

TechnoAP SDD Products

Silicon Drift Detector Adjustment Procedure

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TechnoAP Co., Ltd.

2976-15 Mawatari, Hitachinaka-shi,
Ibaraki 312-0012

TEL : 029-350-8011

FAX : 029-352-9013

URL : <http://www.techno-ap.com>

e-mail : info@techno-ap.com

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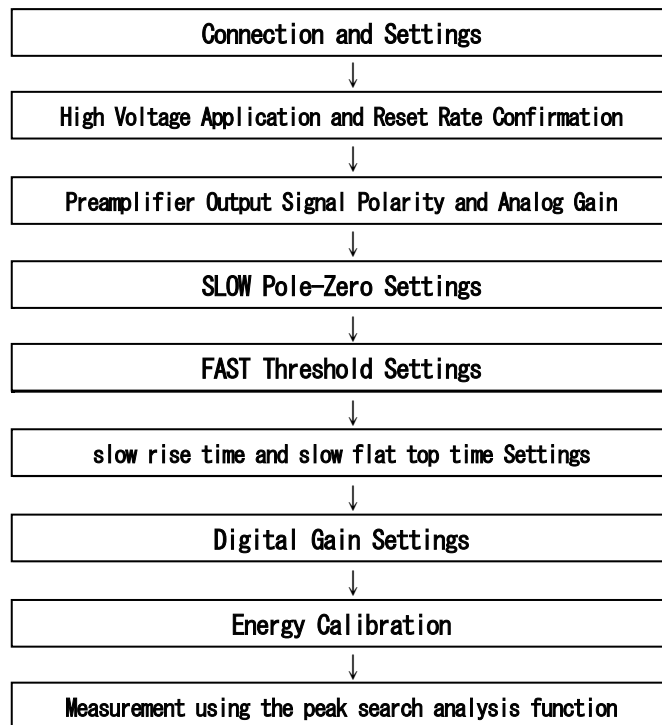
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1. Overview

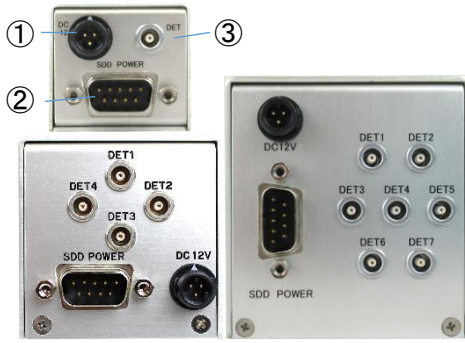
This document describes the adjustment procedure for a silicon drift detector using the APU101X, a DSP-equipped product manufactured by TechnoAP.

For details on device connections, parameters, and troubleshooting, please refer to the respective instruction manuals.

The flow of the adjustment procedure is as follows.

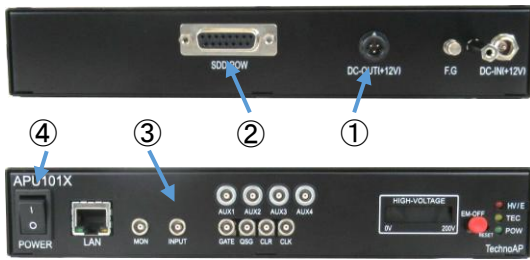


2. Connection and Settings



Back of the SDD detector (Top left: 1 element, Bottom left: 4 elements, Right: 7 elements).

- ① HR30 connector for fan power supply
- ② Dsub 9-pin connector for preamp power supply, Peltier power supply, and HV power supply
- ③ LEMO connector for preamp signal output

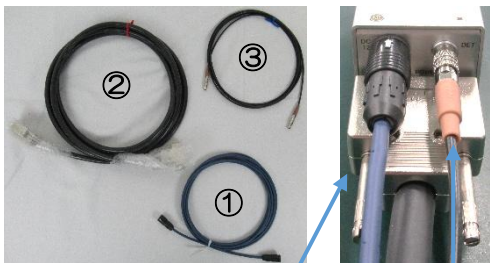


Back and front of APU101X.

- ① HR30 connector for fan power supply
- ② Preamp power supply, Peltier power supply, HV power supply
- ③ LEMO connector for preamp output signal input
- ④ POWER switch. "0"...Off, "1"...On



The compact version of APU101X also has the same functions.

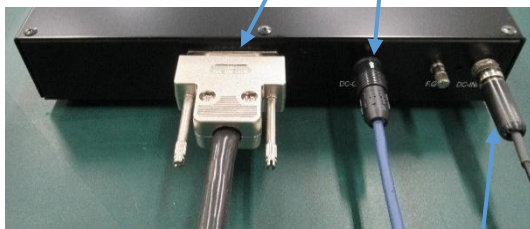


Verify the cables connecting to the detector.

- ① HR30 connector cable
- ② Dsub9-Dsub15 cable for preamp power supply, Peltier power supply, and HV power supply
- ③ LEMO cable for preamp signal output

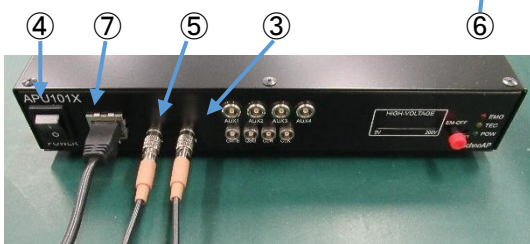


Ensure that the APU101X is powered off, and connect the same numbers together.

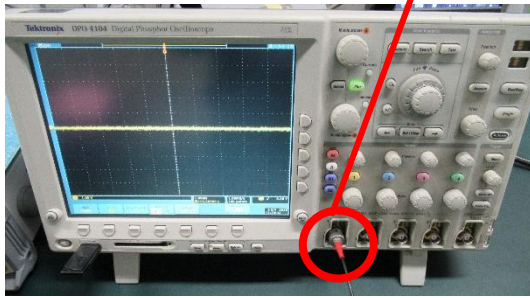


This is the state after connecting cables ① to ③. Further connect the following to the APU101X.

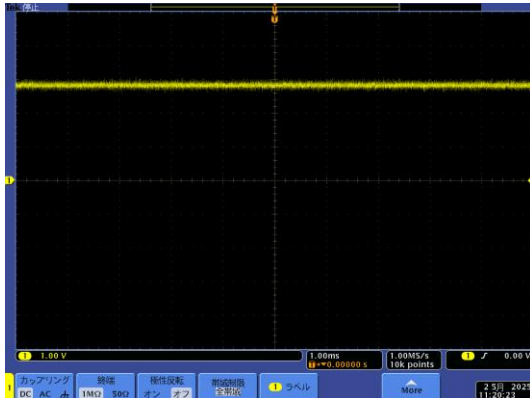
- ⑤ LEMO cable for signal output to oscilloscope. The end of the cable is currently unconnected.
- ⑥ Included power cable for APU101X
- ⑦ LAN cable for PC connection



Preamp signal output



Temporarily connect the preamp signal connected to front ③ to the oscilloscope. Before turning on the power, it is 0V.



Turn ON the POWER switch on the front ④. Power is supplied to the APU101X, and the supply of preamp power and Peltier power to the SDD detector begins.

Looking at the oscilloscope, it can be confirmed that the preamplifier output signal sticks near +3V.

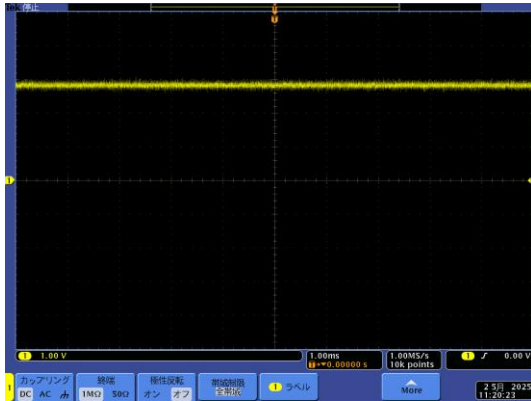
If sticking near +3V cannot be confirmed, an abnormality in the preamplifier power supply is suspected. Immediately turn OFF the POWER switch and discontinue use.

3. High Voltage Application and Reset Rate Confirmation

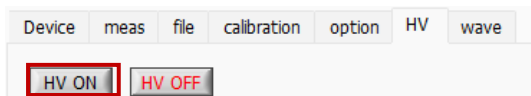
HV off					acq.	save	error	mode	histogram
net	FWHM	FWHM	FWHM	FWTM			meas. mode	real time	
(cps)	(ch)	(%)					meas. time	24:00:00	
NaN	0.0	0.000	0.000	0.000			real time	00:00:00	
NaN	0.0	0.000	0.000	0.000			data file size(byte)	0.000	
000	0.0	0.000	0.000	0.000			meas. count	0 / 1	
000	0.0	0.000	0.000	0.000			quick scan	0 / 10	
000	0.0	0.000	0.000	0.000			peltier	on	
000	0.0	0.000	0.000	0.000			HV output	0 V	
000	0.0	0.000	0.000	0.000			HV status	shutdown	
000	0.0	0.000	0.000	0.000			set voltage(V) sweep(V/min)		
000	0.0	0.000	0.000	0.000				-168 V 400 V/min	

Launch the application and check the "HV" settings.

The polarity of the SDD detector is neg. The high-voltage power supply is set to apply a voltage of -168V. The sweep speed is set to 400V/min.



Oscilloscope image before high voltage application (when OFF).



When starting high voltage application, click the red box "HV ON".

HV sweep					acq.	save	error	mode	histogram
net	FWHM	FWHM	FWHM	FWTM			meas. mode	real time	
(cps)	(ch)	(%)					meas. time	24:00:00	
NaN	0.0	0.000	0.000	0.000			real time	00:00:00	
NaN	0.0	0.000	0.000	0.000			data file size(byte)	0.000	
000	0.0	0.000	0.000	0.000			meas. count	0 / 1	
000	0.0	0.000	0.000	0.000			quick scan	0 / 10	
000	0.0	0.000	0.000	0.000			peltier	on	
000	0.0	0.000	0.000	0.000			HV output	-47 V	
000	0.0	0.000	0.000	0.000			HV status	shutdown	
000	0.0	0.000	0.000	0.000			set voltage(V) sweep(V/min)		
000	0.0	0.000	0.000	0.000				-168 V 400 V/min	

During high voltage application, "HV sweep" will light up on the output as shown in the red box.

The blue box shows the monitor voltage of the currently applied voltage value.



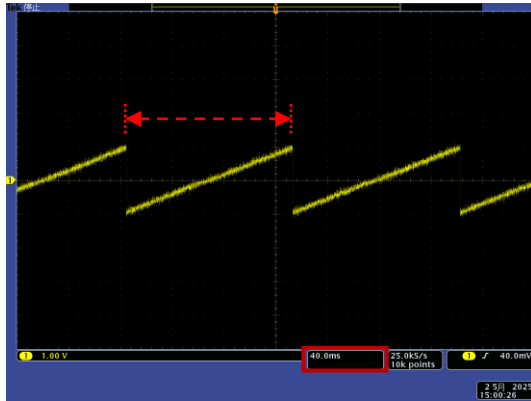
Example during sweep, reset rate approx. 60 ms. Gradually expand.

In the case of a transistor reset type preamplifier, positive polarity can be confirmed if it rises to the right as shown in the figure.

HV on					acq.	save	error	mode	histogram
net cps)	FWHM (ch)	FWHM (%)	FWHM	FWTM				meas. mode	real time
NaN	0.0	0.000	0.000	0.000				meas. time	24:00:00
NaN	0.0	0.000	0.000	0.000				real time	00:00:00
000	0.0	0.000	0.000	0.000				data file size(byte)	0.000
000	0.0	0.000	0.000	0.000				meas. count	0 / 1
000	0.0	0.000	0.000	0.000				quick scan	0 / 10
000	0.0	0.000	0.000	0.000				peltier	on
000	0.0	0.000	0.000	0.000				HV output	-166 V
000	0.0	0.000	0.000	0.000				HV status	shutdown
000	0.0	0.000	0.000	0.000				set voltage(V)	
000	0.0	0.000	0.000	0.000				sweep(V/min)	-168 V 400 V/min

Once the high voltage application is complete, the red box will change to "HV ON".

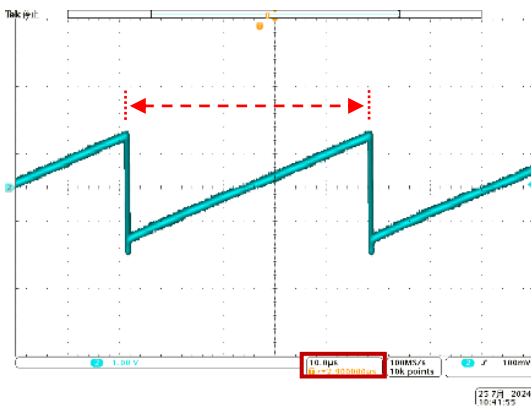
⚠ Never disconnect cables while high voltage is applied. Doing so may cause malfunction.



Example after application is complete, reset rate approx. 130ms.

The reset rate value varies depending on the detector, but if normal, a value of a few ms to several hundred ms can be confirmed.

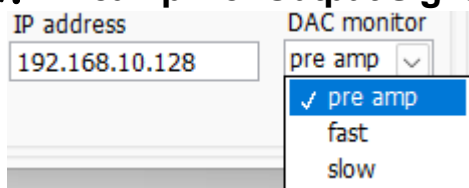
If application does not start even after turning "HV-ON", an abnormality in the HV power supply is suspected. Immediately press "HV-OFF", turn OFF the POWER switch, and discontinue use.



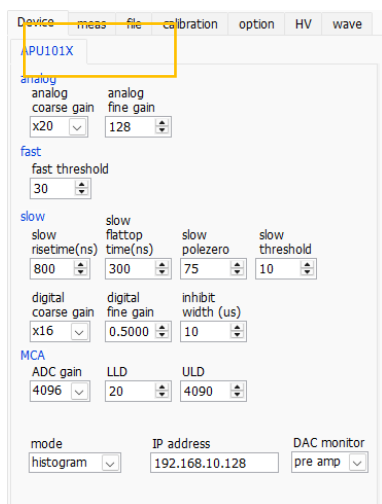
Example of abnormal signal, reset rate approx. 50 µs.

If the reset rate is less than 1 ms, an abnormality in the Peltier power supply is suspected. Since there is a risk of damaging the SDD detector element, immediately execute "HV-OFF", ensure the HV output has become 0V, then turn off the APU101X power and discontinue use.

4. Preamplifier Output Signal Polarity and Analog Gain Settings



In the application's Device tab, select "pre amp" as the monitor signal type in "DAC monitor type". The type of waveform output from the monitor will switch to the pre amp signal.



Disconnect the preamplifier signal currently connected to the oscilloscope and connect it to the INPUT terminal of the APU101X, and instead connect the MONI terminal to the oscilloscope.



Adjust the Device tab "analog coarse gain" and "analog fine gain".

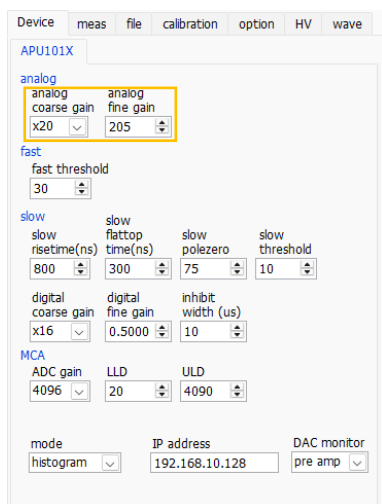
This is a view of the "preamp" output from the monitor, with the oscilloscope's vertical and horizontal scales changed.

"analog fine gain" adjustment. The setting range is 85 to 255, corresponding to x0.5 to x1.5.

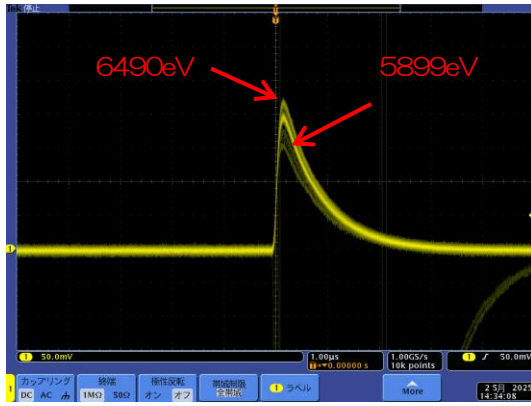
The full scale of the APU101X monitor output is $\pm 1V$. If the energy full-scale range is 30keV, the signal peak of 5899eV@Fe-55 will be 197mV.

$$197 \text{ mV} \doteq 5899 \text{ keV} \div 30 \text{ keV} \times 1000 \text{ mV}$$

With the setting values in the above figure, it can be confirmed that the wave height is still small.



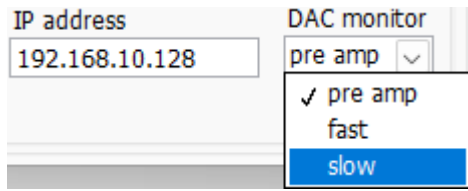
Application screen after adjustment.



After adjustment, the prominently displayed waveform for 5899 eV of Fe-55 was successfully set to approximately 197 mV.

Based on the above formula, calculate the full-scale range of the energy of the radiation source to be used and the energy you want to confirm, to find the optimal adjustment value.

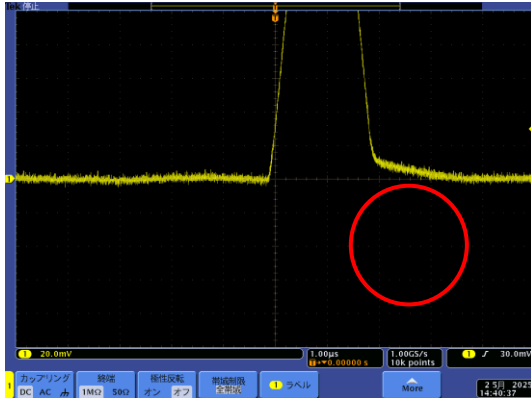
5. SLOW Pole-Zero Settings



Select "slow" for the monitor signal type in the application. The type of waveform output from the monitor will switch to the slow signal.

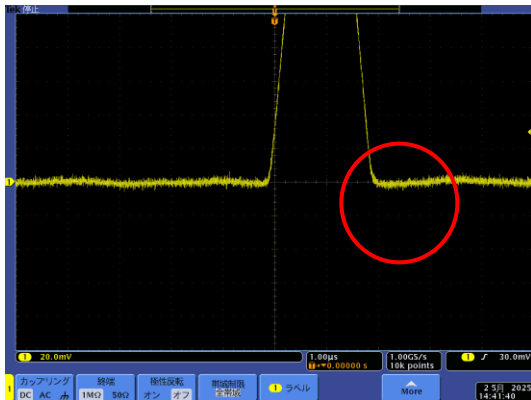
"slow" is a waveform processed by the Trapezoidal Filter based on the preamp signal.

The wave height of "slow" is the energy information itself, so its adjustment is important.

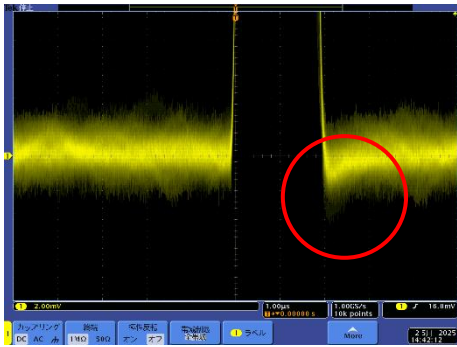


Before adjustment, this is an oscilloscope image of the slow signal when the value of the Device tab "slow pole zero" is 70 digit.

An overshoot can be observed after the fall of the waveform.

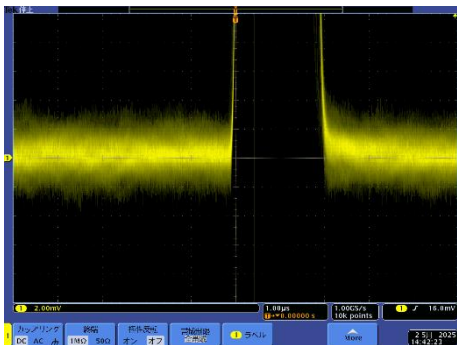


By adjusting the value of "slow pole zero" to 76 digit, it was possible to create a slow waveform without overshoot.



This is the oscilloscope's voltage range changed from 20 mV to 2 mV. In this state, an undershoot can be confirmed.

Even if it seemed to be adjusted correctly in the 20 mV voltage range, it became clear that further adjustment is needed when switching to the 2 mV range.

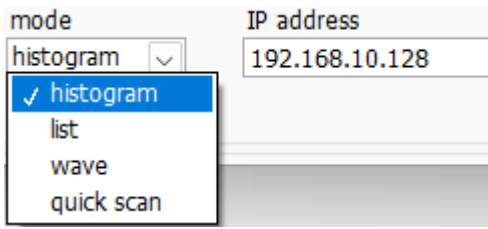


When "slow pole zero" was adjusted to 75 digit, the undershoot disappeared, but a slight overshoot is visible.

The value of "slow pole zero" significantly affects the energy resolution. Even a difference of 1 or 2 digits has a large impact, so perform repeated measurements in the actual environment to find the optimal adjustment value.

Also, the value of "slow pole zero" itself varies depending on the detector. Always adjust while confirming with an oscilloscope.

6. FAST Threshold Settings

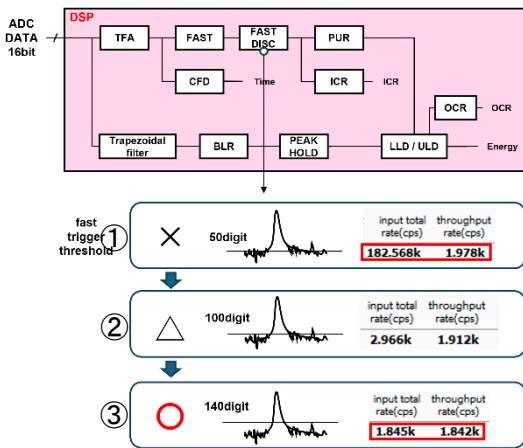


The FAST function generates a FAST system filter waveform by differentiating and integrating the captured preamplifier output signal in a timing filter amplifier circuit. Based on that waveform, when it exceeds this threshold, it acquires the timing for obtaining time information at that point and the timing for starting waveform generation in the spectroscopy amplifier circuit. This setting is mainly related to time acquisition (timestamp).

From the Device tab, set the mode to "histogram" and start the measurement.

CH	input total count	throughput count	input total rate(cps)	throughput rate(cps)	pileup rate(cps)	dead time ratio(%)
CH1	10.952M	114.503k	182.568k	1.978k	0.000	0.0

Paying attention to the CH at the top of the application, it was confirmed that the count rates are unbalanced, with an "input total rate" of approx. 182 kcps compared to a "throughput rate" of approx. 1.9 kcps.



This phenomenon is a state where the "fast trigger threshold", which is the threshold for the fast signal, is set too low, making it easier to detect noise and resulting in numerous counts. Figure ①

By gradually increasing the "fast threshold" value in the Device tab and setting it to 140 digit, the "input total rate" and "throughput rate" settled to a similar level. Figure ③

The "fast threshold" value also varies depending on the detector. While monitoring the "input total rate", set it a few digits higher than the noise level boundary where the value drastically increases.

7. slow rise time and slow flat top time Settings

Slow rise time	Slow flat top time
300 ns	300 ns
500 ns	300 ns
800 ns	300 ns
1000 ns	300 ns
2000 ns	300 ns

For high count rates



Default

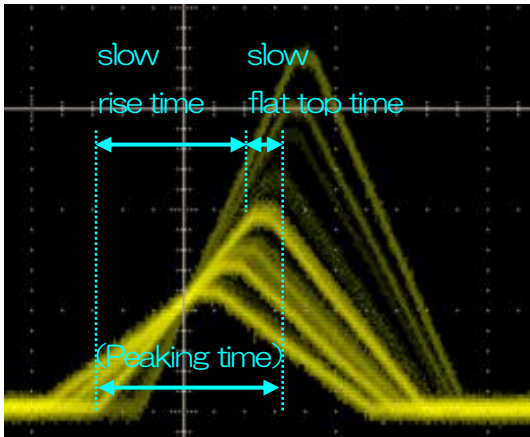


For high resolution

The settings for "slow rise time" and "slow flat top time" are also highly influential setting values for obtaining good energy resolution measurements.

If set shorter, the throughput increases, enabling higher count rate measurements, but the energy resolution decreases.

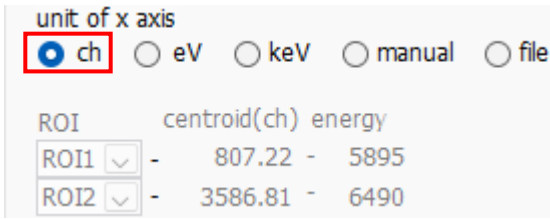
Conversely, if set too long, the energy resolution is good, but the throughput decreases, leading to a tendency of not being able to gain counts.



As a guideline, the setting value for the "slow flat top time" should be approximately twice the slowest 0 to 100% rise (or fall) time of the preamplifier output signal. The default setting is 300 ns.

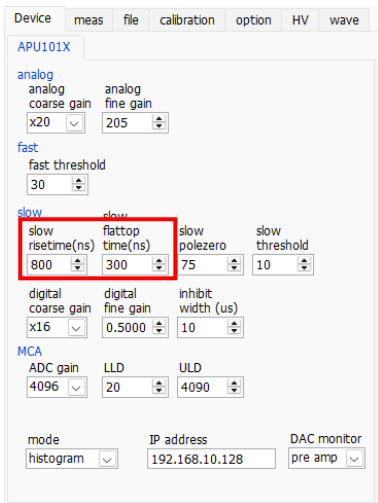
For the optimal setting values depending on the customer's own measurement environment, based on the default values, change the values of "slow rise time" from 100 ns to 10 μ s, and "slow flat top time" from 100 ns to 400 ns, perform repeated measurements, and it becomes necessary to understand the dependence of resolution on both parameters.

8. Digital Gain Settings



From the Device tab, set the mode to "histogram" and start the measurement.

Check the "ch" box in calibration.



Adjust the digital gain to match the full scale of the analog gain. Change the setting values and repeat Stop -> config -> clear -> start.

If you want to adjust the energy full scale to 30 keV, when the ADC gain (the fineness of the X-axis) is 4096, adjust so that the spectrum peak of 5899 eV@Fe-55 stands at approximately 805 ch.

$$805 \text{ ch} \doteq 5899 \text{ keV} \div 30 \text{ keV} \times 4096 \text{ ch}$$

ROI No.	peak (ch)	centroid (ch)	peak (count)	gross (count)	gross (cps)	net (count)	net (cps)	FWHM (ch)	FWHM (%)	FWHM	FWTM
ROI1	535	535.71	9.504k	126.840k	2.114k	125.778k	2.096k	12.4	2.319	136.713	248.177

With the setting values in the above figure, it can be confirmed that the peak position is still low.



ROI No.	peak (ch)	centroid (ch)	peak (count)	gross (count)	gross (cps)	net (count)	net (cps)	FWHM (ch)	FWHM (%)	FWHM	FWTM
ROI1	805	824.14	515.000	12.360k	68.667	12.360k	68.667	16.6	2.062	121.539	230.294

After adjustment, it can be confirmed that the peak position has become an appropriate value.

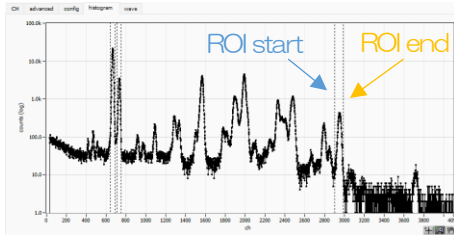
9. Energy Calibration

Device	meas	file	calibration	option	HV	wave
ROI	ROI CH	ROI start (eV)	ROI end (eV)	energy (eV)	Gauss fitting	
1	CH1	5671.5	6112.6	5899	<input type="checkbox"/>	
2	CH1	6267	6708.1	6490	<input type="checkbox"/>	
3	CH1	25903.4	26785.6	26334	<input type="checkbox"/>	

Energy calibration is a calibration that converts the scale of the X-axis from units like ch to keV when an ROI is set for a peak of a known energy.

Display the calibration tab of the application.

For example, when using Fe-55 and Am-241 sources, enter the known energy in the energy column as shown in the red box.



Enter the ch information into the blue-framed "ROI start" and the yellow-framed "ROI end" while checking the spectrum. Alternatively, you can set them by dragging the ROI lines on the spectrum with your mouse.

This is the spectrum after entering numerical values for ROI start and ROI end. Vertical lines indicating ROI start and end are displayed across the peak.

calibration		energy (eV)		unit	
<input type="radio"/> ch	<input checked="" type="radio"/> eV	<input type="radio"/> keV	<input type="radio"/> manual	*a	9.083
ROI1	653.65	5899	+b	-41.915	
ROI3	2905.07	26344	unit	keV	

Perform energy calibration based on two points of known energy: 5899 eV and 26344 eV.

Select ROI1 (5899 eV) and ROI3 (26344 eV) in the ROI selection in the red box.

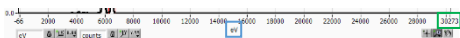
When the eV box in the blue box is checked, energy calibration using the linear equation $ax+b$ was achieved as shown in the green box, based on the information from ROI1 and ROI3.

Before energy calibration



The X-axis of the spectrum was converted to energy units. Regarding the maximum value, compared to 4095 for ch, it became 30273 eV after calibration.

After energy calibration



ROI No.	peak (ch)	centroid (ch)	peak (count)	gross (count)	gross (cps)	net (count)	net (cps)	FWHM (ch)	FWHM (%)	FWHM (eV)	FWTM (eV)
ROI1 : 677	676.70	10.618k	166.706k	2.778k	163.042k	2.717k	14.5	2.166	127.666	235.772	
ROI2 : 743	743.85	1.737k	30.550k	509.167	27.290k	454.842	15.6	2.116	137.300	248.179	

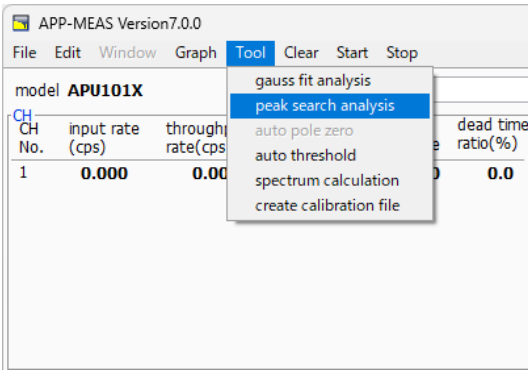
Once the calibration is complete, the FWHM and FWTM in the red box of the ROI information at the top right of the application will be converted from numerical values in ch to numerical values in keV.

In particular, the half-width energy of 5899 eV@Fe-55 is cited as an indicator of the quality of the SDD detector and measurement module.

5899 eV was set for ROI1. The energy resolution is shown as 127.666 eV.

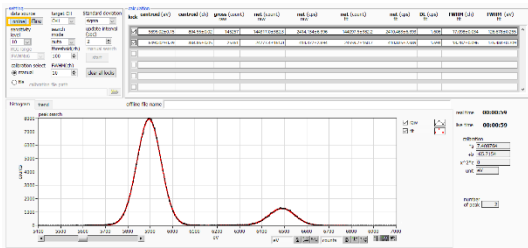
Depending on the environment, please ensure that it is generally less than 135 eV.

10. Measurement using the peak search analysis function



Open peak search analysis.

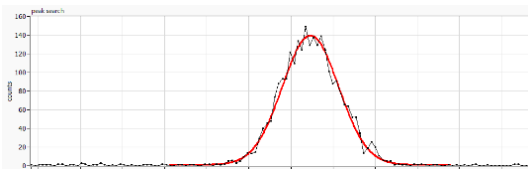
Click "Tool - peak search analysis".



The peak search analysis screen will open.

The figure is an enlarged view of the vicinity of 5899 eV and 6490 eV of Fe-55.

Since it will be used in real-time during measurement this time, "online" was selected for the data source in the orange box.



Start the measurement from the main application in this state. When started, the automatic updating of the histogram will begin, and peaks caught by the peak search will be successively added to the calculation column. You can view the calculated values of each peak using the scroll bar in the red box.

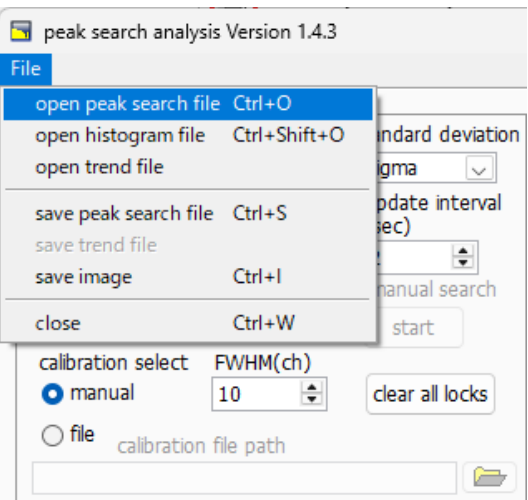
The updating of the histogram begins, and it can be seen that a Gaussian fit (red) is applied to the raw data (black) as shown in the figure.

lock	energy (eV)	centroid (eV)	gross (count)	net (count)	FWHM (ch)	FWHM (eV)	FWTM (eV)	calibration "a"	calibration "b"	calibration unit
<input checked="" type="checkbox"/>	5899.5	5899.4	323.075K	316.718K	14.1	126.040	230.090			8.956
<input type="checkbox"/>	6494.1	6493.9	58.542K	53.322K	15.0	134.603	245.723			43.335
<input type="checkbox"/>	26352.2	26352.8	13.937K	12.993K	29.4	263.270	480.608			
<input type="checkbox"/>	3670.3	4162.2	1.157K	1.157K	13.3	119.135	217.485			
<input type="checkbox"/>	4138.3	4138.4	3.387K	1.137K	10.6	95.012	173.447			

When checked as shown in the red box, the calculation results are retained on the upper side.

Various information such as energy resolution, error, and count rate can be obtained from the calculation results.

This time, in a 2-minute measurement, it can be seen that a good energy resolution of 126.04 eV was obtained for 5899 eV.



Peak search analysis also has a function to read and reconfirm previously acquired data.

You can load a file by selecting "offline" for the data source and selecting "File-open histogram file".

TechnoAP Co., Ltd.

Address: 2976-15 Mawatari, Hitachinaka-shi, Ibaraki 312-0012

TEL.: 029-350-8011 FAX: 029-352-9013

URL : <http://www.techno-ap.com> e-mail : info@techno-ap.com