USB-MCA4

APG7400A

software

Manual

Version 1. 4. 2
December 2023

TechnoAP Co., Ltd.

Safety Precautions / Disclaimer

Thank you very much for purchasing the USB-MCA-AMP, Model: APG7305A (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.

Table of Contents

1. **Overview**

USB-MCA4 (USB - Multi Channel Analyzer 4 CH, USB - Multichannel Analyzer 4 CH) manufactured by TechnoAP Co., Ltd.APG7400A (hereinafter referred to as this device) has a high - speed successive approximation ADC for each channel of 4 channels for signal input, it is a lightweight and compact MCA that operates only with USB bus power without using the AC adapter.

The preamplifier signal from the detector is input to a spectroscope amplifier (linear amplifier), and the output signal amplified and waveform-shaped (shaped) by the analog circuit is input to this device. The amplitude (wave height value, peak value) of this signal includes radiation energy information and the like. MCA is a wave height analyzer that detects this signal and digitally converts the maximum crest value to generate a spectrum (histogram).

"Dead time" is an indicator of MCA performance. Dead time is a time zone when MCA cannot measure peak value. The radiation causes irregular events. Therefore, while executing from event occurrence to peak detection, wave height value digital conversion, memory rewrite, peak value resetting, a new event cannot be measured. The dead time of this device is fixed 1.5 μsec.

There are four measurement operations: **histogram** mode, **list** mode, **MCS** (Multi Channel Scaler) mode, and **coincidence** mode.

Histogram mode: spectral data is generated with the energy peak value such as keV on the horizontal axis and the count on the vertical axis.

List mode: when detecting a valid event (an event where the signal from the amplifier exceeds the threshold and the crest value is between LLD and ULD), the elapsed time from the start of measurement, the crest value and the channel number are displayed, it transfers to the computer as list data of length of 8 bytes and saves it in the file. Both data will be transferred to computer via USB cable.

MCS mode: spectrum data is generated with the horizontal axis representing time from nanosecond to one second and the vertical axis counting. Select the horizontal axis's dwell time (time width per channel) from a minimum of 40 nanoseconds up to 100 seconds in advance. The number of channels can be 4096 and 232 counts per channel. Valid events within the LLD and ULD ranges are detected, and the corresponding elapsed time channels are counted and added based on the time information at the timing exceeding the threshold.

Coincidence mode: is a mode in which CH1 and CH2 are used to acquire simultaneously detected time and wave height value within a set time. The set time range is from the minimum plus or minus 40 ns to the maximum plus or minus 10 μs. You can save two channel simultaneous list data in list mode and create two-dimensional histogram (2048 x 2048 channels) with horizontal axis CH1 PHA and vertical axis CH2 PHA.

The software that comes with this device is driver software and applications that run on Windows.
This manual explains the handling of this device.

2. Specifications

Product name: USB-MCA4   * Same as the attached application name

Model: APG7400A   * Including products with alphabets following the model

1. Analog input

Number of channels	4 channels
Input range	0 (zero) to + 10 V
Input impedance	1 kΩ (ohm)
Input pulse width	Minimum 100 nanoseconds up to 100 microseconds *The threshold is exceeded

2. ADC

Conversion method	Successive approximation type
Resolution:	16 bits
Conversion time + reset time	1.5 μs
ADC gain	4096, 2048, 1024, and 512 channels
Threshold	Full scale 0 (zero) to 50 % (percent), set from computer
LLD	Full scale 0 (zero) to 100 % (percent), set from computer
ULD	Full scale 0 (zero) to 100 % (percent), set from computer

3. Perfomance

Dead time	1.5 microseconds fixed *Spectroscopy amplifier processing time is not included
Integral nonlinearity	Plus, or minus 0.025 % (typ.) or less
Differential nonlinearity	Plus, or minus 1 % (typ.) or less

4. External input

GATE	It functions as time stamp clear (CLR) when measuring in LIST mode.
VETO	It functions as MCS time count clear (CLR) when measuring with MCS mode (option).

5. Measurement modes

Histogram mode	Maximum 4096 channels, 2^{32} counts per channel
List mode	Time information per event, CH number, peak height
MCS mode	40 nanoseconds to 100 seconds per channel, 4096 channel, 2^{32} counts
Coincidence mode	Simultaneous measurement by CH1 and CH2. Create two-dimensional histogram
Communication interface	USB 2.0 *It is recommended to use USB cable length of two meters or less, USB 3.0 port. If you have a low power consumption function on a USB port, such as a laptop computer, please cancel it or use it with a USB hub with power supply with the AC adapter.

6. Application software: Windows version, USB-MCA4 software and driver software
    * Sample programs such as Linux and Visual C ++ / C # are available for support on our website.

7. Dimension: 70 mm (W) x 160 mm (D) x 20 mm (H)

8. Weight: 230g

9. Accessories:

    Manual

    CD-ROM for Driver and Application software installation

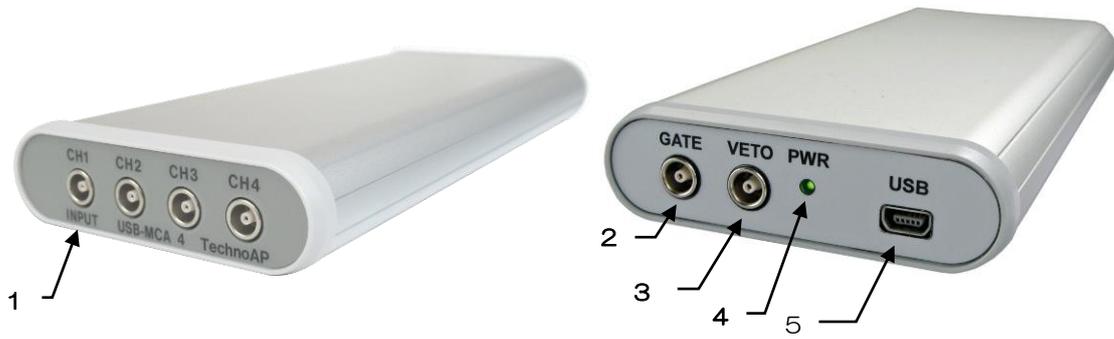   USB cable * Cable with USB (A) male and USB (Mini-B) male connectors

3.　 **Appearance**

Image 1: APG7400A

FRONT

1. INPUT	Amplifier signal input connector (manufactured by LEMO: EPL.00.250.NTN) 1 to 4 channels. * In coincidence mode, CH1 and CH2 are used

BACK

2. GATE	LEMO connector for external GATE signal input. Input LV - TTL level signal. Data acquisition with input "High", data not acquired with "Low".
3. VETO	LEMO connector for external VETO signal input. Input LV - TTL level signal. Data not acquired with Input "High" data acquisition with input "Low". LIST mode or MCS mode (option) Time count clear (CLR) is entered during measurement and cleared at input "rising edge (pulse width of 100 nanoseconds or longer)".
4. PWR	LED turns on when power is on (connected to computer).
5. 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.
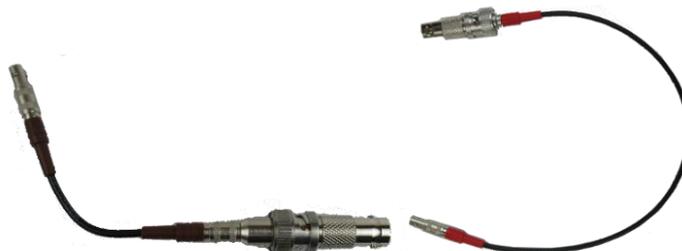
Image. 3　LEMO-BNC conversion cables
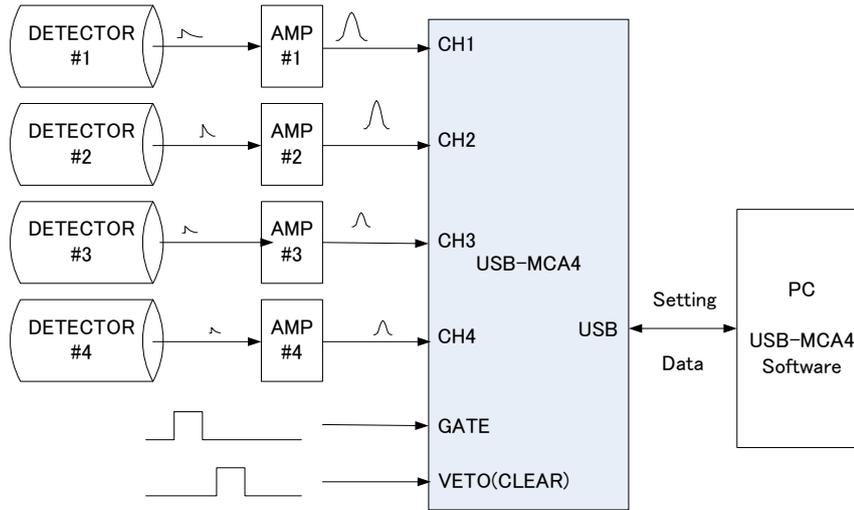
4.　Setup

4.1.　Connection

Figure 1: Connection when using this device

1. Connect the USB-MCA 4 and the computer with the included USB cable.

   A: *It is necessary to install the driver software on the computer to be connected for the first time. For the installation method of the driver software, refer to the following.

   B: *Do not connect the signal cable when the power of this equipment is OFF.

2. Confirm that the "PWR" LED is on.

3. Connect the preamplifier output signal of the detector (DETECTOR in the above figure) to the linear amplifier (spectroscopic amplifier, AMP in the upper figure).

4. Connect the waveform-shaped output signal of the linear amplifier to one of "CH1" to "CH4" of this unit.

5. When control by external signal is required, input the LV - TTL level to the GATE or VETO terminal. When a cable is connected to the GATE terminal, data is acquired when the peak is detected from CH1 to CH4, or when the signal is in the high state. Or when a peak is detected from CH1 to CH4 while the cable is connected to the VETO terminal, data is acquired when the signal is open, or the signal is in the Low state.

6. VETO pin functions as CLR pin when LIST mode / MCS mode (option) is executed. When the rising edge signal is detected while the cable is connected to the terminal, the LIST time stamp / MCS time counter is cleared.

4．2． Installation of the driver software

The first time you connect this unit, you need to install the driver software from the included CD.

Windows 7

1. **REQUIRED** Log in as Administrator or login with administrator privileges.
2. Connect the device to the computer with a USB cable.
3. "Device driver software is installed" is displayed at the lower right of the desktop.
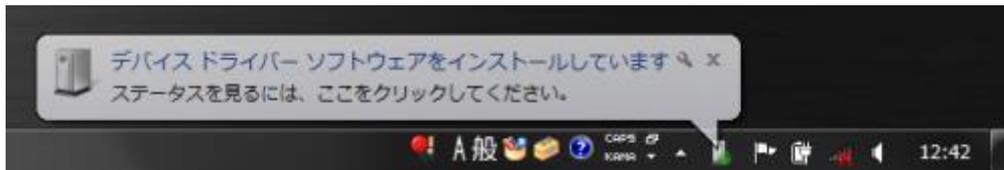
If "Device driver software was not installed correctly" is displayed, open the device manager, and check the "USB-MCA 4" icon. Right click on the icon and click "Update Driver Software".
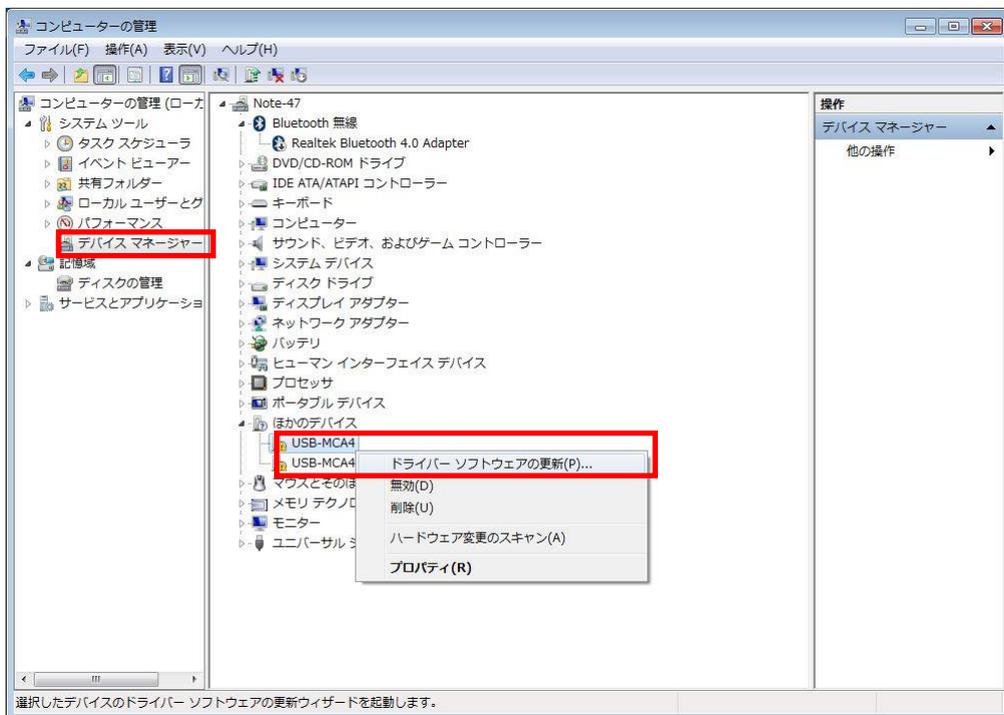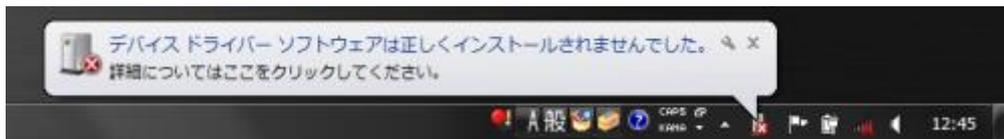
4. Advance interactive installation

Refer to the "Driver" folder on the attached CD.

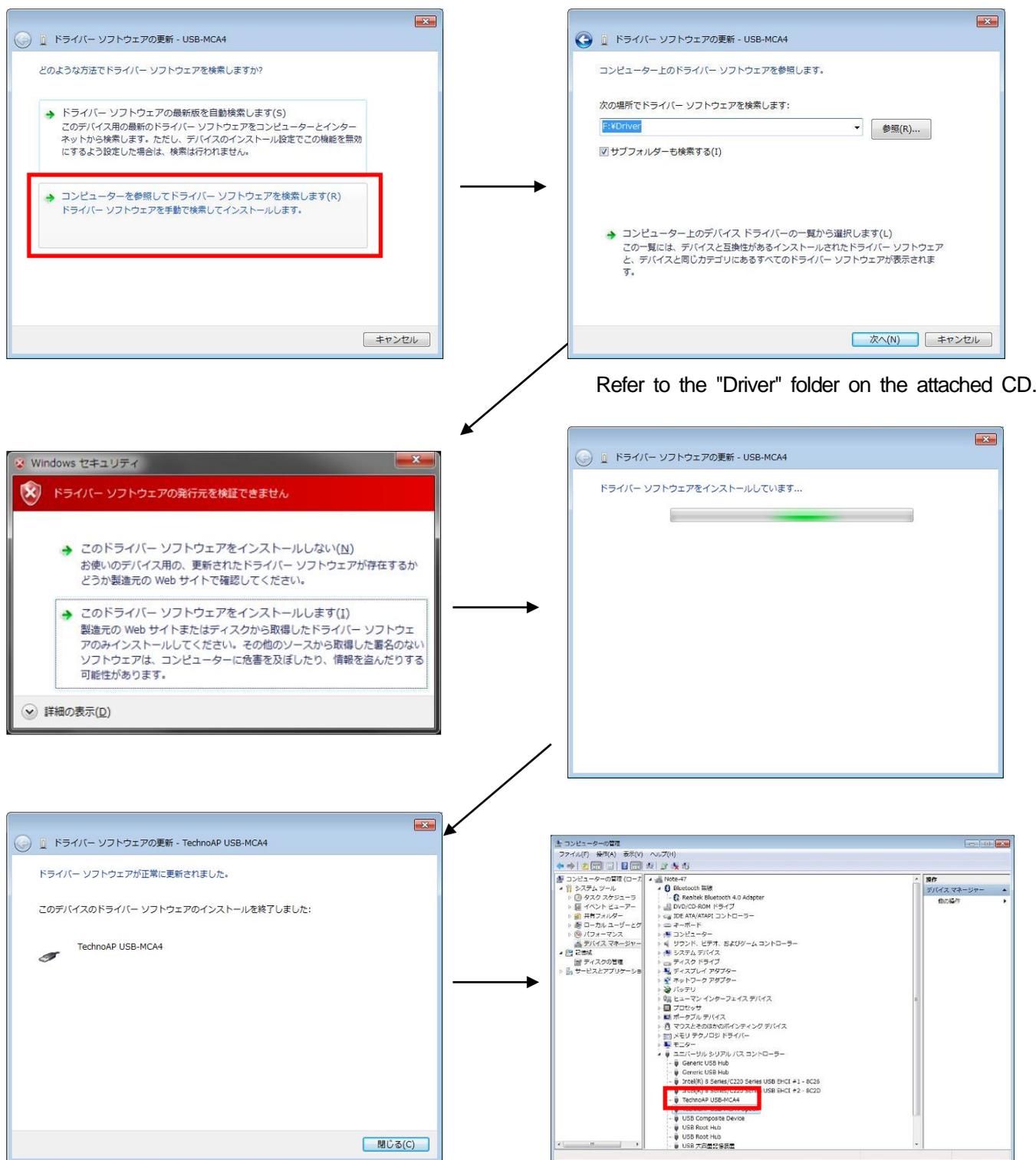Continue to install "TechnoAP USB-MCA4 Option". "TechnoAP USB-MCA4" After installing the driver software, install "TechnoAP USB-MCA4 Option" by the same procedure. Confirm that the two icons "TechnoAP USB - MCA 4" and "TechnoAP USB - MCA 4 Option" are normal in the device manager. After installing the driver software successfully, install the application. The installation procedure is described in the next chapter.

Windows 8 (64 bit)

In Windows 8 (64 bit), to prevent users from accidentally installing driver software, driver software without a digital signature cannot install as standard. Since this driver software does not have a digital signature, it is necessary to "disable driver signature enforcement" before installation. The procedure is as follows.

1. Display the charm on the start screen.
   - For mouse operation: Move the mouse to the upper right corner or the lower right corner of the screen.
   - Touch operation: Swipe from the right side of the screen toward the center.

2. Select "Setting" from the charm and select "Change computer setting" from the setting menu.
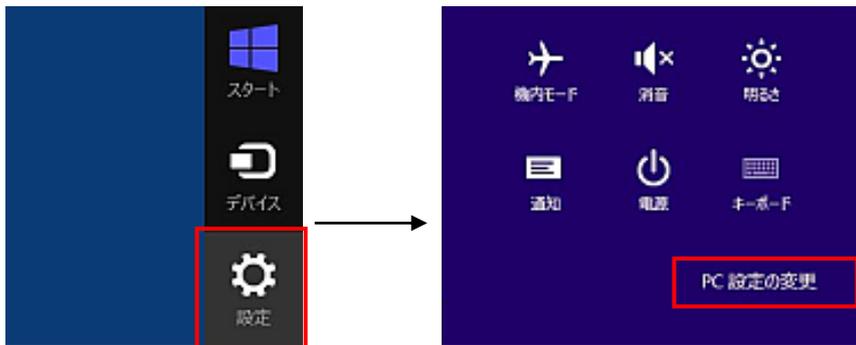
3. Select "General" from the "Settings" screen of the computer and select "Customize startup of computer" - "Restart now".

4. Select "Troubleshooting" from "Select option" screen and select "Advanced option" from "Troubleshooting" screen.
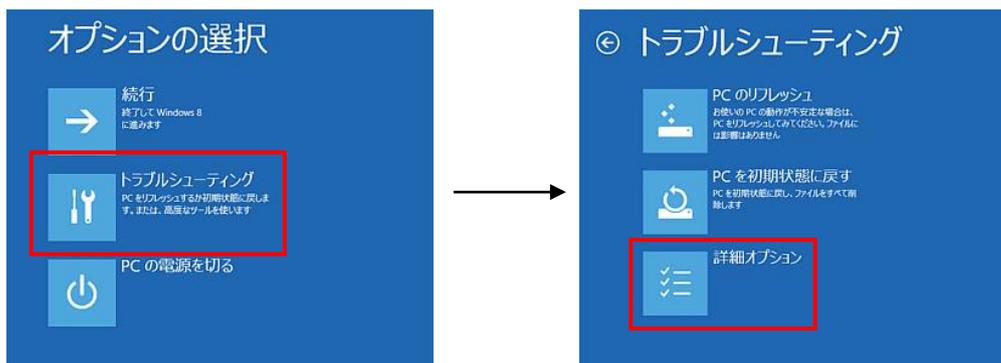
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5. Select "Startup Settings" from the "Advanced Options" screen and select "Restart" on the "Startup Settings" screen.

6. On the "Startup Settings" screen after rebooting, press the "7" key and select "**7) Disable Driver Signature Enforcement**".
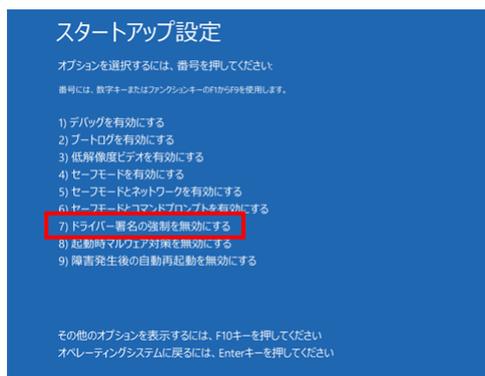
7. **IMPORTANT** After rebooting, log in as administrator or log in with administrator privilege account.
8. Connect the USB-MCA 4 to the computer with a USB cable.
9. Right click on the start screen, display "APP / BAR", select "ALL APP", and select "CONTROL PANEL" from APPLICATION view.
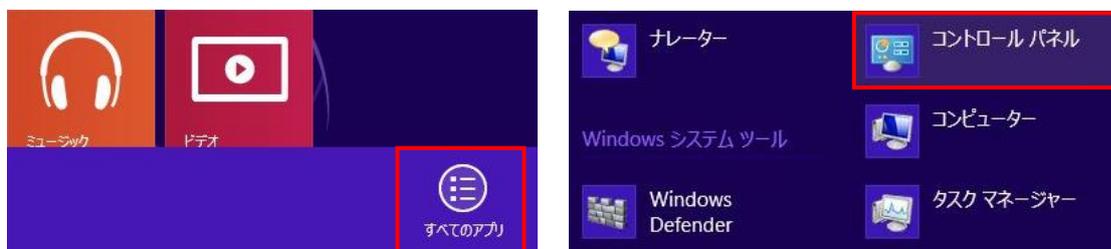
10. Select "Device Manager" from "Control Panel" and display "Device Manager".
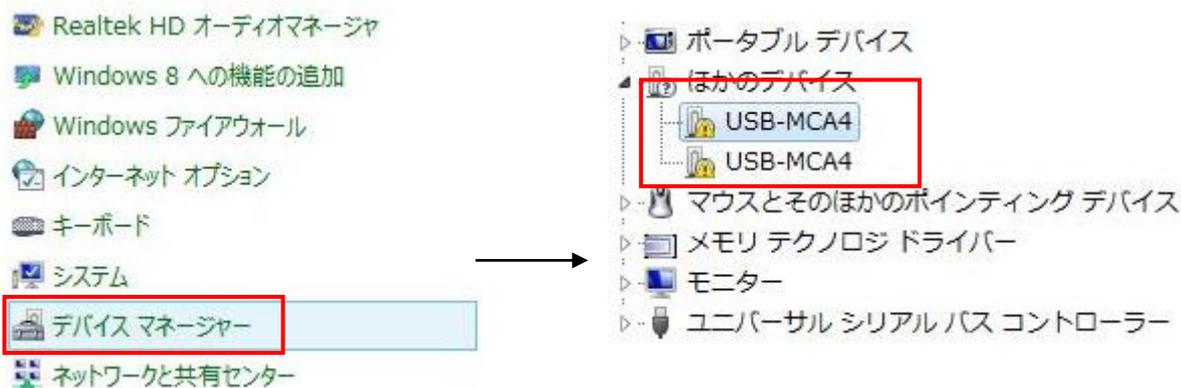
11. Right-click on "USB-MCA4", select "Update driver software (P)" and select "Search for driver software by computer (R)".
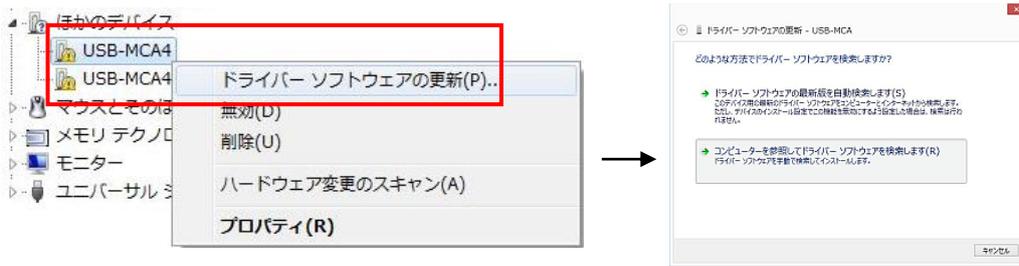
12. When "Update Driver Software" screen is displayed, select "Reference (R)", when the "Browse Folder" screen appears, select the drive where the driver software of "USB-MCA 4" is stored, OK "is selected. When you return to the "Update Driver Software" screen, select "Next (N)".

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

14. When "TechnoAP USB-MCA4" is displayed on the "Device Manager" screen, right click on the remaining "USB-MCA4 4" and repeat from (11) to update the remaining driver software.
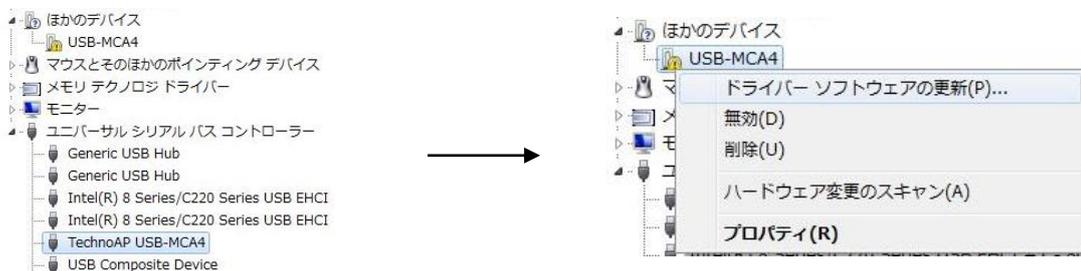
15. "TechnoAP USB-MCA4 Option" is displayed on the "Device Manager" screen, and installation of the driver software is completed.

Windows 10 (64 bit)

In Windows 10 (64 bit), to prevent users from accidentally installing driver software, driver software without a digital signature can not install as standard. Since this driver software does not have a digital signature, it is necessary to "disable driver signature enforcement" before installation. The procedure is as follows.

1. Click the "Windows" mark   at the lower left of the screen to display "Start menu".
2. Select "Settings" from the start menu and select "Update and security" from the setting menu.
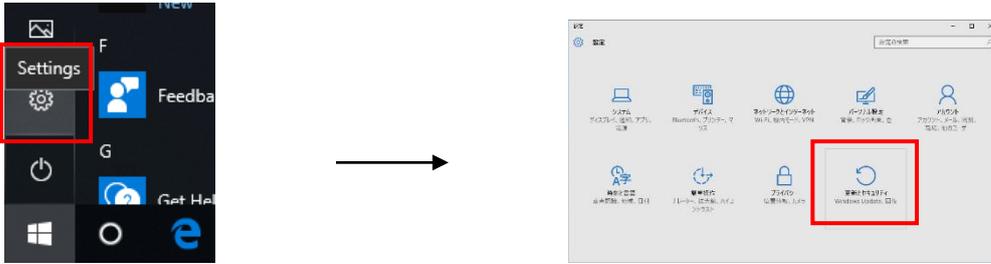
3. Select "Recovery" from the "Update and Security" screen and select "Advanced startup" - "Restart now".
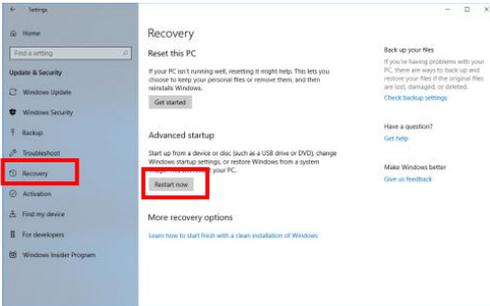
4. Select "Troubleshoot" from "Choose an option" screen and select "Advanced options" from "Troubleshoot" screen.
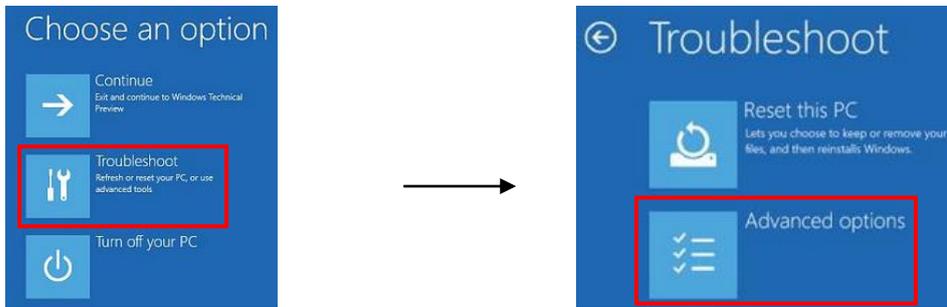
5. Select "Startup Settings" from the "Advanced Options" screen and select "Restart" on the "Startup Settings" screen.

6. On the "Startup Settings" screen after rebooting, press the "7" key and select "**7) Disable driver signature enforcement**".
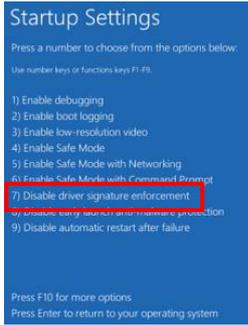

7. **IMPORTANT** After rebooting, log in as administrator or log in with administrator privilege account.

8. Connect the USB-MCA 4 to the computer with a USB cable.

9. Right-click the "Windows" mark on the lower left of the screen, display "Menu", select "Device Manager".
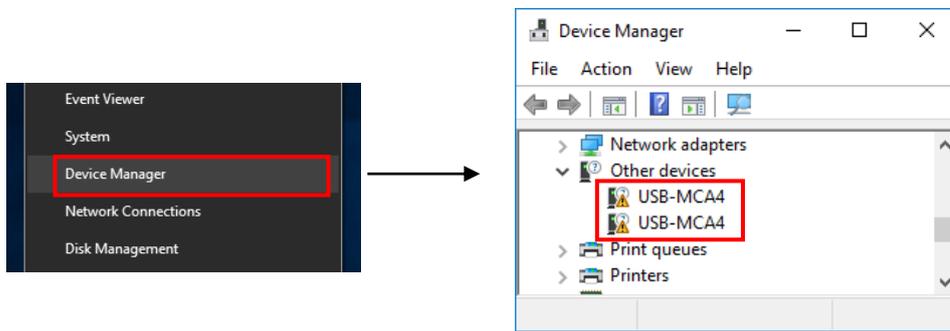
10. Right-click on "USB-MCA4", select "Update driver" and select "Browse my computer for driver software (R)".
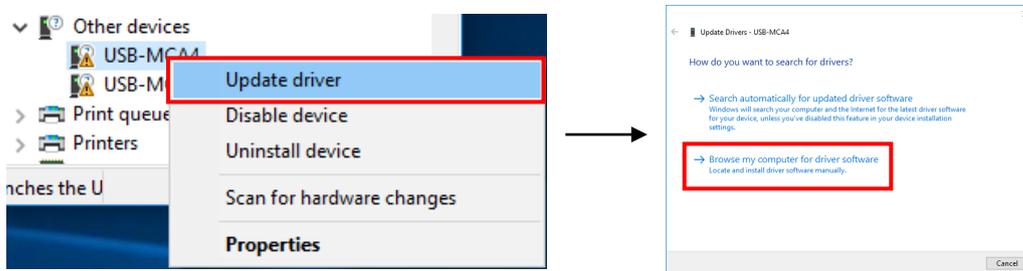
11. When "Update Drivers" screen is displayed, select "Browse…", when the "Browse for Folder" screen appears, select the drive where the driver software of "USB-MCA 4" is stored, OK "is selected. When you return to the "Update Drivers Software" screen, select "Next".

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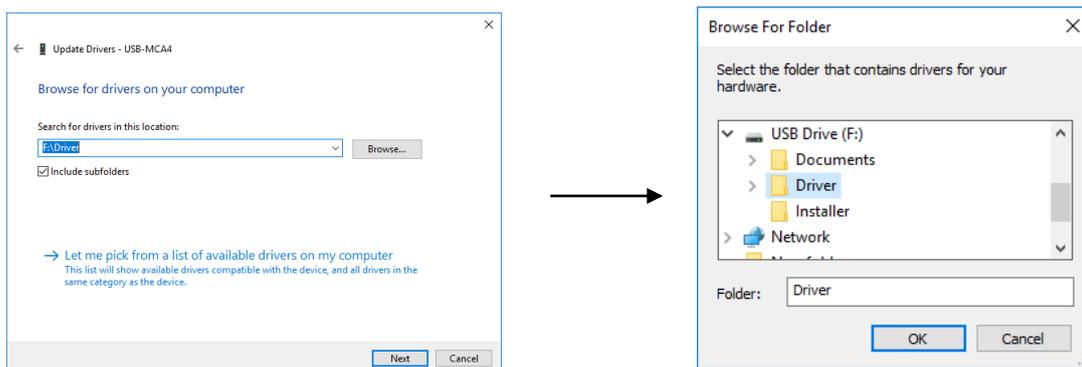
12. When "Windows Security" screen appears, select "Install this driver software (I)". When "Driver software has been successfully updated" is displayed, select "Close".
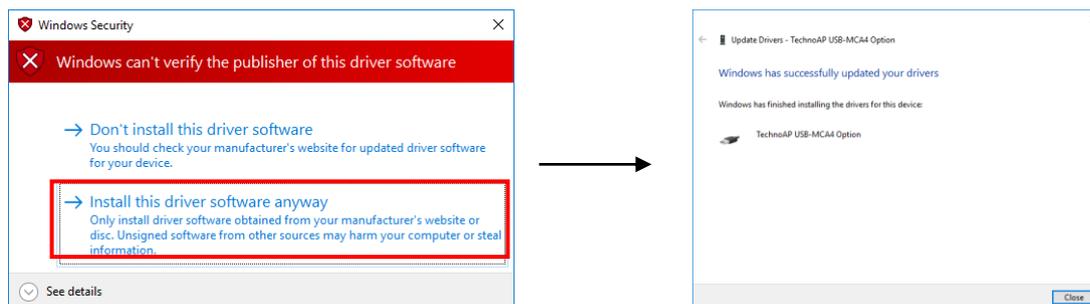
13. When "TechnoAP USB - MCA4" is displayed on the "Device Manager" screen, right click on the remaining "USB - MCA4 4" and repeat from (11) to update the remaining driver software.
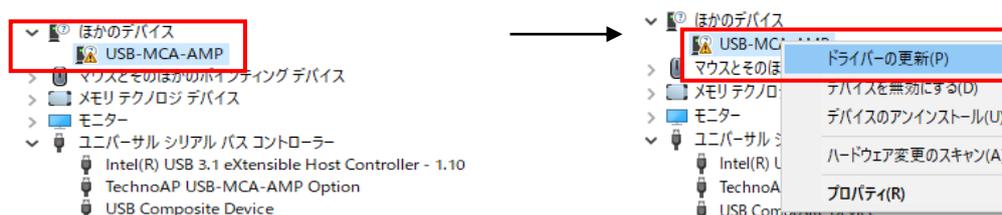

14. If "TechnoAP USB-MCA-AMP" is not displayed on the "Device manager" screen, select "Show hidden devices" from "Display" in the device menu.
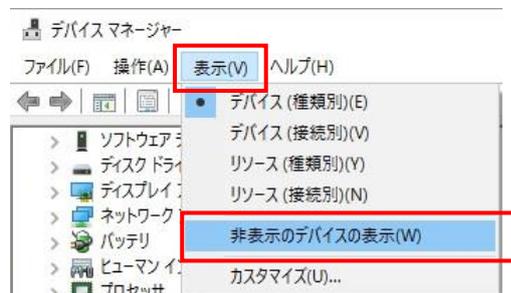
15. "TechnoAP USB - MCA4 Option" is displayed on the "Device Manager" screen and installation of the driver software is completed.

4．3． Installation of the application software

After the driver software is successfully installed according to the procedure in the previous chapter, you need to install the application (executable file) of USB-MCA 4 and the runtime engine of LabVIEW which is the development environment. The installer on the accompanying CD includes USB-MCA 4 application and LabVIEW runtime engine, which can be installed at the same time.
The installation procedure is as follows.

Windows 7 (the same for Windows 8 as well)

1. **REQUIRED** Login as Administrator or login with administrator privilege account.
2. Execute "Setup.exe" in the "Application" folder in the attached CD. Proceed with installation interactively.
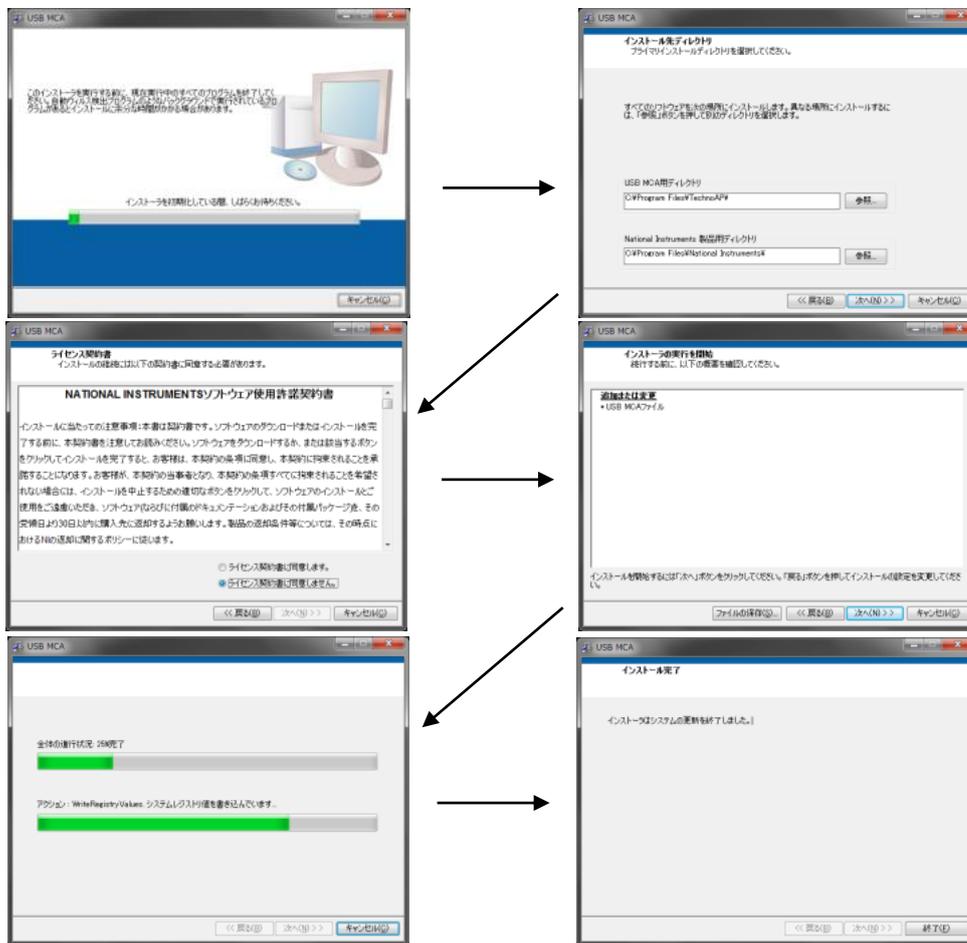
3. Execute "Start button" - "TechnoAP" - "USB-MCA4".
4. Application "USB-MCA4" starts up.

If the "connection error" dialog box is displayed immediately after startup, please confirm that this equipment is connected properly with the computer, or whether it is recognized by the device manager.

Windows 10

1. Select "setup.exe" in the "Application" folder in the attached CD. Select "Administration" in the application tool of the menu and select "Run as Administrator"
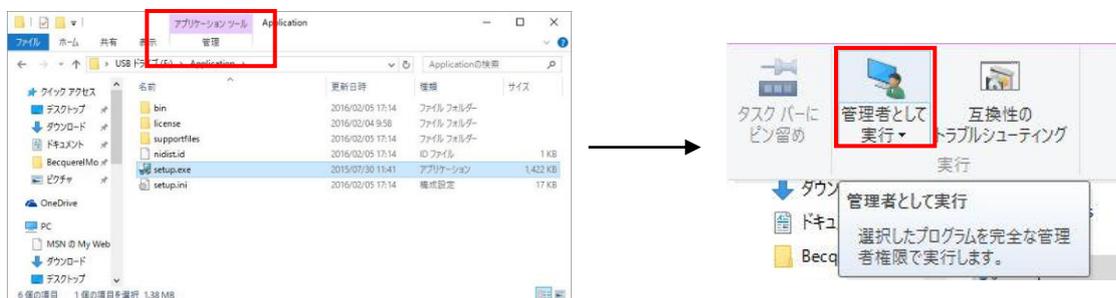
2. Execute "setup.exe" in the "Application" folder in the attached CD. Proceed with installation interactively.
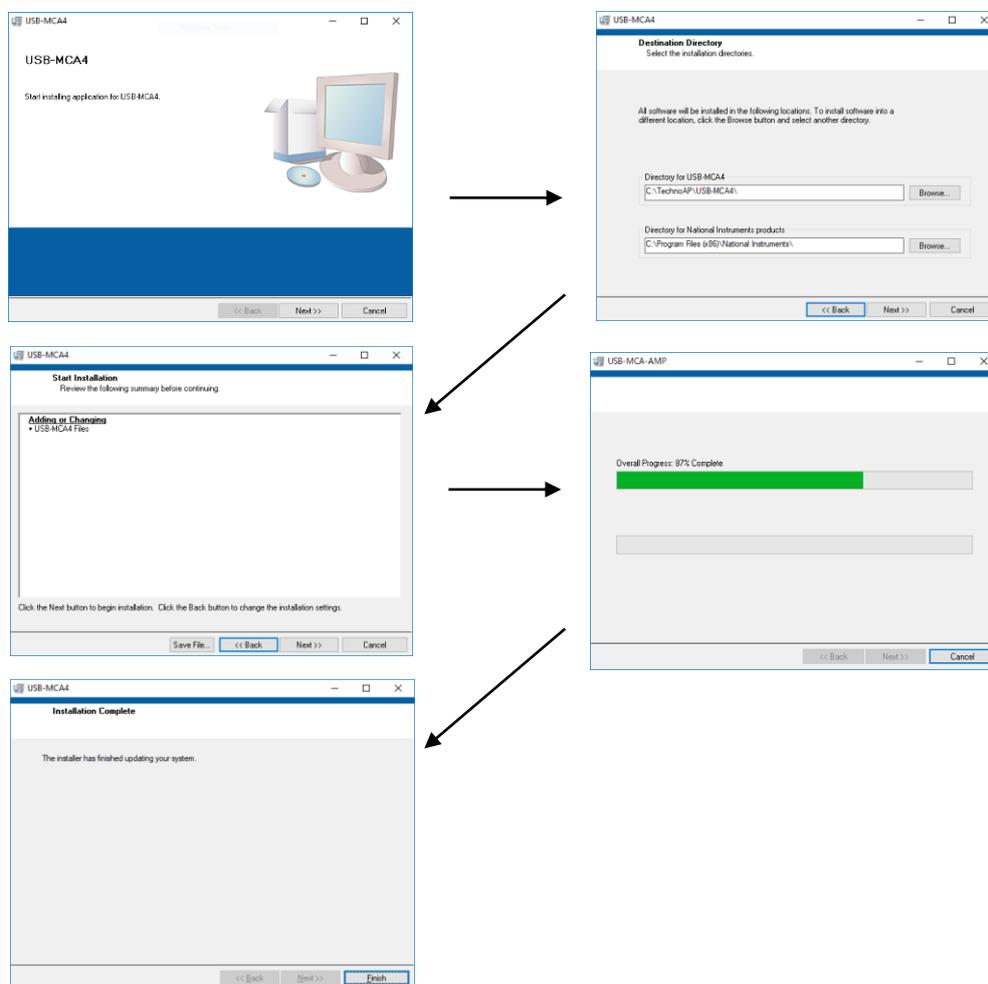
3. Since it is displayed to restart the computer, click the "Restart" button to reboot.

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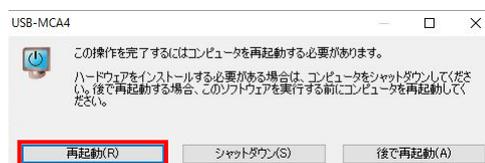
4. Right-click on the "Windows" mark ⊞ at the bottom left of the screen, display "Menu" and execute "All Applications" - "TechnoAP" - "USB - MCA 4".

5. The application "USB-MCA 4" is activated.

If the "connection error" dialog box is displayed immediately after startup, please confirm that this equipment is connected properly with the computer, or whether it is recognized by the device manager.

* Uninstall

To uninstall, select "USB - MCA 4" from "Settings" - "Apps" - "Apps & features" and select "USB-MCA4".

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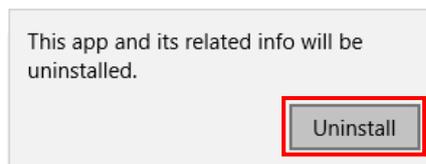
5. Application screen

5.1. Startup screen

If you run "USB - MCA 4" (Windows 8) in "Start button" - "TechnoAP" - "USB - MCA 4" (Windows 7) or Start screen or "Application view", the following start screen will be displayed.
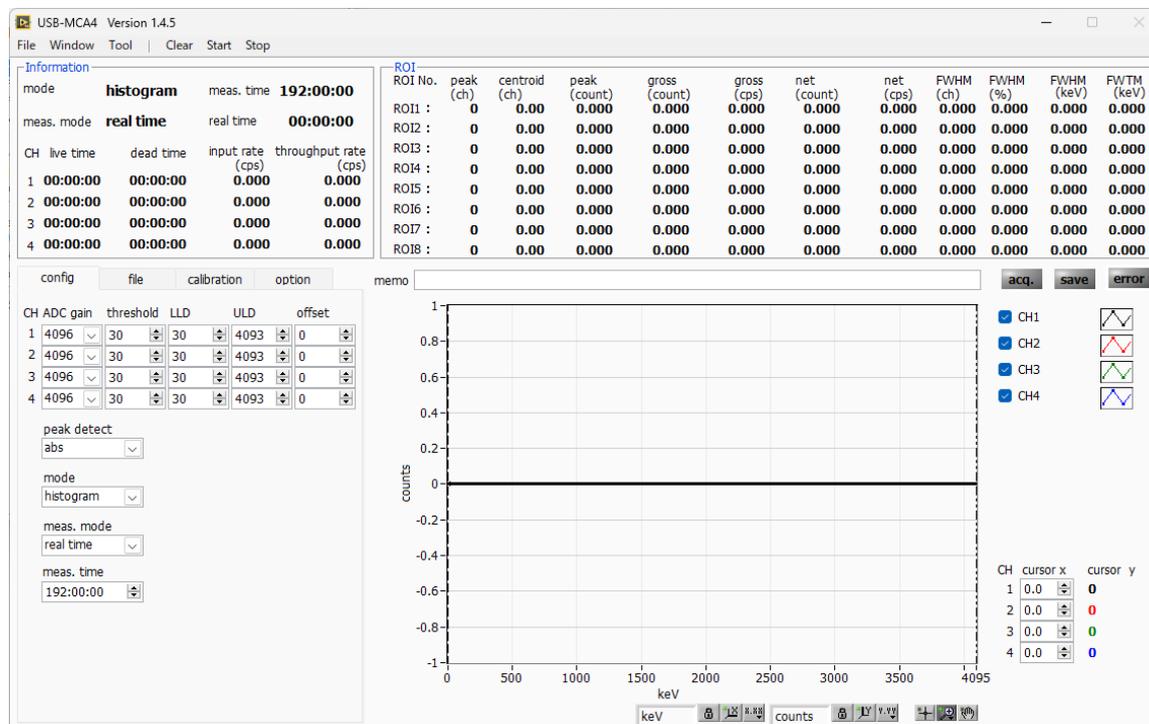
Image. 4 USB-MCA 4 startup window

Menu section

File - open config	Reading the configuration file
File - open histogram	Reading histogram data file
File - open 2D histogram	Read coincidence 2-dimensional histogram data file
File - save config	Save the current settings to a file
File - save histogram	Save current histogram data to a file
File - save 2D histogram	Save the current coincidence two-dimensional histogram data to a file
File - save image	Save this device screen as PNG format image
File - convert to text from binary list data file	CSV format conversion of binary format list data file
File - quit	Application termination
Window - histogram	Display histogram graph
Window - 2D histogram	Display 2D histogram graph
Clear	Initialization of 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	Setting of ROI (Region of Interest) etc. on energy calibration
option	Settings for options such as MCS

Information section

mode	Displayed histogram, list, coincidence and MCS
meas. mode	Measurement mode. Display "real time" or "live time"
meas. time	The set measurement time
real time	Real time (actual measurement time)
live time	Live time (effective measurement time). real time - dead time (see below)
dead time	Dead time (invalid measurement time). real time - live time. When the input signal exceeds "threshold" as described later, peak is detected, and its peak is converted to AD It is dead time until resetting and resetting.
input rate (cps)	Number of counts per second when the input signal level exceeds the threshold level
throughput rate (cps)	Number of counts per second secured as peak between LLD and ULD

ROI section

The calculation result between ROIs is displayed for each CH.

peak (ch.)	Maximum count channel
centroid (ch.)	The center value (channel) calculated from the sum of all counts
peak (count)	Maximum count
gross (count)	Sum of counts between ROI
gross (cps)	Sum of counts between ROIs per second
net (count)	The sum of the counts obtained by subtracting the background between ROI
net (cps)	The sum of the counts obtained by subtracting the background between ROIs per second
FWHM (ch.)	FWHM (channel)
FWHM (%)	FWHM / peak value * 100
FWHM	Half width
FWTM	1/10 width of peak

acq. LED	Blinking during measurement
save LED	Lit while data is being saved
error LED	Lit when an error occurs

5．2． Quit window

To exit the application, click the menu "File" - "quit". After execution, the following confirmation screen of termination is displayed.
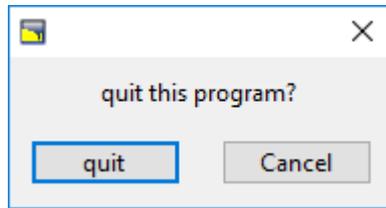
Image. 5　Quit confirmation screens

To quit, click the "quit" button. After execution, the application screen disappears, and it ends.

5．3． config tab

Image. 6　config tab

ADC gain	Gain of ADC. Select from 4096, 2048, 1024, and 512 channels. The input voltage range of the amplifier output signal of each channel is 0 to 10V. Divide this range by the above channel. For high energy resolution detectors such as germanium semiconductor detectors, data can be acquired with fine resolution by selecting 4096. However, when the count is small, it takes time to acquire the peak. Since energy resolution is inferior, such as NaI (Tl) scintillation detector, if it cannot be divided finely, set 4096 channels and so on.
threshold	Setting of the timing threshold of the waveform acquisition start timing. Unit is digit. The setting range is 0 to 4095. Set to a value less than LLD. It triggers peak detection and AD conversion from the timing when the waveform shaping input signal exceeds the set value of the threshold. If this setting is set too high, peak value of low energy cannot be acquired. On the contrary, if the setting is too small, let's pick up the noise. For example, when "ADC gain" is "4096nitially set "threshold" and "LLD" around 100. While looking at the histogram "input rate / throughput rate" little by little, discerns the boundary between noise increase in value and sets the threshold value slightly above it.
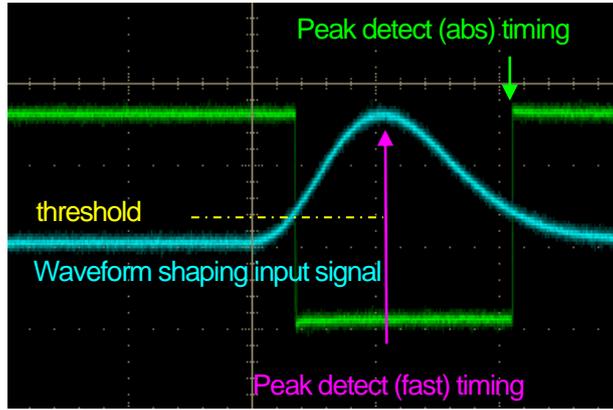
Image. 7　threshold and peak detection (abs / fast) timing

LLD	Set up energy Lower-Level Discriminator. The unit is ch. Channels below this threshold are not counted. Set it to a value greater than or equal to threshold and less than ULD.	
ULD	Set up energy Upper-Level Discriminator. The unit is ch. We do not count ch above this threshold. Set it to a value larger than LLD.	
offset	Sets the offset in the positive direction. The unit is ch. By adding the offset setting value, it is possible to shift the spectrum to the right (direction of pulse height). It can be used for peak position adjustment and so on.	
peaks detect	***Selection of detection method of peak (maximum pulse height).***	
	abs	Pulse heigh input signal exceeds threshold, after reaching the peak, attenuates and falls below threshold, performs AD conversion. It is possible to acquire the maximum pulse height more definitely.
	fast	When the input signal exceeds threshold, the AD conversion is executed at the timing when it first reaches the peak. It is suitable for measurement and pile-up countermeasure at high count (more than several kcps).
mode	***Selection of operation mode***	
	histogram	The pulse height of the linear amplifier signal is stored in the maximum 4096 channels, and a histogram of the horizontal axis energy and the vertical axis count is created.
	list	The time stamp when the linear amplifier signal exceeds the threshold, the maximum pulse height and the channel number are set as one event data, data is continuously transferred to the personal computer and the file is saved.
	MCS	Generate spectral data with the horizontal axis as time (nano-second to second) and the vertical axis as count. Since the horizontal axis is the time width per channel in advance, the dwell time can be selected from a minimum of 40 nanoseconds to a maximum of 100 seconds, and the number of channels can be 16384, 232 counts per channel. When a valid event within the LLD and ULD range is detected, the count is added to the corresponding elapsed time channel based on the time information at the timing exceeding the threshold at that time.
	Coincidence	Using CH1 and CH2, it acquires simultaneous detected time and wave height value within set time. The set time range is from a minimum of ± 40 ns to a maximum of ± 10 μsec. Save 2-channel simultaneous list data as list mode and create 2-dimensional histogram (2048 × 2048 channels) by PHA on horizontal axis CH 1 and PHA on vertical axis CH 2.
meas. mode	***As the measurement mode, select "real time" or "live time".***	
	real time	Measure preset time data
	live time	Measure until effective measurement time (difference between real time and dead time) reaches preset time.
meas. time	Measurement time setting. The setting range is 0 to 192 hours (8 days). If it is set to 0, there is no stop by the measurement time, and even if it exceeds 192 hours, measurement will continue until you click the menu "Stop".	

5．4．　file tab
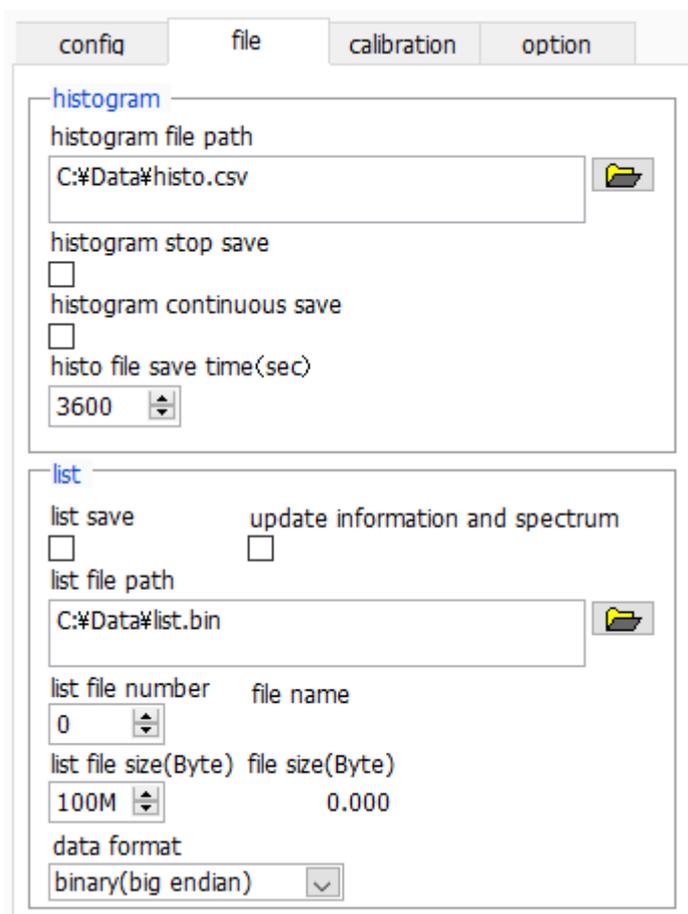
Image.8　file tab

Histogram section

histogram file path	Sets the absolute path of the histogram data file. Files without extensions are also possible. **! CAUTION!** This file name is not saved. Based on this file name, create the following format. As an example, set "C:￥Data￥histogram.csv" to "histogram file path" and "10" to "histogram file save time (sec)", the date is "2015/12/23" and time is "12:34:00", data storage starts with the file name" C:￥Data￥histogram_20151223 _ 123400.csv ". After 10 seconds, save as "C:￥Datahistogram_20151223_123510.csv" file.
histogram stop save	When measurement is completed, histogram data is saved in a file. The file is saved in the same format as described above.
histogram continuous save	Sets whether to store histogram data in a file at preset time intervals. **! CAUTION!** Depending on the processing status, the saving interval may be shifted. Please use it for simple backup.
histo file save time (sec.)	Sets the time interval of consecutive saving of histogram data. The unit is seconds. The setting range is from 5 seconds to 3600 seconds.

List section

list save	After starting the measurement, save the list data sent to the PC to the list data file.
update information and spectrum	During measurement in list mode, data acquisition and display of "Information" section will be performed. Also, it creates a histogram from the received event data and displays it. **! CAUTION!** This process takes time. Please be aware that it may not be processed correctly depending on the performance and specifications of your computer, and it may not be able to receive all event data.
list file path	Sets the absolute path of the list data file. Files without extensions are also possible. **! CAUTION!** This file name is not saved. Based on this file name, create the following format. As an example, if "list file path" is set to "C:￥Data￥list.bin" and "list file number" is set to "10", the file "C:￥Data￥list _ 000010.bin" Start saving data by name. "List file number" is updated to "11" when it reaches the preset file size with "list file size (Byte)" and saved as "C:￥Data￥list _ 000011.bin" file.
list file number	It is a number automatically added to the list data file name. Up to "999999" can be used. Next to "999999" is zero.
file number	The list data file name created from "list file path" and "list file number".
list file size (Byte)	Sets the maximum size to save the list data file. Set it as "1 M" "10 M" "100 M" etc. by SI notation. Set it from "1 M" byte to "2 G" byte.
file size (Byte)	Displays the size of the currently saved list data file. "0.789 M", "10.100 M", "1.230 G", etc. are displayed as SI notation.
data format	*Select the file saving format such as binary and text of the list data.*

	binary (big endian)	Big endian binary file format. You can reduce the file size. The most significant byte occupies the lowest memory address. It is common as network byte order. You can easily check the alignment of the data by eye.
	binary (little endian)	Little endian binary file format. You can reduce the file size. The least significant byte occupies the highest memory address. Used on Windows, Mac OS X, Linux. It is difficult to visually check the sequence of data.
	txt (CSV)	Comma (,) delimited text format. You can easily check the data with Notepad or Excel. **! Caution!** Data such as commas and line feeds are also added, and as the measurement time gets longer, the number of digits of the time data also increases. Therefore, the amount of data per event increases and the file size increases.

5. 5.　calibration tab
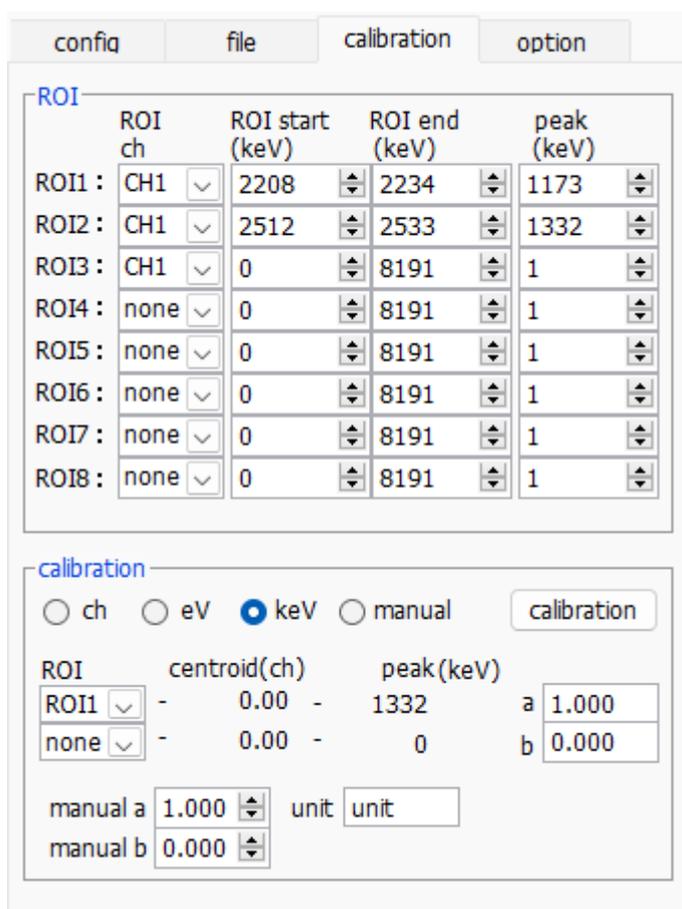
Image. 9　calibration tab

Setting of ROI (Region of Interest) and energy calibration. Set the ROI to the spectrum peak, calculate the peak count number, full width at half maximum, etc.

ROI section

ROI CH	Select the channel number for ROI. A maximum of 8 ROIs can be set for one channel signal
ROI start	Set the start position of the ROI. Unit depends on energy calibration situation.
ROI end	Set the end position of the ROI. Unit depends on energy calibration situation.
peak	The energy value etc. of the peak position (channel) etc are defined. In the case of Co - 60, set it to 1173 or 1332. When "ch" is selected in the next "calibration" part, the peak between the ROI is detected, keV / ch is calculated from the peak position (ch) and the set energy value and applied to the calculation result of the half width.

Calibration section

Types of calibration	Select the X axis unit from the following. In the case of MCS mode (option), the horizontal axis is time, so select "ns" "us" "ms" "sec". It is not "eV" and "keV".
ch	Display in ch (channel) unit. Units such as "FWHM" of "FWTM" of ROI are optional.
eV	Display in eV unit. Calculate the slope a and intercept b of the linear function y = ax + b so that the channel becomes eV by two-point calibration of two kinds of peaks (center value) and energy value in one spectrum and set it on the X axis. The unit of "FWHM" of ROI "FWTM" is "eV".
keV	Display in keV unit. 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 values in one spectrum and set it on the X axis. The unit such as "FWHM" of ROI "FWTM" is "keV". As an example, if there are 1173.24 keV for Co-60 in channel 5717.9 and 1332.5 keV for Co-60 in 6498.7 channel, a is 0.20397 and b is 6.958297 automatically from two-point calibration.
manual	Energy calibration is performed by arbitrarily setting slope a, intercept b and unit label of the linear function y = ax + b with "manual a", "manual b" and "unit".
ROI	Select the ROI number for energy or time calibration. On the right side "centroid" and "peak", the central value of the ROI being selected, and the energy value being set are displayed. For example, when "ROI 1" and "none" are selected, one-point calibration is performed based on the peak center value of ROI 1 and preset "peak". When "ROI 1" and "ROI 2" are selected, the peak center value of ROI 1 and ROI 2 and the two-point calibration with "peak" set in advance.
a and b	The slope of the linear function y = ax + b for creating the horizontal axis of the histogram graph, which is the calculation result of the energy calibration, is displayed in "a" and the intercept is displayed in "b."
Manual a and b	The gradient in the linear function y = ax + b for creating the graph horizontal axis, which is the calculation result of energy calibration, is shown by a and the intercept is displayed in b.
calibration button	Energy calibration is executed according to the type of calibration. After execution, the slope a and intercept b of the linear function y = ax + b applied to the horizontal axis of the graph are calculated and displayed on the lower "a" and "b". For the calculation method, refer to "8.5. Calculation method of two-point calibration" below. For example, if "keV" is selected in the "calibration" part as shown below and the "calibration" button is clicked, each peak is extracted from "centroid" value and "peak" value of "ROI 1" and "ROI 2" Energy calibration is executed so that it becomes the energy value, and the unit of horizontal axis unit of graph, set value of ROI, calculation result of ROI is also "keV".
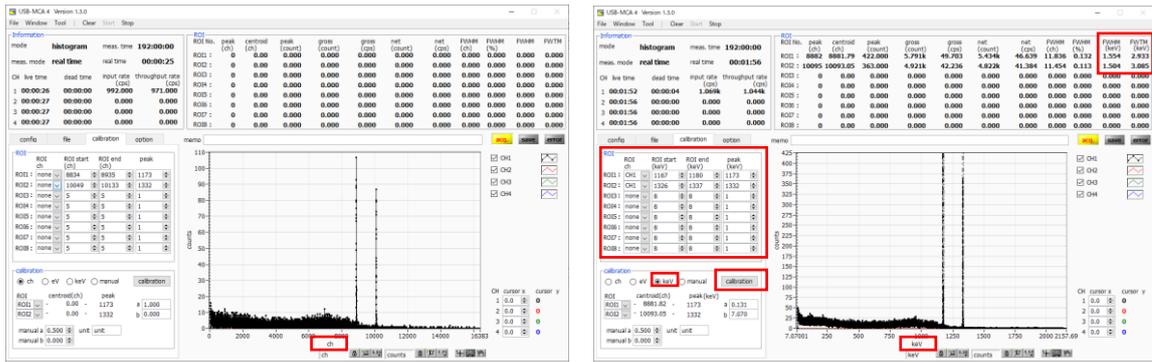
Image. 10　Select "keV" in calibration section
LEFT: before energy calibration execution, **RIGHT:** after energy calibration execution

5．6． option tab

Configure settings such as MCS (Multi Channel Scaler) and coincidence (simultaneous measurement).
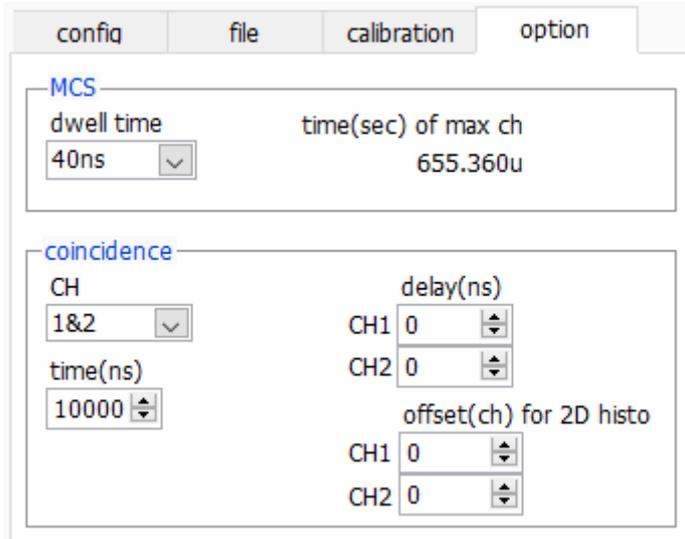
Image. 11　config tab
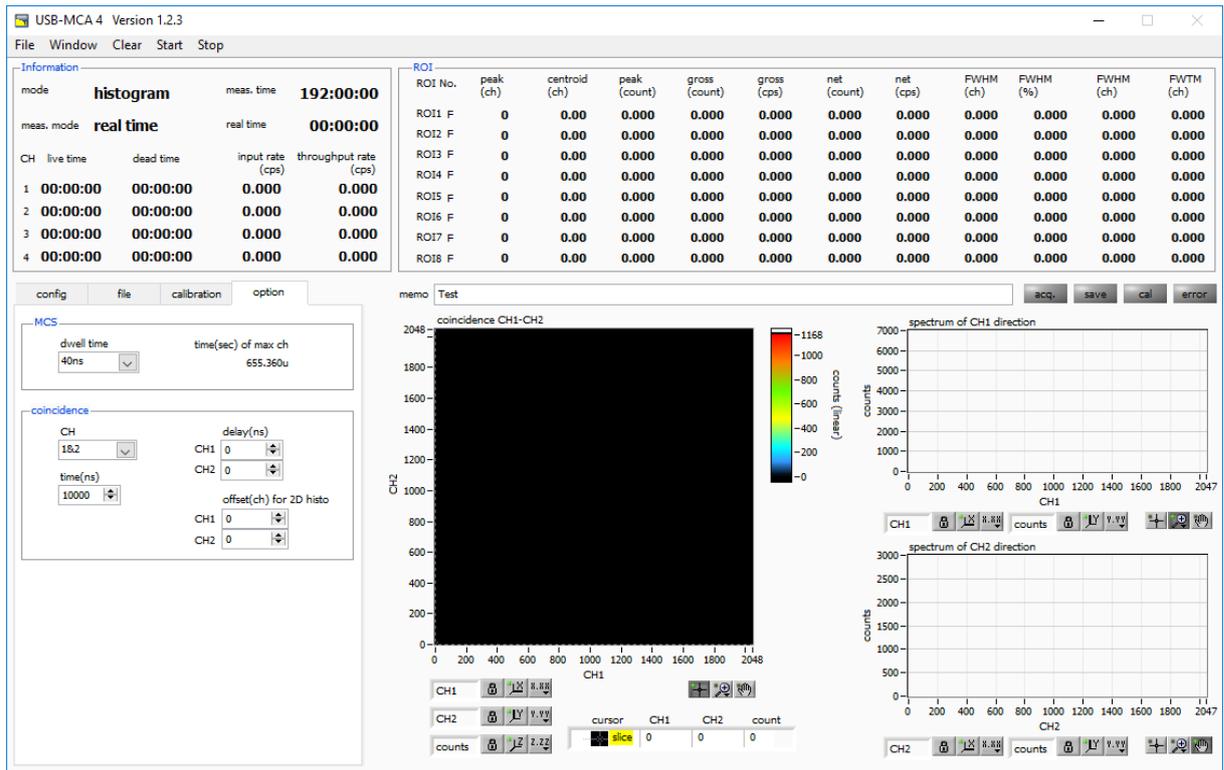
Image. 12　coincidence two-dimensional histogram

MCS section

dwell time	Time width per channel. Choose from a minimum of 40 ns to a maximum of 100 s. The selection items are as follows.							
	40 ns	80 ns	120 ns	160 ns	200 ns	240 ns	280 ns	320 ns	360 ns
	400 ns	440 ns	480 ns	520 ns	560 ns	600 ns	640 ns	680 ns	720 ns
	760 ns	800 ns	840 ns	880 ns	920 ns	960 ns	1 µs	2 µs	5 µs
	10 µs	20 µs	50 µs	100 µs	200 µs	500 µs	1 ms	2 ms	5 ms
	10 ms	20 ms	50 ms	100 ms	200 ms	500 ms	1 s	2 s	5 s
	10 s	20 s	50 s	100 s					
time (sec) of max. ch	Displays the time of the maximum channel based on the setting of dwell time. With 16384 channels, the minimum 40 ns is 655.36 µs (655 360 ns) from 40 ns × 16384 channels.							

coincidence section

CH	The target channels. Only channel 1 and channel 2.
time (ns)	Time range for judging the coincidence number. The setting range is 40 ns to 10,000 ns (10 µsec). If the time from exceeding the threshold of one channel to the threshold exceeding the threshold of the other channel falls within this setting range, it becomes the same number of clocks.
delay (ns)	Coincidence number delay time. Adjust the delay of signal transmission between channels. The setting range is 0 to 10,000 ns (10 µsec). Please use it for adjustment such as when there is time lag due to cable length etc.
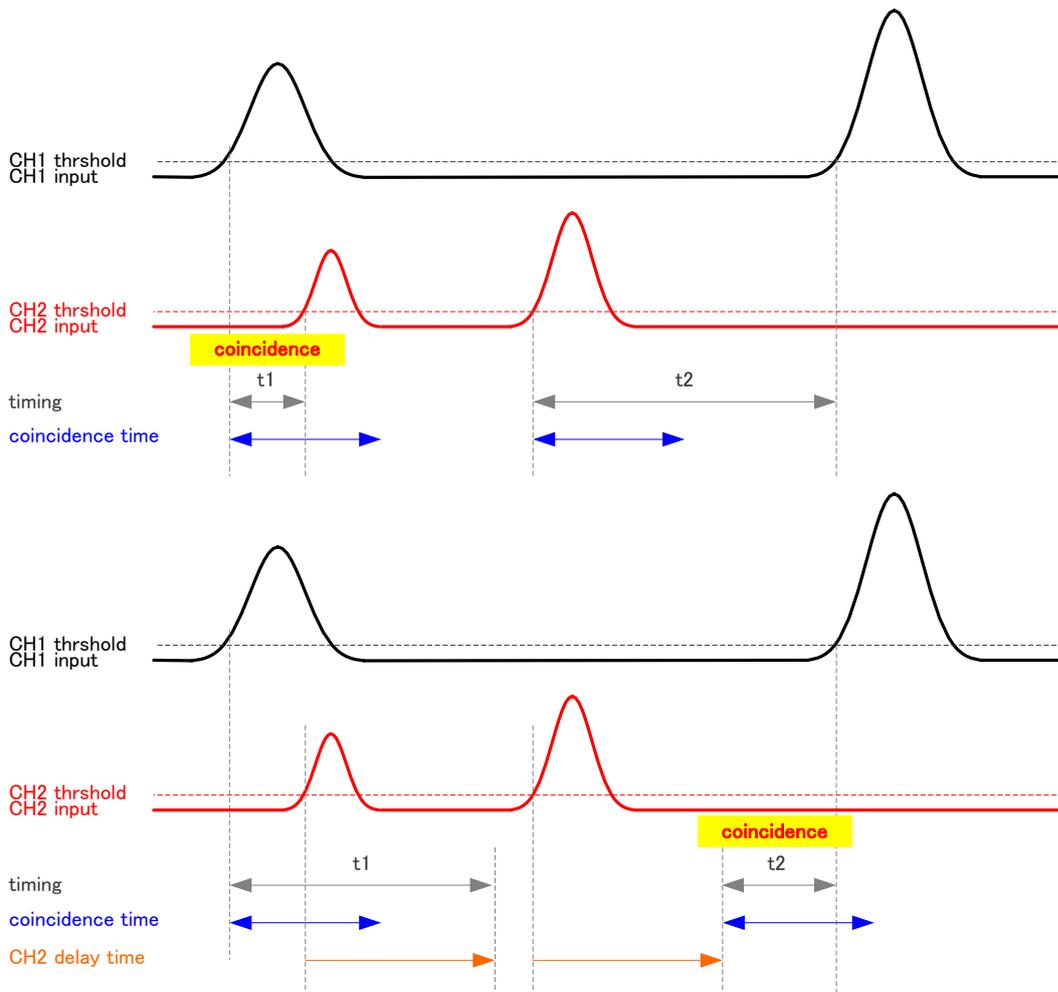
Figure. 2   Example of coincidence timing (**UPPRER:** delay is not used, **LOWER:** CH2 delay time is used)

offset (CH) for 2D histo	Set offset channel to coincidence 2D histogram. The setting range is 0 to 2048 (4096 - 2048) channels. Since the display range is 2048 × 2048 channels, adjust the offset value so that the peak falls within this range.

graph	Two-dimensional histogram graph. The X axis is the pulse height (ch) of CH1, the Y axis is the pulse height (ch) of CH2, and the Z axis is the count number. The maximum number of channels on the X and Y axes is 2048 channels.
spectrum of CH1 direction	One-dimensional channel addition histogram graph viewed from CH 1 side is displayed
spectrum of CH2 direction	One-dimensional channel addition histogram graph viewed from CH 2 side is displayed

5.7. **Graph**

graph	Display spectrum of CH1 and Gaussian fit spectrum with data between each ROI.
cursor x	There is a dotted line cursor for each channel, and the value of the count on the spectrum in the set channel is displayed in "cursor y" of the corresponding channel.
Plot legend	et the color of the graph and the type of line. You can switch display / non-display in the sub menu on the graph.
X axis range	Right click on the X axis and check "AUTO SCALE" to set the automatic scale. When unchecked, it will no longer be automatic scale and the minimum and maximum values of the X axis will be fixed. To change the minimum or maximum value, you can change the mouse pointer by placing it over the numerical value to be changed and clicking or double-clicking it.
Y axis range	Right click on the Y axis and check "AUTO SCALE" to set the automatic scale. If you uncheck it, it will no longer be automatic scale and the minimum and maximum values on the Y axis will be fixed. To change the minimum or maximum value, you can change the mouse pointer by placing it over the numerical value to be changed and clicking or double-clicking it.
x axis keV	On the X axis, set auto scalability, precision, mapping (linear / logarithm).
y axis counts	On the Y axis, set auto scalability, precision, mapping (linear / logarithm).
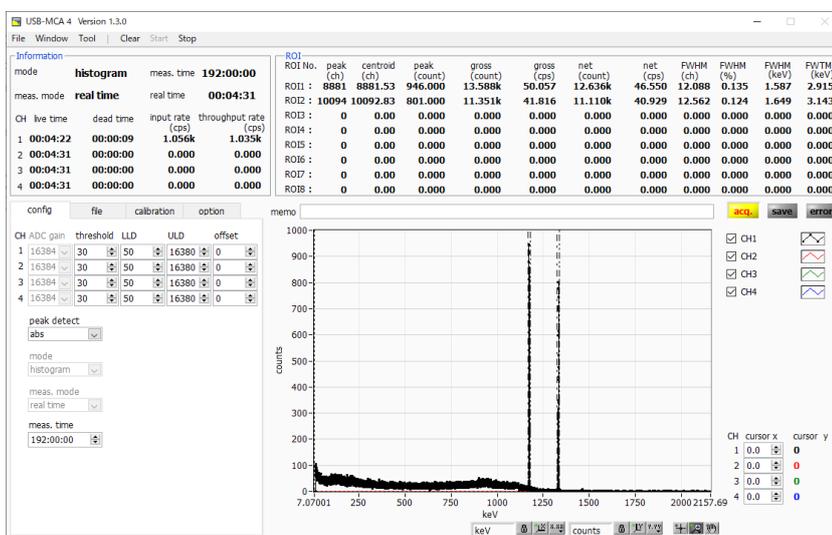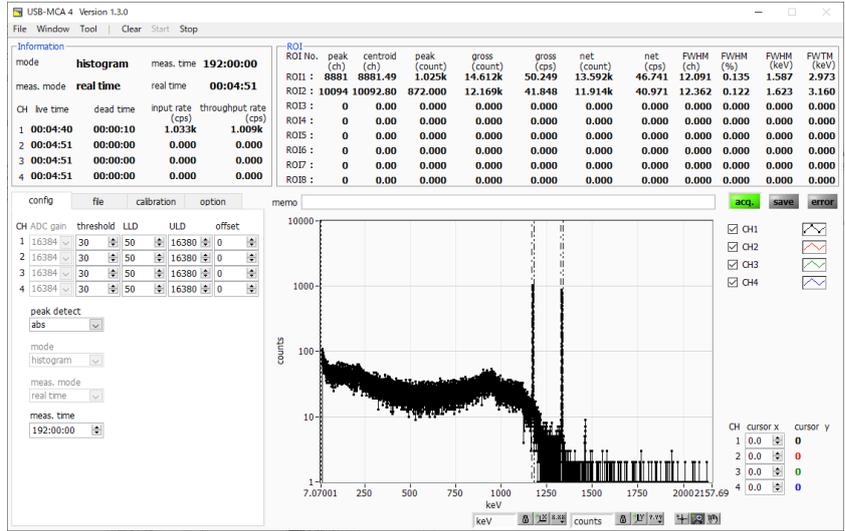
Image. 13　**UPPER:** Linear in vertical axis mapping mode, **LOWER:** Logarithmic

⊹	Cursor movement tool. The cursor can be moved on the graph when setting the ROI.	
🔍	Zoom. You can select and execute the following six zooms in and zoom out by clicking.	
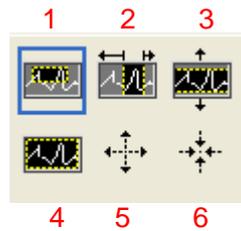
Image. 14　Zoom in and zoom out tool

1	Rectangle zoom	Use this option to click the point on the display that you want to corner in the zoom area and drag the tool until the rectangle occupies the zoom area.
2	X zoom	Zoom in on the area of the graph along the X axis.
3	Y zoom	Zoom in on the area of the graph along the Y axis.
4	Fit zoom	Automatically scale all X and Y scales on the graph.
5	Zoom out centering on points.	Click the center point to zoom out.
6	Zoom in around a point.	Click the center point to zoom in.

✋	Pan tool. You can grab a plot and move on the graph.

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6.   Measurement

6. 1.   Histogram mode

1. Select "histogram" in "mode" in "config" tab.

2. Click "Clear" on the menu. The internal histogram data is initialized. To continue the histogram or measurement result measured last time, start the next measurement without clicking "Clear".

3. When you click the "Start" menu, measurement is started after all settings are sent to this device.

4. After the start of measurement, transition to the following state.

    - "Acq" LED flashes.

    - The measurement status is displayed in the "Information" section.

    - "Histogram" is displayed in "mode".

    - Measurement set time is displayed in "meas. Time".

    - Real time acquired from this device is displayed in "real time".

    - The live time acquired from this device is displayed in "live time" of each channel.

    - The dead time acquired from the Switch is displayed in "dead time" of each channel.

    - For "ROI", for each "ROI No.", the center value, the gross count (sum within range), the rate, the net count (the total within the range minus the background subtracted from the background) by the ROI range setting in the "calibration" Count) and the calculation result such as rate, half width, 1/10 width etc. are displayed.

    - In the graph, a histogram of peak value is displayed on the horizontal axis.
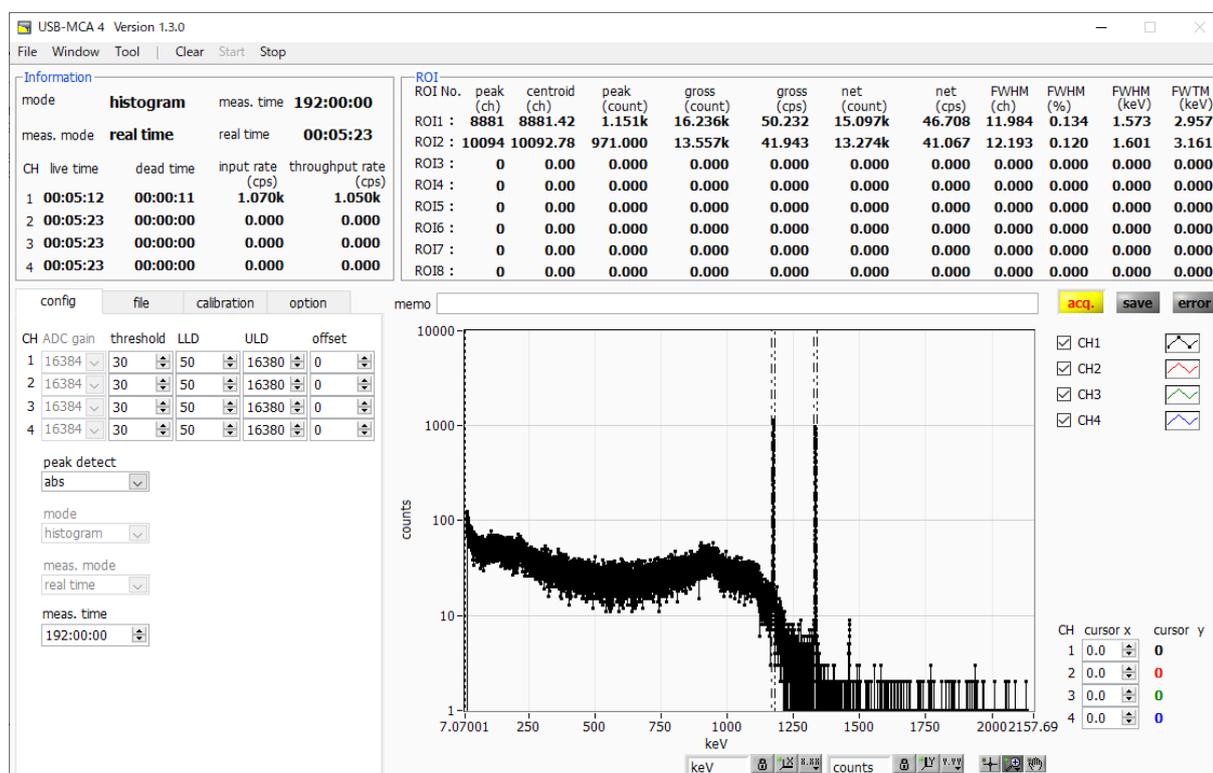
Image. 15   Window of histogram mode measurement

６．２． **List mode**

1. Measurement is conducted previously in the histogram mode, and the state of the spectrum, the count rate, and the like are confirmed.
2. Select "list" in "mode" in "config" tab.
3. In the "file" tab, set the data save destination in the "list" block.
4. Click the menu "Clear". The in-device list measurement data is initialized.
5. When clicking the "Start" menu, measurement is started after all settings are transmitted to this device.
6. After the start of measurement, transition to the following state.
   - "Acq" LED flashes.
   - "Save" LED flashes.
   - The measurement status is displayed in the "Information" section.
   - "List" is displayed in "mode".
   - Measurement set time is displayed in "meas. Time".
   - Real time acquired from this device is displayed in "real time".
   - In the "file" tab, the file name being saved in "file name" is displayed, and the file size being saved in "file size" is displayed. When "list file size" is reached, the saved file is closed. "List file number" is incremented by one, "file name" becomes the new file name and the saving process is continued.

If "update information and spectrum" in the "file" tab is checked, "ROI" contains the center value, the gross count (in-range total) by ROI range setting in the "calibration" tab for each "ROI No.") And the calculation result such as rate, net count (net count obtained by subtracting background from in-range sum) and rate, half width, 1/10 width, etc. are displayed. A histogram is displayed on the graph.

! Caution!

Since histogram display in list mode is heavy load on the PC, please be careful when measuring high counting etc.

The time stamp of the list data can be cleared even during measurement by using the VETO (CLR) terminal. When the rising edge of the LV - TTL level (pulse width of 100 ns or more) is detected, the time stamp is cleared.
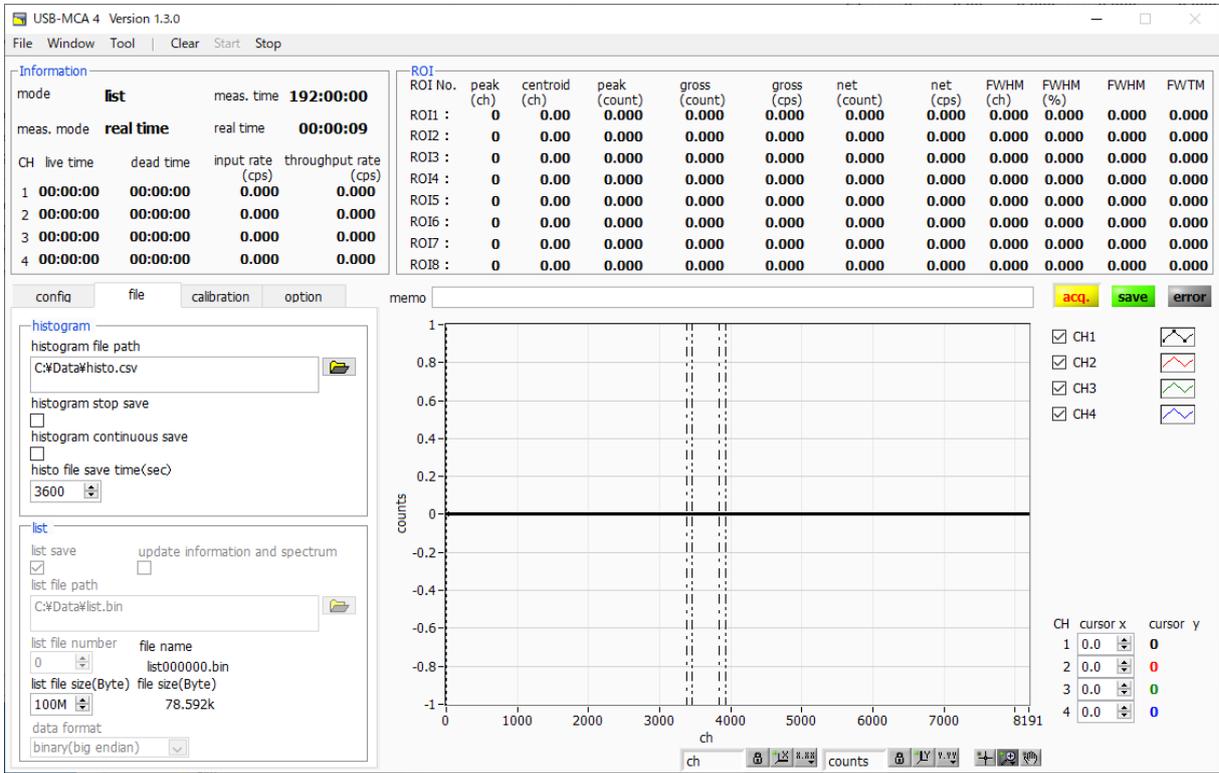
Image. 16   Window of list mode measurement

6．3． **Coincidence mode**

1. Connect signals from the linear amplifier to CH1 and CH2. CH3 and CH4 are not used.

2. Check the spectrum of the current CH1 and CH2 in the histogram mode and check where the center channel of the peak of interest is. In "config" tab "mode" select "histogram".

3. In "config" tab, set "LLD" and "ULD" widely.

4. When you click "Clear" and "Start" on the menu, measurement is started after all settings are sent to this machine.

5. Set the ROI to the read peak of attention of CH1 and CH2 and check the value of "centroid (ch)". In the figure below, CH1 is 5474.35 and CH2 is 5475.80.
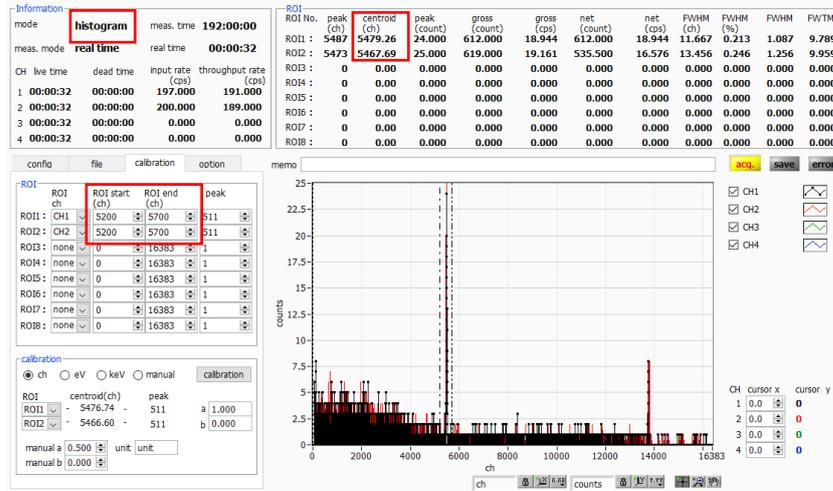
Image. 17   Check the centroid (ch) of the peak of interest in the histogram mode

6. After checking the value of "centroid (ch)", click the menu "Stop" to stop the measurement.

7. Set "LLD" and "ULD", measure again in histogram mode, and confirm that histogram within the range of "LLD" and "ULD" can be obtained.
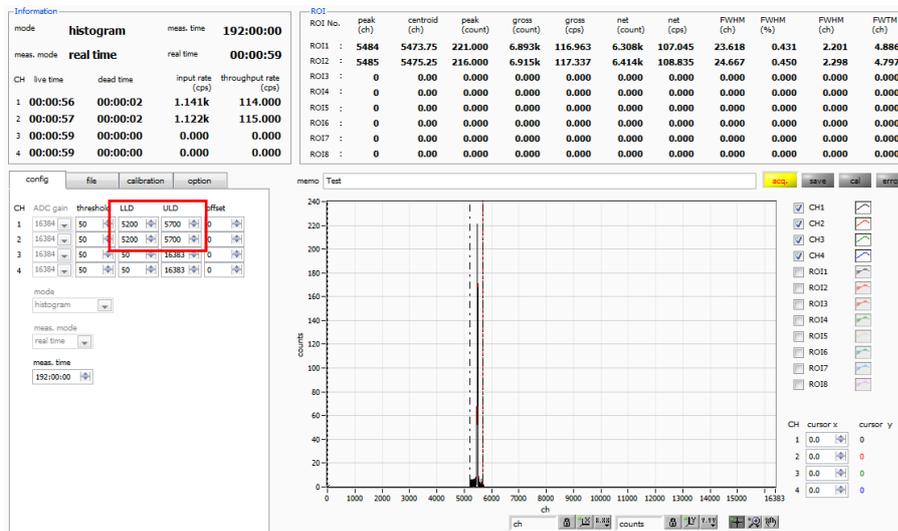
Image. 18   Check the setting status of LLD and ULD in histogram mode

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8. Before starting measurement with the coincidence 2D histogram, click "Window" and "2D histo" in the menu to switch to the screen for 2D histogram. In addition, since the data for coincidence 2D historical data is generated on this application based on the list data, for display and saving, use the "list save" and "update information and spectrum" check boxes in the "file" tab.
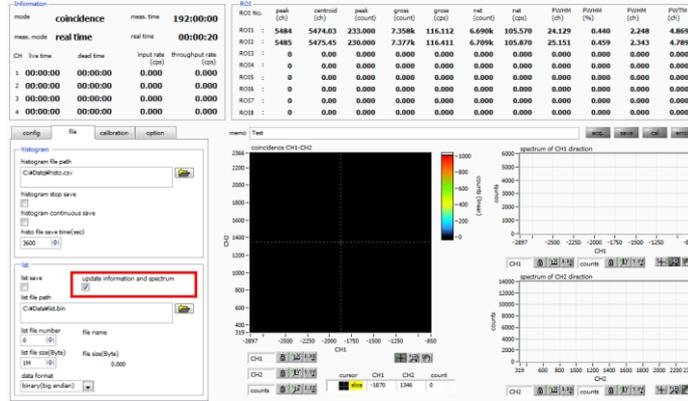
Image. 19   "file" tab setting

9. Setting of "coincidence" part in "option" tab. In the case of the above example, since the centroid value of the energy band whose coincidence is desired to see exceeds the range of the range of two-dimensional histories (CH 1) 2048 × (CH 2) 2048, "offset (ch) for 2 D histo" It is necessary to set. When setting to center 1024 ch, set it from center value-1024 ch to 4451 ch.

10. In the "config" tab, select "coincidence" in "mode".

11. Click "Clear" on the menu. The internal buffer list measurement buffer data is initialized.

12. When you click "Start" on the menu, measurement is started after all settings are sent to this device.

13. After the start of measurement, it transits to the following state.

    - "Acq" LED flashes.

    - "Coincidence" is displayed in "mode".

    - Measurement set time is displayed in "meas. Time".

    - The real time acquired from this equipment is displayed in "real time" in real time acquired from this equipment.

    When "update information and spectrum" is checked

    - The measurement status is displayed in the "Information" section.

    - A map graph is displayed on the coincidence 2D histogram.

    - Spectra are displayed in the graph from CH1 direction and graph on CH2 direction side.
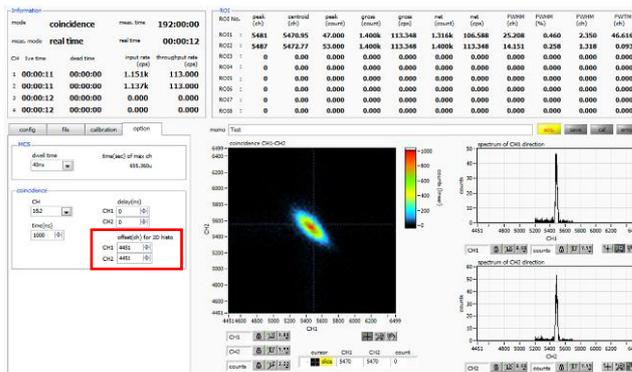
Image. 20   Coincidence 2D histogram * Reference data

6．4． Multi-Channel Scaler (MCS) mode

1. Select "MCS" in "mode" in "config" tab.

2. Set "LLD" and "ULD" in "config" tab. Use the time when crest value within this range was acquired.

3. Select the measurement time per channel at "dwell time" in the "Options" tab.

4. The calibration on the horizontal axis of the graph is adjusted in the calibration tab. If you already know the peak time, select from ns, us, ms, sec and set the ROI peak to that time. If you are unsure, check manual, enter the time selected in dwell time in manual a, and enter the unit's name in unit.

5. In MCS mode, it is possible to measure two patterns depending on whether to use the elapsed time reset signal from the outside.

   Reset use: Connect periodic events that reset the elapsed time to the VETO (CLR) terminal as a reset signal. Generate histogram of elapsed time from reset to event detection. When the rising edge of the LV - TTL level (pulse width of 100 ns or more) is detected at the VETO (CLR) terminal, the elapsed time is reset. When the maximum crest value in the ULD is detected from the LLD after securing the elapsed time until the input signal to the channel exceeds the threshold after the reset, the "dwell time" based on the secured elapsed time one is added to the channel corresponding to the elapsed time in the histogram having the interval channel. Adjust the reset signal or "dwell time" so that the reset period is less than "time (sec) of max ch".

   Reset not used: Based on the elapsed time from measurement start to event detection, one is added to the channel corresponding to that elapsed time in the histogram having the channel of "dwell time" interval. Because the elapsed time is not reset, the channel to be added moves to the larger channel as the measuring time passes. It can be used for half-life measurement etc.

6. Click "Clear" on the menu. The MCS histogram data in this device is initialized. To continue the histogram or measurement result measured last time, start the next measurement without clicking "Clear".

7. When you click "Start" on the menu, measurement is started after all settings are sent to this machine.

8. After the start of measurement, transition to the following state.

   - "Acq" LED flashes.

   - The measurement status is displayed in the "Information" section.

   - "MCS" is displayed in "mode".

   - Measurement set time is displayed in "meas. Time".

   - Real time acquired from this device is displayed in "real time".

   - The graph shows the MCS histogram with time on the horizontal axis.

   - Events exceeding "time (sec) of max ch" will be added to the last 4095 channels.
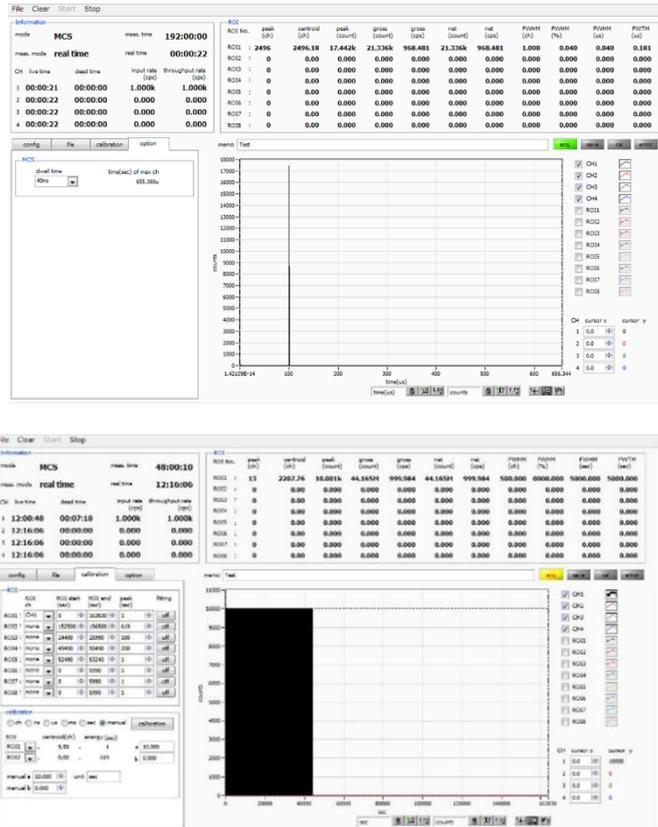
Image. 21　Window of MCS histogram mode measurement

UPPER: With reset. When the event occurred one hundred μsec after reset is repeatedly measured

LOWER: No reset. When the 1 kHz simulation signal is measured with dwell time: 10 sec

6. 5.　Measurement stops

- When "meas. Mode" is "real time", measurement will end when "real time" reaches "meas. Time".

- When "meas. Mode" is "live time", measurement will end when the latest "live time" reaches "meas. Time".

- To stop during measurement, click "Stop" on the menu. Stop measurement after execution.

7. Files

7. 1. Histogram data file

1. File format

   Comma Separated Values (csv) Text Format

2. File name

   Any

3. Configuration

Header section

Memo	Memo
Measurement mode	Select "Real time" or "Live time" mode
Measurement time	Unit is seconds
Real time	Real time
Live time	Live time per channel. Unit is seconds.
Dead time	Dead time per channel. Unit is seconds.
Start time	Measurement start time
End time	Measurement stop time

*The following items are saved for each channel.

   - ADC gain

   - Threshold

   - LLD

   - ULD

   - offset

*The following items are **NOT** saved for each channel.

Mode	Mode
meas. mode	Measurement mode
meas. time	Measurement time. Unit is seconds.
CH1 Cursor X	Cursor position for CH1 and count value on CH1 histogram
CH2 Cursor X	Cursor position for CH2 and count value on CH1 histogram
CH3 Cursor X	Cursor position for CH3 and count value on CH1 histogram
CH4 Cursor X	Cursor position for CH4 and count value on CH1 histogram

Calculation section

*The following items are saved for each channel.

ROI No.	Input channel number subject to ROI.
ROI start	ROI start position (ch)
ROI end	ROI end position (ch)
peak	Peak energy value between ROI
fitting	Fitting applies
peak (ch)	Peak position between ROI (ch)

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centroid (ch)	Center position between ROI (ch)
gross (count)	Sum of counts between ROI
gross (cps)	Gross (count) for one second
net (count)	The sum of the counts obtained by subtracting the background between ROI
net (cps)	Net (count) for one second
FWHM (ch)	FWHM between ROI (ch)
FWHM (%)	FWHM between ROI (%)
FWHM (keV)	FWHM between ROI (keV etc.)
FWTM (keV)	One-tenth (1/10) width between ROI (keV etc.)

Status section

*The following items are saved for each channel.

throughput count	Number of events processed
throughput rate	Number of events processed per second

Data section

data	Histogram data for each channel. Maximum 4096 points.

７．２． **List data file**

The format of the data file saved in list mode. The data saved at coincidence mode (option) has the same format.

1. File format
   Binary, big endian / little endian format, or text (CSV) format

2. File name
   It becomes the file path set to "list file path" in the "file" tab, adding "file number" 0 plus six places.

   Example 1: If "list file path" is set to "D:￥data￥123456.bin" and "number" is set to "1"
   "D:￥data￥123456 _ 000001.bin".
   Example 2: If "list file path" is set to "D:￥data￥123456" and "number" is set to "100"
   "D:￥data￥123456 _ 000100".

   When "list file size" is reached, the file being saved is closed. After that, it automatically advances "list file number" one by one, opens a new file, and continues saving the data file.

3. Configuration (big endian format)

64-bit per event (8 bytes, 4 WORD)

63	60	59	48
3	0	43	32
Vacant [3…0]		ABS [43…32]	
47			32
31			16
ABS [31…16]			
31			16
15			0
ABS [15…0]			
15	14	13	0
1	0	13	0
CH [1…0]		PHA [13…0]	

Figure. 4   List data (80 bit) configuration, big endian

Vacant	4-bit. From 63-bit to 60-bit.
ABS	Absolute count (measured elapsed time, Real Time). 44-bit (ABS [43...0]). 40 ns per 1-bit. Maximum measurement time is about 8 days (8 days = 2^44 * 40 ns). From 59-bit to 48-bit ABS [43…32] From 47-bit to 32-bit ABS [31…16] From 31-bit to 16-bit ABS [15…0]
CH	Channel number. 2-bit (CH [1…0]). Zero is CH 1, 1 is CH 2, 2 is CH 3, 3 is CH 4. From 15-bit to 14-bit CH [1…0]
PHA	Pulse heigh. 14-bit (PHA [13…0]) From 0 to 4095 From 13-bit to 0-bit. PHA [13…0]

4. Configuration (little endian format)

64-bit per event (8 bytes, 4 WORD)

63		56	55		52	51		48
39		32	3		0	43		40
			Vacant			ABS		
ABS [39…32]			[3…0]			[43…40]		
47		40	39					32
23		16	31					24
ABS [23…16]			ABS [31…24]					
31		24	23					16
7		0	15					8
ABS [7…0]			ABS [15…8]					
15		8	7	6	5			0
7		0	1	0	13			8
			CH					
PHA [7…0]			[1…0]		PHA [13…8]			

Figure. 5   List data (80 bit) configuration, little endian

| Vacant	4-bit. From 55-bit to 52-bit.
ABS	Absolute count (measured elapsed time, Real Time). 44-bit (ABS [43...0]). 40 ns per 1-bit. Maximum measurement time is about 8 days (8 days = 2⁴⁴ * 40 ns). From 63-bit to 56-bit ABS [39…32] From 51-bit to 48-bit ABS [43…30] From 47-bit to 40-bit ABS [23…16] From 39-bit to 32-bit ABS [31…24] From 31-bit to 24-bit ABS [7…0] From 23-bit to 16-bit ABS [15…8]
CH	Channel number (0 to 3). 2-bit (CH [1…0]). From 7-bit to 6-bit CH [1…0]
PHA	Pulse heigh. 14-bit (PHA [13…0]) From 0 to 4095 From 5-bit to 0-bit. PHA [13…8]

7．3． List data file conversion

List mode Convert the binary format list data file saved by measurement to comma-separated text (csv) format. It is saved in the form of "ABS (absolute count), CH number, PHA (crest value)" in one line per event.
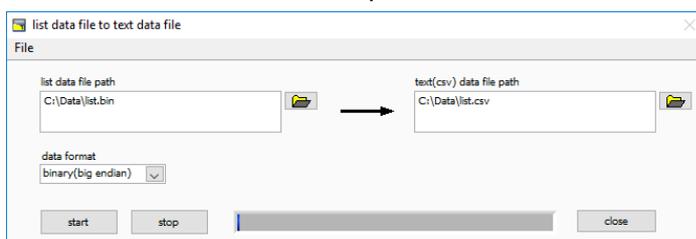
	Binary	**Text**
Absolute count (ABS)	In units of 40 ns	In unit of ns
Number of channels	0 to 3	1 to 4
Pulse heigh (PHA)	0 to 4095	0 to 4095

Use the following procedure to convert the binary format list data file to text (CSV) format.

1. Click "File" - "convert to text from binary list data file" in the menu.
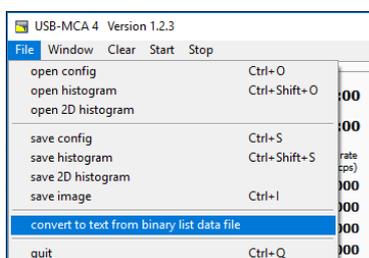
The following "list data file to text data file" window opens.

list data file path	List mode Set binary format list data file before conversion saved by measurement to absolute path.
data format	List mode Set the binary format list data file format saved by measurement. Select from "binary (big endian)" or "binary (little endian)".
text(csv) data file path	Sets the converted list data file in comma-separated text (csv) format as an absolute path and saves it.

2. Click "start" button to start conversion. Conversion is complete when the status bar becomes full. To stop the conversion, click the "stop" button.
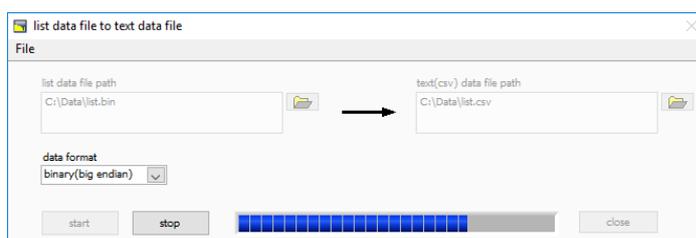
3. Click the "close" button to finish converting the list data file.

7．4． **Coincidence two-dimensional histogram data file**

After measurement in coincidence mode, you can save coincidence 2D histogram data to a file by clicking "File" - "save 2D histogram" in the menu at an arbitrary timing.

1. File format

   Comma Separated Values (csv) Text Format

2. File name

   Any

3. Configuration

Header section

Memo	Memo
Measurement mode	Select "Real time" or "Live time" mode
Measurement time	Unit is seconds
Real time	Real time
Live time	Live time per channel. Unit is seconds.
Dead time	Dead time per channel. Unit is seconds.
Start time	Measurement start time
End time	Measurement stop time

*The following items are saved for each channel.

- ADC gain

- Threshold

- LLD

- ULD

- offset

*The following items are **NOT** saved for each channel.

Mode	Mode
meas. mode	Measurement mode
meas. time	Measurement time. Unit is seconds.
dwell time	Dwell time. Unit is seconds.
CH1 Cursor X	Cursor position for CH1 and count value on CH1 histogram
CH2 Cursor X	Cursor position for CH2 and count value on CH1 histogram
CH3 Cursor X	Cursor position for CH3 and count value on CH1 histogram
CH4 Cursor X	Cursor position for CH4 and count value on CH1 histogram

Calculation section

*The following items are saved for each channel.

ROI No.	Input channel number subject to ROI.
ROI start	ROI start position (ch)
ROI end	ROI end position (ch)

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peak	Peak energy value between ROI
fitting	Fitting applies
peak (ch)	Peak position between ROI (ch)
centroid (ch)	Center position between ROI (ch)
gross (count)	Sum of counts between ROI
gross (cps)	Gross (count) for one second
net (count)	The sum of the counts obtained by subtracting the background between ROI
net (cps)	Net (count) for one second
FWHM (ch)	FWHM between ROI (ch)
FWHM (%)	FWHM between ROI (%)
FWHM (keV)	FWHM between ROI (sec etc.)
FWTM (keV)	One-tenth (1/10) width between ROI (sec etc.)

Status section

*The following items are saved for each channel.

throughput count	Number of events processed
throughput rate	Number of events processed per second

2DHistogram

CH1 Offset (ch)	Offset channel to coincidence two-dimensional histogram of CH1
CH2 Offset (ch)	Offset channel to coincidence two-dimensional histogram of CH2

Data section

data	Histogram data for each channel.
	Maximum 4096 points.
	The channel (bin) of CH1, the channel (bin) of CH2, the order of count.
	The number of lines is variable length.

7. 5. **Multi-Channel Scaler (MCS) data file *option**

1. File format

   Comma Separated Values (csv) Text Format

2. File name

   Any

3. Configuration

Header section

Memo	Memo
Measurement mode	Select "Real time" or "Live time" mode
Measurement time	Unit is seconds
Real time	Real time
Live time	Live time per channel. Unit is seconds.
Dead time	Dead time per channel. Unit is seconds.
Start time	Measurement start time
End time	Measurement stop time

*The following items are saved for each channel.

   - ADC gain

   - Threshold

   - LLD

   - ULD

   - offset

*The following items are **NOT** saved for each channel.

Mode	Mode
meas. mode	Measurement mode
meas. time	Measurement time. Unit is seconds.
dwell time	Dwell time. Unit is seconds.
CH1 Cursor X	Cursor position for CH1 and count value on CH1 histogram
CH2 Cursor X	Cursor position for CH2 and count value on CH1 histogram
CH3 Cursor X	Cursor position for CH3 and count value on CH1 histogram
CH4 Cursor X	Cursor position for CH4 and count value on CH1 histogram

Calculation section

*The following items are saved for each channel.

ROI No.	Input channel number subject to ROI.
ROI start	ROI start position (ch)
ROI end	ROI end position (ch)
peak	Peak energy value between ROI
fitting	Fitting applies
peak (ch)	Peak position between ROI (ch)

centroid (ch)	Center position between ROI (ch)
gross (count)	Sum of counts between ROI
gross (cps)	Gross (count) for one second
net (count)	The sum of the counts obtained by subtracting the background between ROI
net (cps)	Net (count) for one second
FWHM (ch)	FWHM between ROI (ch)
FWHM (%)	FWHM between ROI (%)
FWHM (keV)	FWHM between ROI (sec etc.)
FWTM (keV)	One-tenth (1/10) width between ROI (sec etc.)

Status section

*The following items are saved for each channel.

throughput count	Number of events processed
throughput rate	Number of events processed per second

Data section

data	Histogram data for each channel. Maximum 4096 points.

8. Functions

8.1. Data acquisition by external GATE input signal timing

To acquire event data at that time according to external conditions when an event occurs, input the LV - TTL level signal to the "GATE" LEMO connector on the front panel. Measurement is performed when it is High, but not when it is Low.

Please input the external GATE input signal in a range sufficient to cover the waveform shaping input signal (see the figure below).

When the waveform shaping input signal exceeds the threshold level Vth from the baseline, the external GATE input signal should be held high. Waveform shaping A / D conversion processing is performed when the input signal falls below the threshold level, and the peak value is determined after 1.2 μs processing time.
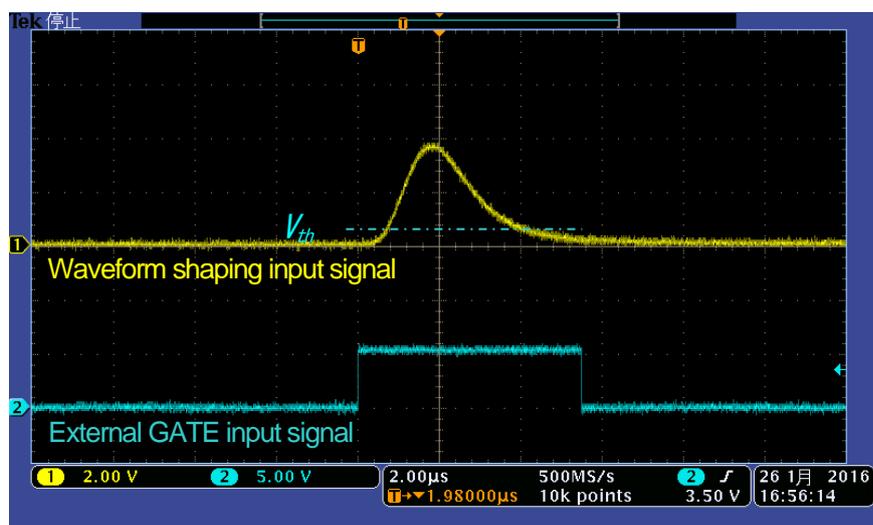

Image. 22　External GATE Input Signal Timing

*The external GATE input signal is LV - TTL level. Lower level of 0.8 V or less is judged as High level above 2.0 V. The maximum input voltage is 5V.

8.2. Data discard by VETO signal timing

If you want to discard the event data at that time due to external conditions at the occurrence of an event, input the LV - TTL level signal to the front panel LEMO connector "VETO". It is the opposite effect of "GATE". Measurement is performed when it is Low, but not when it is Low. The timing is the same as GATE mentioned above.

8. 3. Calculation method of full width at half maximum (FWHM)

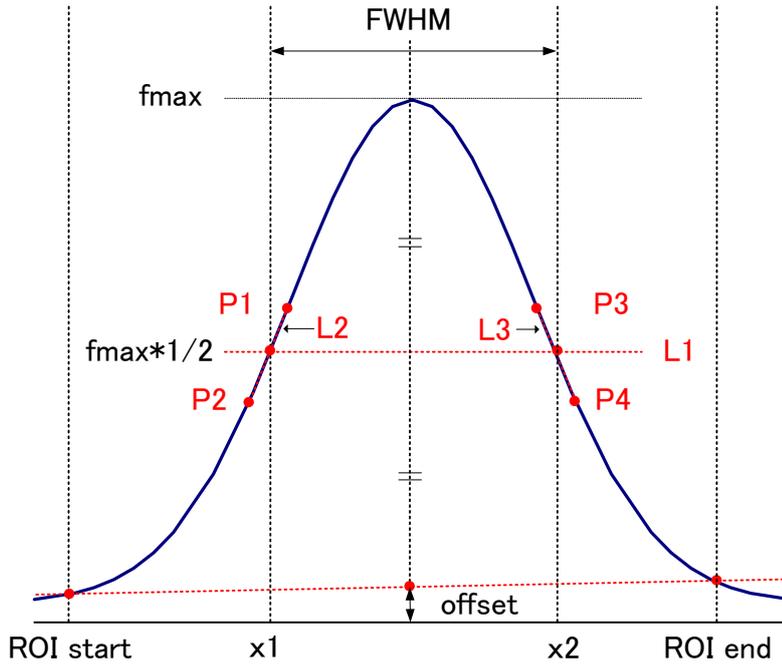The calculation method of Full Width at Half Maximum (FWHM) in "status" tab is as follows.

Figure. 6 FWHM calculation

1	Detects the maximum value fmax between ROI Start and ROI end in the histogram.
2	Connect the intersection of the histogram and ROI start with the intersection of the histogram and ROI end with a straight line. Calculate the background offset (offset) by obtaining the intersection of the straight line and the line drawn vertically from the peak value fmax to the x axis.
3	Calculate half (1 / 2) of the part obtained by subtracting offset from fmax and draw a straight line L1 parallel to the X axis.
4	Calculate two points where the histogram and L1 intersect, we detect the intersecting before and after points P1 and P2, and P3 and P4.
5	A straight line L2 connecting P1 and P2 and a straight line L3 connecting P3 and P4 are drawn.
6	Calculate the X coordinate x1 of the intersection of L1 and L2 and the X coordinate x2 of the intersection of L1 and L3.
7	The difference between x2 and x1 is FWHM

8．4． Calculation method of gross count and net count

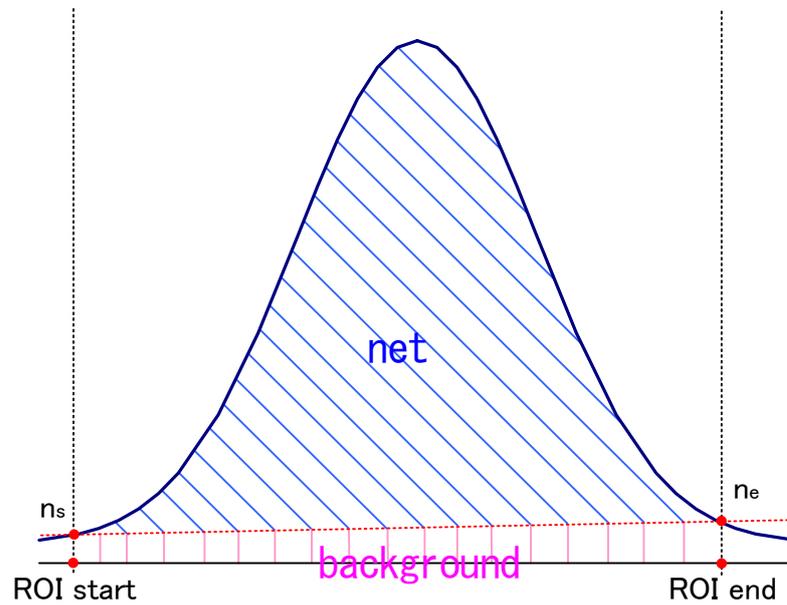"Gross" count and "net" count in the "ROI" section are calculated by the Kobel method.

Figure. 7　Gross count and net count calculation

1	The "gross" count is the sum of the 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 (hatched in blue in the above figure).
3	The background count connects the intersection point ns of ROI start and spectrum, and the intersection point ne of the spectrum with ROI end with a straight line. The area of the rectangle surrounding the four points of ROI start, ns, ne, and ROI end (pink line in the above figure).

8. 5. Calculation method of two-point calibration

1. histogram mode

In energy calibration, to convert X axis unit scale of graph to energy (e.g., keV), two-point calibration is performed by using two energy peak centroid and peak energy value. One-point calibration is also possible.

Refer to the "centroid (ch)" value of ROI 1 / ROI 2 displayed in "ROI" at the top of the graph. Set "ROI start (keV)" and "ROI end (keV)" with "ROI" on the upper side of the "calibration" tab. Or set the range of ROI 1 and ROI 2 by moving the cursor on the graph.

Select the radio button "keV" with "calibration" at the bottom of the "calibration" tab. In "calibration" on the lower side of "calibration" tab, select "ROI 1" and "ROI 2" for ROI.

Set to "peak (keV)" to what keV the energy of each peak of ROI 1 / ROI 2 corresponds.

Clicking on the "calibration" button automatically reflects the inclination a and intercept b of the linear equation y = ax + b calculated by the following formula in the lower "a" and "b".
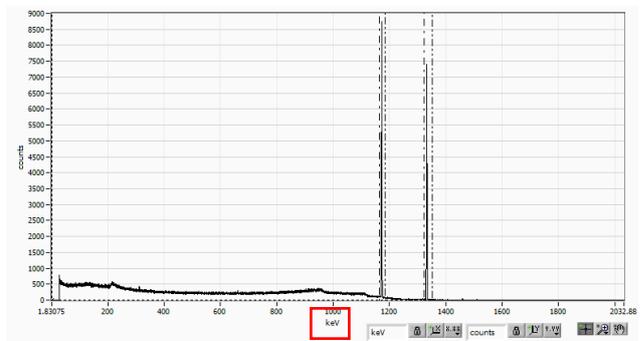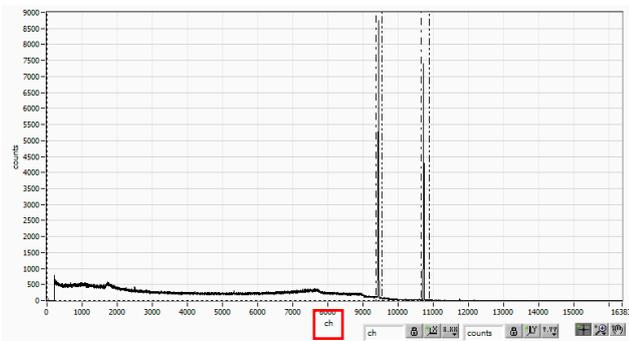

Image. 23 **LEFT:** Before Energy Calibration, **RIGHT:** After Energy Calibration

a = (peak1 - peak2) / (centroid1 - centroid2)
b = y – ax

In case of the center grid of Co-60 at 1173 keV is 9446.99 ch and the centroid at 1332 keV is 10729.53 ch,

a = (1332 - 1173) / (10729.53 – 9446.99) = 0.124
b = 1332 – 0.124 * 10729.53 = 1.831

Therefore, it is automatically reflected as "0.124" in "a" and 1.831 in "b", and the unit scale in the X axis is created with the linear expression 0.124 * ch + 1.831.

2.　　Multi-Channel Scaler (MCS) mode

Select "manual" in the "calibration" tab. Set "dwell time" to "manual a" and "0" to "manual b", execute the time calibration by executing the "calibration" button.

As with the energy calibration described above, to set the X axis unit scale of the time calibration graph to time (example: us), two-point calibration is performed using the centroid of two peaks and the peak time value. One-point calibration is also possible.

Set "dwell time" and "caliration" to "ch" and start measurement. Refer to the "centroid (ch)" value of ROI 1 / ROI 2 displayed in "ROI" at the top of the graph. Set "ROI start (ch)" and "ROI end (ch)" with "ROI" on the upper side of the "calibration" tab. Or set the range of ROI 1 and ROI 2 by moving the cursor on the graph.

Select the radio button "us" with "calibration" at the bottom of the "calibration" tab. In "calibration" on the lower side of "calibration" tab, select "ROI 1" and "ROI 2" for ROI.

Set to "peak (us)" how many microseconds each peak time of ROI 1 / ROI 2 corresponds.

Clicking on the "calibration" button automatically reflects the inclination a and intercept b of the linear equation y = ax + b calculated by the following formula in the lower "a" and "b"
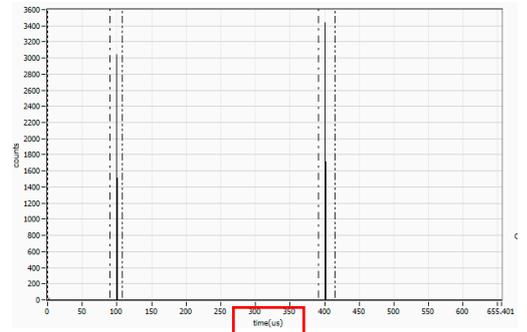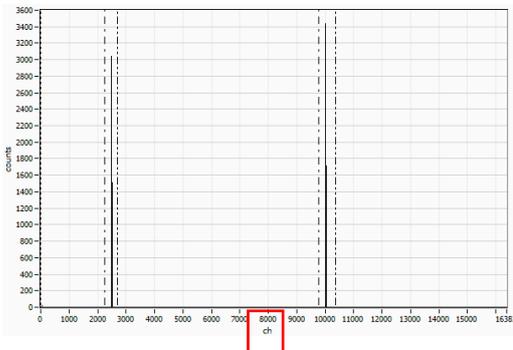

Image. 24　**LEFT:** Before Energy Calibration, **RIGHT:** After Energy Calibration

a = (peak1 - peak2) / (centroid1 - centroid2)
b = y – ax

In case of the centroid of the time difference 100 us peak is 2500 ch and the 400 us centroid is 10000 ch,
a = (400 - 100) / (10000 – 2500) = 0.04
b = 400 – 0.004 * 10000 = 0

Therefore, it is automatically reflected in "a" to 0.04, "b" to 0, and the unit scale on the X axis is created with the linear expression 0.04 * ch + 0. In addition, basically "a" is equal to the value set in "dwell time".

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9. **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.

9. 1. **Startup screen**

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

Image 25. 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 window in png format
File - close	Exit window
Information	Display the information window. Display precautions when using this screen on the dialog screen Image 26. Information window

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 three 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.

9. 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
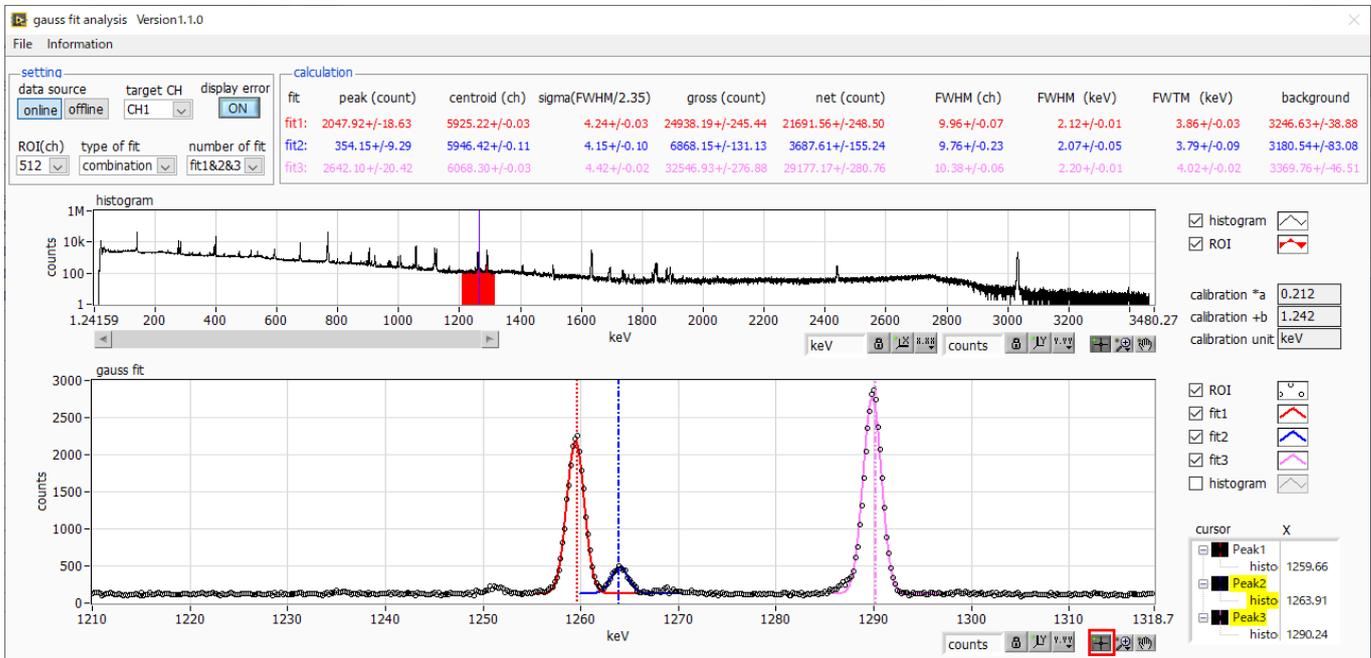

Image.27　Gauss fit screen, **ONLINE**

9．3．　**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

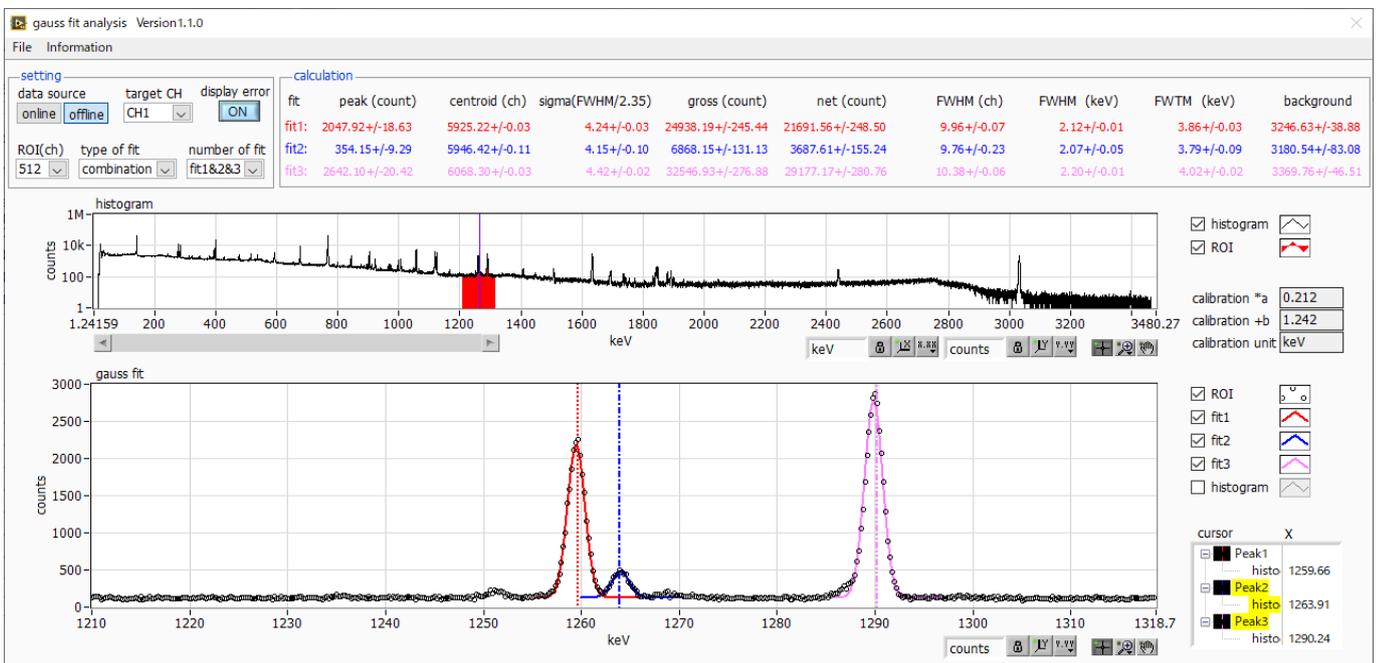The rest of the procedure is the same as the on-line mode.

Image.28　　Gauss fit screen, **OFFLINE**

9．4． **Notes**

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

1.　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.

2.　The peak to be fitted should be displayed without being cut off at both ends of the gauss fit graph.

3.　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.

9．5． **End**

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

10. **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.

10. 1. Startup screen

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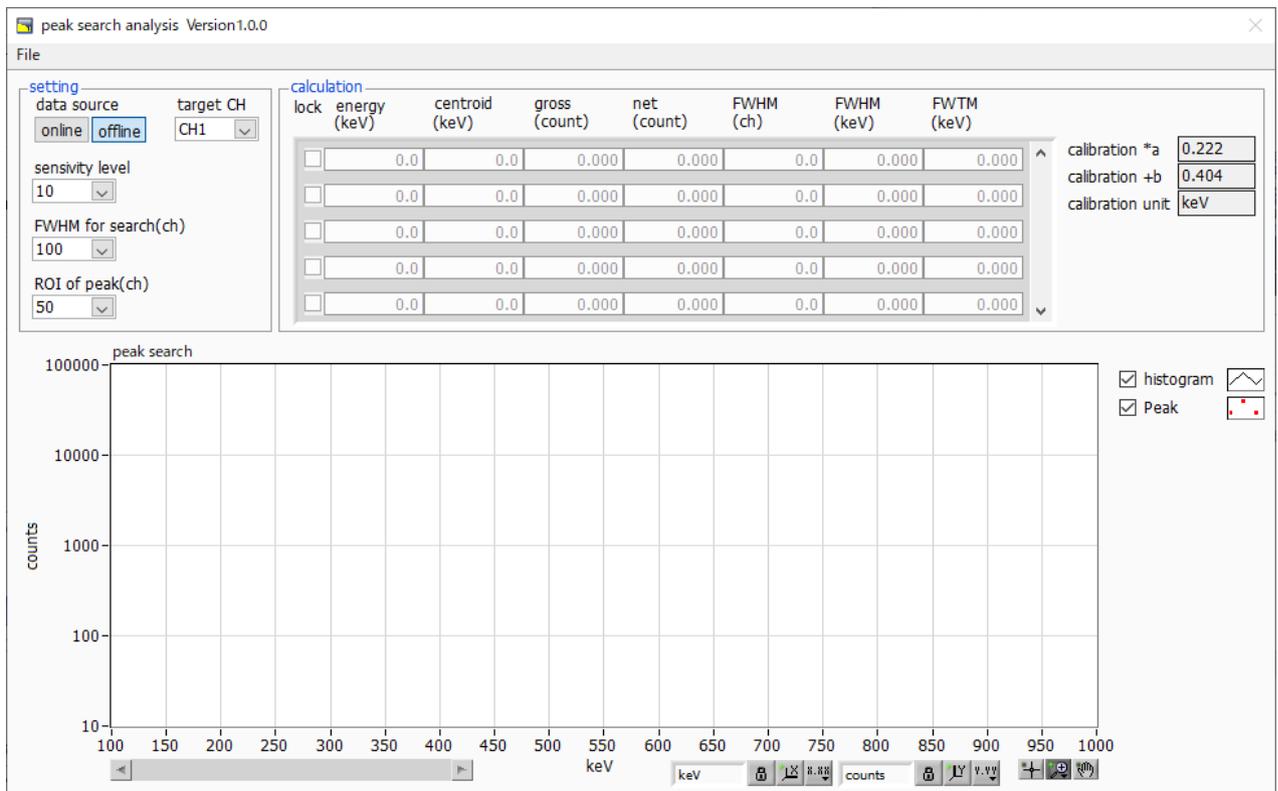

Image.29　　Peak search startup screen

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.

10. 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.
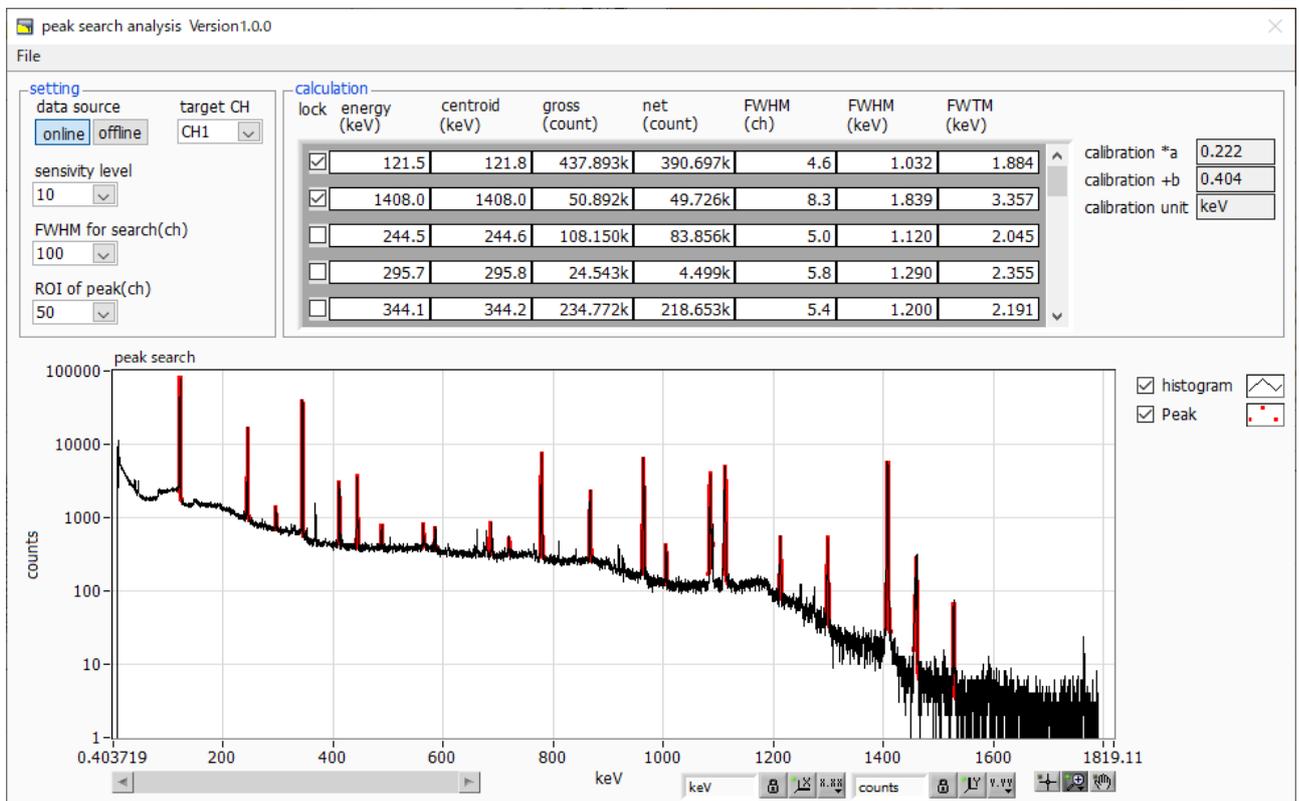

Image. 30　Peak search screens, **ONLINE**

１０．３． 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

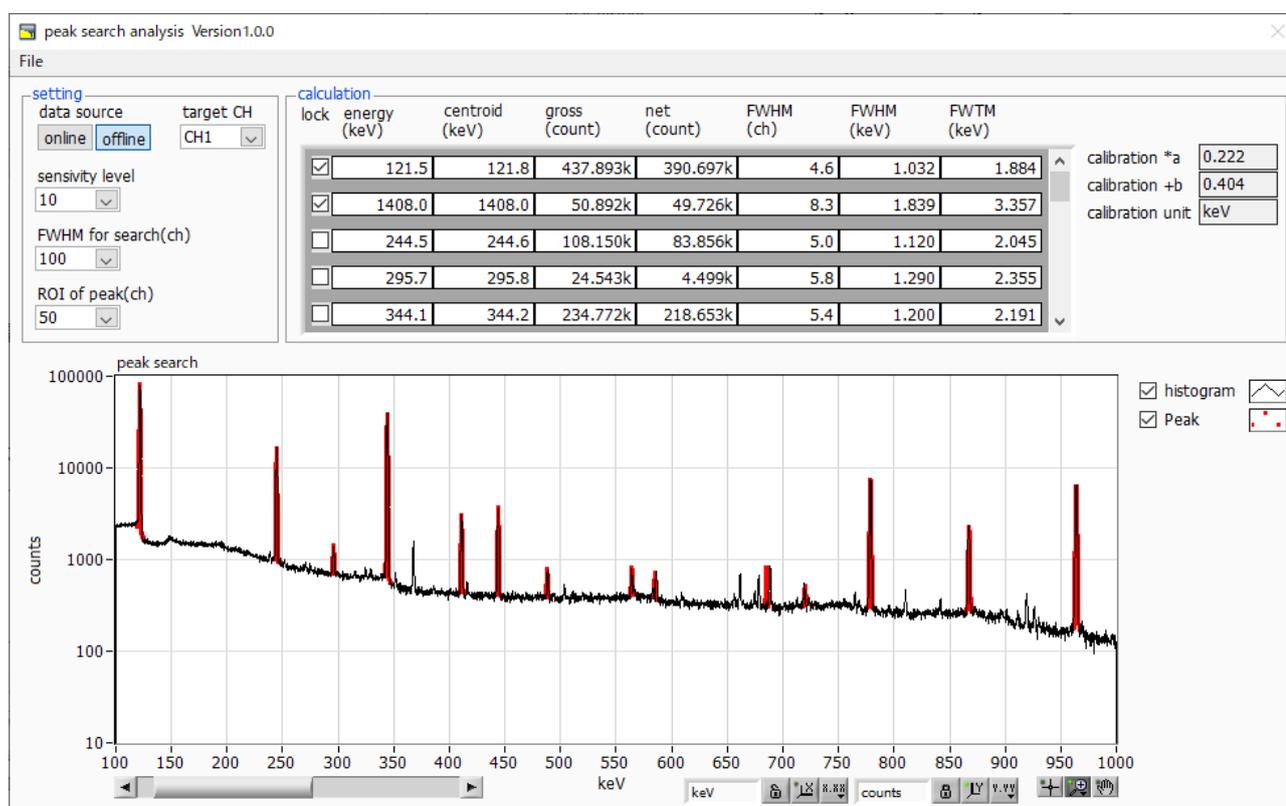The rest of the procedure is the same as the on-line mode..

Image. 31　Peak search screens, **OFFLINE**

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1０．４．**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.

1０．５．**End**

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

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