Positron annihilation Lifetime / Coincidence Doppler Broadening measurement device

Instruction manual

Version 1.9
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TechnoAP Co., Ltd.

ADD : 2976-15 Mawatari, Hitachinaka-shi, Ibaraki, Japan
ZIP Code: 312-0012
TEL: 029-350-8011
FAX: 029-352-9013
URL: http://www.techno-ap.com
e-mail: order@techno-ap.com

Contents

1. Safety Precautions / Disclaimer

Thank you very much for purchasing the positron lifetime measurement device (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

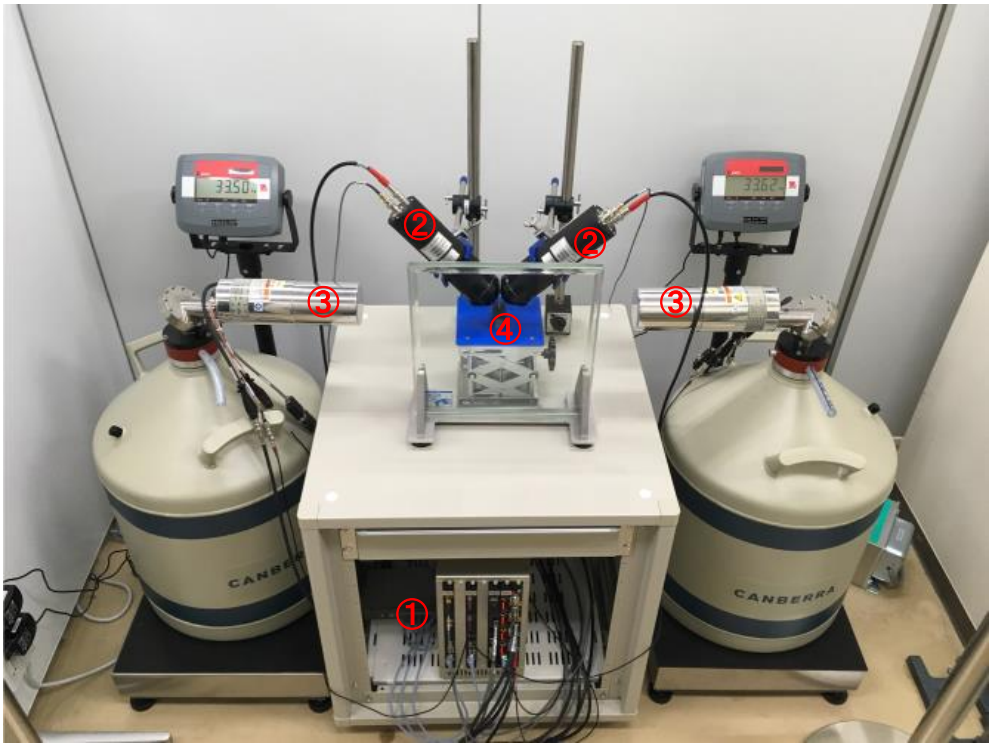
- This device cannot be used for applications requiring special quality and reliability related to human life, accident.
- This device cannot be used in places with high temperature, high humidity and high vibration.
- Do not apply strong shock or vibration to this device.
- Do not disassemble or modify this device.
- Do not wet this device with water or condensation. Do not operate this device with wet hands.
- If there is heat generation, deformation, discoloration, odor, etc. in this device, stop using it immediately and contact us.

Notes

- Use this device at room temperature in the operating temperature range and use it so that there is no condensation.
- If there is smoking or abnormal heat generation in this device, turn off the power immediately.
- Be careful of static electricity because this device is a precision electronic device.
- Do not store this device in a dusty place or high temperature / high humidity place.
- Do not place devices that emit strong electromagnetic waves, such as mobile phones and transceivers, close to this device.
- This device may malfunction in environments with high electrical noise.
- The specifications of this device and related documents may be subject to change without prior notice.

2. Overview

This device is the measuring system that had the gamma beam energy spectrum measurement, the CDB (Coincidence Doppler Broadening) measurement, the PALS (Positron Annihilation lifetime Spectroscopy) measurement, waveform of 3GSPS measurement, AMOC (Age-Momentum Correlation) measurement function. This device is comprised of the following product mainly.



Picture 1: Configuration example of this device *Computer for measurement is also required

① Positron annihilation Lifetime / Coincidence Doppler Broadening measurement device
DSP (Digital Signal Processing) for gamma ray spectrum measurement (Model: APV8002)
Timespectrum meter for the PALS (Positron Annihilation lifetime Spectroscopy) measurement (Model: APV8702)
High voltage power supply with 4 channels (Model: APV3304)
Preamplifier power supply with 4 channels (Model: APV4004)
VME powered crates with 7 slots (Model: APV9007)
② BaF_2 scintillation detector
③ Germanium semiconductor detector
④ Radiation source Na-22 and Sample

This device is connected to a switching hub with a PC (hereinafter PC) and a LAN cable and operated with the supplied application software "Positron Annihilation" (hereafter this software). You use that software for parameter setting of each module, reading of spectrum data, and analysis of data.

The lifetime data file is saved even in prn format (space delimited) which is easily readable by PALSfit 3 (http://palsfit.dk/) developed by DTM (Technical University of Denmark) in Denmark.

This manual describes the handling of this device.
* The contents of this manual are subject to change without notice.

Revision history

Date	Version	Comments
2017 March	1.0	First edition
2017 December	1.1	Update application software screen
2018 March	1.2	Update CDB mode item
2018 March	1.3	Modification of partial expression
2018 May	1.5	Review of all contents
2018 September	1.6	Data file header added, some added and modified
2019 February	1.7	Update connection wiring diagram
2019 September	1.8	Added CDB mode function information and CDB & lifetime mode information. CDB mode data file format change
2020 June	1.9	Added the extension of the life measurement range of 1000ns. Added the AMOC initial processing and lifetime mode setting.

3. Setup

3. 1. Cable connection

After confirming that all the devices connected to this equipment are in the OFF state, connect this equipment with various cables to Germanium semiconductor detector, BaF_2 scintillation detector, etc. Connection diagrams corresponding to each measurement mode are shown. For details of each measurement mode, refer to "5. Measurement" below.

(1) wave mode, lifetime mode

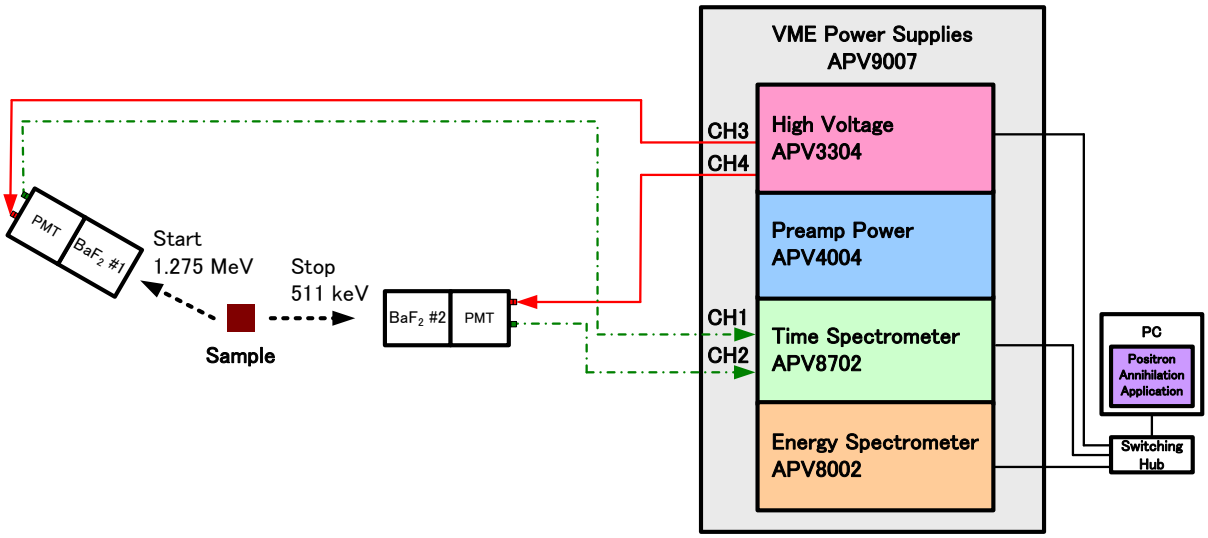


Figure 1: Connection diagrams of wave mode and lifetime mode

- Connect high voltage power supply APV3304 and each detector with the cable (red) with the SHV connector. In the standard specification, connect CH3 and CH4 of APV3304 to BaF_2 scintillation detector.

  ***High voltage power supply CH1 and CH2 are the maximum rating for Germanium semiconductor detector + (plus) 5,000 V. Do not connect to the BaF_2 scintillation detector.**

- Connect the time spectrometer APV8702 and the BaF_2 scintillation detector with a cable with SMA connector (green). If the detector side is a BNC connector, use the BNC-SMA conversion adapter. Connect START detector to CH1 and STOP detector to CH2 of APV8702.

- Connect APV3304 and APV8702 and a PC to a switching hub with an LAN cable (black).

(2) CDB mode, energy mode

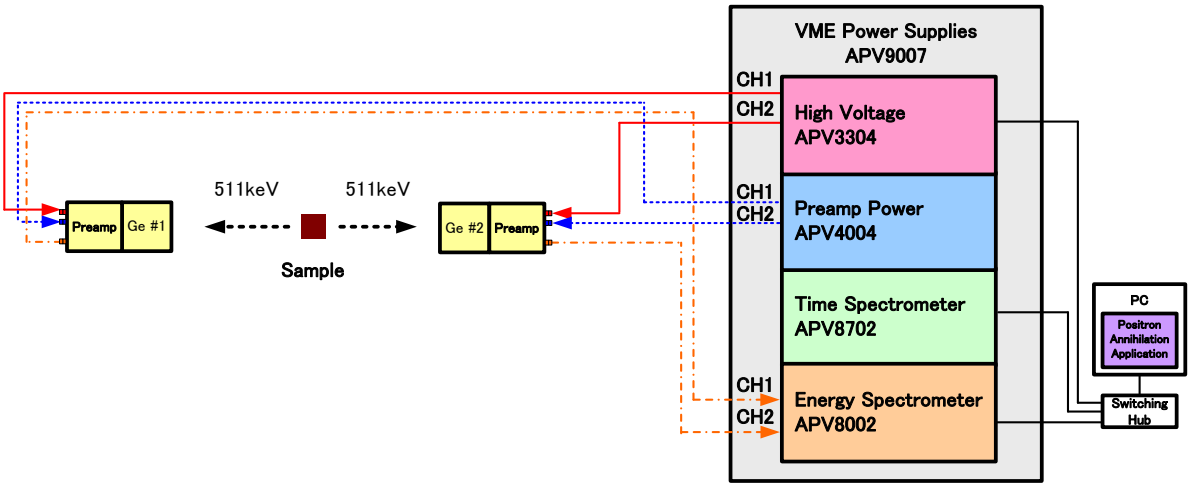


Figure 2: Connection diagrams of CDB mode, energy mode

- Connect high voltage power supply APV3304 and each detector with the cable (red) with the SHV connector. In the standard specification, connect CH1 and CH2 of APV3304 to Germanium semiconductor detector.

  ***High voltage power supply CH3 and CH4 are the maximum rating for BaF_2 scintillation detector - (minus) 4,000 V. Do not connect to Germaniumu semiconductor detector..**

- Connect pre-amp power supply APV4004 and a Germanium semiconductor detector with the cable (blue) with the standard 9-pin “D-type” (D-Sub 9-pin) connector.

- Connect DSP APV8002 and a Germanium semiconductor detector with the cable (orange) with the BNC connector. CH1 and CH2 of APV8002 use BNC-LEMO conversion adapter for LEMO connector.

- Connect APV3304 and APV8002 and a PC to a switching hub with an LAN cable (black).

(3) CDB & Lifetime mode

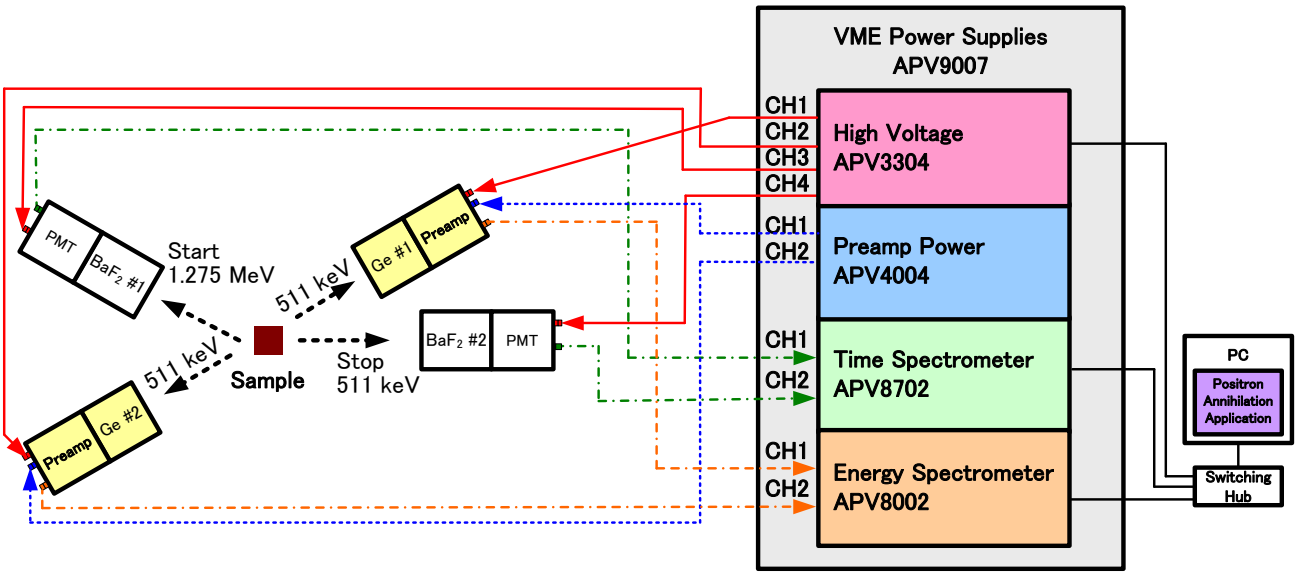


Figure 3: Connection diagrams of CDB & Lifetime mode

- Connect the high voltage power supply module APV3304 and each detector with a cable (red) with SHV connector. In the standard specification, CH1 and CH2 of APV3304 are connected to Ge semiconductor detector, and CH3 and CH4 are connected to BaF2 scintillation detector.

***High-voltage power supplies CH1 and CH2 have a maximum rating of + 5000 V for Ge semiconductor detectors. The high-voltage power supplies CH3 and CH4 have a maximum rating of -4000 V for BaF_2 scintillation detectors. Please be careful when handling when connecting.**

- Connect the preamplifier power supply module APV4004 and the Ge semiconductor detector with a D-sub 9-pin connector cable (blue).

- Connect the time spectrometer APV8702 and BaF2 scintillation detector with a cable with SMA connector (green). If the detector side is a BNC connector, use a BNC-SMA conversion adapter. Connect the START detector to CH1 of the APV8702, and the STOP detector to CH2.

- Connect DSP module APV8002 and Ge semiconductor detector with BNC connector cable (orange). Since CH1 and CH2 of APV8002 are LEMO connectors, use a BNC-LEMO conversion adapter.

- Connect APV3304, APV8702, APV8002 and PC to the switching hub with a LAN cable (black).

(4) AMOC mode

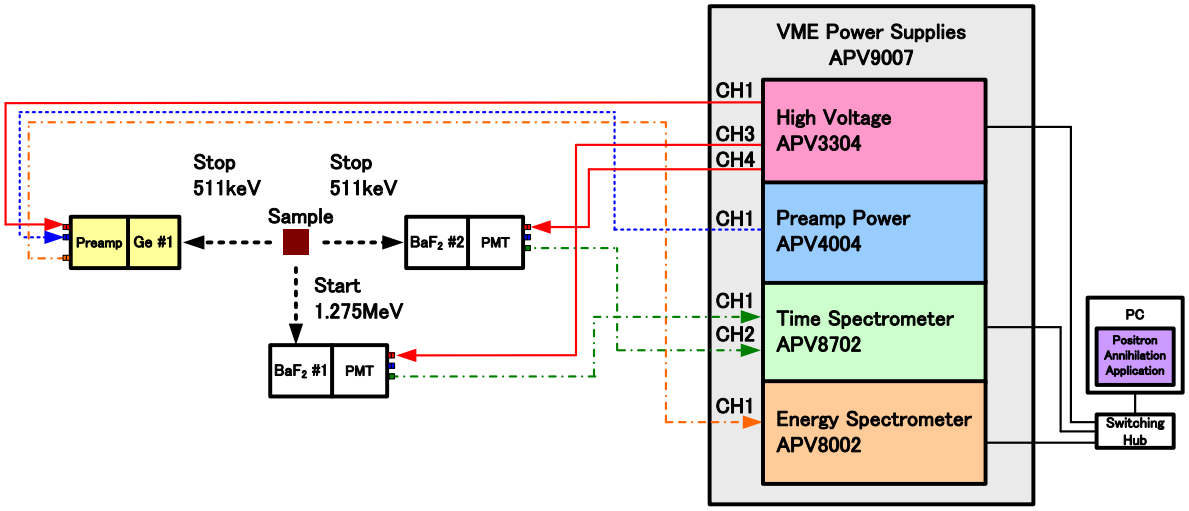


Figure 4: Connection diagrams of AMOC mode

- Connect high voltage power supply APV3304 and each detector with the cable (red) with the SHV connector. In the standard specification, connect Germanium semiconductor detector to CH1 and BaF_2 scintillation detector to CH3 and CH4 of APV3304.

  ***High voltage power supply CH1 and CH2 are the maximum rating for Germanium semiconductor detector + (plus) 5,000 V. High voltage power supply CH3 and CH4 are the maximum rating for BaF_2 scintillation detector - (minus) 4,000 V. Please be careful when handling when connecting.**

- Connect pre-amp power supply APV4004 and a Germanium semiconductor detector with the cable (blue) with the standard 9-pin “D-type” (D-Sub 9-pin) connector.

- Connect the time spectrometer APV8702 and the BaF_2 scintillation detector with a cable with SMA connector (green). If the detector side is a BNC connector, use the BNC-SMA conversion adapter. Connect START detector to CH1 and STOP detector to CH2 of APV8702.

- Connect DSP APV8002 and a Germanium semiconductor detector with the cable (orange) with the BNC connector. CH1 and CH2 of APV8002 use BNC-LEMO conversion adapter for LEMO connector.

- Connect APV3304 and APV8002 and a PC to a switching hub with an LAN cable (black).

3. 2. Power on

Before turning on the power, check the following matters.

(1) There is no error or abnormality in the above-mentioned cable connection.
(2) Turn OFF the power switch of CH1 to CH4 of APV3304.

Turn on the power to each device in the following order.

(1) Switching hub
(2) Personal Computer
(3) VME powered crates APV9007

After turning on the power of each device, confirm the following points.

(1) View the preamplifier output signal of the Germanium semiconductor detector with an oscilloscope and confirm that there is no abnormality.
(2) View the anode output signal of the BaF_2 scintillation detector with an oscilloscope and confirm that there is no abnormality.

Note that when turning off the power of each device, the above order is reversed.

3. 3. Installation of the application

This device is controlled by Ethernet communication from a dedicated application software "PositronAnnihilationSystem" running on Windows (hereafter: this software). When using, you need to install the executable file of this software and the LabVIEW runtime engine of National Instruments on the Personal Computer used for measurement. Installation of this application is done by the installer which is included in the attached CD-ROM. The installer includes an executable file and the LabVIEW runtime engine and can be installed interactively. The installation procedure is as follows.

(1) Log in to a Personal Computer with administrator privileges.
(2) Execute "Setup.exe" in "Installer" folder on attached CD-ROM. Proceed with installation interactively.
The default installation location is as follows.
C: ¥Program Files¥TechnoAP¥ PositronAnnihilationSystem
(3) A short cut icon will be made on the desktop after installation is completed.

To uninstall, select "PositronAnnihilationSystem" from "Add / Remove Programs" and delete it.

3. 4. Setup of the network

Connect the Personal Computer and this device with network equipment such as LAN cable and switching hub. For the connection method, refer to the manual of each module (APV8002, APV8702, APV3304) which is a component of this equipment.

(1) Change the network information of the Personal Computer.

IP address	192.168.10.2 *It can be set arbitrarily. However, it sets a value which does not duplicate with the IP address described later
Subnet mask	255.255.255.0
Gateway (Default)	192.168.10.1

(2) Execute the ping command at the command prompt and check the connection between each module and the PC.

The IP address of each module is on the board. Please use wired LAN and disable wireless LAN when not using wireless LAN. The default network information is as follows.

* Network information of **APV8002**

IP address	192.168.10.**128** (Factory setting)
Subnet mask	255.255.255.0 (Factory setting)
Gateway (default)	192.168.10.1 (Factory setting)

* Network information of **APV8702**

IP address	192.168.10.**129** (Factory setting)
Subnet mask	255.255.255.0 (Factory setting)
Gateway (default)	192.168.10.1 (Factory setting)

* Network information of **APV3304**

IP address	192.168.10.**130** (Factory setting)
Subnet mask	255.255.255.0 (Factory setting)
Gateway (default)	192.168.10.1 (Factory setting)

3. 5. Start of the application software

(1) Double click the "Start button" - "TechnoAP" - "Positron Annihilation" or the shortcut icon on the desktop.
(2) "PositronAnnihilationSystem" starts up.

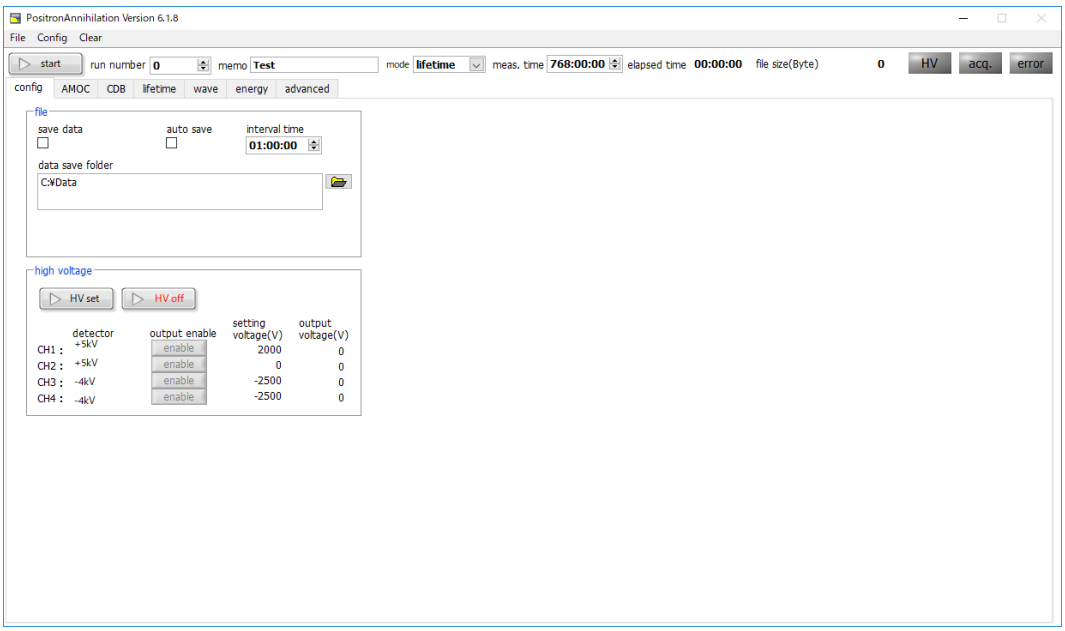


Figure 5: Startup screen

*If "connection error" is displayed at startup, refer to "7.1. Communication error" below.

4. Application screen

4. 1. Startup screen

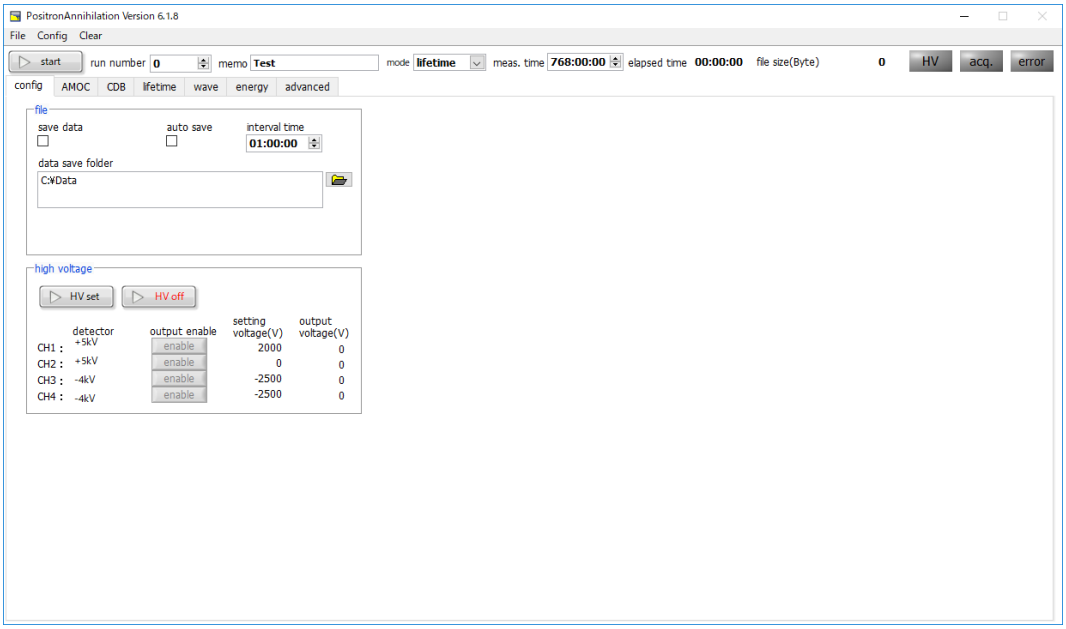


Figure 6: Startup screen

Menu

It consists of "File", "Config", "Clear".

File - open config file	Load the configuration file.
File - open AMOC file	Load the AMOC data file.
File - open CDB file	Load the CDB data file.
File - open lifetime file	Load the lifetime spectrum data file.
File - open energy file	Load the energy spectrum data file.
File - open list file	Load the list data file.
File - save config file	Save current setting in a file.
File - save AMOC file	Save the spectrum data which it acquired with AMOC mode.
File - save CDB file	Save the lifetime spectrum data which it acquired with CDB mode.
File - save lifetime file	Save the lifetime spectrum data which it acquired with lifetime mode.
File - save wave file	Save the waveform data which it acquired with wave mode.
File - save energy file	Save the waveform data which it acquired with wave mode.
File - save image file	Save the capture image of the screen in PNG form file.
File - reconnect HV device	Perform reconnect with high voltage power supply module.
File – quit	Quit this application

Tab

It consists of "config", "AMOC", "CDB", "lifetime", "wave", "energy", "advanced".

config	Settings related to measurement data saving.
AMOC	Display measurement data in AMOC mode and set measurement.
CDB	Display measurement data in CDB mode and set measurement.
lifetime	Display measurement data in lifetime mode and set measurement.
wave	Display the measurement data of the wave mode
energy	Display measurement data in energy mode and set measurement.
advanced	Setting operation parameters of APV8002, APV8702, APV3304.

Other

Common setting and control of each measurement mode is performed.

"start/stop" button	Start and stop the measurement in the currently selected measurement mode
run number	Measurement number. It is automatically added to the file name when measuring data is automatically saved. The allowable range is from 0 (zero) to 999999. When auto saving is set to ON, the number increments by one at the end of measurement or interruption of measurement.
memo	Text box. Please use for measurement data management.
mode	Measurement mode. Select the measurement mode from the pull-down menu displayed by clicking. Mode change during measurement cannot be performed.
meas. time	Measurement time setting. Measurement will be terminated automatically when the measurement time reaches the time set here.
elapsed time	Measurement time indication. Displays the elapsed time since the start of measurement.
file size (Byte)	Displays the file size of list data in AMOC mode.
HV (LED)	It lights up when high voltage power supply is applied.
acq. (LED)	Flashes during measurement
error (LED)	Error indication. It lights in red when communication error etc. with this equipment occurs.

4. 2. Config tab

Common settings in each mode and simple control of high voltage power supply are performed

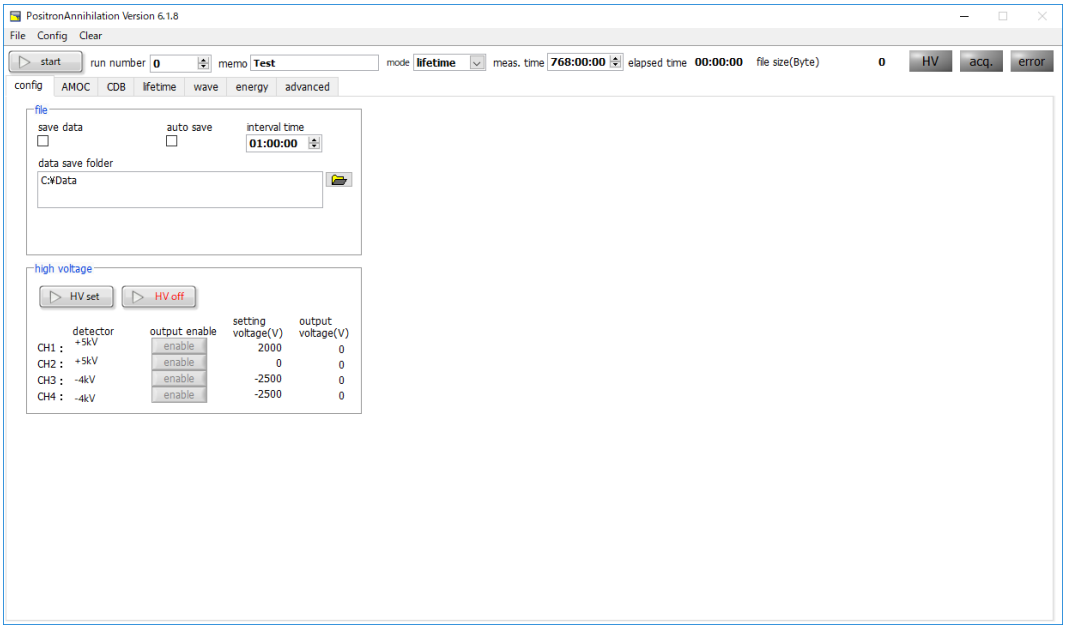


Figure 7: config tab

Section: file

save data	Check the check box to enable the auto save function. When checked, the run number will be incremented by one at the end of measurement or suspension of measurement.
auto save	Check the check box to activate the periodical saving function during measurement.
interval time	Set the time interval to save periodically. The setting range is from 10 seconds to 1 hour.
data save folder	Select the directory of the auto save destination.

Attention

The setting cannot be changed during measurement except for the interval time specified above. To save the data at the end of measurement and during measurement, click the item from the menu file and save it.

Section: high voltage

HV set button	High voltage section and advanced tab high voltage Send all settings in the section.
HV off button	Turn off the high voltage power supply output of all channels.
detector	Displays the high voltage detector group setting in the advanced tab.
output enable	Select high voltage power output availability for each channel. advanced Tab high voltage Interlocking with output enable button. When the ON / OFF switch of the high voltage power supply front panel is OFF, it becomes invalid gray state and cannot be selected.
setting voltage (V)	Displays the voltage (V) setting in the high voltage section of the advanced tab.
output voltage (V)	Display high voltage power supply output voltage value for every channel.

4. 3. AMOC tab

The measurement result of AMOC mode is displayed. AMOC mode is a mode that performs AMOC (lifetime-energy correlation method, Age-Momentum Correlation) measurement that simultaneously acquires time information and energy information using APV8002 and APV8702.

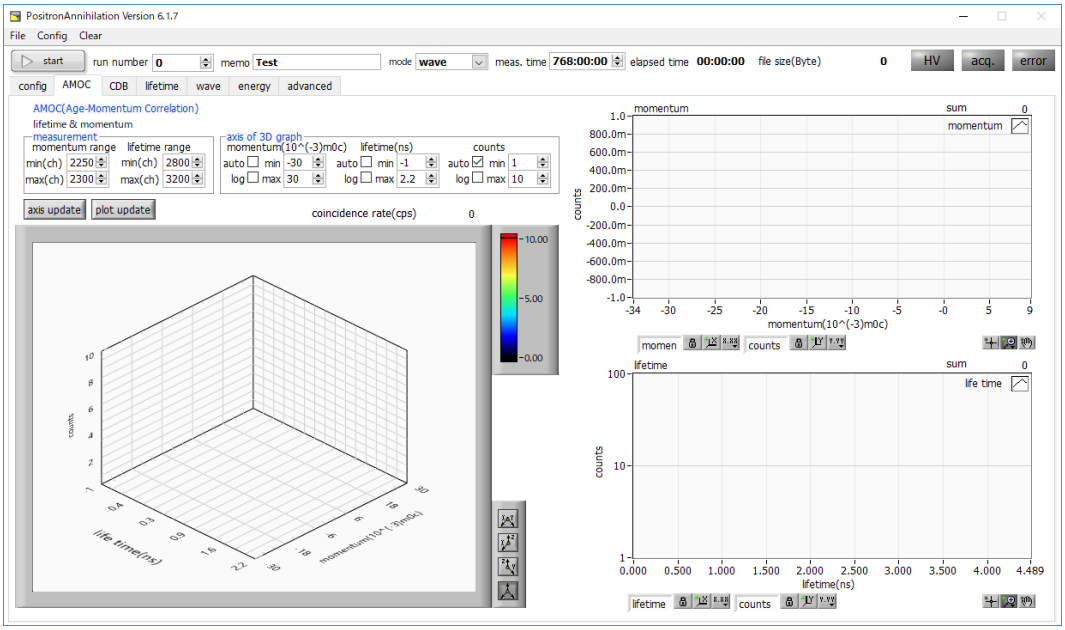


Figure 8: AMOC tab

On the AMOC tab, the integrated spectrum and count rate of valid event data when measuring in AMOC mode are displayed. The three-dimensional spectrum on the left of the screen, the momentum spectrum on the upper right of the screen and the lifetime spectrum at the lower right of the screen.

measurement part	Setting of memory range of three-dimensional histogram. In the momentum range, enter the energy range to be captured in the three-dimensional histogram of the energy spectrum acquired in energy mode in units of channels. It is also possible to enter from the ROI setting of the energy tab. For lifetime rage, enter the time range to be captured in the three-dimensional histogram of the lifetime spectrum acquired in lifetime mode on a channel basis. It is also possible to enter from the ROI setting at the bottom right of the lifetime tab
axis of 3D graph	Setting display of axis of graph of three-dimensional histogram
coincidence rate (cps)	Count rate of valid events
Graph on the left side of the screen	Graph of three-dimensional spectrum The x axis is the momentum of the event data acquired by APV8002 The y axis shows the lifetime of the event acquired by APV8702 The z axis is the frequency
Graph on the right side of the screen	Momentum (energy) spectrum The x axis is momentum The y axis is the frequency

Graph on lower right of the screen	Lifetime spectrum The x axis is lifetime The y axis is the frequency

4. 4. CDB tab

CDB mode uses simultaneous events from two Germanium semiconductor detectors using APV8002 and performs CDB (Coincidence Doppler Broadening) measurement.

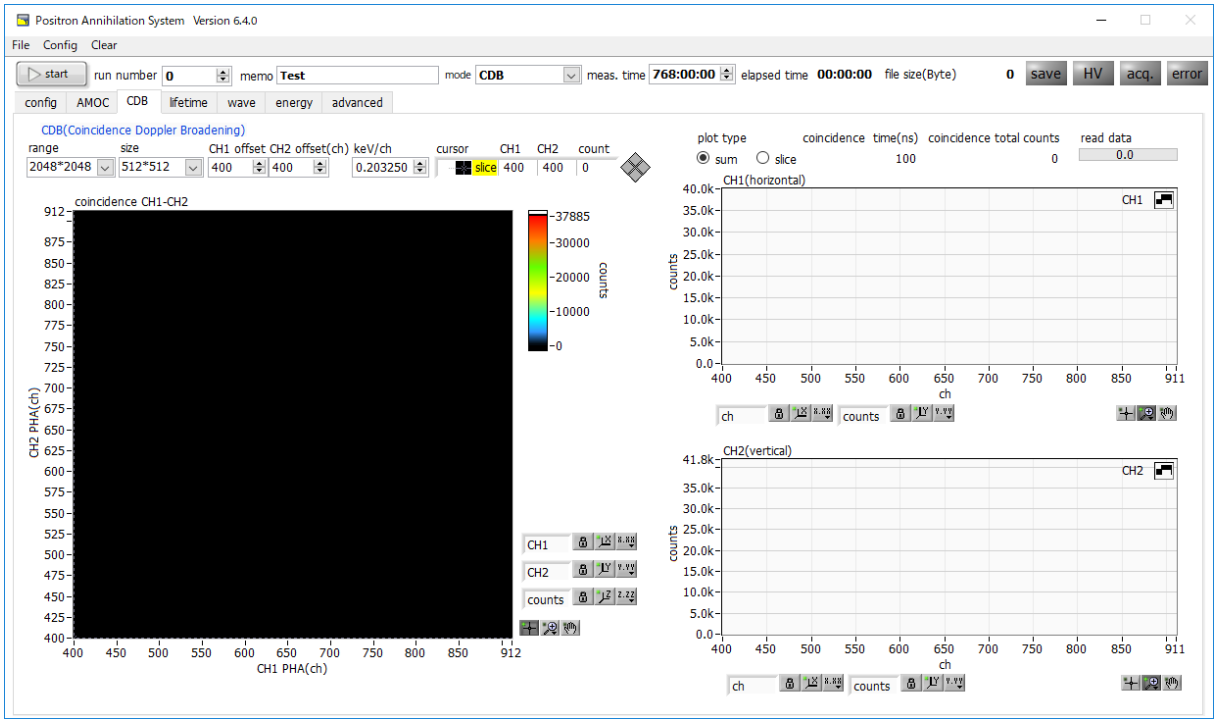


Figure 9: CDB tab

On the CDB tab, the integrated spectrum of valid event data in the CDB mode measurement is displayed. The two-dimensional spectrum on the left side of the screen and the two-dimensional SUM / slice spectrum on the right side of the screen.

range	Select the shape of the 2D spectrum. Fixed to 2048 * 2048.
size	Select the size of the 2D spectrum from 512 * 512 or 2048 * 2048.
CH1 offset CH2 offset (ch.)	Peak position offset adjustment. The 2D spectrum is up to 512 or 2048 ch., and if the peak position (centroid) to be measured is outside this range, adjust the offset. For example, if the peak position is 3000 ch. and the above-mentioned size is 512, and you want to display the peak position approximately at the center of the graph, set the offset value to 2744 ch. (= 3000 ch. - 512 ch. / 2).
keV / ch	Set the energy value keV per channel of 2D spectrum arbitrarily. This setting has no effect on each graph and is stored in the header of the CDB data file as information. For setting, first measure energy such as 511 keV in energy mode, perform energy calibration, and copy the calculated slope * a.
Cursor, CH1, CH2, count	Set the vertical cursor in the 2D spectrum to CH1 or drag and drop the cursor and operate the horizontal cursor to CH2 or set by dragging and dropping to operate the intersection. The count of is displayed in count.
2-dimension spectrum	Based on the CH1 and CH2 peak values (PHA) obtained at the same time, the vertical cursor in the CH12 dimension spectrum is set to CH1 on the X axis, or the

	count of the intersection point of the cursor is displayed in count.
plot type	From the two-dimensional spectrum, select either the one-dimensional graph based on the total of channels when viewed from the CH1 or CH2 side, or the cross-sectional graph at the set location. **sum:** Sum of channels when viewed from each direction of CH1 and CH2 **slice:** Slice by cursor position on 2D histogram graph
coincidence time (ns)	Displays the set value at coincidence time in the advanced tab.
coincidence total counts	Total number of counts displayed in the 2D spectrum.
read data	Reading state of 2D spectrum. When the progress bar is full, data loading is completed and the 2D spectrum, CH1 (horizontal) graph, and CH2 (vertical) graph are updated.
CH1 (horizontal)	Displays a one-dimensional spectrum viewed from the CH1 side according to the plot type.
CH2 (vertical)	Displays a one-dimensional spectrum viewed from the CH2 side according to the plot type.

4. 5. lifetime tab

Display settings and results for lifetime measurement. Before measuring in the AMOC mode, confirm the waveform by lifetime measurement.

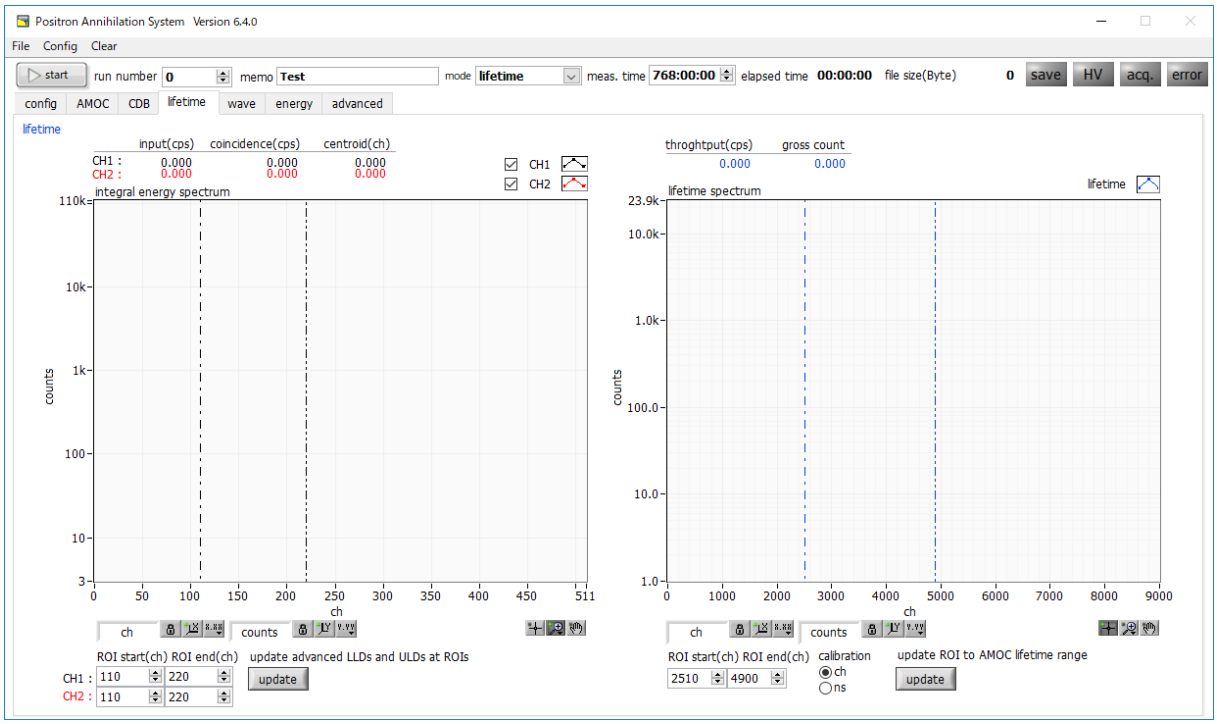


Figure 10: lifetime tab (left side: CH1 is peak of 1275 keV, CH2 is peak of 511 keV, the right side: Lifetime spectrum)

On the lifetime tab, the integrated spectrum of effective lifetime data and various count rates are displayed in the lifetime mode measurement. The left side of the screen is the energy spectrum, the right side is the life spectrum. Valid event data is event data that satisfies conditions such as threshold, LLD, ULD, and coincidence. These conditions are set in APV8702 part in the advanced tab.

Input (cps)	Count rate of the analog comparator
coincidence (cps)	Analog threshold, Coincidence Measurement rate of events captured in the waveform processing processor satisfying the conditions of coincidence. CFD / LET conditions such as Walk, LLD, ULD etc are not reflected
centroid (cps)	The center value in the ROI
integral energy spectrum	Energy spectrum graph with energy (ch.) on the horizontal axis and frequency as the vertical axis. Energy is obtained by integrating the crest value of the wave data captured by the processor over time. In channel 1, set the energy range taking the timing of START (1275 keV), set the energy range taking the timing of STOP (511 keV) in channel 2 and reflect the timing in the lifetime spectrum by setting each LLD and ULD It is possible.
ROI start (ch.) *left side	Set the starting position of the ROI in the lifetime spectrum graph for each channel. The target cursor in the graph moves in conjunction with the setting.
ROI end (ch.) *left side	Set the ending position of the ROI in the lifetime spectrum graph for each channel. The target cursor in the graph moves in conjunction with the setting.

update button *left side	The setting values of the ROI start, and ROI end described above are reflected in the LLD and ULD of the advance tab. After reflection, start measurement in AMOC mode or lifetime mode and update the lifetime spectrum graph based on the time information of events selected within the applicable energy range. For example, if you set the range of 1275 keV at Na-22 at CH1 and the peak at 511 keV at CH2 with ROI start and ROI end respectively, you can acquire the time difference spectrum at 1275 keV detection time - (minus) 511 keV detection time.
throughput (cps)	Analog threshold, coincidence, rise threshold, CFD walk, CFD threshold, LLD, ULD This is the count rate of valid events satisfying the conditions.
gross count	This is the sum of counts between ROIs in the lifetime spectrum described below.
lifetime spectrum	The horizontal axis represents the time difference between CH1 and CH2, and the vertical axis represents the life spectrum. The time difference is calculated as the time difference between the discrimination timing of CH1 and CH2 by taking the CFD timing for the wave data captured by the processor. CH1 is started, CH2 is STOP.
ROI start (ch.) *right side	Set the start position of ROI in lifetime spectrum graph. The target cursor in the graph moves in conjunction with the setting.
ROI end (ch.) *right side	Set the end position of ROI in lifetime spectrum graph. The target cursor in the graph moves in conjunction with the setting.
Calibration	Switch the unit of the horizontal axis using ch or ns. In the case of ns, it is approximately 10.4 ps / ch.
update button *right side	The values of ROI start and ROI end are reflected in the lifetime range of the AMOC tab.

4. 6. wave tab

Check the output signal from the BaF_2 scintillation detector. Before measuring in lifetime mode or AMOC mode, check whether the waveform is saturating, and whether the baseline or threshold is appropriate.

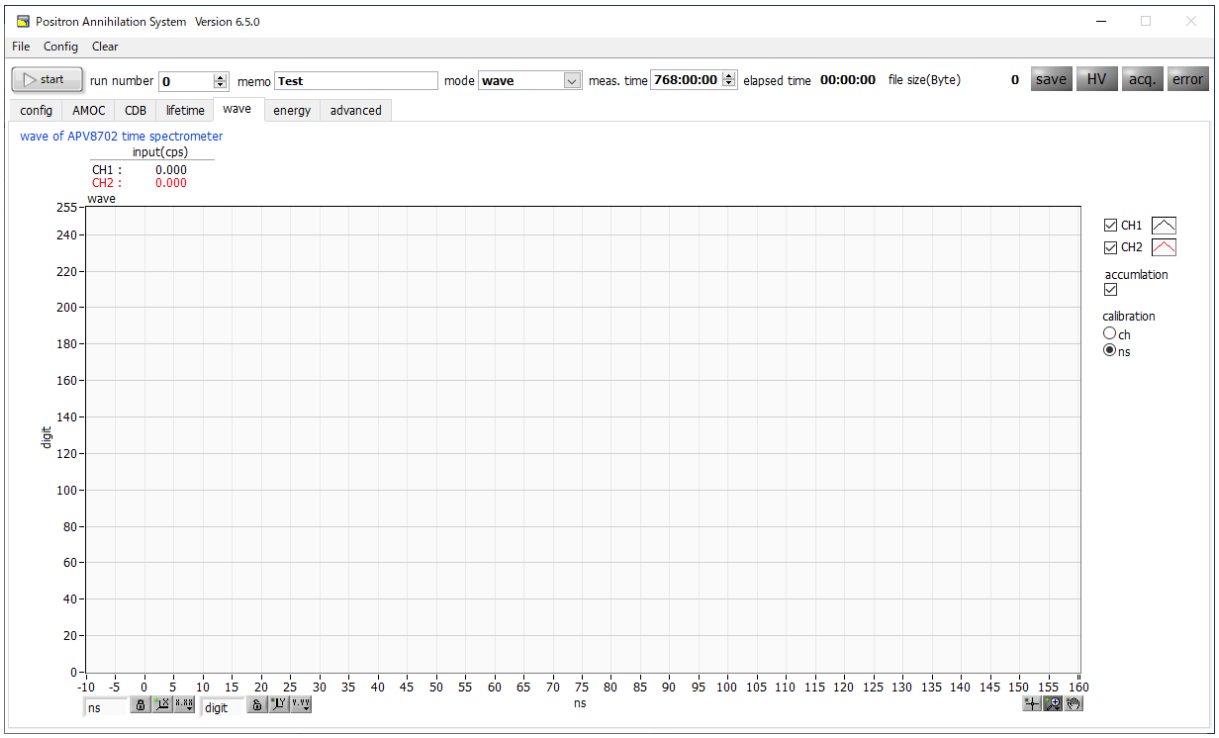


Figure 11: wave tab

Input (cps)	Count rate of analog comparator. Counts when analog threshold is exceeded.
wave (graph)	Display wave data captured from the ADC during wave mode measurement as a graph. The horizontal axis represents sampling number / time, and the vertical axis represents ADC code (0 to 255). By setting in the advanced tab, the waveform baseline is set to 240 digits and the waveform is set to 0 to 240 digits.
accumulation	Selection of presence or absence of afterimage function of wave data. When the check is ON, there is afterimage present
calibration	Select unit of horizontal axis from “ch” or “ns”. In the case of ns, it is about 333 ps / ch.

4. 7. energy tab

This tab is used in energy mode. The preamplifier output signal of the Germanium semiconductor detector is waveform-shaped using APV8002, and the calculation result of energy spectrum, count rate, ROI is displayed based on that data. It is also used for AMOC mode and CDB mode adjustment.

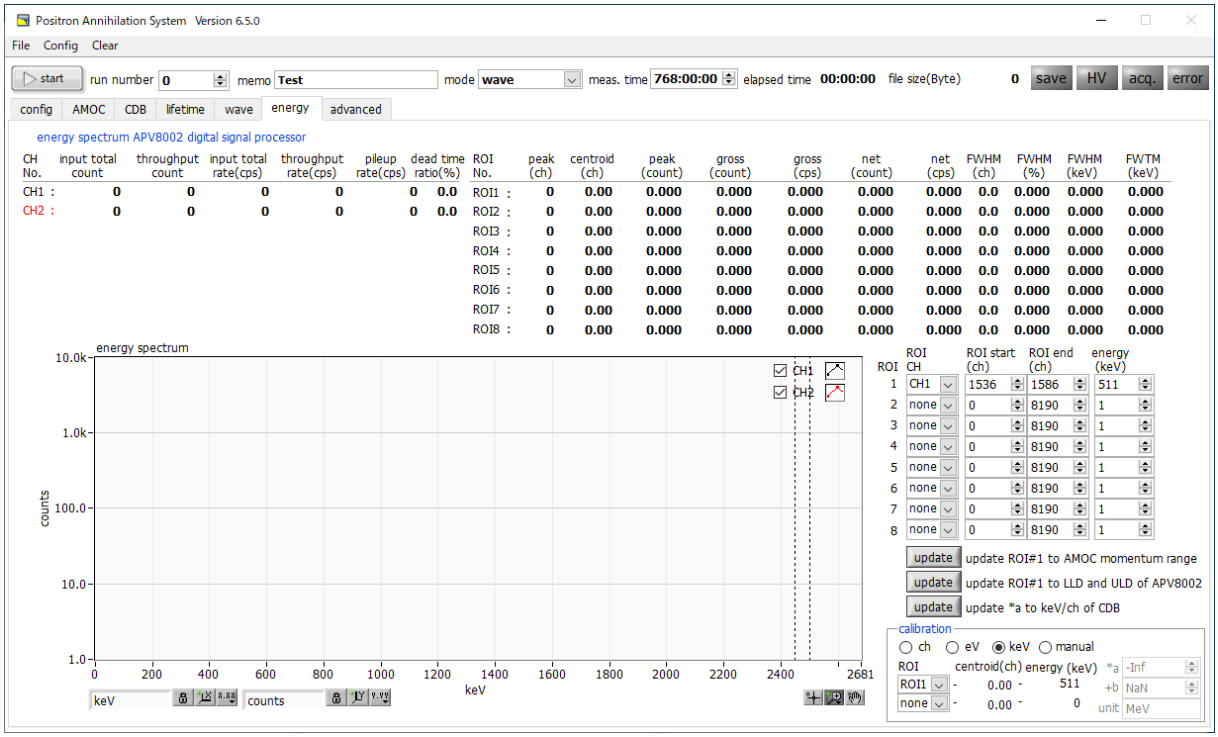


Figure 12: energy tab

input total count	Number of events with input.
throughput count	Number processed for input.
input count rate (cps)	Number of events with inputs per second.
throughput count (cps)	Number of events processed per second input
pileup rate (cps)	Number of pile-up counts per second.
dead time ratio (%)	Dead time ratio. Instantaneous value for each acquisition
energy spectrum	Energy spectrum. Histogram of horizontal axis energy, vertical axis frequency.
ROI CH	Select the target channel for ROI calculation from ROI 1 to ROI 8.
ROI start (ch.)	Sets the start position of the ROI. Unit is ch.
ROI end (ch.)	Sets the end position of the ROI. Unit is ch.
energy	Define the energy value of the peak position (ch.). In the case of Co-60, it is set to 1173 or 1332 (keV).
update *upside	Copy the ROI1 setting to the range of energy (momentum) graph in AMOC mode.
update *middle	Copy the ROI1 settings to LLD and ULD of CH1 and CH2 of APV8002 in the advanced tab. Used for settings before starting the CDB mode measurement.
update *lower side	Copy the slope * a for energy calibration to keV / ch in the CDB tab.
calibration	Select the unit of X axis. The labels of the X axis are also changed according to the setting.

ch	Display in ch. (channel) unit. The unit such as "FWHM" of "FWTM" of ROI is arbitrary.
eV	Unit display of eV. On the X axis, the gradient a and intercept b of the linear function y = ax + b are calculated so that ch becomes eV by two-point calibration of two kinds of peaks (center value) and energy values in one histogram Set. The unit such as "FWHM" of ROI "FWTM" becomes "eV".
keV	Unit display of keV. On the X axis, the slope a and intercept b of the linear function y = ax + b are calculated so that ch becomes keV by two-point calibration of two types of peaks (center value) and energy values in one histogram Set. The unit such as "FWHM" of ROI "FWTM" becomes "keV". For 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 automatically calculated as 0.20397 and "b" is calculated as 6.958297 from two-point calibration. ***This slope a is used when setting keV / ch on the CDB tab.**
manual	Set the slope “a”, intercept “b” and unit label of the linear function y = ax + b arbitrarily and set it on the X axis. Unit is set arbitrarily.

4. 8. advanced tab

This tab is for setting detailed settings of all modules to be used. There are two types of APV8702, normal version and high frequency pulse compatible version, unused setting masked to gray and invalid.

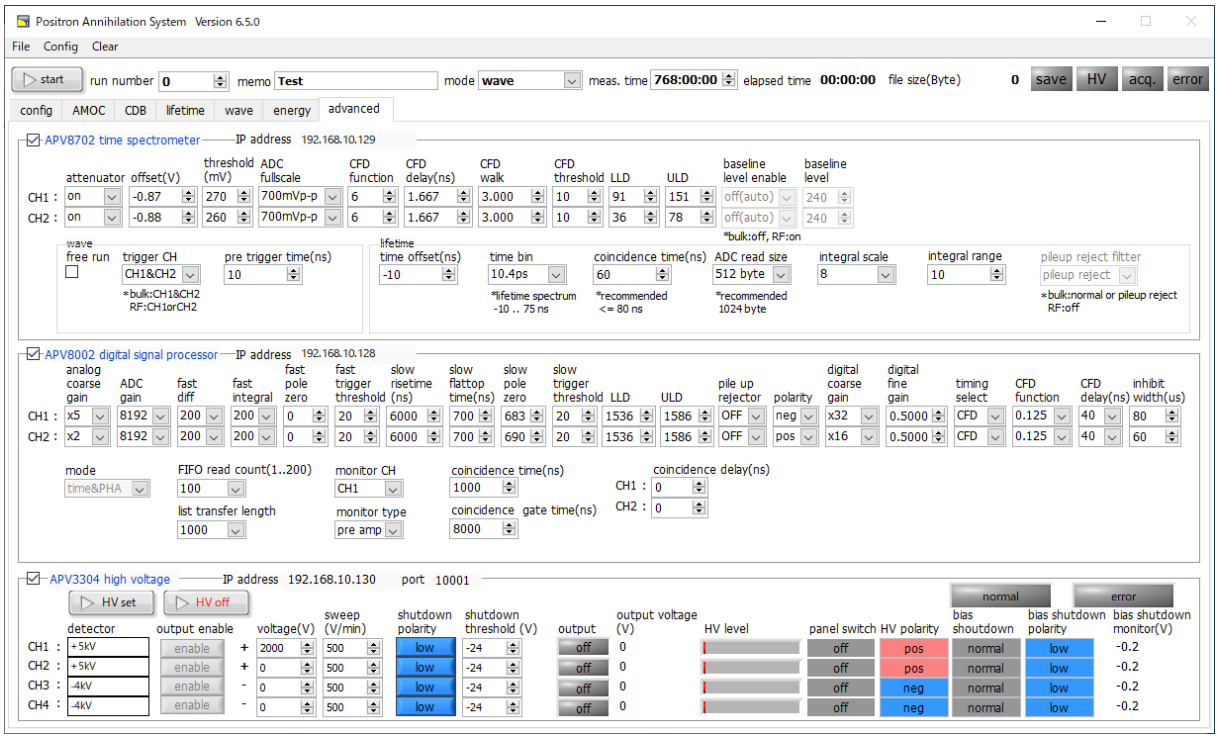


Figure 13: advanced tab (Standard version)

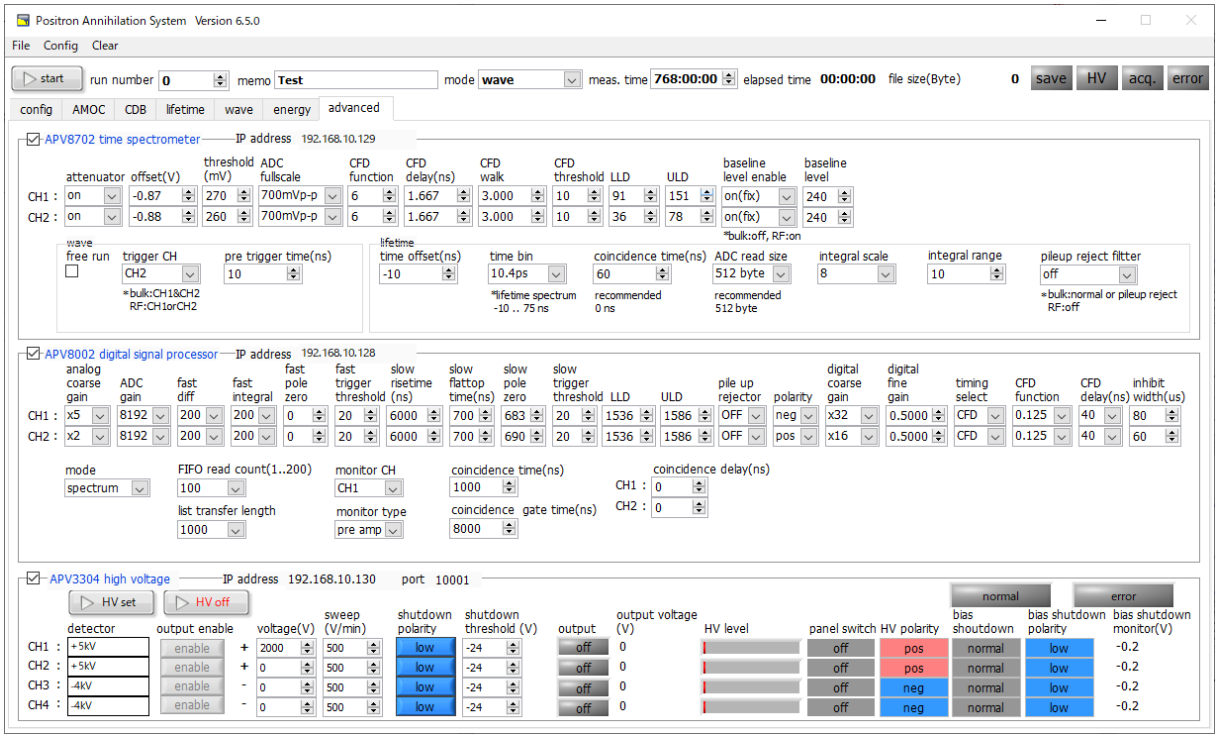


Figure 14: advanced tab (High frequency pulse compatible version)

Section: APV8702 time spectrometer (for BaF_2 scintillation detector)

attenuator	Setting of attenuators in input signal. It is 1 / 5 when it is off or on.
offset (V)	Setting of offset adjustment in input signal. Usually around - (minus) 1V. It is used when adjusting the baseline.
threshold (mV)	Set analog threshold. Usually 270 to 300 mV. It is also used for removal of unnecessary low energy area in lifetime mode.
ADC fullscale	Analog full-scale range of ADC. Input voltage at the input terminal when attenuator is turned off.
CFD function	Setting relating to original magnification reduction ratio of CFD. The usual setting value is 6 or 7.
CFD delay (ns)	Setting related to CFD delay time. The usual setting value is 1.333 or 1.667.
CFD walk	Setting related to CFD walk. The usual setting value is 3.
CFD threshold	Setting related to CFD threshold. The usual setting value is 10.

Supplement

In this device, CFD (Constant Fraction Discriminator) processing is performed from the captured waveform to calculate the zero-cross timing of each CH. Since CFD processing waveform cannot be confirmed, the above four settings are gradually changed and adjusted while confirming with the life spectrum.

LLD	It is setting the lower limit value of Integral energy Spectrum. Based on peaks at 1275 keV and 511 keV in the energy spectrum of Na-22, it is used as the lower threshold for narrowing the timing.
ULD	It is setting the upper limit value of Integral energy Spectrum. Based on peaks at 1275 keV and 511 keV in the energy spectrum of Na-22, it is used as the upper threshold for narrowing the timing.
baseline level enables	Select whether to use fixed base line level. When it is off (auto), the baseline level is determined by computation from near the waveform capture. If on, use the value of the next baseline level as the fixed baseline level. It is effective only with high frequency (RF) pulse compatible version. This is a countermeasure in cases where the high-frequency pulse is included in the baseline calculation range and the baseline cannot be calculated correctly.
baseline level	When the above baseline level enable is turned on Set the set value here to a fixed baseline level. The usual setting value is 240.
free run	If you check this, you can internally generate a 10 Hz trigger signal and continuously acquire waveform data. It is used for the above offset adjustment, noise level checking, etc.
trigger ch	Select the channel to be triggered. (CH. 1 / CH. 2 / CH. 1 & CH. 2). For bulk measurement, use Channel 1 & Channel 2 which is simultaneous measurement. For high frequency (RF) pulse compatible version, use single trigger of Channel 1 or Channel 2.
pre trigger time (ns)	Trigger timing setting in wave mode. It is possible to collect waveform data for the

	time set before the trigger timing. Usually 10ns, setting range is 0 to 50ns.
time offset (ns)	Set time offset of lifetime spectrum in lifetime mode. Normally -10ns, setting range is -1000ns to 0. The setting is 0 for the radio frequency (RF) pulse compatible version.
time bin	This is a setting of the time width per bin of lifetime spectrum graph in lifetime mode. The usual setting value is 10.4 ps.
coincidence time (ns)	The upper limit of the range considered to be simultaneous. Usually 60ns, setting range is 10 to 1300ns. The setting is 0 for the frequency (RF) pulse compatible version.
ADC read size	This is the read processing size of the waveform data stored in the ADC of APV8702. Normally 512 bytes, the setting range is 512 bytes to 4096 bytes. As a guideline for setting, set 512 bytes when the time difference is short or when the count is large, and set 4096 bytes when the time difference is long, and the count is small.

Supplement

The combination of time bin, coincidence time, and ADC read size determines the approximate measurable range of the lifetime spectrum. The recommended combination settings are as shown in the table below.

time bin	coincidence time	ADC read size
10.4 ps	< 30 ns	512 byte
10.4 ps	< 80 ns	1024 byte
20.8 ps	< 150 ns	2048 byte
41.6 ps	< 310 ns	4096 byte
83.3 ps	< 660 ns	4096 byte
166.6 ps	< 1100 ns	4096 byte

Table 1. Recommended combination setting of time bin, coincidence time and ADC read size

integral scale	Setting of horizontal scale conversion of integral energy spectrum. Set the waveform integration result to 1 (one) / set value. When the gain is high, and the integration range is wide, the integration result becomes a large value, so adjust it to fit 512 channels.
integral range	Setting concerning integral range of integral energy spectrum. The usual setting value is 10. The integrated value is equivalent to energy.
pileup rejector filter	Pileup up reject is a function to eliminate the waveform as inappropriate for arithmetic processing, such as overlapping waveforms. Usually select normal (minimum required reject) or pileup reject. For high frequency (RF) pulse compatible version, set it to off.

Section: APV8002 digital signal processor (for Germanium semiconductor detector)

analog coarse gain	Analog coarse gain. Amplification magnification of the preamplifier output signal captured inside. Selected from 1, 2, 5, 10 times. Connect the oscilloscope to the MONI output terminal on the front panel of the board and adjust the signal level so that the signal level falls within 0 (zero) to 1 V by setting the monitor type to preamp as described later.
ADC gain	Gain of ADC (Number of channels or bins) Normal setting value is 8192 channels.
fast diff	Constant of fast differential circuit. The usual setting value is 200.
fast integral	Constant of fast integrating circuit. The usual setting value is 200.
fast pole zero	Setting of fast pole zero cancellation. Normal setting value is 0 (zero) (automatic setting).
fast trigger threshold	This is the threshold value of the waveform acquisition start timing using the fast filter. The unit is digit. Normal setting value is 10 to 20. If the noise level is high, it may be 30 or more. While checking the count rate of input total rate (cps), set it to a value slightly larger than the noise level where the value becomes extremely large. Based on the preamplifier output signal, a fast filter waveform with differentiation and integration processing of the timing filter amplifier circuit is generated. When it reaches or exceeds this threshold in that waveform, we obtain the timing information acquisition timing at that point and the timing of the start of filter waveform generation in the spectroscopy amplifier circuit. It mainly relates to time acquisition (time stamp).
slow risetime (ns)	Sets the rise time of the slow filter. It is usually 6000 ns (linear amp equivalent to 3 μsec). If it is set small, the count increases but the energy resolution becomes worse.
slow flattop time (ns)	Sets the flat top time of the slow filter. It is usually 700 ns
slow pole zero	Set slow pole zero cancellation. Connect the oscilloscope to the MONI output terminal on the front panel of the board, adjust the monitor type to slow as described below, and adjust the pole zero so that there is no overshoot or undershoot near the baseline.

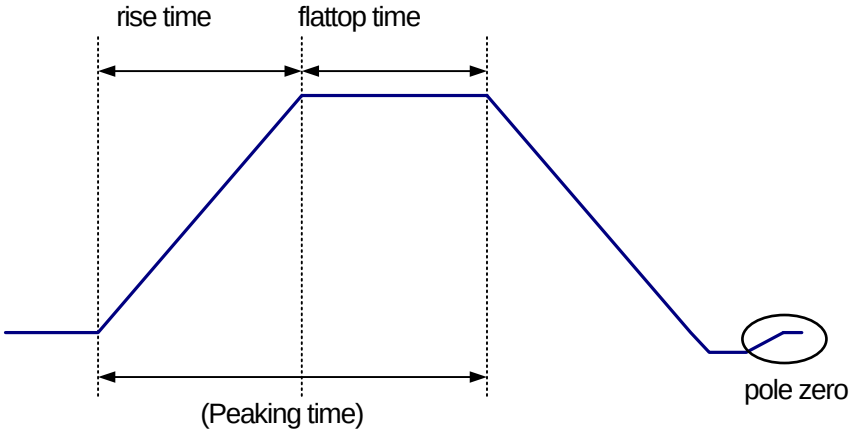


Figure 15: rise time and flattop time and pole zero

slow trigger threshold	Sets the threshold of the start timing of waveform acquisition using the slow filter. Normal setting value is 20 to 30. Set it slightly above the noise level and within the range below the LLD described below. Set it to a value slightly larger than the noise level where the value becomes extremely large while confirming the count rate of throughput rate (cps). When the filter waveform of the generated spectroscopic amplifier reaches or exceeds this threshold value, peak value at a preset time (slow rise time + slow flattop time) is acquired.
LLD	Set energy LLD (Lower Level Discriminator). The unit is ch. Channels below this threshold are not counted. Set to a value greater than or equal to show trigger threshold and less than ULD.
ULD	Set energy ULD (Upper Level Discriminator). The unit is ch. Channels above this threshold are not counted. Set it to a value larger than LLD.

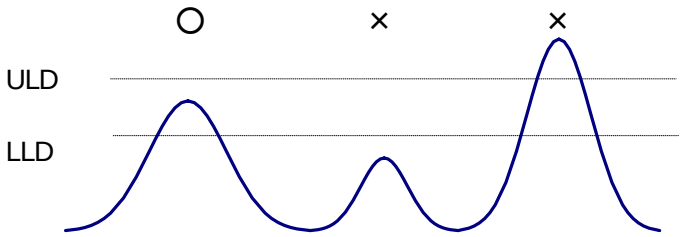


Figure 16: LLD and ULD

pileup rejecter	Set whether to use pile up reject. In normal setting it is OFF.
polarity	Select polarity of the preamplifier signal. “pos” is a positive polarity, “neg” is a negative polarity.
digital coarse gain	Adjust the coarse gain digitally. Select from 1 time, 2 times, 4 times, 8 times, 16 times, 32 times, 64 times, 128 times.
digital fine gain	Adjust the fine gain digitally. The setting range is from 0.3333 to 1. It is used for fine adjustment of the peak position of the energy spectrum.
timing select	Select the timestamp timing. Leading Edge Timing (LET). It is the timing when a certain trigger level "t" is reached. The trigger acquisition timing differs as the wave height changes like a' and b'.

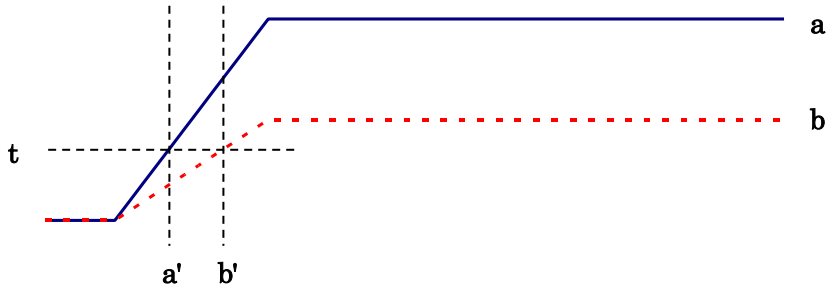


Figure 17: Concept of Leading Edge Timing (LET)

Constant Fraction Discriminator Timing (CFD)

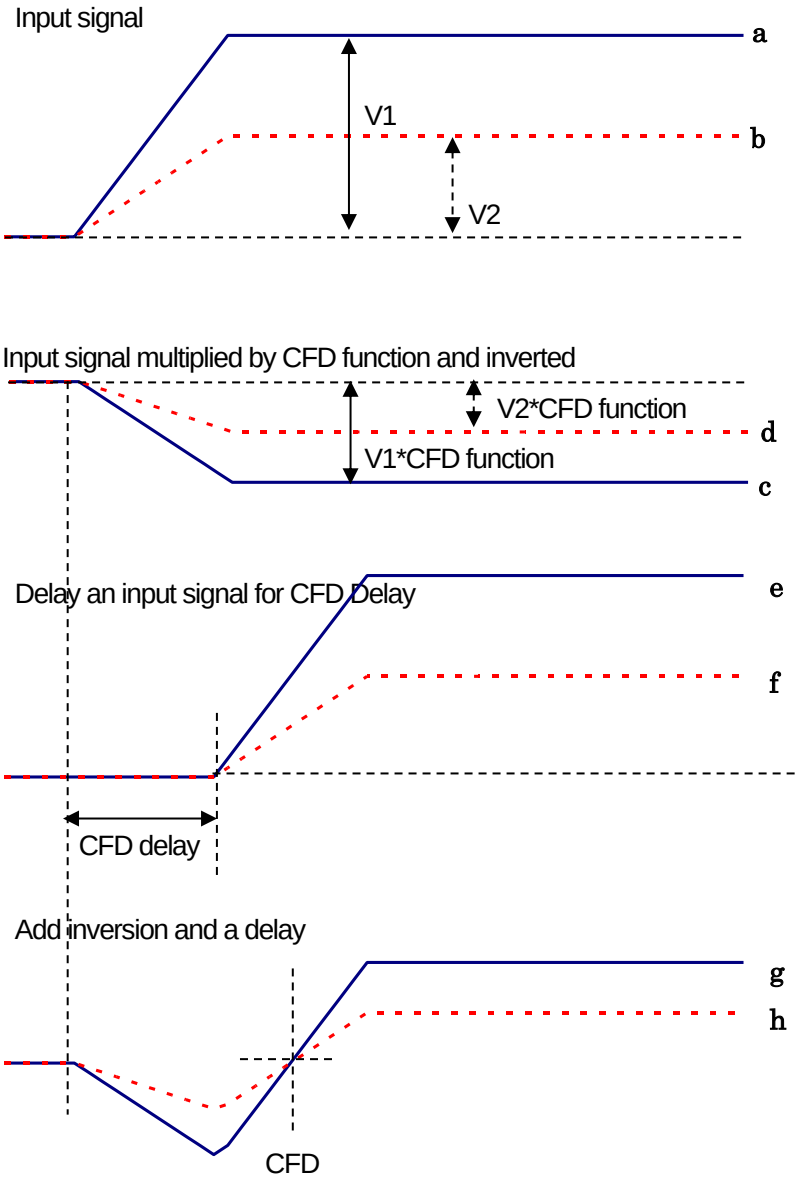


Figure 18: Concept of Constant Fraction Decorrelator Timing (CFD)

For the different waveforms a and b in the above figure, generate waveforms like the following waveforms "c and d", "e and f", "g and h".

Waveforms c and d	Waveforms a and b are multiplied by CFD function, inverted waveform
Waveforms e and f	Waveforms a and b delayed by CFD delay
Waveforms g and h	A waveform obtained by adding waveforms c and e and a waveform obtained by adding waveforms d and f CFD, which is the zero-crossing timing of waveforms g and h, has a characteristic that it is constant even if the wave height changes if the rise time of the waveform is the same.

CFD function	Magnification for reducing the original waveform for calculation of CFD. Select from “0.125”, “0.25”, “0.375”, “0.4”, “0.5”, “0.625”, “0.75”, and “0.875”.

CFD delay	Setting of delay time of CFD. Select from “10”, “20”, “30”, “40”, “50”, “60”, “70” and “80” ns.
inhibit width (ns)	This is a setting to adjust the time width of the inhibit signal of the reset Germanium semiconductor detector inside the DSP. The setting range is 0 (zero) to 16383 ns.
monitor CH.	Select the channel number of the DAC output.
monitor type	Select the waveform of the DAC output. By viewing the output signal of the DAC with an oscilloscope, the processing state can be confirmed inside the DSP. **pre-amp**: preamplifier signal **fast**: FAST type filter signal **slow**: SLOW filter signal **CFD**: CFD signal
coincidence time	It is the time range considered as simultaneous measurement. It is usually 100 ns. Fast type filter is used for simultaneous judgment.
coincidence gate time (ns)	Sets the time to wait for peak value calculation in simultaneous measurement. Normally set with a value sufficiently larger than “slow rise time + slow flattop time”. If slow rise time is 60000 and slow flattop time is 700, the setting value is 8000.
coincidence delay time (ns)	Delay time for simultaneous judgment. Normal setting value is 0 (zero). It is used for fine adjustment such as cable length difference.

Section: APV3304 high voltage (for high voltage power supply)

HV set button	Send all settings to be described later to the APV3304
HV off button	Turn OFF the high voltage power supply output of all channels. Step down according to sweep (V / min.).
normal / emergency off	It turns on by hardware failure or long press of the panel “EM-OFF” switch for 3 seconds or longer. When lighting up, step down the high voltage output of all channels according to sweep (V / min.). To cancel, turn off the power of the VME powered crates.
error	Lights up when a communication error occurs.
detector	Detector name. Enter an arbitrary character.
output enable	Selection of ON / OFF of high voltage power supply. When the ON / OFF switch on the front panel of APV3304 is OFF, become gray color and invalid, and when ON, it is selectable. Turn on the ON / OFF switch of the output channel, click the enable button of that channel, and click the HV set button to start high voltage power output control.
voltage	Setting of voltage value. For APV3304 for this device, maximum setting voltage values are normally + (plus) 5000 V for CH1 and CH 2, and - (minus) 4000 V for CH3 and CH4 respectively. Polarity cannot be selected and depends on the state of APV3304. The polarity can be confirmed by the HV polarity described later.
sweep (V / min.)	This is the voltage rise amount for 1 minute when transitioning to the set high voltage value Voltage (V).

	Caution **Setting a large value will rapidly supply high voltage to the detector. It is necessary to set it to an appropriate value so that the equipment such as the detector does not break down.**
shutdown polarity	Set the polarity to be the bias shutdown at the signal input terminal from SHTD 1 for CH1 on the front panel of APV3304 to SHTD 4 for CH4. Used with the shutdown threshold (V) described below. For example, if shutdown polarity is set to low and shutdown threshold (V) is set to 4 (V) and 5.3 V is applied to SHTD 2, if a voltage of 4 V or less is applied to the SHTD 2 terminal, bias shutdown control start. Specification of bias shutdown differs depending on detector manufacturer and model, so it is necessary to fully confirm beforehand. The factory setting is low.
shutdown threshold (V)	APV3304 Setting of the threshold for bias shutdown at the signal input terminal from SHTD 1 for CH1 of the front panel to SHTD 4 for CH4. Used with the shutdown polarity mentioned above. The factory setting is -24V.
output	Displays the output status of the high voltage power supply. **Off**: High voltage output OFF **Flashing**: Transiting to the set high voltage **On**: Outputting the set high voltage
output voltage (V)	Displays the current output voltage value. Accuracy is about ± 5% specifications of mounted high voltage power supply. In this specification the monitor accuracy at 1% or less of the rated output is not guaranteed. Since the output voltage has load dependency, the display may be different from the set voltage (V) depending on the magnitude of the load.
HV level	Displays the current output voltage value with a progress bar. It is maximum + (plus) or –(minus) 5000 V.
panel switch	The status of the front panel ON / OFF switch is displayed.
HV polarity	Displays the polarity of the high voltage power supply mounted on the APV3304. Normal CH1 and CH2 are pos (positive polarity), CH3 and CH4 are neg (negative polarity).
bias shutdown	It lights up when the bias shutdown condition is satisfied. The condition depends on the specification of the bias shutdown signal of the detector and the setting of shutdown polarity and shutdown threshold (V) as described above.
shutdown polarity	Display setting status of the above shutdown polarity.
bias shutdown monitor (V)	Displays the voltage value (V) of the signal input from SHTD 1 to SHTD 4. The above shutdown polarity and shutdown threshold (V) settings are determined based on this value. If the output impedance of the detector is high, it may not be displayed correctly.

*** Depending on the specifications of the bias shutdown signal, jumper settings on the APV3304 board may be required. For details, refer to the "APV3304 Instruction Manual".**

5. Measurement

5. 1. Application of high voltage power supply

Apply high voltage to each detector when starting measurement.

Please check the following points before operating high voltage power supply.

* SHV cable and preamplifier power cable are correctly connected without disconnection.

* High voltage polarity (positive or negative) of the detector, maximum rated voltage, amount of voltage (V / min.) to boost or step down in 1 minute

* Confirm the notes of "APV3304 Instruction Manual" other than this instruction manual.

(1) Check the following points in the high voltage section in the advanced tab.

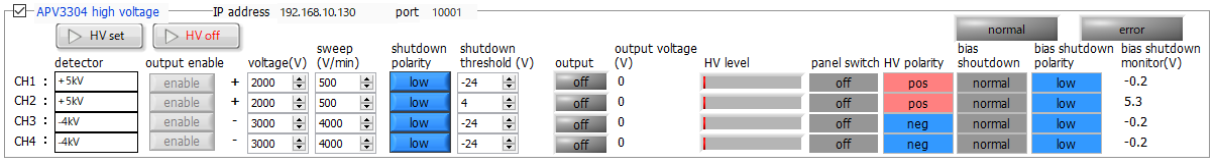


Figure 19: High voltage section at startup

- "output enable" is OFF and gray and invalid.
- The value of sweep (V / min.) is set appropriately for the connected detector. For example, set CH1 and CH2, to which the Germanium semiconductor detector is connected, to 500 V / min. if you want to boost 500 V per minute. For CH3 and CH4 to which the BaF_2 scintillation detector is connected, set 4000 V / min. for boosting 4000 V per minute.
- If the detector does not have a bias shutdown signal, set shutdown polarity and shutdown threshold (V) to low and - (minus) 24 V for convenience. If the level of the bias shutdown signal of the channel corresponding to the front panel SHTD 1 to SHTD 4 connector of the APV3304 is less than - (minus) 24 V, it is regarded as bias shutdown and it cannot be applied. The level of the bias shutdown signal is displayed on bias shutdown monitor (V). An example of bias shutdown is described in CH2 if there is no bias shutdown signal in the detector shown below

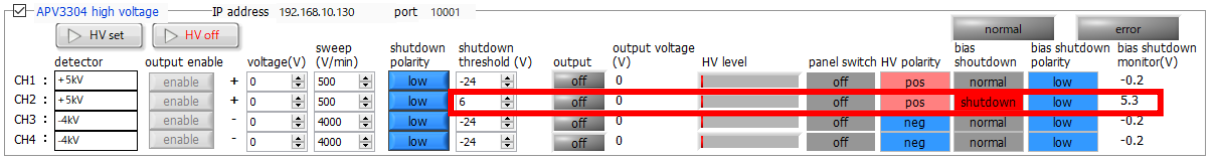


Figure 20: Status of CH2 bias shut down

The setting of CH2 is low and the bias shutdown monitor (V) is 5.3 V against (+) 6 V, which is less than 6 V, so it is displayed as shutdown in red. In this case, application cannot be started. In addition, when this state is reached during the application, the voltage is stepped down according to the setting of sweep (V / min.).

- "output" is off and the output voltage (V) is a value near 0 (zero).

(2) Observe the output signal from the detector with an oscilloscope. In case of abnormal operation after start of application, immediately click on the HV off button or press the EM - OFF (emergency high voltage power output stops button) button on the APV3304 front panel for 3 seconds or longer or turn OFF the ON / OFF switch to turn on the high voltage power supply Turn OFF the output.

(3) Turn on the switch on the front panel of the APV3304. The panel switch lights up and turns on, and the output enable button becomes configurable.

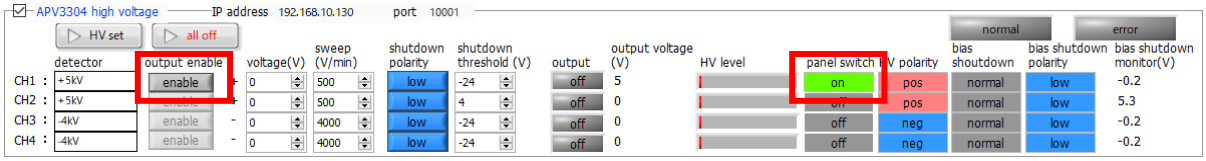


Figure 21: State of CH1 configurable

(4) Enter the voltage value corresponding to the detector at the voltage (V) and turn on the output enable button.

(5) Click the HV set button. After clicking, the current setting state of all 4 channels is transmitted to the board and the application is started. During application, output flashes and the output voltage (V) and HV level increase.

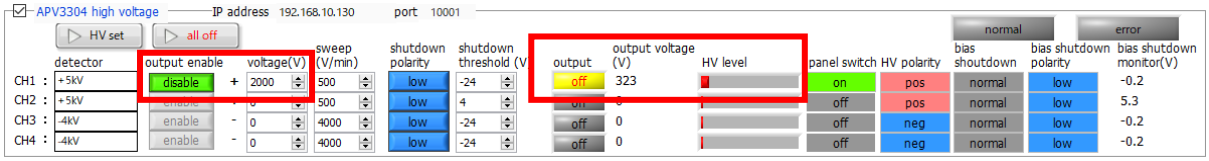


Figure 22: State of CH1 under voltage

(6) When the voltage set to the voltage (V) is reached, output lights up, and the output voltage (V) and HV level are close to the set value. Also, the HV on the upper right of the screen will light up.

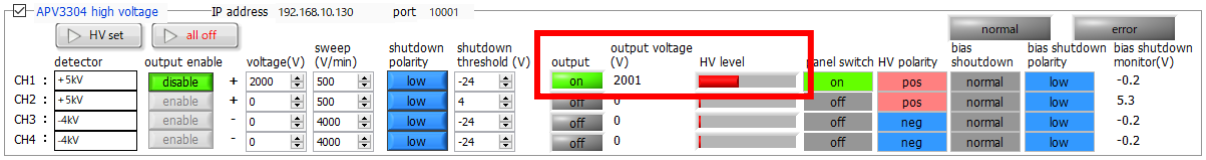


Figure 23: CH1, application complete

(7) If it is only ON / OFF operation of the high voltage power supply, it can also be executed from the high voltage section in the config tab.

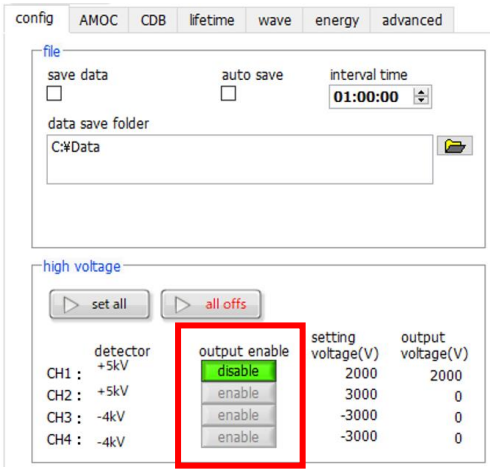


Figure 24: High voltage power supply setting and status display on the config tab

5. 2. energy mode

In the energy mode, gamma ray energy spectrum measurement is performed using only APV8002.

5. 2. 1. Environment

（1） When using energy mode, please connect this equipment as shown below.

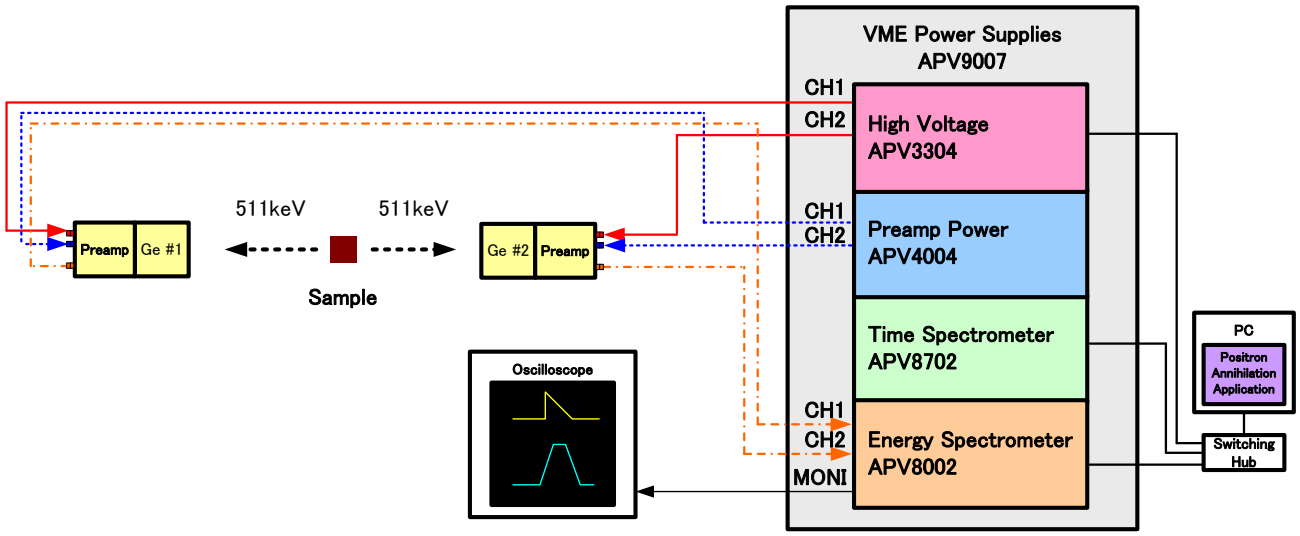


Figure 25: Connection diagrams of energy mode

5. 2. 2. Adjustment

（1） Make the following settings in the advanced tab. The settings in the figure below are guidelines and may vary depending on the environment.

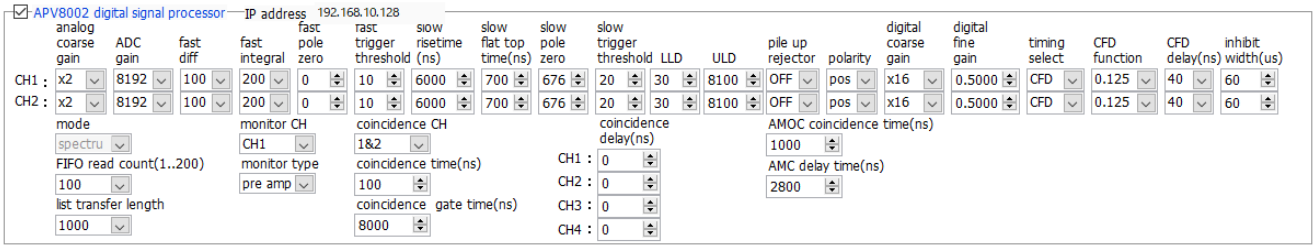


Figure 26: Energy mode setting *just a reference

- Select energy in mode.
- Set the parameters of APV8002 with reference to the above figure. For the explanation of each parameter, refer to "4.8.advanced tab" and “DSP software manual”.
- Set “meas. time” to the maximum of 768 hours.
- During adjustment, if save data is set to OFF in the config tab, data is not saved for each measurement.
- Connect the oscilloscope to the MONI terminal on the front panel of the APV8002. By connecting, the state of signal processing inside the APV8002 can be confirmed as an oscilloscope as a waveform, and the gain and the pole zero can be adjusted. As a guide for setting the oscilloscope, the horizontal axis is 100 μsec / Div., And the vertical axis is 100 mV / Div.
- Click Config on the menu and send the settings to APV8002.

（2） Prepare for adjustment of the analog system. The analog system is the setting on the APV8002 side according to the preamplifier output signal of the Germanium semiconductor detector.

- Set polarity of detector with polarity. Set “pos” for positive polarity and “neg” for negative polarity.
- The analog coarse gain should be × 2 times or × 5 times.
- Set monitor CH to “CH1” and monitor type to “preamp”. You can check the preamplifier signal in the APV8002 of CH 1 from the MONI terminal on the oscilloscope. Check that the signal of the preamplifier is within the range of 0 (zero) to + (plus) 1 V and does not saturate.

（3） Adjustment of analog gain and analog pole zero. Adjust the wave height of the preamplifier signal to be in the range of 400 mV to 600 mV while turning "F. G" (fine gain of analog) on the front panel of DSP.

Setting with resistance feedback type

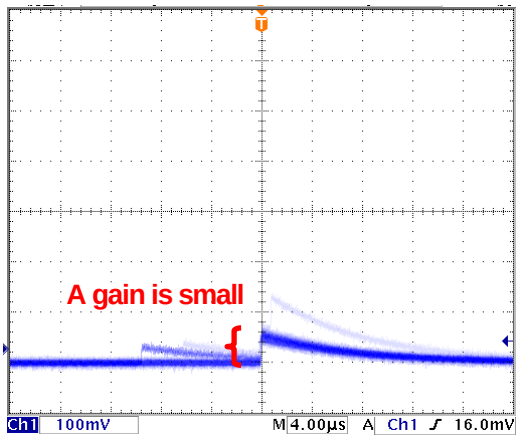


Figure 27: Before adjustment

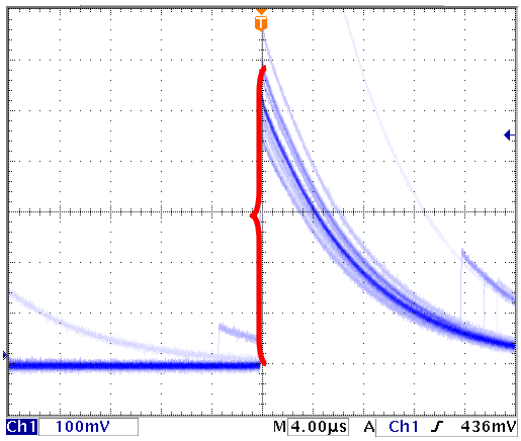


Figure 28: After adjustment

Adjust the pole zero of the preamp signal while turning "P. Z" (analog pole zero) on the front panel of the DSP.

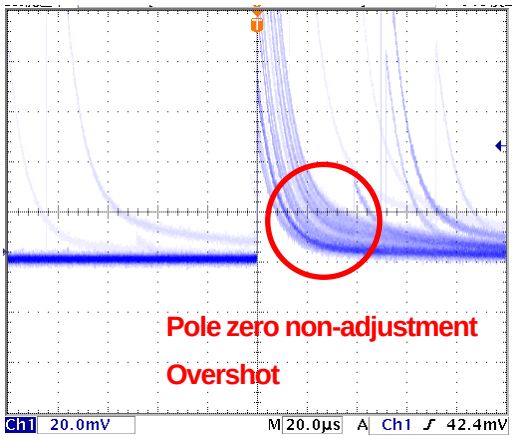


Figure 29: Before adjustment
(in the case of an overshot)

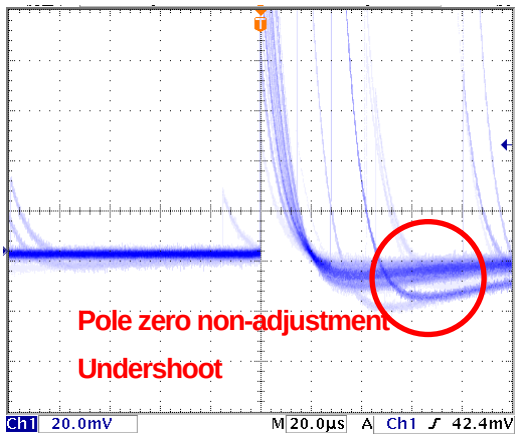


Figure 30: After adjustment
(in the case of undershoot)

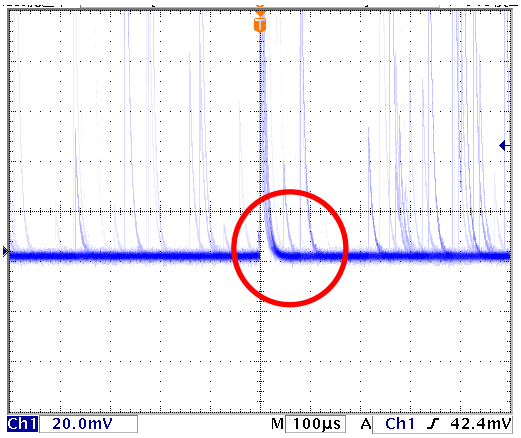


Figure 31: After adjustment

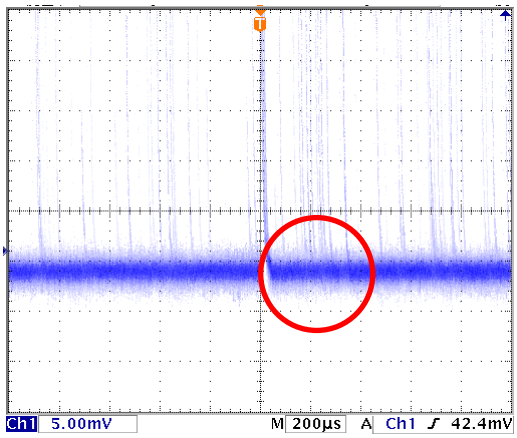


Figure 32: After adjustment (expansion)

Setting of the reset type

① Check the preamplifier output signal from the "MONI" terminal on the front panel of the DSP with an oscilloscope

② Turn the "P. Z" (analog pole zero) on the front panel of the DSP counterclockwise until the tone sounds "tick".

③ While turning "F. G" (Analog fine gain) on the front panel of the DSP, adjust the wave height of the preamplifier signal from 400 mV to 600 mV.

（4） Adjust digital pole zero. Set monitor CH to CH1 and monitor type to slow. The slow filter (trapezoidal filter) waveform shaping signal in the APV8002 of CH 1 can be confirmed from the MONI terminal with an oscilloscope.

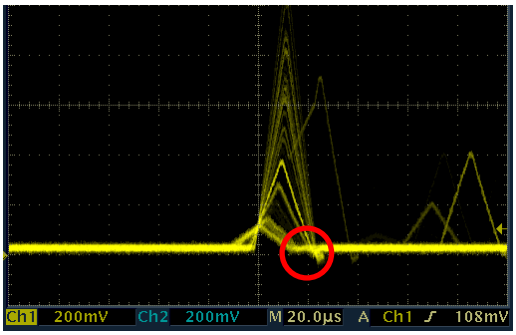


Figure 33. Before adjustment (undershoot)

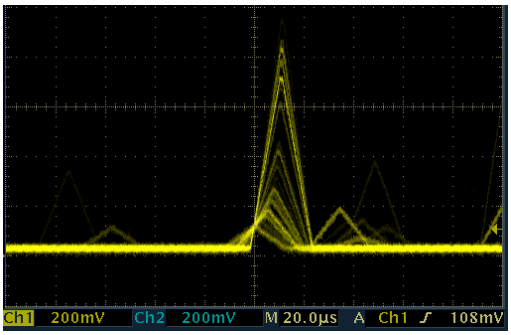


Figure 34. After adjustment

（5） Set the threshold. The threshold setting is used as the threshold of the gated baseline restore (BLR). There are two types: fast trigger threshold and slow trigger threshold. The fast trigger threshold is the threshold for detecting the signal from the timing filter. The slow trigger threshold is the threshold for identifying the signal from the waveform shaping filter.

Click the start button to start the measurement.

First, input the "fast trigger threshold" to some extent (about 50) and observe the input total rate (cps). We gradually reduce the threshold and find a value that increases the input total rate (cps). Since its value is the boundary between the signal and noise, set it to about + (plus) 3 to + (plus) 10 from that value. The standard is 10 to 20. Next, input "slow trigger threshold" to some extent (about 50) and observe the throughput rate (cps). We slowly reduce slow trigger threshold and find a value that increases throughput rate (cps). Since its value is the boundary between the signal and noise, set it to about + (plus) 3 to + (plus) 10 from that value. The standard is 20 to 30.

The energy resolution tends to improve as both values are as close as possible to the noise level.

（6） Adjust digital fine course gain and digital fine gain. Click the start button to start the measurement. By adjusting the digital coarse gain and digital fine gain, you can adjust the position of the horizontal axis of the peak of interest in the energy spectrum.

The explanation concerning the above adjustment only describes points of importance. Depending on your experimental environment, other settings may be required. In that case please refer to the “DSP software manual”.

5. 2. 3. The measurement

Measurement is started after completion of the above adjustment.

（1） When measurement starts, the display automatically switches to the energy tab. During measurement, acq.LED flashes, indicating that the device and this application are communicating. Count rate information and energy spectrum graph are displayed. You can calibrate the energy on the horizontal axis of the graph by operating the ROI setting or display the calculation result on the ROI. For details of each setting, refer to "4.7.energy tab".

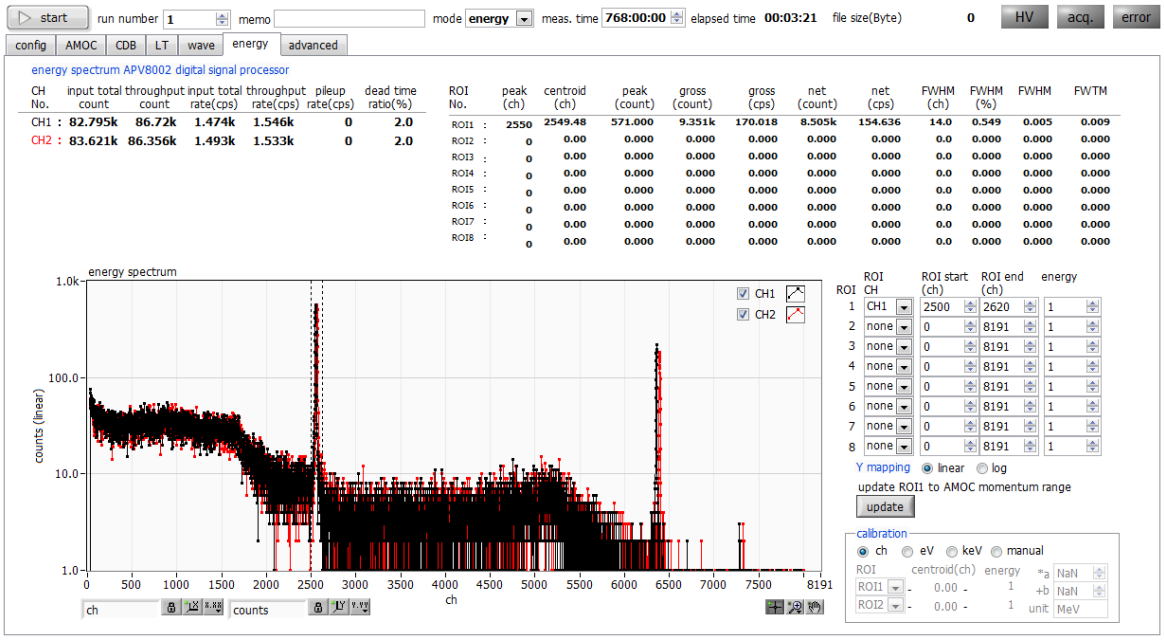


Figure 35: energy mode measurement screen (Na-22 spectrum)

- Measurement stops when elapsed time reaches “meas.time” or by clicking the start button (the display automatically changes to stop after measurement starts).

- If the “save data” item is checked on the config tab, the measurement data and the config file are automatically saved when measurement stops. The save destination is the path displayed at the bottom of the config tab. Measurement data can also be saved by clicking save energy file in the menu bar after stopping measurement. For details on the config tab settings, see “4.2. Config tab”.

5. 3. CDB mode

In CDB mode, simultaneous events from two Germanium semiconductor detectors are acquired using APV8002 and CDB (Coincidence Doppler Broadening) measurement is performed.

5. 3. 1. Environment

（1） When using the CDB mode, connect this device as shown below.

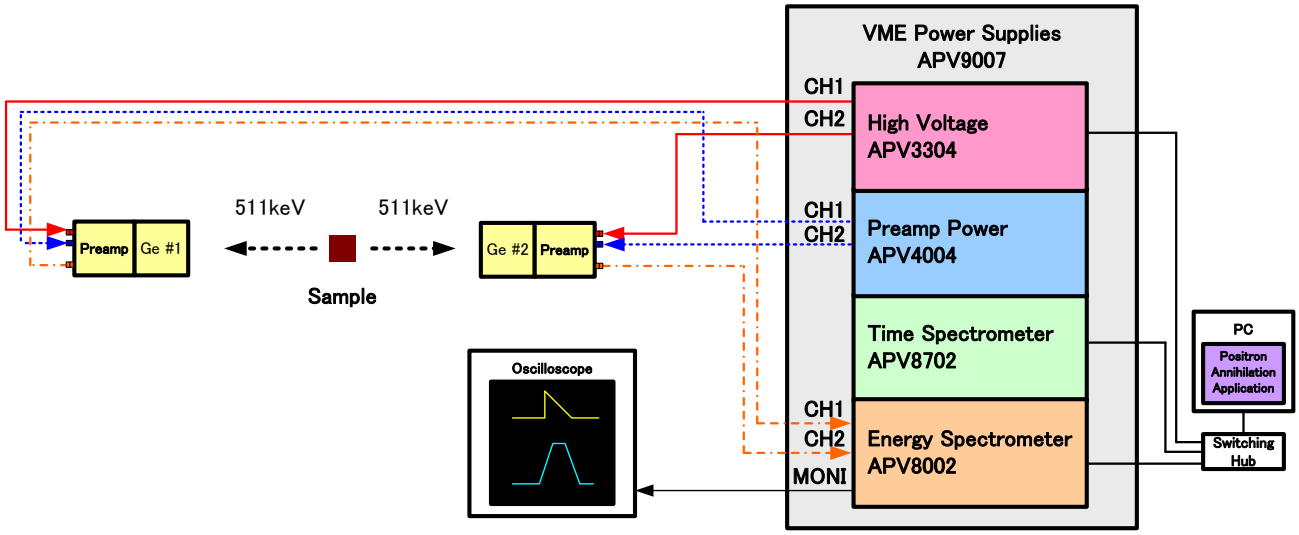


Figure 36: Connection diagram of CDB mode

5. 3. 2. Adjustment

(1) Measurement is performed by switching the operation mode to energy mode. Adjust the advance tab so that a peak of 511 keV appears in CH1 and CH2 of the energy spectrum graph of the energy tab. For operations on energy mode, see “5.2. energy mode”.

(2) Set ROI start (ch) and ROI stop (ch) to peak at 511 keV peak in energy spectrum of energy tab. When set, the corresponding cursor will move in the graph (downward arrow in the figure below).

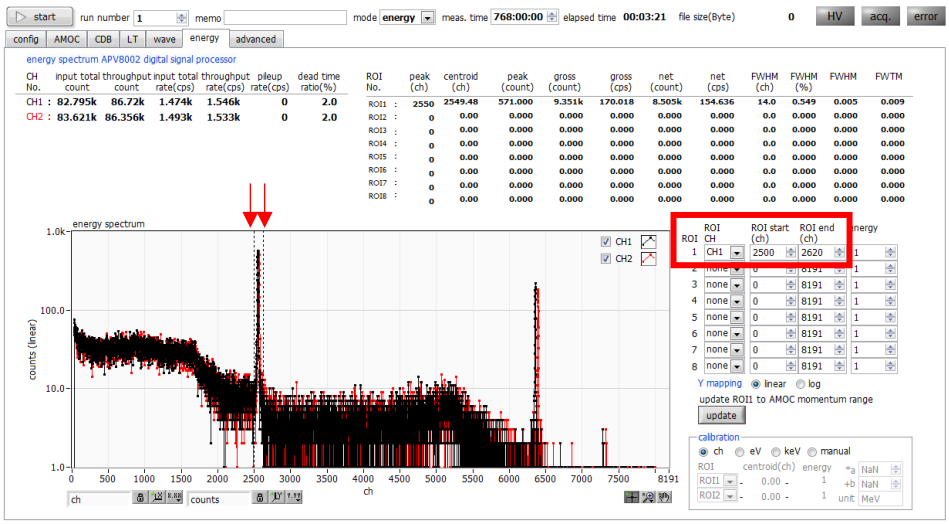


Figure 37: ROI setting

(3) Enter ROI start (ch) in the LLD item on the advanced tab and ROI stop (ch) value in the ULD item or click the update button and start measurement again in energy mode.

(4) Confirm that the spectrum reflecting the setting of LLD / ULD is displayed in energy spectrum.

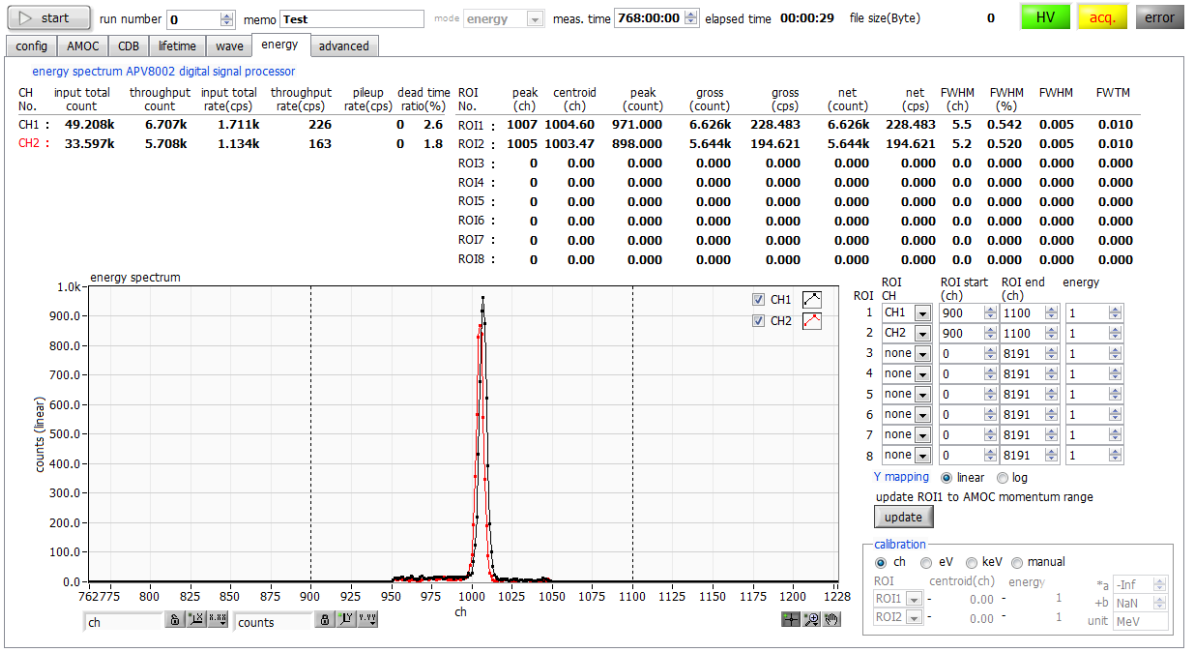


Figure 38: Energy spectrum with LLD and ULD set to surround the 511 keV peak

(5) When you finish adjusting in CDB mode, follow the steps below to make the settings.

- Click the mode pull - down menu and select CDB.
- Switch to the CDB tab.
- In the range select 2048 * 2048.
- Enter the CHL offset (ch) / CH2 offset (ch) **LLD value** of each CH set on the advanced tab. Since the output range of the CDB data is 2048 ch, adjust 511 keV so that this setting will be increased further if the peak does not fall within 2048 ch after LLD.
- Set “meas. time”.

5. 3. 3. The measurement

Measurement is started after completion of the above adjustment.

（1） Click the start button to start the measurement.

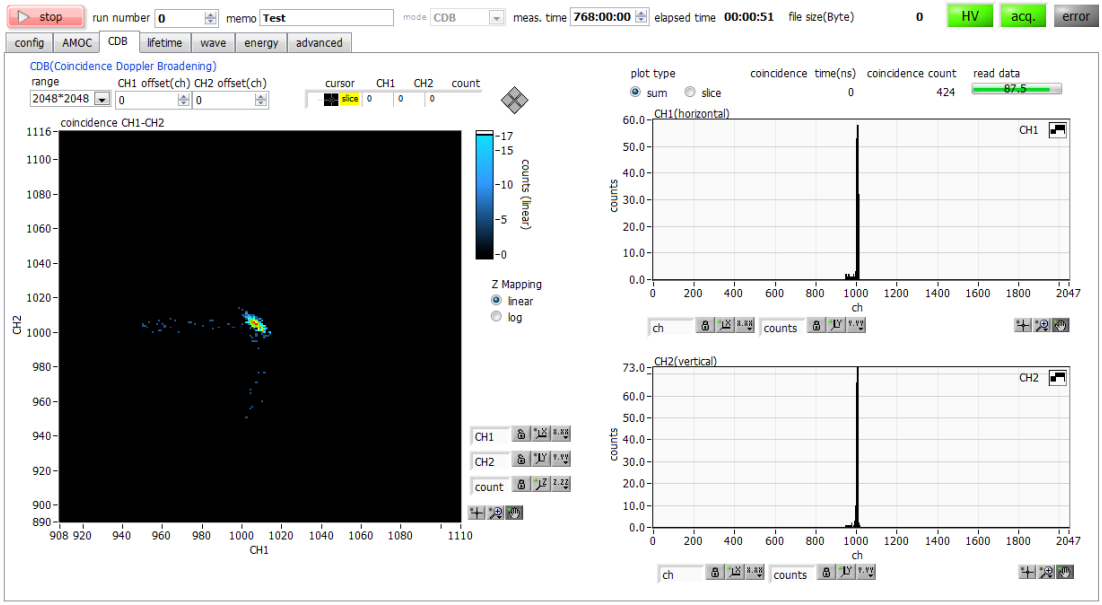


Figure 39: Energy spectrum with LLD and ULD set to surround the 511 keV peak

- During reading, the read data progress bar increases, and the reading progress is displayed. It takes about 5 seconds to read one time.
- Double-click the number of the graph scale, and input a value, and can perform scale adjustment.
- During measurement, acq. LED blinks to indicate that the device and this application are communicating. A two-dimensional histogram is displayed in "coincidence CH1 - CH2".
  When sum is selected by plot type, the total sum spectrum in the vertical and horizontal directions of the two-dimensional histogram is displayed in the upper and lower graphs on the right side.
  By selecting slice with plot type, you can display the slice graph of the energy two-dimensional spectrum graph on the right side by operating the cursor on the graph.

- elapsed time arrives at “meas.time”, or the measurement stops by clicking a stop button.

- If the save data item is checked on the config tab, the measurement data and the config file are automatically saved when measurement stops. The save destination is the path displayed at the bottom of the config tab. Measurement data can also be saved by clicking save CDB file in the menu bar after stopping measurement. For details on the config tab settings, refer to “4.2. Config tab”.

5. 4. wave mode

Wave mode is a mode to acquire waveform data of input signal using APV8702. Before measuring Lifetime mode, always check the waveform in wave mode.

5. 4. 1. Environment

（1） When using wave mode please connect this device as shown below.

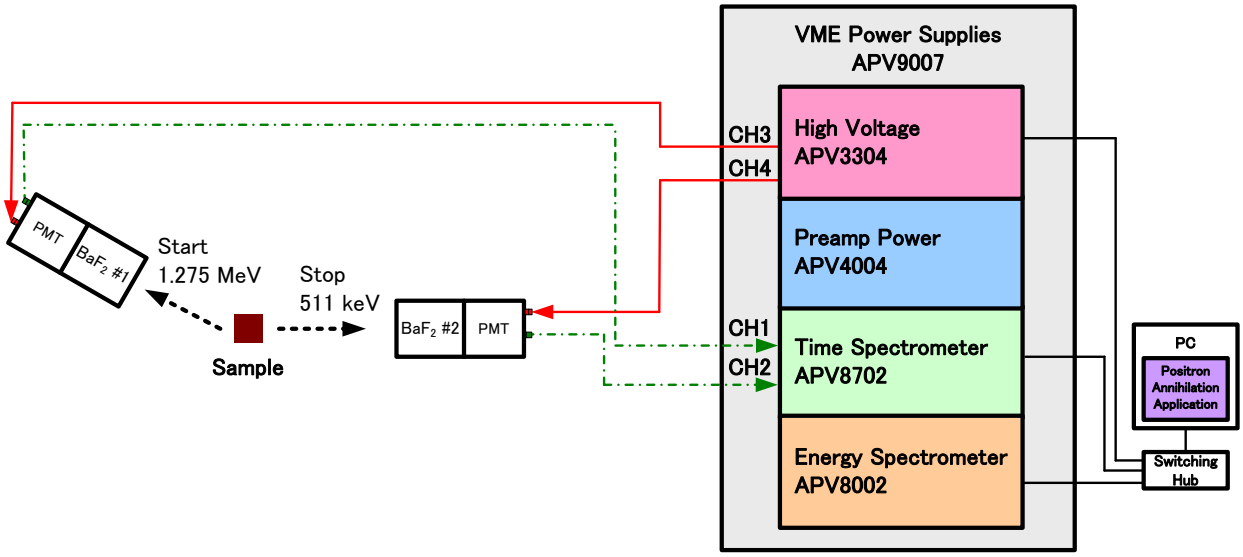


Figure 40: Connection diagram of wave mode

5. 4. 2. Adjustment

（1） Turn off the high voltage power supply to the BaF_2 scintillation detector.
（2） In the advanced tab, make the following settings. The setting in the figure below is a guide only and it depends on the environment.

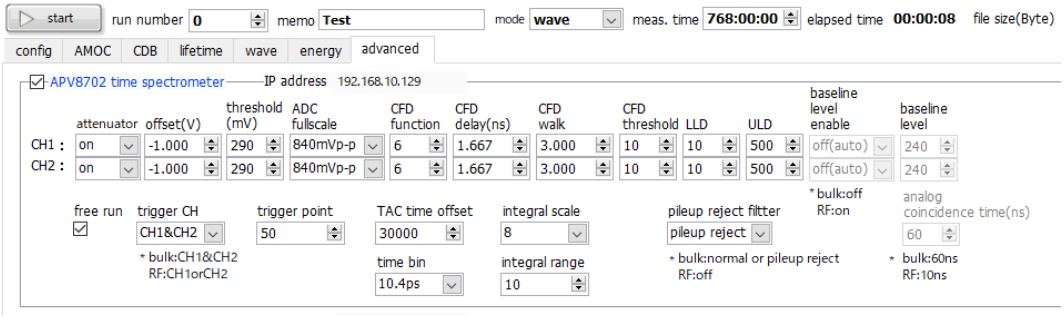


Figure 41: wave mode setting *just a reference

- Select wave in mode.
- Set the parameters of APV8702 referring to the above figure. For the explanation of each parameter, refer to "4.8.advanced tab".
- Check free run.
- Set “meas. time” to the maximum of 768 hours.
- When "save data" in the config tab is set to "OFF" during the adjustment, data is not saved for each measurement.
- Click the start button to start measurement.

（3） When the measurement starts, the display automatically switches to the wave tab. During measurement, acq. LED blinks, indicating that the device and this application are communicating. Wave graph shows two waveforms. In the figure below the free run is operating and the offset of the baseline is unadjusted.

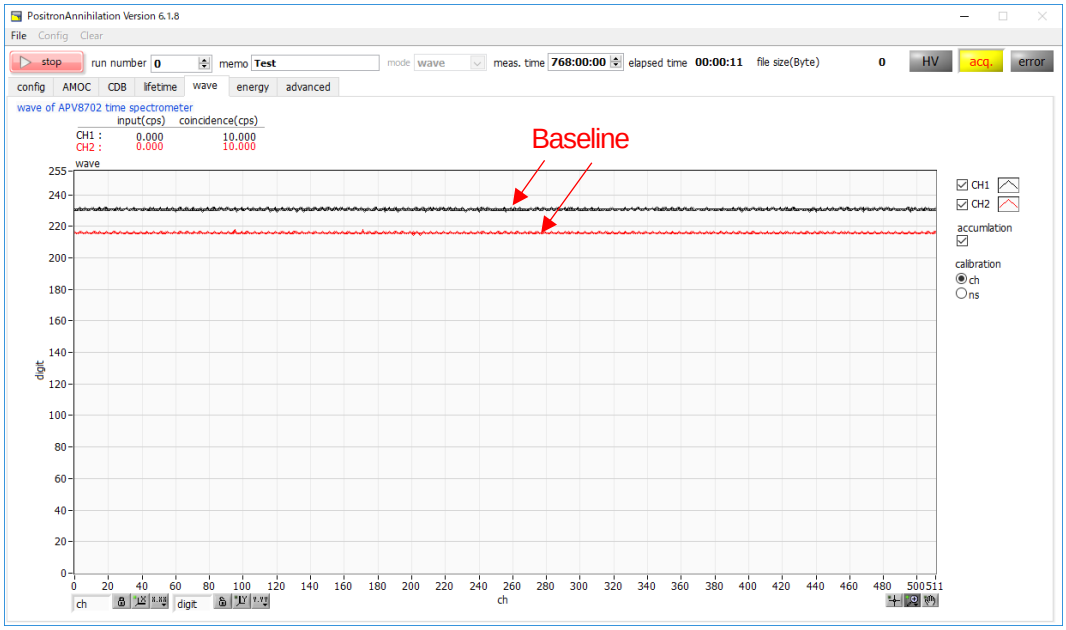


Figure 42: Free run before offset adjustment

（4） Adjust the offset. Run it with free run and set offset (V) shown below so that the value of the vertical axis of CH1 and CH2 's base line becomes around 240 digits. Stop the measurement, adjust the offset (V) setting with the decimal value and repeat the measurement again.

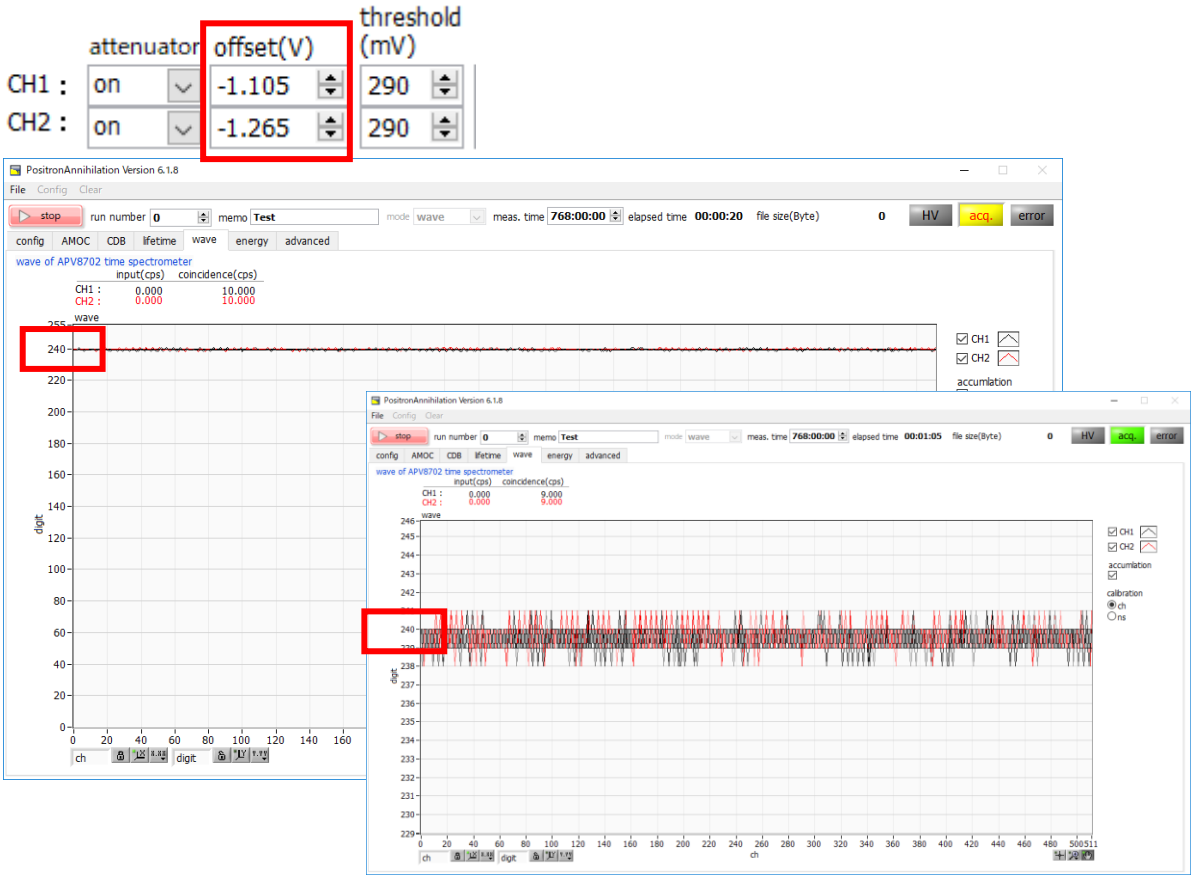


Figure 43: After offset adjustment (**upper side**: advanced tab setting, **left side**: Whole, **right side**: Zoom in)

（5） Apply a high voltage power supply to BaF_2 scintillation detector.

（6） Check the wave height value. Uncheck free run and measure in wave mode. Use a source as needed. In the figure below, the trigger CH is CH1 & CH2, and the waveform at the timing exceeding threshold is displayed. Make sure that the wave height level of the waveform of CH1 and CH2 is sufficiently within 0 (zero) to 255 digits on the vertical axis.

Figure 44: Confirmation of wave height value and input (cps)

- Increasing the value of threshold approaches the baseline and the input (cps) increases. When threshold falls outside the signal range, input (cps) becomes 0 (zero) and wave update stops.
- The threshold value of the blue character in the above figure and the dotted line are merely indications and are not accurate.

（7） Adjust the wave height value. Ensure that the wave height level of CH1 and CH2 waveforms falls within 0 to 255 digits on the vertical axis. Uncheck free run and start measurement. In the case of the figure below, the wave height level of both channels protrudes far beyond the range.

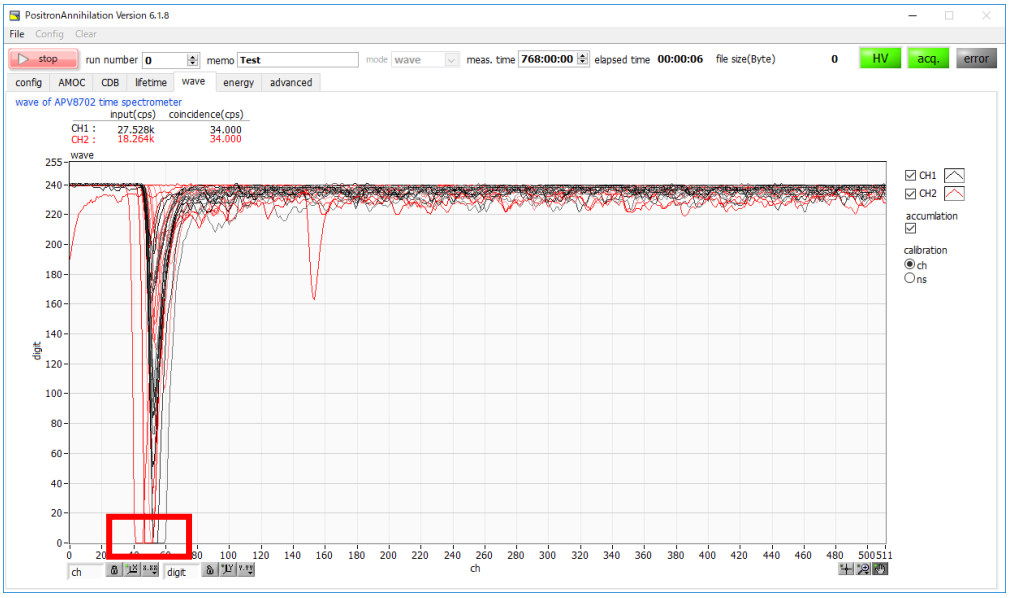


Figure 45: wave height level adjustment

If the Peak value (vertical axis) does not fall within the range of 0 to 255 digits, it may rise before the rise of the lifetime spectrum as shown in the figure below.

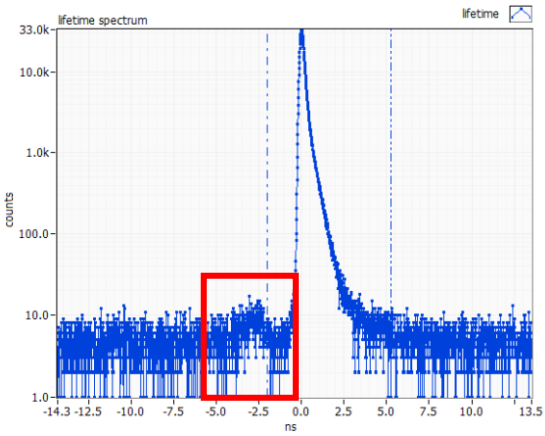


Figure 46: Rise of life spectrum

Set the wave height level within the vertical axis according to the following setting.

- Turn on attenuator. Along with this, if the wave height becomes too small, it may be necessary to increase the high voltage.
- Extend “ADCfullscale” to 840 mVp-p and so on.
- Attach an external attenuator between the connection of CH1 and CH2 of APV8702. In this case, time resolution and the like may be deteriorated.
- Reduce the voltage value of the applied high voltage power supply. In this case, time resolution and the like may be deteriorated.

5. 4. 3. The measurement

The measurement is started after completion of the above adjustment.

（1） Set according to the following procedure. The setting is only a guide and it changes according to the equipment configuration and use.

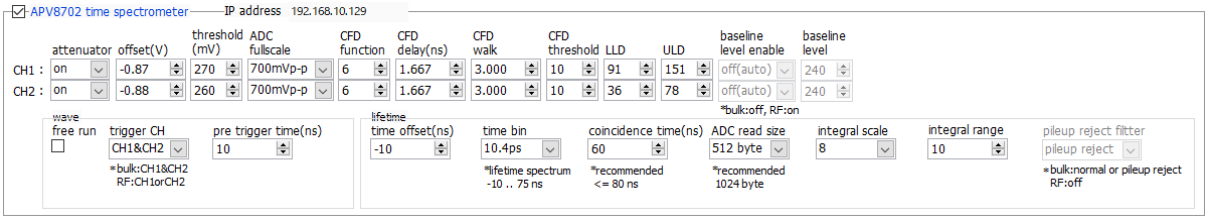


Figure 47: setting example

- Select wave in mode.
- Set the parameter of APV8702 referring to the above figure.
  For the explanation of each parameter, refer to "4.8.advanced tab".
- By setting save data ON in the config tab, data can be automatically saved for each measurement.

（2） Click the start button to start the measurement.

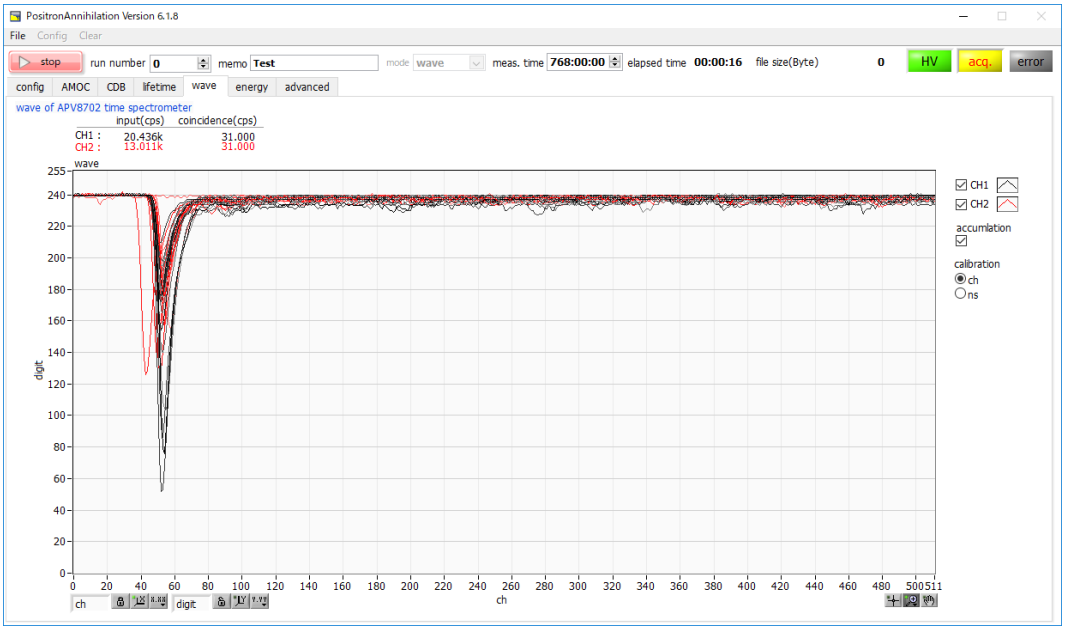


Figure 48: wave mode measurement

- The waveform under measurement is displayed on the graph.
- When "meas. time" is reached, the measurement ends. To stop measurement, Click the stop button.
- When save data in the config tab is ON, the following files are created in the set folder. For details of the file, refer to "**6.6.wave data file**" described later.

  RUN 999999_config.ini: Configuration file

  RUN 999999_wave.csv: wave data file

  *999999 is the run number at the time of measurement.
- If save data is ON in the config tab, the run number is automatically incremented by 1 (one).

5. 5. lifetime mode

In the lifetime mode, APV8702 is used to perform positron lifetime measurement. When using Lifetime mode, connect this unit as shown below.

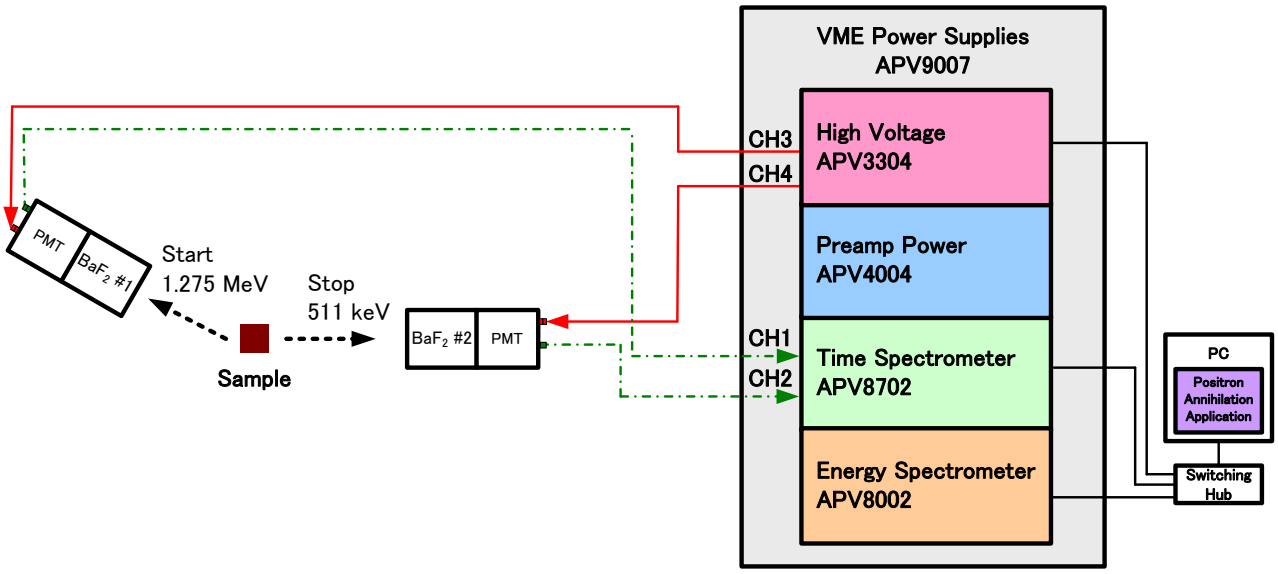


Figure 49: Connection diagram of lifetime mode

5. 5. 1. Adjustment

（1） Switch the operation mode to wave mode and measure. Adjust the advance tab so that the waveform data of ch1 and ch2 are displayed in the wave graph of the wave tab. For operation in wave mode, refer to "5.4.wave mode".

（2） Refer to the figure below for setting example.

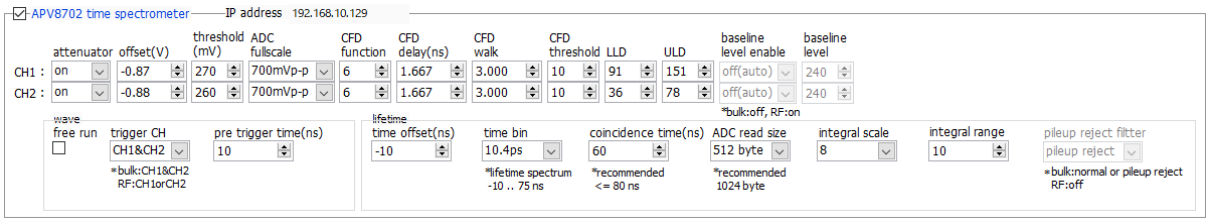


Figure 50: Setting example

- Click a pull-down menu of mode and select lifetime.
- Switch to advanced tab, set LLD is 10, and ULD is 500 in both CH.
- Set “meas. time” to the maximum of 768 hours.
- When "save data" in the config tab is set to "OFF" during the adjustment, data is not saved for each measurement.

- Click the start button to start the measurement. The window switches to the lifetime tab in the figure below.

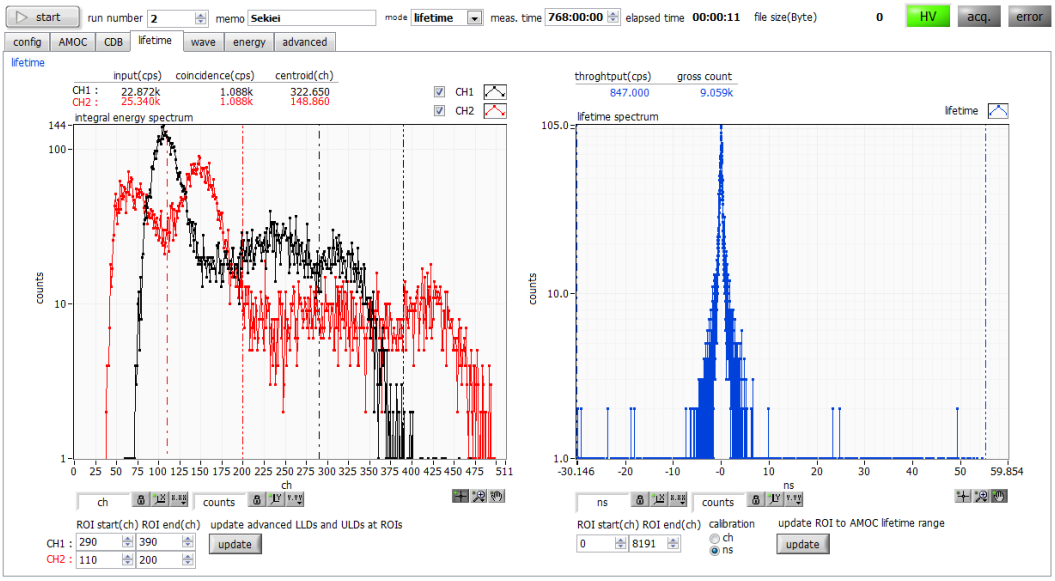
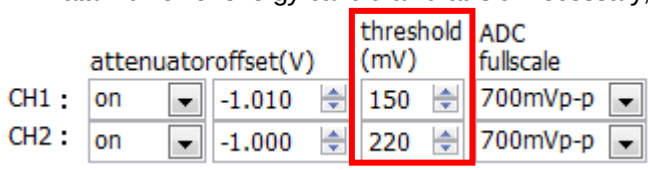


Figure 51: Lifetime mode (before adjustment of threshold, LLD, and ULD)

- The QDC spectrum is displayed on the integral energy spectrum graph on the left side. Calculate the count until the photoelectric effect peak at 511 keV and 1275 keV of Na - 22 can be discriminated.
- When the counting has been sufficiently accumulated, click the stop button to stop the measurement.
- For CH 1, 1275 keV is set as the START timing, and CH 2 is set as the STOP timing at 511 keV. Data with lower energy band than that is unnecessary, so adjust threshold and truncate it.



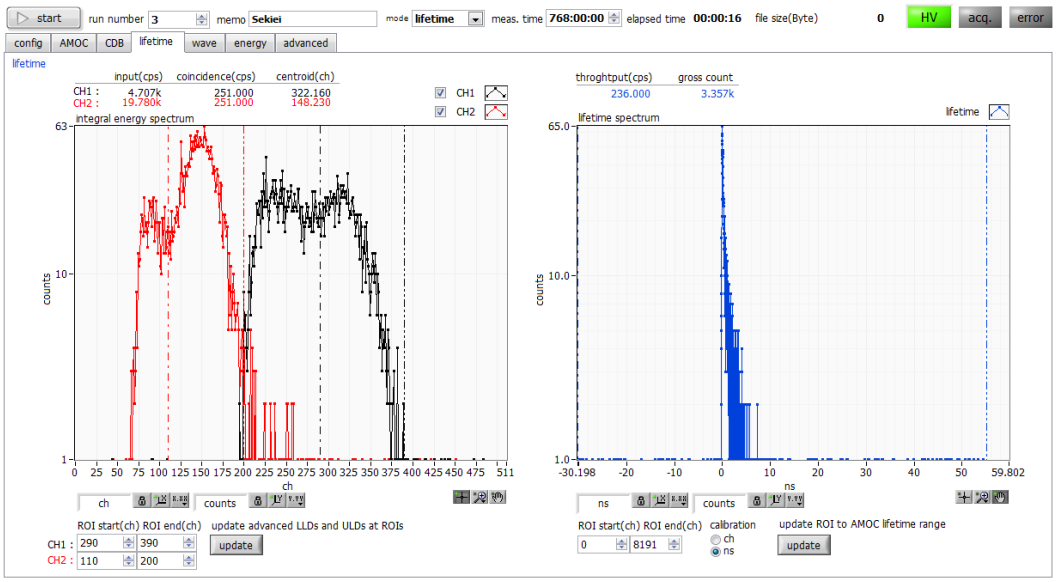


Figure 52: Lifetime mode (after adjustment of threshold, before adjustment of LLD and ULD)

Start measurement by clicking the start button. The low energy side of the left QDC graph is truncated.

- Input of values of ROI start, ROI end. Adjust the numerical values so that the ROI of CH1 is 1275 keV and the ROI of CH2 is 511 keV and click the update button. The setting of the ROI after clicking is reflected in the LLD and ULD in the advanced tab.

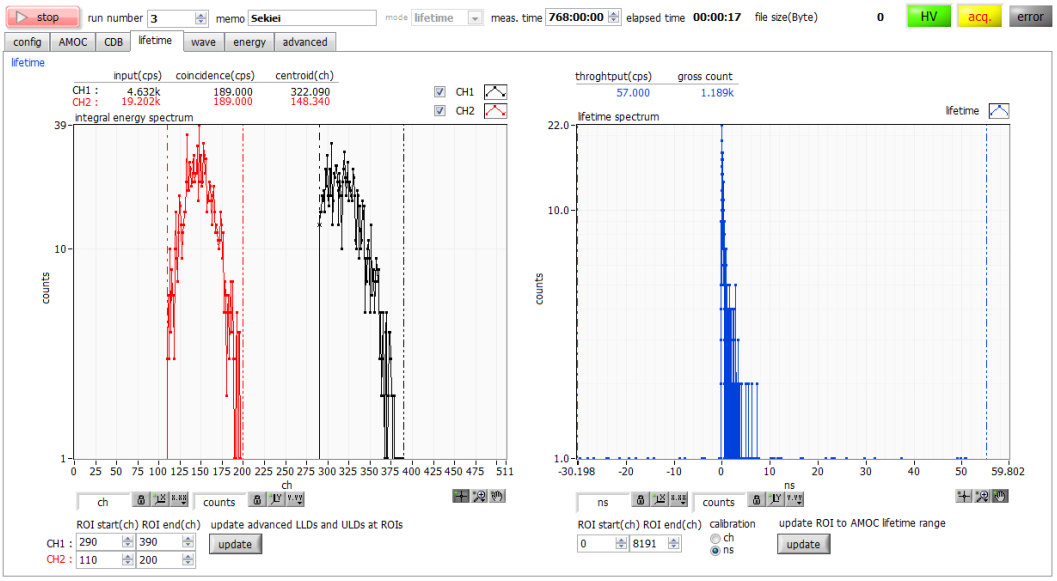


Figure 53: Lifetime mode (after adjustment of threshold, LLD and ULD)

Click the start button to start measurement. In the left QDC graph, the low energy side and the high energy side are truncated in the range of LLD and ULD.

In the lifetime spectrum on the right side, a histogram of the time difference between the START timing of 1275 keV of CH 1 and the STOP timing of 511 keV of CH 2 is displayed.

Useful information

The counting rate is recommended to be 100cps or less in the display of throughput (cps). Up to 200 cps is a guideline. Higher counts may increase pileup and affect the spectral shape.

If there is an abnormality in the spectrum shape, the following may be a concern.

- Use the high-voltage power cable and signal cable from the detector in an extended state. Do not wrap cables or bundle tightly.
- There are many gaps between the source and sample, or the sample and source are misaligned.

5. 5. 2. The measurement

The measurement is started after completion of the above adjustment.

(1) Set according to the following procedure. The setting is only a guide and it changes according to the equipment configuration and use.

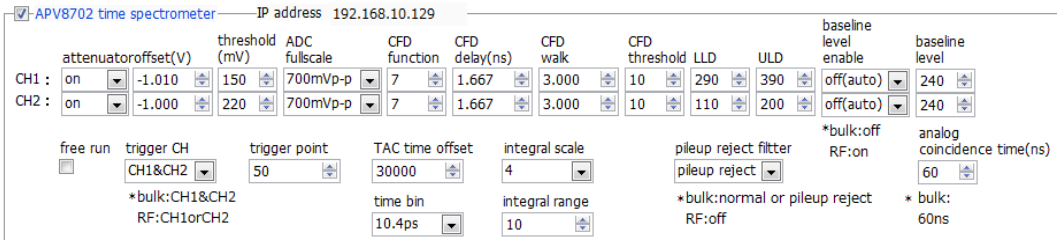


Figure 54: Setting example

- Select lifetime in mode.
- Set the parameter of APV8702 referring to the above figure.
  For the explanation of each parameter, refer to "4.8.advanced tab".
- By setting save data ON in the config tab, data can be automatically saved for each measurement.

(2) Click the start button to start the measurement.

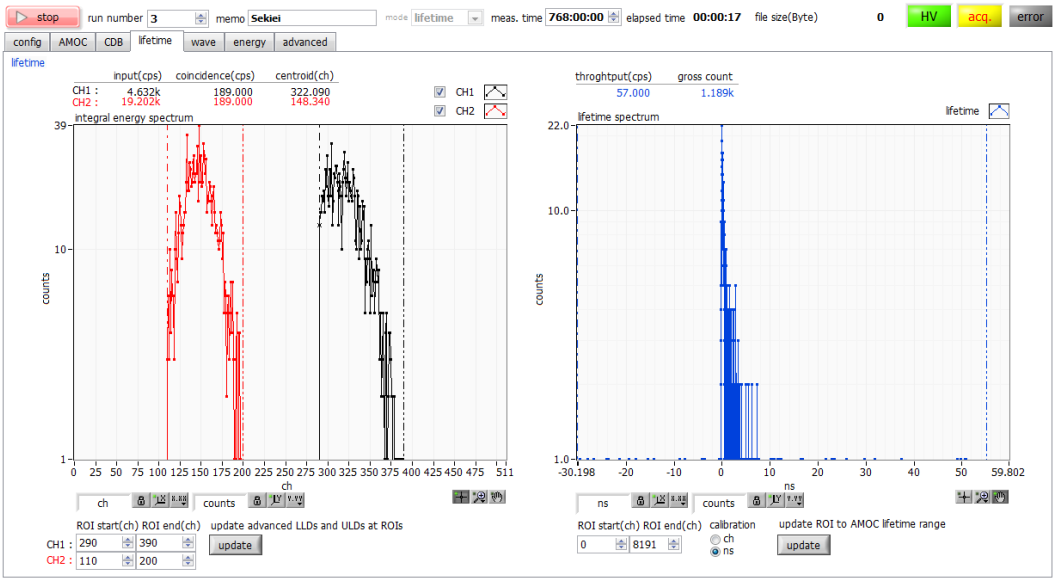


Figure 55: Lifetime mode measurement

- In the integration energy spectrum graph on the left side of the lifetime tab in the measurement, a spectrum of 1275 keV can be displayed in CH1 and a spectrum of 511 keV in CH2 can be displayed. In the lifetime spectrum on the right side, a histogram of the time difference between the START timing of 1275 keV of CH1 and the STOP timing of 511 keV of CH2 is displayed.
- When “meas. time” is reached, the measurement is completed. To stop measurement, Click the stop button.
- When save data in the config tab is ON, the following files are created in the set folder. Refer to "6.3.**lifetime data file**" below for the details of the file.
  RUN 999999_config.ini: Configuration file
  RUN 999999_LT_diff.csv: lifetime spectrum (comma-separated text format)
  RUN 999999_LT_diff.dat: lifetime spectrum (10 digits left space packed text format)
  RUN 999999_LT_diff_rev.dat: lifetime inverted spectrum (10 digits left space packed text format)
  RUN 999999 _ LT _ integral.csv: integral energy spectrum (comma-separated text format)
  * 999999 is the run number at the time of measurement.

5. 6. CDB&lifetime mode

CDB & lifetime mode is a mode that uses APV8002 and APV8702 to perform CDB mode measurement and lifetime mode measurement simultaneously.

5. 6. 1. Environment

When using CDB & lifetime mode, connect the device as shown below.

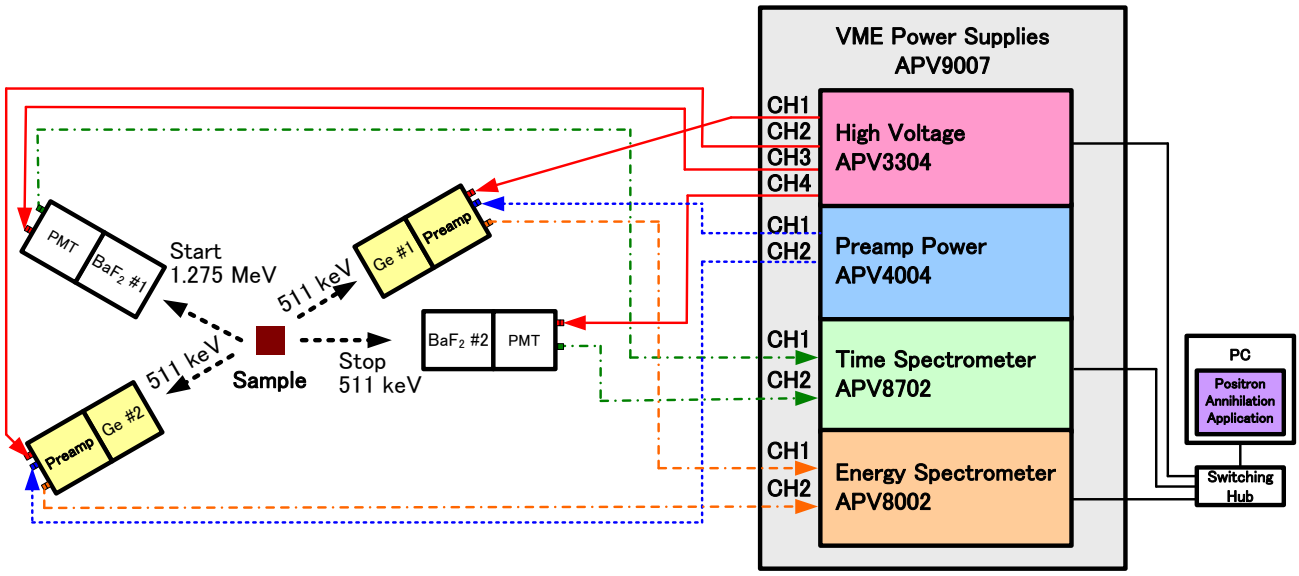


Figure 56: Connection wiring diagram of CDB & lifetime mode

5. 6. 2. Adjustment

Set in the advanced tab. Refer to the settings in the CDB mode and lifetime mode described above for the settings.

5. 6. 3. Measurement

1. Select “CDB&lifetime” in mode.
2. Set “meas.time” to a maximum of 768 hours.
3. When save data in the config tab is turned ON, data can be automatically saved for each measurement.
4. Click the start button to start measurement.
   The content of the measurement is the same as the CDB mode and lifetime mode described above.

5. 7. AMOC mode

AMOC mode uses APV8002 and APV8702 to measure AMOC (lifetime-energy correlation method, Age-Momentum Correlation) measurement which simultaneously acquires time information and energy information.

5. 7. 1. Environment

（1） When using the AMOC mode, connect this device as shown below.

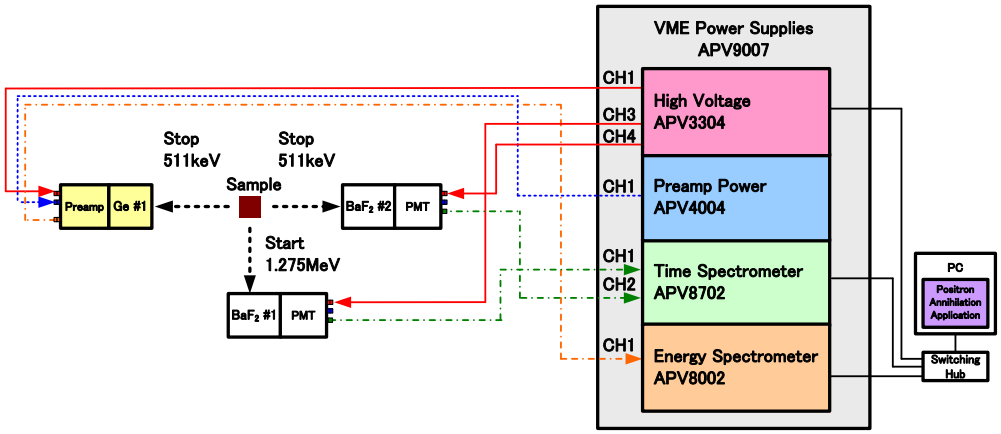


Figure 57: Connection diagram of AMOC mode

5. 7. 2. Adjustment

（1） Switch the operation mode to energy mode and measure. Adjust the parameters on the advance tab so that the energy spectrum of the Germanium semiconductor detector is displayed on CH1 of the energy spectrum graph of the energy tab. For the operation in energy mode, refer to "5.2.energy mode".

After confirming the peak spectrum of 511 keV, set the ROI start and ROI end of ROI 1 to sandwich this peak, and click the update button. After clicking, this ROI start, and ROI end are reflected in min (ch) and max (ch) of the momentum range in the AMOC tab.

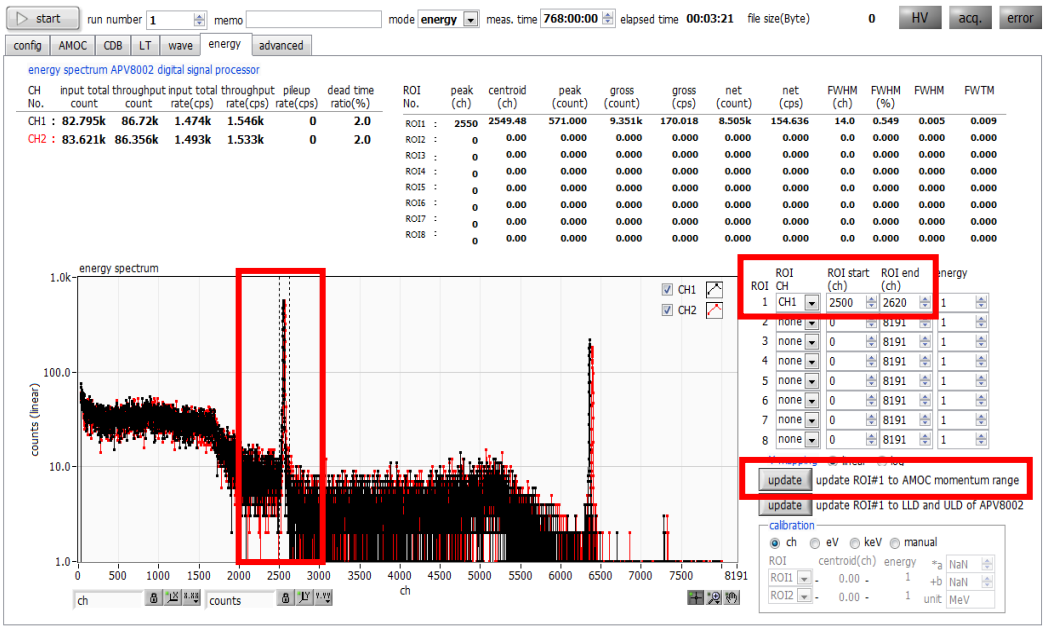


Figure 58: Setting energy region in energy mode

（2） Switch the operation mode to wave mode and measure. Adjust the parameter of the advance tab so that the waveform data of ch1 and ch2 are displayed in the wave graph of the wave tab. For operation in wave mode, refer to "5.4.wave mode".

（3） Switch the operation mode to life mode and measure. Adjust the parameters of the advance tab so that the lifetime spectrum is displayed in the lifetime spectrum graph of the lifetime tab. For the operation in the lifetime mode, refer to "5.5.lifetime mode".

After confirming the peak of the life spectrum, set ROI start and ROI end to sandwich this peak, and click the update button. After clicking, this ROI start, and ROI end are reflected in min (ch) and max (ch) of lifetime range in the AMOC tab.

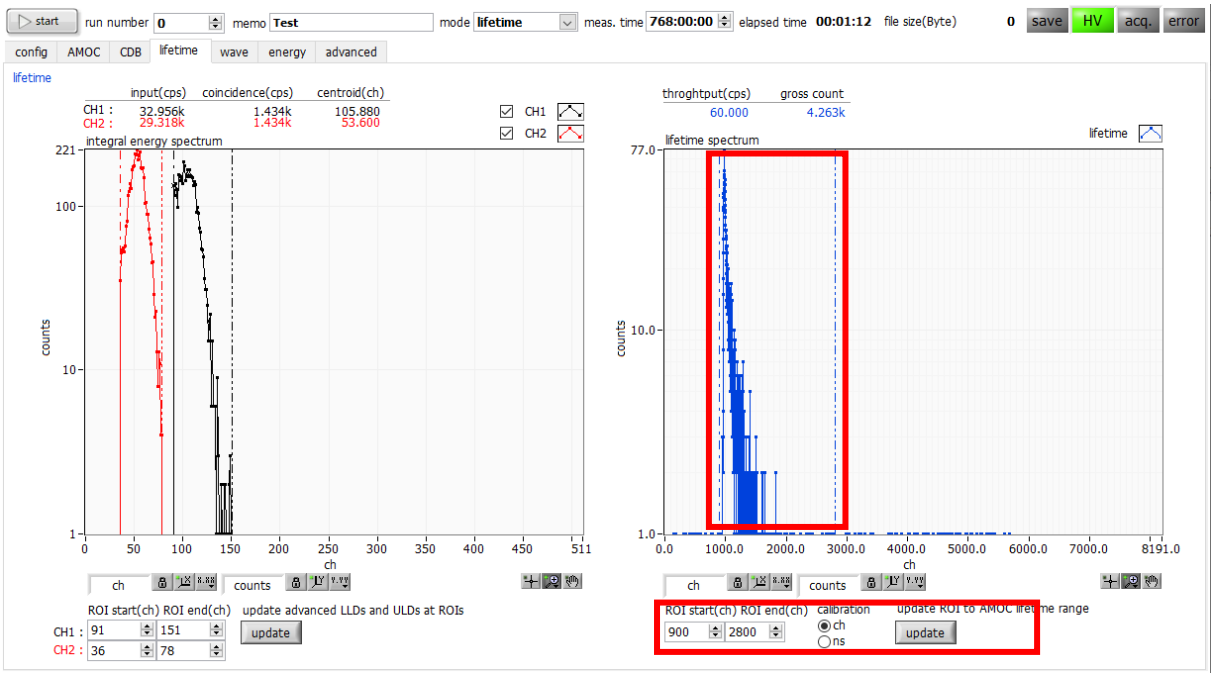


Figure 59: Setting lifetime area in lifetime mode

（4） Refer to the figure below for setting example.

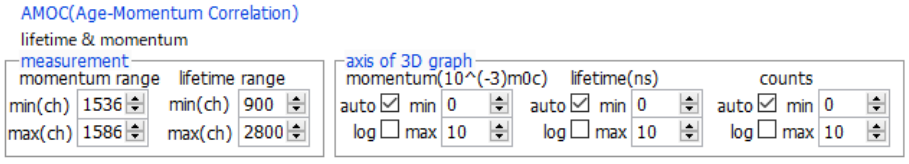


Figure 60: Setting example

- Switch to the AMOC tab. The momentum range and the lifetime range reflect the values of clicking the update button in the energy tab and the lifetime tab in the above adjustment.
- Set the display range of 3-dimensional graph in the AMOC tab with axis of 3D graph. To reflect the setting, click the axis update button.
- Set “meas. time” to the maximum of 768 hours.
- When save data in the config tab is turned OFF, data is not saved for each measurement.

- Select AMOC in mode.
- By setting save data ON in the config tab, data can be automatically saved for each measurement.
- Click the start button to start measurement.

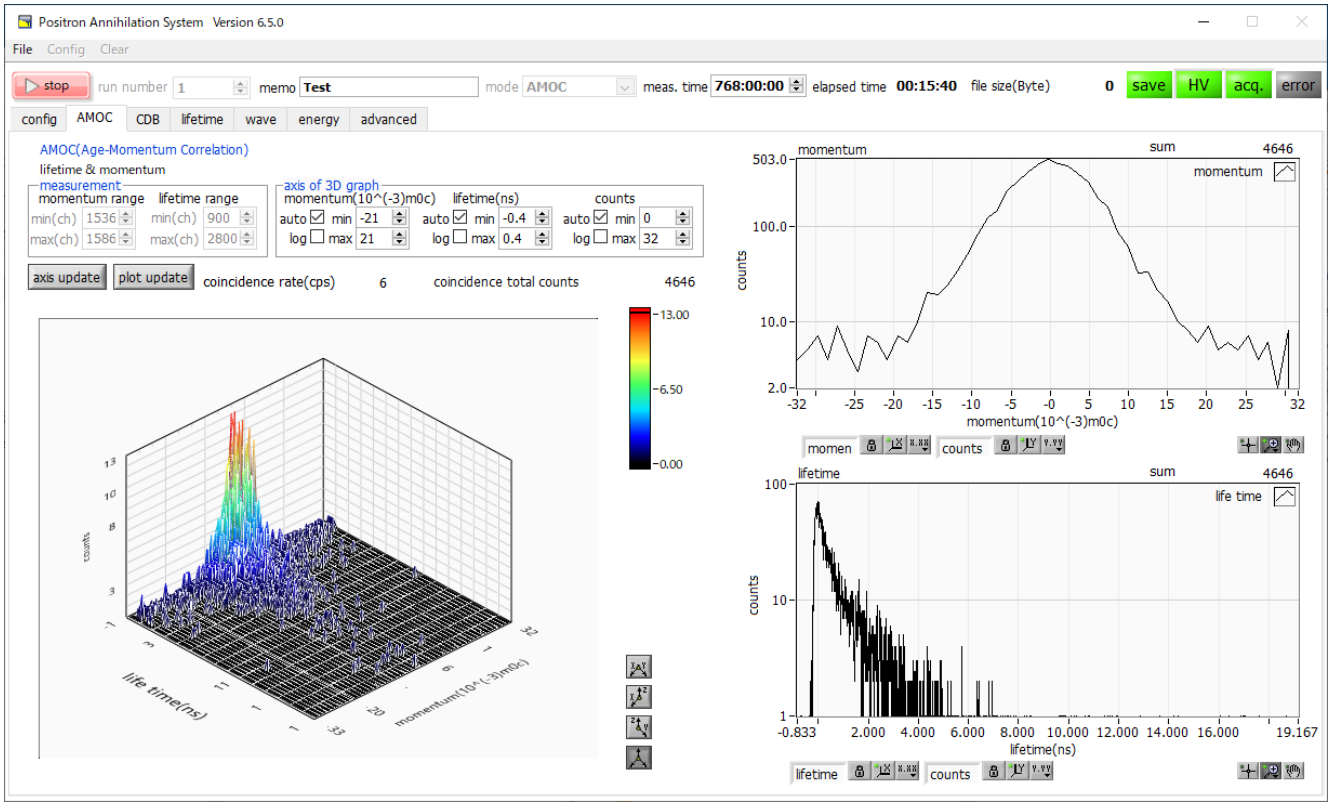


Figure 61: AMOC measurement

- During the measurement, the AMOC measurement graph is displayed in the 3D graph on the left side of the lifetime tab. The horizontal axis is life, the vertical axis is energy, and the height axis is count.

  Note

  If the PC specifications are low, or if the momentum range or lifetime range setting range is wide (especially for the first time), the application may freeze or it may take 10 minutes or more to display the graph.
- The energy spectrum is displayed on the momentum graph on the upper right side, and the lifetime spectrum is displayed on the lifetime graph on the lower right side.
- When “meas. time” is reached, the measurement is completed. To stop measurement, Click the stop button.
- When save data in the config tab is ON, the following files are created in the set folder. For details of the file, refer to "6.5.**AMOC data file**" later.
  999999 is the run number at the time of measurement

6. File

6. 1. Configuration file

This is the configuration file of this application. The file name is RUN999999_config.ini. It is stored together with data at the end of each mode measurement. You can reproduce the setting by reading the file from the menu.

Example:

```
[System]
PCConfigPort = 55001
PCStatusPort = 55000
PCDataPort = 55002
DevConfigPort = 5000
DevStatusPort = 5001
DevDataPort = 5002
SubnetMask = "255.255.255.0"
Gateway = "192.168.10.1"
ChNumber = 2

[3G]
Enable = 1
IP = "192.168.10.129"
CH1 = "0 0 150 6 0 230 0 0 0 0 7 1.666665 3 10 290 372 0 0 0 0 0 0 150 255 0 -1.01 1 0 60 31 0 0 240"
CH2 = "0 0 220 6 0 230 0 0 0 0 7 1.666665 3 10 110 195 0 0 0 0 0 0 220 255 0 -1 1 0 60 31 0 0 240"
Mode = 0
WaveTrigCH = 3
WaveTrigMode = 0
ADCBufSize = 0
ADCReadSize = 1
TrigPoint = 50
CalcFIFOIRQTrig = 200
CalcDiscriMode = 0
TimeOffset = 30000
TimeBin = 3
IntegralScale = 2
IntegralRange = 10
CoinGateTime = 3
PileupRejectFilter = 1
ForRF = 1

[DSP]
Enable = 1
IP = "192.168.10.128"
CH1 = "1 0 3 4 6000 700 0 676 10 30 8100 20 0 0 4 0.5000 1 0 3 60"
CH2 = "1 0 3 4 6000 700 0 676 10 30 8100 20 0 0 4 0.5000 1 0 3 60"
CH3 = "3 0 4 4 6000 700 0 680 30 30 8190 30 0 1 5 0.5000 1 0 0 40"
CH4 = "3 0 4 4 6000 700 0 672 30 30 8190 30 0 1 5 0.5000 1 0 0 40"
CH5 = "3 0 4 4 6000 700 0 680 30 30 8190 30 0 1 5 0.5000 1 0 0 40"
CH6 = "3 0 4 4 6000 700 0 680 30 30 8190 30 0 1 5 0.5000 1 0 0 40"
CH7 = "3 0 4 4 6000 700 0 680 30 30 8190 30 0 1 5 0.5000 1 0 0 40"
CH8 = "3 0 4 4 6000 700 0 680 30 30 8190 30 0 1 5 0.5000 1 0 0 40"
MOD = 0
MMD = 0
MTM = 2764800
CLS = 0
DAC = 0
CCH = 0
CTM = 100
CGT = 8000
CDL = "0 0 0 0"
FRC = 100
LTL = 1000
CMR = 2
CMO = "0 0"
ACT = 1000
ACD = 2800

[HV]
Model = "APV3304"
Enable = 1
IP = "192.168.10.130"
Port = 10001
CH = 4
HV1 = "+5kV 2000 500 8192 8192 8176 8439 8120 8162 0 -24 6000"
HV2 = "+5kV 0 500 8192 8192 8197 8371 8192 8102 0 -24 6000"
HV3 = "-4kV 3000 4000 8232 8192 8240 8253 8156 8080 0 -24 4000"
HV4 = "-4kV 3000 4000 8232 8192 8240 8249 8080 8089 0 -24 4000"

[Config]
RunNumber = 5
Memo = "SUS"
Mode = 3
MeasTime (s) = 2764800
SaveData = 1
SaveFolder = "/C/Data/180510_KUR_Sekiei"
ListSave = 1
ListPath = "/C/Temp/list_.bin"
ListFileNum = 16
ListFileSize (Byte) = 100000000
```

```
AutoSave = 1
IntervalTime (s) = 3600

[AMOC]
MeasRange = "2250 2300 2800 3200"
3DAxis = "0 0 -30 30 0 0 -1 2.2 1 0 1 10"
LifeAxis = "2 0 0 4.487472 2 1 1 100"
MomeAxis = "2 0 -33.885286 9.472864 2 0 -1 1"
LifeMultOffset = "0.010417 0"
MomeMultOffset = "0.867163 -33.885286"

[CDB]
MapAxis = "0 0 1186 1216 0 0 1185 1213 0 0 0 100"
MapCursor = "998.800895 1002.813793"
HoriVertPlotType = 1
HoriGraphAxis = "2 0 0 2047 2 0 -1 1"
VertGraphAxis = "2 0 0 2047 2 0 -1 1"

[LifeTime]
InteROI = "290 372 110 195"
InteGraphAxis = "2 0 0 511 2 1 3 321"
InteGraphEnergy = "0 0"
InteGraphXScale = 0
LifeROI = "0 8191"
LifeGraphAxis = "0 0 -4.96875 30.03125 2 1 1 513"
LifeGraphXScale = 1

[Wave]
Display = "1 1"
Accume = 0
XScale = 0
WaveAxis = "2 0 0 511 0 0 0 255"
XScaleA = 1.000000

[Energy]
Display = "1 1 1 1 1 1 1 1"
ROIch = "1 0 0 0 0 0 0 0"
ROI = "0 8191 0 8191 0 8191 0 8191 0 8191 0 8191 0 8191 0 8191"
Energy = "1 1 1 1 1 1 1 1"
Axis = "2 0 0 8191 2 0 -1 1"
XScale = 0
XScaleCentroid (ch) = "0 0"
XScaleEnergy (keV) = "1 1"
XScaleA = -Inf
XScaleB = NaN
ManualUnit = "MeV"
CalibrationROI = "1 2"
CalculationSmoothing = 1
```

6. 2. energy data file

It is data of energy mode. Energy spectrum data, calculation result between status and ROI, and the like are stored. A comma-separated text format file. The file name is RU999999_spectrum.csv.

Example:

```
[Header]
Measurement mode, Real Time
Measurement time,2764800
Real time,39
Live time,36
Dead time,3
Start Time,15/12/21 17:47:45
End Time,15/12/21 17:48:55
//CH#,ACG,ADG,FIT,FDI,SFR(ns),SFP(ns),FPZ,SPZ,FTH,LLD,ULD,STH,PUR,POL,DCG,DFG,TMS,CFF,CFD,IHW,PZD,FGD,DIF,BRS,BTS
CH1,2,0,3,3,6000,700,0,680,10,30,8100,20,0,0,5,0.632033,1,0,3,60
CH2,2,0,3,3,6000,700,0,680,10,30,8100,20,0,0,5,0.708600,1,0,3,60
CH3,2,1,4,4,6000,700,0,680,30,30,8190,30,0,1,5,0.500000,1,0,0,40
CH4,2,1,4,4,6000,700,0,672,30,30,8190,30,0,1,5,0.500000,1,0,0,40
CH5,2,1,4,4,6000,700,0,680,30,30,8190,30,0,1,5,0.500000,1,0,0,40
CH6,2,1,4,4,6000,700,0,680,30,30,8190,30,0,1,5,0.500000,1,0,0,40
CH7,2,1,4,4,6000,700,0,680,30,30,8190,30,0,1,5,0.500000,1,0,0,40
CH8,2,1,4,4,6000,700,0,680,30,30,8190,30,0,1,5,0.500000,1,0,0,40
MOD,0
MMD,0
MTM,2764800
CLS,0
[Calculation]
//ROI_CH,ROI_start,ROI_end,Energy,peak (ch) ,centroid (ch) ,peak (count) ,gross (count) ,gross (cps) ,net (count) ,net (cps) ,FWHM (ch) ,FWHM (%) ,FWHM,FWTM
CH1,1990,2095,1173,2036,2036.16,2556,34452,883.385,33082.486,848.269,11.291,0.555,6.505,13.56
CH1,5027,5143,1333,5082,5081.96,1163,9194,235.744,9086.362,232.984,7.125,0.14,1.869,3.543
CH0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
CH0,4614,5344,511,0,0,0,0,0,0,0,0,0,0,0
CH0,5958,6032,1274,0,0,0,0,0,0,0,0,0,0,0
CH0,0,8191,1,0,0,0,0,0,0,0,0,0,0,0
CH0,0,8191,1,0,0,0,0,0,0,0,0,0,0,0
CH0,0,8191,1,0,0,0,0,0,0,0,0,0,0,0
[Status]
//CH, input total count,throughput count,input total rate (cps) ,throughput rate (cps) ,pileup rate (cps) ,dead time ratio (%)
CH1,241307,224267,6153,5739,0,8.2
CH2,0,0,0,0,0,0
CH3,0,0,0,0,0,0
CH4,0,0,0,0,0,0
CH5,0,0,0,0,0,0
CH6,0,0,0,0,0,0
CH7,0,0,0,0,0,0
CH8,0,0,0,0,0,0
[Data]
ch,CH1,CH2
0,0,0
1,0,0
2,0,0
3,0,0
4,0,0
5,0,0
6,0,0
7,0,0
8,0,0
9,0,0
10,0,0
11,0,0
12,0,0
13,0,0
14,0,0
15,0,0
16,0,0
17,0,0
18,0,0
19,0,0
20,0,0
21,0,0
22,0,0
23,0,0
24,0,0
25,0,0
26,0,0
27,0,0
28,0,0
29,0,0
30,0,0
31,55,0
32,67,0
33,60,0
34,74,0
35,56,0
 :
* For 8192ch
```

6. 3. lifetime data file

Data in lifetime mode. The following files with different formats are saved at the same time.

(1) Lifetime spectrum (file name is RUN999999 _ LT_diff.dat)

Lifetime spectrum (file name is RUN999999_LT_diff_rev.dat)

prn (space delimited text) format. Read data using PALSfit3 (http://palsfit.dk/) developed at DTU (Technical University of Denmark) in Denmark. The first line is saved in Time / bin (ns), 10 digits left-justified space format from the second line. The one with _rev appended to the file name has a form in which the sequence of spectrum is inverted (reverse).

Example:

```
0.010417
        20
        29
        26
        19
        25
        13
        20
        26
        24
        28
        25
        28
        28
        24
        27
        28
        32
        17
        19
        19
        21
        32
        19
        23
        22
        29
        17
        17
        31
        22
        18
        21
        16
        20
        22
        22
        19
        15
        24
        26
        23
        15
        17
        22
        15
        27
        18
        32
        17
        28
        19
        18
        17
        17
        15
        27
        21
        15
        25
        27
        20
        28
        21
        15
 :
* For 8192ch
```

(2) Lifetime spectrum (file name is RUN999999_LT_diff.csv)

csv (comma delimited text) format.

Example:

```
[Header]
meas.start,2018/05/11,10: 19:30
meas.end,2018/05/11,18: 20:32
meas.time (s), 2764800
elapsed time (s), 28862
EnergyROICH1 (ch), 290,372
EnergyROICH2 (ch), 110,195
LifetimeROI (ch) ,0,8191
input (cps) ,7851,43067
coincidence (cps), 338,338
centroid (cps), 317.92,146.28
throughput (cps), 88
gross count,2740070
a,0.010417
b,-30.125000
TimePerCh(ns),0.010417
[Data]
20
29
26
19
25
13
20
26
24
28
25
28
28
22
22
19
15
24
26
23
15
17
22
15
27
18
32
17
28
19
18
17
17
15
27
21
15
25
27
20
28
21
15
15
24
25
17
26
31
27
24
32
19
31
22
22
18
13
12
12
14
22
16
16
13
18
15
10
15 :
* For 8192ch
```

(3) Energy spectrum (file name is RUN999999_LT_integral.csv)

csv (comma separated text) format.

The _integral file is saved when the [Lifetime] section SaveIntegral = 1 in config.ini.

Example:

```
[Header]
ROIstart(ch),310,133
ROIend(ch),380,199
energy(keV),0,0
input(cps),6634,26725
throughput(cps),272,272
centroid(ch),333.37,163.46
gross count,4019800,4019800
net count,1754576.285714,2232106
FWHM(keV),0,0
FWTM(keV),0,0
a,1.000000
b,0.000000
[Data]
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,0
0,36629
0,37595
0,39427
0,41190
0,42655
0,44559
* For 512ch
```

6. 4. CDB data file

Tab-delimited text format. Mainly the ch coordinate data of CH1 and CH2 and the count number of that position are saved in order of ch (bin) of CH1, ch (bin) of CH2, and the count number. The maximum number of rows is 4M (2048 * 2048).

Example:

[Header]
CH1Range=2048
CH2Range=2048
CH1Offset=0
CH2Offset=0
meas.start,2018/09/26,08:34:16
meas.end,2018/09/26,08:34:31
meas.time(s),2764800
elapsed time(s),14
total counts,14300
[Data]

# CH1 (ch)	CH2 (ch)	Counts
912	933	1
912	948	1
912	1012	1
912	1018	1
912	1033	1
912	1035	1
912	1036	3
912	1037	7
912	1038	14
912	1039	14
912	1040	16
912	1041	20
912	1042	14
912	1043	8
912	1044	2
912	1045	2
912	1046	2
912	1080	1
912	1088	1
912	1089	1
912	1129	1
913	918	1
913	935	1
913	984	1
913	1030	1
913	1035	3
913	1036	1
913	1037	11
913	1038	13
913	1039	17
913	1040	21
913	1041	11
913	1042	10
913	1043	16
913	1044	4
913	1045	1
913	1144	1
914	923	1
914	925	1
914	982	1
914	991	1
914	994	1
914	1002	1
914	1021	1
914	1023	1
914	1031	1
914	1032	2
914	1034	1
914	1036	4
914	1037	7
914	1038	9
914	1039	19
914	1040	22
914	1041	14
914	1042	16
914	1043	10
914	1044	4
914	1049	1
914	1109	1
914	1145	1
915	913	1
915	956	1
915	973	1
915	991	1
915	995	1
915	1018	1
915	1032	1
915	1034	1
915	1035	2

* Variable-length record

6. 5. AMOC data file

It is data in AMOC mode. The following files with different formats are saved at the same time.

(1) AMOC data (file name is RUN999999_AMOC_3D.csv)

A comma-separated text format. The ch data of momentum and lifetime and the count number of its position are mainly stored in order of momentum (bin), lifetime (bin), count number. The storage size is variable length of momentum range (ch) × lifetime range (ch).

Example:

```
[Header]
meas.start,2018/09/26,08:34:16
meas.end,2018/09/27,08:34:31
meas.time(s),2764800
elapsed time(s),86414
total counts,1430120
Momentum start,-45.002651,1990
Momentum end,58.045506,2095
Life time start,-0.802083,2800
Life time end,2.322905,3100
[Data]
# Momentum (ch) ,Life time (ch) ,Counts
1990,2868,1
1990,2869,1
1990,2870,1
1990,2875,1
1990,2879,1
1990,2880,1
1990,2882,2
1990,2884,1
1990,2887,2
1990,2895,1
1990,2918,1
1991,2865,1
1991,2869,1
1991,2872,1
1991,2874,1
1991,2876,1
1991,2878,1
1991,2880,1
1991,2881,3
1991,2882,1
1991,2884,1
1991,2887,1
1991,2894,1
1991,2895,1
1991,2898,1
1991,2909,1
1991,2914,1
1992,2864,1
1992,2867,2
1992,2871,3
1992,2873,1
1992,2876,1
1992,2877,1
1992,2880,1
1992,2882,1
1992,2889,2
1992,2929,1
1992,2946,1
1992,3080,1
1993,2867,1
1993,2872,1
1993,2873,1
1993,2879,1
1993,2880,1
1993,2882,1
1993,2883,1
1993,2885,1
1993,2886,1
1993,2891,1
1993,2893,1
1993,2902,1
1993,2903,1
1993,2924,1
1993,2955,1
1993,2962,1
1994,2866,1
1994,2868,1
1994,2869,2
1994,2876,1
1994,2877,1
1994,2884,1
1994,2890,1
1994,2898,1
:
* For range specification
```

(2) AMOC Lifetime spectrum (file name is RUN999999_AMOC_LT.csv)

csv (comma delimited text) format. Lifetime spectral data in the AMOC tab.

```
[Header]
a,0.010417
b,-0.802083
[Data]
0
1
0
0
0
2
1
0
1
3
1
0
2
1
1
1
1
1
0
0
1
1
2
1
2
0
0
0
0
1
0
0
2
1
1
1
0
1
3
2
1
3
1
2
1
2
5
2
3
4
4
5
14
17
29
33
61
102
130
180
256
338
499
603
769
1038
1196
1465
1724
2065
2285
2508
2715
2913
3127
3292
3297
 :
* For 8192ch
```

(3) AMOC Energy spectrum (file name is RUN999999_AMOC_mo.csv)

csv (comma delimited text) format. Momentum spectral data in the AMOC tab.

```
[Header]
a,0.981411
b,-45.002652
[Data]
14
18
17
16
15
25
15
25
15
15
13
23
30
17
18
17
21
17
27
21
13
29
21
26
28
42
44
47
56
65
88
83
119
164
220
292
345
456
611
789
992
1221
1478
1615
1910
2006
2026
2012
1955
1788
1520
1269
1006
802
591
459
358
281
220
158
115
102
70
60
36
28
33
25
18
19
16
8
7
9
14
10
9
5
10
9
 :
* For 8192ch
```

(4) AMOC List data (file name is RUN999999_list.bin)

Big-endian format binary data. Momentum spectral data in the AMOC tab.

160 bits per event (20 bytes, 10 WORD)

Bit: 15 Bit: 0

APV8002 ABS[47...32]			
APV8002 ABS[31...16]			
APV8002 ABS[15...4]			APV8002 ABS fixation decimal [3...0]
Space [2...0]	APV8002 PHA (momentum) [12...0]		
Space [8...0]		UNIT[3...0]	CH[2...0]
lifetime CH1 integral[15...0]			
lifetime CH2 integral[15...0]			
lifetime MSB[31...16]			
lifetime LSB[15...0]			
dummy data 0xABCD			

6. 6. wave data file

csv (comma delimited text) format. 512 waveform data of 16 times of CH1 and CH2 are saved.

Example:

ch,CH1 (digit) ,CH2 (digit) ,CH1-1,CH1-2,CH1-3,CH1-4,CH1-5,CH1-6,CH1-7,CH1-8,CH1-9,CH1-10,CH1-11,CH1-12,CH1-13,CH1-14,CH1-15,CH1-16,CH2-1,CH2-2,CH2-3,CH2-4,CH2-5,CH2-6,CH2-7,CH2-8,CH2-9,CH2-10,CH2-11,CH2-12,CH2-13,CH2-14,CH2-15,CH2-16
0,239,240,239,239,239,240,239,239,239,239,239,239,238,239,239,239,239,239,240,241,240,241,240,240,240,240,240,240,240,240,240,240,241,240,240
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44,239,240,239,239,238,238,239,240,239,239,239,238,238,239,239,238,239,239,238,240,42,240,232,241,240,241,239,235,204,240,241,239,233,238,240
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46,239,240,239,236,238,236,236,238,237,238,236,236,233,238,238,235,236,239,240,86,240,205,239,240,240,229,220,179,238,239,221,213,226,240
47,239,240,239,231,238,232,234,237,234,235,229,233,227,236,235,227,232,238,240,105,239,183,239,240,237,217,208,180,233,238,198,199,216,240
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49,227,239,227,214,224,215,224,220,206,214,201,221,207,221,224,199,214,227,239,149,232,164,240,237,223,195,193,190,217,225,116,190,200,235
50,218,240,218,204,209,209,216,198,173,197,184,218,203,209,216,187,205,210,240,164,226,169,239,233,208,194,195,194,211,213,84,195,201,229
51,206,239,206,198,185,208,209,172,135,182,173,218,201,197,212,180,200,184,239,173,216,176,239,227,189,196,199,199,209,201,74,201,204,214
52,195,236,195,195,160,209,206,146,100,174,168,218,199,188,209,177,199,153,236,183,209,180,240,218,178,201,203,204,212,193,88,204,205,190
53,189,229,189,195,140,211,203,127,79,174,171,219,201,183,210,181,200,127,229,192,206,184,240,210,178,205,210,209,216,191,109,209,207,161
54,188,220,188,197,133,212,203,119,74,178,178,220,203,183,212,185,203,113,220,200,207,191,241,207,186,209,214,212,221,195,125,214,209,138
55,186,202,186,199,136,213,205,121,83,182,186,224,207,185,216,191,207,111,202,208,210,198,239,209,196,214,217,215,222,197,138,218,211,127
56,186,182,186,201,148,216,208,130,101,187,193,224,210,187,217,197,211,118,182,212,211,205,240,214,204,220,218,218,223,201,151,220,214,127
57,192,168,192,206,160,218,212,142,119,193,201,226,215,191,220,204,215,127,168,215,212,211,240,217,207,223,219,222,224,204,165,223,217,134
58,200,168,200,210,171,219,217,154,135,199,207,229,219,196,221,209,220,137,168,219,215,214,241,217,209,223,221,225,225,208,176,224,221,147
59,204,176,204,215,180,223,220,168,147,206,212,232,222,201,223,213,223,151,176,223,217,218,239,218,212,223,223,227,227,212,181,227,222,162
60,207,185,207,218,186,225,223,180,158,210,215,232,223,206,224,216,225,164,185,224,220,220,240,220,216,224,226,229,229,216,185,227,225,179
61,210,191,210,223,192,228,225,187,169,213,217,232,225,210,226,220,228,177,191,225,221,220,240,222,220,226,228,231,230,217,190,228,228,190
62,213,195,213,224,196,229,227,193,178,215,220,233,227,213,228,223,230,184,195,227,224,223,240,224,223,228,230,233,230,219,197,231,230,197
63,218,198,218,227,201,231,228,200,188,218,223,235,230,216,230,225,231,191,198,228,225,226,239,226,224,232,231,232,230,220,205,234,231,203
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65,224,209,224,229,206,234,233,206,200,224,228,235,232,220,234,228,232,206,209,228,226,230,240,229,229,235,233,233,232,225,214,235,235,212
66,227,214,227,230,210,234,232,209,207,226,230,236,234,223,235,230,232,211,214,227,227,230,240,230,231,235,234,234,236,228,217,235,235,214
67,229,218,229,232,213,235,233,213,212,229,231,238,236,225,235,231,233,215,218,229,228,231,239,232,232,236,235,237,236,230,220,235,234,217
68,230,222,230,232,215,235,234,217,216,229,231,235,235,225,235,231,234,218,222,229,230,232,239,234,233,239,236,237,237,231,220,235,234,220
69,233,224,233,233,218,235,235,222,219,230,233,237,236,228,237,233,235,221,224,230,232,233,240,235,234,238,236,237,237,233,222,236,235,223
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80,234,239,234,236,230,238,239,231,227,236,233,236,234,236,237,235,238,231,239,224,238,233,240,239,237,238,237,233,239,237,232,238,238,235
:
For 512 points

7. Troubleshooting

7. 1. Communication error

（1） "connection error" occurs

At startup or when an error occurs in the menu "config", there is a possibility that the network is not connected properly.

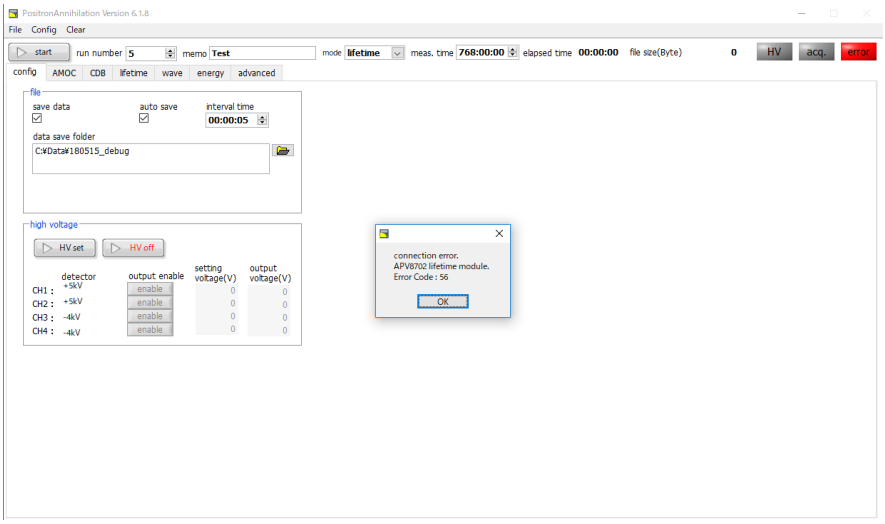

Figure 62: Device connection error at startup

Check the following points.

① Use a switching hub.

② Each port number in the [System] section in config.ini of the configuration file before startup is defined as shown below, and "IP" of each device is correctly described. For example, "192.168.10.128" for DSP. Also start this application and confirm that the display of "IP Address" of the DSP in the advanced tab is the same.

```
[System]
PCConfigPort = 55000
PCStatusPort = 55001
PCDataPort = 55002
DevConfigPort = 5000
DevStatusPort = 5001
DevDataPort = 5002
SubnetMask = "255.255.255.0"
Gateway = "192.168.10.1"
ChNumber = 2
```

③ Confirm whether it is the setting that the network information of the PC can connect to DSP.
The default values of the DSP are as follows.

IP address	192.168.10.128 (APV8002) 192.168.10.129 (APV8702) 192.168.10.130 (APV3304)
Subnet mask	255.255.255.0
Gateway (default)	192.168.10.1

Turn on the power supply while the Ethernet cable is connected.
Execute the ping command at the command prompt and check the connection between each module and the PC.
Turn on the power of each module again and execute the ping command again.

④ Turn off virus detection software and fire fall software.

⑤ Set the power saving function of the PC to "always ON". Sweep function etc are all turned OFF.

⑥ In the case of notebook PC etc., disable the wireless LAN function.

⑦ Set not to automatically operate Windows update or restart and make the Internet unconnected.

7. 2. AMOC 3D graph malfunction

(1) If there is a problem with the display of the 3D graph in the AMOC tab

disable the device by right clicking the icon of the device driver being used by the display adapter of the device manager.

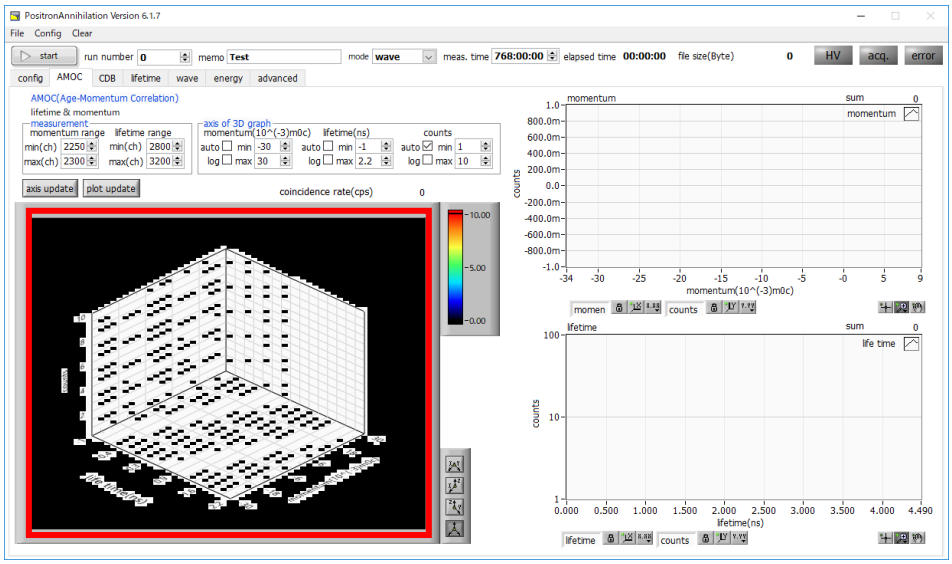

Figure 62: 3D graph display error in AMOC tab

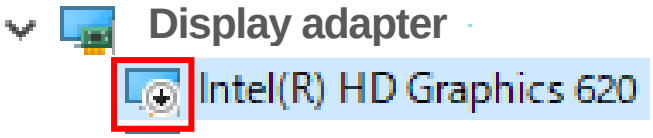

Figure 64: Device Invalid State for Device Manager / Display Adapter

(2) Data is not displayed on the 3D graph

If the PC specifications are low, or if the momentum range or lifetime range setting range is wide (especially for the first time), the application may freeze or it may take 10 minutes or more to display the graph.

7．3．　Method of operation. How to set time resolution and energy resolution

If the basic performance is not in lifetime mode or energy mode, please refer to the video explaining the adjustment method below.

https://www.youtube.com/channel/UCAgOkt_V_I7OzELMfiR2WBw

Figure 65: Video explaining how to adjust the device on YouTube

7．4．　Connector conversion adapter

(1) BaF_2 detector side BNC - SMA conversion adapter

“33_BNC-SMA-50-1/1--_U” made by HUBER+SUHNER company

BNC plug (male) - SMA Jack (female)

(2) DSP module side BNC - LEMO conversion adapter

“33_QLA-BNC-01-1/1--_N” made by HUBER+SUHNER company

QLA-01 (LEMO) plug (male) - BNC Jack (female)

8. Warranty policy

The warranty conditions of "our product" are as follows.

Warranty period	One year from date of purchase.
Guarantee contents	Repair or replacement will be carried out in case of breakdown even though you have used correctly according to this instruction manual within the warranty period
Out of warranty	We do not warranty if the cause of the failure falls under any of the following. (1) Failure or damage due to misuse or improper repair or modification or disassembly. (2) Failure and damage due to falling etc. (3) Breakdown / damage in harsh environments (high temperature / high humidity, under zero, condensation etc.). (4) Causes other than the above, other than "our products". (5) Consumables. (6) Natural disasters such as fire, earthquake, flood damage, lightning, etc. and breakdown due to theft. (7) When the cause of the malfunction is found to be wet

After you start using our products, we assume that you have agreed to all the above items.

CONTACT INFORMATION

TechnoAP Co., Ltd.	
ADD	2976-15 Mawatari, Hitachinaka-shi, Ibaraki, 312-0012, Japan
TEL	+81-29-350-8011
FAX	+81-29-352-9013
WEB	http://www.techno-ap.com
Email	order@techno-ap.com

[Business Hour]: Monday to Friday, 9:30 to 17:00 (Japan Time)

Distributor or Agent