

USB-MCA-AMP

APG7305B

Instruction Manual

Version 1. 4. 0

JUL. 2026

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Safety Precautions / Disclaimer

Thank you very much for purchasing the USB-MCA-AMP, Model: APG7305B (hereinafter "This device") of TechnoAP Co., Ltd. (hereinafter "We"). Please read this "Safety Precautions / Disclaimer" before using this device, be sure to observe the contents, and use it correctly.

We are not responsible for any damage caused by abnormality of device, detector, connected device, application, damage to failure, other secondary damage, even if accident caused by using this device.



Prohibited matter

- Cannot be used for applications that require special quality and reliability related to human life and accidents.
- Please refrain from using in places with high temperature, high humidity and vibration (excluding countermeasures).
- Do not apply power that exceeds the rating.
- Do not turn on the board product with other metals in contact with the board surface.



Cautions

- If there is smoke or abnormal heat generation, turn off the power immediately.
- It may not work properly in a noisy environment.
- Be careful of static electricity.
- Product specifications and related documents are subject to change without notice.

Warranty conditions

The warranty conditions for "our products" are as follows.

- Warranty period: One year after purchase.
- Warranty details: If the product breaks down during use within the warranty period, it will be repaired or replaced.
- Not covered by warranty: We do not guarantee if the cause of failure falls under any of the following.
 - (A) Use other than the original usage of "our products"
 - (B) In addition to the above, causes other than "our company" or "our products" (including force majeure such as natural disasters)
 - (C) Consumables, etc.

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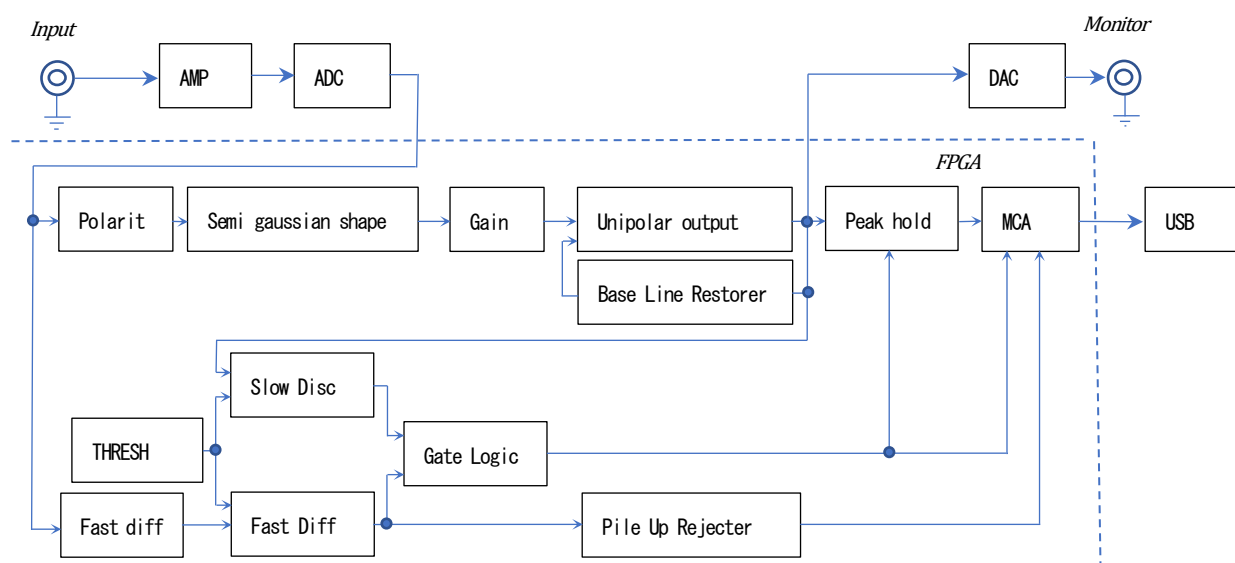
1. Overview

USB-MCA-AMP (One-channel Multi Channel Analyzer with built-in spectroscopy amplifier) Model: APG7305B (hereinafter this device) is connected to a semiconductor detector, proportional counter, scintillation detector, etc. is an MCA that can directly input the preamp output signal. This device is equipped with a traditional analog circuit spectroscopy amplifier function, and parameters such as shaping time, gain and pole zero are set from the application on the PC. Based on the setting, the peak value is calculated by digital signal processing of semi-Gaussian waveform shaping. It does not use an AC adapter for power. A lightweight and compact MCA that operates only with USB bus power.

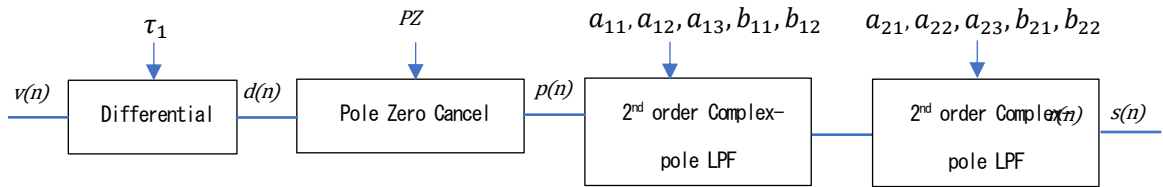
There are usually two operations related to measurement: histogram mode and waveform mode. In the histogram mode, spectral data is generated with energy wave height values such as keV on the horizontal axis and counts on the vertical axis. In waveform mode, input signal such as detector preamplifier output to this device, timing processing signal (fast), semi-Gaussian waveform (slow) to PC. It can be used for gain or pole zero adjustment.

The software that comes with this device is driver software and applications that run on Windows.

This manual explains the handling of this device.



【Semi Gaussian shaping】



$$d(n) = v(n) - v(n-1) + \tau_1 * d(n-1),$$

$$p(n) = v(n) * PZ + d(n),$$

$$r(n) = a_{11}p(n) + a_{12}p(n-1) + a_{13}p(n-2) + b_{11}r(n-1) + b_{12}r(n-2),$$

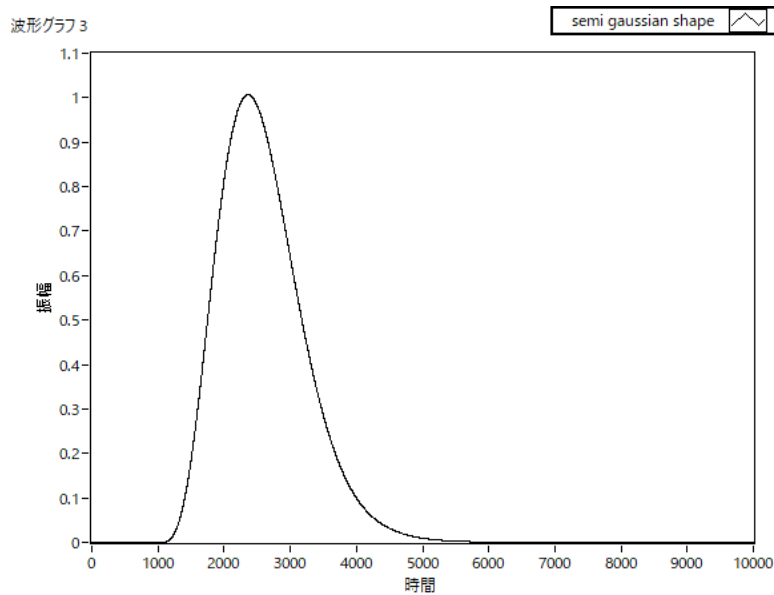
$$s(n) = a_{21}r(n) + a_{22}r(n-1) + a_{23}r(n-2) + b_{21}s(n-1) + b_{22}s(n-2),$$

Where:

τ_1 : differential time ,

$a_{11}, a_{12}..b_{22}$: integral time

PZ : polezero



Specifications

Product name: USB-MCA-AMP * Same as the attached application name

Model: APG7305B * Including products with alphabets following the model

Analog Input	1 channel
Input range	$\pm 1.5V$ * Preamplifier output signal
Waveform processing	Semi-Gaussian peaking time 2.2τ
Shaping time	0.25, 0.375, 0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 6, 8, 10 μs
Baseline restorer	Auto active gate
Gain	x 1 to x 500
ADC Gain	4096, 2048, 1024, 512, 256 channel
Peak detection mode	Absolute pulse
Throughput	50 kcps or more
Integral nonlinearity	$\pm 0.025\%$ or less
Derivative non-linearity	$\pm 1\%$ or less
Threshold	0 to 50% Full-scale from PC
ADC LLD	0 to 100% Full-scale from PC
ADC ULD	0 to 100% Full-scale from PC
External input	GATE and VETO
Operation mode	Histogram and Waveform
Communication I / F	USB 2.0, USB mini-B, Plug: Receptacle * Connect this device to a USB port capable of supplying power of USB 3.0 or more and 0.6A or more. If the power supply capacity of the USB 2.0 port is 0.5A, it may not work properly or may cause a failure. * USB cable length of 2 m or less is recommended. In the case of laptop PC, please cancel if there is a low power consumption setting in the USB port or use a USB hub with power supply by AC adapter. Some USB hubs may require a ground connection with the detector or PC.
Software	Windows OS version, Application USB-MCA-AMP software and Driver software
Dimension	70 (W) x 160 (D) x 20 (H) unit: mm
Weight	About 230g
Accessories	Manual CD-ROM for Driver and Application software installation USB cable * Cable with USB (A) male and USB (Mini-B) male connectors

2. Appearance

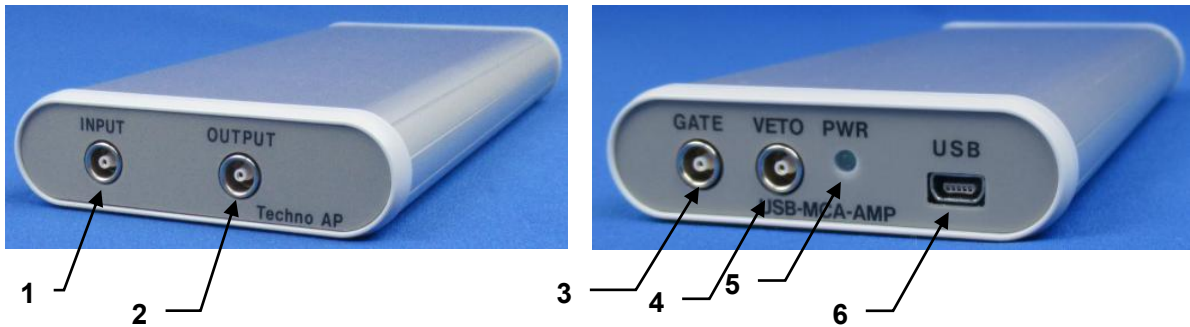


Image. 1 APG7305B

Front		
1	INPUT	LEMO (EPL.00.250.NTN) connector for preamplifier signal input
2	OUTPUT	LEMO (EPL.00.250.NTN) connector for signal processing result selection DAC output
Back		
3	GATE	LEMO (EPL.00.250.NTN) connector for external GATE signal input. Input LV-TTL level signal. Input HIGH for data acquisition, LOW for data not acquired.
4	VETO	LEMO (EPL.00.250.NTN) connector for external VETO signal input. Input LV-TTL level signal. Input HIGH for data not acquired, LOW for data acquisition
5	PWR	LED lights up when the power is on (connected to a PC).
6	USB	USB 2.0 Mini-B receptacle (female)

*Conversion adapter

For the signal input connector to this device, use LEMO, EPL.00.250.NTN or a connector of equivalent shape. When using a signal cable with a BNC connector, it is possible to connect to this device by using the following conversion adapter.

Manufacturer: HUBER+SUHNER
Model: 33_QLA-BNC-01-1/1--_NE
Specifications: QLA-01 to BNC

Connector Gender 1: Interface QLA-01
Connector Gender 2: Interface BNC



Image. 2 33_QLA-BNC-01-1/1--_NE

If the adapters interfere with each other, use the LEMO-BNC conversion cable as shown in the photo below.

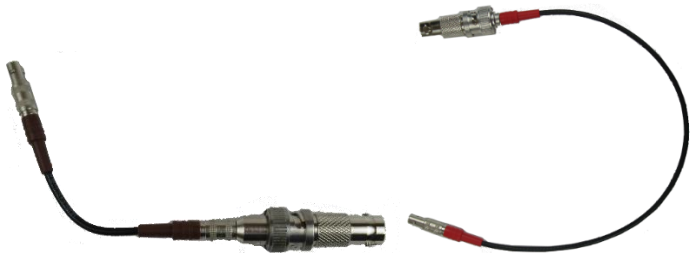


Image. 3 LEMO-BNC conversion cable

3. Setup

3. 1. Connection

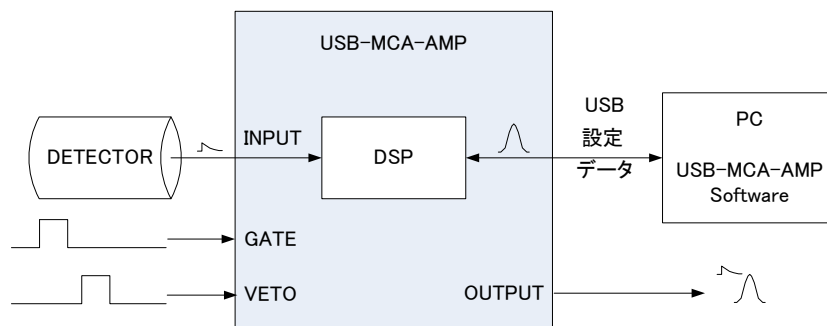


Fig. 1 Connection when using MCA

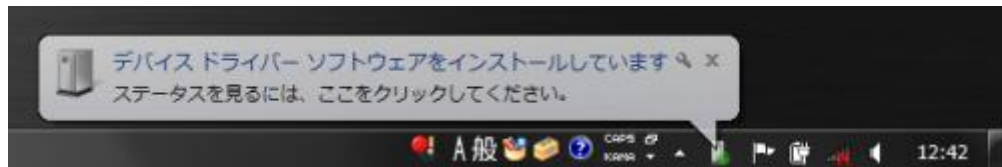
1	Connect USB-MCA-AMP and PC with the supplied USB cable. NOTE: It is necessary to install the driver software on the PC to be connected for the first time. See below for how to install the driver software. NOTE: Do not connect the signal cable from the detector when the power of this device is OFF.
2	Check that the "PWR" LED lights up to indicate that the power is on.
3	Connect the preamp output signal of the detector (DETECTOR shown above) to the "INPUT" of this device.
4	If control by an external signal is required, input the LV-TTL level to the GATE or VETO terminal. When a peak is detected with a cable connected to the GATE terminal, data is acquired when the signal is open or high. Or when detecting a peak with a cable connected to the VETO terminal, data is acquired when the signal is open, or the signal is low.

3. 2. Installation of the driver software

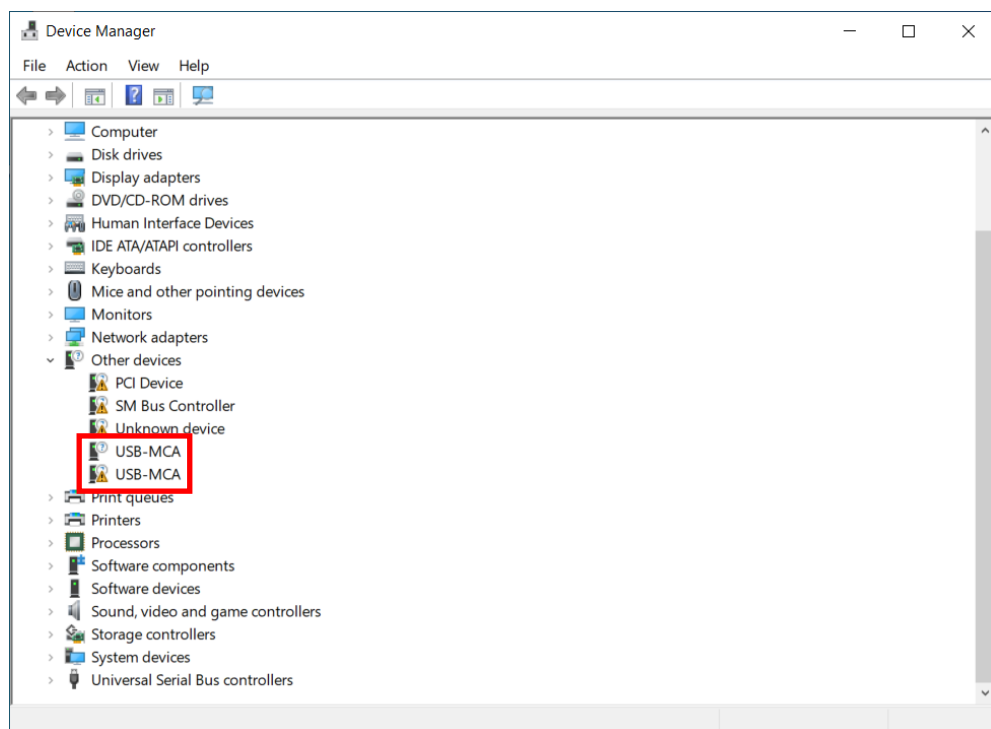
The first time you connect this device to the computer, you need to install the driver software from the included CD-ROM.

For Windows 7

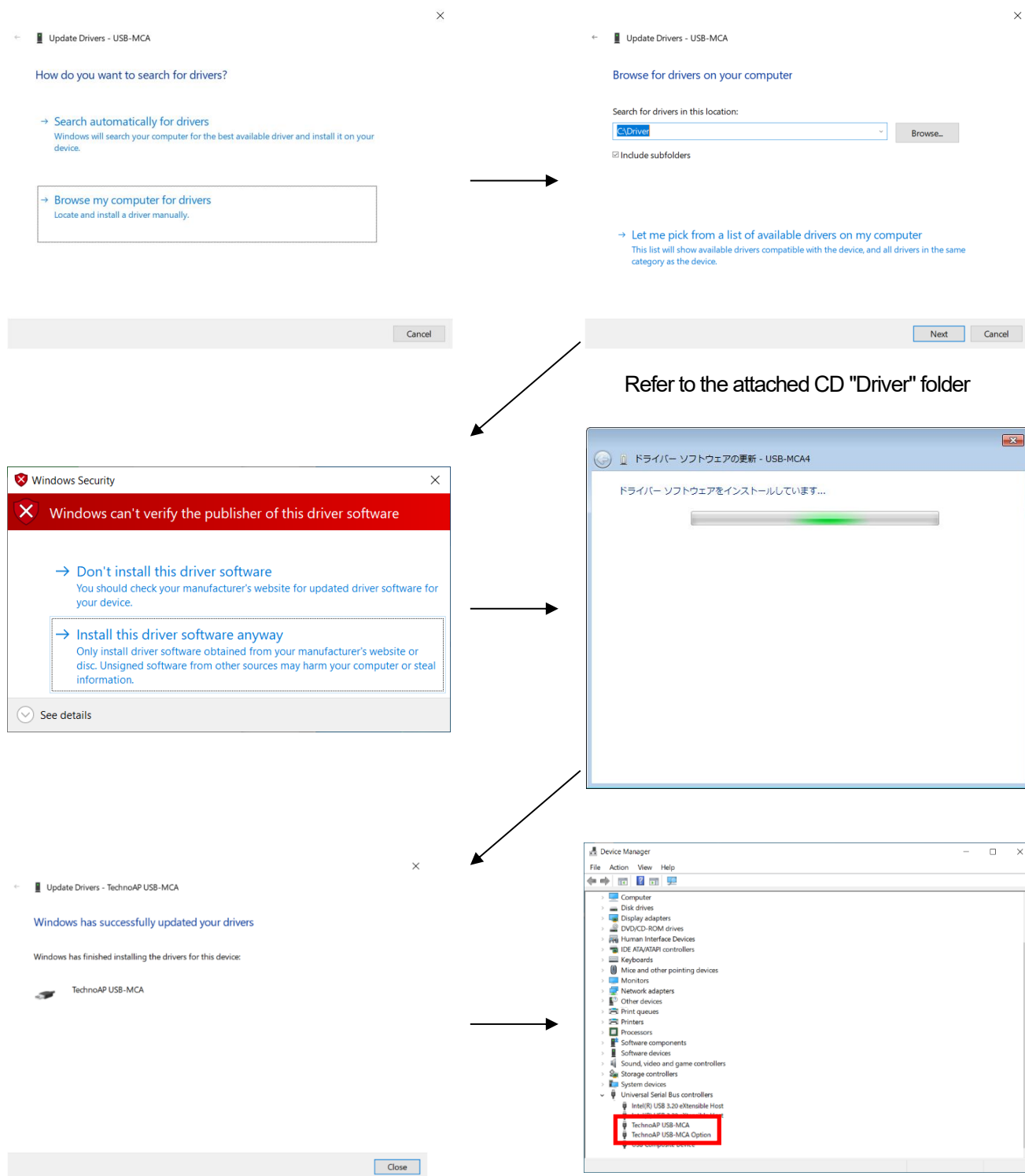
- (1) **REQUIRED** Log in as Administrator or log in as an account with administrator privileges.
- (2) Connect this device to a PC with a USB cable.
- (3) "Installing device driver software" is displayed at the bottom right of the desktop.



After this, if the message "The device driver software was not installed correctly" is displayed, open the device manager, and check the "USB-MCA-AMP" icon. Right-click on the icon and click "Update Driver Software".



(4) Proceed with the installation interactively.

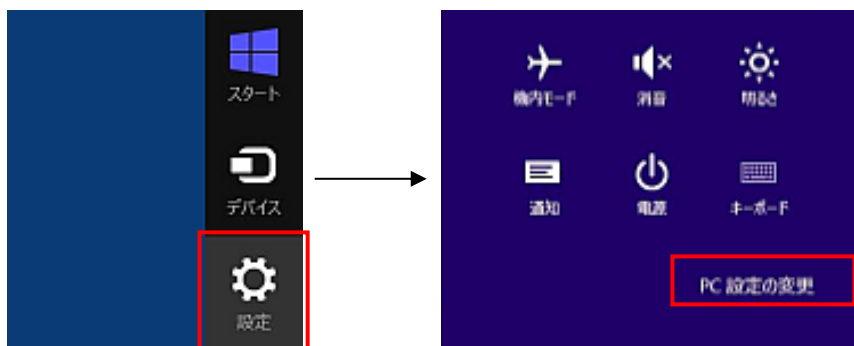


Next, install "Techno AP USB-MCA-AMP Option". After installing the "Techno AP USB-MCA-AMP" driver software, install the "Techno AP USB-MCA-AMP Option" using the same procedure. In Device Manager, check that the two icons "Techno AP USB-MCA-AMP" and "Techno AP USB-MCA-AMP Option" are normal. After successfully installing the driver software, install the application. The installation procedure is described in the next chapter.

For Windows 8 (64bit)

In Windows8 (64bit), driver software without a digital signature cannot be installed by default to prevent users from accidentally installing driver software. This driver software does not have a digital signature, so you need to "disable driver signature enforcement" by following the steps below before installing.

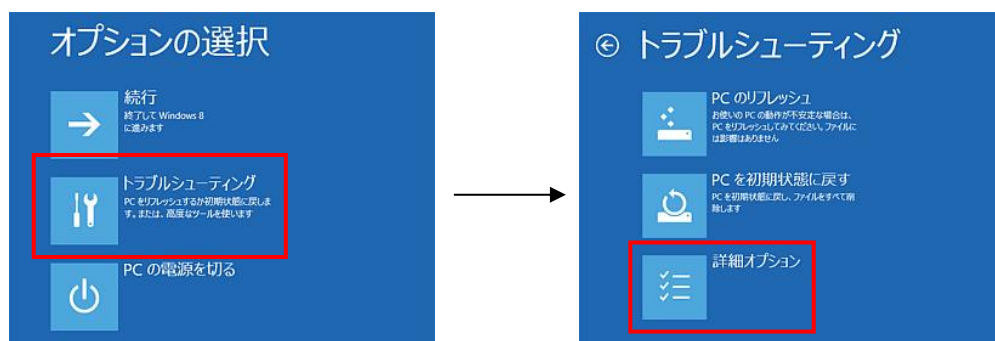
- (1) Display the charm on the start screen
 - For mouse operation: Move the mouse to the upper right or lower right corner of the screen.
 - For touch operation: Swipe from the right side of the screen toward the center.
- (2) Select "Settings" from the charms and select "Change PC settings" from the settings menu.



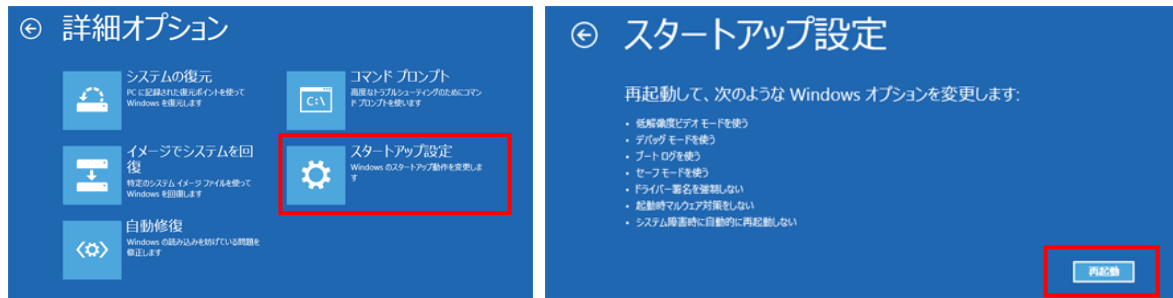
- (3) Select "General" from the "PC Settings" screen, and then select "Customize PC startup"-"Restart now".



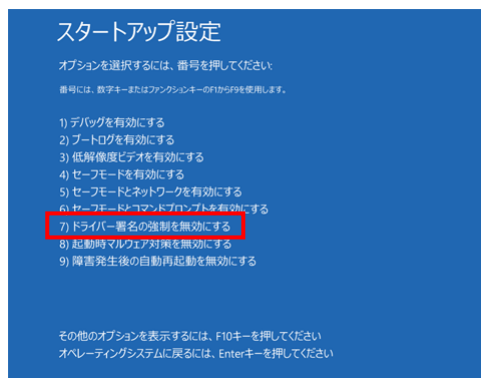
- (4) Select "Troubleshooting" from the "Choose Options" screen, and select "Advanced Options" from the "Troubleshooting" screen.



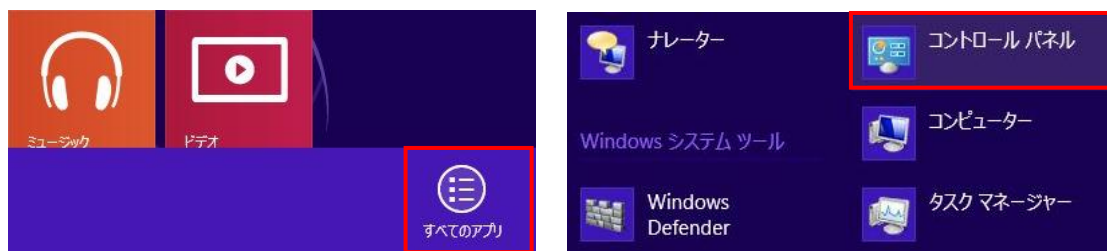
- (5) Select "Startup Settings" from the "Advanced Options" screen, and then select "Restart" from the "Startup Settings" screen.



- (6) After restarting, press the "7" key on the "Startup Settings" screen and select "7) Disable driver signature enforcement".



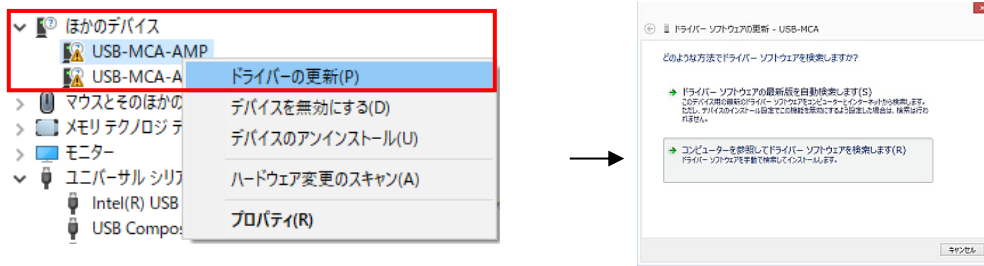
- (7) **REQUIRED** After rebooting, log in as Administrator or log in with an account with administrator privileges.
 (8) Connect USB-MCA-AMP to your PC with a USB cable.
 (9) Right-click on the Start screen to display the "Apps Bar", select "All Apps", and then select "Control Panel" from the "Apps" view.



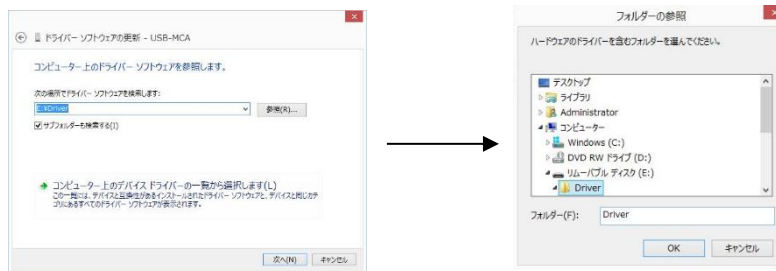
- (10) Select "Device Manager" from "Control Panel" to display "Device Manager".



- (11) Right-click "USB-MCA-AMP", select "Update Driver Software (P)", and select "Browse my computer for driver software (R)".



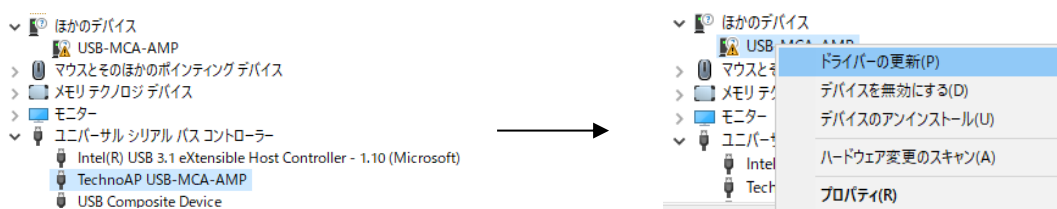
- (12) When the "Update Driver Software" screen is displayed, select "Browse (R)", and when the "Browse for Folder" screen is displayed, select the drive where the "USB-MCA-AMP" driver software is stored. Select OK. When you return to the "Update Driver Software" screen, select "Next (N)".



- (13) When the "Windows Security" screen appears, select "Install this driver software (I)". When the message "Driver software has been updated successfully" is displayed, select "Close (C)".



- (14) When "Techno AP USB-MCA-AMP" is displayed on the "Device Manager" screen, right-click the remaining "USB-MCA-AMP" and repeat from (11) to update the remaining driver software.

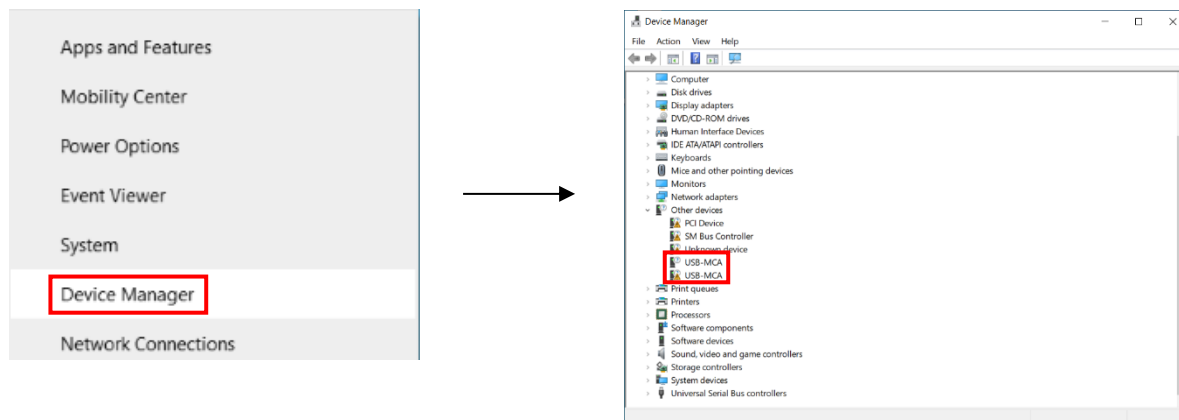


- (15) The "Techno AP USB-MCA-AMP Option" is displayed on the "Device Manager" screen, and the driver software installation is complete.



For Windows 11 and Windows 10

- (1) **(Required)** Log in as an Administrator or with an account that has administrator privileges.
- (2) Connect the USB-MCA-AMP to your PC using the USB cable.
- (3) Right-click the Start button and select "Device Manager" from the pop-up menu.



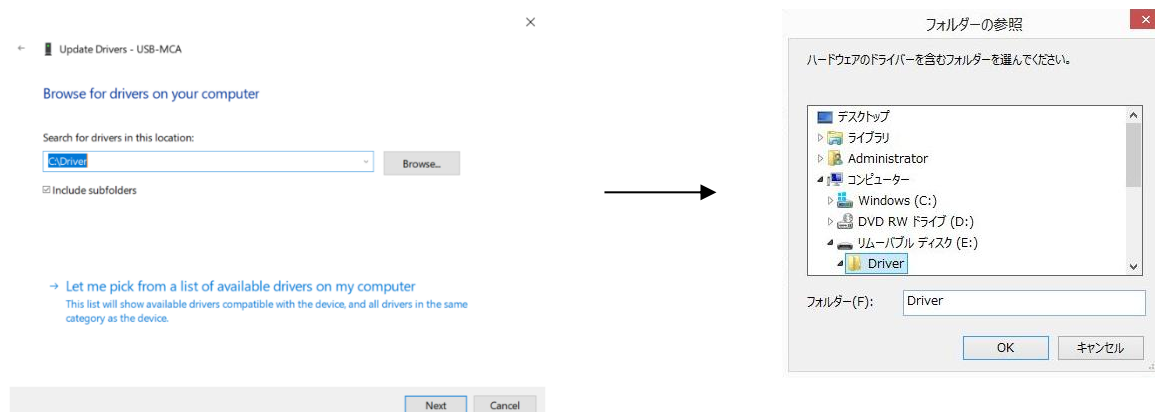
- (4) Right-click one of the "USB-MCA-AMP" entries, select "Update driver", and then select "Browse my computer for drivers".



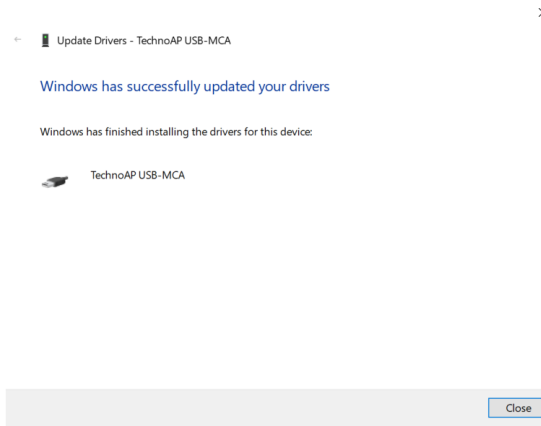
- (4) When the "Update Drivers" window appears, click "Browse...".

When the "Browse For Folder" window appears, select the folder where the USB-MCA-AMP driver software is saved (Driver\Windows10-11), and click "OK".

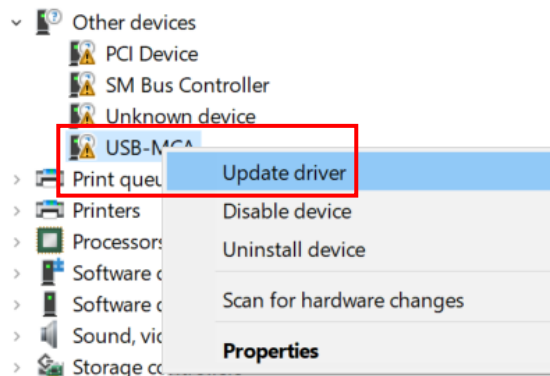
Once you return to the "Update Drivers" window, click "Next".



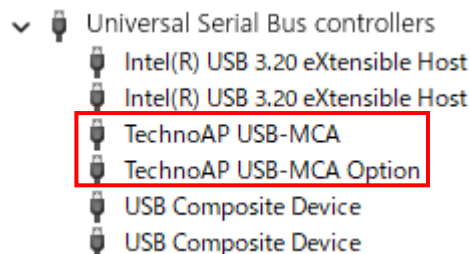
(6) When the message "Windows has successfully updated your drivers" is displayed, click "Close".



(7) Right-click the remaining "USB-MCA-AMP" entry and repeat the steps from (5) to update the remaining driver software.



(8) The driver software installation is complete when "TechnoAP USB-MCA-AMP" and "TechnoAP USB-MCA-AMP Option" are displayed in the Device Manager window.

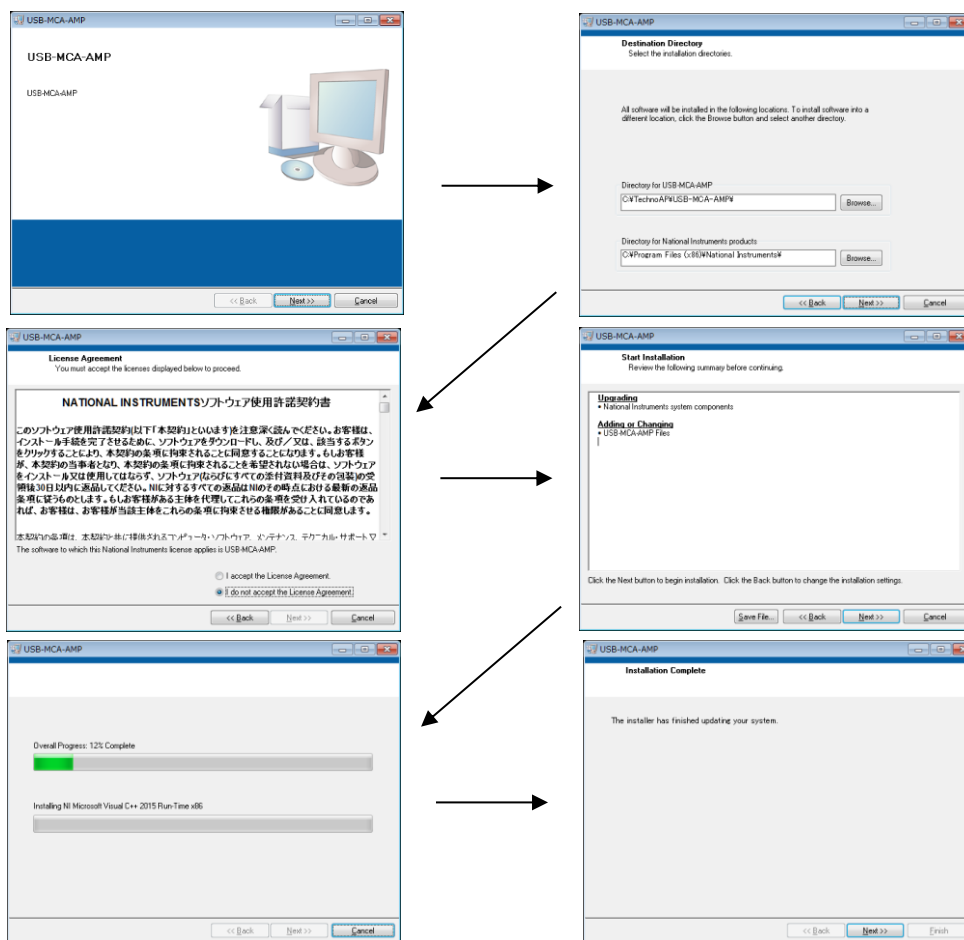


3. 3. Installation of the application software

After the driver software has been successfully installed as described in the previous chapter, you need to install the USB-MCA-AMP application (the executable file) and the LabVIEW runtime engine, which is the development environment. The installer on the included CD contains the USB-MCA-AMP application and the LabVIEW runtime engine, which can be installed at the same time. The installation procedure is as follows.

For Windows 7 * Same for Windows 8

- (1) **REQUIRED** Log in as Administrator or log in as an account with administrator privileges.
- (2) Execute "setup.exe" in the "Application" folder in the attached CD. Proceed with the installation interactively.

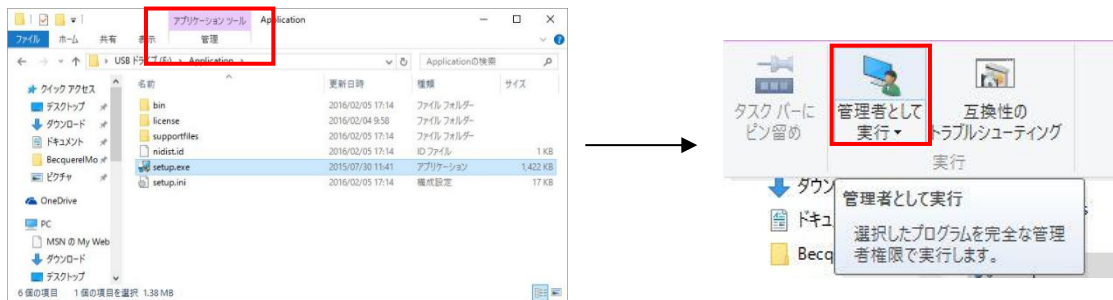


- (3) Execute "Start Button"-"Techno AP"-"USB-MCA-AMP".
- (4) The application "USB-MCA-AMP" will start.

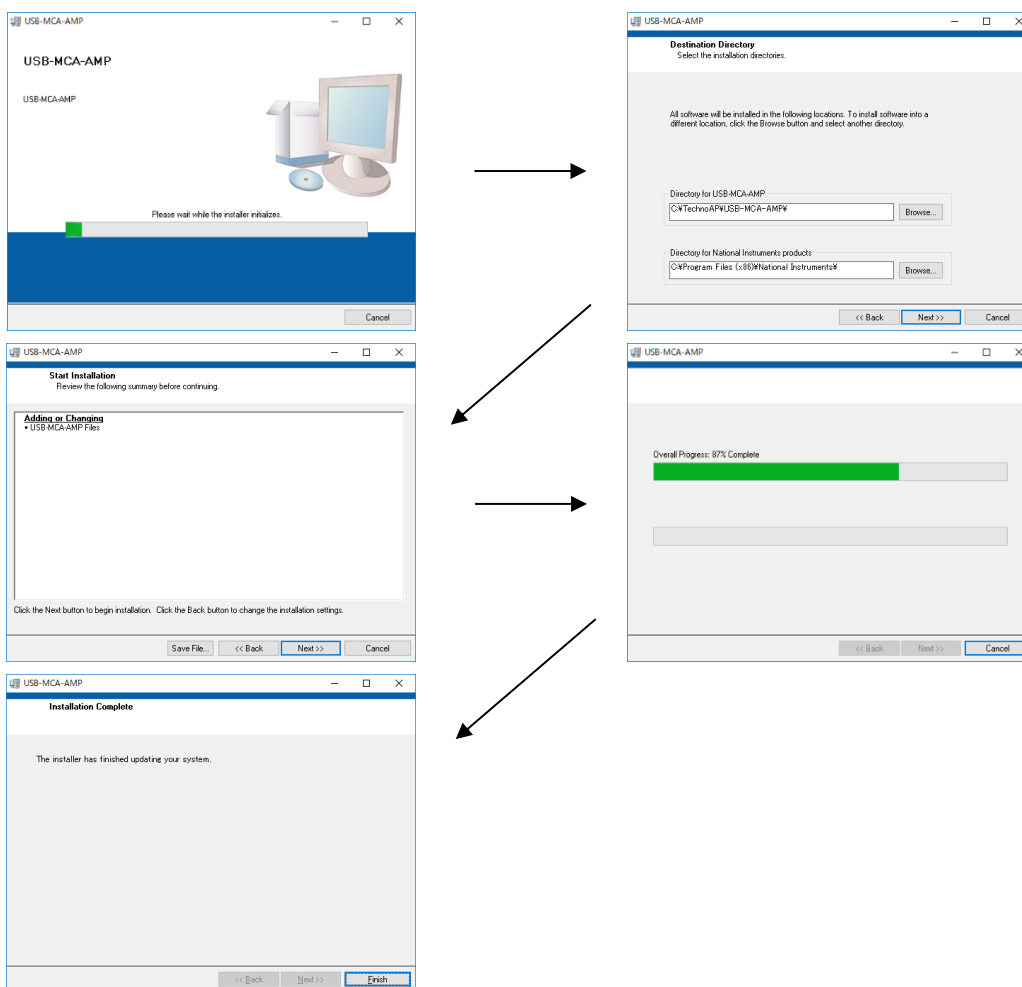
If the "connection error" dialog is displayed immediately after startup, check whether the device is properly connected to the PC and whether the device is recognized by the device manager.

For Windows 10

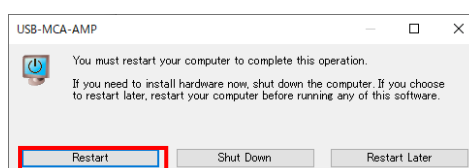
- (1) Select "Setup.exe" in the "Application" folder in the supplied CD. Select "Manage" in the application tool of the menu and select "Run as administrator".



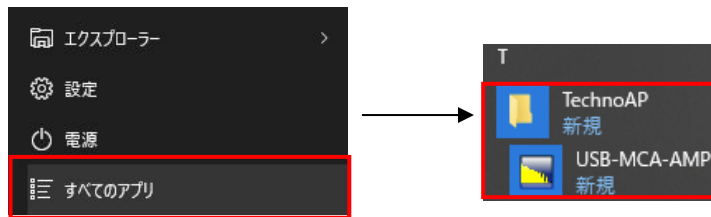
- (2) Run "Setup.exe" in the "Application" folder in the supplied CD. Proceed with the installation interactively.



- (3) Display the computer restart, click the "Restart" button to restart.



- (4) Right-click the "Windows" mark  at the bottom left of the screen to display "Menu" and execute "All apps"-
"TechnoAP"-"USB-MCA-AMP".



- (5) The application "USB-MCA-AMP" starts up.

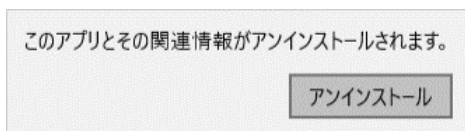
If a "connection error" dialog is displayed immediately after startup, check if the device is correctly connected to the PC or if the device manager recognizes the device.

* Uninstall

To uninstall, select "USB-MCA-AMP" from "Settings"-"System"-"Apps and Features" and select "Uninstall".



"Uninstall this application and its related information will be stalled easily" is displayed. Select "Uninstall".



4. Application screen

4. 1. Startup screen

Execute in order of start button, "TechnoAP", "USB-MCA-AMP". Alternatively, if you execute the shortcut icon "USB-MCA-AMP" on the desktop, the following startup screen will be displayed.

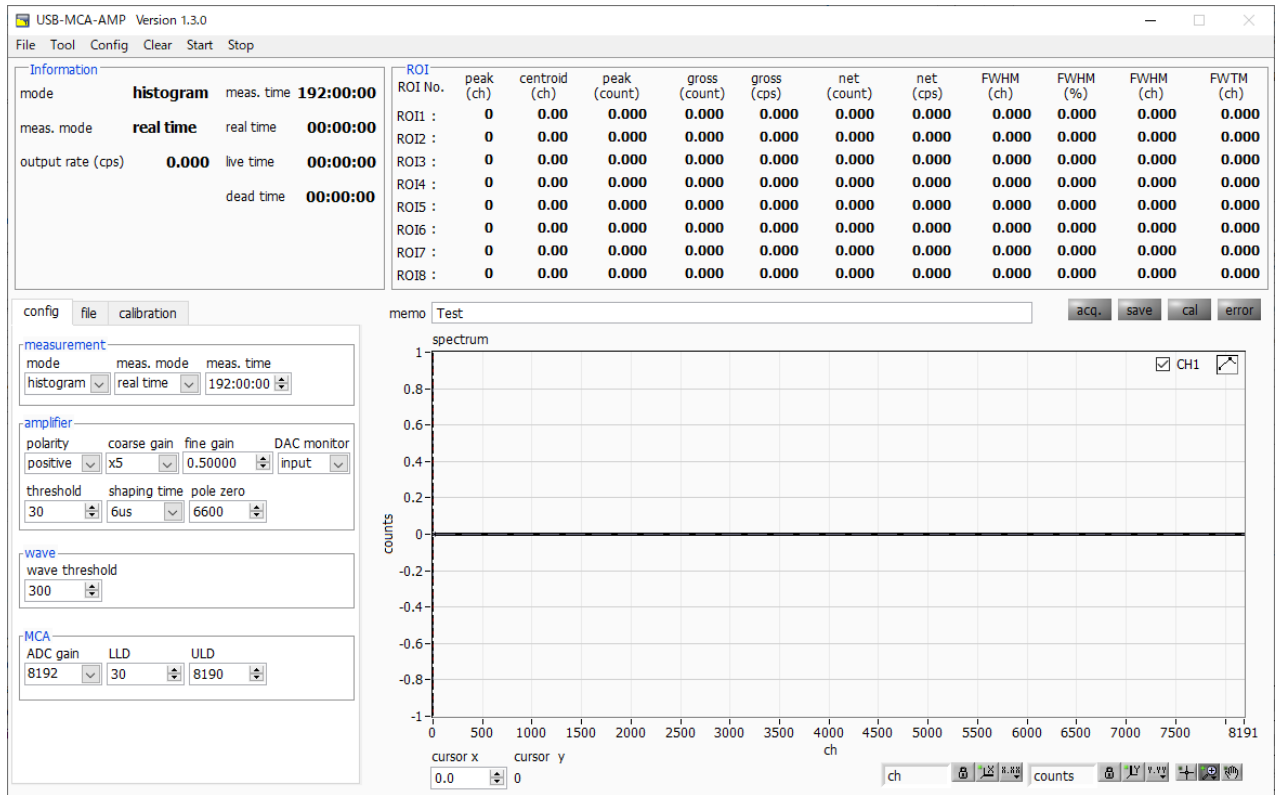


Fig. 2 Startup screen of USB-MCA-AMP

Menu section

File - open config	Reading the configuration file
File - open histogram	Reading histogram data file
File - open wave	Reading waveform data file
File - save config	Save the current settings to a file
File - save histogram	Save current histogram data to file
File - save wave	Save waveform data to file
File - save image	Save this device screen as PNG format image
File - quit	Terminate this application
Tool - gauss fit analysis	Open gauss fit screen. Performs Gaussian fitting on the specified peak and performs half-value width analysis, etc.
Tool - peak search analysis	Open peak search screen. Perform peak detection on histogram data and perform half-value width analysis, etc.
Config	Send all settings to this device
Clear	Initialize histogram data in this device
Start	After sending all settings to this device, send measurement start to this device
Stop	Send measurement stop to this device

Tab section

config	Measurement settings
file	File settings
calibration	Settings such as ROI (Region Of Interest) for energy calibration

Information section

mode	Display "histogram" and "wave"
meas. mode	Measurement mode. Display "real time" or "live time"
meas. time	Set measurement time
real time	Real time (actual measurement time)
live time	Live time (effective measurement time). Real time minus dead time (see below)
dead time	Dead time (invalid measurement time). real time minus live time This is the dead time from when the input signal exceeds "threshold" (described later) to when a peak is detected, and its peak value is determined.
output rate (cps)	Number of counts per second between LLD and ULD, secured as a peak

ROI section

Display the calculated result between ROIs for each channel.

peak (ch)	Channel with maximum count
centroid (ch)	Center value (ch) calculated from the sum of all counts
peak (count)	Maximum count
gross (count)	Sum of counts between ROIs
gross (cps)	Sum of counts between ROIs per second
net (count)	Sum of counts minus background between ROIs
net (cps)	Sum of counts minus background between ROIs for 1 second
FWHM (ch)	Half width (ch)
FWHM (%)	Half width / Peak value * 100
FWHM	Half width
FWTM	1/10 the width of the peak

acq. LED	Blinks during measurement
save LED	Lights up while saving data
cal LED	Lights up while calculating data between ROIs
error LED	Lights up when an error occurs

4. 2. Quit screen

To exit the application, click "File" and then "quit" on the menu bar. After execution, the following confirmation screen for ending is displayed.

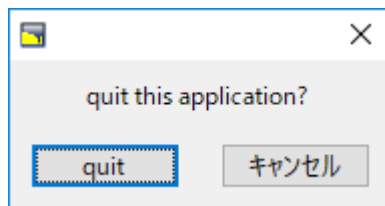


Fig. 3 Quit confirmation window

Click the "quit" button to finish. After execution, the application screen disappears and ends.

4. 3. config tab

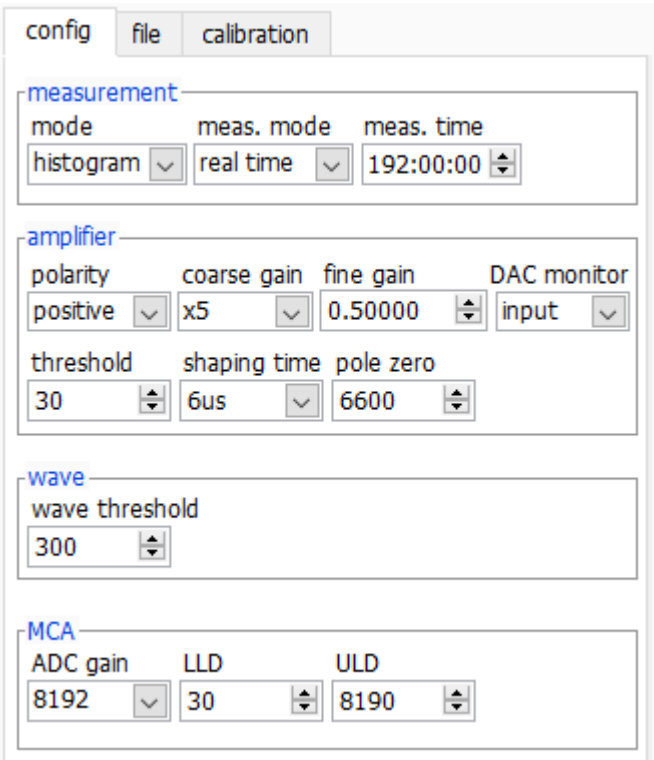
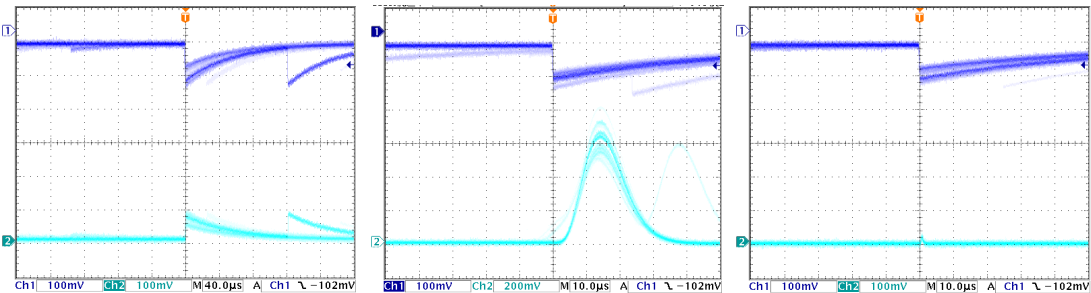
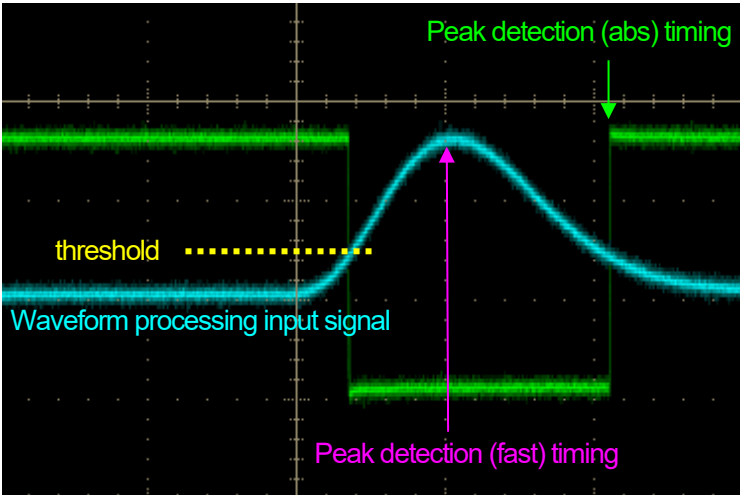


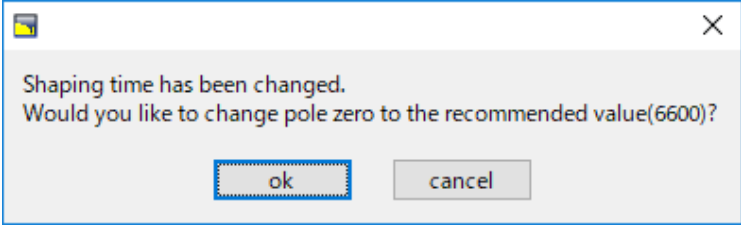
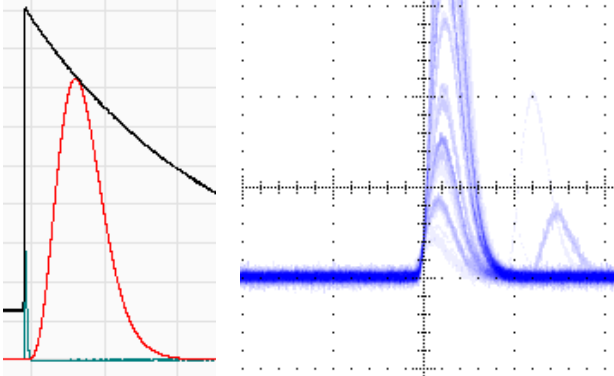
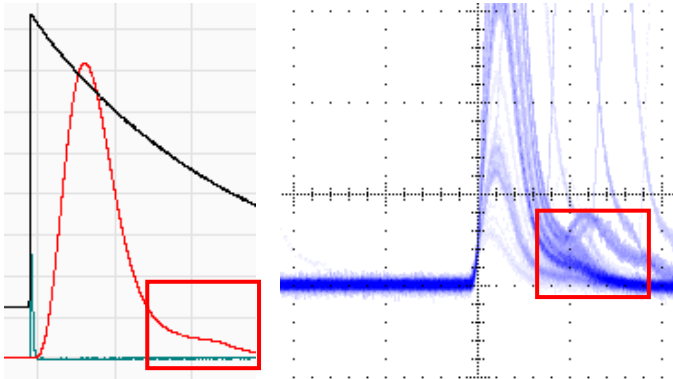
Fig. 4 config tab

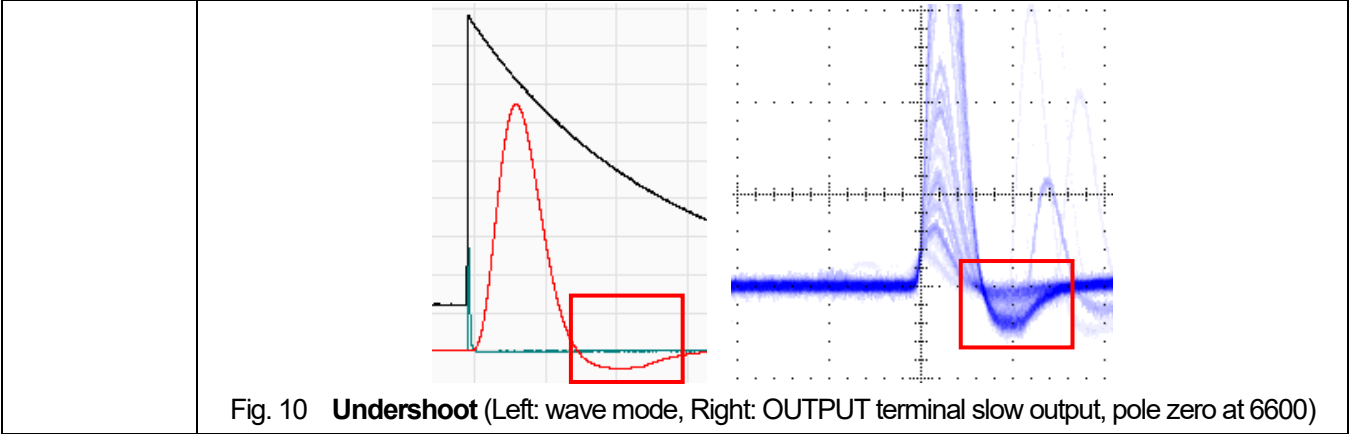
measurement section

mode	Operation mode selection	
	histogram	Store the preamp signal peak value on up to 4096 channels. A histogram with energy on the horizontal axis and counts on the vertical axis is created.
	wave	Displays the waveform of the input signal (such as the preamplifier output from the detector) to this device, the timing processing signal (fast) inside this device, and the semi-Gaussian waveform (slow) preamplifier signal.
meas. mode	Select "real time" or "live time" as the measurement mode.	
	real time	Measures preset time data.
	live time	It measures until the effective measurement time (the difference between real time and dead time) reaches a preset time.
meas. time	Measurement time setting. The setting range is 0 to 192 hours (8 days). When set to 0, there is no stop by the measurement time, and even if it exceeds 192 hours, the measurement is continued until you click "Stop" on the menu bar.	

amplifier section

polarity	Input signal polarity selection. Select “positive” for positive polarity and “negative” for negative polarity.
coarse gain	Selection of course gain. For the analog input signal, select from “× 1”, “× 2”, “× 5”, “× 10” and amplify by the magnification. The recommendation is “× 1”, but if the wave height of the input signal is small, increase it to “× 2” or more. As described later, select “input” in “DAC monitor”, display the signal from the OUTPUT terminal with an oscilloscope, and set so that it can be settled within 2 V without saturation.
fine gain	Fine gain setting. Multiply the generated semi-gaussian waveform.
DAC monitor	The status of the input signal or signal processing acquired by this device is analog output from the OUTPUT terminal on the front panel. The waveform to be output is selected from one of "input", "slow" and "fast". Make sure that all are within 2 V and not saturated.  Detector signal and input, Detector signal and slow, Detector signal and fast
threshold	Set the threshold for the waveform acquisition start timing. The unit is digit. The setting range is 0 to 4095. Set to a value less than or equal to LLD. Triggers peak detection and AD conversion when the waveform shaping input signal exceeds the threshold setting value. If you set this setting too high, you will not get low energy peak values. Conversely, if the setting is too small, noise will be spread out. If "ADC gain" is "4096", set "threshold" and "LLD" to about 100 at first. While looking at the "output rate" and the histogram, gradually lower it to determine the boundary between noise that increases in value and use the value slightly higher as the threshold.  Peak detection (abs) timing threshold Waveform processing input signal Peak detection (fast) timing Fig. 6 threshold and peak detection (abs) timing

shaping time	Performs semi-Gaussian waveform shaping on the preamp output signal to improve S / N. The setting value is selected from the following. 0.25, 0.375, 0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 6, 8, 10 μs The shaping time constant (peaking time) is 2.2τ (tau). If you change the settings, you also need to change "pole zero" described later. By clicking on the "ok" button in the following dialog that appears when changing this setting, you can see the standard value of pole zero.  Fig. 7 Dialog asking for confirmation of pole zero
pole zero	This setting is for the end of the semi-Gaussian shaped signal. The default value is 6600 (when shaping time is 6 μs). Select slow in wave mode or DAC monitor and check the output signal of the OUTPUT terminal with an oscilloscope. Adjust this value so that it is flat if there is an overshoot or undershoot as shown below.  Fig. 8 Correct (Left: wave mode, Right: OUTPUT terminal slow output, pole zero at 6600)  Fig. 9 Overshoot (Left: wave mode, Right: OUTPUT terminal slow output, pole zero at 6600)



wave section

wave threshold	The threshold for the preamp output signal at the start of waveform acquisition. Acquire a waveform that exceeds this value.
----------------	---

MCA section

ADC gain	ADC gain. Select from 4096, 2048, 1024 and 512 channels. The maximum non-saturating range of the waveform shaped signal is divided by the channels described above. For high energy resolution detectors such as HPGe semiconductor detectors, selecting 4096 allows you to acquire data with finer resolution. However, when the count is low, it takes time to acquire the peak. Since the energy resolution of NaI (TI) scintillation detectors etc. is slightly inferior, if it cannot be divided finely, 4096 channels etc. are set.
LLD	Set the energy LLD (Lower Level Discriminator). The unit is ch. Channels below this threshold are not counted. Set to a value greater than threshold and less than ULD.
ULD	Set the energy ULD (Upper Level Discriminator). The unit is ch. Channels above this threshold are not counted. Set to a value larger than LLD.

4. 4. file tab

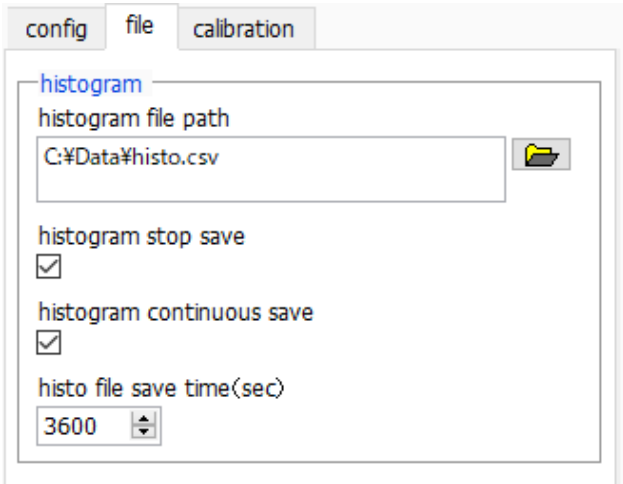


Fig. 11 file tab

histogram section

histogram file path	Set the absolute path of the histogram data file. NOTE It is not saved with this file name, but based on this file name, it has the following format. As an example, set "C: ¥ Data ¥ histogram. Csv" in "histogram file path" and "10" in "histogram file save time (sec)", and the date and time is 2015/12/23 12: 34:00. If so, start saving data with the file name "C: ¥ Data ¥ histogram_20151223_123400.csv". After 10 seconds, save the file as "C: ¥ Datahistogram_20151223_123510.csv".
histogram stop save	The histogram data is saved to a file at the end of measurement. The file save destination is the same as the above format.
histogram periodic save	Set whether to save histogram data to a file at set time intervals. NOTE Depending on the processing status, the save interval may be shifted. Used for simple backup.
periodic save interval (sec.)	Set the time interval for continuous storage of histogram data. The unit is seconds. The setting range is 5 seconds to 86400 seconds.

4. 5. calibration tab

Set ROI (Region Of Interest) and energy calibration. By setting the ROI to the spectral peak, the peak count number and half width are calculated.

The screenshot shows the 'calibration' tab with the following data:

ROI	ROI ch	ROI start (ch)	ROI end (ch)	peak (ch)
ROI1	CH1	4762	4831	1173
ROI2	CH1	5410	5515	1333
ROI3	none	0	0	1
ROI4	none	0	0	1
ROI5	none	0	0	1
ROI6	none	0	0	1
ROI7	none	0	0	1
ROI8	none	0	0	1

ROI	centroid(ch)	peak (ch)
ROI1	0.00	1173
ROI1	0.00	1173

manual a: 1.000, manual b: 0.000, unit: MeV

Fig. 12 calibration tab

ROI section

ROI CH	Select the channel number of ROI target. Up to 8 ROIs can be set for one channel signal
ROI start	Set the start position of the ROI. The unit depends on the energy calibration situation.
ROI end	Set the end position of the ROI. The unit depends on the energy calibration situation.
peak (ch)	Defines the energy value of the peak position (ch). For Co-60, set this to 1173 or 1332. When "ch" is selected in the next "calibration" section, a peak between ROIs is detected, and keV / ch is calculated from the peak position (ch) and the set energy value, and the calculation result of the half width It becomes.

calibration section

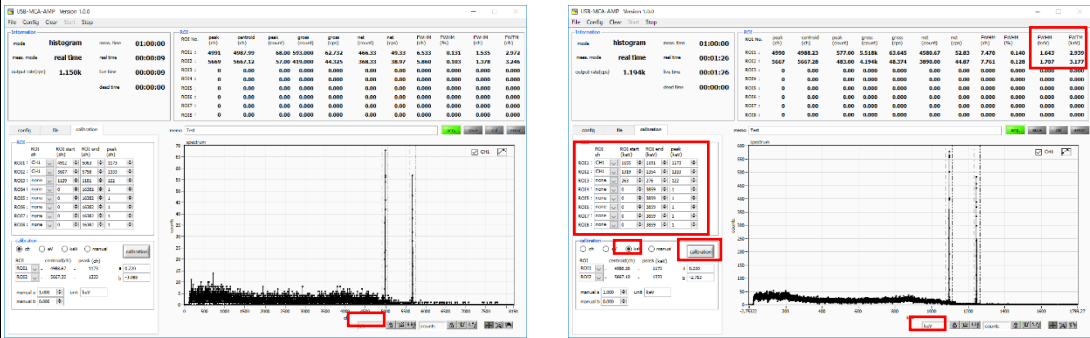
Type of calibration	Select the unit of the X axis from the following four.
ch	Unit display of Ch (channel). Units such as ROI "FWTM" "FWHM" are arbitrary.
eV	Unit display of eV. Calculate the slope a and intercept b of the linear function $y = ax + b$ so that ch becomes eV by two-point calibration of two types of peaks (center value) and energy value in one spectrum, and set as the X axis You The unit such as "FWTM" of "FWTM" of ROI is "eV".
keV	Unit display of keV. Calculate the slope a and intercept b of the linear function $y = ax + b$ so that ch becomes keV by two-point calibration of two types of peaks (center value) and energy value in one spectrum, and set as the X axis You The unit such as "FWTM" of "FWTM" of ROI is "keV". As an example, if there are 1173.24keV of Co-60 in 5717.9ch and 1332.5keV of Co-60 in 6498.7ch, a is calculated automatically as 0.20397 and b as 6.958297 from 2-point calibration.
manual	Setting of slope a, intercept b and unit label of linear function $y = ax + b$. Set at "manual a", "manual b" and "unit" as needed and use for energy calibration.
ROI	Select the target ROI number for energy or time calibration. The "centroid" and "peak" next to the right show the center value of the selected ROI and the energy value being set. For example, when "ROI1" and "none" are selected, one-point calibration is performed using the peak center value of ROI1 and the preset "peak". When "ROI1" and "ROI2" are selected, 2-point calibration is performed using the peak center values of ROI1 and ROI2 and the preset "peak".
manual a and b	The slope of the linear function $y = ax + b$ is displayed as a, and the intercept as b to create the graph of the energy calibration calculation result.
Calibration button	Perform energy calibration according to the type of calibration. The slope a and the intercept b of the linear function $y = ax + b$ applied to the horizontal axis of the graph after execution are calculated and displayed in the lower "a" and "b". For the calculation method, refer to "7.7. Calculation method of 2-point calibration" below. For example, select "keV" in the "calibration" section as shown in the figure below, and click the "calibration" button. Each peak will be each from the "centroid" and "peak" values of "ROI1" and "ROI2". The energy calibration is performed to obtain the energy value of, and the horizontal axis unit of the graph, the setting value of the ROI, and the unit of the calculation result of the ROI are also "keV". 

Fig. 13 When "keV" is selected in the calibration section
Left: before energy calibration, **Right:** after energy calibration

4. 6. Graph

spectrum graph	In histogram mode, the horizontal axis is energy, and the vertical axis is count histogram.
cursor x	Set the position of the dotted line cursor in the graph. The count value on the spectrum at the set position is displayed in "cursor y".
cursor y	Set the position of the dotted line cursor in the graph. To set the cursor X direction, use "cursor x" or drag and drop the cursor.
Plot legend	Set the graph color, line type, etc. You can switch between showing and hiding in the submenu on the graph.
X axis range	Right-click on the X axis and select "Auto scale" to make it auto scale. When deselected, auto scaling is canceled, and the X axis minimum and maximum values are fixed. If you want to change the minimum or maximum value, place the mouse pointer over the number you want to change and click or double-click to change it.
Y axis range	Right-click on the Y axis and select "Auto scale" to make it auto scale. When deselected, auto scaling is canceled, and the Y axis minimum and maximum values are fixed. If you want to change the minimum or maximum value, place the mouse pointer over the number you want to change and click or double-click to change it.
x axis keV	In the X-axis, set whether auto-scaling, accuracy, mapping (linear / logarithm).
y axis counts	In the Y-axis, set whether auto-scaling, accuracy, mapping (linear / logarithm).

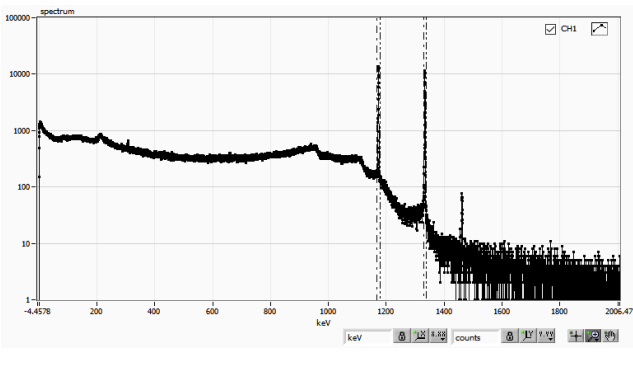
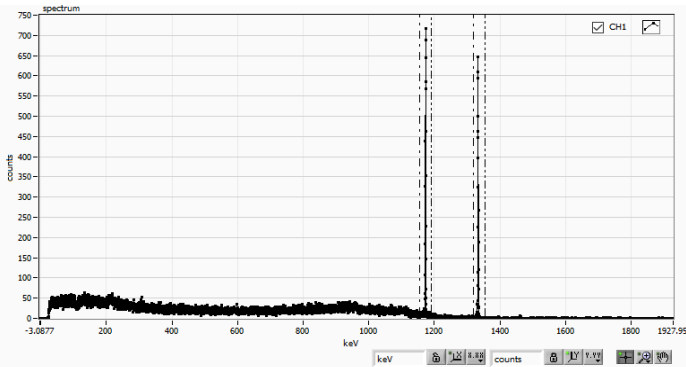
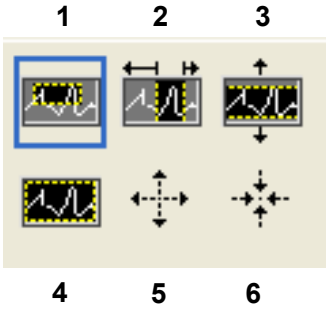


Fig. 14 Histogram graph **LEFT**: linear in vertical axis mapping mode, **RIGHT**: logarithmic

wave graph	Displays the input waveform, semi-Gaussian processed waveform, and timing processed waveform. It is possible to adjust gain and pole zero while checking the semi-Gaussian processed waveform. Fig. 15 Waveform graph
------------	---

accumulation	Overlapping enable / disable setting. When ON, the waveform is displayed by superimposing the last 16 times read last time.
	It is a cursor movement tool. The cursor can be moved on the graph when setting the ROI.
	Zoom. Click to select and execute the following 6 types of zoom in and zoom out.  Fig. 16 Graph, tools for zoom-in and zoom-out 1. Square: Use this option to click a point on the display that you want to be a corner of the zoom area and drag the tool until the rectangle occupies the zoom area. 2. X-Zoom: Zooms in on the area of the graph along the x-axis. 3. Y-Zoom: Zooms in on the area of the graph along the Y axis. 4. Fit zoom: Auto scale all X and Y scales on the graph. 5. Zoom out around the point: Click the center point to zoom out. 6. Zoom in around the point: Click the center point to zoom in.
	Pan tool. You can grab the plot and move it over the graph.

5. Measurement

5. 1. Histogram mode

1	Select "histogram" in "mode" in "config" tab. "histogram" is displayed for "mode" in the "Information" section.
2	Click "Clear" on the menu bar. The histogram data in this device is initialized. If you want to continue the previously measured histogram or measurement results, start the next measurement without clicking "Clear".
3	Click "Start" on the menu bar to start measurement after all settings have been sent to this device.
4	After starting measurement, transition to the following state. - "acq" LED blinks. - The measurement status is displayed in the "Information" section. - Real time acquired from this device is displayed in "real time". - The "live time" of each channel will display the live time acquired from this device. - The dead time obtained from this device is displayed in "dead time" of each channel. - For "ROI" for each "ROI No.", center value, gross count (total within range) and rate, net count (total within range total minus background) by setting "ROI range" in "calibration" tab Calculation results such as net count, rate, half width, 1/10 width etc are displayed. - The graph displays the histogram of the peak value on the horizontal axis.

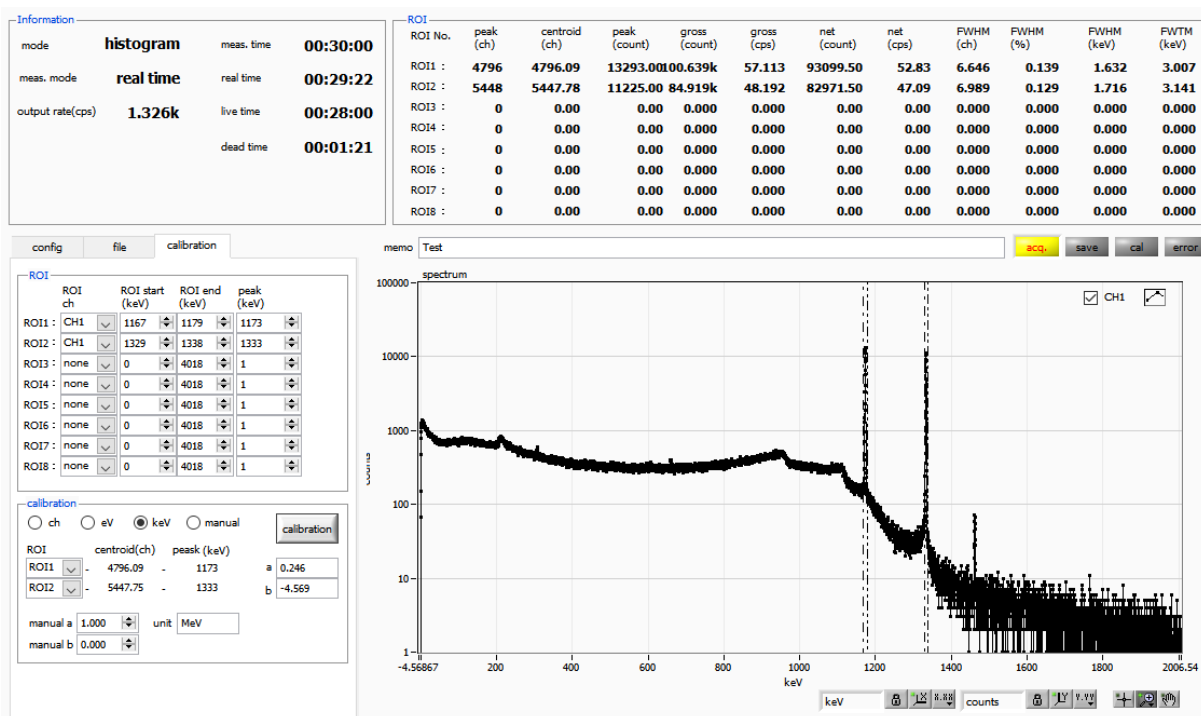


Fig. 17 Histogram mode measurement screen

5. 2. Waveform mode

1

It is used to check the input waveform and signal processing waveform before histogram mode measurement.

2

Select "wave" in "mode" in the "config" tab. "wave" is displayed for "mode" in the "Information" section.

3

Click "Start" on the menu bar to start measurement after all settings have been sent to this device.

4

After starting measurement, transition to the following state.

- "acq" LED blinks.
- The measurement status is displayed in the "Information" section.
- Real time acquired from this device is displayed in "real time".

Information

mode

wave

meas. time

01:00:30

meas. mode

real time

real time

00:03:54

output rate(cps)

5.762k

live time

00:02:49

dead time

00:01:04

ROI

ROI No.	peak (ch)	centroid (ch)	peak (count)	gross (count)	gross (cps)	net (count)	net (cps)	FWHM (ch)	FWHM (%)	FWHM (keV)	FWTM (keV)
ROI1	4797	4797.88	2939.00	35.637k	442.977	27203.67	338.15	8.641	0.181	2.120	4.415
ROI2	5449	5449.81	2743.00	32.883k	408.744	26555.33	330.09	8.696	0.160	2.134	4.596
ROI3	0	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.000	0.000
ROI4	0	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.000	0.000
ROI5	0	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.000	0.000
ROI6	0	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.000	0.000
ROI7	0	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.000	0.000
ROI8	0	0.00	0.00	0.000	0.000	0.00	0.00	0.000	0.000	0.000	0.000

config

file

calibration

measurement

mode

wave

meas. mode

real time

meas. time

01:00:30

amplifier

polarity

negative

coarse gain

x5

fine gain

9.600000

DAC monitor

input

threshold

20

shaping time

6us

pole zero

6700

wave

wave threshold

300

MCA

ADC gain

8192

LLD

20

ULD

8190

peak detect

abs

memo

Test

acq

save

cal

error

wave

nt

ch

20000

18000

16000

14000

12000

10000

8000

6000

4000

2000

-100

-79.2

-60.0

-40.0

-20.0

0.0

20.0

40.0

60.0

80.0

100.0

120.0

140.0

160.0

180.0

200.0

220.0

248.4

us

input

slow

fast

accumulation

us

digit

Y

Y.Y

+

0

00

Fig. 18 Waveform mode measurement screen

5. 3. Measurement stops

When "meas. Mode" is "real time", the measurement ends when "real time" reaches "meas. Time".

When "meas. Mode" is "level time", the measurement ends when the latest "live time" reaches "meas. Time".

Click "Stop" on the menu bar to stop during measurement. Stop measurement after execution.

6. File

6. 1. Histogram data file

1	File format	Text format separated by comma (csv)
2	File name	Create arbitrarily
3	Configuration	
	[Header]	Header section
	memo	Memo
	meas. mode	Measurement mode. Real time or live time.
	meas. Time (sec)	Measurement time. Unit is seconds
	real time (sec)	Real time per channel. Unit is seconds
	live time (sec)	Live time per channel. Unit is seconds
	dead time (sec)	Dead time per channel. Unit is seconds
	start Time	Measurement start date time
	end Time	Measurement end date time
	mode	Histogram or wave
	polarity	Polarity
	coarse gain	Coarse gain
	fine gain	Fine gain
	shaping time	Shaping time
	pole zero	Pole zero
	wave threshold	Wave threshold
	ADC gain	ADC gain
	threshold	Threshold
	LLD	Energy LLD
	ULD	Energy ULD
	peak detect	Peak detection method (abs.)
	cursor x (any)	Cursor position for acquiring histogram count value. The unit is displayed on the X-axis in the graph.
	cursor y (count)	Cursor position and count value on the histogram
	[Calculation]	Calculation section, NOTE: The following is saved for each ROI
	ROI No.	Input channel number targeted by ROI.
	ROI start (ch)	ROI start position (ch.)
	ROI end (ch)	ROI end position (ch.)
	peak (any)	Definition energy value of peak between ROI
	peak (ch)	Peak position between ROIs (ch.)
	centroid (ch)	Center position between ROIs (ch.)
	peak (count)	Maximum peak count between ROIs
	gross (count)	Sum of counts between ROIs
	gross (cps)	1 second gross (count)

	net (count)	Sum of counts minus background between ROIs
	net (cps)	1 second net (count)
	FWHM (ch)	Half-width between ROIs (ch)
	FWHM (%)	Half-width between ROIs (%)
	FWHM (any)	Half-width between ROIs (keV etc)
	FWTM (any)	1/10 width between ROIs (keV etc)
	[Status]	Status section
	output rate (cps)	Number of events processed per second
	[Data]	Data section
	X-axis data (channel or eV, keV, arbitrary), histogram data. Up to 4096 points.	

6. 2. Waveform data file

This is the format of the data file saved in waveform mode.

1	File format	Text format separated by comma (csv)
2	File name	Create arbitrarily
3	Configuration	
	[Header]	Header section
	memo	Memo
	meas. mode	Measurement mode. Real time or live time.
	meas. time (sec)	Measurement time. Unit is seconds
	real time (sec)	Real time per channel. Unit is seconds
	live time (sec)	Live time per channel. Unit is seconds
	dead time (sec)	Dead time per channel. Unit is seconds
	start time	Measurement start date time
	end time	Measurement end date time
	mode	More. wave
	polarity	Polarity if input signal
	coarse gain	Coarse gain
	fine gain	Fine gain
	shaping time	Shaping time
	pole zero	Pole zero
	wave threshold	Wave threshold
	ADC gain	ADC gain
	threshold	threshold
	LLD	Energy LLD
	ULD	Energy ULD
	peak detect	Peak detection method (abs.)
	[Status]	Status section
	output rate (cps)	Number of events processed per second
	[Data]	Data section
	Time (us), input, slow, fast. Up to 4096 points.	

7. Functions

7. 1. Data acquisition by external GATE input signal timing

When you want to acquire event data at that time from an external condition when an event occurs, input a LV-TTL level signal to the LEMO connector "GATE" on the front panel. When it is high, it measures. When it is low, it does not measure.

Set the external GATE input signal to slow with the DAC monitor and input it in such a range (see the figure below) that the slow output signal from the OUTPUT terminal is sufficiently covered. The guideline for the pulse width of the external GATE input signal is $\times 8$ for shaping time.

Adjust so slow pole zero does not overshoot or undershoot. Keep the external GATE input signal high until the slow output signal goes from the baseline to the point where it exceeds the threshold level V_{th} .

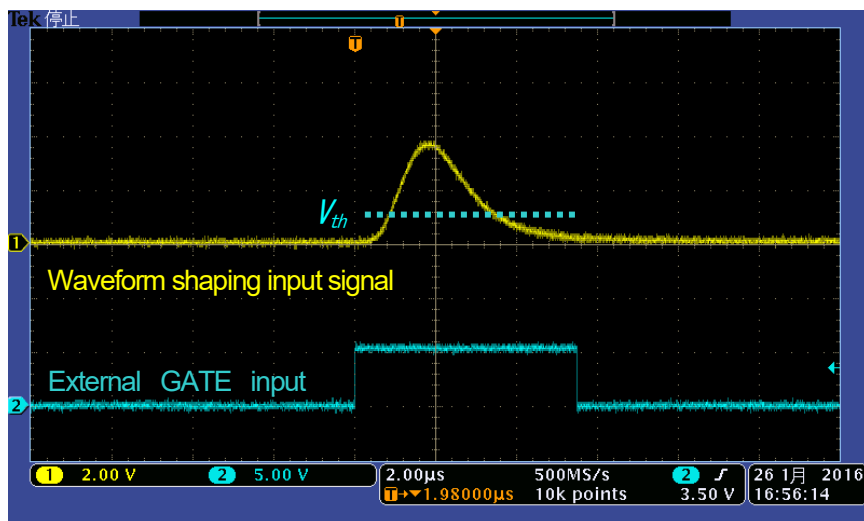


Fig. 19 External GATE input signal timing

NOTE: As for the external GATE input signal, at LV-TTL level, 0.8 V or less is judged as LOW level and 2.0 V or more is judged as High level. The maximum input voltage is 5V.

7. 2. Data discard by external VETO signal timing

When you want to acquire event data at that time from an external condition when an event occurs, input a LV-TTL level signal to the LEMO connector "VETO" on the front panel. Contrary to the "GATE" function, it measures when it is low and does not measure when it is low. The timing is the same as GATE described above.

7. 3. Calculation method of FWHM (half width)

The FWHM (Full Width at Half Maximum) in the "status" tab is calculated as follows.

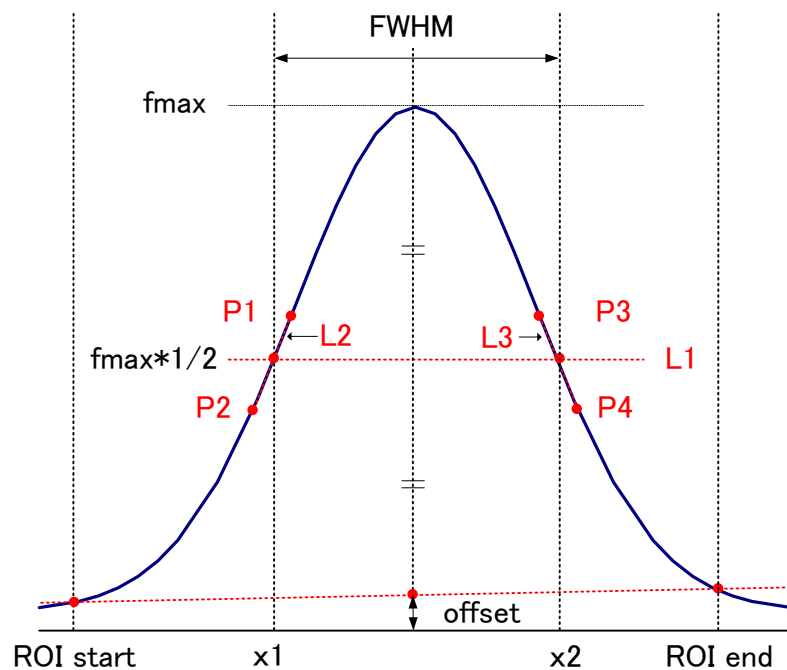


Fig. 20 Calculation of FWHM

1	The maximum value f_{max} between ROI Start and ROI end in the histogram is detected.
2	Connect the intersection point of histogram and ROI start with the intersection point of histogram and ROI end. The background offset (offset) is calculated by finding the intersection of the straight line and the line drawn vertically from the peak value f_{max} to the x axis.
3	Calculate $1/2$ of f_{max} minus offset and draw a straight line L1 parallel to the X axis.
4	In order to find two points where the histogram and L1 intersect, the crossing points P1 and P2 and P3 and P4 are detected.
5	Draw a straight line L2 connecting P1 and P2 and a straight line L3 connecting P3 and P4.
6	Find the X coordinate x_1 of the intersection of L1 and L2, and the X coordinate x_2 of the intersection of L1 and L3.
7	The difference between x_2 and x_1 is FWHM

7. 4. Calculation of gross count and net count

The "gross" and "net" counts in the "ROI" part are calculated by the Covell method.

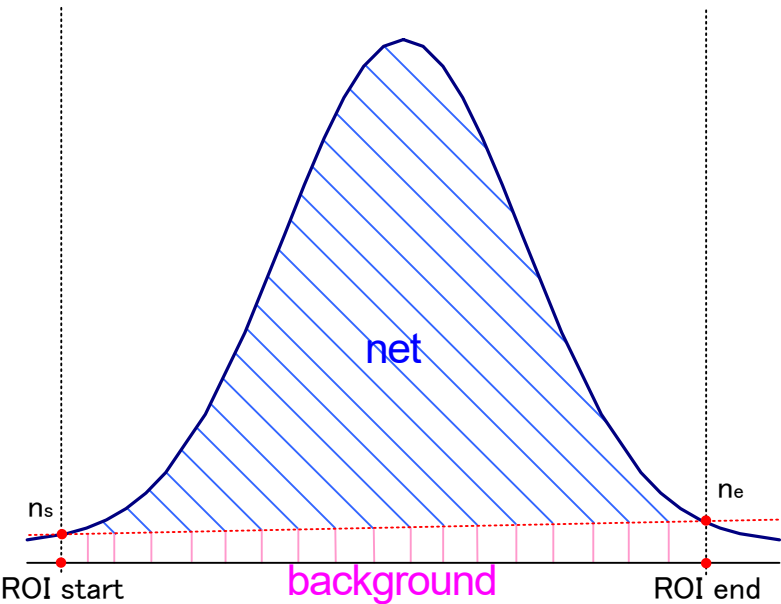


Fig. 21 Calculation of gross count and net count

1	"gross" count is the sum of counts between ROI start and ROI end.
2	The "net" count is the net count of the peak minus the background count from the "gross" count (blue shaded area above).
3	Background (background) count connects ROI start and spectrum intersection ns with ROI end and spectrum intersection ne by a straight line. This is the area of the rectangle surrounding the four points of ROI start, ns, ne and ROI end (pink line in the above figure).

7. 5. Calculation method of two-point calibration

In histogram mode

Perform a two-point calibration using the centroid of the two energy peaks and the peak energy value to make the unit scale of the X axis of the graph an energy (e.g., keV). One-point calibration is also possible.

ROI		
ROI No.	peak (ch)	centroid (ch)
ROI1	: 9446	9446.99
ROI2	:10728	10729.54

Set "ROI start (keV)" and "ROI end (keV)" in the upper "ROI" in the "calibration" tab, referring to the "centroid (ch)" value of ROI1 / ROI2 displayed in "ROI" at the top of the graph. Or set the range of ROI1 and ROI2 by cursor movement of the graph.

calibration					
☐ ch ☐ eV ☒ keV ☐ manual calibration					
ROI	centroid(ch)	energy (keV)	a	b	
ROI1	9446.99	1173	1.000		
ROI2	10729.53	1332	0.000		

Select the radio button "keV" in "calibration" at the bottom of the "calibration" tab. Select "ROI1" and "ROI2" as the ROI in "calibration" at the bottom of the "calibration" tab.

ROI				
ROI	ch	ROI start (keV)	ROI end (keV)	energy (keV)
ROI1	CH1	1164	1185	1173
ROI2	CH1	1323	1352	1332

Set the peak energy of each of ROI1 / ROI2 to "keV" for how many keV it corresponds.

calibration					
☐ ch ☐ eV ☒ keV ☐ manual calibration					
ROI	centroid(ch)	energy (keV)	a	b	
ROI1	9446.99	1173	0.124		
ROI2	10729.53	1332	1.831		

When you click the "calibration" button, the slope a and intercept b of the linear equation $y = ax + b$, which are calculated by the following equation, are automatically reflected in the lower positions of "a" and "b".

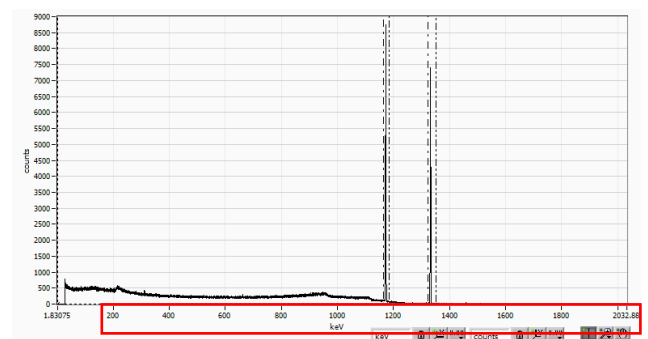
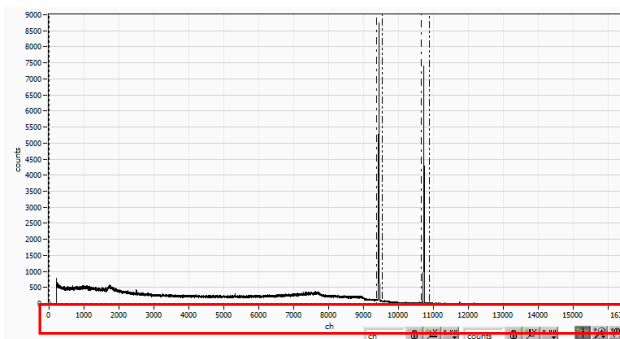


Fig. 22 Before energy calibration (Left), After energy calibration (Right)

$$a = (\text{peak1} - \text{peak2}) / (\text{centroid1} - \text{centroid2})$$

$$b = y - ax$$

For example, using Co-60, with 1473 keV centroid 9446.99 ch. And 1332 keV centric 10729.53 ch.

$$a = (1332 - 1173) / (10729.53 - 9446.99) = 0.124$$

$$b = 1332 - 0.124 * 10729.53 = 1.831$$

As described above, "a" is automatically reflected as "0.124" and "b" is automatically reflected as "1.831", and the unit scale of the X axis is created by the linear expression $0.124 * \text{ch} + 1.831$.

8. Gauss-fit

This software has a peak analysis function by Gauss fitting. By opening the dedicated screen, you can calculate the half-value width, etc. by dividing the peaks with a small number of counts and the peaks that overlap with each other during measurement or for the histogram data in the data file.

8. 1. Startup screen

Select Tool from the menu bar and execute gauss fit analysis. After execution, the startup screen shown below will be displayed.

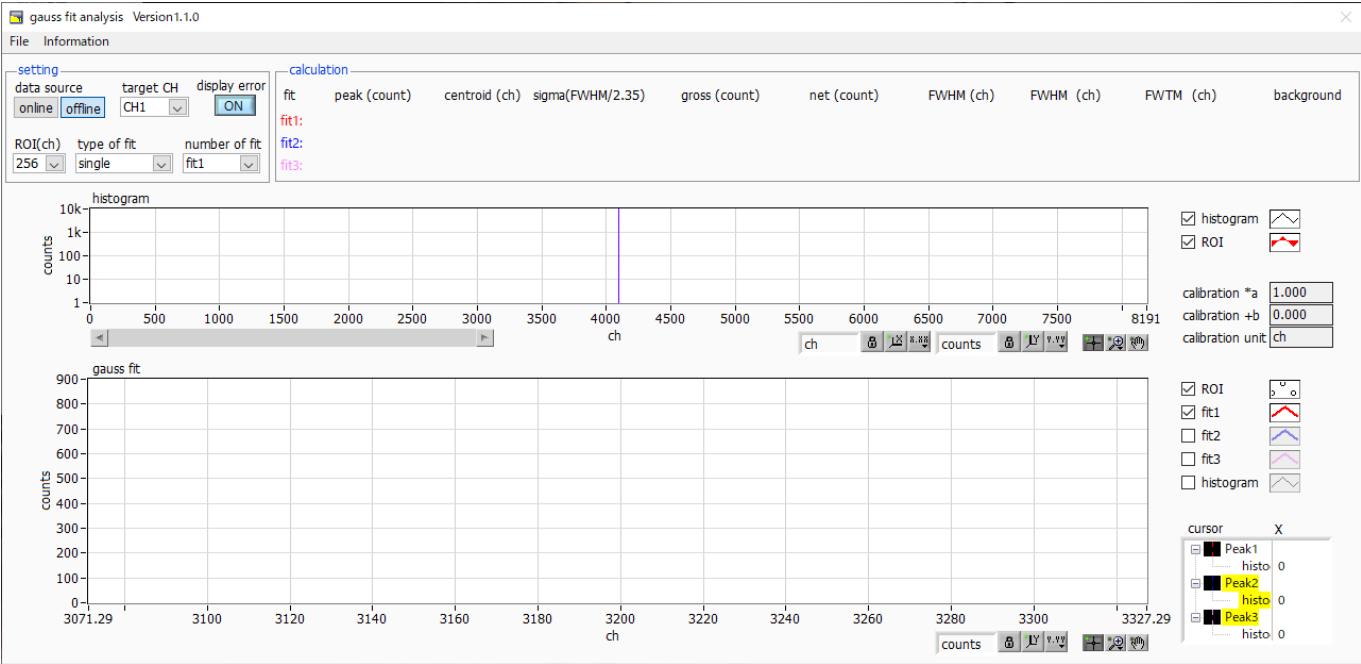


Fig. 23 Gauss fit startup screen

Menu section

File - open gauss fit file	Read Gauss fit file
File - open histogram file	Read histogram data file
File - save gauss fit file	Save Gaussian fit data to a file
File - save image	Save screen in png format
File - close	Exit screen
Information	Display the information screen. Display precautions when using this screen on the dialog screen

Fig. 24 Information screen

Setting section

data source	Select the data to be analyzed
online	Targets the data being measured on the main screen
offline	Targets the data in the pre-read histogram data file or Gauss fit data file
target CH	Analysis target CH setting
display error	Select the error to be displayed
ROI (ch)	It is the number of data points to be analyzed to be displayed in the graph of gauss fit. Choose from 256 or 512 channels
type of fit	Select the type of Gaussian fit either single or combination. Single is normally sufficient. Select combination in case two or three peaks come too close to fit.
number of fit	Setting the number of Gaussian fits. Gaussian fit analysis can be performed on up to 3 peaks for a single histogram

Calculation section

peak (count)	Maximum count
centroid (ch)	Median value (ch) calculated from the sum of all counts
sigma(FWHM/2.35)	Standard deviation
gross (count)	Sum of counts
net (count)	Sum of counts minus background
FWHM (ch)	Half width
FWHM	Half width * The unit is the energy calibration state on the main screen.
FWTM	1/10 width of the peak * The unit is the energy calibration state on the main screen.
background	background value
calibration *a	The energy calibration factor *a on the main screen is displayed
calibration +b	The energy calibration factor +b on the main screen is displayed.
calibration unit	The unit on the main screen is displayed
histogram graph	The histogram plot in the histogram graphs the histogram data for Gaussian fit. The ROI plot is the part displayed in the gauss fit graph and is displayed in red. You can change the display position while keeping the number of display points constant by moving the horizontal slide bar at the bottom left of the graph to the left or right. If each check box is checked, the plot is displayed, and if it is not checked, the plot is hidden.
gauss fit graph	From the histogram data displayed in the histogram graph, the channel set by ROI (ch) is extracted from the start position of the X axis of the gauss fit graph and displayed. The fit1 to fit3 plots are Gaussian-fitted data for the peaks set by each cursor. Histogram plots are concatenated data of Gaussian fit results. You can change the display position while keeping the number of display points constant by dragging the graph area after select the pan button  at the bottom right of the graph to the left or right. The X of the cursor at the bottom right of the graph is the position of the cursor to be aligned with the Gaussian fit target peak, and you can also move the cursor by directly inputting X. If each check box is checked, the plot is displayed, and if it is not checked, the plot is hidden.

8. 2. On-line

For the histogram acquired during measurement, perform Gaussian fit analysis for the specified peak according to the following procedure.

1. Select data source, "online".
2. Start measurement in histogram mode. The histogram during measurement is displayed in the histogram graph.
3. In the gauss fit graph, the histogram of the part of interest in the histogram graph is displayed. To set the horizontal axis range of this graph, enter the minimum value of the horizontal axis of the gauss fit graph directly or move the vertical cursor in the histogram graph to the target range. After that, the histogram graph will have the range selected in the gauss fit graph red.
4. Set up to three vertical cursors at the approximate peak part of the analysis target. To set the cursor, drag the red, blue, and pink vertical cursor lines while the button in the red frame in the figure below is pressed, and drop them on the peak part. Alternatively, you can move the cursor and set it by entering a numerical value in the X value of the cursor at the bottom right of the screen.
5. Calculation results such as half-value width based on each Gaussian fit data are displayed in the calculation section

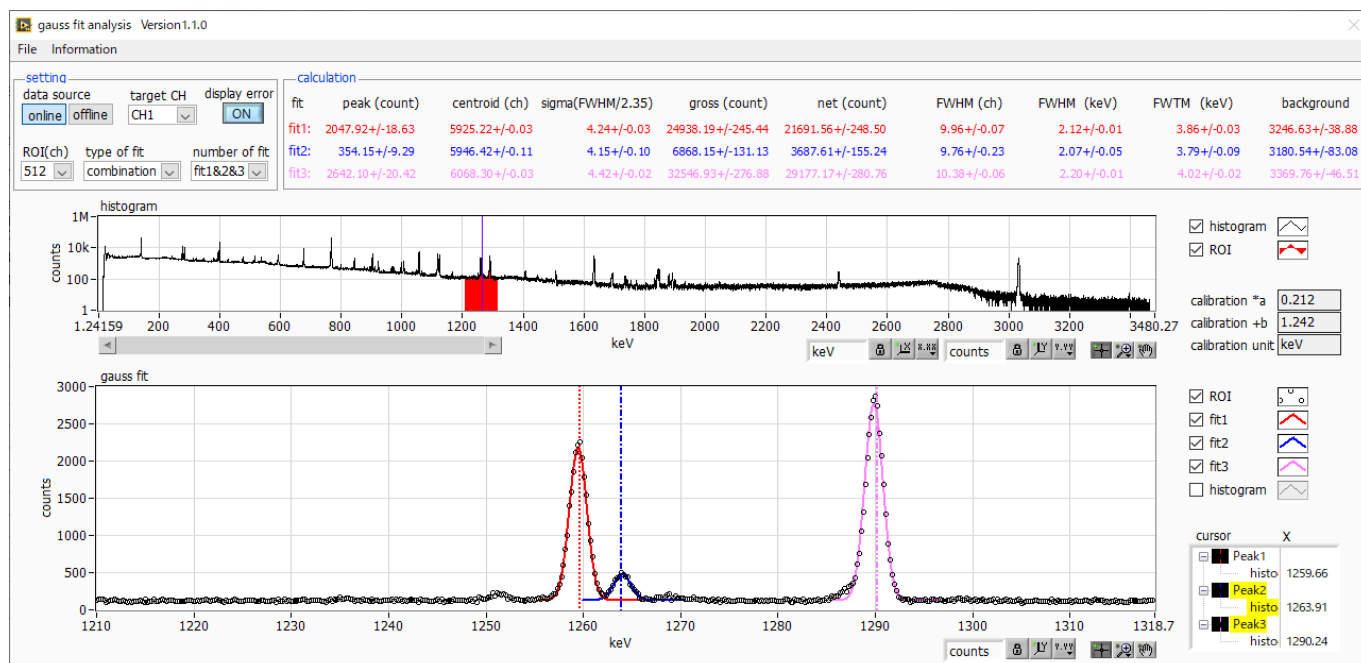


Fig.25 Gauss fit screen, **ONLINE**

8. 3. Off-line

For the histogram obtained by reading the histogram data file or the Gauss fit data file, perform Gauss fit analysis for the specified peak by the following procedure.

1. Select data source, "offline".
2. Click open gauss fit file or open histogram file from file in the menu. A file selection dialog is displayed. Select the data file to be read and open it. The histogram in the data file is displayed in the histogram graph

The rest of the procedure is the same as the on-line mode.

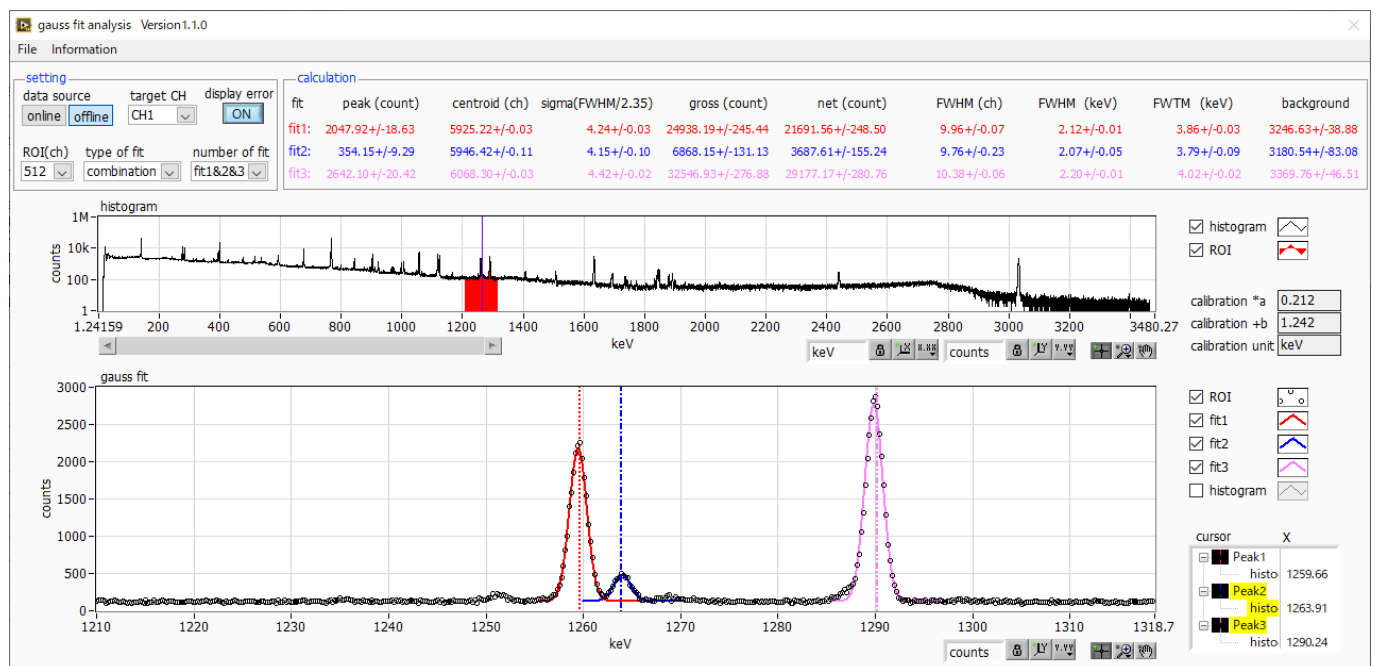


Fig.26 Gauss fit screen, OFFLINE

8. 4. Notes

Please note the following points to operate normally on the Gauss fit screen.

- When selecting combination as type of fit and setting the number of fit to two or more, set fit1 and fit2 in this order from the left in the gauss fit graph. If fit1 is not working properly, the following fit2 and fit3 will also be hidden.
- The peak to be fitted should be displayed without being cut off at both ends of the gauss fit graph.
- If the peak value on the calculation tab and the peak value on the gauss fit graph do not match, move the horizontal axis range of the graph or the fit cursor.

8. 5. End

To close this screen, click close from File on the menu bar.

9. Peak search

This software has a function to automatically detect peaks and perform peak analysis. You can open the dedicated screen and automatically detect the peak and calculate the half width etc. for the histogram data of the data file during measurement.

9. 1. Startup screen

Execute peak search analysis from Tool on the menu bar. After execution, the startup screen shown below will be displayed.

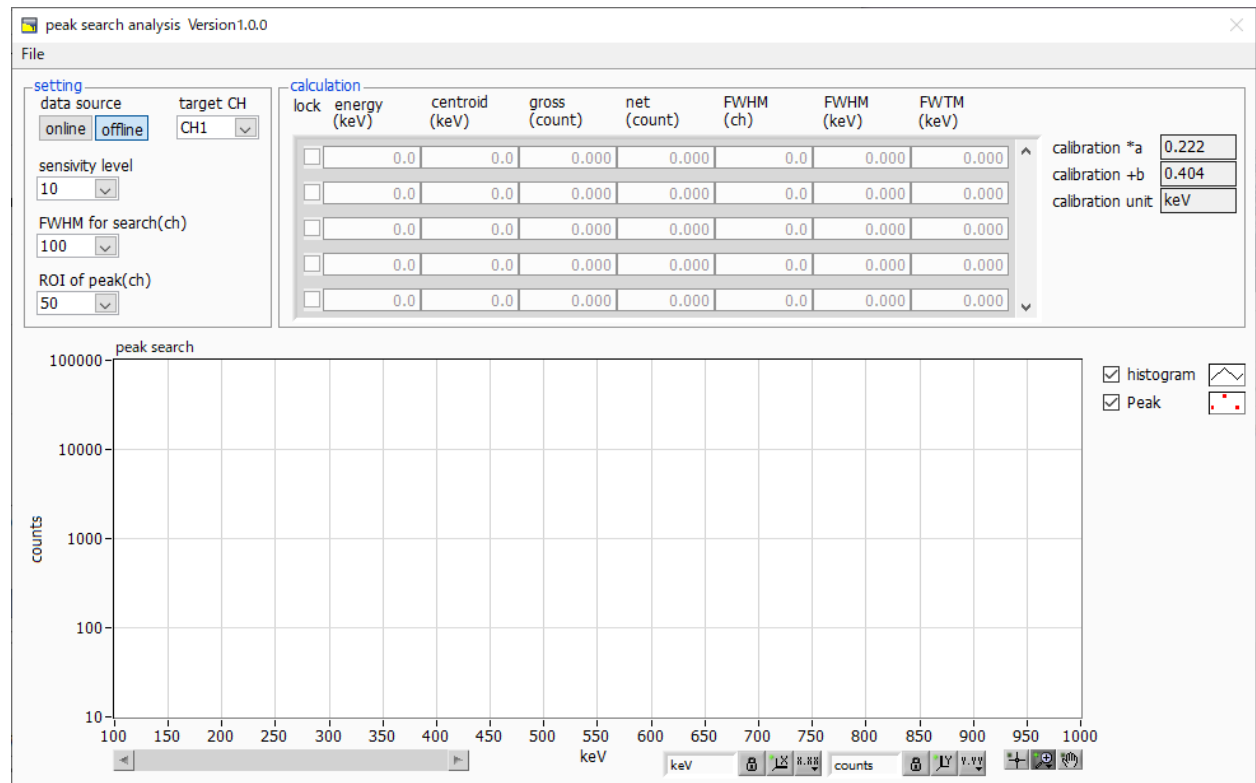


Fig.27 Peak search startup screen

Menu section

File - open peak search file	Read peak search file
File - open histogram file	Read histogram data file
File - save peak search file	Save peak search to a file
File - save image	Save screen in png format
File - close	Exit screen

Setting section

data source	Select the data to be analyzed
online	Targets the data being measured on the main screen
offline	Targets the data in the pre-read histogram data file or Gauss fit data file
target CH	Analysis target CH setting
sensitivity level	Selection of peak detection threshold. If the value is small, even a slight peak will be detected.
FWHM for search (ch)	Approximate half-value width required for peak search. The unit is channel. Set the approximate half width from the actual peak by channel (point)
ROI of peak (ch)	Setting the number of ROI plots (CH) for the peak

Calculation section

lock	If you want to display it at the top of the list, turn on the check. If it is OFF, the display position may move up or down each time a peak is detected.
centroid (ch)	Median value (ch) calculated from the sum of all counts
gross (count)	Sum of counts
net (count)	Sum of counts minus background
FWHM (ch)	Half width
FWHM	Half width * The unit is the energy calibration state on the main screen.
FWTM	1/10 width of peak * The unit is the energy calibration state on the main screen.
calibration *a	The energy calibration factor *a on the main screen is displayed.
calibration +b	The energy calibration factor +b on the main screen is displayed
calibration unit	The unit on the main screen is displayed.
peak search graph	The histogram plot in the peak search graph displays the histogram data of the peak search target as a graph. The Peak plot is the part where the peak is detected and is displayed in red with a Gaussian fit. You can change the display position while keeping the number of display points constant by moving the horizontal slide bar at the bottom left of the graph to the left or right. If each check box is checked, the plot is displayed, and if it is not checked, the plot is hidden.

9. 2. On-line

Perform peak search analysis using the following procedure for the histogram acquired during measurement.

1. Select data source online
2. Start measurement in histogram mode. The histogram being measured is displayed in the peak search graph.
3. In the peak search graph, the peak part where the peak is detected is gauss-fitted and a red histogram is displayed.
4. In the calculation section, the calculation results such as the half-value width are displayed for each peak detected. If the peak is detected or not detected, the calculation result display may move up and down, making it difficult to see. In this case, if you turn on the lock check, it will always be displayed at the top.

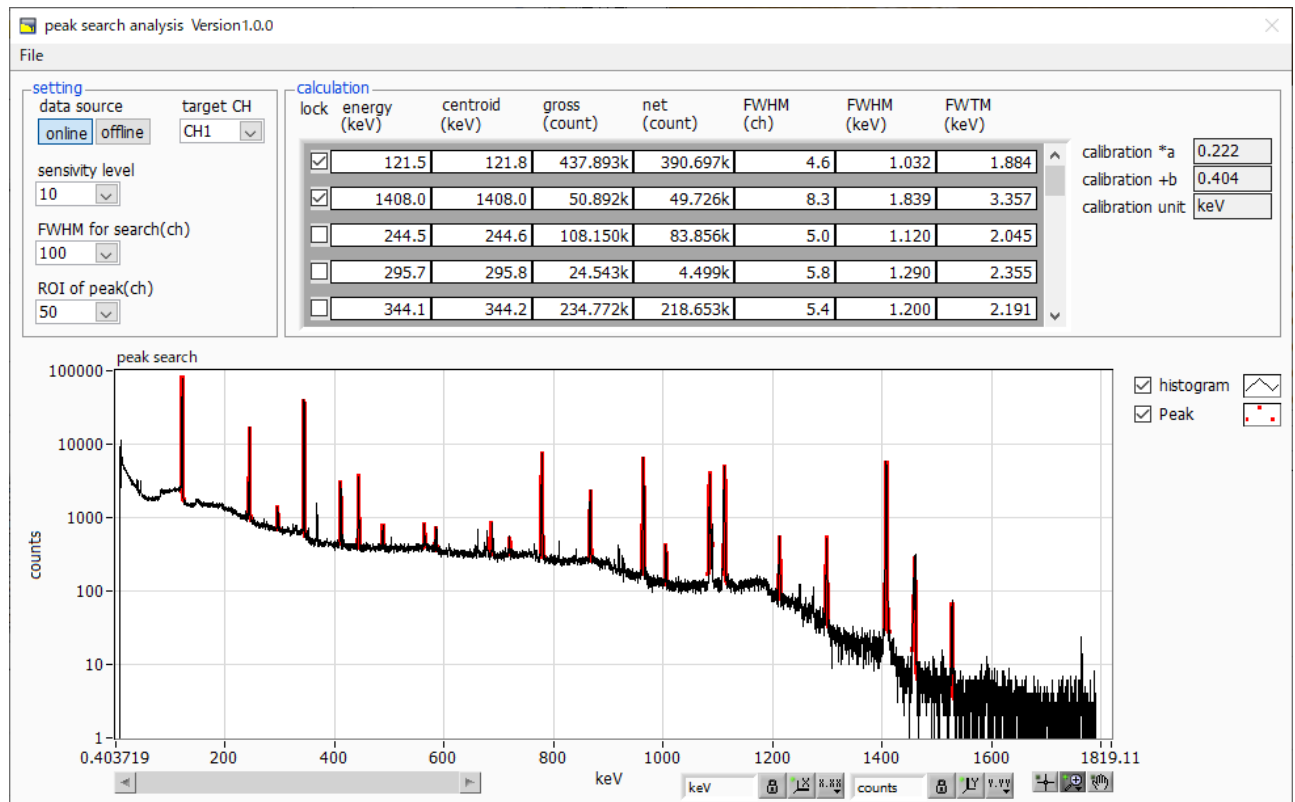


Fig. 28 Peak search screen, **ONLINE**

9. 3. Off-line

Perform peak search analysis according to the following procedure for the histogram obtained by reading the histogram data file or peak search data file.

1. Select data source as offline
2. Click open peak search file or open histogram file from file on the menu bar. A file selection dialog is displayed. Select the data file to be read and open it. The histogram in the data file is displayed in the peak search graph

The rest of the procedure is the same as the on-line mode.

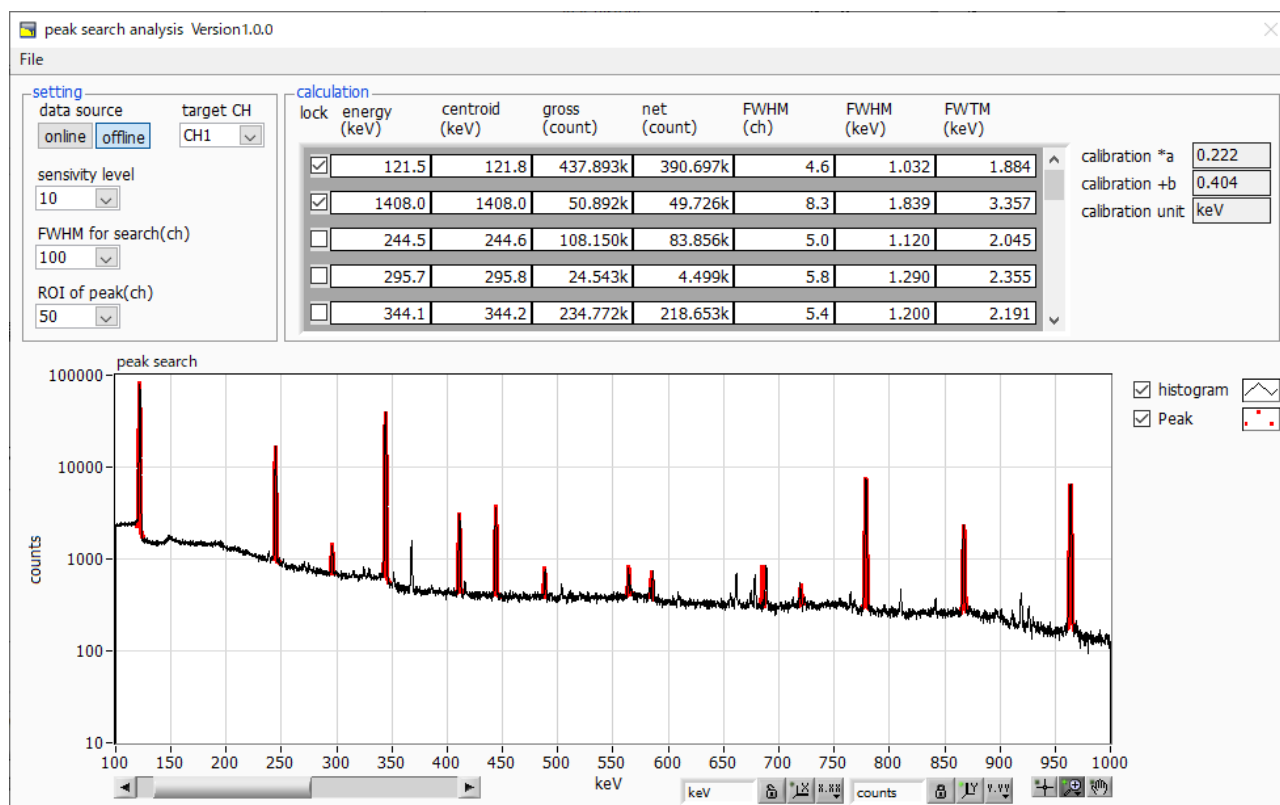


Fig. 29 Peak search screen, **OFFLINE**

9. 4. Notes

Please note the following points to operate normally on the peak search screen.

- The degree of peak search changes by adjusting the sensitivity level, FWHM for search (ch.), and ROI of peak (ch.).
Adjust each setting to the optimum while observing the shape of the red peak detection part.

9. 5. End

To close this screen, click close from File on the menu bar.

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