Efficiency Calibration’ in the menu bar to open the efficiency calibration dialog box.

⑤ Click the ‘Automatic Calibration’ button to pop up the Automatic Efficiency Calibration Dialog Box. Click ‘Add’ to add a blank list, double-click the cell to enter edit mode, and input the corresponding calibration source information, including nuclide, calibration activity, and calibration date. You can also import an already edited .csv file (which contains three columns of data: the first column is the nuclide name, the second column is the calibration activity, and the third column is the calibration date, as shown in Fig.49).

⑥ Click the ‘Start Calibration’ button to complete the automatic efficiency calibration.

Note: For the use and precautions of automatic efficiency calibration, see ‘4.3.2.2 Automatic Efficiency Calibration’.

9.8 Modify Device Name

The device name is displayed in the upper left corner of the spectrum window, settings window, and other functional windows. This name can be modified by double-clicking the device name in the Configuration software main window list or right-clicking and selecting "Modify Name" to open the Modify Name window. After entering the new name, press the "Enter" key on the keyboard to successfully modify it. The new name will be displayed in the upper left corner of each functional window in the software.

Note: For our company's latest hardware (October 2024 and later) MCA devices, the name will be written into the MCA device. For older versions of MCA devices, the modified name is only stored in the local software.

10 Summary of Keyboard and Mouse Operations

The summary of keyboard and mouse operations is shown in Tab.1 below:

Tab.1: Summary of Keyboard and Mouse Operations

Mouse	Left-click	① Click, select. ② Control the vertical positioning of the marker line. ③ Hold down the left mouse button to drag a rectangle, which can be used for ROI operations on the spectrum. Under the screenshot function, it is used to select the screenshot area. ④ In the list window, hold down the left mouse button and drag the mouse up and down to select multiple lines continuously. ⑤ Ctrl + left-click for multiple selection. ⑥ Shift + left-click to select multiple lines continuously.
	Double-click with the left mouse button.	① Double-click on a peak in the spectrum to automatically locate a single peak and mark the ROI (this function is available after energy calibration). ② Double-click on the top bar of the window to maximize/restore the window.
	Scroll wheel	① Scroll the wheel to zoom in/out on the spectrum along the X-axis based on the mouse position. ② Ctrl + scroll wheel to zoom in/out on the spectrum along the Y-axis. ③ Press the wheel button to pan the spectrum (along the X-axis).
Keyboard	F1	Open the About GammaSense dialog box
	F7	With mark enabled, ROI left boundary shifts left by 1 channel / With mark disabled, vertical marker line shifts left by 10 channel.
	F8	With mark enabled, ROI left boundary shifts right by 1 channel / With mark disabled, vertical marker line shifts right by 1 channel.
	F9	With mark enabled, ROI right boundary shifts left by 1 channel / With mark disabled, vertical marker line shifts left by 1 channel.
	F10	With mark enabled, ROI right boundary shifts right by 1 channel / With mark disabled, vertical marker line shifts right by 10 channel.
	F11	Full Spectrum display.
	+ or =	Vertical marker line shifts right by 1 channel.
	-	Vertical marker line shifts left by 1 channel.
	←	Based on the vertical marker line, zoom out the spectrum along the X-axis, with the Y-axis automatically scaling proportionally.
	→	Based on the vertical marker line, zoom in the spectrum along the X-axis, with the Y-axis automatically scaling proportionally.
	↑	Zoom in the spectrum along the Y-axis.
	↓	Zoom out the spectrum along the Y-axis.
	Alt+F1	Linear display.
	Alt+F2	Logarithmic display.
	Alt+S	Open Device List.
	Ctrl+F4	Exit software.
	Ctrl+O	Open spectrum.
	Ctrl+P	Export spectrum
	Ctrl+S	Save spectrum
	Ctrl+Alt+S	Enable Screenshot function

APPENDIX A: Activity Calculation Formula

$$A = \frac{(N_s/T_s - N_b/T_b) \times F_{MP} \times F_{Sam} \times F_{CS}}{F_{SA} \times \varepsilon \times P \times F_{CP}}$$

In the above formula:

A: The activity of nuclides in the sample, the unit is *Bq*.

N_s: Net count of the full-energy peak in the sample measurement.

T_s: Live time of sample measurement, the unit is *s*.

N_b: Net count of background peak.

T_b: Live time of background measurement, the unit is *s*.

F_{MP}: The decay correction factor for short-lived nuclides during the measurement period. If the half-life of the nuclide being analyzed is greater than 100 times the sample measurement time, F_{MP} can be set to 1. $F_{MP} = \frac{\lambda T_c}{1-e^{-\lambda T_c}}$.

F_{Sam}: The decay correction factor for short-lived radionuclides during the sampling period, assuming that the concentration of the radionuclides in the air and during the sampling process is constant. $F_{Sam} = \frac{\lambda T_S}{1-e^{-\lambda T_S}}$. Suitable for aerosol samples.

F_{CS}: The coincidence summing correction coefficient. For nuclides emitting single-energy rays, or when the corresponding correction coefficient for the analyzed rays is not significant, the F_{CS} can be taken as 1. Otherwise, the F_C should be estimated.

F_{SA}: The self-absorption correction coefficient for the sample with respect to the efficiency calibration source. If the density of the sample is the same or similar to the density of the efficiency calibration source, the F_{SA} is taken as 1.

ε: The detection efficiency of the full-energy peak for the corresponding energy γ-ray.

P: The emission branching ratio of the corresponding energy γ-ray.

F_{CP}: The decay correction coefficient during sample cooling period, which is the decay correction for the time interval from the start of sampling to the start of sample measurement. $F_{CP} = e^{-\lambda \Delta t}$.

In the calculation formula for F_{MP}, F_{Sam} and F_{CP}:

λ: Decay constant, the unit is s^{-1}. $\lambda = \frac{ln2}{T_{1/2}}$, $T_{1/2}$ is half-life, the unit is *s*.

T_c: The real-time duration for sample measurement, in seconds (s).

T_S: The duration of the sampling period, which is the time interval from the start of sampling to the end of sampling, measured in seconds (s).

Δt: The decay time for the nuclide, which is the time interval from the start of sampling to the start of sample measurement, the unit is *s*. For aerosol samples, it refers to the time interval between the end of sampling and the beginning of measurement.

e: The natural constant.

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