Digital Signal Processor

APV8016A
(APV8008A)

Instruction Manual

Safety Precautions / Disclaimer

Thank you very much for purchasing the APV8016A (hereinafter "This board") 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 a power supply that exceeds the rating.
- Do not turn the power on while other metals are in contact with the board surface.

⚠ Note

- If there is smoking or abnormal heat generation in this device, turn off the power immediately.
- This board may not work properly in noisy environments.
- Be careful with static electricity.
- The specifications of this board and the contents of the related documents are subject to change without notice.

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.

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1．Overview

1．1．Overview

TechnoAP's DSP (Digital Signal Processor) products are multi-channel analyzers (MCA) with real-time digital signal processing capability.

In conventional radiation measurement, signals from a preamplifier are passed to a spectroscopy amplifier, amplified and waveform shaped by analog circuits, and then analyzed for spectra according to a measurement device such as an MCA.

In the case of DSP, the signal from the preamplifier is directly converted to digital using an extremely fast 100 MHz, 14 Bit A/D converter. The digitally converted data is sent to a highly integrated FPGA (Field Programmable Gate Array) for spectral analysis using numerical operations. The preamplifier signal is trapezoidally filtered (Trapezoidal Filter) in real-time by the pipelined architecture of the FPGA.

The DSP configuration integrates a spectroscopic peer amplifier and an MCA to perform pulse shaping using the latest digital signal processing techniques instead of traditional analog methods.
In addition to the trapezoidal filter, the DSP has a timing filter amplifier, CFD, and waveform digitizer.

It provides excellent energy and time resolution and is extremely stable even at high counting rates. It also offers throughput (>100Kcps) higher than gate integrator amplifiers, which boast the highest throughput of any analog system.

Multi-channel DSPs with up to 16 channels are available with all ADCs operating synchronously and can also be synchronized between modules. It can be applied to multi-channel systems, coincidence and anti-coincidence systems, and energy and time correlation analysis.

This manual describes this equipment.

* The board of this device may be revised, and there may be additional changes in functions such as the presence or absence of jumpers on the board and the presence or absence of GND terminals. The revision number (e.g., APV8016A5) may be indicated on the board silk.
* In the text, "CH" is case-sensitive for signal input channels and "ch" for bin number channels. List" and "event" are synonymous.
* The APV in the model's name indicates the VME standard size board type. A separate VME power supply rack (such as our APV9007) is required to supply power to this board type. In addition, the type of model in which this board is housed in a unit (chassis) and AC power supply can be used directly is marked with APU instead of APV. For example, the model in which the VME-type APV8016A is installed in a unit is called

APU8016A. This manual also includes a description of the APU8016A.

* The 8CH version is APV8008A, and the functions are described as the same except for the number of CHs.

* The functions can be added to this device as an option. In this document, the function part is specified as (optional).

1．2．Features

The main features are as follows.

- Digital signal processing for gamma-ray/X-ray spectroscopy
- Suitable for multi-channel, multi-functional systems such as HPGe semiconductor detectors, multi-element semiconductor detectors, and anticompton spectrometers
- Spectral analysis of scintillation (NaI(Tl), LaBr3(Ce)) detectors
- Digital Pulse Shaping using highly integrated FPGA
- Data recording via Ethernet (TCP/IP)
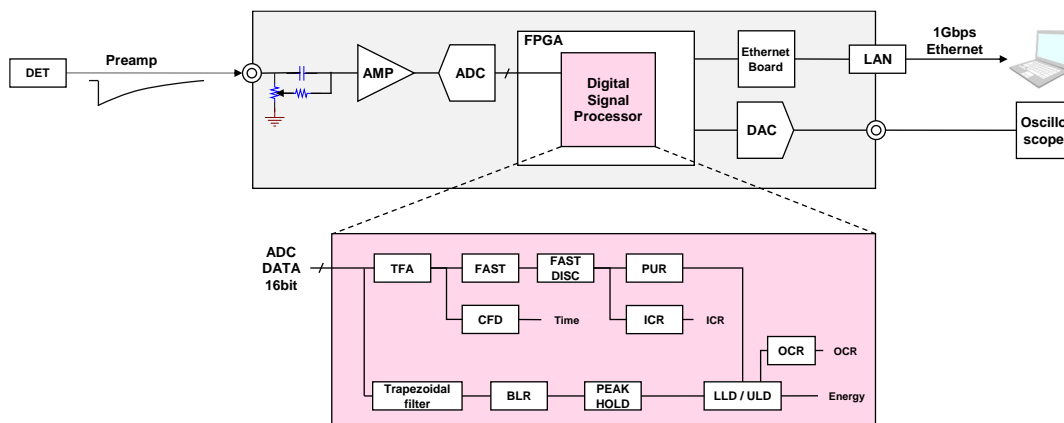
Figure 1　DSP configurations

The output signal from the detector's preamplifier is directly input to the board and digitized by a high-speed ADC (100MSPS) in the DSP. The A/D converter, which is the heart of the digital pulse processing, uses the latest 100 MHz, 16 Bit high-speed, high-resolution pipeline type ADC to directly digitize the signal from the preamplifier.

Trapezoidal waveform processing is performed by hardware operation in FPGA. The shaping time required for trapezoidal waveform shaping is set by parameters from a PC, and both FAST and SLOW systems digitally detect peak values using peaking time (peakingtime = rise time + flat top time).

The FAST and SLOW systems are processed by two different filter blocks.
The FAST system acquires timing and performs pile-up rejection (Pile up Reject).
The SLOW system performs Pole zero Cancel and Baseline Restorer processing followed by energy analysis.

Preamplifier signals and trapezoidal waveform processing signals imported into FPGA are output via DAC (Digital Analog Converter), and operation can be checked on a digital oscilloscope.

Settings and data acquisition for the DSP are performed by the supplied DSP application (hereinafter referred to as "this application"). This application runs on Windows. The DSP

communicates only via TCP/IP or UDP network communication, so no special libraries are required, and the DSP can be used in non-Windows environments as well.

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2. Specifications

（1） Analog Input
- Number of channel　　　　16
- Input range　　　　　　±12 V　　　* ±12 V with input protection circuit
- Input impedence　　　　1 kΩ
- Coarse gain　　　　　　×1、×2、×5、×10
- Frequency band　　　　DC to 25MHz
- First-stage differencial circuit 6.8 μs fix　　　* Can be changed upon request
- Attenuator　　　　　　None or 1/10　　　* Depends on jumper setting on board

（2） ADC
- Sampling frequency　　　100 MHz
- Resolution　　　　　　16 Bit
- Input range　　　　　　±2 V
- Base line noise　　　　0.104 mV (1.7 LSB Rms)
- Energy Resolution　　　1.70 keV@1.33 MeV (typ.)
- Spectral broadenning　　12 % or less (1 kcps to 100 kcps)
- Throughput　　　　　　200 kcps and more
- Integral non-linearity　　±0.025 % (typ.)
- Peak shift　　　　　　THD
- Drift characteristics　　THD
- Pulse pair resolution　　1.25 × (Risetime + Flat top Time)　　　* Guideline

（3） MCA
- ADC gain　　　　　　16384, 8192, 4096, 2048, 1024, 512, 256 channel
- Operation mode　　　　Histogram, List and Wave
- Event transfer rate　　Approx. 20 Mbyte per sec.　　* 16 Byte (128 Bit) per event

（4） Option
- list-pileup-wave　　　　Pileup waveform data is added to the list data when a pileup is detected.
- list-wave　　　　　　Adds waveform data of selected CH to list data

（５） Digital pulse shaping
- FAST Differential time constant   ext, 20, 50, 100, 200 ns
- FAST Integral time consant   ext, 20, 50, 100, 200 ns
- SLOW Rise time   0.05 µs to 8 µs
- SLOW Flat top time   0.01 µs to 2 µs
- Digital course gain   ×1, ×2, ×4, ×8, ×16, ×32, ×64, ×128
- Digital Fine gain   ×0.333 to ×.0
- Trigger timing   LET (Leading Edge Timing), CFD (Constant Fraction Disicriminator Timing)
- Digital CFD   39.0625 ps time resolution
- Digital Pole zero cancel, Digital Baseline Restorer, Digital Pile up Reject
- LLD (Low Level Discriminator)
- ULD (Upper Level Discriminator)

（６） Communication Interface
- LAN   TCP/IP   Gigabit Ethernet, 1000 Base-T, for data transfer
          UDP   For command transparency

（７） Current consumption
    * For the APV8016A, values for other boards are less than this.
  +5 V   4.0 A (max.)
  +12 V   2.0 A (max.)
  -12 V   0.4 A (max.)

（８） Form
- VME type (VME6U)   APV8016A
- Unit type   APU8016A

（９） Outer diameter dimensions
- VME type (VME6U)   20 (W) x 262 (H) x 187 (D) mm
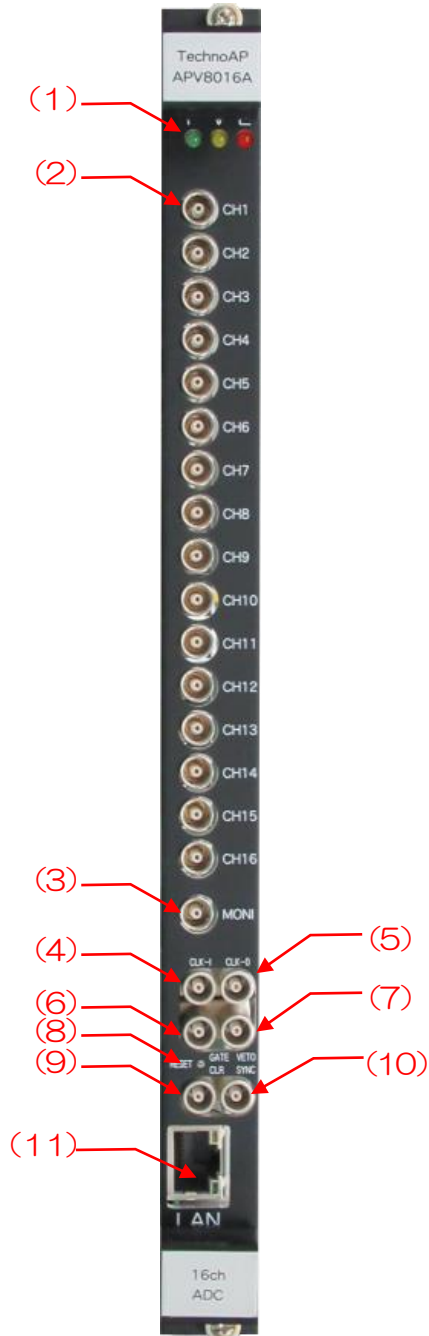- Unit type   300 (W) x 56 (H) x 335 (D) mm

（１０） Weight
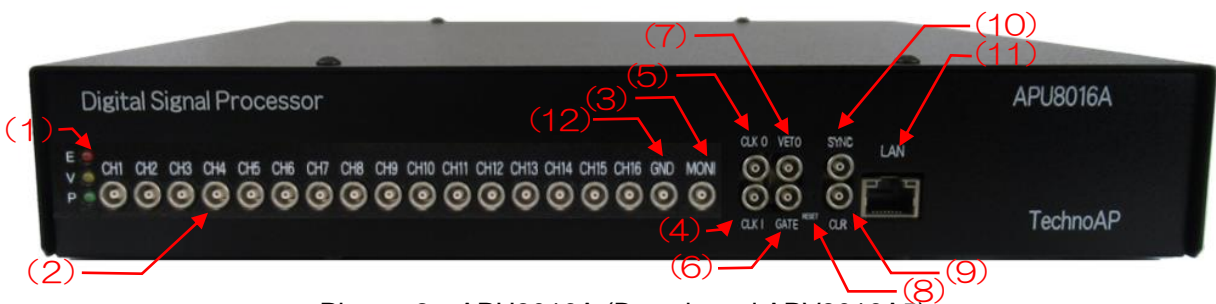- VME type (VME6U)   Approx. 400g
- Unit type   Approx. 3100g

（１１） Reqauired specifications of computer
- OS   Windows 7 or later, 32 bit or 64 bit later
- Network Interface
- Screen resolution   Full HD (1920 × 1080) and more recommended

3．Appearance

Picture 1　APV8016A (Base board APV8016A4)

Picture 2　APU8016A (Base board APV8016A5)

（１）	LED	P (green) lights up when power is turned ON, V (orange) and E (red) are not used.
（２）	CH1 to CH16	LEMO 00.250 compatible connector for signal input. Input range ±1V, course gain selectable from x1, x4, x10, x20 from application, input impedance 1kΩ.
（３）	MONI	LEMO 00.250 compatible connector for monitor output. DAC outputs signals, etc. during DSP processing of the selected 1CH.
（４）	CLK-I	LEMO 00.250 compatible connector for external clock signal input. An external clock can be used to synchronize with external devices. (When using, input a 25MHz, Duty cycle 50% LVTTL or TTL signal before turning on the power.
（５）	CLK-O	LEMO 00.250 compatible connector for external clock signal output. Outputs 25MHz LVTTL signal with 50% duty cycle.
（６）	GATE	LEMO 00.250 compatible connector for external GATE signal input; accepts LVTTL or TTL signals. Enables data acquisition while input is High.
（７）	VETO	LEMO 00.250 compatible connector for external VETO signal input; accepts LVTTL or TTL signals; disables data acquisition while high.
（８）	RESET	Reset button; press and hold for at least 3 seconds to reset the device.
（９）	CLR	LEMO 00.250 compatible connector for external clear signal input; LVTTL or TTL logic signal input; clears counter data, which is time information at the time of event detection, at the rising edge of High.
（１０）	SYNC	LEMO 00.250 compatible connector for time correction input, LVTTL or TTL signal input. Used to clear time information with other boards at the start of measurement.
（１１）	LAN	RJ45 connector for Ethernet cable. 1000Base-T.
（１２）	GND	LEMO 00.250 compatible connector for GND.

3．1．On-board setting

Refer to the silk frames in the picture below on the board of this device and make settings for each CH input.

3．1．1．In case of the Base board APV8016A5

（1）**Blue frame**: **First-stage differential circuit jumper**

With jumper is valid　　For resistive feedback preamplifier (default)

No jumper is invalid　　For transistor-reset preamplifier.

In the picture below, **JP1** in the upper blue frame has no jumper because only one side is inserted, while **JP3** in the lower blue frame has a jumper because both sides are inserted.

← Without jumper (with only one side plugged in)
For transistor-reset preamplifier

← With jumpers
For resistive feedback preamplifier
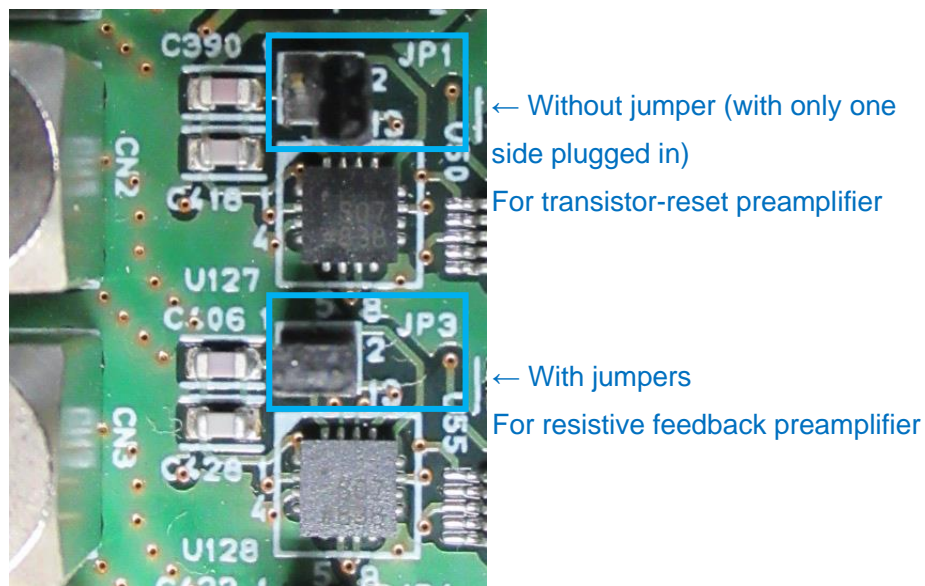
Picture 3　　APV8016A5 board CH1 and CH2 input section

Example of resistive feedback type pream
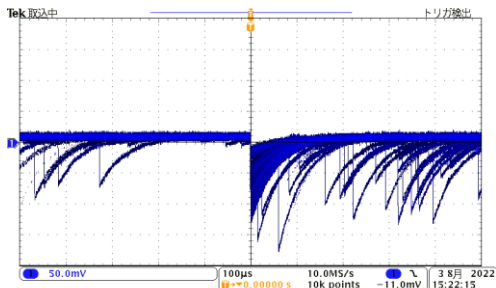
Example of transistor-reset preamplifier output

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（2）**Orange frame**: **Clock setting**

To operate using an external clock, set jumpers (jumpers No. 2 and No. 3, and No. 4 and No. 5) as shown on the left side of the picture below, and input a 25MHz, 50% duty cycle LVTTL or TTL clock signal to the CLK-I connector on the front panel, and turn the power supply ON.

To operate with an internal clock, set jumpers (jumpers No. 1 and No. 2, and No. 5 and No. 6) as shown on the right side of the photo below, and turn the power supply ON.
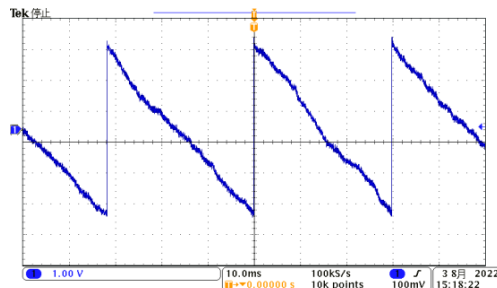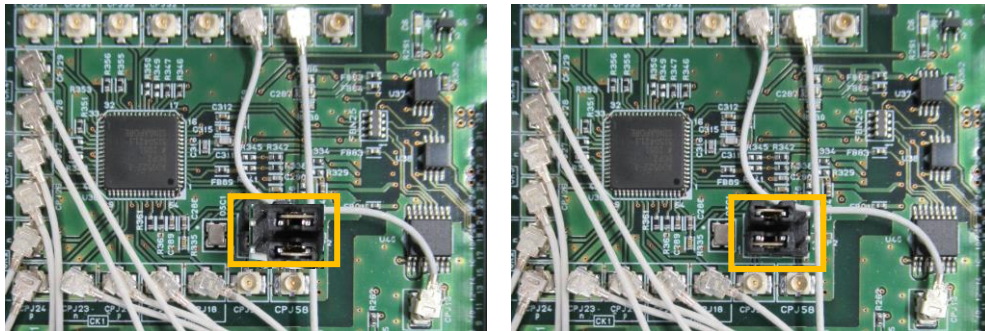

Picture 4 　Clock settings. LEFT: external clock, RIGHT: internal clock

3．1．2．　In case of the Base board APV8016A4

（1）　**Yellow frame**: **Jumper for attenuator**. The upper silk in the picture above is not x0.1 but x1.
　　　　　With upper jumper & without lower jumper: **No attenuator (default)**
　　　　　Without upper jumper & with lower jumper: **1/10 attenuator**

（2）　**Blue frame**: **First-stage differential circuit jumper**
　　　　　No DC jumper: First-stage differential circuit (6.8 µs) enabled (default)。
　　　　　With DC jumper: First-stage differential circuit disabled.

（3）　**Green frame**: Analog pole zero circuit jumper.
　　　　　With RF jumper & without TR jumper: Analog pole zero circuit enabled, for
　　　　　　　　　　　　　　　　　　　　　resistive feedback preamplifier output signal
　　　　　　　　　　　　　　　　　　　　　input (default).
　　　　　Without RF jumper & with TR jumper: analog pole zero circuit disabled, for
　　　　　　　　　　　　　　　　　　　　　transistor reset preamplifier output signal
　　　　　　　　　　　　　　　　　　　　　input.
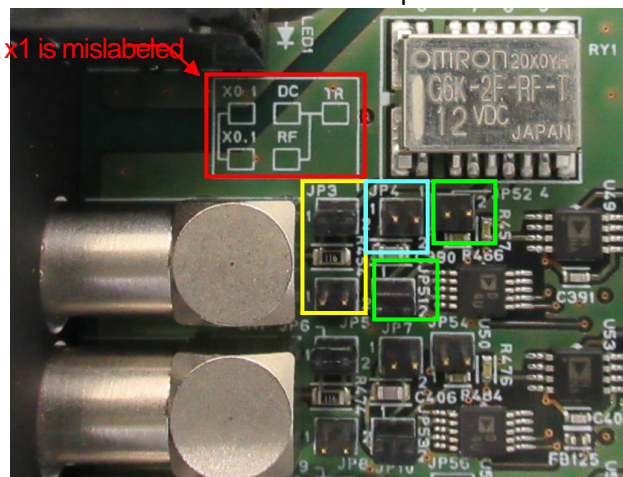
Picture 5 　APV8016A4 base board 　CH1 input section

　　　　　　　　　　　　　　　　　　　　TechnoAP Co., Ltd.

without attenuator, with first-stage differential circuit enabled and analog pole zero circuit enabled.

（4） **Orange frame**: **Clock setting**

To operate using an external clock, set the jumpers as shown on the left side of the photo below, input a 25MHz, 50% duty LVTTL or TTL clock signal to the CLK-I terminal on the front panel, and turn the power supply ON.
To operate with an internal clock, set jumpers (jumpers No. 1 and No. 2, and No. 5 and No. 6) as shown on the right side of the photo below, and turn the power supply ON.
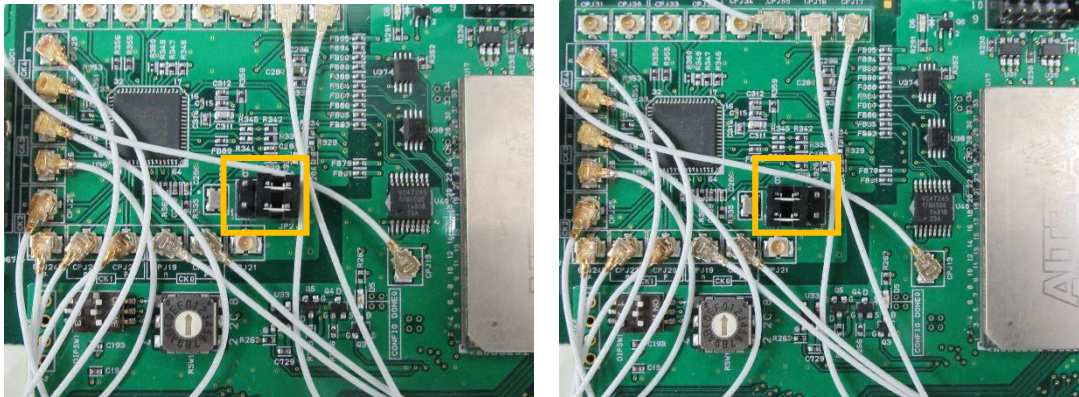
Picture 6　Clock settings, LEFT: external clock setting, RIGHT: internal clock setting.

4． Application installation and network configuration

4．1． Application Installation

This application runs on Windows. When using this application, it is necessary to install the EXE (executable format) file of this application and the LabVIEW runtime engine from National Instruments on the PC to be used.

Installation of this application is performed by the installer included on the accompanying CD. The installer includes the EXE (executable format) file and the LabVIEW runtime engine, which can be installed at the same time. The installation procedure is as follows.

（1） Log in to Windows with administrative privileges.
（2） Run Setup.exe in the Installer folder on the included CD-ROM. Proceed with the installation in an interactive manner. The default installation destination is "C:¥TechnoAP". In this folder, the application's executable file APP8016A.exe and the configuration file config.ini containing the settings will be installed.
（3） Click Start button, TechnoAP, APP8016A in order and run.

To uninstall, go to Add or Remove Programs and select APP8016A to remove it.

4．2． Connection

Connect this device and PC with an Ethernet cable; use a crossover cable depending on the PC. When using a hub, use a switching hub.

4．3． Network setup

Check the communication status of this device and this application by the following procedure.

（1） Turn on the PC and change the network information of the PC.

IP address　　　　　　　192.168.10.2　* Addresses not assigned to this device.

Sub-net mask　　　　　255.255.255.0

Default gateway　　　　192.168.10.1

（2） Turn on the VME Crate power supply and wait for about 10 seconds after turning on the power.

（3） Check the communication status between the PC and the device by executing the ping command at the Windows command prompt to see if the device and the PC are connected. The IP address of the device is located on the board or on the back of the unit. The factory default network information for this device is as follows.
IP address　　　　　　　192.168.10.128
Sub-net mask　　　　　255.255.255.0
Default gateway　　　　192.168.10.1

> ping 192.168.10.128

Figure 2　Confirm communication connection, execute ping command

（4） Launch this application. Search for APV8016A from the shortcut icon APV8016A on the desktop or the Windows button and launch it.
If an error message is displayed when this application is launched, stating that the connection with this device has failed, please refer to the troubleshooting described below.

5. Application window

5.1. Startup window

When this application is run, the following startup window will appear.
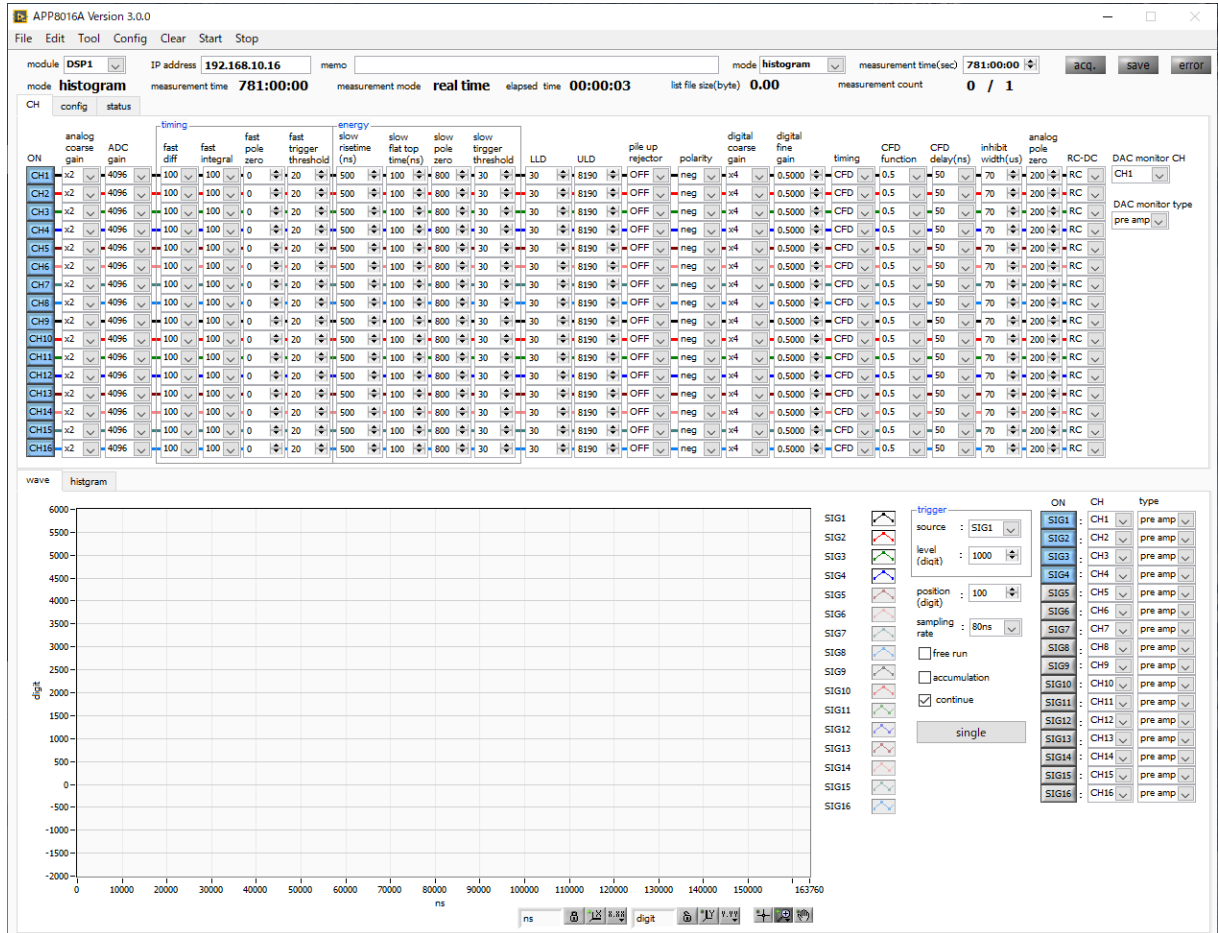
Figure 3 Startup window (may differ from image due to options and updates)

・Menu

File - open config	Load configuration file
File - open histogram	Load histogram data file
File - open wave	Load waveform data file
File - save config	Save current settings to a file
File - save histogram	Save current histogram data to file
File - save wave	Save waveform data file
File - save image	Save this application window as PNG format image
File – reconnect	Reconnect
File - quit	Quit application
Edit - copy setting of CH1	CH1 settings in the CH tab are reflected in all other CH settings

Edit - copy setting of CH1 to all modules

CH1 settings in the CH tab are reflected in the settings of all CHs of all other modules

|	
Edit - IP configuration	Change the IP address of this device
Tool – auto analog polezero	Automatic analog polezero window display. Automatically adjusts analog polezero.
Tool – gauss fit analysis	Gaussian fitting window display. Performs Gaussian fitting on specified peaks and performs half-width analysis, etc.
Tool – peak search analysis	Peak Search window display. Performs peak detection on histogram data, half-width analysis, etc.

Config	Set all items to this device
Clear	Initialize histogram data in this device
Start	Start measurement to this device
Stop	Stop measurement to this device

・Tab

CH	Settings for each input CH.
config	Settings other than input CH and settings related to storage and measurement.
option	Displayed when additional options are available　　* optional.
status	Displays count rates for each CH and calculation results between each ROI.
wave	Display of Waveform Data.
histogram	Histogram display, Region Of Interest (ROI) setting.

module	Select equipment to be measured.
IP address	IP Address. Defined in the configuration file, IP address of the DSP selected in module.
memo	Optional text box. Please use for measurement data management.
mode	Mode of operation. Select from the following modes.
・**histogram**	Histogram mode: Stores the wave height value of the preamplifier output signal (wave height value of the SLOW system filter) in up to 16384 channels and obtains a histogram of horizontal axis energy and vertical axis counts.
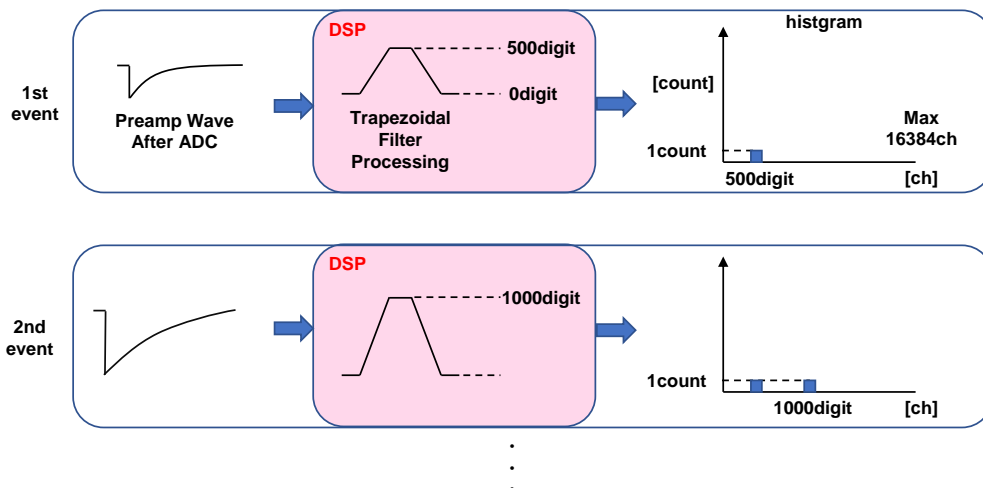
• **list** List Mode. Transfers data to the PC continuously as a single event data with the timestamp, wave height value and CH number of the preamplifier output signal.
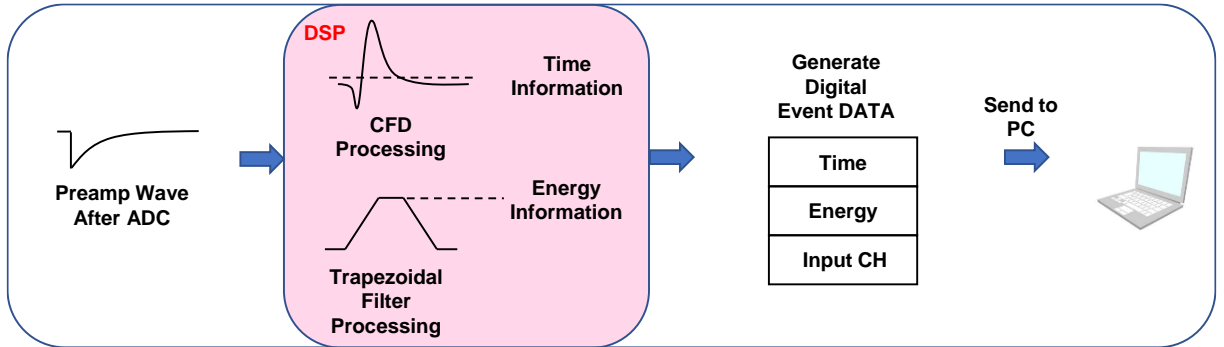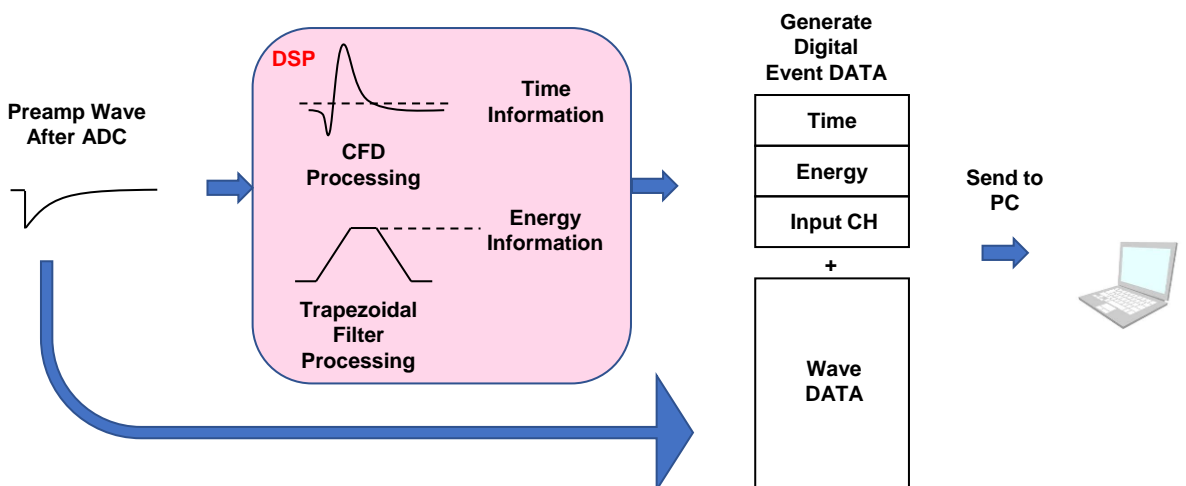

• **wave** Check waveform data during signal processing like an oscilloscope.
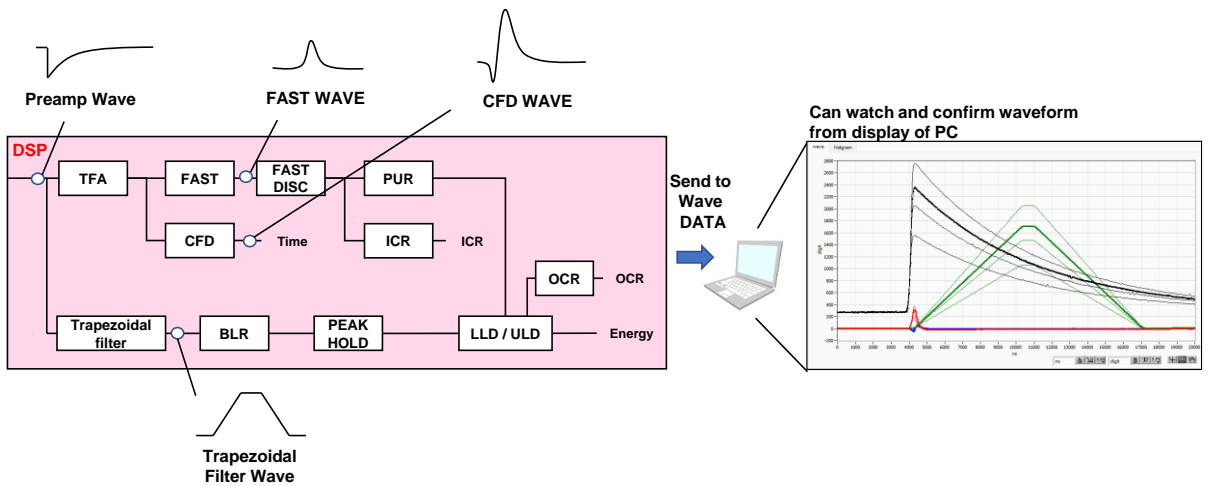
• **list-wave** Waveform data can also be acquired in the list data. * optional.

・**list-pup-wave**　　Only waveform data piled up in the list data can be acquired.　　*

optional
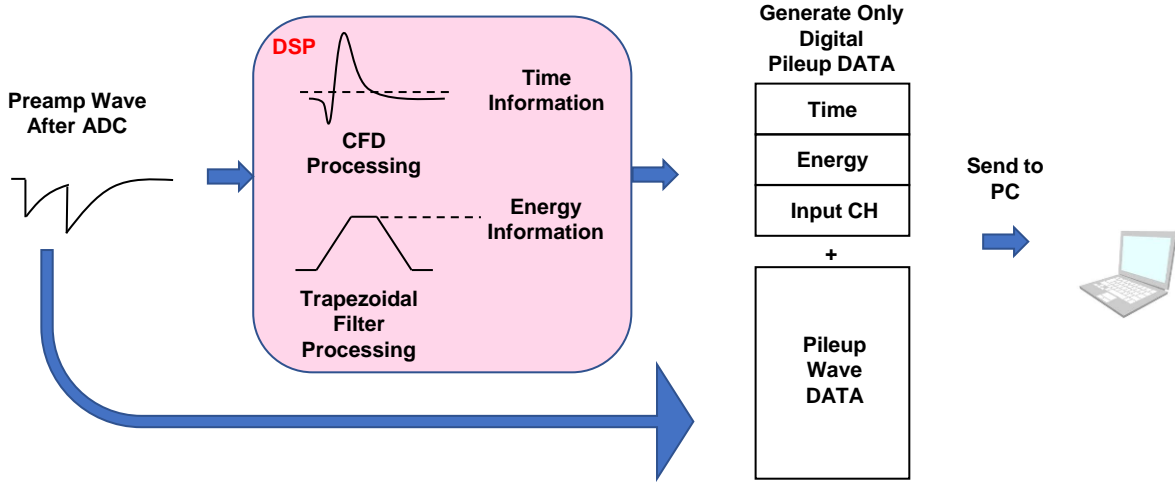
measurement time	Measurement time. Setting range is 00:00:00 to 781:00:00.
acq. LED	Flashing during measurement.
save LED	Flashes during data storage.
error LED	Error indication.
mode	Operation Mode. Displays the name of the operating mode being set.
measurement time	Set measurement time.
measurement mode	Measurement mode, displaying real time or live time.
elapsed time	Measurement elapsed time.
file size(byte)	Displays the capacity (in Bytes) of the file in which event data is being saved.
measurement count	Displays the current/total number of measurements. The total number of measurements is specified in the auto stop condition section in the config tab described below.

5．2． CH tab

Figure 4　CH tab

ON	CH avaliabilitiy
analog coarse gain	Analog coarse gain; select from x1, x2, x5, or x10. Amplifies the captured preamplifier output signal in the circuit section.
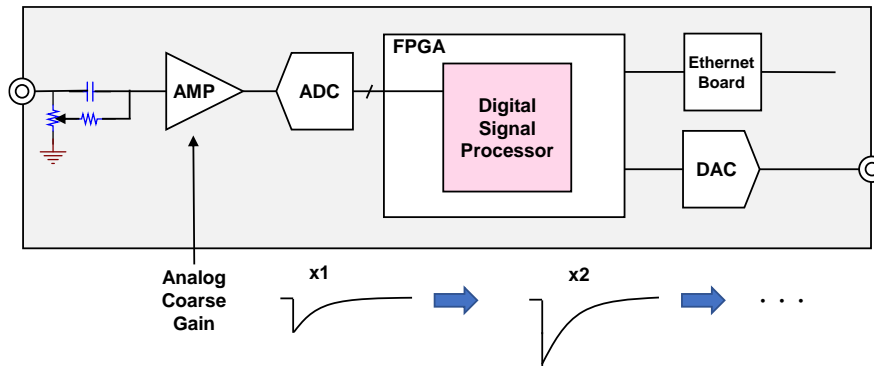
ADC gain	Gain of ADC (channel). 16384, 8192, 4096, 2048, 1024, 512, 256 channels (ch) to choose from. this is the number of divisions on the horizontal axis of the histogram graph.
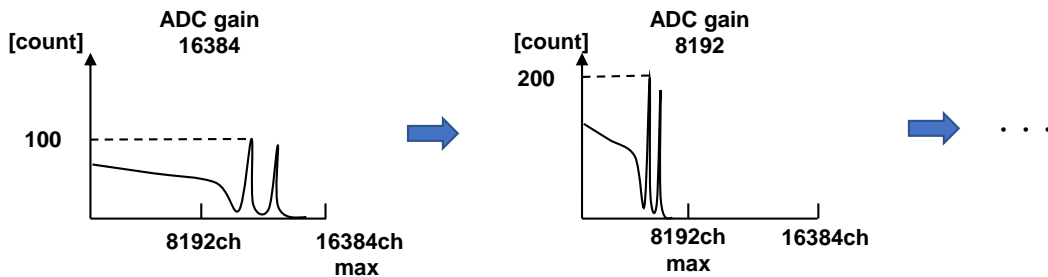
fast diff   Select the constant of the FAST differential circuit from ext (excluded, no filter used), 20, 50, 100, and 200. For detectors with fast rise time, select ext or 20; for Ge semiconductor detectors, select 100 or 200.
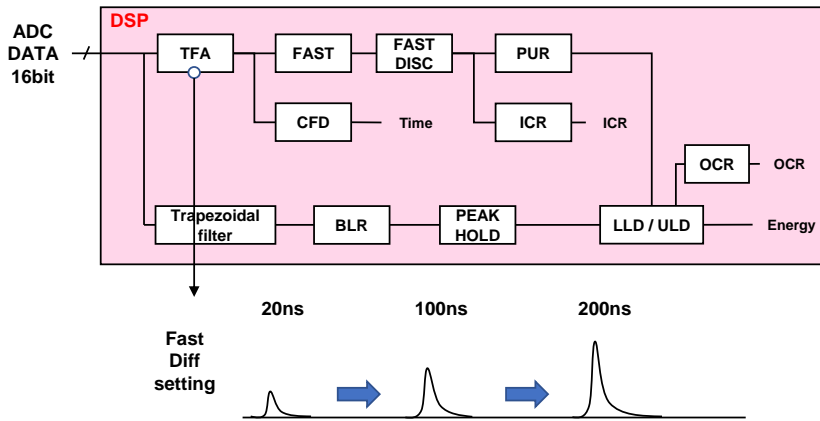
fast integral   Select the constant of the FAST integrating circuit from ext (excluded, no filter used), 20, 50, 100, and 200. For detectors with fast rise time, select ext or 20; for Ge semiconductor detectors, select 100 or 200.
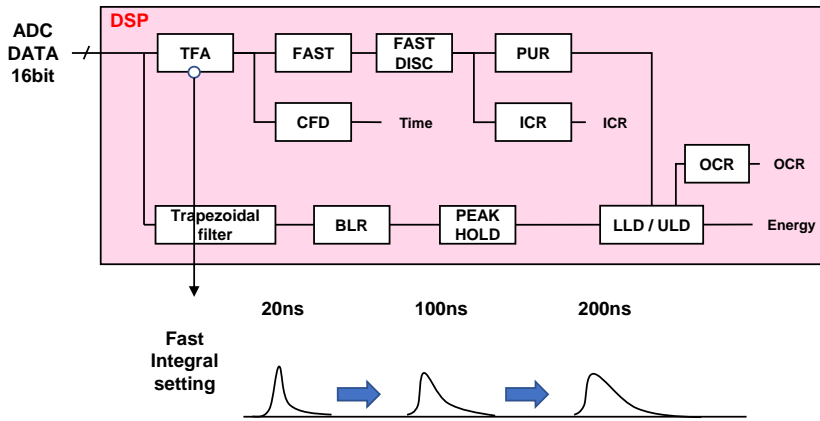
fast pole zero   FAST pole zero cancel setting. Setting range is 0 to 8192.
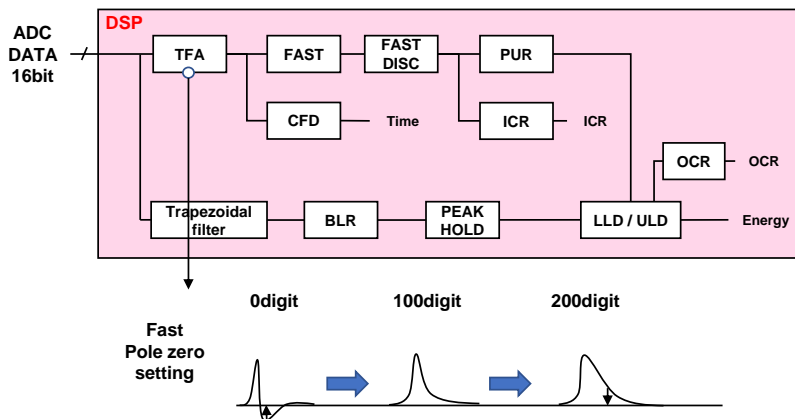
fast trigger threshold Threshold value for the timing of the start of waveform acquisition using FAST-type filters. The unit is digits, and the setting range is from 0 to 1000. The default setting is 50 digits. The FAST filter waveform is generated by differential and integral processing of the timing filter amplifier circuit based on the preamplifier output signal. When the waveform exceeds this threshold value, the timing for acquiring time information at that point and the timing for starting waveform generation in the spectroscopy amplifier circuit are acquired. It is mainly related to time acquisition (time stamp). If the threshold value is too small, noise is easily detected and the input total rate (cps) will increase, so while watching the input total rate (cps), set the value a few digits higher than the borderline of the noise level where the value increases extremely.
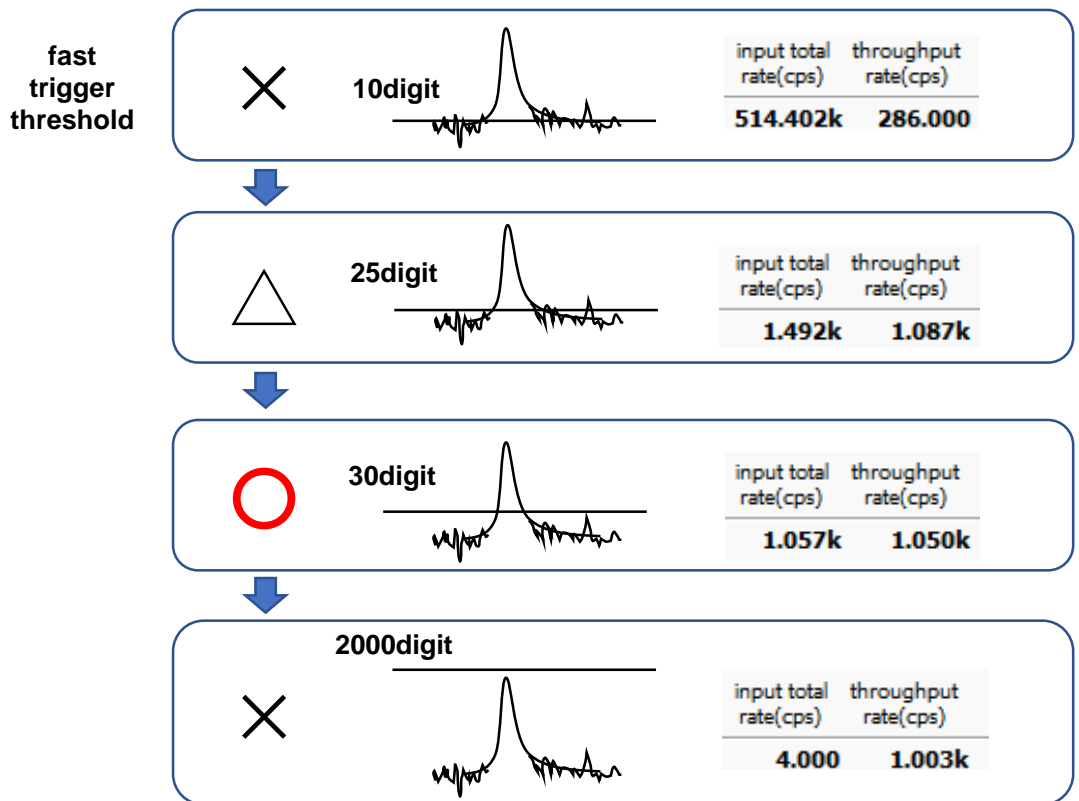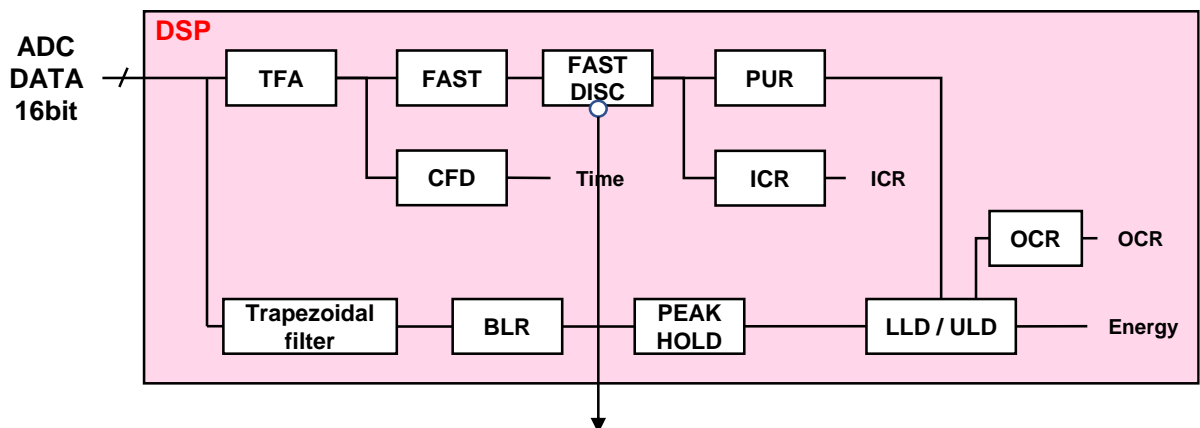
slow risetime(ns)   Rise time of a SLOW filter. This is the rise time to reach the upper bottom of the SLOW-type (trapezoidal) filter in the figure below. Shorter values tend to have poorer energy resolution but more throughput, while longer values tend to have better energy resolution but less throughput. Since the peaking time of linear amplifiers is often 2.0 to 2.4 x time constant, a rise time of about twice the time constant of the linear amplifier will give similar resolution. The default setting is 6000 ns. This corresponds to a shaping time of 3 µs for a linear amplifier.
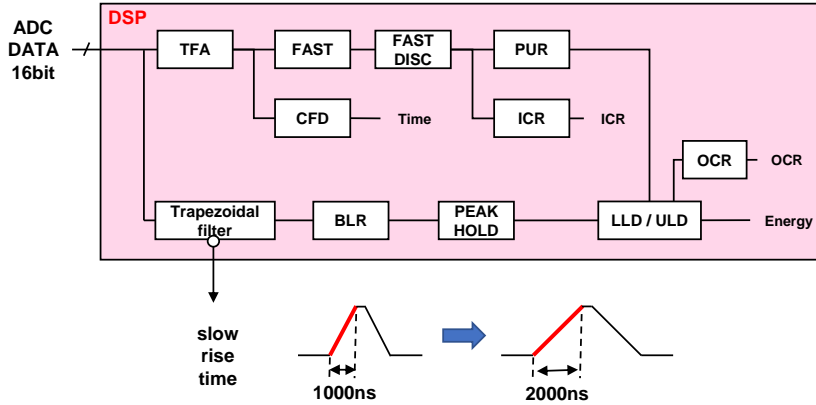
slow flat top time(ns)   Flat top time of a SLOW filter. This is the time at the top of the SLOW (trapezoidal) filter in the figure below. The length of the trapezoidal top part is used to adjust the wave height error caused by variations in the rise (fall) of the preamplifier output signal. The setting value is from 0 to 100% of the rise (fall) time of the preamplifier output signal and should be twice the slowest time. The default setting is 700 ns. (In this case, the slowest rise (fall) time is assumed to be 350 ns.

* The throughput of the DSP is shown in the following equation.

(slow rise time + slow flattoptime) × 1.25
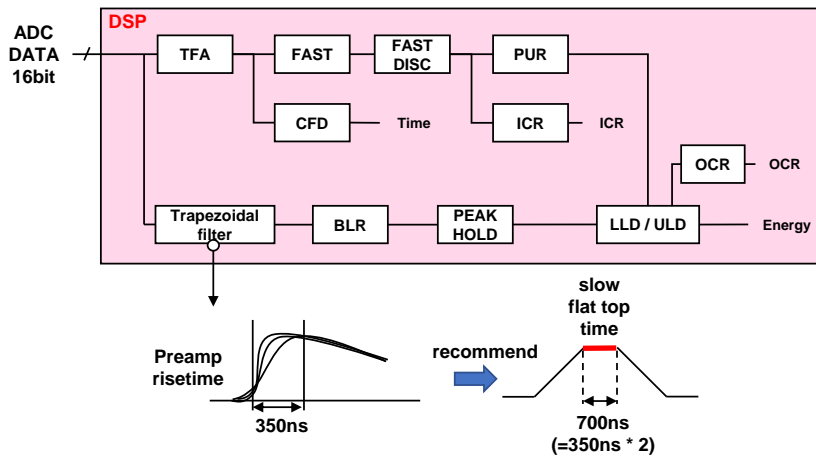
slow pole zero   SLOW-type pole zero cancellation; the falling undershoots, or overshoot of the SLOW-type filter can be reduced by setting this value appropriately. The default setting is 680. Since this value varies depending on the detector, connect the MONI terminal on the front panel to the oscilloscope, select the SLOW filter in the DAC monitor type, and adjust the SLOW filter so that the falling edge of the SLOW filter is flattened.
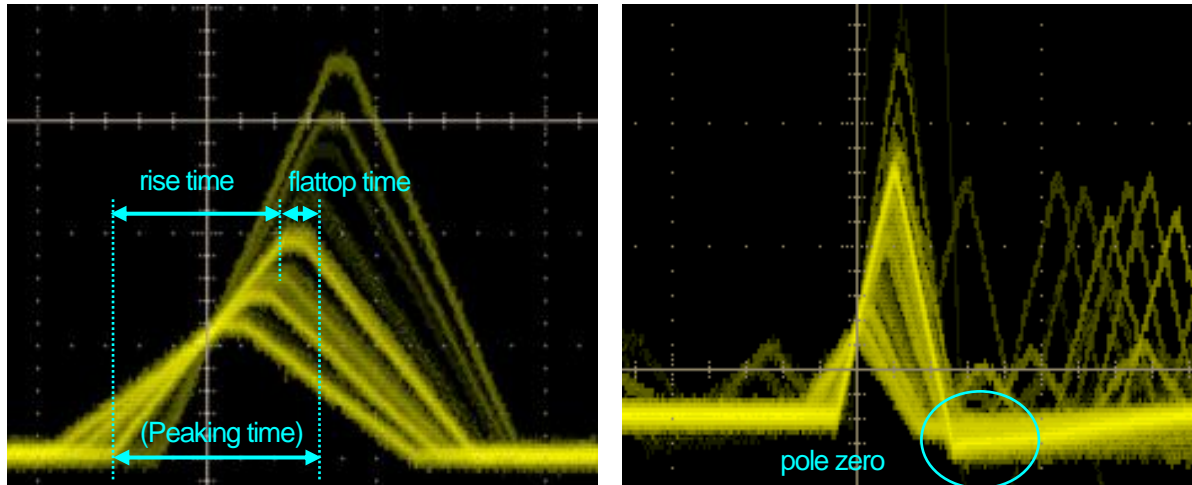
Figure 5   SLOW type (trapezoidal) filter

* The figure on the right shows an example where there is an undershoot in the SLOW filter and pole zero is not set. In this case, lowering the value of the SLOW pole zero from the current setting will lift the undershoot to the upper side.

slow trigger threshold Threshold value for the timing of the start of waveform acquisition for the Slow system filter. Unit is digits. The setting range is from 0 to 8191. The default setting is 50 digits. Set this value up or down by about 10 digits above the noise level where the throughout rate (cps) increases. Set this value below the LLD described below. When the generated SLOW filter waveform exceeds this threshold value, the wave height value at the preset time (slow rise time + slow flattop time) is secured.
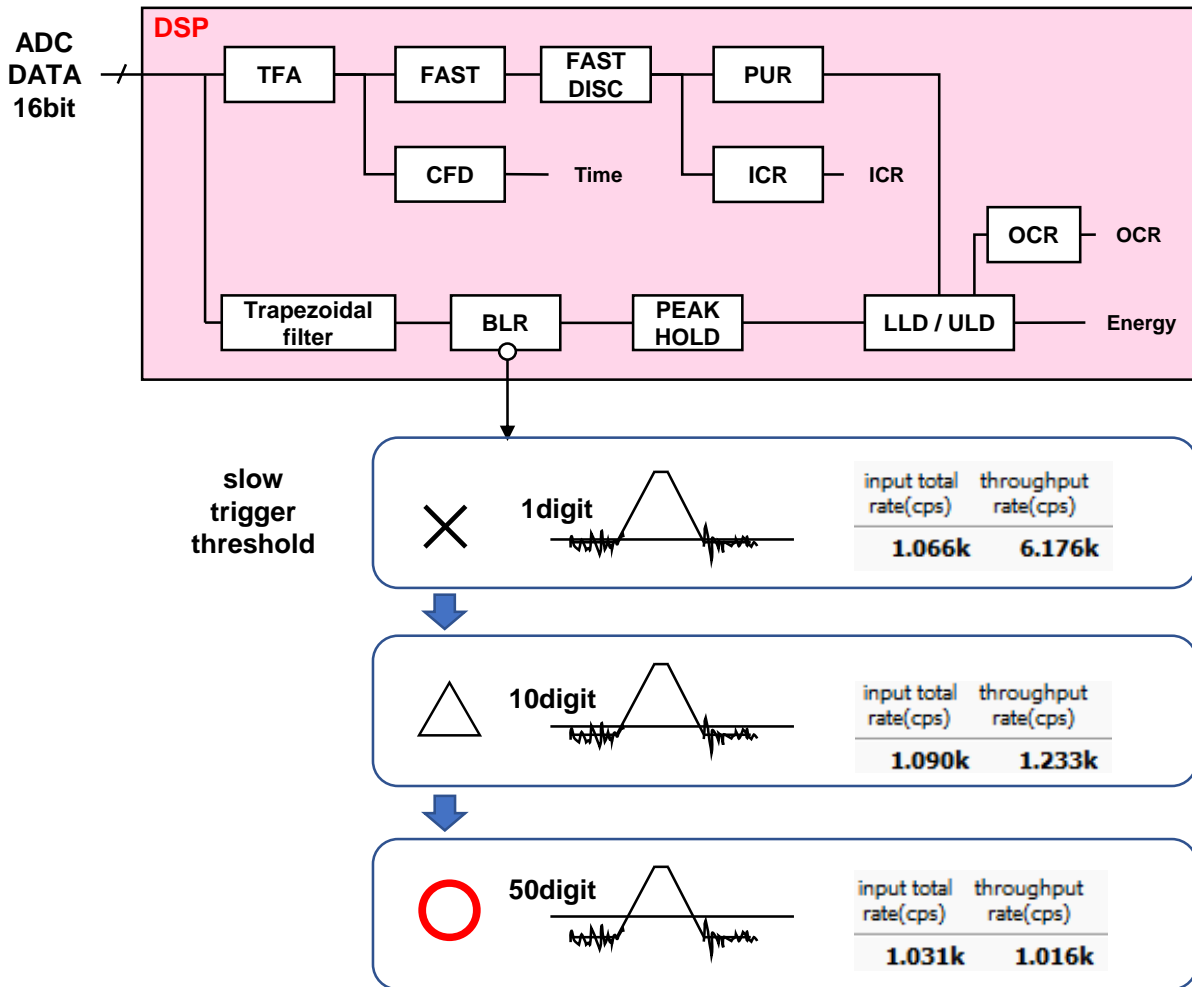
LLD   Energy LLD (Lower Level Discriminator). The unit is ch. The ch below this threshold is not counted. set to a value greater than the show trigger threshold but less than the ULD.

ULD   Energy ULD (Upper Level Discriminator). The unit is ch. Set to a value greater than the LLD and less than the ADC gain.
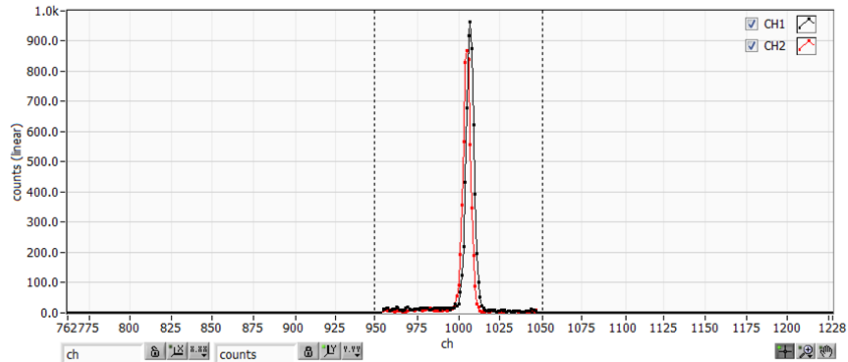
Figure 6   Setting example of LLD and ULD

* The above figure shows an example where the LLD is set to 955 and the ULD to 1045; you can see that the areas smaller than the LLD and larger than the ULD are not measured.

pile up rejector   Enables/disables pileup rejection, valid when ON. As shown in the figure below, two pulses generated below the rise time of the waveform-shaped signal overlap, resulting in a different value from the actual peak value. Under high counts, this can result in significant background noise. Pile-up rejection is performed to exclude this event by digital signal processing. The target time is (risetime + flattoptime) × 1.25. If two events occur during this time, they are rejected. The higher the number of pile-up rejections, the greater the difference between multiple input counts and zero throughput counts.
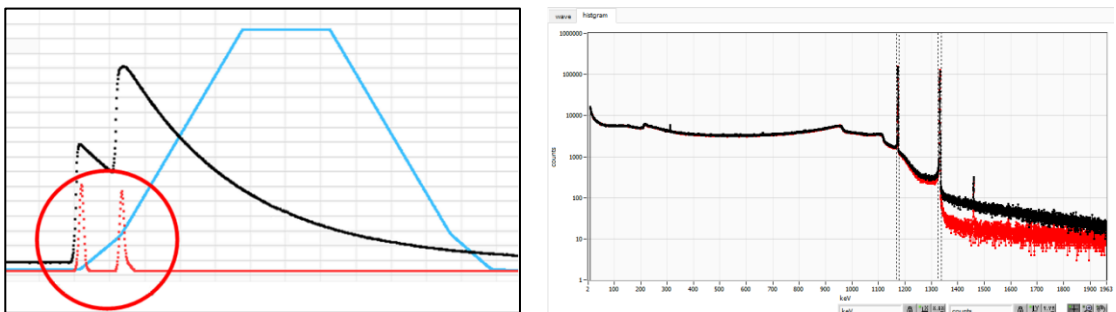
Figure 7   LEFT: Pile-up event, RIGHT: No blue reject, red reject

polarity   Polarity of the input preamplifier output signal. pos = positive polarity, neg = negative polarity
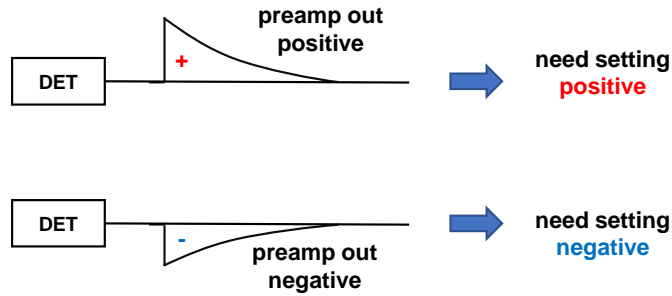
digital coarse gain   The gain is digitally selected from x1, x2, x4, x8, x16, x32, x64, and x128. In the case of a trapezoidal filter, the integral circuit is calculated by sum-of-products operations; the larger the slow rise time, the greater the number of sum-of-products operations and the larger the value, and the smaller the value, the smaller. This value is used in conjunction with the slow rise time setting.
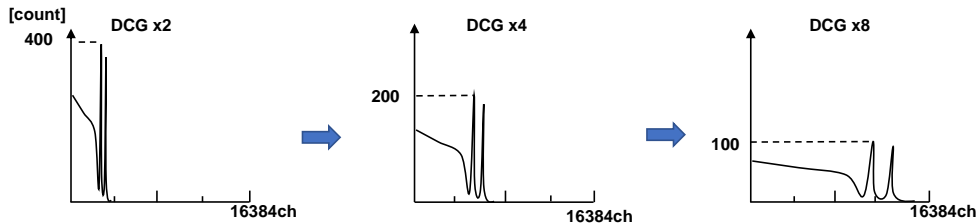
digital fine gain   Digitally sets the fine gain. The setting range is from 0.3333 to 1x and is used for correction in the same way as digital coarse gain. The resulting histogram can be used to adjust the peak position of the histogram.

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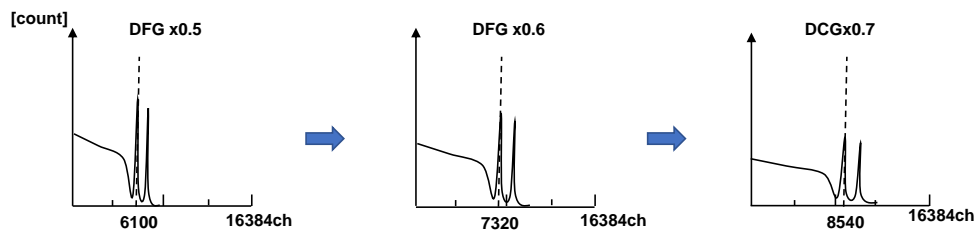
timing   Select the timing acquisition method to determine the time when the event was detected (time stamp) from LET (Leading Edge Timing) or CFD (Constant Fraction Disicriminator Timing).

LET: Leading Edge Timing (Leading Edge Timing)
The timing at which a certain trigger level t is reached. (Trigger acquisition timing is also different if the slope of the rising edge changes, as in the case of 'a' and 'b'.
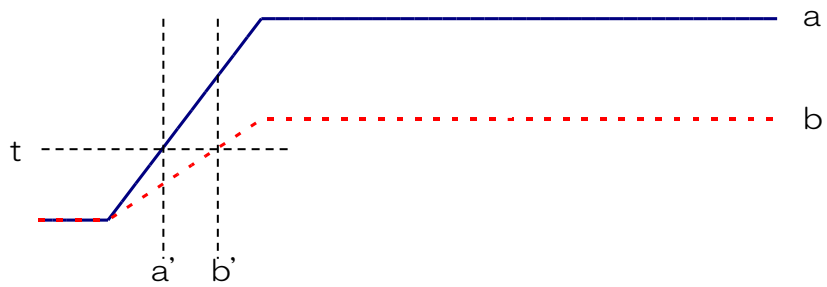
Figure 8   Concept of Leading Edge (Leading Edge Timing)

CFD: Constant Fraction Disicriminator Timing

For the different preamp waveforms, a and b in the figure below, the following waveforms c, d and e, f and g, h are generated.

Waveforms c, d: Waveforms a and b multiplied by CFD function and inverted

Waveforms e, f: Waveforms a and b delayed by CFD delay

Waveforms g, h: Waveforms c and e plus waveforms d and f

CFD, the zero-crossing timing of waveforms g and h, is characterized by the fact that it is constant even if the wave height changes, if the start time of the rise of the waveform is the same.

Input signal

a

V1

b

V2

Inverts input signal multiplied by CFD functions.

V2 * CFD function

d

V1 * CFD function

c

Input signal delayed by CFD delay

e

f

CFD delay

Add reversals and delays.

g

h

CFD
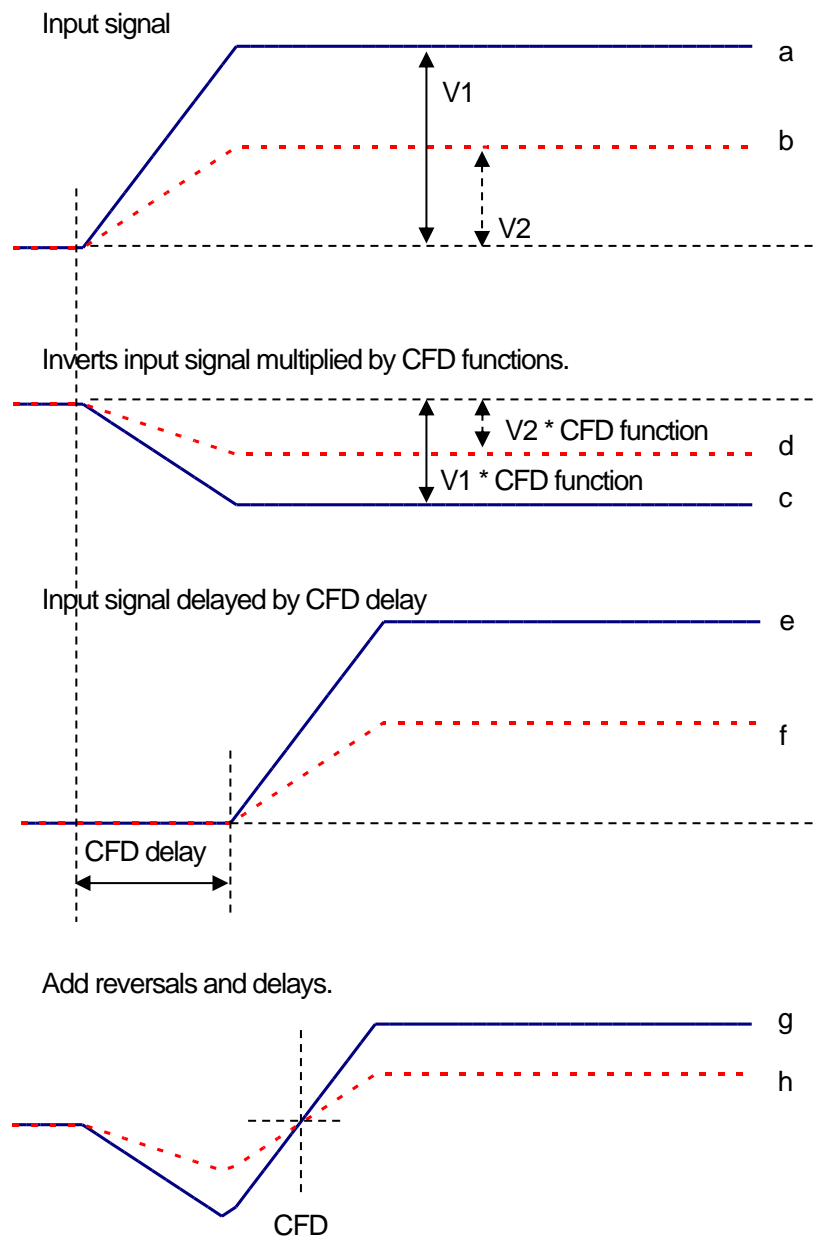
Figure 9   Concept of Constant Fraction Disicriminator Timing

Constant fraction timing is realized by digital signal processing using FPGA.
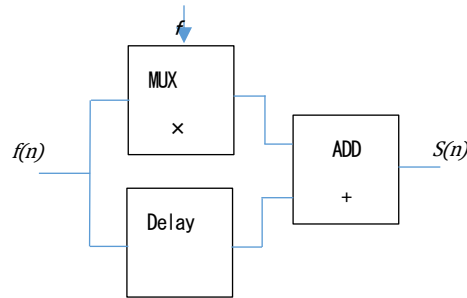
$$s(n) = fv(n) - v(n - delay)$$

The time pickoff algorithm we have developed for digital signal processing uses a polynomial approximation based on the least-squares method from sampled waveform data.

$$L(a, b, c) = \sum_{i=1}^{N} \{ y_i - (ax_i^2 + bx_i + C) \}^2$$

The time information is calculated more precisely by finding the parameters a, b, and c that minimize the time information (a, b, and c) and obtaining interpolation at the zero crossing point for CFD and at the threshold point for leading edge.

The FPGA pipelined computation allows a series of calculations to be performed at extremely high speeds of approximately 100 ns or less, resulting in low dead time and high throughput.

CFD function	Magnification for reducing the original waveform for CFD calculation, selected from 0.125, 0.25, 0.375, 0.625, 0.75, and 0.875. Default is 0.25 to 0.625 times.
CFD delay	Select the time to delay the original waveform for CFD calculation from 10, 20, 30, 40, 50, 60, 70, and 80ns. Default is 50 to 80ns.
inhibit width(μs)	Dead time width from the time of reset detection for transistor reset type preamplifier. (The INHIBIT signal from the detector is processed internally without input and no counting is performed during this period.

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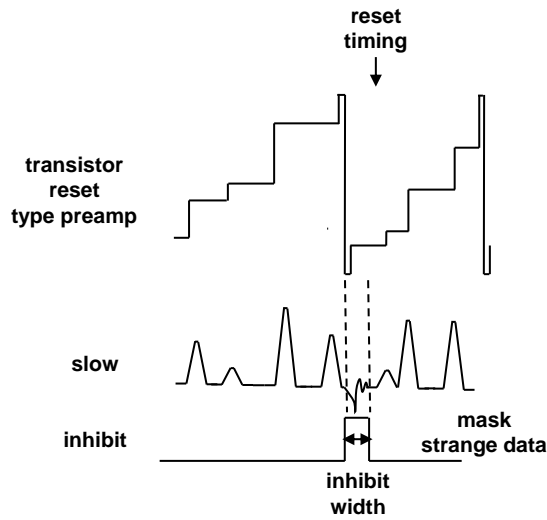
analog pole zero   Analog Pole Zero. Sets the internal differentiation of the input preamplifier output signal to correct for overshoot or undershoot on the falling edge of that signal. Setting range is 0 to 255.
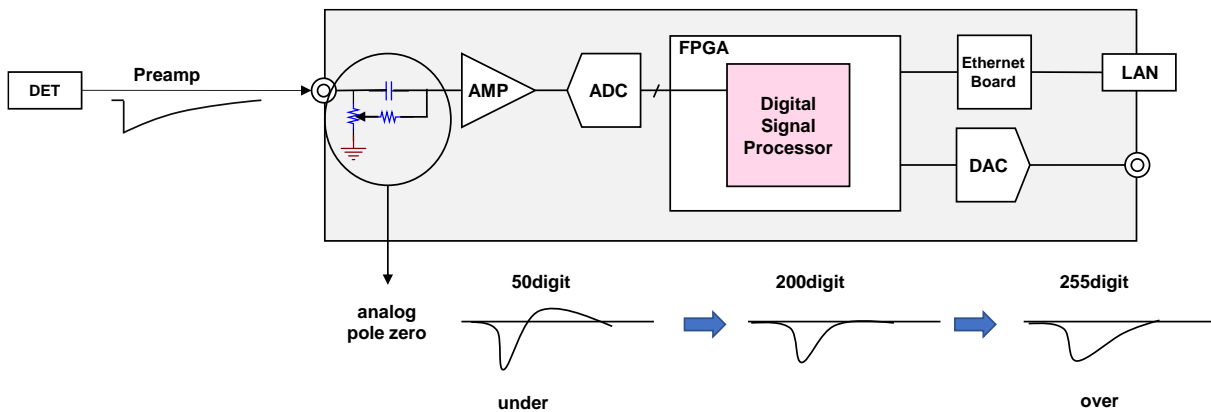
RC-DC   Enable/Disable setting for first-stage differential circuit.

                         RC   First-stage derivative circuit used. Normally 6.8 μsec. set when the decay of the signal from the detector is longer than 50 μsec as a guide (default).

                         DC   First-stage derivative circuit not used. Set when the decay of the signal from the detector is shorter than 50μsec as a rough guide.
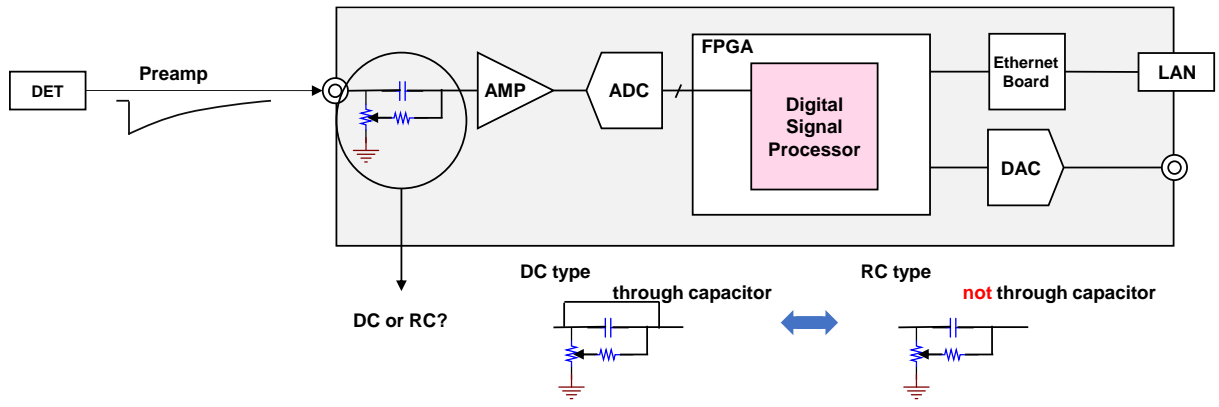
DAC monitor CH   Select the CH number for DAC output. The waveform selected under DAC monitor type for the selected CH is output from the MONI pin.

DAC monitor type   Waveform selection for DAC output; the selected type of waveform signal among the waveforms processed inside the DSP is output from the MONI pin. By viewing this signal on an oscilloscope, you can check the processing status inside the DSP.

     pre amp   Differentiated signal from the preamplifier signal. Used to confirm that the energy range to be measured is within 2V when taken internally, and for analog pole zero adjustment.

     fast   FAST filter signal

     slow   SLOW system filter signal. Used for pole zero adjustment after waveform shaping processing.

     CFD   CFD signal, which allows the user to check the CFD delay and CFD function setting status when CFD timing is used.
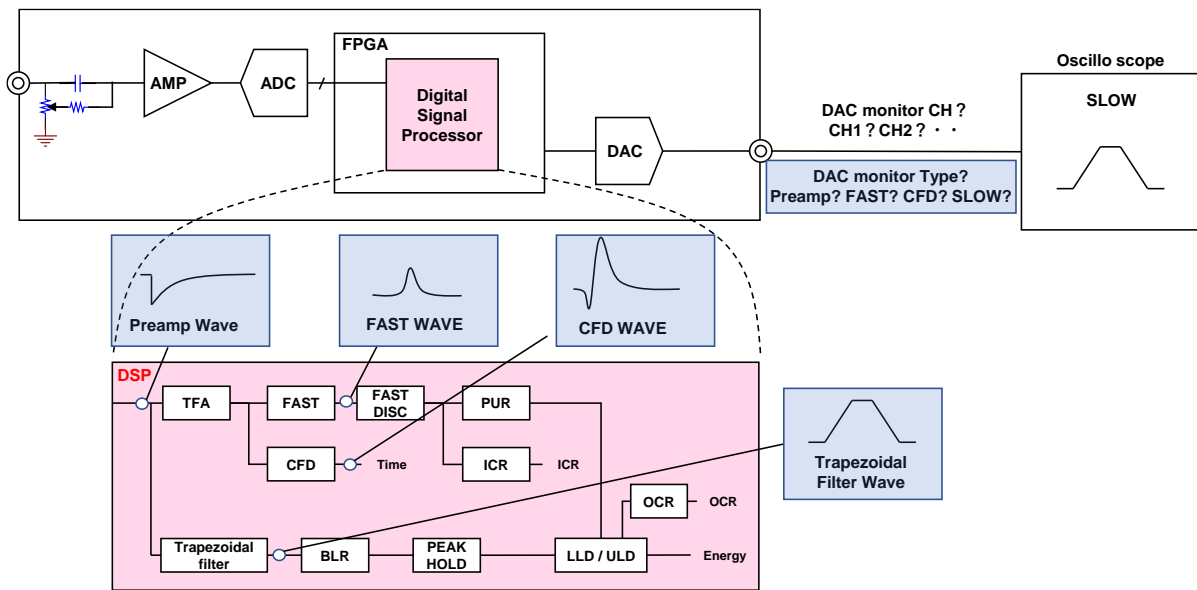
Figure 10   DACmoniter simplified drawing

5．3． config tab
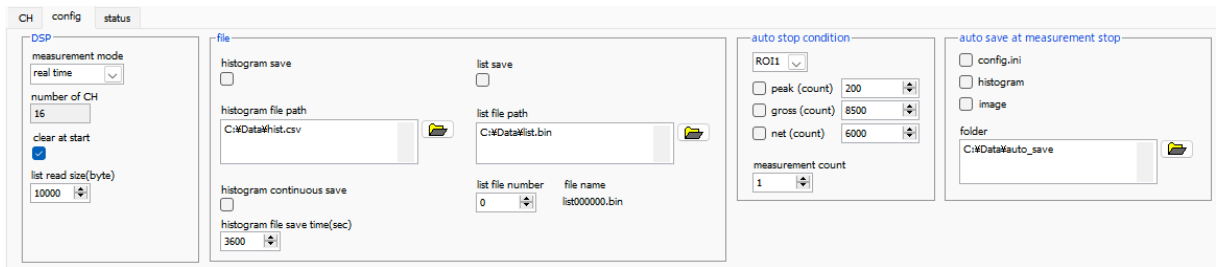
Figure 11　config tab

・DSP part

measurement mode	Select real time or live time
	real time: Measure data for a preset time.
	live time: Measure until the effective measurement time (difference between real time and dead time) reaches the preset time.
number of CH	The number of CHs for this device. Displays the number of CHs for this device.
clear at start	Sets whether to perform histogram data initialization at the start of measurement.
list read size(byte)	Minimum read data length in list mode. Unit is Byte, usually set to 10000. At high count rates, set to 20000 Bytes to allow the PC side to receive many events. At low count rates, lower the setting so that fewer events can be received.

・file part

histogram save	Saves the histogram data displayed in the histogram tab to a file at the end of measurement. The file is saved in the format described below.
histogram file path	Set the absolute path of the histogram data file. No extension is also possible.
	Note The file will not be saved with this file name but will be formatted as follows based on this file name.
	Example: If the histogram file path is set to C:¥Data¥histogram.csv and the date and time is 2022/09/01 12:00:00, the data saving will start with the file name C:¥Data¥histogram_20220901_120000.csv
histogram continious save	
	Sets whether to save histogram data at set time intervals.
	Note.
	Depending on processing conditions, there may be a discrepancy between the interval specified below and the actual storage interval. Please use for simple backup.
histo file save time (sec)	

	Sets the time interval for continuous storage of histogram data. The unit is seconds. The setting range is from 5 to 3600 seconds.
list save	Sets whether the list data is saved in a file or not. (Valid only when list mode is selected.
list file path	Set the absolute path of the listing data file. No extension is also possible. *Note* The file will not be saved with this file name but will be formatted as follows based on this file name. Example: If the list file path is set to C:¥Data¥list_.bin and the list file number is 0 as described below, data saving will start with the file name C:¥Data¥list_000000.bin
list file number	Sets the starting number of the number appended to the list data file, from 0 to 9999999, reset to 0 if the number exceeds 9999999.
file name	Displays the file name when the file is saved based on the list file path and list file number.

・auto stop condition part

Specify the stop condition for a single measurement. Measurement stops when any one of the conditions checked below is true or when the measurement time is reached.

ROI select	Select one ROI for the following various counts.
peak(count)	When the peak(count) of the ROI selected above exceeds the value specified here, the stop condition is satisfied.
gross(count)	When the gross(count) of the ROI selected above is greater than or equal to the value specified here, the stop condition is satisfied.
net(count)	When the net(count) of the ROI selected above exceeds the value specified here, the stop condition is satisfied.
measurement count	Specifies the number of repetitive measurements.

・auto save at measurement stop part

Selects and specifies the target to be saved automatically at each measurement stop.

config.ini	When checked, the configuration file is saved. The file name extension will be .ini
histogram data	When checked, histogram data at the time of measurement stop is saved in a file. The file name extension will be csv
image	When checked, the entire window that was displayed when the measurement was stopped is saved to a file. (The file name extension will be png.. *NOTE* Both the upper half (CH, config, status tabs) and the lower half (wave,

histogram tabs) are saved as they were selected and displayed when the measurement was stopped. Note that not all tabs are saved.

folder   Specify the destination folder and base file name. Immediately after the name specified here, a "_YYYYMMDD_hhmmss" format string indicating the date and time when the measurement stopped (year, month, date, hour, minute, second) is appended, followed by an extension for each file type.

5.4. status tab

Figure 12　status tab

・CH part

Displays the status of each CH

input total count	Number of events with input.
throughput count	Number of inputs processed.
input total rate(cps)	Number of events with input per second.
throughput rate(cps)	Number of inputs processed per second.
pileup rate(cps)	Pileup counts per second.
dead time ratio(%)	Percentage of dead time. Instantaneous value per uptake.

・ROI part

Displays the calculated results between ROIs

peak(ch)	Maximum count ch.
centroid(ch)	Center value calculated from the sum of all counts (ch).
peak(count)	Maximum count.
gross(count)	Sum of counts between ROIs.
gross(cps)	gross(count) / measurement elapsed time.
net(count)	Sum of counts minus background between ROIs.
net(cps)	net(count) / measurement elapsed time.
FWHM(ch)	Half-width (ch).
FWHM(%)	Half-width (%). Half width / ROI defined energy x 100.
FWHM	Half-width.
FWTM	1/10 width.

５．５．　wave tab

The status of signal processing inside this device can be acquired as waveform data with this application. When adjusting signal processing before measurement, the preamp and slow signals from the MONI terminal are checked with an oscilloscope, and this function can do the same.
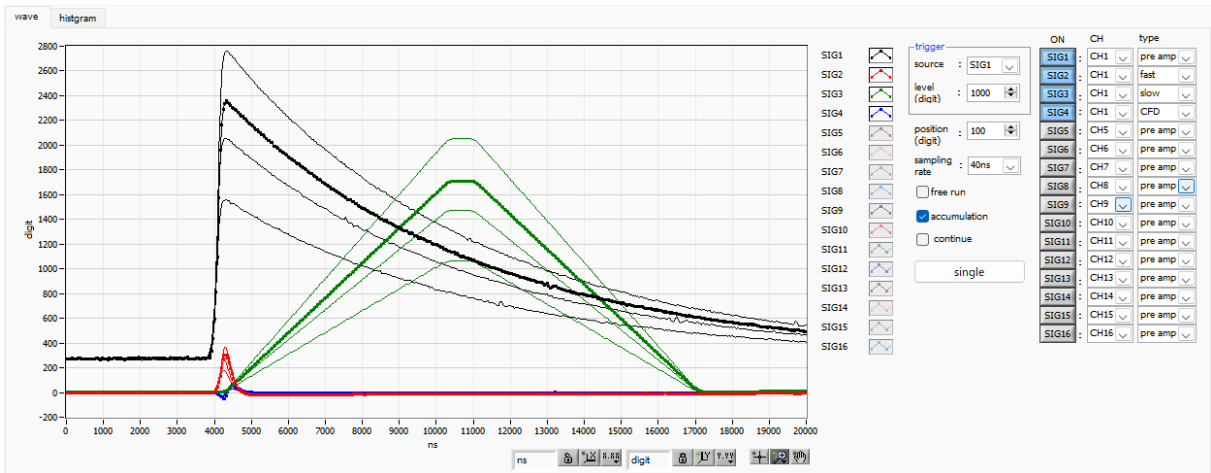
Figure 13　wave tab

Graph　　　　　　　Waveform graph. waveform data is displayed during measurement when wave is selected in mode in config tab.

・trigger part

source　　　　　　Trigger Source. Select the waveform number to trigger on.

level(digit)　　　　Set the trigger level. It is like the rising edge trigger on an oscilloscope. The trigger occurs when the threshold is exceeded, and the waveform data is acquired.

position(ns)　　　Set the trigger position. Set when waveform data before the trigger is applied is needed, etc.

sampling rate　　Set the sampling frequency. Select sampling interval time from 10 ns, 20 ns, 40 ns, 80 ns, 160 ns, 320 ns, 640 ns, 1280 ns, 2560 ns, 5120 ns.

free run　　　　　Acquire waveforms regardless of trigger level.

accumlation　　　Enables/disables superimposition of several waveform data.

continue　　　　Select continuous waveform capture.

single　　　　　Performs single-trigger capture.

ON　　　　　　Enable/disable waveform display

type　　　　　Select CH and waveform type.

　　　　　　　preamp　　　Preamplifier Signal

　　　　　　　fast　　　　FAST filter signal

　　　　　　　slow　　　　SLOW filter signal

　　　　　　　CFD　　　　CFD signal

5．6．option tab＊optional

The following optional features can be added.

5．6．1．list-pileup-wave part＊optional

When a pileup is detected in list-pup-wave mode, information on the existence of the pileup is included in the list data, and the waveform data of the pileup is appended after the list data.
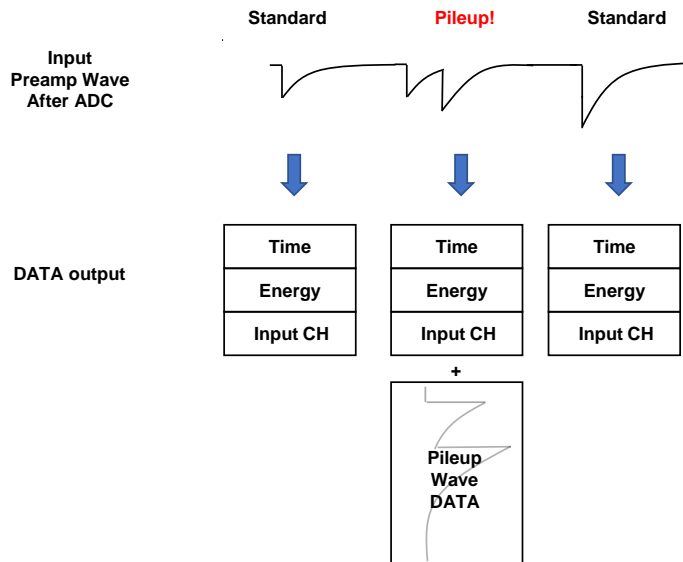
Figure 14　Simplified diagram of data acquisition
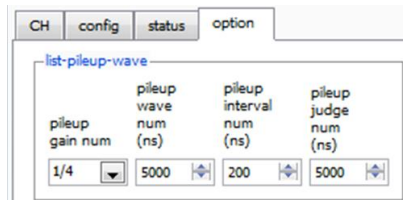
Figure 15　option tab (list-pileup-wave)

pileup gain num   Sampling frequency of the pile-up waveform can be set; if 1/4 is set, data is output every 4 points from the actual sampled data.

○ **: Sampling point 10ns(100MHz)**

Gain num 1/1 pileup wave data
10ns sampling

Gain num 1/2 pileup wave data
20ns sampling
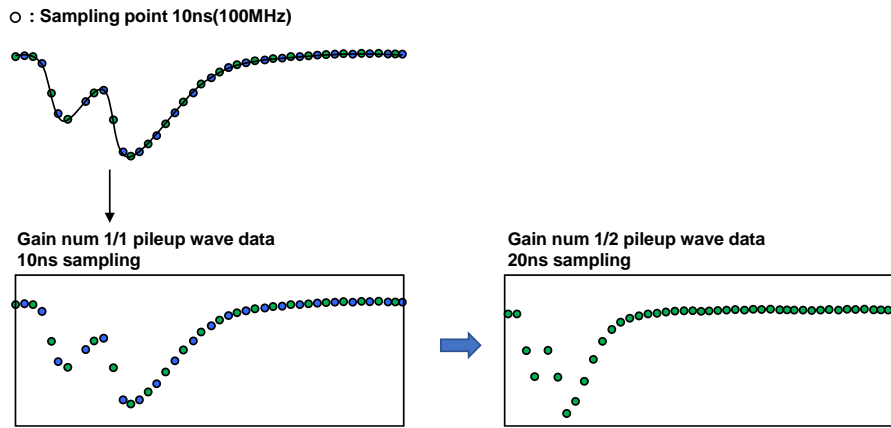
pileup wave num   Sets the number of waveform points to be acquired for pileup waveforms.

Wave num 20 digit (point)

Wave num 40 digit (point)
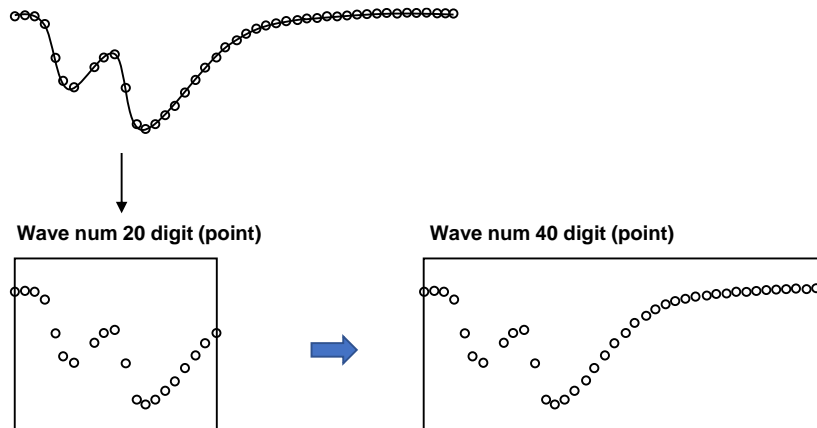
pileup interval num   Sets the start time of the pile-up judgment.

Input
Preamp Wave
After ADC

Fast
signal

Fast
Discri

Pileup judge start
Interval = 0

Pileup judge start
Interval = 10

Can delay start timing
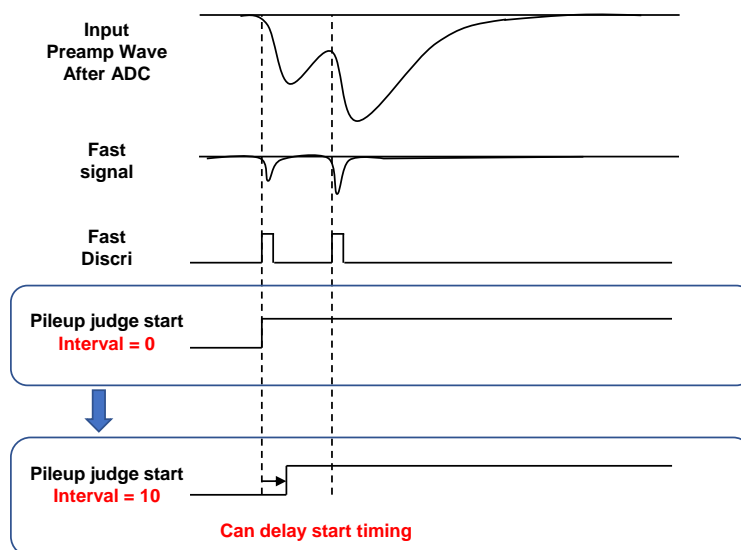
pileup judge num   Sets the end time of the pile-up judgment.
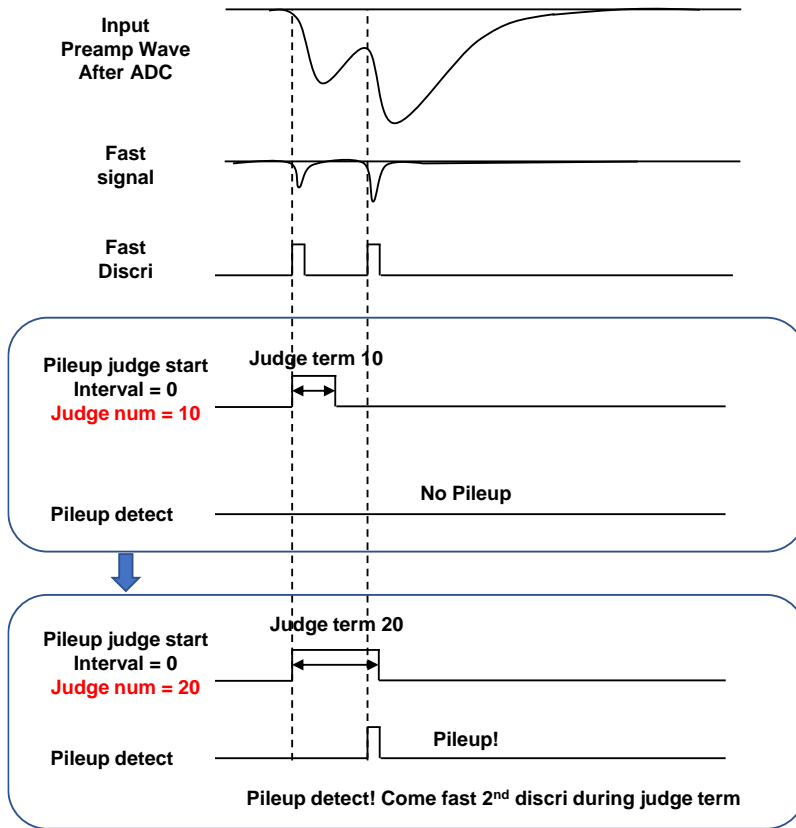
5．6．2． list-wave part＊optional

Whether or not waveform data is added to each CH during list mode can be set.
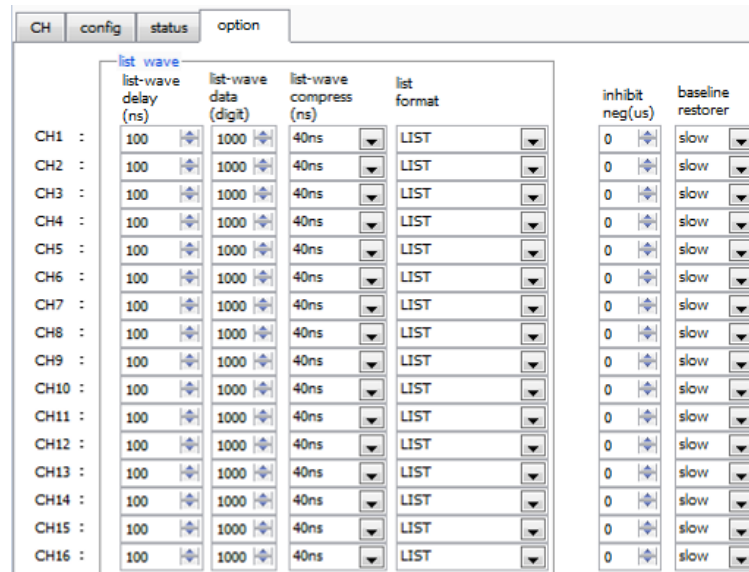
Figure 16   option tab (list-wave)

list-wave delay   Sets the delay time (waveform position) for waveform data acquisition. Unit is ns.
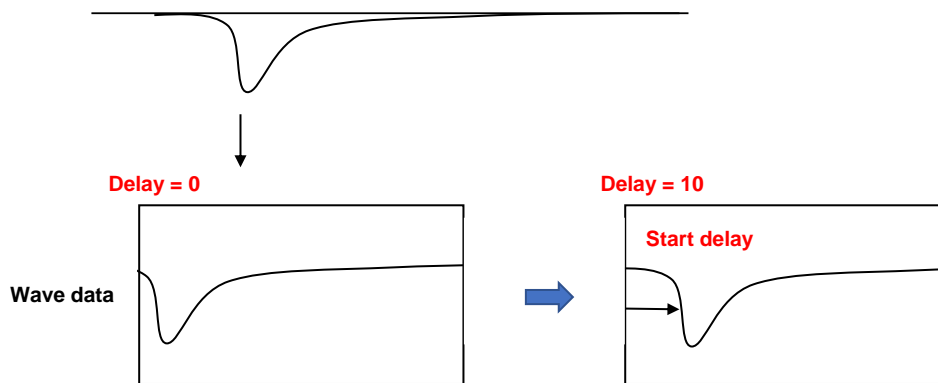
list-wave data   Sets the number of waveform data points for waveform data acquisition. Max. 1000 points.

Wave data = 15   **Wave data = 30**
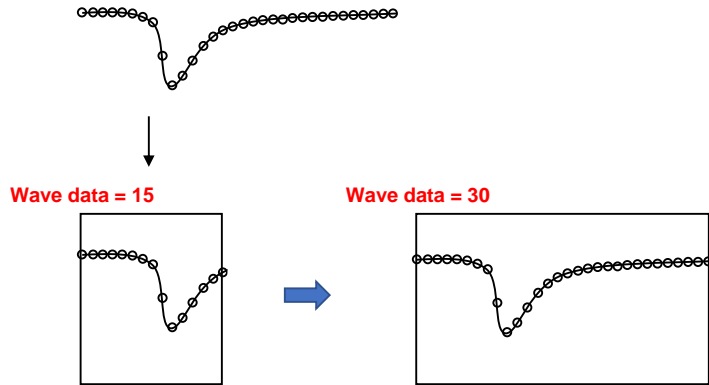
list-wave compress   Sets the time accuracy per point for waveform data acquisition, from 10 ns to 1280 ns.

Sampling 10ns (100MHz)

compress num 10ns
1point is 10ns   **compress num 20ns**
1 point is 20ns
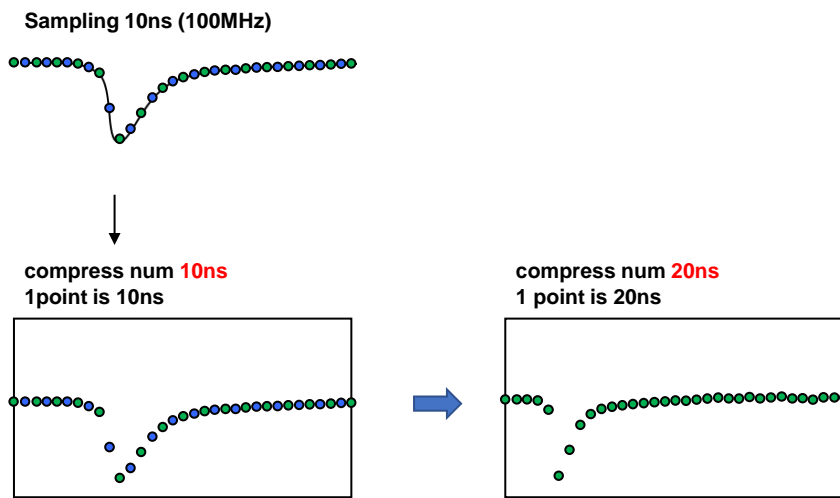
list format   Sets the format of the list data

        LIST   80-byte data per event.

        LIST-WAV   Mixed LIST data and waveform data.

Input
Preamp Wave
After ADC

LIST format

Time	Time	Time
Energy	Energy	Energy
Input CH	Input CH	Input CH

LIST-WAV format

Time	Time	Time
Energy	Energy	Energy
Input CH	Input CH	Input CH
+	+	+
Wave DATA	Wave DATA	Wave DATA

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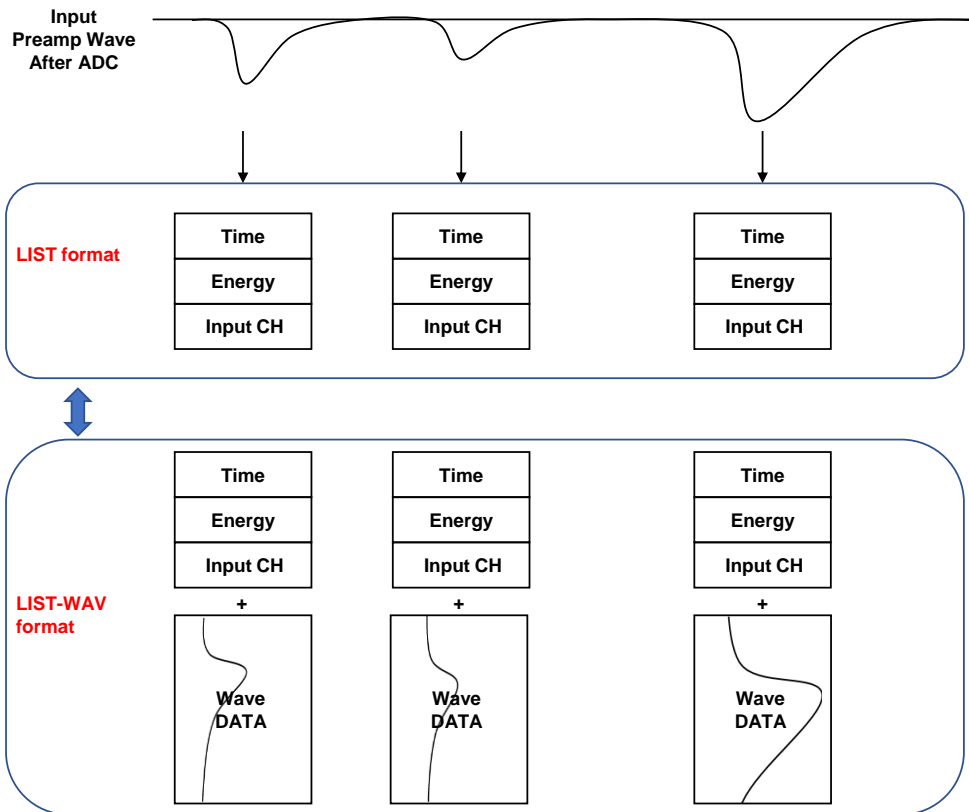
inhibit neg   Dead time can be set when a signal opposite to the set polarity is received. Max. 163 µs
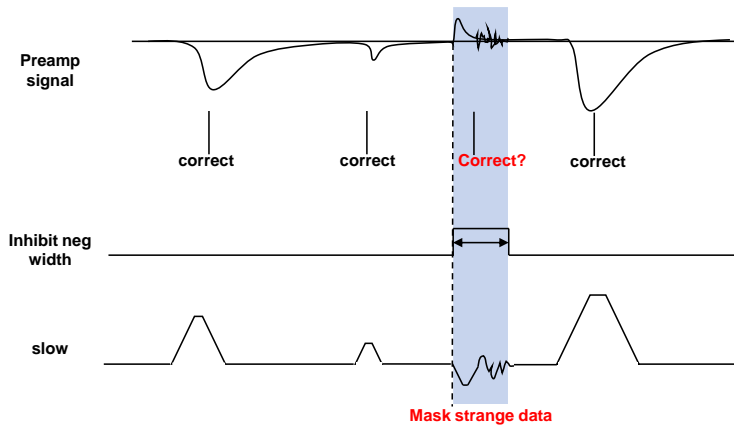
baseline restorer   normal   Normal setting
                         slow   This setting allows you to set the baseline restorer slower than the normal setting. This setting can be used for low counts such as a few cps or when higher resolution is required.

5．7．histogram tab
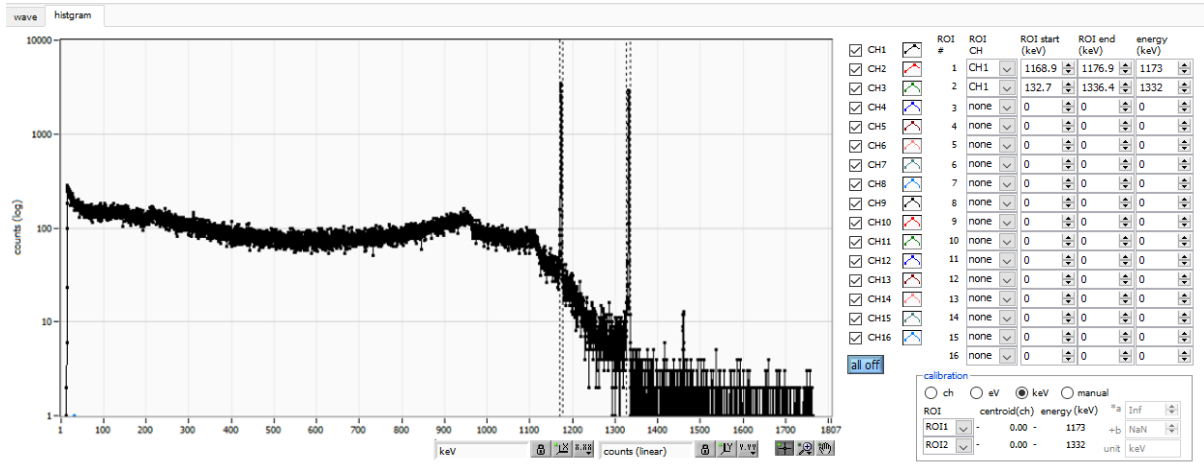
Figure 17   histogram tab

Graph	Histogram graph, if histogram is selected in mode in config tab, energy histogram is displayed during measurement.
Checkbox	Selection of whether to display a histogram for each CH in the graph.
ROI CH	Select the CH number to which the ROI (Region Of Interest) is to be applied; up to 16 ROIs can be set for a single histogram.
ROI start	Start position of the ROI. The unit is the unit selected in the calibration described below.
ROI end	End position of the ROI. The unit is the unit selected in the calibration described below.
energy	Define the energy value of the peak position (ch). 1173 or 1332 (keV) is set for Co-60. When ch is selected in the calibration described below, the peak between ROIs is detected and keV/ch is calculated from the peak position (ch) and the set energy value and applied to the result of the calculation of the FWHM.
calibration	X-axis units. X-axis labels will change according to the setting.

	ch	Display in units of ch (channel); units such as FWHM of FWTM of ROI are optional.
	eV	The slope a and the intercept b of the linear function y=ax+b are calculated and set on the X-axis so that ch is eV by two-point calibration of the two types of peaks (center values) and energy values in a histogram.
	keV	The unit of keV is displayed. Example: If there are 1173.24 keV of Co-60 at 5717.9 ch and 1332.5 keV of Co-60 at 6498.7 ch, a is automatically calculated as 0.20397 and b as 6.958297 from the two-point calibration.
	manual	Set the slope a, the intercept b, and the unit label of the linear function y=ax+b arbitrarily and set them on the X axis. The

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units can be set arbitrarily.

Y mapping	Select the mapping for the Y axis of the graph. The Y-axis labels will change according to the settings. linear straight line log logarithm
smoothing	Smoothing function to calculate half-widths when statistics are low.
X axis calibration	Select the unit of measure for the X axis.
Y axis calibration	Select the unit for the Y-axis.
X axis range	Right-click on the graph and check Auto Scale to make it auto scale. If unchecked, it will no longer be auto scale and the minimum and maximum values on the X axis will be fixed. To change the minimum or maximum value, place the mouse pointer over the value to be changed and click or double-click it.
Y axis range	Right-click on the graph and check Auto Scale to make it auto scale. If unchecked, it will no longer be auto scale and the minimum and maximum values on the Y-axis will be fixed. To change the minimum or maximum value, place the mouse pointer over the value to be changed and click or double-click it.
⊹	Cursor movement tool, which allows you to move the cursor on the graph by dragging it with the mouse when setting the ROI.
⊕	Zoom. Click to select and execute the following six types of zooming in and out.
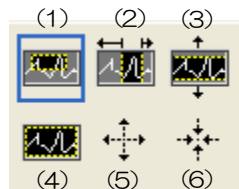
Figure 18   Graph, Zoom in and out tool

（1）Quadrangle   Zoom Using this option, click on a point on the display that is a corner of the zoom area and drag the tool until a rectangle occupies the zoom area.

（2）X-zoom   Zoom in on a region of the graph along the x-axis

（3）Y-zoom   Zoom in on a region of the graph along the Y-axis

（4）Fit zoom   Auto scale all X and Y scales on graph

（5）Zoom out around the point   Click on the center point to zoom out

（6）Zoom in around the point   Click the center point to zoom in

🖐	Pan tool Plots can be grabbed and moved around on the graph.

6．Setup tutorial

6．1．Checking the preamplifier output signal

（1） Connect the preamplifier output signal to an oscilloscope and check the wave height (mV) and polarity.
In the case of a transistor-reset preamplifier, a right ascension indicates positive polarity, and a right descent indicates negative polarity.
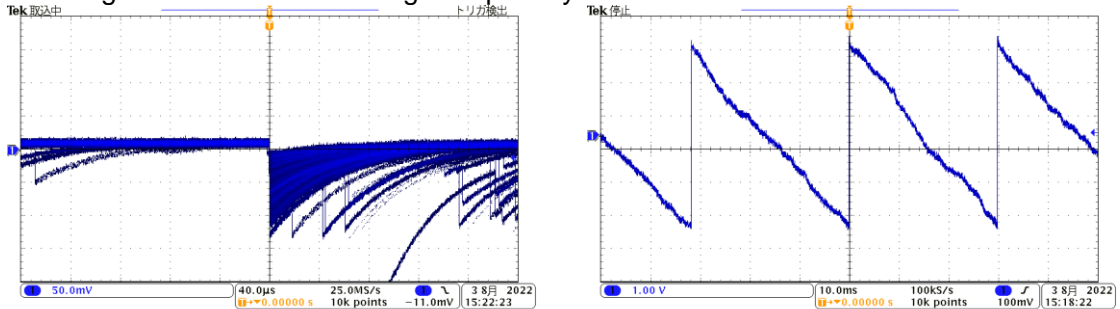
Figure 19   LEFT: Resistive feedback type for negative polarity,
RIGHT: Transistor reset type for negative polarity

6．2．Power supply and connection

（1） Turn off the power to all devices.
（2） Connect the LAN connector on the front panel to the PC with a LAN cable.
（3） If using a switching hub, turn it ON.
（4） Turn on the power to the device.
（5） Turn on the power of the PC.
（6） Connect the CH1 terminal on the front panel to the preamplifier output signal.
（7） Connect the MONI terminal on the front panel to the oscilloscope.

6．3．Setting excecution

（1） Launch this application.
（2） Set the CH tab, config tab, option tab if any, etc. First, set the polarity correctly to the polarity in the red frame in the figure below, so that the input preamp output signal can be properly processed internally.
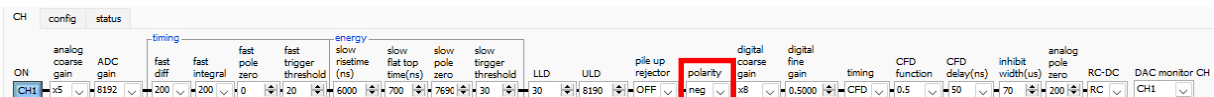
Figure 20   Example of polarity setting in CH tab

（3） Click Config menu to make all settings.

6．4．Analog Course Gain and Analog Pole Zero Adjustment of Preamplifier Output Signal

The ultra-low noise high-speed programmable gain amplifier can amplify signals from the preamplifier that require fast rise time and low noise with high accuracy. The analog course gain can be set by selecting x2 or x4 in the analog course gain in the CH tab.

* This device does not have analog fine gain setting.

An anti-aliasing low-pass filter is placed at the front of the ADC to improve S/N and eliminate fold-back noise. The cutoff frequency is set at 16 MHz.

The setting method varies depending on whether the output signal of the preamplifier of the detector input to this device is a resistive feedback type or a reset type.

6．4．1．Resistive feedback preamplifier output signal

Preamplifier output signals usually have a decay of about 50µs to 100µs. The decay is too long for this device to process, so it cannot handle high counts. Therefore, the signal is differentiated to a time constant that is easy to process internally. The undershoot that occurs in such a case is shown in the following equation, which, like the conventional analog method, causes poor overload characteristics in this device as well.

$$\text{Undershoot (\%) = different amplitude / preamp decay time}$$

（1） Check the oscilloscope for the preamp signal, which is a derivative of the preamplifier output signal from the MONI terminal on the front panel.
（2） While switching the analog course gain, adjust the preamp signal so that the wave height including the energy element to be measured stays within 1V.
For example, when measuring energy up to 2000 keV, if there is a Co-60 checking source, adjust the portion where the 1332 keV@Co-60 overlap is darker than 0.666 V (1V÷2000 keV×1332 keV).
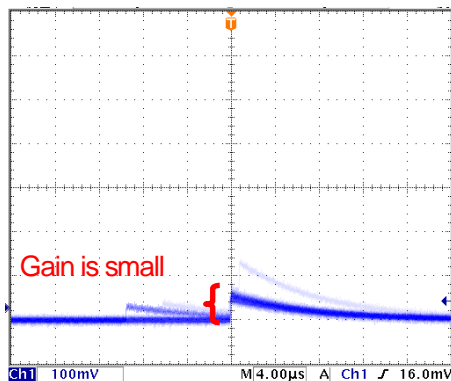
Figure 21　Before adjustment
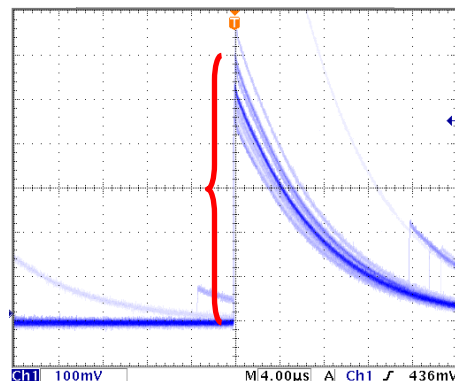
FIgure 22　After adjustment

（3） Change the analog pole zero setting and adjust the pole zero so that the falling edge is flat while switching between the vertical and horizontal ranges of the oscilloscope.
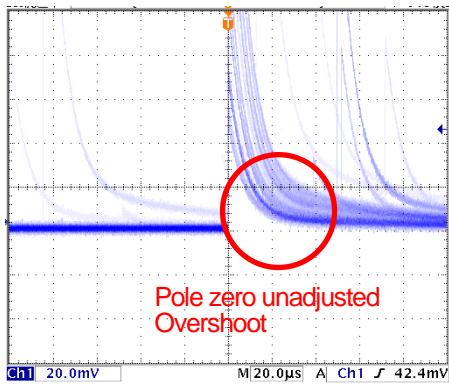
Figure 23　Before adjustment (Overshoot)
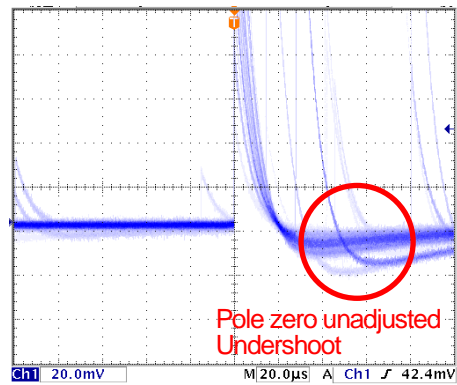
Figure 24　Before adjustment (Undershoot)
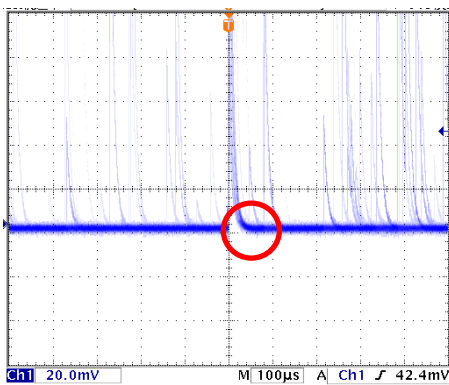
Figure 25　After adjustment
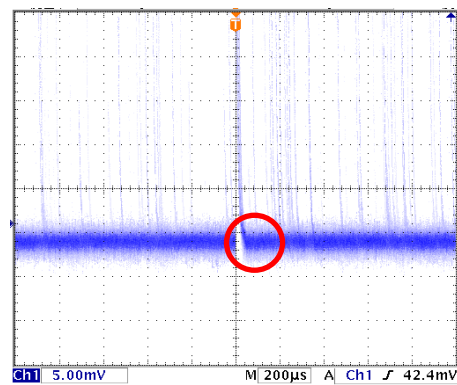
Figure 26　After adjustment,
when the horizontal axis is widened

6．4．2． For transistor-reset preamplifier output signal

（1） If power cannot be turned off, set analog pole zero to 0.
（2） If the power can be turned off, turn off all power and unplug this unit from the power rack. If it is a unit type, unscrew the lid and open it slowly, taking care of the cables attached to the lid. Remove the jumper in the red frame in the photo below from the board while checking against the jumper setting near the connector of the CH that inputs the preamplifier output signal in the photo below. (Removing it will disable the analog pole zero adjustment.

← Without jumper (with only one side plugged in)

For transistor-reset preamplifier

Picture 7　APV8016A5 base board　CH1 input section
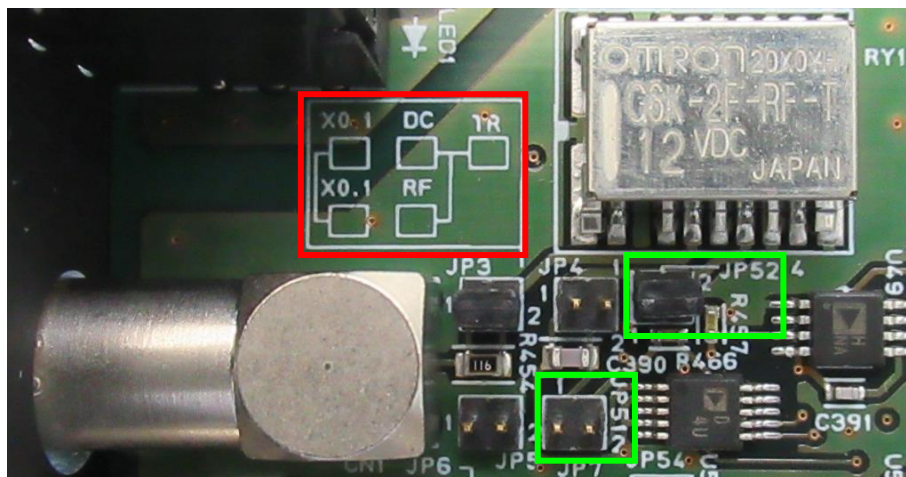
Picture 8　APV8016A4 base board　CH1 input section

When inputting a transistor-reset preamplifier output signal

(without attenuator, with first-stage derivative circuit enabled and analog pole zero circuit

disabled)

（3） Check the oscilloscope for the preamp signal, which is a derivative of the preamplifier output signal from the MONI terminal on the front panel.
（4） While switching analog course gain, adjust the wave height including the energy element of the preamp signal to within ±1 V.

6．5．FAST filter setting

The instrument has FAST filters to obtain time information during radiation detection and SLOW filters to obtain energy (wave height). First, the settings related to the FAST filter must be configured. The settings have the same characteristics as general timing filter amplifiers.

The light blue waveform in the figure below shows the waveform when the FAST system differential fast diff is set to 200 ns and the FAST integral fast integral is set to 200 ns.
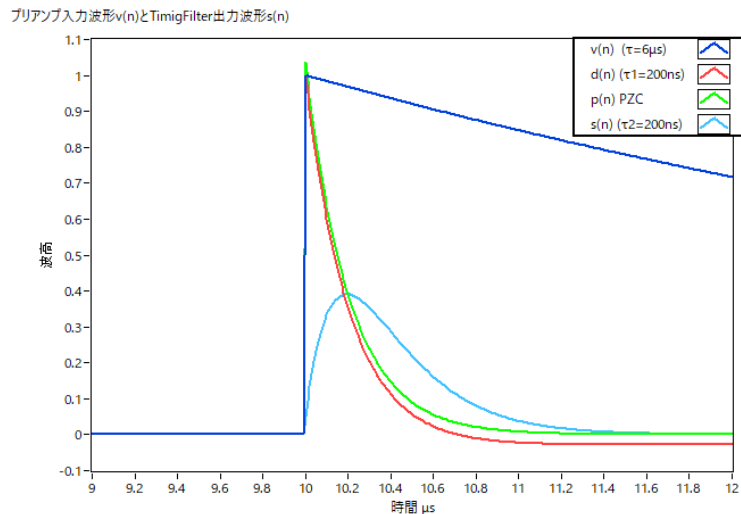
Figure 27　FAST filter (colour: light blue)
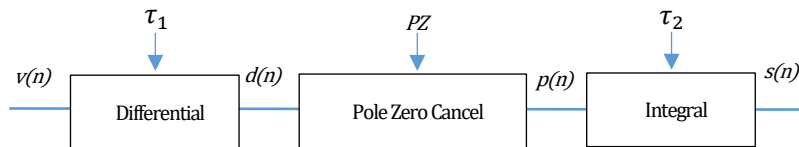
$$d(n) = v(n) - v(n-1) + \tau_1 * d(n-1) \, ,$$

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

$$s(n) = (1 - \tau_2) * p(n) + \tau_2 * s(n-1) \, ,$$

$Where$:

τ_1 : $differential\ time$,

τ_2 : $integral\ time$

PZ : $polezero$

Figure 28　　FAST filter block diagram and equations

Describes the settings for FAST-type filters.

（1） Connect the MONI terminal to the oscilloscope, select the appropriate DAC monitor CH, and set the DAC monitor type to fast. Prepare to see this signal on the oscilloscope.
（2） Set the constant of the FAST differential circuit with fast diff, selecting from ext (excluded, no filter used), 20, 50, 100, and 200.
（3） Set the constant of the FAST integral circuit with fast integral. select from ext (excluded, no filter used), 20, 50, 100, and 200.
（4） Adjust pole zero with fast pole zero. The default setting is 0 (automatic setting). The setting must be adjusted each time fast diff or fast integral is changed, but the setting is not as strict as the SLOW pole zero described below.
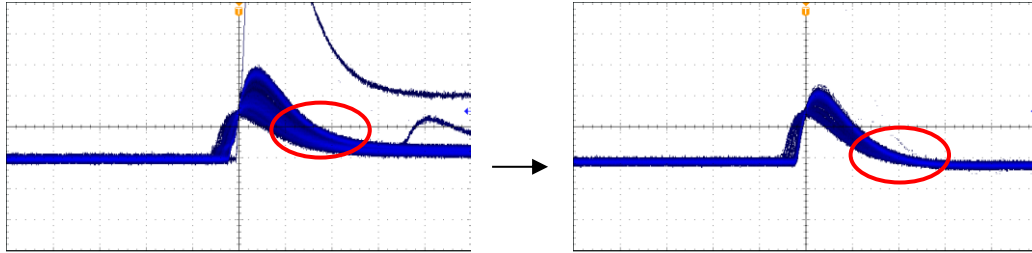
Figure 29　fast pole zero LEFT: Before adjustment (overshoots), RIGHT: After adjustment

The fast diff and fast integral settings depend on the detector and signal conditions. Examples of settings are shown below.

Detector	Features	fast diff	fast integral
LaBr$_3$ (Ce) scintillator	Fast risetime	20	ext or 20
Ge semiconductor	High energy resolution	100	100

Table 1　　fast diff and fast integral configuration examples
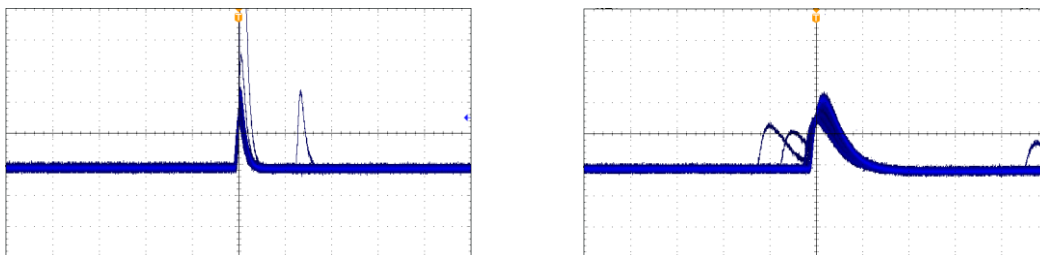
Figure 30　　Setting comparison of fast diff and fast integral

LEFT: 20 & 20,　RIGHT: 100 & 100

（5） Set the threshold for the signal detection of the FAST system filter at the fast trigger threshold. When the threshold is exceeded, a leading edge timing (LET) time stamp is performed. It is also used as a threshold for the baseline restorer and pileup rejector. This value should be set to the lowest possible value that can be discriminated from noise when connected to a detector.

First, input a somewhat large value (around 100) and observe the input total rate (cps), then gradually decrease the fast trigger threshold, and find a value at which the input total rate (cps) becomes large. This value is the boundary between signal and noise, so set the value to about +3 to +10 above that value.

6．6． SLOW filter setting

The SLOW trapezoidal filter performs SLOW trapezoidal shaping on the preamplifier output signal. As an algorithm for the trapezoidal filter (Trapezoidal Filter), the filter block, which consists of a pipelined architecture, calculates the delay, add/subtract, and integral values required for the trapezoidal filter in synchronization with the 100 MHz clock of the ADC.
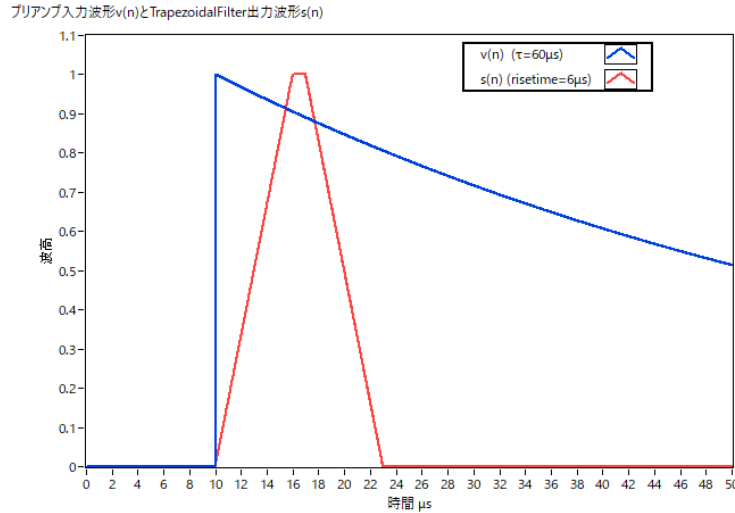
Figure 31　SLOW filter (red line)
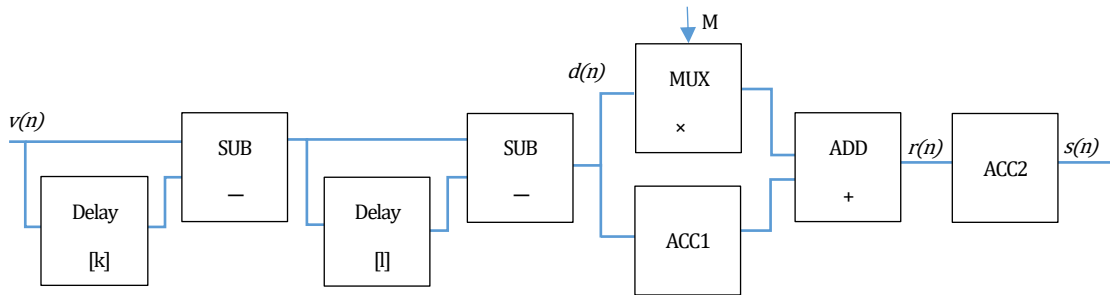
$$d(n) = v(n) - v(n-k) - v(n-l) + v(n-k-l)\,,$$

$$p(n) = p(n-1) + d(n)\,,$$

$$r(n) = p(n) - M * d(n)\,, \quad n \geq 0\,,$$

$$s(n) = s(n-1) + r(n)\,, \quad n \geq 0\,,$$

$$Where:$$

$$k : risetime\,,$$

$$l : risetime + flottoptime\,,$$

$$M : pole\ zero$$

References:

[1] V.T. Jordanov and G.F. Knoll, Nucl Instr.

and Meth.A353(1994)261-264

Figure 32　SLOW filter (Trapezoidal Filter) Block Diagrams and Formulas

　　　　TechnoAP Co., Ltd.

The figure below shows the difference in pulse response between the conventional analog Semi Gauss Filter and the DSP, which has about 1/2 the time to peak and 1/3 the pulse width compared to the Semi Gauss Filter.
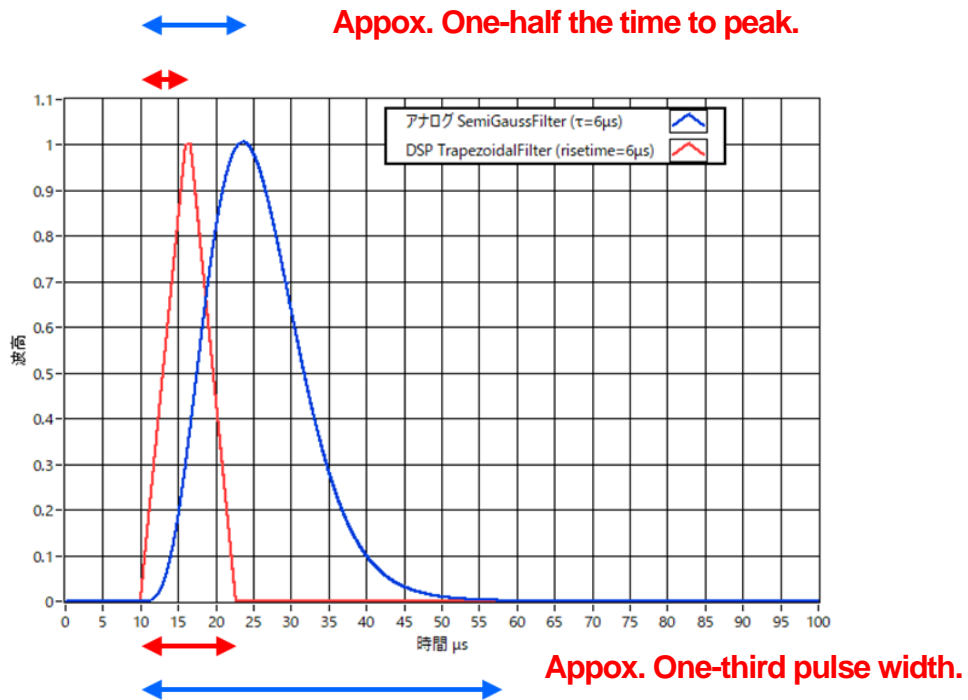
Figure 33   Difference in response between Trapezoidal Filter and Semi Gauss Filter

Despite the faster pulse response of the DSP, a comparison of the energy resolution using the Ge semiconductor detector shows that the same high resolution can be obtained at low rates at the Input Rate as shown in the figure below, and at higher rates, the data is obtained with more resolution maintained than the Semi Gauss Filter The higher rates allow the data to be obtained with better resolution than with the Semi Gauss Filter.

The digital Trapezoidal Filter process provides higher counts and richer data, allowing a variety of analyses compared to the Semi Gauss Filter.
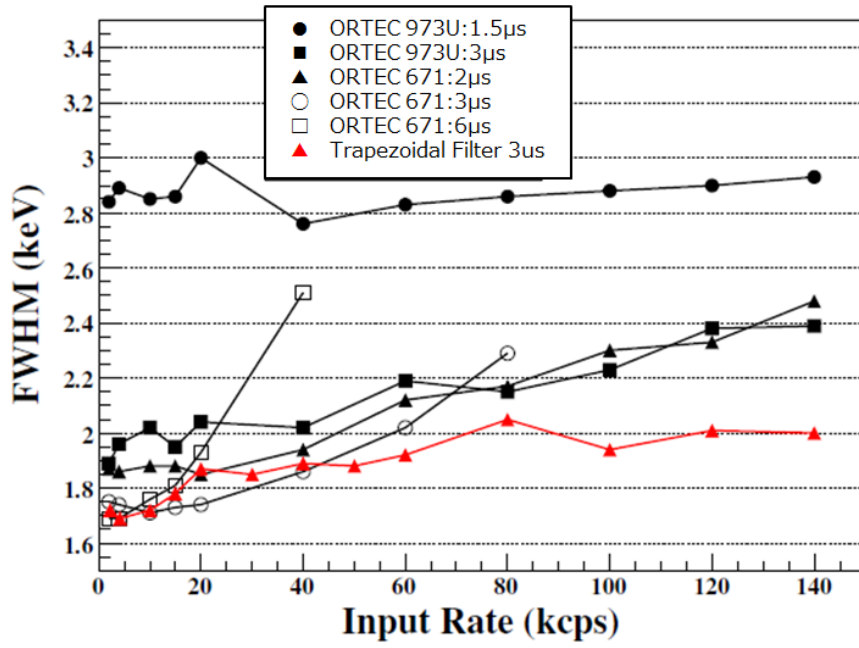
Figure 34   Difference in counting rate and energy resolution

between Trapezoidal Filter and Semi Gaussian Filter

TechnoAP Co., Ltd.

Describes the SLOW filter settings.

（1） Connect the MONI terminal to the oscilloscope, set the DAC monitor CH to the appropriate CH, and set the DAC monitor type to slow. Prepare to see the signal on the oscilloscope.

（2） To achieve the same conditions as when the linear amplifier shaping time is set to 3 µs, set the slow rise time to 6000 ns. This value affects the energy resolution. A shorter setting allows higher counts, but the energy resolution is reduced. Conversely, setting it too long may result in a low counting rate. The default setting is 6000 ns.

（3） Set the slow flattop time. For resistive feedback preamplifier output signals, set a value between 0 and 100 % of the rise time, twice the slowest rise. The recommended value is 700 ns. (In the case of transistor reset type, adjust in ±100 ns increments from 700 ns while checking the energy resolution (half value width).

（4） Set SLOW pole zero. This setting can be used to reduce overshoot and undershoot at the falling edge of SLOW filters. The default setting is 680. (This setting varies depending on the detector, so use an oscilloscope to set the optimum value.
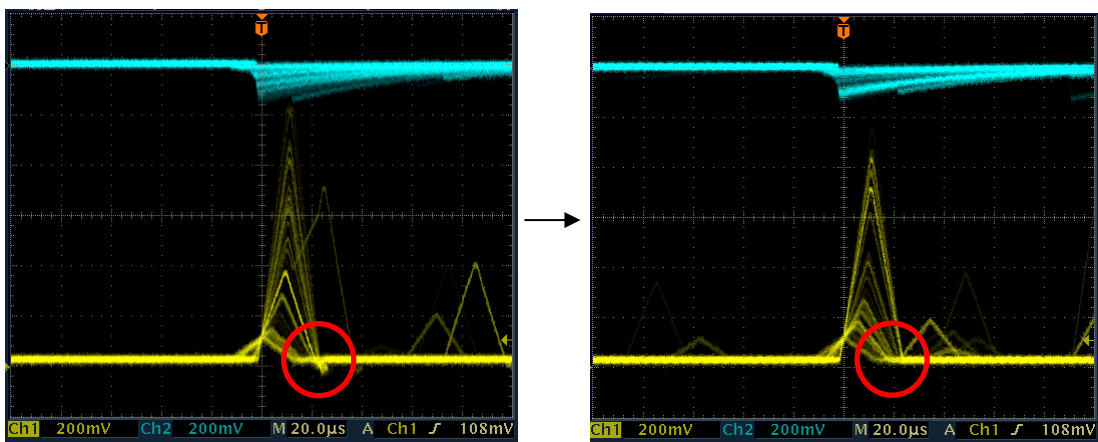
Figure 35　slow pole zero LEFT: Before adjustment (undershoot), RIGHT: After adjustment

６．７． SLOW threshold setting

First, input a somewhat large value (around 100) and observe the throughput rate (cps), then gradually decrease the slow trigger threshold, and find a value at which the throughput rate (cps) becomes large. This value is the boundary between signal and noise, so set the throughput rate (cps) to +3 to +10 above this value. The default setting is 30.

7．Measurement

7．1．Setting

（1）Click on Menu Config to send all settings to this device. After execution, the histogram data in the DSP will be initialized.

（2）To initialize the last measured histogram or measurement results, click on Menu Clear. To continue with the histogram data without initialization, start the next measurement without clicking on "Clear" in the menu.

7．2．Start measurement

Click on the menu Start. The measurement will start, and the following will be performed.
- The measurement status of each CH is displayed in the CH section.
- The acq LED blinks.
- The measurement time displays the set measurement time.
- The elapsed time acquired from the device is displayed in "real time".
- live time" displays the live time acquired from the device.
- dead time" displays the dead time acquired from this device.
- The ratio of dead time / real time (%) is displayed in the dead time ratio.

7．3．Histogram mode

When histogram is selected in mode in the config tab and measurement is started, the following is executed.
- Histogram" is displayed in mode.
- The calculation results for each ROI are displayed in the ROI section.
- The histogram is displayed in the histogram tab.
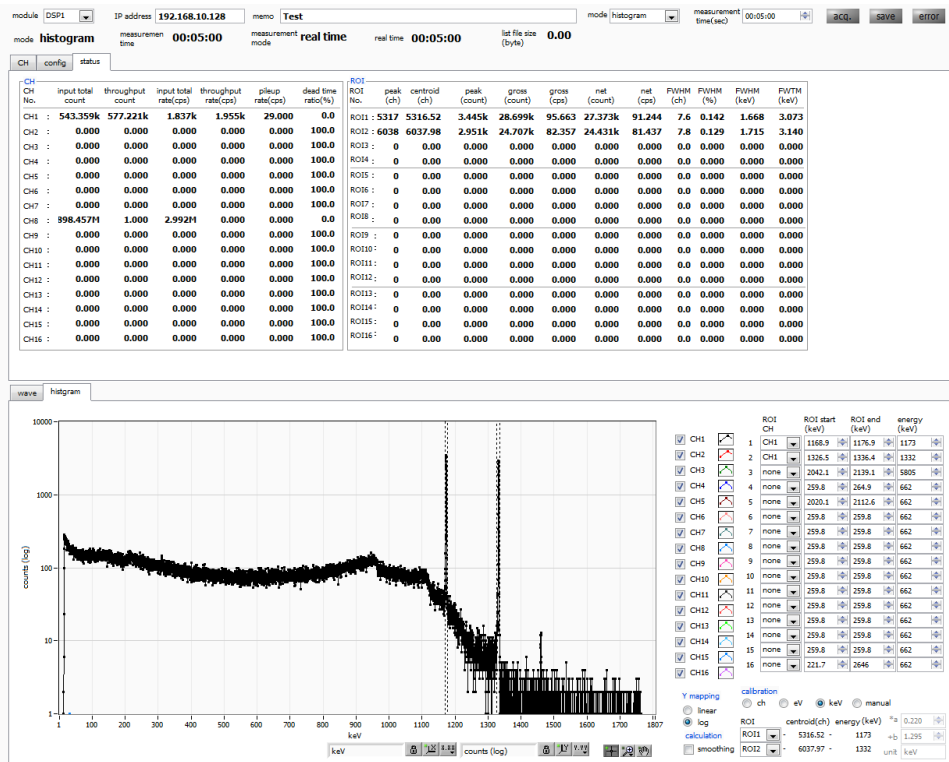
Figure 36　histogram mode measurement

7．4．List mode

When the measurement is started by selecting "list" in the mode in the config tab, the following is executed.
- The mode is displayed as "list".
- The save LED blinks and list file size (bytes) displays the size of the file currently being saved.

7．5．List wave mode＊optional

If you select "list-wave" in the mode in the config tab and start the measurement, the following will be performed.
- The mode is displayed as "list-wave".
- save LED blinks and list file size (bytes) displays the size of the currently saved file.

7．6．List pile-up wave mode＊optional

If you select "list-pup-wave" in the mode in the config tab and start the measurement, the following will be performed.
- The mode is displayed as "list-pup-wave".
- save LED blinks and list file size (bytes) displays the size of the currently saved file.

7．7．Stop measurement

- When the measurement mode is "real time", the measurement is terminated when the real time reaches the measurement time.
- If the measurement mode is "livel time," measurement will end when "live time" reaches "measurement time.
- To stop measurement during measurement, click "Stop" in the menu. Measurement is stopped after execution.
- The save LED turns off.
- The update of real time stops.
- Update of live time stops.
- Update of deadl time is stopped.
- Update of list file size (byte) is stopped.
- Update of dead time ratio is stopped.

8．Quit

Click on the menu File - quit. After a confirmation dialog appears, click the quit button to exit this application and the window will disappear. The next time the application is launched, the settings at the time of quit will be applied.

9．Various data files and formats

9．1．Histogram data file

（1） File format
Comma-separated CSV text format
（2） File name
Set arbitrarily
（3） Component
It consists of Header, Calculation, Status and Data parts.

[Header]

Memo	Memo
Measurement mode	Real Time or Live Time
Measurement time	Unit is seconds.
Real time	Real time
Live time	Live time
Dead time	Dead time
Start Time	Measurement start time
End Time	End time of measurement

* Saved for each CH below

ACG	Course gain
ADG	ADC gain
FFR	Rise time of FAST system
FFP	FAST system flat top time
SFR(ns)	SLOW system rise time
SFP(ns)	SLOW system flat top time
FPZ	Pole zero cancellation for FAST system
SPZ	SLOW-type Pole Zero Cancel
FTH	FAST system threshold
LLD	Energy LLD
ULD	Energy ULD
STH	SLOW system threshold
PUR	Pile up reject
POL	Polarity
DCG	Digital Course Gain
TMS	Timing Selection
CFF	CFD Function
CFD	CFD Delay
IHW	Inhibit Width
PZD	Analog pole zero
FGD	Baseline count manual

DIF   (Not used)

BRS   Baseline Restorer Selection

BTS   (not used)

IHT   (not used)

* End of each CH

MOD   Operation Mode

MMD   Measurement mode

MTM   Measurement time

CLS   Clock selection

SCS   WAVE sampling selection

[Calculation]

Save for each ROI below

ROI_ch   Input channel number of the ROI

ROI_start   ROI start position (ch)

ROI_end   ROI end position (ch)

Energy   Energy value of the peak between ROIs

peak(ch)   Peak position between ROIs (ch)

centroid(ch)   Center position between ROIs (ch)

peak(count)   Peak count value between ROIs

gross(count)   Sum of counts between ROIs

gross(cps)   gross(count)/measurement elapsed time

net(count)   Sum of counts subtracting background between ROIs

net(cps)   net(count)/Measurement elapsed time

FWHM(ch)   Half width between ROIs (ch)

FWHM(%)   Half width between ROIs

FWHM   FWHM width at half maximum between ROIs

FWTM   1/10 width between ROIs

[Status]

* Saved for each CH below

input total count   Total count

throughput count   Throughput count

input total rate   Total count rate

throughput rate   Throughput count rate

pileup rate   pileup rate

dead time ratio   dead time ratio

[Data]

Histogram data for each channel. Maximum 16384 points.

9．2．List data file

（1） File format

Binary, network byte order (big-endian, MSB First) format

（2） File name

The file number is the file path set in the "list file path" in the "config" tab, with 0's and 6 digits appended to it. For example, if list file path is set to D:¥data¥123456.bin and file number is set to 1, the file size is D:¥data¥123456_000001.bin.

When list file size is reached, the file being saved is closed. After that, it automatically moves up the list file number by one, opens a new file, and continues to save the data in the file.

（3） Component

80 bit per 1 event (10 Byte, 5 WORD)

Bit79					64
		real time[47..32]			
63					48
		real time[31..16]			
47					32
		real time[15..0]			
31	24	23	22 20	19	16
real time fixed minority [7..0]		Vacant	unit[2..0]	CH[3..0]	
15	14	13			0
WAV	PFG		PHA[13..0]		

Figure 37　list data format

- Bit79 to Bit32   real time. 48Bit. 10ns per 1Bit.
  Maximum measurement time is about 32 days (32 days $\fallingdotseq 2^{48}$ * 10ns)
- Bit31 to Bit24   real time fixed minority. 8Bit. 39.0625ps per 1Bit
- Bit23   Vacant
- Bit22 to Bit20   unit. Unit number. 3Bit. 0 is unit 1, 7 is unit 8
- Bit19 to Bit16   CH. channel number. 4Bit. 0 is CH1, 15 is CH16.
- Bit15   WAV. Waveform data flag. 1Bit. 1 is waveform set
- Bit14   PFG. Pile-up flag. 1Bit. 1 is pile-up occur
- Bit13 to Bit0   PHA (wave height value). 14Bit for ADC gain max. 16384

9. 3. List waveform data file＊optional

（1） File format

Binary, network byte order (big-endian, MSB First) format

（2） File name

The file number is the file path set in the "list file path" in the "config" tab, with 0's and 6 digits appended to it. For example, if list file path is set to D:¥data¥123456.bin and file number is set to 1, the file size is D:¥data¥123456_000001.bin.

When list file size is reached, the file being saved is closed. After that, it automatically moves up the list file number by one, opens a new file, and continues to save the data in the file.

（3） Component

80 bit per 1 event (10 Byte, 5 WORD)

Bit79				64
	real time[47..32]			

63				48
	real time[31..16]			

47				32
	real time[15..0]			

31	24	23	22　　20	19　　16
real time fixed minority [7..0]		空き	unit[2..0]	CH[3..0]

15	14	13		0
WAV	PFG		PHA[13..0]	

wave number[15..0]

header[31..16]

header[15..0]

wave data[15..0] × wave number

Figure 38　list-wave data format

- Bit79 to Bit32　　　　real time. 48 Bit. 10ns per 1 Bit
  Maximum measurement time is about 32 days (32 days ≒ 2^{48} * 10 ns)
- Bit31 to Bit24　　　　real time fixed minority. 8Bit. 39.0625 ps per 1 Bit
- Bit23　　　　　　　　Vacant
- Bit22 to Bit20　　　　unit. Unit number. 3 Bit. 0 is unit 1, 7 is unit 8
- Bit19 to Bit16　　　　CH. channel number. 4 Bit. 0 is CH1, 15 is CH16.
- Bit15　　　　　　　　WAV. Waveform data flag. 1 Bit. 1 is waveform set. If 1, the waveform data described below is added.
- Bit14　　　　　　　　PFG. Pile-up flag. 1 Bit. 1 is pile-up occur.

- Bit13 to Bit0   PHA (wave height value). 14 Bit for ADC gain max. 16384
- Waveform data   wave number. 16 Bit. Waveform points
- Waveform data   header. 32 Bit. The following CH information is added as a header.

CH1 header	0 x 57415630 (=WAV0)
CH2 header	0 x 57415631 (=WAV1)
CH3 header	0 x 57415632 (=WAV2)
CH4 header	0 x 57415633 (=WAV3)
CH5 header	0 x 57415634 (=WAV4)
CH6 header	0 x 57415635 (=WAV5)
CH7 header	0 x 57415636 (=WAV6)
CH8 header	0 x 57415637 (=WAV7)
CH9 header	0 x 57415638 (=WAV8)
CH10 header	0 x 57415639 (=WAV9)
CH11 header	0 x 57415641 (=WAVA)
CH12 header	0 x 57415642 (=WAVB)
CH13 header	0 x 57415643 (=WAVC)
CH14 header	0 x 57415644 (=WAVD)
CH15 header	0 x 57415645 (=WAVE)
CH16 header	0 x 57415646 (=WAVF)

- Waveform data   wave data. 16 Bits per waveform, with an offset of 32767, negative numbers from 0 to 32767, and positive numbers from 32768 to 65535. waveform information for wave number is added.

9．4． List pile-up waveforme data file＊optional

（1） File format

Binary, network byte order (big-endian, MSB First) format

（2） File name

The file number is the file path set in the "list file path" in the "config" tab, with 0's and 6 digits appended to it. For example, if list file path is set to D:¥data¥123456.bin and file number is set to 1, the file size is D:¥data¥123456_000001.bin.

When list file size is reached, the file being saved is closed. After that, it automatically moves up the list file number by one, opens a new file, and continues to save the data in the file.

（3） Component

80 bit per 1 event (10 Byte, 5 WORD) + pile-up data

Bit79						64
		real time[47..32]				
63						48
		real time[31..16]				
47						32
		real time[15..0]				
31		24	23	22	20	19 16
real time fixed minority [7..0]			Vacant	unit[2..0]		CH[3..0]
15	14	13				0
WAV	PFG	PHA[13..0]				
wave number[15..0]						
header[31..16]						
header[15..0]						
wave data[15..0] × wave number						

Figure 39　list-pileup-wave data format

- Bit79 to Bit32　　　real time. 48 Bit. 10ns per 1 Bit.
  Maximum measurement time is about 32 days (32 days $\fallingdotseq 2^{48}$ * 10 ns)
- Bit31 to Bit24　　　real time fiexed minority. 8 Bit. 39.0625ps per 1 Bit.
- Bit23　　　　　　　Vacant
- Bit22 to Bit20　　　unit. Unit number. 3 Bit. 0 is unit 1, 7 is unit 8
- Bit19 to Bit16　　　CH. channel number. 4 Bit. 0 is CH1, 15 is CH16.
- Bit15　　　　　　　WAV. Waveform data flag. 1 Bit. 1 is waveform set
- Bit14　　　　　　　PFG. Pile-up flag. 1 Bit. 1 is pile-up occur. If 1, the waveform data described below is added.

- Bit13 to Bit0   PHA (wave height value). 14 Bit for ADC gain max. 16384.
- Pile-up data   wave number. 16 Bit. Waveforme points.
- Pile-up data   header. 32 Bit. The following CH information is added as a header.

CH1 header	0 x 57415630 (=WAV0)
CH2 header	0 x 57415631 (=WAV1)
CH3 header	0 x 57415632 (=WAV2)
CH4 header	0 x 57415633 (=WAV3)
CH5 header	0 x 57415634 (=WAV4)
CH6 header	0 x 57415635 (=WAV5)
CH7 header	0 x 57415636 (=WAV6)
CH8 header	0 x 57415637 (=WAV7)
CH9 header	0 x 57415638 (=WAV8)
CH10 header	0 x 57415639 (=WAV9)
CH11 header	0 x 57415641 (=WAVA)
CH12 header	0 x 57415642 (=WAVB)
CH13 header	0 x 57415643 (=WAVC)
CH14 header	0 x 57415644 (=WAVD)
CH15 header	0 x 57415645 (=WAVE)
CH16 header	0 x 57415646 (=WAVF)

- Pile-up data   wave data. 16 bits per waveform. 32767 offset. 0 to 32767 are negative numbers and 32768 to 65535 are positive numbers. wave number is added to the waveform information.

10. Tool - gauss fit analysis

This application has a peak analysis function using Gaussian fitting. Opening a dedicated window, it is possible to separate peaks with low counts or overlapping peaks and calculate half-widths, counts, etc., for histogram data in the measurement or in a data file.

Gaussian fitting uses a Gaussian function + linear equation that takes background into account as the model function.

Initial parameter values are automatically calculated from the range set by the ROI. The Gaussian fitting algorithm uses the Levenberg-Marquardt method, which improves convergence by combining the best aspects of the steepest descent method and the Gauss-Newton method.

$$f(x\,;\,A\,,\mu\,,\sigma\,,a\,,b) = A exp\left\{-\frac{(x-\mu)^2}{2\sigma^2}\right\} + (ax+b)$$

$Where$:

$A:\ amplitude\,,\ \mu:\ center\,,\ \sigma:\ standard\ deviation$

$a:\ slope\,,\ b:\ intercept$

Formula 1　Gaussian function + linear equation

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10. 1. Startup window

Click Menu > Tool > gauss fit analysis to execute. After execution, the startup window shown below is displayed.
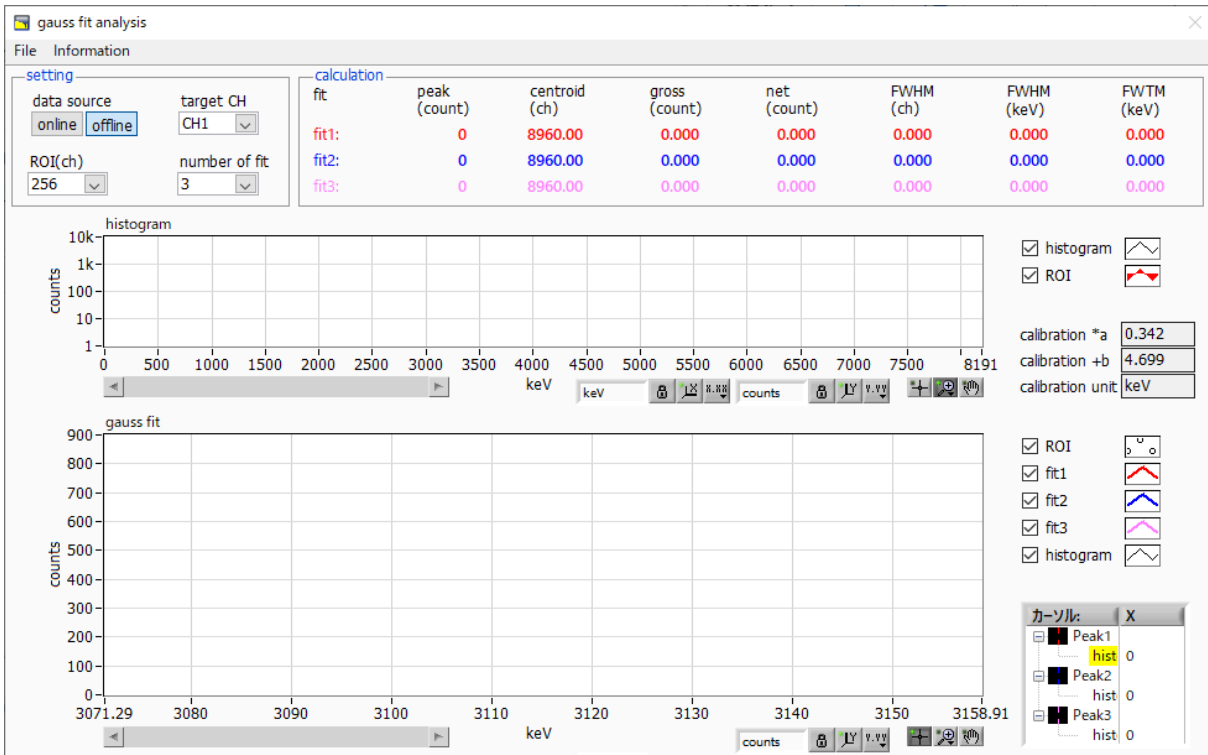
Figure 40 Gaussian fitting startup window

・Menu part

File - open gauss fit file	Gaussian fitting file loard
File - open histogram file	Histogram data file loard
File - save gauss fit file	Save Gaussian fitting data to file
File - save image	Save window in png format
File - close	Exit window
Information	Displays an information window. Displays precautions for using this window on the dialog window.
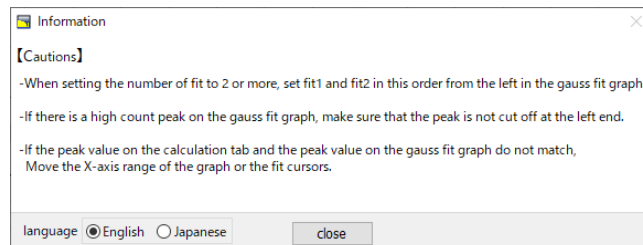
Figure 41 information window

・setting part

data source	Select the data to be analyzed.
online	Targets data currently being measured on the main window.
offline	Targets data in a pre-loaded histogram data file or Gaussian fit data file.
target CH	Setting of CH for analysis.
ROI(ch)	The number of data points to be displayed in the gauss fit graph. 256 or 512 channels can be selected.
number of fit	Set the number of Gaussian fits. It can run a Gaussian fit analysis on up to three peaks in a histogram.

・calculation part

|	
peak(count)	Maximum count.
centroid(ch)	Center value calculated from the sum of all counts (ch).
gross(count)	Sum of counts.
net(count)	Sum of counts minus background.
FWHM(ch)	Half-width.
FWHM	Half-width. * Unit is the energy calibration status on the main window
FWTM	Width of one-tenth of the peak. * Unit will be the energy calibration state on the main window.

calibration *a	The energy calibration factor*a is displayed on the main window
calibration +b	The energy calibration factor +b is displayed on the main window.
calibration unit	The unit will be displayed on the main window
histogram graph	The histogram plot in the histogram graph displays the histogram data for the Gaussian fit, and the ROI plot is the portion of the histogram displayed in the Gaussian fit graph and is displayed in red. By moving the horizontal slide bar in the lower left corner of the graph to the left or right, you can change the display position while keeping the number of points constant. Checking each checkbox displays the plot, and unchecking each checkbox hides the plot.
gauss fit graph	From the histogram data displayed in the histogram graph, the channels set by ROI(ch) are extracted and displayed from the start position of the X axis of the gauss fit graph. fit1 to fit3 plots are the Gaussian fit data for the peaks set by each cursor. The histogram plot is a concatenation of the Gaussian fit results. By moving the horizontal slide bar in the lower left corner of the graph to the left or right, you can change the display position while keeping the number of points constant. The cursor X in the lower right corner of the graph is the cursor position to be aligned with the Gaussian fit target peak. Checking each checkbox displays the plot, and unchecking each checkbox hides the plot.

１０．２．Online Gaussian Fit Analysis

Gaussian fit analysis is performed on the histograms acquired during measurement for the specified peaks using the following procedure.

（１） Select the data source as online.

（２） Starts measurement in histogram mode. The histogram being measured is displayed on the histogram graph.

（３） The gauss fit graph displays a histogram of the area of interest in the histogram graph. To set the range of the horizontal axis of this graph, first deactivate the auto scale of the horizontal axis, and then enter the minimum value of the horizontal axis of the gauss fit graph directly, or use the X-zoom function of the graph. After setting, the histogram graph will show the selected range in red on the gauss fit graph.

（４） Set up to three vertical cursors at the approximate peak area to be analyzed. To set the cursors, with the red button pressed, drag the red, blue, and peach vertical cursor lines, respectively, and drop them on the peak area. Alternatively, the cursors can be moved and set by entering a numerical value in the X value of the cursor in the lower right corner of the window.

（５） Calculation results such as half-widths based on each Gaussian fit data are displayed in the calculation section.
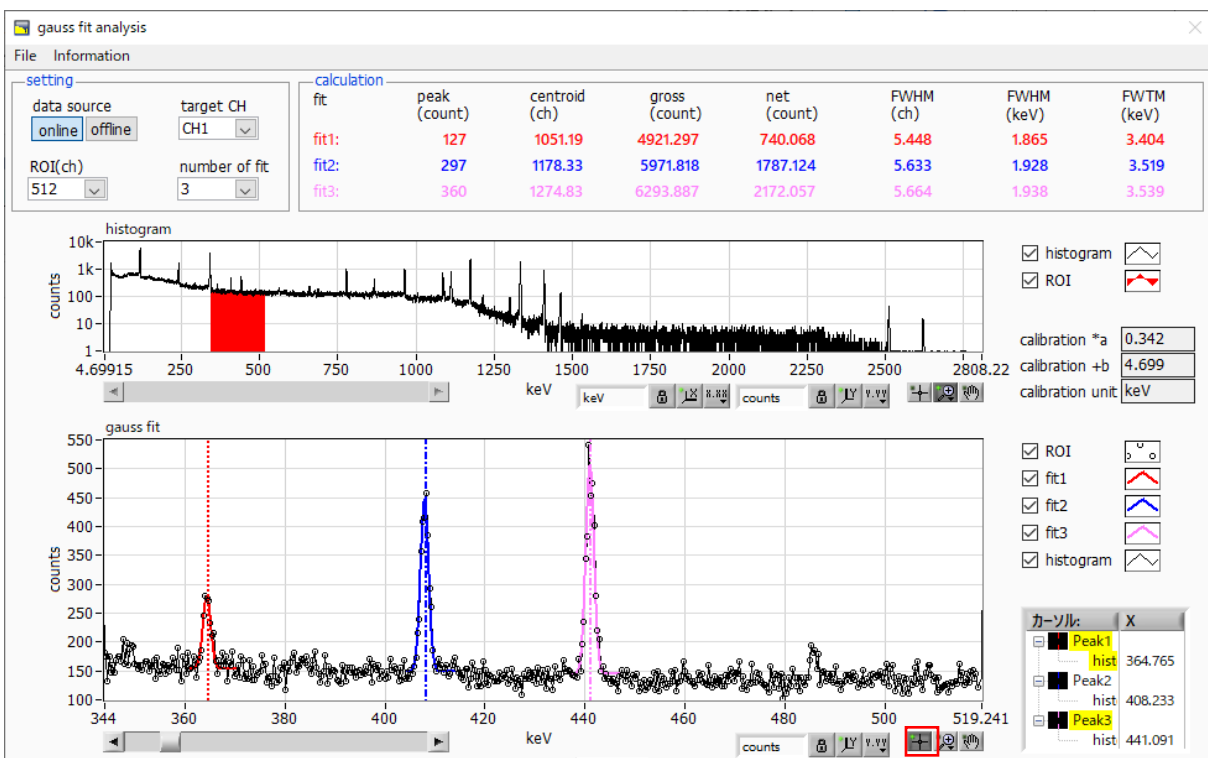
Figure 42　Gaussian fiting window, **ON-LINE**

１０．３．Offline Gaussian Fit Analysis

Perform a Gaussian fit analysis on the specified peak for the histogram obtained by reading a histogram data file or a Gaussian fit data file by the following procedure.

（１） Select data source as offline

（２） Click the menu, file, open gauss fit file or file, open histogram file, in that order. A file selection dialog appears. Select and open the data file to be read. The histogram in the data file will be displayed in the histogram graph.

The rest of the procedure is the same as the on-line mode.
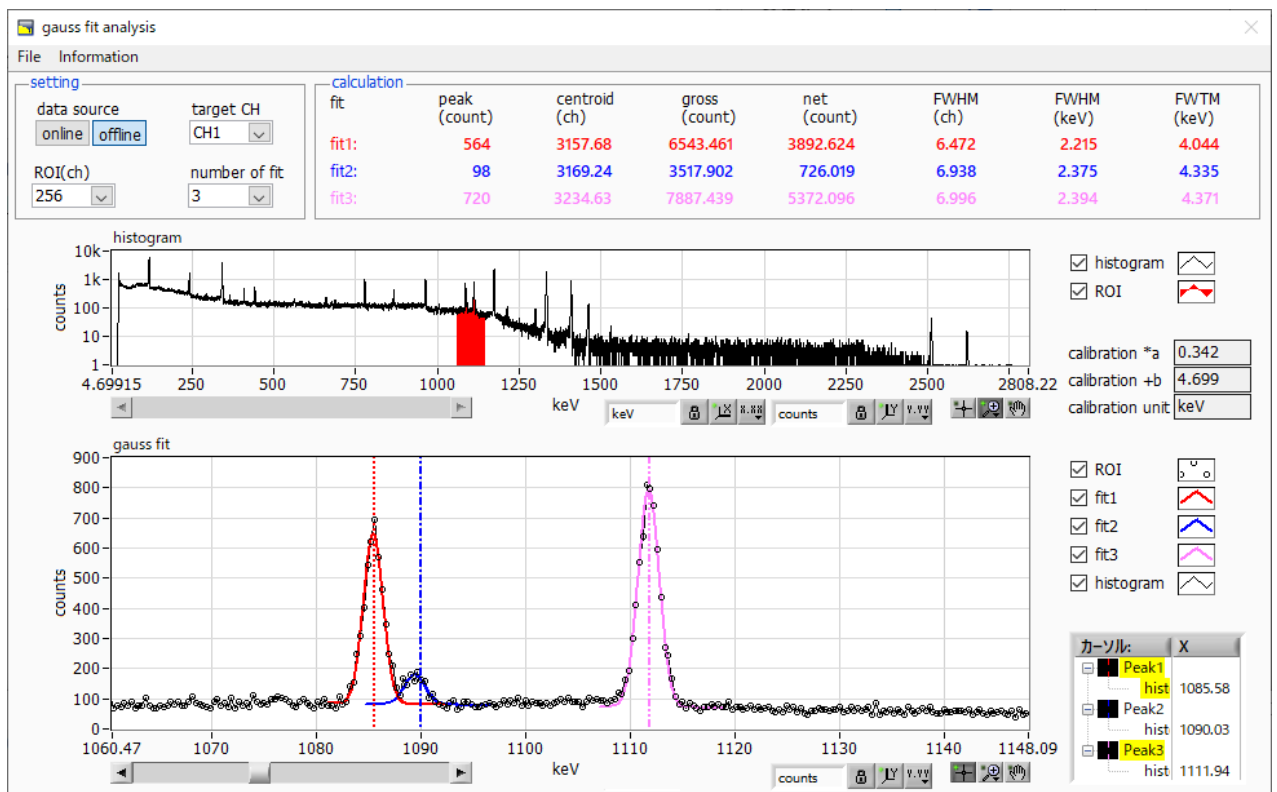
Figure 43　Gaussian fitting window, **OFF-LINE**

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10. 4. Precautions

Please note the following for proper operation on the Gaussian Fit window.

- If the number of fits is set to 2 or more, set fit1 and fit2 in the order from left to right in the gauss fit graph. if fit1 is not working properly, the following fit2 and fit3 will also be hidden.
- The peak to be fit is not cut off at both ends of the gauss fit graph, so that the entire peak is displayed.
- If the peak values in the calculation tab do not match the peak values in the gauss fit graph, please move the cursor on the horizontal axis range of the graph or on the fit.

10. 5. Quit

To close this window, click "File" and "close".

11. Tool – peak search analysis

This application has a peak search function that automatically detects peaks. Opening a dedicated window, it can automatically detect peaks and calculate half-widths, counts, etc. for histogram data during measurement or in a data file.

Peak search is performed by creating a Gaussian smoothing second derivative filter, performing smoothing second derivative on the obtained spectrum, and comparing it to the counting error. All filter parameters are automatically calculated.

$$f(x\,;a\,,\mu\,,\sigma) = \frac{a(x-\mu)^2 e^{-\frac{(x-\mu)^2}{2\sigma^2}}}{\sigma^4} - \frac{ae^{-\frac{(x-\mu)^2}{2\sigma^2}}}{\sigma^2}$$

$where:$

$a:\ amplitude\,,\ \ \mu:\ center\,,\ \ \sigma:\ standard\ deviation$
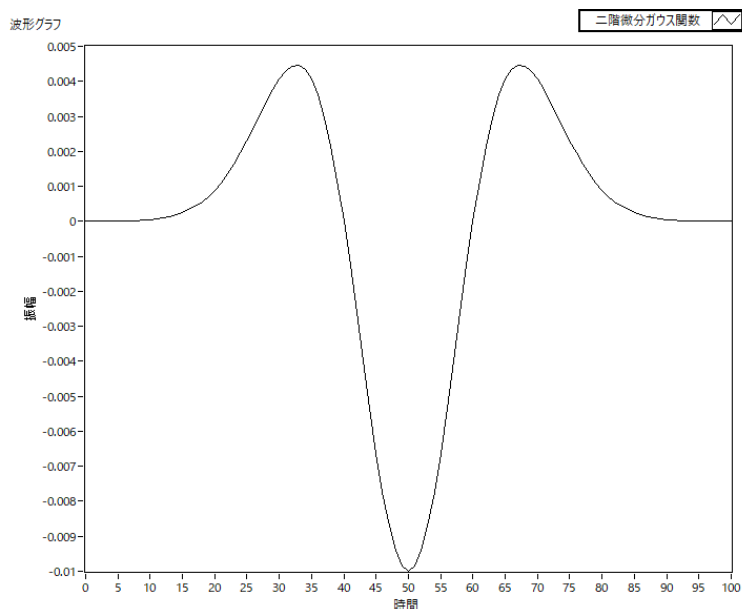
Formula 2　Second-order differential Gaussian function

11．1．Startup window

Click "Menu", "Tool", and then "peak search analysis" to execute. After execution, the startup window shown below is displayed.
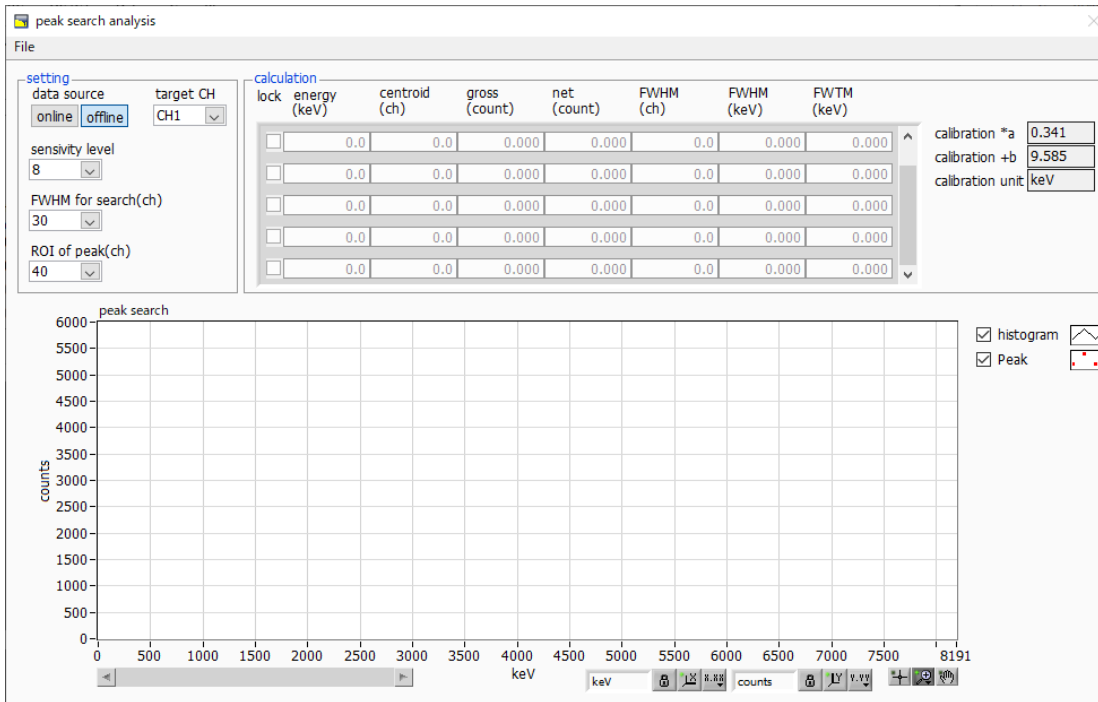

Figure 44　Peak search startup window

・Menu part

File - open peak search file	Peak search file loard
File - open histogram file	Histogram data loard
File - save peak search file	Peak search data write
File - save image	Save window in png format
File - close	Quit window

・setting part

data source　　　　　　Select the data to be analyzed.

   online　　　　　　Targets data currently being measured on the main window.

   offline　　　　　　Targets data in a pre-loaded histogram data file or Gaussian fit data file.

target CH　　　　　　Setting of CH for analysis.

sensivity level　　　　Selection of peak detection threshold. Smaller values will detect even the smallest peaks.

FWHM for search(ch)　　Approximate half-width required for peak search. Unit is channel. Set the approximate half-width from the actual peak in channels

(points).

ROI of peak(ch)   Set the number of ROI plots (CH) against the peak.

 • calculation part

lock   Check ON if you want to display it at the top of the list; if OFF, the display position may move up or down with each peak detection.

centroid(ch)   Center value calculated from the sum of all counts (ch).

gross(count)   Sum of counts.

net(count)   Sum of counts minus background.

FWHM(ch)   Half-width

FWHM   Half-width * Unit is the energy calibration status on the main window.

FWTM   Width of one-tenth of the peak * Unit will be the energy calibration state on the main window.

calibration *a   The energy calibration factor*a is displayed on the main window.

calibration +b   The energy calibration factor +b is displayed on the main window.

calibration unit   The unit will be displayed on the main window.

peak search graph   The histogram plot in the peak search graph displays the histogram data of the peak search target, and the peak plot is the area where the peak was detected and is displayed in red with a Gaussian fit. By moving the horizontal slide bar at the bottom left of the graph to the left or right, the number of points displayed remains constant while the display position can be changed. Checking each checkbox displays the plot, and unchecking each checkbox hides the plot.

１１．２．Online Peak Search Analysis

Peak search analysis is performed on histograms acquired during measurement using the following procedure.

（１） Select the data source as online.

（２） Start measurement in histogram mode. The histogram being measured is displayed on the peak search graph.

（３） The peak search graph displays a red histogram with a Gaussian fit of the detected peaks.

（４） The calculation results, such as the half value width, are displayed for each peak detected in the calculation section. When peaks are detected or not, the calculation results may move up and down, making them difficult to see. In this case, check the lock checkbox to always display the results at the top.
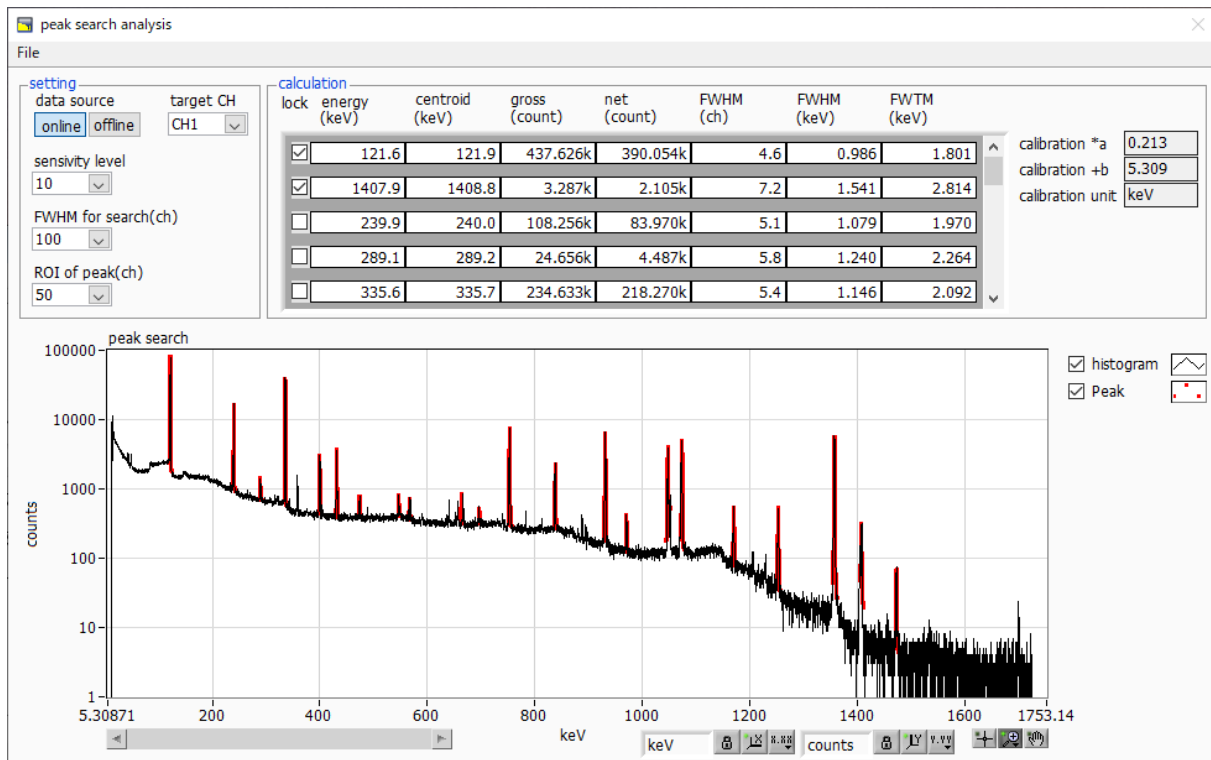

Figure 45　Peak search window, **ON-LINE**

11．3．Offline Peak Search Analysis

Peak search analysis is performed on histograms obtained by reading a histogram data file or a peak search data file using the following procedure.

（1） Select the data source as offline.

（2） Click the menu, file, open, peak search file or file, open histogram file, in that order. A file selection dialog will appear. Select and open the data file to be read. The histogram in the data file will be displayed in the peak search graph.

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

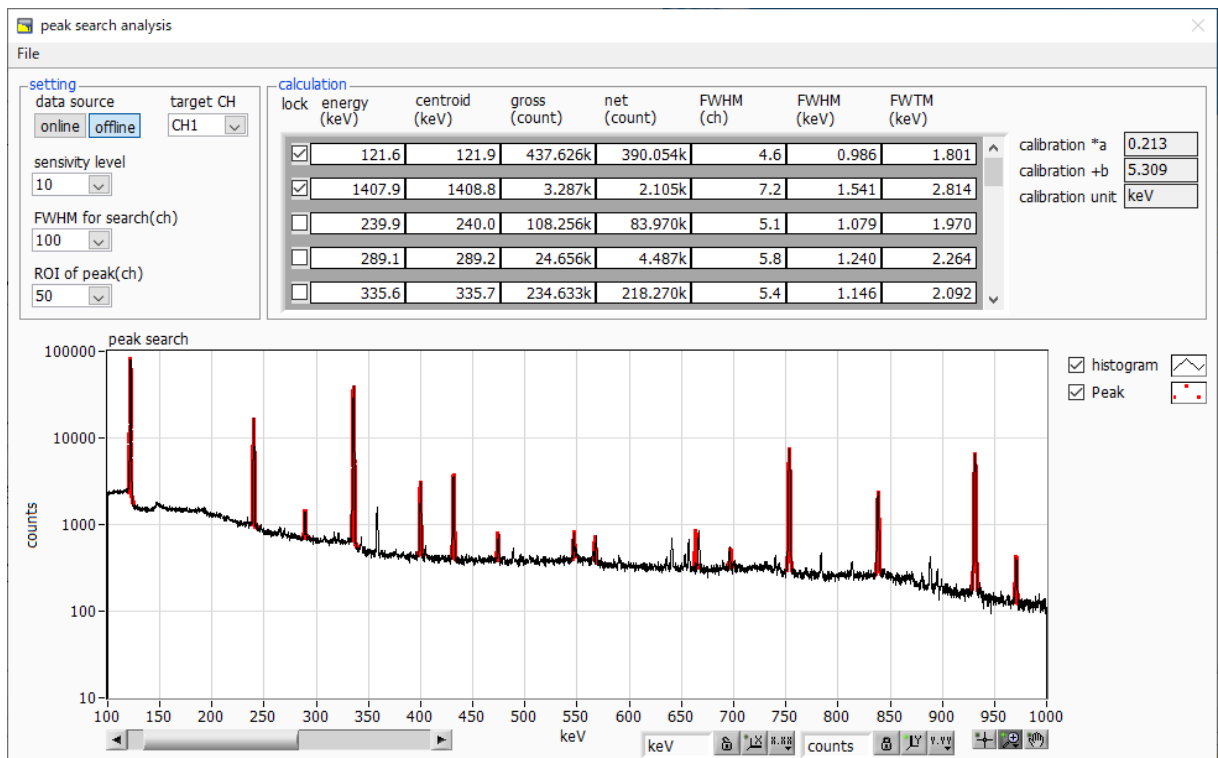Figure 46　Peak search window, **OFF-LINE**

11．4．Precautions

Please note the following for proper operation in the peak search window.

• Peak search is affected by adjusting the sensitivity level, FWHM for search (ch), and ROI of peak (ch). Adjust each setting to the optimum level while observing the shape of the red peak detection area.

11．5．Quit

To close this window, click "File" and "close" in turn.

12.　Tool‐auto analog pole zero

This application has a function to automatically adjust the analog pole zero value. The dedicated window can be opened before measurement to automatically adjust the analog pole zero.

The auto analog pole zero setting is calculated by measuring the preamplifier decay time, and the optimal value is calculated by fitting the preamplifier waveform function to the decay time measurement.

The preamplifier waveform function uses an exponentially modfied Gaussian disstribution as a model function, which is often applied to the preamplifier waveforms of semiconductor detectors such as HPGe in particular. The measurement is repeated several times to reduce the error.

However, the calculation may not be possible when the count rate is high, the preamplifier waveform does not resemble the model function, or the waveform is over-range.

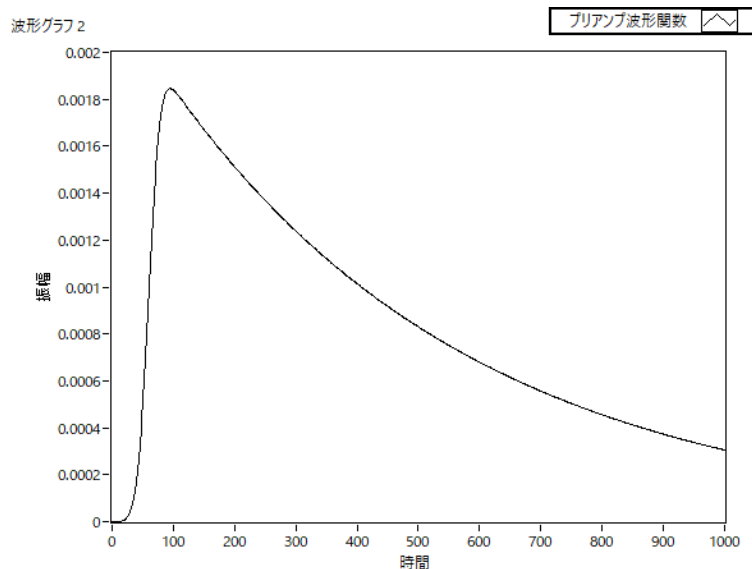$$f(x\,;\,\mu\,,\sigma\,,\lambda) = \frac{\lambda}{2} e^{(2\mu + \lambda\sigma^2 - 2x)} \operatorname{erfc}\left(\frac{\mu + \lambda\sigma^2 - x}{\sqrt{2}\sigma}\right)$$

$$where\,,$$

$$erfc(x) = 1 - \operatorname{erf}(x)$$

$$= \frac{2}{\sqrt{\pi}} \int_{x}^{\infty} e^{-t^2} dt$$

$$\lambda : decay\,,\ \mu : center\,,\ \sigma : standard\ deviation$$

Formula 3　exponentially modfified Gaussian disstribution

１２．１． Startup window

Click the "menu", "Tool", "auto analog polezero", and then execute. After execution, the startup window shown below is displayed.
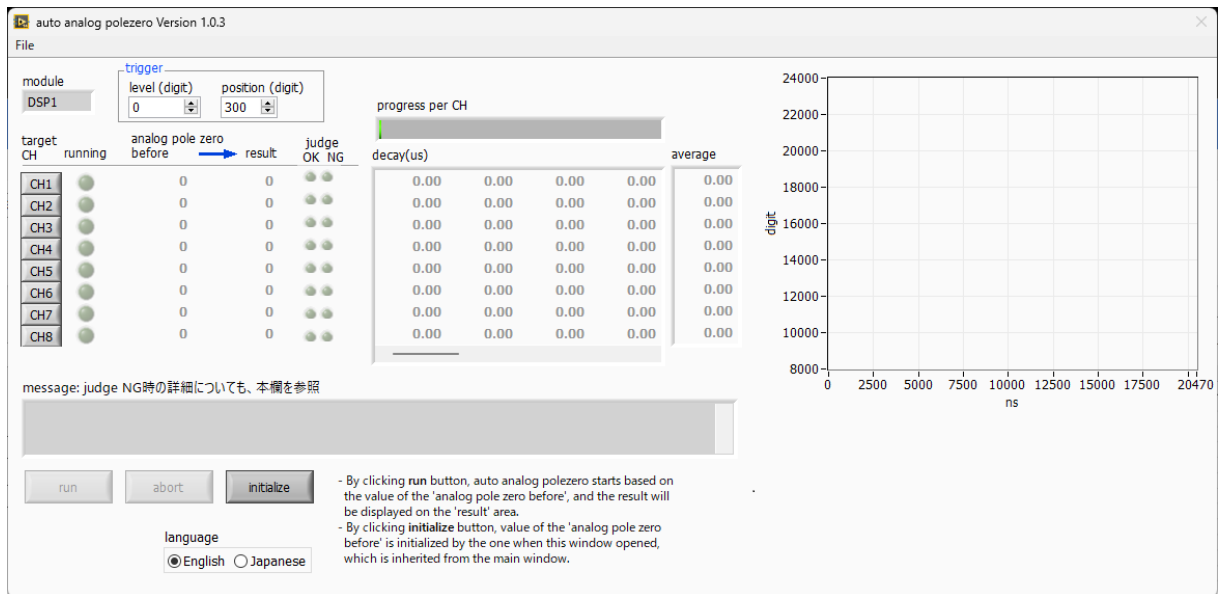

Figure 47　Auto analog pole zero startup window

・Menu part

File - close 　　　　　　　　　Exit window

・on-window

target CH 　　　　　Select target CH

running 　　　　　Auto analog pole zero in progress CH LED lights up.

analog pole zero before 　　　　Pre-execution analog pole zero setting.

analog pole zero result 　　　　Analog pole zero setpoint after execution.

judge OK NG 　　　　Interpretation of results.

decay(μs) 　　　　Decay (decay portion) time history of the waveform taken during the execution of auto analog pole zero. Measured a certain number of times.

average 　　　　average of decays per CH

progess per CH 　　　Procression rate per CH

message 　　　　Execution result display.

run 　　　　Auto analog pole zero execution starts. auto analog pole zero is executed only for the CH selected in target CH.

abort 　　　　Auto analog pole zero execution abort.

initialize 　　　　Reset the analog pole zero value to ones when this tool starts.

language 　　　　Switch language of the explanatory text.

１２．２． Execution

Auto analog pole zero execution.

（１） Before opening this window, check whether the signal input to each CH of the device is positive or negative, and set the polarity in the main window in advance.

（２） Select the target CH with tagget CH.

（３） Click the run button. Auto analog pole zero will start immediately.

The running LED is lit on the CH being processed, and the decay time of the acquired waveform is displayed in the decay column for a certain number of times.

After the specified CH has been acquired a certain number of times, the calculated value is displayed in the analog pole zero result, and the execution result comment is displayed in the message column.
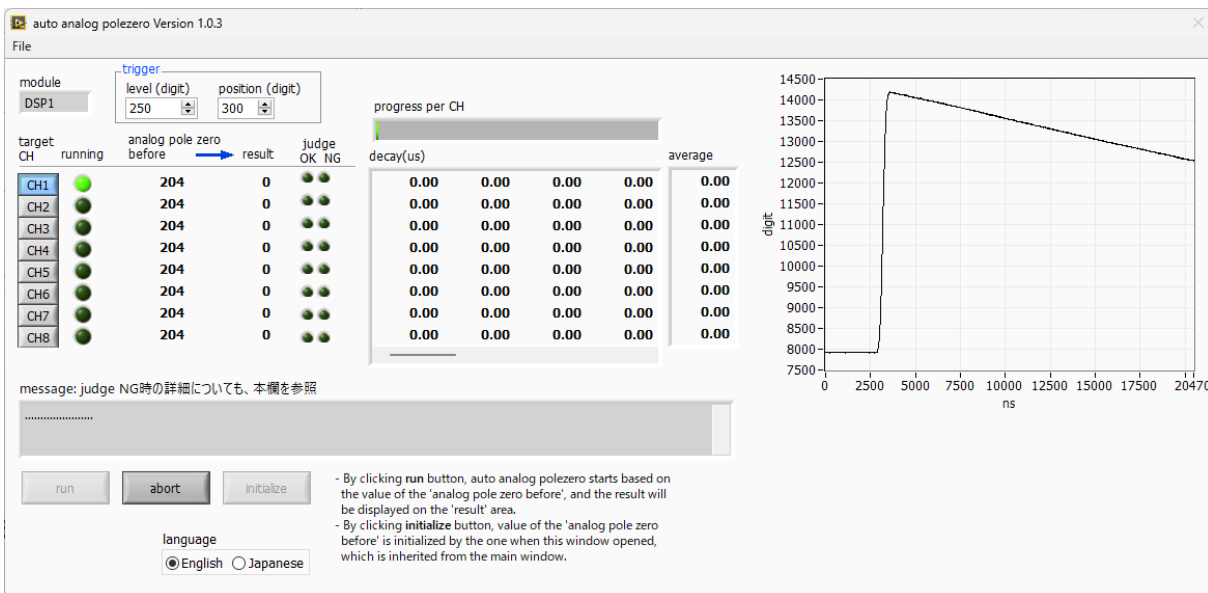

Figure 48　Auto analog pole zero execution window

To abort during execution, click abort. It will be aborted immediately after the click.

１２．３．Precautions

Please note the following for proper operation in the Auto Analog Pole Zero window.

（１） Correctly set the polarity of the input signal in the POLARITY on the main window.

（２） If the count is low, use a checking source, etc.

１２．４．Quit

To close this window, click "File", "close" in turn.

If you have executed at least once, a confirmation dialog will be displayed, so you can select whether to reflect the result in the analog pole zero on the main window side.

If you choose Yes, only the analog pole zero result of the successfully completed CH will be reflected in the analog pole zero on the main window.

13. Troubleshooting

13. 1.　　Connection error occurs

If you get a connection error at startup or in menu config, your network may not be connected properly. In this case, check the following.

（1） Confirm that the IP in the configuration file config.ini is set to 192.168.10.128, that each port number in the [System] section is defined as follows, and that the IP address is the same when you start this application.

　　　[System]

　　　PCConfigPort = 55000

　　　PCStatusPort = 55001

　　　PCDataPort = 55002

　　　DevConfigPort = 4660

　　　DevStatusPort = 5001

　　　DevDataPort = 24

　　　SubnetMask = "255.255.255.0"

　　　Gateway = "192.168.10.1"

（2） Check if the PC's network information is configured to connect to this device. The default values for this device are as follows.

　　　IP address　　　　　192.168.10.128

　　　Sub-net mask　　　　255.255.255.0

　　　Default gateway　　　192.168.10.1

（3） There is a conflict with an arbitrary port number on the PC side for the UDP connection. In this case, define another number for Port in the configuration file config.ini before startup.

（4） Turn on the power with the Ethernet cable connected.

（5） Execute the ping command at the command prompt to check if the device and PC can communicate.

（6） Turn the power of the device back on and execute the ping command again.

（7） Turn off virus detection software and firewall software.

（8） Always turn on power-saving functions such as PC sleep mode.

Disable the wireless LAN function for laptops, etc.

13. 2. Command error occurs

The combination of firmware and application for this device may not match due to the presence or absence of options, etc. Please contact us for further information.

13. 3. Histogram is not displayed

If nothing appears in the histogram tab graph after executing Menu Start, check the following

points

（1） Set CH1 to ON at plot ON in the histogram tab.
（2） Check if input total rate (cps) and throughput rate (cps) are counting.
（3） Set DAC monitor CH to CH1 and DAC monitor type to pre-amp, and check that the pre-amp wave height is not too small or too large, and that it is within 1V.
（4） Set DAC monitor type to fast and check if the FAST filter signal is output.
（5） Set the DAC monitor type to slow and check if the SLOW filter signal is output.
（6） Make sure that the fast trigger threshold and slow trigger threshold values are not too small or too large, and while watching the input total rate (cps) and throughput rate (cps) counts, change the settings from 100 to 30 or so.
（7） Right-click on the X and Y axes of the graph to set auto scale.

13. 4. Change IP addres

Refer to the attached "Instruction Manual: How to Change the IP Address of the APG5107-

Equipped Product". (If you do not have the attached document, please contact us.

14. APV8016A performance graph

14. 1. Energy resolution and counting rate

High resolution and high counting rate spectroscopy is possible with the latest digital signal processing.
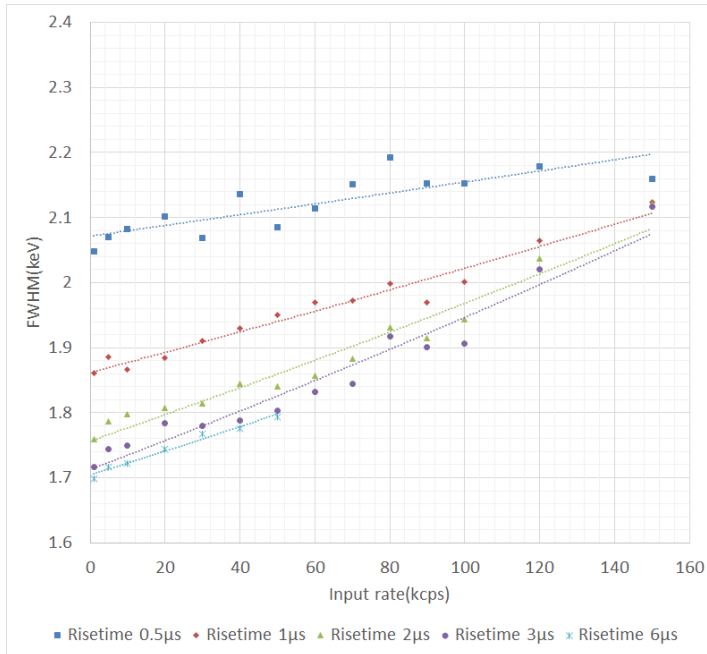

14. 2. Input and output count rates

The use of digital signal processing by FPGA eliminates the dead time of conversion and reset time in conventional MCA. The throughput of this device is well consistent with the paralysis model curve $m=ne^{(-n\tau)}$ where τ = risetime + flattoptime. However, since the response speed of the detector is also a factor, the slower the detector or the higher the counts, the greater the difference will be.
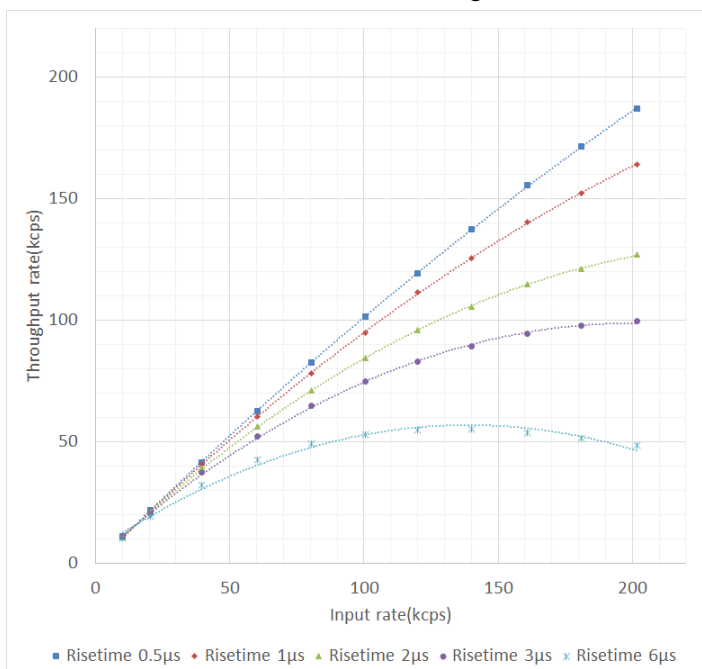
* By our own PGT IGC10200 HPGe detector.

１４．３． Linearity

APV8016A has very good linearity; when energy spectra were measured with Ge semiconductor detectors using Eu152 and Co60 sources, the theoretical values were compared with the actual measured ch. The calibration of the ch and energy of the spectrum was performed at 121 keV and 1332 keV, and it was confirmed that the deviation from the theoretical value is smaller than 1ch in the entire energy band, and the linearity is good.
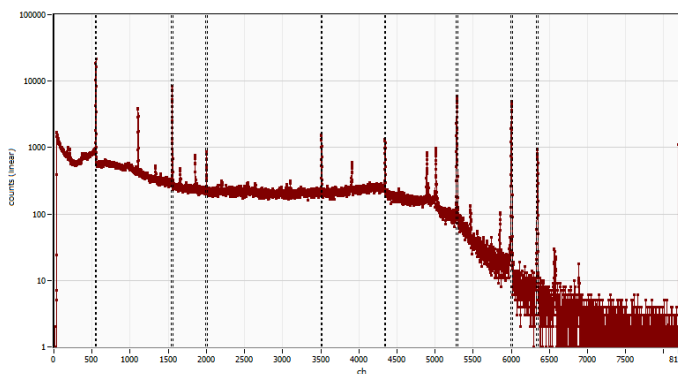

Eu-152 と Co-60 エネルギー(keV)	理論値(ch)	計測値(ch)	差(ch)
121.7817	550.0400	550.04	0.0000
344.2785	1552.0371	1552.03	0.0071
443.9650	2000.9675	2000.46	0.5075
778.9045	3509.3416	3509.86	-0.5184
964.0720	4343.2291	4343.08	0.1491
1173.2280	5285.1469	5285.23	-0.0831
1332.4920	6002.3800	6002.38	0.0000
1408.0130	6342.4830	6342.41	0.0730

15. Example of Measurement

15. 1. Energy spectrum when using transistor reset type Ge semiconductor detector

The APV8016A is equipped with a CR circuit on its inputs, allowing it to handle a wide variety of high-count inputs. One of the inputs is a transistor reset type input, which is designed to handle large voltage swings during reset in CR circuits that are digitized with a large transient response. The DSP is designed to sense the reset immediately, and to process the next signal as fast as possible after a dead time.
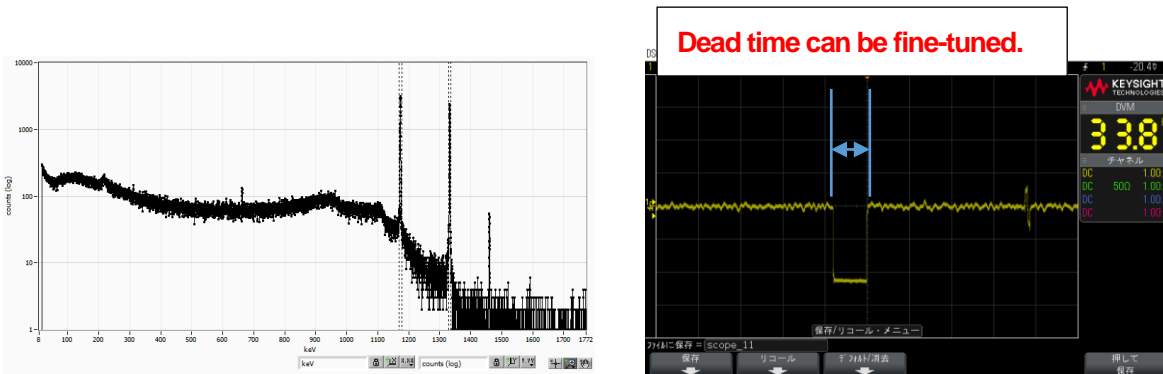
* Measurement by our own CANBERA reset type Ge detector and processing at reset of slow waveform

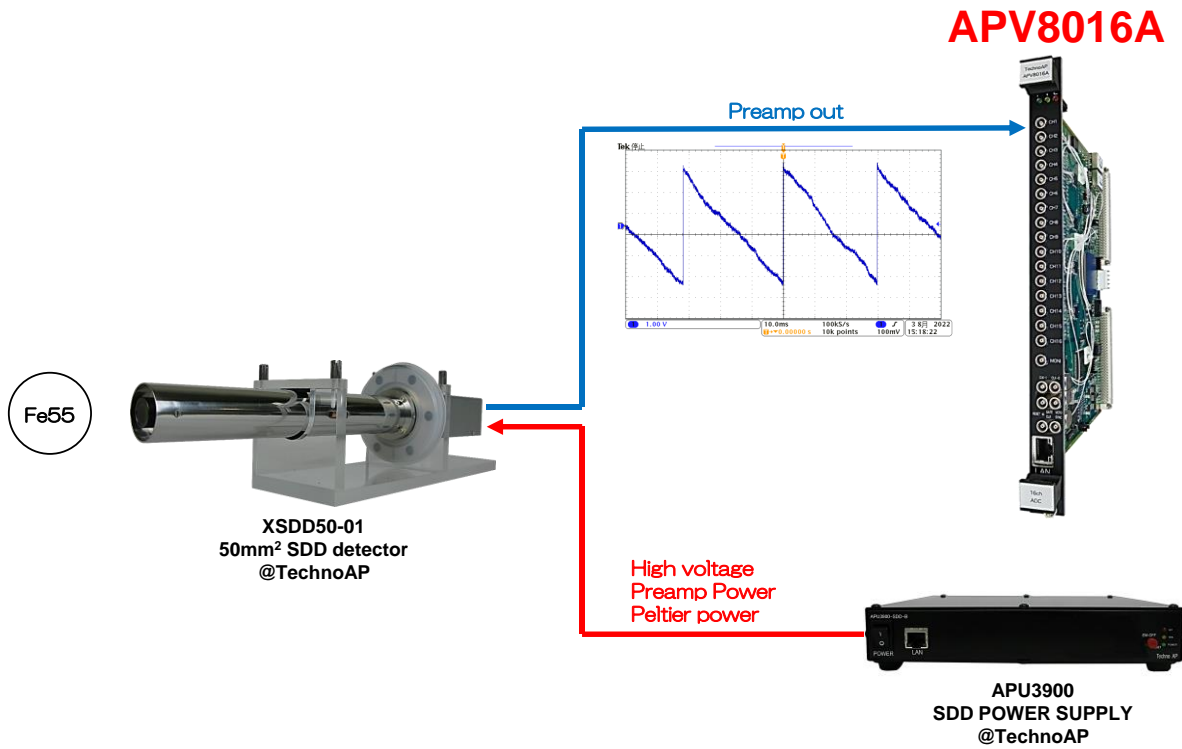## 15. 2. Example of multi-element Ge detector measurement

The following is an example of using a multi-element Ge semiconductor detector. Although the input signal level differs from detector to detector, the gain and Trapezoidal Filter settings can be set very precisely, so that even with multi-element, multi-CH, it is possible to obtain an energy spectrum with exactly matched peak positions. Also, the matching of the energies makes it easier to analyze the list data.
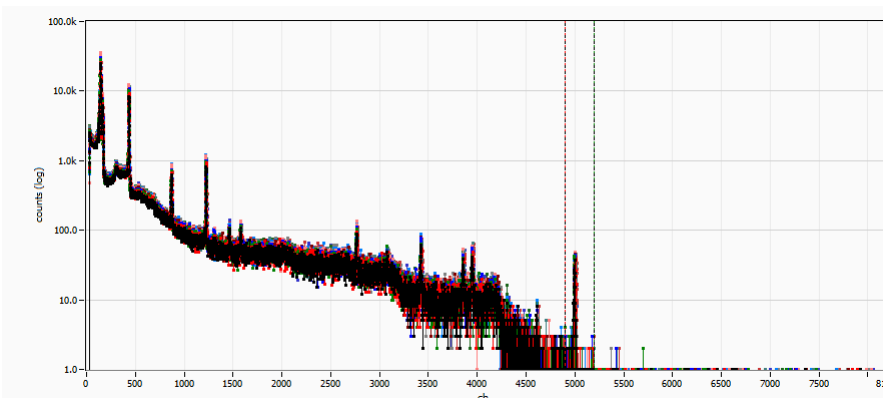
* Example using pixel/strip Ge semiconductor detector

## 15.3. Example of Silicon Drift Detector (SDD) measurement

The silicon drift detector is capable of high energy resolution and high-count measurement of X-rays. The APV8016A can input and measure signals from the SDD detector. The APV8016A has an optimized recovery process from a reset signal to achieve high counting and high resolution. An energy resolution of 126eV@5.9keV is achieved using a Cube-type silicon drift detector.

APV8016A

Preamp out

Fe55

XSDD50-01
50mm² SDD detector
@TechnoAP

High voltage
Preamp Power
Peltier power

APU3900
SDD POWER SUPPLY
@TechnoAP

ROI No.	peak (ch)	centroid (ch)	peak (count)	gross (count)	gross (cps)	net (count)	net (cps)	FWHM (ch)	FWHM (%)	FWHM (eV)	FWTM (eV)
ROI1 :	750	749.65	88.846k	1.550M	5.168k	1.498M	4.993k	16.0	2.142	126.364	231.663
ROI2 :	825	824.53	21.818k	440.341k	1.468k	375.308k	1.251k	17.2	2.091	135.676	249.977

ROI1 : 5.9keV@Fe55Kα   ROI2 : 6.4keV@Fe55Kβ
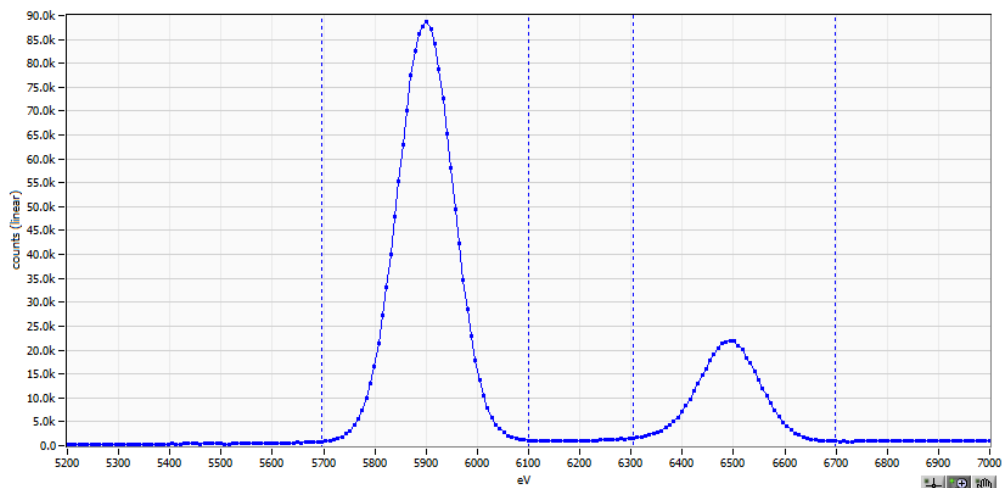
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