8CHSpectroscopy Amplifier

A1008

Instruction Manual

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TechnoAP Co., Ltd.

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Safety Precautions / Disclaimer

Thank you very much for purchasing this product from TechnoAP Co., Ltd. Before using this product, please read this "Safety Precautions and Disclaimer" and be sure to observe the contents and use the product properly.

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. Consumables.

― Content ―

1. Overview

The A1008 is a module that incorporates eight channels of spectroscopy amplifiers within a single NIM width. Waveform shaping is implemented using an active filter design, achieving a near-ideal Gaussian response.

It employs a discrete amplification circuit utilizing state-of-the-art low-noise FETs, keeping the input noise level below 4 µV. An active-gated baseline restorer is also included, making the module suitable for high count-rate measurements. The A1008 delivers excellent energy resolution and linearity, particularly when used with HPGe semiconductor detectors.

2. Specifications

- **Gain**: Up to ×750

1. **Waveform Shaping**: Semi-Gaussian shaping; Peaking time: 2.2τ; Pulse width: 6τ
2. **Noise Performance**: Equivalent input noise ≤ 4 µV at gain ≥ 100, shaping time 2 µs
3. **Nonlinearity**: < ±0.05% at 2 µs shaping time
4. **Baseline Restorer**: Active-gated, auto-threshold method
5. **High Count-Rate Capability**: Maximum peak broadening of 15% at 2 µs, 50 kcps input rate
6. **Input Polarity**: Positive/Negative (selectable via internal switch)
7. **Attenuator**: ×0.1 / ×1.0 (selectable via internal jumper)
8. **Coarse Gain**: ×20 / ×50 / ×100 / ×200 / ×500 (selectable via internal switch)
9. **Fine Gain**: ×0.5 to ×1.5 (adjustable via front-panel potentiometer)
10. **PZ Adjustment**: 40 µs to ∞ (adjustable via front-panel potentiometer)
11. **Shaping Time**: 0.5 / 2 / 6 µs (3-position selectable via internal switch)
12. **Offset Voltage**: ±40 mV (adjustable via front-panel potentiometer)
13. **Input Characteristics**:
    • 8 channels
    • LEMO connectors
    • Input range: ±1.5 V
    • Input impedance: 1 kΩ
14. **Output Characteristics**:
    • LEMO connectors
    • Output range: Unipolar positive 0–10 V
    • Output drive current: 45 mA
15. **Preamplifier Power Supply**: D-Sub 9-pin; +24 V, -24 V, +12 V, -12 V
16. **Power Consumption**:
    • +12 V: Max 200 mA
    • -12 V: Max 180 mA
    • +24 V: Max 220 mA
    • -24 V: Max 200 mA
    ※ Preamplifier power consumption not included
17. **Form Factor**: NIM module, single width
18. **Dimensions**: 34 (W) × 221 (H) × 249 (D) mm (excluding protrusions)
19. **Weight**: Approx. 980 g

3. Appearance

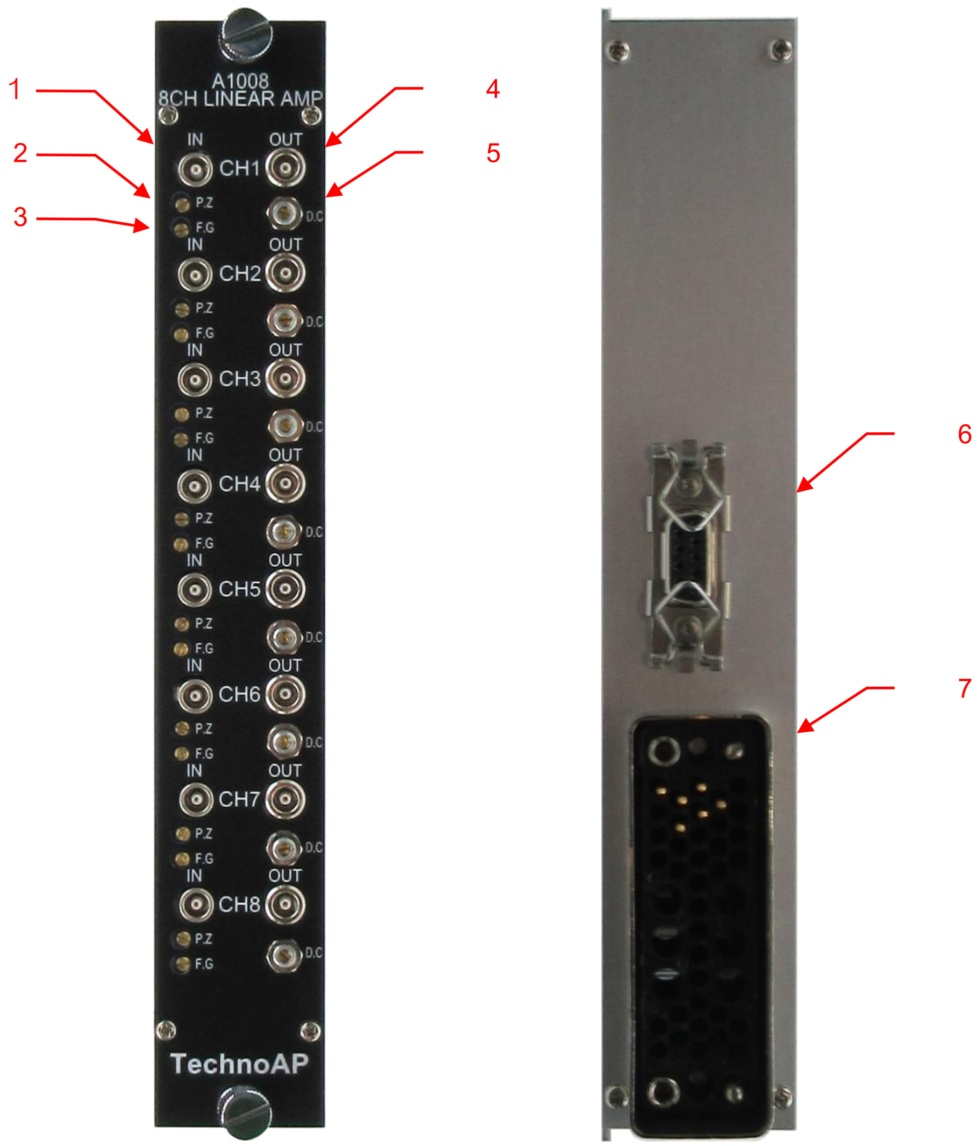

Figure 1. A1008 (Left: Front Panel, Right: Rear Panel)

1. **IN**
   Signal input LEMO connector compatible with 00.250 series.

2. **P.Z**
   Pole-zero adjustment potentiometer.

3. **F.G**
   Fine gain adjustment potentiometer.

4. **OUT**
   Signal output LEMO connector compatible with 00.250 series.

5. **D.C**
   Offset voltage adjustment potentiometer.

6. **Preamplifier Power Supply Connector**
   D-sub 9-pin connector for preamplifier power supply. Supplies ±12V and ±24V according to NIM standard pin assignments.

7. **NIM Bin Power**
   Connects to NIM bin power supply to provide power to this unit.

4. Board

Figure 2. A1008 Internal Board (Left: Component Side, Right: Solder Side)

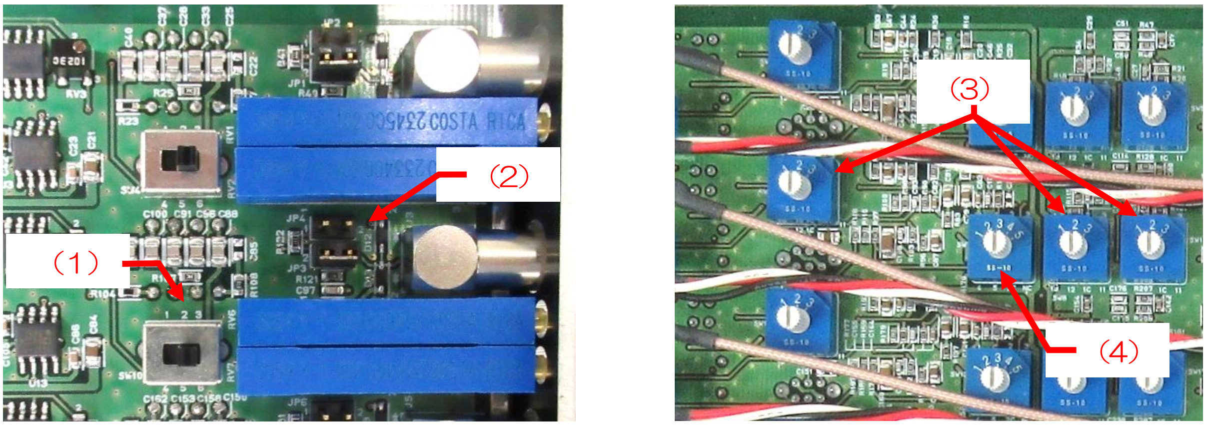

Figure 3. Enlarged View of A1008 Internal Board (Left: Component Side, Right: Solder Side)

※Always turn off the power to the unit before opening the cover. Use a screwdriver to loosen the screws.

1. **Input Polarity Selector Switch**

   Left: Negative polarity　/　Right: Positive polarity

2. **Attenuator Selector Jumper**

   Upper: ×0.1　/　Lower: ×1.0

3. **Shaping Time Selector Switch**

   1: 0.5 μs　/　2: 2 μs　/　3: 6 μs

   ※ Three arrow-marked switches function as one set. Ensure all are set to the same position.

4. **Coarse Gain Selector Switch**

   1: ×20　/　2: ×50　/　3: ×100　/　4: ×200　/　5: ×500

5. Connections

※Changing internal board settings or connecting/disconnecting the preamplifier power cable while the unit is powered on may cause damage to the device. Always turn off the power before performing these operations.

6. Preamplifier Power Supply

The pin assignments follow the NIM standard as shown in the table below.

Table 1. Preamplifier Power Connector Pin Assignments

1	GND	6	-24V
2	GND	7	+24V
3	NC	8	NC
4	+12V	9	-12V
5	NC		

7. Block Diagram

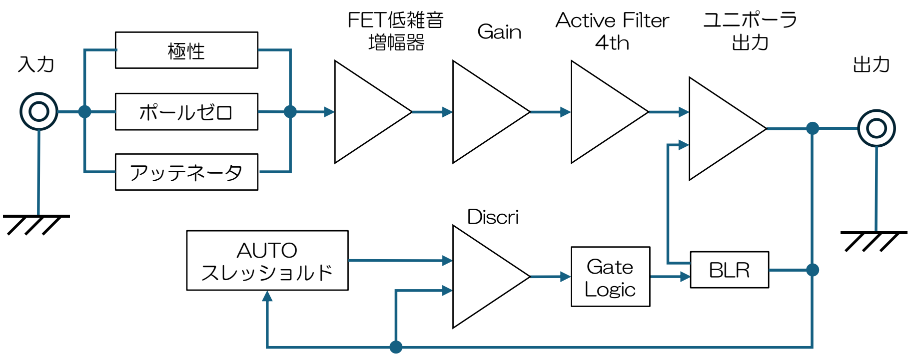

Figure 1. Block Diagram

The A1008 has an input impedance of approximately 1 kΩ. It is capable of accepting both positive and negative pulses with a rise time of less than 700 ns and a fall time greater than 40 μs.
Three shaping time constants are available, which can be selected by switching the rotary switch on the circuit board.

The input stage of the spectroscopic amplifier consists of a differentiator circuit with pole-zero adjustment. Signals from a resistive-feedback preamplifier typically have a sharp rise and a long decay tail, forming tail pulses with decay times of approximately 50 to 100 μs.
When passed through a simple differentiator, such signals result in tail pulses with undershoot, which can degrade energy resolution.
By applying proper pole-zero adjustment, the tail pulse can be shortened and the undershoot eliminated, thereby improving resolution.

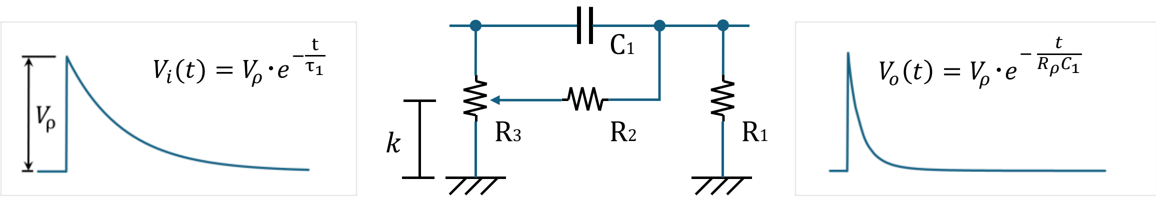

Figure 1. Pole-Zero Adjustment Circuit

$$V_o(s) = V_i(t) \times F(t) \quad \cdots \ (1)$$

$F(t)$ *: Transfer function*

Expressing equation (1) in terms of its Laplace transform,

$$V_o(s) = V_\rho \times \frac{1}{s + \frac{1}{\tau_1}} \times \frac{s + \frac{k}{R_2 C_1}}{s + \frac{R_1 + R_2}{R_1 R_2 C_1}} \quad \cdots \ (2)$$

By adjusting the resistance of R[3], the value of k is set according to the following relation:

$$s + \frac{k}{R_2 C_1} = s + \frac{1}{\tau_1} \quad \cdots \ (3)$$

When this condition is satisfied, equation (2) becomes:

$$V_o = V_\rho \times \frac{1}{s + \frac{1}{\tau_1}} \times \frac{s + \frac{1}{\tau_1}}{s + \frac{1}{\mathrm{R}_\rho C_2}} = \frac{V_\rho}{s + \frac{1}{\mathrm{R}_\rho C_2}} \quad \cdots \ (4)$$

And

$$\mathrm{R}_\rho = \frac{\mathrm{R}_1 \mathrm{R}_2}{\mathrm{R}_1 + \mathrm{R}_2}$$

$$V_o = V_\rho \cdot e^{-\frac{t}{R\rho C_1}} \quad \cdots \ (5)$$

The pole-zero adjustment circuit is a differentiating circuit with a variable resistor connected across the capacitor. This adjustment is performed by turning the potentiometer located on the front panel using a precision screwdriver or similar tool. Use an oscilloscope to observe the pulse tail on an expanded voltage scale during the adjustment process. If the pulse exhibits undershoot, rotate the potentiometer clockwise. If the pulse exhibits overshoot, rotate the potentiometer counterclockwise. Always perform pole-zero adjustment when the shaping time constant is changed. Inadequate adjustment may result in degraded resolution. If the preamplifier does not exhibit a tail, as in the case of transistor reset-type preamplifiers, rotate the potentiometer fully clockwise until it reaches its stop.

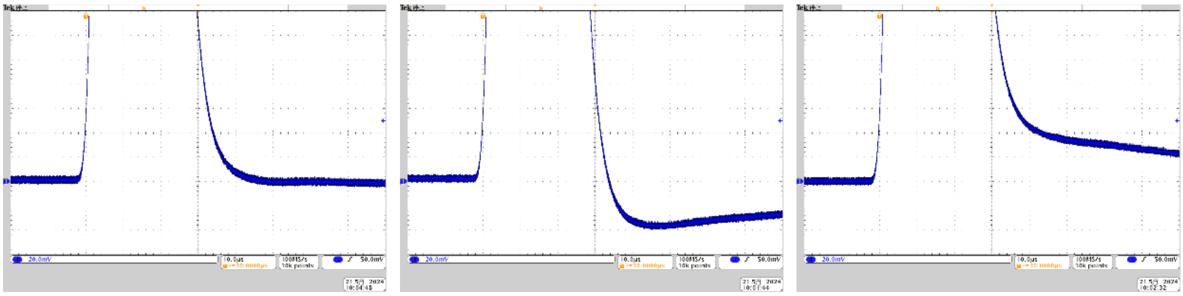

Figure 1: Pole-Zero Adjustment (Left: Proper Adjustment, Center: Undershoot, Right: Overshoot)

The first stage of the amplification circuit employs a state-of-the-art dual-pair JFET to form a hybrid amplifier configuration, achieving both low voltage noise and low current noise characteristics that cannot be realized with commercially available operational amplifiers. The equivalent input noise at a shaping time of 2 μs is as low as 4 μV (at Gain ×100).

The gain can be switched using the Coarse Gain rotary switch mounted on the board, allowing selection between ×20, ×50, ×100, ×200, and ×500. The Fine Gain can be adjusted from ×0.5 to ×1.5 by turning the potentiometer on the front panel.

The semi-Gaussian shaping circuit (active filter type) consists of a differentiator with pole-zero adjustment in the first stage, followed by an amplifier and then an integrator, as shown in Figure 4.

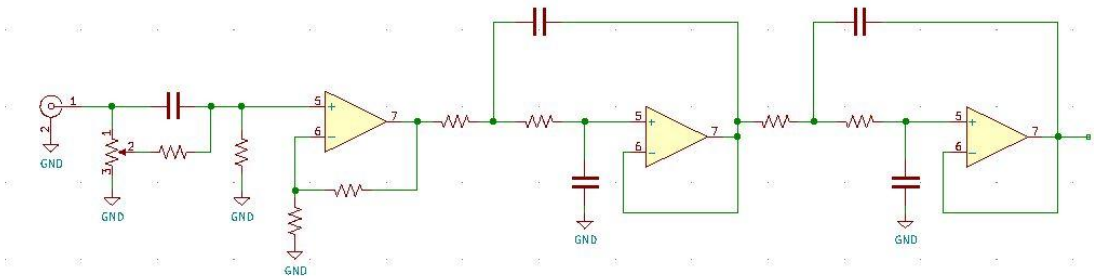

Figure 1: Semi-Gaussian Shaping Circuit

Compared to the ideal Gaussian shaping, complete Gaussian shaping cannot achieve the theoretical signal-to-noise (S/N) performance of a cusp-shaped response. However, the Laplace-transformed expression for Gaussian shaping, shown in Equation (6), yields an S/N ratio of 1.12. In practice, it is impossible to perform an infinite number of integrations.

$$G(s) = \frac{s}{s+(1/\tau)} \times \frac{1}{\{s+(1/\tau)\}^n} \quad (n \to \infty) \qquad \cdots (6)$$

To approximate Gaussian shaping as closely as possible while maintaining practical implementation, a **semi-Gaussian shaping** approach is used. By employing active filters in the integrator stage and adjusting the sharpness of the filters using parameters k1k_1k1 and k2k_2k2, an S/N ratio of 1.14 can be achieved. The corresponding Laplace-transformed expression is given in Equation (7).

$$G(s) = \frac{s}{s + (1/\tau)} \times \frac{1}{\{[s + (1 - k_1 j)/\tau]\,[s + (1 + k_1 j)/\tau]\,[s + (1 - k_2 j)/\tau]\,[s + (1 + k_2 j)/\tau]\}}$$

$$j = \sqrt{-1}$$

$$\cdots \quad (7)$$

The output of the A1008 is a unipolar pulse with a maximum pulse height of 10 V. The output current is 45 mA, and the output impedance is 50 Ω. It features an active gated baseline restorer (BLR), and the threshold is automatically controlled. Our in-house developed BLR demonstrates excellent performance; even with a shaping time of 2 µs and an input count rate of 50 kcps using an HPGe semiconductor detector, the resolution degradation is limited to only 15%. The offset voltage can be adjusted via a potentiometer on the front panel.

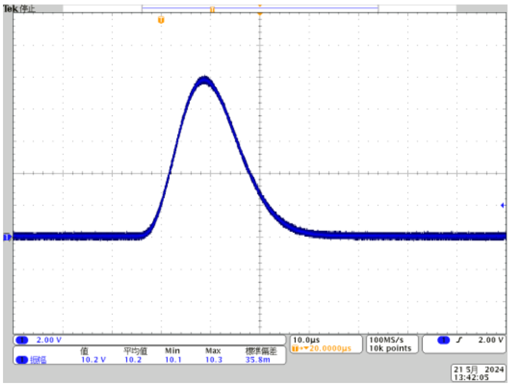

Figure 2: 10 V Pulse Height Output (Shaping Time: 6 µs, Decay: 100 µs Signal)

8. Setting

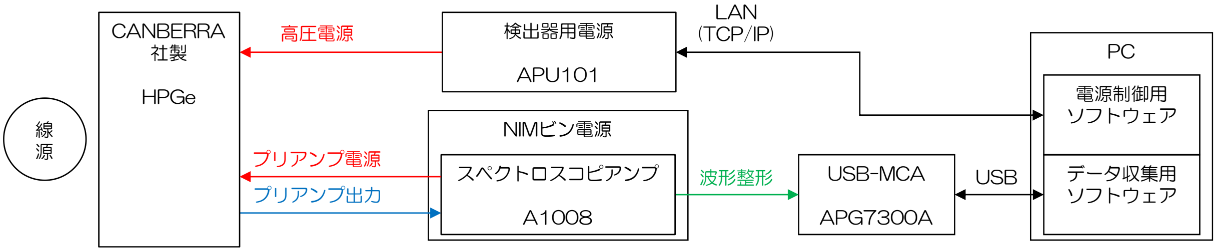

Figure 2: Example of Detector Connection

Test Environment

Radioactive Sources Used: ^241Am, ^152Eu, ^137Cs, ^60Co

Preamplifier Output Polarity: NEG

Spectroscopy Amplifier Settings

Polarity: NEG

Attenuator: ×1.0

Coarse Gain: ×50

Shaping Time: 6 μs

USB-MCA Settings

ADC Resolution: 16,384 channels

Lower Level Discriminator (LLD): 80

Upper Level Discriminator (ULD): 16,380

Threshold: 50

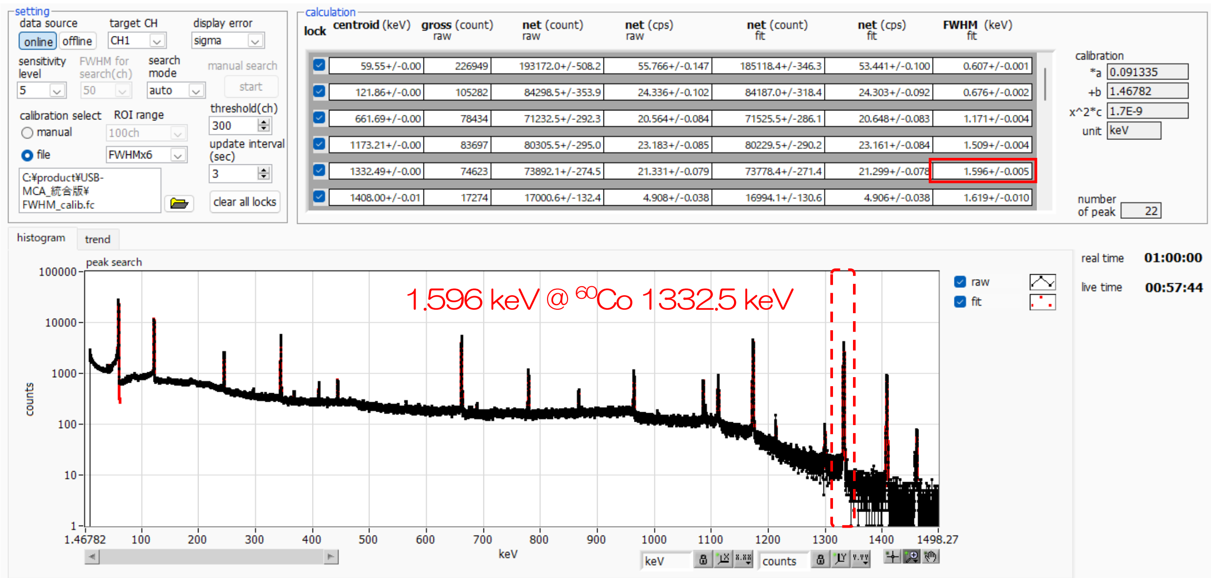

Figure 2: USB-MCA Spectrum

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