Nuclear radiation analyzer KC761x
(Radiation Spectrometer and Dosimeter)

User Manual

Support version FW V1.7

科新社

Executive Summary

This manual introduces the concept and basic principle of energy spectrometer, and provides a comprehensive explanation of the structure, functions and usage of the KC761x energy spectrometer.

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KC761x Multifunctional Handheld Energy Spectrum Analyzer User Manual

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Security matters

In this brochure:

⚠ "Dangerous" means a matter that may result in personal injury;

❗ "Warning" means a matter that may lead to the loss of equipment or a major error;

ℹ "Important" refers to a statement that requires special attention.

⚠ Dangerous

Disassemble the sensor module.

Throw into the fire or place in a hot place.

Power is supplied by means or parameters other than those indicated by the instrument and specified in the manual.

Storage or use in environments with combustible/explosive gases, dusts.

Use when the instrument is malfunctioning or parts are missing.

Place it in a place where children can reach it.

❗ Warning

This instrument is not a consumer product and should only be used by professionals in accordance with the manual and the manufacturer's regulations.

Instruments are not to be disassembled by non-authorized personnel.

Modifications are prohibited.

Radio transmitting devices (2.4GHz 802.11b/g/n, Bluetooth.Complies with CE/FCC) are included, please observe local laws and regulations.

Not all types of radiation can be detected correctly by the KC761x, and the user should be aware of the possibility of missing or false alarms.

Disclaimers

This instrument is a professional device, not a consumer product, and the rules for consumer products do not apply.

To the extent permitted by law, the maximum liability of the manufacturer shall be the purchase price, regardless of damages, and shall not be liable for any loss of time, business, inconvenience, profit, abuse, or any consequential damages. The manufacturer's decision to repair, replace or return the product and refund the purchase price is the sole remedy for the user and the purchaser. The warranty period is the final period for which the manufacturer is liable for the product.

Users are requested to comply with nuclear safety related regulations and use it only for legitimate scientific research, teaching, environmental protection, security and other purposes, and prohibit it from being used for purposes directly related to life safety or any illegal purposes. Designers, producers, sellers, service providers, community event organizers, etc. of KC761x have fulfilled the necessary publicity and warning obligations and are not responsible for the user's actions.

The instrument has a networking feature, which is a convenience only and not an official feature. Users should fully assess the risks of networking before enabling the networking function. When network connected, the user should ensure that the tested object does not involve state secrets, trade secrets, personal privacy or other non-disclosable contents, and know that the data may be erroneous, tampered, contaminated, stolen, etc. The system may also be subject to network attacks. The manufacturer does not make any guarantees for information security.

No guarantee of feasibility for aviation, aerospace, submarine, life support and other scenarios. Any promises made by the seller do not imply knowledge of or agreement with the manufacturer.

The firmware built in inside the instrument may be improved at any time, and the functionality or method of operation may differ slightly from this manual.

* * *

Packing list

Spectrometer………… 1pc

Carrying rope…………1pc

User manual ………… 1copy

Power supply method

One of the following power supply methods can be used

a. (1) 5AA NiMH battery × 3, nominal voltage 1.2V; or, (2) 5AA/LR6 dry cell batteries×3, including carbon, alkaline batteries and disposable lithium-iron batteries with a nominal voltage of 1.5V.It should be used correctly and maintained properly according to the requirements of the battery manufacturer.

b. 5V±10%, ripple <0.5% via USB (Type-C) interface.

Due to the low power consumption, some cell phone chargers will assume there is no load and automatically sleep. KC761 (no model letter version) cannot be powered with PD charging protocol (no CC pin pull-down resistor).

c. POE power supply through network port, 24~60V.

Three methods can be used simultaneously. KC761x can charge the NiMH battery.

Exposure limits

Exposure to the following types and intensities of radiation only:

a. γ rays (includingX rays), ＜6MeV，≤10Gy/h

b. β rays, ＜6MeV，≤1Gy/h

c. α rays, ＜12MeV，≤1Gy/h

d. Neutrons, $\leq 1\times10^{4}cm^{-2}s^{-1}$， However, high-dose exposure can result in the generation of induced radioactive products, rendering the instrument unusable.

e. Other, ＜12MeV，≤1mGy/h

Not suitable for applications requiring extremely high reliability. This instrument may go down or malfunction under certain types and intensities of radiation exposure.

Warranty

The instrument is guaranteed for 1 year or an accumulated dose of 10Gy(excluding neutron exposure), whichever comes first. The warranty period of the optional sensor is determined separately. During the quality guarantee period, the manufacturer is responsible for free repair if the product fails due to quality problems.

The following are not covered by the warranty:

Aging, wear and tear, appearance damage; collision, drop, extrusion, pinprick and other violent damage; sensor damage after tearing off or damaging the protective film of the sensor; using non-specified power supply; lightning, electric shock, EMP attack, etc.; exceeding the allowable temperature and humidity, altitude, etc.; Instrument internal liquid feed, corrosive gas, radioactive dust, etc.； disassembly, self-repair, modification; failure caused by not operating in accordance with the user manual; abnormalities following exposure to neutrons or other irradiation capable of producing induced radioactivity; the presence of radioactive contamination; failure caused by irradiation exceeding the exposure limit; battery leakage, explosion; other failures not caused by quality problems.

If the irradiation causes software failure, the manufacturer will re-program it free of charge during the warranty period.

The user can send the instrument back to the manufacturer's after-sales service department through the dealer or by himself, accompanied by a description of the fault phenomenon and contact information. After receiving the instrument, the manufacturer will evaluate the fault and repair it if it is covered by the warranty, while the repair cost will be evaluated and explained to the user if it is not covered by the warranty.

The repaired equipment **must not** be radioactive or contaminated with other dangerous substances, and the activity of induction radioactivity must not exceed 2.5nCi, otherwise the user will be held responsible.

Environmental Protection

This instrument contains plastic housing, circuit board and its attached electronic components, metal parts (brass, iron and nickel, tin plating), glass, silicone rubber seals and scintillation crystals and other parts. After the instrument is dispose, it should be recycled separately.

Due to the necessity of detecting radiation and the need to consider the reliability for extreme environments, this instrument contains toxic and hazardous substances.

In the following table, ×indicates that the content exceeds the limit value of GB/T 26572-2011 or is dangerous.

Component name	The composition and content of toxic and harmful substances in products						
	Lead	Mercury	Hexavalent chromium	Cadmium	Thallium	Polybrominated biphenyls	Polybrominated diphenyl ethers
Circuit Boards	×	○	○	○	○	○	○
Scintillator	○	○	○	○	×	○	○
Other	○	○	○	○	○	○	○

The environmentally safe service life of this instrument is tentatively set at 10 years.

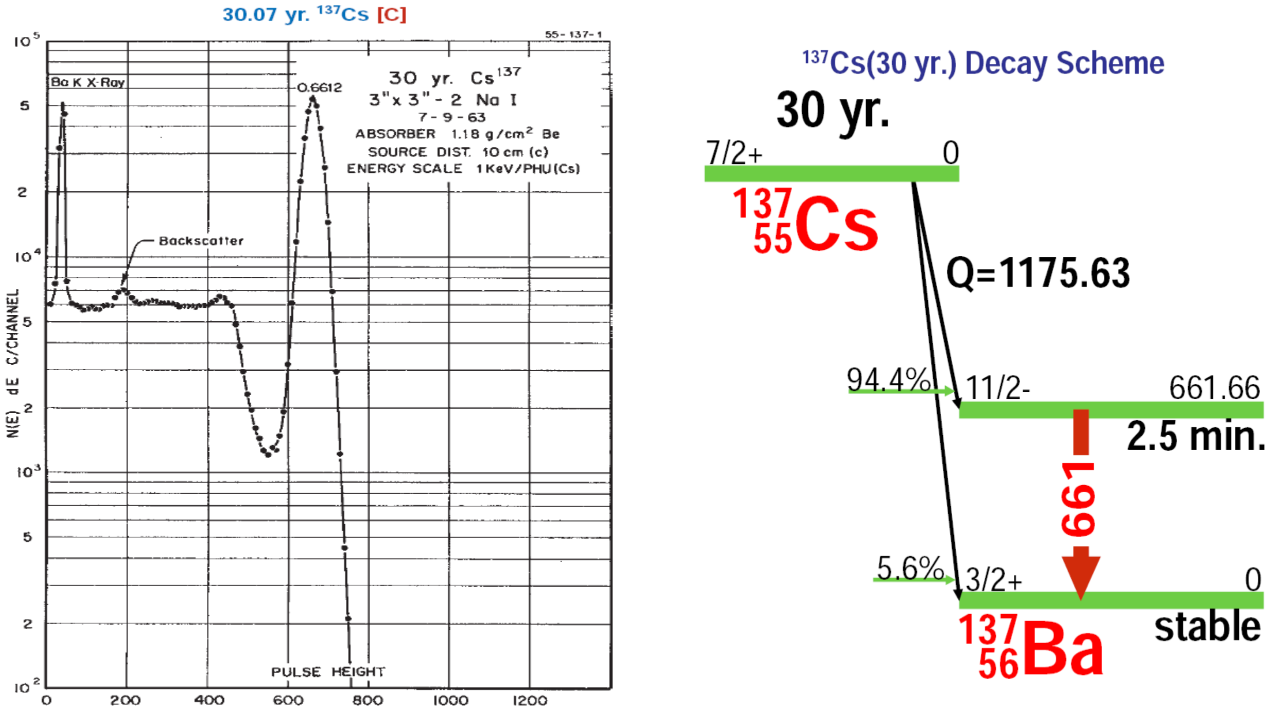
Table of Contents

1、Overview

An energy spectrometer is a powerful radiation testing instrument, usually used to test the energy and magnitude of rays.

The common Geiger counter is an old and simple instrument, which usually can only determine the strength of the radiation. In order to clarify the nature of the radiation, the easy way is to determine both the energy and the magnitude of the radiation, which requires an energy spectrometer.

For light, the graph drawn with its wavelength as the horizontal axis and its strength as the vertical axis is called a spectrogram. The energy and wavelength of rays can be converted into each other, the shorter the wavelength (the higher the frequency), the greater the energy. In the case of X rays or γ-rays, using wavelength as the horizontal axis is not intuitive enough, so using energy as the horizontal axis and strength as the vertical axis, the plotted spectrum is the energy spectrum.



Left: γ-ray energy spectrum of ^{137}Cs, Right: Decay process of ^{137}Cs (R.L.Heath)

Other radiations, such as α and β-rays, also exist in terms of energy levels, and their energy spectra can be measured using appropriate techniques. The energy of solid particle rays can be attenuated as they pass through the medium, so different test environments will result in different energy spectra, usually recommend measurements in vacuum. And it can be roughly assumed that the γ-rays are only attenuated in strength, the energy always remains the same.

In the case of visible light, for example, strength (magnitude) refers to brightness; energy refers to the color, where color and brightness are separate concepts from each other. Purple light must have a higher energy than red light, but red light can be brighter than purple light. Similarly, the energy of radiation and the strength of radiation are separate concepts from each other.

Energy spectrum is an important technical tool for identifying nuclides and specifying the nature of radiation. Different radioactive elements, it and its decay products emit rays with a specific energy distribution. The energy spectrum of a ray can be determined to know what is emitting it.

Geiger counters are difficult to warn of nuclear accidents or fallout at an early stage. Because normal background radiation can fluctuate widely even at the same location, if the Geiger counter reading changes slightly, it is hard to distinguish between normal fluctuations and the presence of a nuclear leak. Energy spectrometers can provide more accurate information even if the strength of the radiation does not change significantly - and can provide immediate warning of a nuclear accident or explosion as soon as artificial radionuclides, which are only found inside a nuclear reactor, are detected. At the time of the Chernobyl nuclear accident, European countries were initially alerted by the discovery of the presence of ^{131} iodine in the air.

1.1、Principle of energy spectrometer

There are two common principles of energy spectrometry:

(1) Using a scintillator to convert radiation into a flash of light, indirectly measured by measuring the brightness of the flash and the amount of the flash, is called a scintillation detector.

(2) The use of a semiconductor to convert radiation into a moveable

charge, and the relatively direct measurement by measuring the amount of charge transferred, is called a semiconductor detector.

This instrument uses the method(1) for γ-rays and neutrons (optional) and the method(2) for α and β-rays.

1.1.1、Scintillation detector

The composition of the gamma scintillator is thallium-activated cesium iodide crystals (standard). After receiving irradiation from the rays, the scintillator emits fluorescence, usually in the visible range. Due to the photo-quantum characteristics of the high-energy rays, a flash of light is produced for each portion of the rays shining on the crystal. The color of the flash is determined by the crystal composition, the brightness of the flash is determined by the energy of the incident rays, and the number of flashes (frequency) is determined by the magnitude of the incident rays. Since the color of the flash is basically constant, the instrument only needs to be concerned with the brightness and frequency of the flash. Therefore, the task now becomes to convert the flash into an electrical signal for easy measurement with some kind of equipment.

But the flash is very faint, the human eye must be completely adapted to the darkness before it can be seen. The duration of the flash is also very short, a single flash is only a few ns to μs in width. To detect it, it is necessary to use a high-sensitivity photoelectric sensor. This instrument uses a silicon photomultiplier tube (SiPM) to solve this problem. It is sensitive enough to detect even a single photon, but the random fluctuations in the output charge are large. To reduce the fluctuations, multiple SiPMs can be used in combination to form an array.

The SiPM is output as a charge, and its output waveform is a pulse with a steep rising edge and only nanosecond-level width at the top. To save power, this instrument uses analog circuitry for pulse processing. The electronic circuitry performs charge-to-voltage conversion (Q-V conversion), pulse shaping (pole-zero phase elimination, S-K filtering), and peak hold, and then sends it to the ADC for sampling. After the ADC completes one sampling, the CPU immediately resets the analog circuitry and waits for the next pulse to arrive. In the extreme case, 30,000 pulses can be collected per second, which corresponds to a dose rate of approximately 0.3 mGy/h. Above this dose rate, the instrument is unable to perform energy spectrum analysis, and can only roughly measure the radiation intensity.

1.1.2、Semiconductor Detectors

The circuit principle and data processing method of semiconductor detectors are almost the same as scintillation detectors, except that the conversion process of semiconductor detectors can be abbreviated as "ray → electrical pulse", while scintillation detectors are "ray → flash → electrical pulse".

This instrument uses PIN tube as sensitive element, it has almost no electric gain, so it needs to be used with extremely sensitive electrostatic amplifier. PIN is less sensitive to higher energy γ radiation, it can be used to measure stronger radiation and achieve larger range; it is more sensitive to α and β radiation, so it is mainly used to measure α and β radiation. However, because the effective area of PIN is small, mainly used to determine the stronger α, βradiation sources, generally not applicable to the assessment of surface contamination.

Both α and β rays are easily shielded, especially α rays, which are almost impossible to penetrate the housing of the instrument, so the housing is opened with windows.

The PIN is sensitive to visible light and the window must be shaded from light, as well as being dust or water resistant. On the inside of the window, there is an aluminized Mylar film with a maximum thickness of 5 μm. On the outside of the window it covered by light-resistance rubber cover(Old model use a sticker). The closed rubber cover allows the pass through the higher energy β-rays, but common α-rays can not. If you need to measure α-rays or lower-energy β-rays, you should open the rubber cover. At this point, only the Mylar film inside the window remains in front of the PIN tube, and higher-energy α-rays can pass through, although they will lose energy and quantity.

When the rubber cover is open, trace amounts of light will still leak in under bright light, so it should not be used under bright light. For testing the energy spectrum of α-rays, a dark vacuum environment is usually used.

The film on the inside of the window is extremely thin and therefore easily damaged. Do not open rubber cover unless it is particularly necessary. Do not open it in water environment.

Warning

PIN detector is a bare chip, it can be damaged by water vapor and dust, such failures are not covered by the warranty.

PIN detectors, although they provide a dose rate display, are converted to 662 keV γ -rays, which is highly influenced by the type of radiation measured, its energy and the measurement environment, making the readings unreliable. The energy spectra of the PIN sensors are only meaningful when measuring alpha-rays and are not calibrated. for reference only.

1.1.3、Multi-channel analyzer

After the pulse voltage is captured by the ADC, it is first counted by the CPU or a specially designed digital circuit. The 8-bit ADC, for example, has a resolution of 256 steps (2^8). The purpose of the statistics is to "count" the number of pulses for each level and then display them on a histogram with horizontal coordinates increasing from 0 to 255 and vertical coordinates representing the number of pulses for each level, i.e., to classify the electrical pulses by their amplitude.

Long ago there was a need in physics to count the number of pulses of a specific voltage in order to detect a specific event. People made a counting device that outputs a counting pulse to drive a totalizer when pulses of a specific voltage range are input (various approaches existed in the early days, such as a mechanical device driven by a solenoid, a voltmeter head that converts to an integral voltage and then drives the scale as a quantity, etc.). For other voltages it does not respond. In research, one such counter is referred to as a channel, and the corresponding product is called a "single-channel analyzer" (SCA). When a more comprehensive amplitude classification is needed, either dozens or hundreds of single-channel analyzers are used, or the voltage range of the single-channel analyzer response is regularly adjusted. The former is very clumsy, and the latter takes a long time and is not suitable for situations where multiple voltages need to be observed simultaneously. In 1952, Atomic Instrument Company (USA) introduced a product with twenty channels integrated, using the name Multi-Channel Analyzer (MCA). On this instrument, the voltage range corresponding to each channel is called the channel width, and the channel corresponding to one voltage is called the channel address (CH).

Multichannel analyzers are just names that have been used to this day, and their principles have changed many times over the course of nearly a century of history. Today's multichannel analyzers are almost all based on commodity analog-to-digital converters (ADCs), the difference being mainly in the means used to capture very narrow pulses. Before the ADC for pulse spreading or peak hold, so that the low-speed ADC can be collected, known as "analog multi-channel"; with high-speed ADC (usually sampling rate ⩾ 50M) directly sampled, and then combined with high-speed digital chip algorithms for processing, known as "digital multi-channel ". The KC761 has three multi-channel analyzers inside.

The channel address of the pulse, i.e., the pulse voltage, represents the energy of the ray. However, this correspondence is affected by the crystal, the optoelectronic device, and the acquisition circuitry, and there is some nonlinearity, which usually requires function fitting. Different sensors have different fitting curves and need to be calibrated at the time of production to solve for the coefficients of the function. With these coefficients, the channel address can be converted to energy and the transverse coordinates can be rearranged in linear or logarithmic energy to obtain an energy spectrum plot.

For example, if an instrument picks up 10,000 pulses, there are 9,998 in 1,000 channels and 2 in 333 channels, so it is possible to know the energy corresponding to 1,000 channels, for example, there are 9,998 copies of 1 MeV rays and 2 copies of 333 channels corresponding to 382 keV rays. If the energy spectrum is scaled by energy, as described above, the channel sites corresponding to each scale are not strictly uniform.

1.1.4、Neutron Sensor

The Neutron Sensor (option) is also a scintillation detector, which uses glass containing $^{6}Li_2O$ as the scintillator, with dimensions of 10mm x 10mm x 3mm in the form of a small square. This scintillator is sensitive to low-energy neutrons with energies from 0.02 eV to 1 keV, and also responds to neutral energy neutrons from 1 keV to 100 keV. Although the neutron response cross section of 6Li is small, the solid has more atoms than the gas, and its sensitivity is often superior to that of a 3He orthogonal counting tube of the same volume.

After neutrons enter the ^{6}Li glass, they undergo a nuclear reaction that releases alpha rays and tritium rays, which excite the cerium (Ce)-doped glass to emit a flash of light, which is then received by a silicon photomultiplier. The brightness of the flash reflects the combination of the energy released by the neutron nuclear reaction and the neutron's own energy. Since the energy released by the neutron nuclear reaction is a constant value, theoretically, the excess over the constant value is the energy of the neutron, and it appears that a neutron spectrum can be obtained. However, since the energy of the thermal neutron is so low that it is negligible compared to the nuclear reaction, it cannot actually be distinguished by the instrument. It can be assumed that what the instrument shows is not the energy spectrum of the neutron, but the energy released by the nuclear reaction.

Therefore, the energy spectrum read out by the neutron detector is only used to determine whether the detected ray is a neutron or not. If the energy does not match the neutron nuclear reaction, it is not a neutron; if it does, it may be a neutron. Lithium glass is also sensitive to Gamma rays and can be interfered with by Gamma rays. The KC761x must select the energies to remove the response caused by Gamma rays. The energy peak of a neutron reaction with a ^{6}Li nucleus is approximately equivalent to the peak of a 1.6 MeV Gamma ray. When counting the neutron dose rate, only signals near 1.6 MeV are selected to exclude interference from common gamma rays. This process is called energy screening and can also be referred to as “energy domain filtering”.

But neutron recognition is hardly fully effective. The energy resolution cannot be infinitely high, and lithium glasses typically have a resolution of only about 20%. To allow for drift, about 15% of the relative width of the passband is needed, e.g. treating all events from 1.4 to 1.8 MeV as neutrons. However, there are few Gamma rays in this range, in particular the radiation produced by the daughter of 232 Th. Lithium glass cannot be used with other improved identification accuracy such as power spectral density. It is susceptible to interference from thorium rays. This is its disadvantage.

High-energy Gamma rays have a strong penetrating ability and have a low probability of acting if they pass through lithium glass from a thin direction. Thick lithium glass (e.g., 10 mm or more) responds to fast neutrons and is used for fast neutron spectroscopy, but has poor immunity to Gamma interference. 3mm is the choice for balancing neutron measurements with resistance to gamma interference.

When measuring neutrons, the KC761 simultaneously enables the gamma ray sensor to monitor which may cause interference and deduct them proportionally from the neutron sensor. The dose rate and count rate displayed by the instrument have undergone interference deduction, while the energy spectrum is the original data before deduction. Deductions are based on statistical patterns and are not reliable. Neutron sensors are only suitable for monitoring Slightly stronger neutron flows in environments with minimal interference from gamma radiation.

Neutrons from radioactive sources or cosmic rays usually have MeV energies and need to be moderated before they can be measured. Hydrogen is the best moderating substance and objects rich in hydrogen are good moderators. When measuring neutrons, polyethylene plastic, water or human tissue should be used to slow the neutrons. Neutron sensors have about 15mm thickness of polyethylene inside as a moderator, but it is still not enough. It is recommended to add an additional polyethylene plastic of at least 8cm thickness or to hold the instrument close to the thigh. The moderator absorbs neutrons, so thicker is not better.

If the neutron count rate is significantly greater after slowing than without slowing, this is generally indicative of the presence of neutrons.

1.2、Energy Resolution

Whatever the detector, due to its own physical characteristics, the voltage obtained is jittered, for example, it is difficult to appear 9998 pulses of exactly 3V, but the actual distribution will only be in the range of, for example, 2.5V to 3.5V, close to the normal distribution. After the statistics, the spectral peaks will be wider than the actual energy distribution of the rays. The relative half-peak width is generally used to describe the performance of an energy spectrometer, which is the ratio of the width at half the height of the spectral peak to the absolute position of the spectral peak centerline, also known as the energy resolution. The smaller the resolution value, the better, but the more expensive the sensor.

Since the energy spectrum is a count of pulse heights, obviously the more pulses collected, the better. In order to get a nice energy spectrum quickly, the distance between the instrument and the radioactive source should be adjusted to find a position where the dose rate is large, but not over the range.

The KC761x has a medium level of resolution and can correctly identify more than two dozen common nuclides. Higher resolution sensors are now becoming popular for cadmium zinc telluride (CZT) materials, and highpurity germanium detectors (for γ-rays) are still the highest resolution. However, these detectors are more expensive, and some require high-voltage power supplies or refrigeration, and cannot be used for the time being in products such as the KC761x, which aims at widespread availability of the new technology.

1.3、Dose rate

Similar to the Geiger counter, this instrument also determines the dose rate of radiation based on the frequency of pulses. Since the Gamma energy represented by the pulse is known, the number of pulses can be corrected according to the sensitivity of the sensor to different energy rays to obtain a dose rate that is still accurate, a practice called **energy compensation**. In addition, the body's ability to absorb different energy rays varies, so a dose equivalent rate can also be obtained.

Dose Rate Units

The KC761x provides several units for the user to choose from. Some of the units do not have a simple conversion relationship with each other, and some have different physical meanings. Among them:

Gray (Gy), rad (rad) is the air specific kinetic energy unit, both have the same physical meaning, can be directly converted, 1Gy = 100 rad. In most cases, the dose and air specific kinetic energy are almost equal, so in this manual do not distinguish, the instrument collectively referred to as dose. The specific kinetic energy of air is the basic data of this instrument.

The roentgen (R) is the unit of exposure. It reflects the amount of charge produced by the ionization of air by roentgen or gamma rays and has a different meaning than the specific kinetic energy of air. However, the quantitative relationship is stable in most cases, and this instrument converts according to 1Gy ≈ 114.5R.

Sv and Rem are the units of dose equivalent, both concepts are the same, can be directly converted, 1Sv = 100Rem. Dose equivalent in the air than the kinetic energy, according to the different radiation hazards on the different corrections, reflecting “equivalent” to how much absorbed dose of harm. The correction factor (conversion factor) is artificially defined. For example, for fast neutrons, the correction factor is set at 20 (for whole body radiation, same below), for 80 keV roentgen rays it is 1.903, for 600 keV gamma rays it is 1.226. The instrument takes the conversion factor for each count, based on the energy or nature of the count, and multiplies it by the specific kinetic energy of the air to get the dose equivalent for that count. Thus, readings in Gy/rad/R and in Sv/Rem are fundamentally different and do not have a fixed conversion relationship.

In addition to these units, the instrument provides an injection rate display for PIN and neutron measurements in Cps/cm2, which is the physical meaning of the number of particles passing per second per square centimeter of cross-section.

The unit setting menu is on the FUNC page.

Any instrument needs to meet a number of prerequisites in order to measure accurate dose rates, and energy spectrometers are no exception.

（1）Impact of energy

The KC761x measures the Gamma energy of each pulse, allowing very precise energy compensation and thus calculating the contribution of each pulse to the dose. The dose rate is more accurate compared to Geiger counters with compensation.

However, the high-energy rays do not necessarily interact completely with the scintillator when they enter it. The high-energy rays may release only part of their energy, known as Compton scattering. Compton scattering manifests itself as a continuous spectrum in the low-energy region. kC761x does not know whether the pulses in the low-energy region are Compton scattering from high-energy rays or real low-energy radiation. Assuming Compton scattering from high-energy rays, but KC761x compensates according to the energy of the pulse, it will treat the high-energy rays as stronger low-energy rays. Depending on the compensation curve, this may cause complex errors.

Therefore, the dose rate accuracy of the KC761x is only accurate for the radioactive material used for calibration. The error increases when measuring other radiation sources such as thorium-uranium mixtures in the environment. Nevertheless, the KC761x remains one of the more accurate of the commonly available portable instruments.

（2）Effects of radiation strength

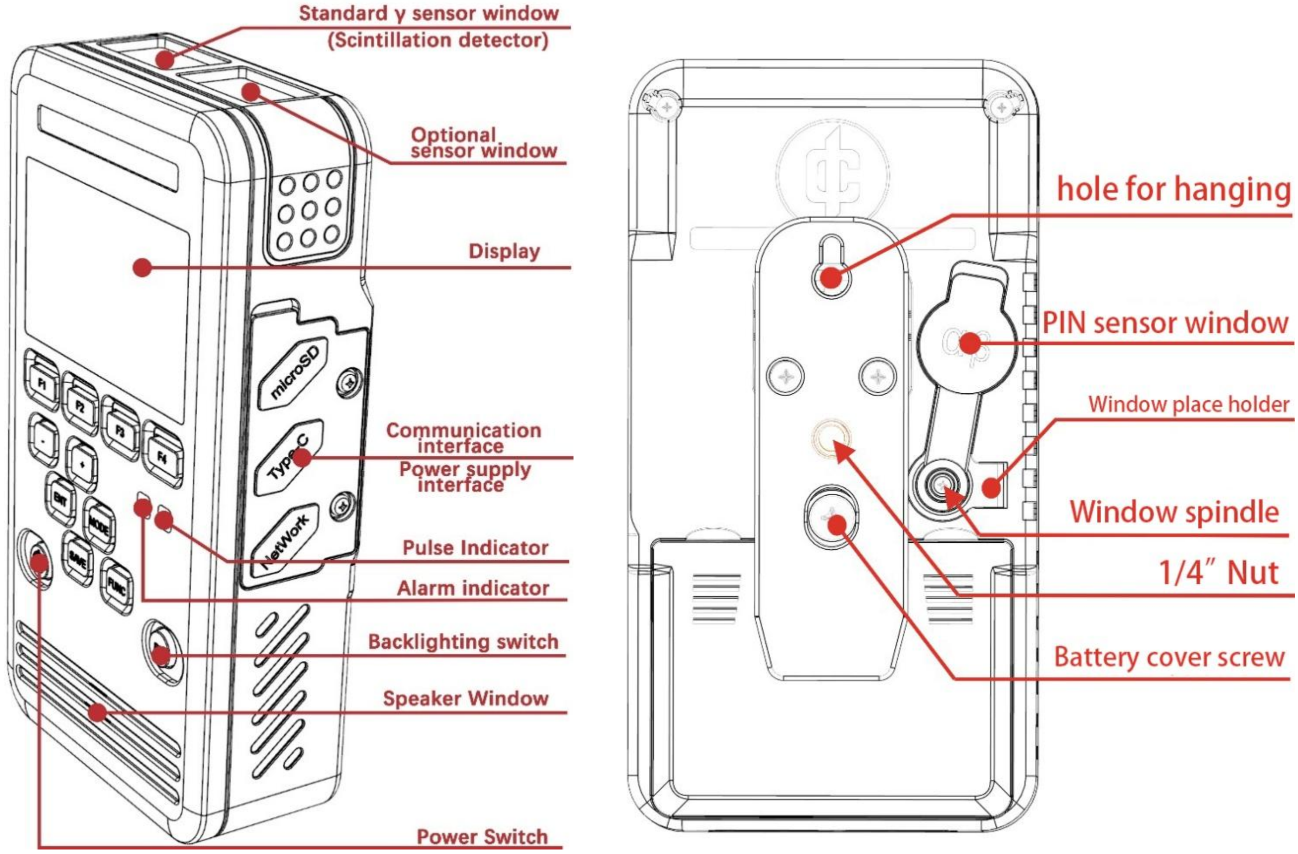
The scintillation counter is only suitable for a narrow range of radiation strength, with a dynamic range better than that of a normal Geiger counter, but less than a Geiger counter with the waiting time technique (TTC). Due to the high efficiency of the scintillation counter, radiation of moderate strength (e.g. 100μGy/h) exceeds the range. After the range is exceeded, the pulses are connected so that there appears to be no pulses. Even very large radiation is measured as small. In order to reduce the probability of misleading, as soon as the scintillation detector exceeds the range, the instrument immediately switches to other mode to avoid missed alarms. The strong radiation measurement capability of the instrument is mainly used to avoid missed alarms, the dose rate reading in this situation is not accurate.

The contribution of noise is larger when the radiation is very weak and close to the background. At this time, the energy spectrogram should be observed to determine the presence of radiation outside the background, the dose rate may have a error.

The KC761x can essentially only count the total detectable effects excited by the rays emitted into the sensor, and the relationship between these effects and dose rate is extremely complex and difficult to convert. Also, in actual radiation testing, the radiation is not pure, making the dose rate even more difficult to measure. User should carry out a more specific calibration according to the characteristics of the radiation measured.

2、Instrument features and functions

The parts of the instrument are shown in the figure below:



2.1、Product highlight

（1）Feature-rich

Equipped with 2.54cm^3 cesium iodide (thallium) scintillation detector and 16mm^{2}PIN detector as standard, it can measure α, β and γ rays.

Each sensor has a separate multi-channel analyzer, all of which can perform spectral analysis and counting.

（2）Power saving and easy access to power

Uses three AA batteries, which are replaceable and easily available.

Under the background radiation, the whole electricity is only 6mA, which can work continuously for about ten days. The power-saving state can further extend the time.

（3）Complete, portable

Most functions can be achieved without connecting to a computer or mobile phone. Less than 0.5kg easy to carry.

（4）**Full range of interfaces**

With Bluetooth and RJ45 network interface, it can be connected to smartphone and computers. RJ45 interface supports POE power supply, no need to set up another power supply, convenient for deployment construction. TF card can be used to store spectra and screen shot. 3.5mm jack can be used with headphones or output the pulse of sensor.

（5）**Waterproof design**

With IP65 protection level, it can be used normally in the rain for a short period of time.

2.2、Sensors

The sensors configured for this instrument are listed in the table below :

Model	CsI Sensors	PIN Sensors	6Li Sensor
KC761	KC7601.21	4×4mm PIN	Not support
KC761A	KC7601.24	4×4mm PIN	Optional
KC761B	KC7601.25	4×4mm PIN	Optional
KC761C	KC7601.26	4×4mm PIN	Optional
KC761CN	KC7601.26	4×4mm PIN	KC7601.31

Information of each sensor is as follows:

（1）**KC7601.21 (For KC761,Stop production)**

10×10×25.4mm CsI(Tl) crystal，2×9mm^2 SiPM， energy resolution about 12%.

（2）**KC7601.24 (For KC761A)**

10×10×25.4mm CsI(Tl) crystal, 36mm^2 SiPM, resolution about 8.2%, all products ≤8.6%.

（3）**KC7601.25 (For KC761B)**

10×10×25.4mm CsI(Tl) crystal, 36mm^2 SiPM, resolution about 7.4%, all products ≤7.8%.

（4）**KC7601.26 (For KC761C/CN)**

10×10×25.4mm CsI(Tl) crystal, $36mm^2$ SiPM, resolution about 6.2% (KC761C)or 5.9%(KC761CN), all products ≤6.5% or 6.2%.

（5）KC7601.31 (For KC761CN or optional for KC761A/B/C)

10×10×3mm ^{6}Li glass, $36mm^2$ SiPM.

Except the PIN sensor, all sensors have built-in memory for calibration data.

Do not attempt to disassemble the sensor and do not squeeze the sensor housing. Removing or squeezing will immediately invalidate the calibration data.

The left sensor slot on the KC761C, KC761CN can only be fitted with the KC7601.26, fitting the wrong model will result in destruction of the sensor.

Sensors may contain highly toxic substances.

2.3、Instrument performance

（1）Energy scale of γ-rays

At completion of production, in the range of 100cps to 10kcps, uncertainty ≤ ± (5% + 20keV) at 23±5°C, or typical uncertainty ± (2% + 10keV).

（2）Energy resolution of γ-rays

Subject to the technical parameters published by the sensor. Additional resolution degradation of the instrument (95% confidence level): $\pm(2/E \times 100\%)$, where E is the peak center energy in keV.

（3）Absorbed dose rate of γ-rays (not guaranteed)

Background～100μGy/h, uncertainty ±15%@662keV

Compensated energy response: -15~+23%（50keV～1.5MeV）, -23%～+43%（30keV～2MeV）

Strong radiation warning : 100μGy/h ～ 10mGy/h , -50% ～ +100%@662keV. Since energy compensation is not possible at this time, the error may be greater at other energies.

10mGy/h to 10Gy/h only for strong radiation alarm.

（4）Dose equivalent rate of γ-rays (not guaranteed)

≤100μSv/h with typical uncertainty ±15%

＞100μSv/h with typical uncertainty -50%～+100%

Dose equivalent (Typical value at ≤100μSv/h, only for KC761x):

HP(0.07): ±30%，HP(3): ±20%

Dose equivalent accumulation limit: ～10Sv

（5）α and β ray measurement

Amplitude scale: count rate is provided for relative measurement, absolute accuracy is not guaranteed, and users can calibrate it by themselves.

Counting rate nonlinearity ≤ 10% (at 10cps to 10kcps).

Energy scale with PIN sensor is just specific α-rays, not for β and γ rays. And the measurement result only for comparison.

ℹ The instrument cannot completely identify α, β, γ rays or neutrons, and the count rate is the total effect caused by all rays.

（6）Neutron measurement (optional)

Subject to the technical parameters published by the sensor. Additional count rate uncertainty of the instrument (when the count rate is <10kcps, it is considered by equal pulse period): ±（5%+2cps）

The energy scale is only used to identify neutron radiation, and the energy spectrogram measures the energy of the same scintillation light energy that caused by Gamma ray, not the actual energy of the neutron.

（7）Measurement time

Accumulation time of energy spectrum: 1s～86400s (maximum pass rate of 30kcps for scintillation detectors and 10kcps for PIN detectors).

Dose accumulation time: any time, since the last time the user clears the accumulated dose, until the accumulated dose is viewed, non-volatile storage cycle ≤ 1h, save when shutdown.

（8）Stability

Temperature stability: within the range of -10～50°C, amplitude drift ≤±10%, energy drift ≤±(5% +20) keV (typ.).

Long-term stability: typical value of amplitude drift ±10%/a, typical value of energy drift for KC761A/B is (±5%+10keV)/a; for KC761C/CN is ±(2%+5keV)/a (temporarily not guaranteed).

（9）Power consumption and battery life

The expected endurance time when using alkaline dry batteries under natural background radiation environment is as follows:

	CsI Sensor	PIN sensor	Li6 sensor
Regular state	11d	6d	7d
Power saving state	14d	7d	8d

Note: Backlight, vibration, Bluetooth, RJ45 interface and OPTIM OFF, Low volume.

（10）Environmental parameters

Temperature range: -10～50°C (normal use); -30～65°C (no guarantee of performance, of which, the LCD display fails below -10°C, Shortened life time above 50°C).

Humidity range: 0% to 100% (short-term, when there is no condensation in the machine).

Altitude: -2000m～15000m (air pressure change rate＜10hPa/min, Allow vacuum).

Waterproof level: IP65 (short-term, must cover all rubber caps).

Anti-vibration: 1g,20Hz,30min.

Fall resistance: any direction, 1.5m (1 time), no functional failure, but there may be performance degradation, display backlight not bright or shell damage.

（11）Others

Overall dimensions: 142mm x 76mm x 34mm (without back clip) or 50mm (with back clip)

Net mass: Approx. 285g (KC761A/B/C); Approx. 305g (KC761CN)

Overall mass: approx. 369g (KC761A/B/C); approx. 389g (KC761CN)

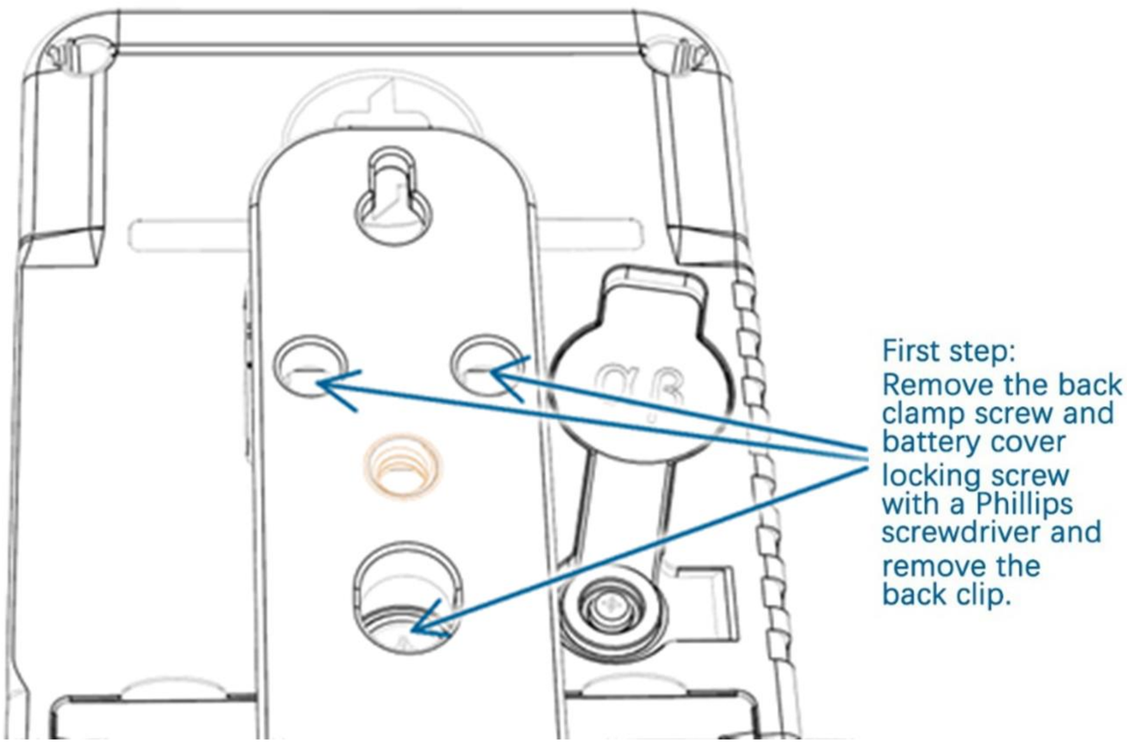
3、Instrument installation

The instrument is shipped without batteries. If the instrument is used as a fixed sensor it should not install batteries and powered by USB or POE only. If used as a portable test device, batteries should be installed.

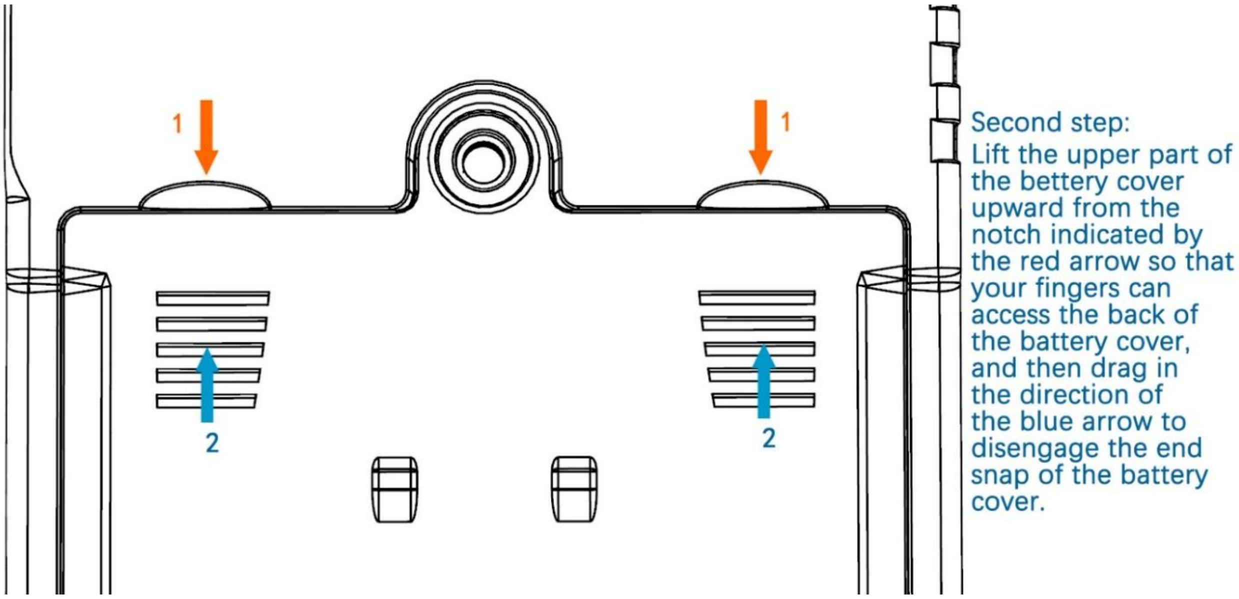
3.1、Battery installation

The battery cover has a waterproof seal and is blocked by a back clip. Although the design contemplates removing the battery cover without removing the back clip, it is more difficult, so it is recommended that the back clip be removed first.

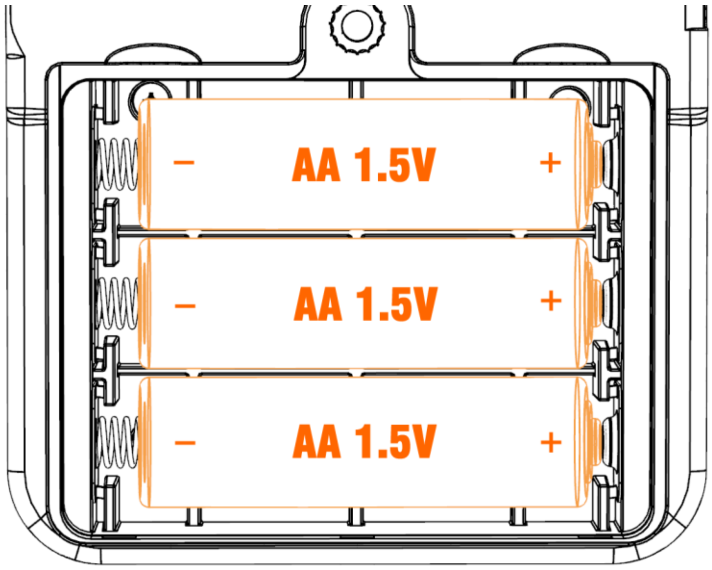
With the back of the instrument up, use a Phillips screwdriver to remove the back clip screw and the battery cover locking screw to remove the back clip.



Insert the tab tool into the notch above the battery cover located on either side of the back clip and lift the top of the battery cover with force. Then drag the battery cover and pull it out.



Load three 5AA batteries according to the direction marked in the battery box. Pay attention to the shape of the spring is normal to avoid being pressed under the batteries.



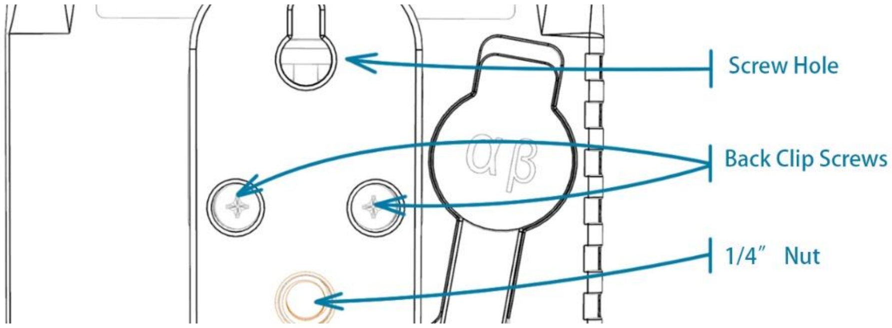
Reinstall the battery cover in the reverse order. Battery cover is more difficult to install, first plug the tail lug into the positioning hole, and then press close to the screw side with force several times, while attention to the state of the waterproof seal. If the seal comes off from the slot on the outside of the cover, the seal should be plugged into the slot first.

ℹ If the battery needs to be replaced, it is recommended to use USB or POE power supply to maintain the instrument always with power, so as not to lose time and cause the time scale of stored data to be misaligned.

3.2、 Fixed installation

If you need to fix the instrument in a certain position for long-term monitoring, etc., you can remove the back clip and fix it using the screw holes of the back clip. The screw diameter is φ3mm, and the maximum length of screwing into the instrument is less than 4mm. Spacers must be used because of the height difference between the nut and the housing surface..

For temporary fixing, use the hook holes on the back clip or 1/4” nut.



The instrument has ability to against rain under the premise that the waterproof rubber is tightly plugged. If the waterproof rubber plug is opened (for example, to connect the network cable), the protection ability will be significantly reduced, and the interface should be made downward and appropriate waterproof and moisture-proof measures should be taken. For long-term fixed use in the outdoors, it must be shielded from rain and sunlight.

If it is necessary to integrate the KC761x with an IoT radio (e.g. 4G router) as a remote monitoring device, special attention should be paid to shielding radio waves. It is recommended to distance the radio antenna from the KC761x. An easy way to do this is to set the antenna 1m away and connect it to the radio via a well-shielded feed line. The antenna should be well matched to avoid the feedline becoming a source of radiation. Radio emissions in close proximity may significantly interfere with the operation of the KC761x, the most sensitive frequency being 2.2GHz.

3.3、 Install TF card

The TF card slot is under the waterproof rubber plug on the right side of the instrument. Re-cover the rubber plug after installation.

TF cards have a maximum capacity of 32GB and need to be formatted to FAT32 file system before installation. Some cards are not compatible. Please try to store data to the TF card with the instrument first and confirm that the data is normal before using it officially.

Must remove TF card before disassemble the device

3.4、Enable Network(Bluetooth)

The connection function of the instrument is off by default, and should be turned on in the software if you need to use it.

Power on → FUNC → Network setting → RJ45 or Bluetooth → On.

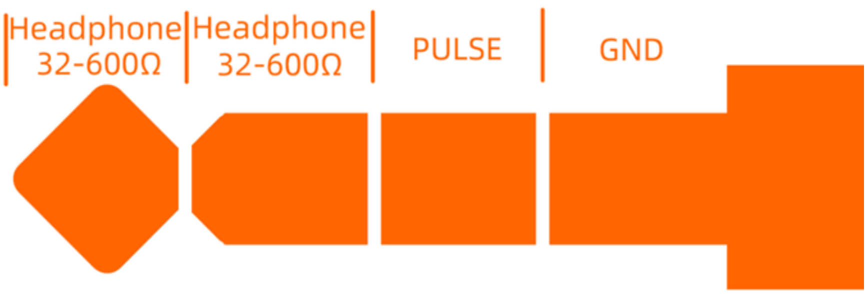
It works in the default after the first opening, and you can modify the setting by yourself.

ℹ When network port is enabled, the power consumption of the device will increase dramatically and the battery life will be shortened to few hours. When network is enabled, please use USB or POE power supply. When net-working is not required, the network connection function should be turned of.

3.5、Pulse output interface

There is a 3.5mm plug at the right communication interface to insert a 3.5mm four-segment audio plug for outputting click audio and raw sensor pulses(After S-K filter). Pulse amplitude is not adjustable.

The interface is defined as follows (for products after March 2023 only):



If need to output audio or pulse, it needs to be turned on in the software FUNC setting.

- Four-segment pins must be used, and the PULSE output must not be short-circuited over time.
- The raw pulse width is about 10μs and cannot be directly sampled by sound card.
- The headphones volume cannot be adjust, should be slowly placed close to the ear to feel the sound level.
- The interface is more fragile and should be avoided under stress.

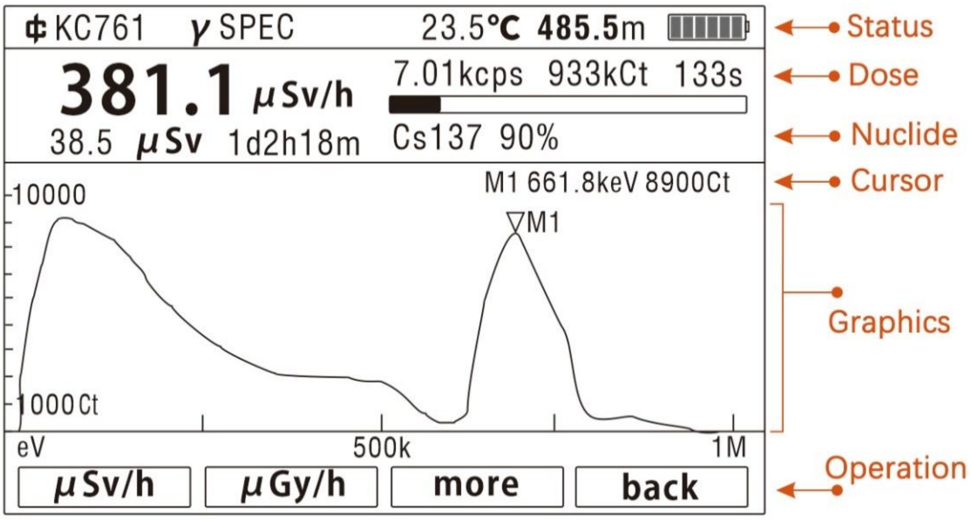
4、 Operation Guide

This guide focuses on the human-machine interaction and operation logic of the instrument, and it is recommended that users read it completely. This manual defaults to the user being able to understand the operating principles and master the operating essentials on their own through trial and error, and does not require a detailed description of all operating steps.

Earlier versions of the software, the operating logic may be very different from this manual, please refer to the actual operating experience of the device.

4.1、 Interaction interface

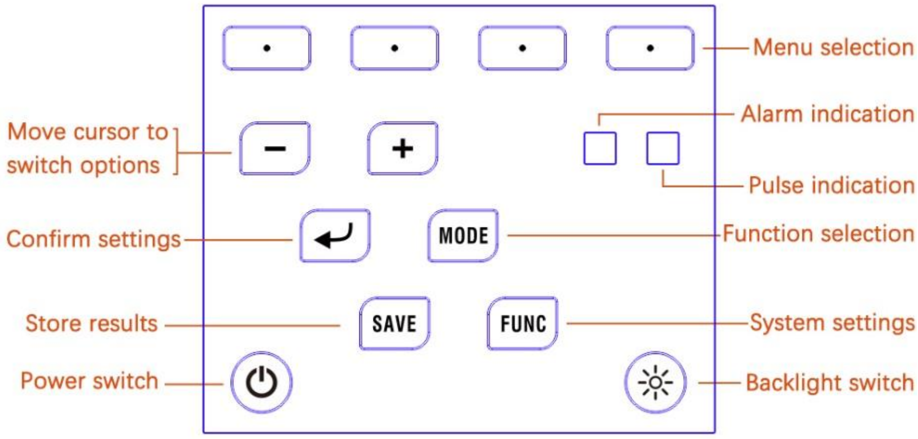
Commonly used display interface partitions are shown in the following figure:



The display style may change as the program is updated.

To save power, the instrument uses a 240×160px monochrome dot matrix LCD screen and the backlight can be turned off at any time. When the backlight is turned on, it will increase the power consumption by about 3mA, and the battery life will be significantly shortened.

The layout and functions of the keyboard are shown in the following figure:



（1）Power Switch

Short press the power switch to power on in the off state.

In the power-on state, press the power switch 1s to popup power off dialog menu. When power off dialog menu popup, short press power switch or confirm button to power off.

Press and hold for 10 seconds to hard completely power off.

Unless setting the global volume to OFF, It will beep once when power on and off.

（2）Backlighting switch

Short press to turn on the backlighting of the display and keyboard, and short press again to turn off the lighting.

Blacklight will turn off after 5 min non operating.

Press and hold the backlight switch for 1 second, the backlight keep on, and a light icon will shows at screen top. short press backlight switch to turn off.

（3）System Settings（FUNC）

Press the key to enter the system configuration menu, press the "-" and "+" keys to switch the setting items (with cursor prompts).

（4）Store results（SAVE）

Short press to store the current spectrogram, spectral table, dose rate table and accumulated dose into TF card.

If no TF card is inserted, the storage function is not available, but the accumulated dose can be recorded.

The FUNC-Advanced menu allows you to set the items to be stored and configure the automatic storage function.

（5）Function Selection（MODE）

Short press to enter the function selection menu, use the menu selection key to select the function you need to use.

Press and hold for 1s to enter the sensor selection menu.

（6）Confirm settings（ENTER）

A short press is used to activate cursors, confirm modifications, confirm selections, etc.

When no setting item is activated, short press to open the marker menu.

（7）-，+

Used by default to move graph coordinates when no setting item is activated.

Used to move cursors in setting menus such as FUNC.

Hold to move continuous.

Used to change values or options when a setup item is activated.

Most changes to setting items need to be confirmed by pressing the Confirm setting key. A few of them take effect in real time.

（8）Menu selection

Used to operate the options on the soft menu.

（9）Pulse indication

When using a PIN or neutron sensor, the pulse indicator flashes immediately when the sensor receives radiation particles.

For CsI detectors, the pulse indicator flashes once every 8 to 32 pulses, in line with the buzzer, due to the high count rate.

This indicator also use to increase the battery charge(excl. KC761)

It can be turned off in FUNC – Sound and Light menu.

（10）Alarm indication

The alarm indicator flashes when the set alarm conditions are reached.

When different levels of alarms are triggered, the color and frequency of the alarm indicator flashes differentl.

Generally, low-level alarms use single-color flashing, and high-level alarms use multi-color flashing, such as red, white and blue alternately.

Alarms are always sounding. The volume of low-level alarm tones depends on the system settings and can be adjusted in FUNC-Sound and Display. The maximum volume is always used for critical alarms.

After an alarm has occurred, the sound can be paused by pressing any key for 1 minute without affecting the flash.

4.2、Function Description

4.2.1、Operation Status

（1）General Status

The default operating state. The type and number of sensors that are turned on in this state depends on the function settings.

（2）Power saving state

Set auto power save in FUNC menu. If there is no operation and alarm, the instrument will automatically enter the power saving state after the set time.

ℹ In the power saving state, it returns to the regular state if external power is connected.

ℹ Power saving states will turn off the display, and the instrument will make the alarm indicator blink green at fixed intervals to indicate that it is still working.

In power saving mode, the energy spectrum or count operates normally, and only the UI function is turned off. It will save about 70% power usage. If radiation exceeding the alarm threshold is encountered, the power saving state will be aborted and returned to the regular state with an alarm. If the radiation is reduced to below the alarm threshold, the instrument enters the power saving state again after a set time. For the total dose rate alarm, it will be in the regular state for a long time after waking up, until the accumulated dose is cleared or the alarm threshold is adjusted upward, so that the alarm can be eliminated before entering the power-saving state again.

To avoid misunderstanding, Auto Power Off (APO) and Auto Power Save cannot work at the same time, only one of them can be turned on.

ℹ The automatic power off (APO) function only takes effect when the battery is used alone. If the USB power supply or POE power supply is connected, the APO function automatically hangs and takes effect again after the external power supply is removed. When used as a remote sensor, please turn off the APO function so that it cannot be turned on again after a power failure.

In the power saving state, if the battery is low, the buzzer beeps once a minute for a long time. When the battery is exhausted, the instrument automatically shuts down. From low battery to battery depletion, it usually takes more than 12 hours.

4.2.2、Basic Mode

All modes are based on the algorithm of the mode and the selected sensor for dose accumulation. After switching modes, the dose continues to accumulate.

（1）Energy spectrum priority

The energy spectrum graph and data related to the energy spectrum are mainly displayed. The count value and dose rate are displayed as secondary contents. When the range is exceeded, it automatically switches to strong radiation mode. The spectrogram does not work normally during strong radiation.

（2）Dose Priority

Displays a trend graph of the count rate or dose rate over time. The count rate displayed in a similar way to the energy spectrum priority mode, but the graph area is slightly smaller and the value area is larger. If a scintillation detector is used and its range is exceeded, it automatically switches to strong radiation mode and the dose rate curve is updated as usual.

4.2.3、Sensor Selection

In Energy Spectrum Priority and Dose Priority modes, press and hold the MODE key to enter the sensor selection menu. Sensors can also be switched in the FUNC-radiation sensor selection. The currently used sensor is indicated in the status bar at the top of the display.

Among them

CsI: scintillation detector (standard), In left sensor slot.

PIN: semiconductor detector.

6Li: neutron detector (optional), In right sensor slot.

Regardless of which sensor is selected, the KC761 may turn on other unselected sensors as needed for alarms and ray identification.

4.2.4、Alarm

The instrument has three alarm scenarios: dose rate alarm, count rate alarm, and total dose alarm.

Each alarm is further has two levels: alarm and critical alarm.

For the dose equivalent rate alarm, the setting range of threshold is 1μSv/h to 99μSv/h (default is 10μSv/h), and the setting range of critical alarm threshold is 0.1mSv/h to 9.9mSv/h (default is 1mSv/h).

Counting rate alarm, general alarm setting range is 10 to 999/$cm^{-2}s^{-1}$ (default 50), the critical alarm setting range is 1 to 29.9k/$cm^{-2}s^{-1}$ (default 10k). To avoid random rise and fall caused fake alarms, counting alarms will use the CPS after smoothing processing.

Threshold ranges for the total dose alarm are 0.1 to 9.9mSv (default 3mSv) and 10 to 999mSv (default 22mSv).

When an alarm occurs, the status bar of the display will shows the alarm type and alarm level. When multiple alarms are occurs, It will displayed in turn.

In addition to the display, when the alarm occurs, the instrument uses sound, light and vibration to alarm.

alarm: a slow beeping sound, a single-color flashing alarm light, and a long intervals vibration.

Critical alarm: a sharp beep or alarm sound, alarm indicator multi-color alternating high light flashing, vibration twice and cycle.

After the alarm is issued, if the instrument is low on power, the system automatically turns off the vibration, reduces the brightness of the alarm light, and the sound signal unchanged.

After the alarm event is eliminated, the alarm is delayed for 3 seconds to stop. When the alarm occurs, short press any button to pause the sound and vibration for 1 minutes, and repeat the button will re-timer. If the alarm is not removed, the sound and vibration will be emitted again when the time is up. New alarm will not effect by this operating and will alarm immediately.

The accumulated dose alarm can not be turn off, It can be eliminated by clearing the accumulated dose by entering the code (7601) in the FUNC-Reset menu, or by raising the alarm threshold in the FUNC-Alarm Settings.

Dose rate and count rate alarm must be turn on at least one.

The switch and threshold of the alarm are set in the alarm submenu under the FUNC menu.

4.2.5、Nuclide identification

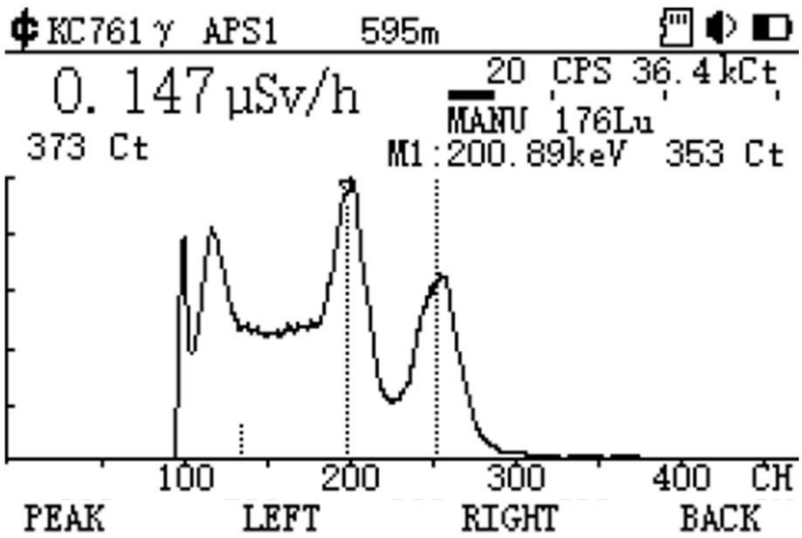
Radioactive isotopes emit rays with specific energies. By measuring the energy of the rays, the spectrometer can identify the isotope that produces the rays. The energy of Gamma rays does not vary with environmental conditions and is easy to measure. The nuclide identification of this instrument is based on the Gamma ray energy spectrum, the data from the neutron sensor is not suitable for nuclide identification, and the PIN sensor is only meaningful when testing Alpha rays, and is not normally used for nuclide identification.

Some isotopes emit rays of various energies, and the amplitude of each has a specific proportionality, which is like a key with multiple teeth, which can only open specific locks, and the identification is more reliable. Some isotopes emit only one type of energy ray, and if there are other rays in the vicinity, they are not easy to recognize them.

(1) Auxiliary manual identification

Manually move the cursor to the top of the characteristic peaks on the energy spectrum, if the energy value corresponding to the cursor is similar to the energy of the radiation emitted by a certain isotope, the instrument will display a vertical dotted line in the position corresponding to all the radiation energies of the isotope, and at the same time display the symbols of the isotope. The height of the dotted line indicates the proportionality of the amplitude of the rays of different energies. Since low energy rays are more easily absorbed by the sensor, and high energy rays tend to penetrate the sensor without having full effect, the peaks of the spectra are not equal even if the dashed lines are of the same height, and usually the higher the energy, the shorter the peaks. However, for dashed lines of equal height, if one corresponds to a distinct spectral peak, then there should be at least a slight bump near the other. If there is none at all, it is a sign that it is not that isotope. In short, the more the spectral peaks overlap with the cue line, the more likely it is to be that nuclide.

The figure below shows a typical energy spectrum diagram, where two very high cue lines appear when the cursor moves to the first characteristic peak, while the symbol ^{176}Lu is displayed. since the second characteristic peak also coincides exactly with the cue lines, it can be assumed that the radiation originates from ^{176}Lu. As you can see from this graph, even though the cue lines are equal, the high energy peaks are lower. The sharp peak on the far left is produced by the fact that this is close to the instrumental noise floor, and the instrument concentrates all the energy near the noise floor on the far left side of the display, and has no specific significance(>9keV part for KC761x may be significant). The second peak from the left is the result of the superposition of the Compton scattering of the uranium background radiation, the ^{176}Lu radiation and K-x 55keV peak. It is no particular significance for isotope identification.



(2) Automatic Identification

KC761 will recognize all the peaks it can find, and by comparing with the nuclide library, the nuclide with the highest correlation will be recognized as the result. The automatic identification based on the spectrum measurement on that time, and the identification result is only for reference, should to check with manual identification.

The automatic identification function works on the premise that the CsI sensor is selected and the total count rate is ⩾30kCt, in which case the automatic identification runs automatically. The result of automatic identification is displayed in the upper right corner of the spectrogram, starting with AUTO, and a short horizontal line is displayed if the identification is not successful. Automatic identification and manual identification are independent of each other and do not affect the operation of manual identification.

(3) Precautions

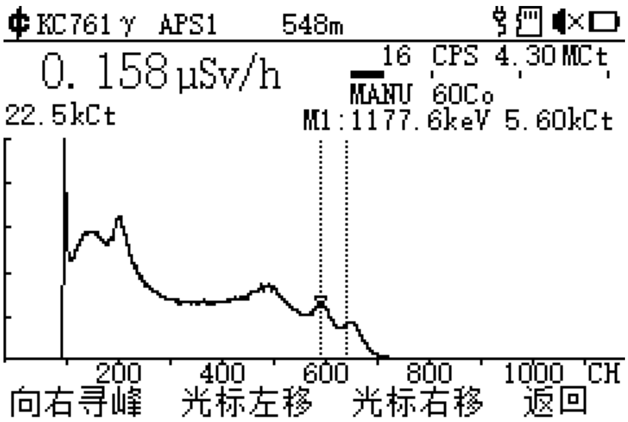
Whether it is automatic or manual identification, it is necessary to accumulate enough counts first to smooth the curve. It is generally recommended that the number of counts be 30kCt or more, the more the better. Before start to measurement it should be clear the spectrum data to avoid the old data confused.

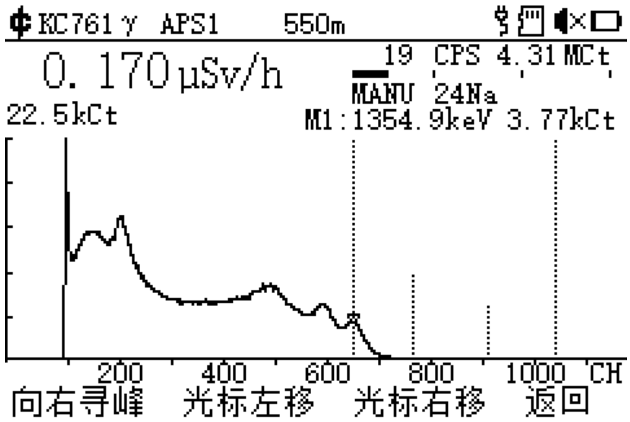
Many isotopes produce radiation in the low-energy region (<250keV), resulting in a very crowded low-energy region, even one energy corresponding to multiple nuclides. The low-energy region is in turn characterized by the presence of a large amount of background radiation, which can lead to spectral bulges even in the absence of noteworthy rays. Priority should be given to finding peaks in the middle and high energy regions for identification.

The fatness of the spectral peaks should be predicted based on the resolution of the sensor and the energy of the rays. Obviously too thin peaks are usually false peaks, and obviously too fat bulges are usually a combination of multiple neighboring peaks or Compton scattering, which is not representative of any of the peaks at its highest point and is a meaningless peak for any isotope. Neither overly thin nor overly fat peaks can be used for nuclide identification.

The instrument is subject to energy drift, and even a 2% drift can cause the peaks to deviate severely from the correct energy. In the low-energy region due to the very high crowding, a slight drift can lead to a sheeted peak. Drift is difficult to avoid completely, and when identifying, if there are peaks in the middle and high energy regions, the peaks in the middle and high energy regions should be used in preference to the peaks in the middle and high energy regions. If the peaks do not coincide with the cue lines, you should observe the overall trend of the spectrogram, move the cursor left and right to understand the neighboring isotopes, and imagine whether the spectrogram can coincide with multiple cue lines after a slight zoom to determine whether it is the cue isotope.

In the left image below, after shifting the cursor, two cue lines are seen that overlap with the peaks, corresponding to the isotope ^{60}Co, although they do not overlap completely, and there is a difference of a few tens of keV, which makes it likely that the rays are from a cobalt source. When the cursor coincides with the rightmost peak, the ^{24}Na cue line appears, but there is no peak on the right contour cue line at all, so the presence of 24Na can be ruled out. Trace Optimization can be turned on to highlight the peaks in the high-energy region.





If conditions permit, try to correct the energy before the test, see section 5.1.

4.2.6、 Auto save

Due to limited memory, the instrument can only display detailed dose rate/count rate data (resolution with seconds) for the past 1 hour and is lost when switched off. The auto-store function can regularly store dose curves, energy spectra and other data into a TF card for later analysis.

Auto storage can be configured in the FUNC-Advanced menu, items include:

(1) Enable Auto Storage. Used to enable or disable auto storage.

(2) Auto Storage Interval. It can be set in the range of 30 minutes to 24 hours and 30 minutes, and the default is 1 hour and 0 minutes. If the period does not exceed 1 hour, dose rate/injection rate test data accurate to the second can be stored continuously. If the period is more than 1 hour, only the data of the past 1 hour will be stored each time it is automatically stored.

(3) Auto Storage Alignment Time. Used to specify the starting point of the cycle. For example, if it is set to 03:07 alignment and the cycle is 30 minutes, it will be automatically saved at the 7th and 37th minutes of each hour. If the period is 5 hours, it will be stored at 03:07, 08:07, 13:07 ......23:07 and aligned once at 3:07 on the next day. That is, the storage at 3:07 is 4 hours

away from the previous storage and will not be postponed to 4:07. Please set the date and time correctly in the FUNC menu.

(4) Enable Spectrum Incremental Save. Ticked by default. If cleared, the spectrogram is re-accumulated, and each time the spectrogram is stored automatically, it is the spectrogram in the previous cycle. If unchecked, it will be accumulated continuously. Spectra data of different cycles can be added together to get the continuous accumulated data. The automatic storage is independent of the instrument display, clearing does not affect the spectra displayed on the instrument.

Writing to TF card is very power-consuming, and too frequent auto-store will shorten the battery life significantly, so it should be set to 1 hour in general. In order to avoid the power crash caused by writing TF card, the auto-store function will not run when the battery voltage is lower than 3.3V. For reliable storage, it is recommended to connect an external power supply.

Storage consumes time (about 1 second) during which the instrument cannot process new data, but caches the new data and counts it as the first second after storage is complete. The cache space is limited and if strong radiation is being experienced, the data for the stored second will be partially lost.

4.3、Menu settings

The state at the last power off is maintained by default when the power is turned on.

In order to avoid shortening the life of the memory by writing it frequently, some operations and data are only stored at regular intervals (e.g. every 30 minutes) and will be forced to be stored once when the instrument is turned off. If the power is forcibly disconnected while the power is on, it will not be saved.

If the factory settings are restored, the instrument defaults to energy spectrum priority mode, using the first registered sensor.

The menu is designed to be logical, simple and easy to remember, and the number of levels is not a priority.

4.3.1、MODE menu

Short press MODE to enter the mode selection menu, and short press MODE again to return to the mode main menu of the current mode.

The mode selection menu is shown in the table below.

Option	Name	Function	Notes
Energy spectrum /SPEC	Energy spectrum priority mode	Enter energy spectrum priority mode	
Dose/DOSE	Dose priority mode	Enter dose priority mode	
Back/BACK		Return to the menu before pressing the MODE key	

Press the button to enter the corresponding mode.

Press and hold the MODE key in the energy spectrum and dose mode to enter the sensor selection menu, as shown in the table below.

Option	Name	Function	Notes
Scintillator/CsI	Scintillation detector	Select left slot senso	
Lithium Glass/6Li	Neutron detector	Select right sensor, specific options subject to actual configuration	Op-tion
Semiconduc-tors/PIN	Semiconductor Detectors	Select PIN Sensor	
Back/BACK		Return to the menu before pressing the MODE key	

The above table is for reference only. The instrument reads the type of sensor installed in each sensor compartment at power-up and displays them in the order of left and right sensors and PIN sensors, if sensor is not installed it will not show up.

It is also possible to select sensors in the FUNC-Radiation Sensor Select menu.

（1）、SPEC menu

Each mode has its own top-level menu. The top-level menu of the Energy Spectrum Priority mode is the SPEC menu.

The [First Level Menu] SPEC menu has the following options:

Option	Name	Function	Notes
MARKER	Cursor	Enter the cursor control menu after pressing the key	With subordinate menu
SCALE	Coordinate set-tings	Set the type of coordinates and their ratio	With subordinate menu
TRACE	Trace operating	Pause, Start and Clear measurement	With subordinate menu
ADV	Advance Set-tings	Set Optimization and DeBackground	With subordinate menu

The [Secondary Menu] Cursor/MARKER menu options are as follows:

Option	Name	Function	Notes
PEAK	Peak Find	Find the peaks in the display area in order to the right	
LEFT	Move the cursor to the left	Move to the left of the current cursor position	Long press to move continuously
RIGHT	Move cursor to the right	Move to the right of the current cursor position	Long press to move continuously
BACK	Back	Return to mode main menu	

After entering the MARKER menu, the "-" and "+" buttons are still used to move the spectrogram, and the cursor follows when moving the spectrogram. The cursor cannot turn off.

The [Secondary Menu] Scale/SCALE menu options are as follows:

Option	Name	Function	Notes
ZoomOut	Zoomed out spectrogram	Increase the coordinate span and make the graph smaller	
ZoomIn	Enlarge Spectrogram	Decrease the coordinate span and make the graph bigger	
AXIS	Set axis mode	Set spectrum aixs	With subordinate menu
BACK	Back	Return to mode main menu	

Scaling is graded, and corresponds to 1, 2, 5, and 10CH per pixel, respectively, and its scale, logarithmic or linear is displayed on the top left of the graph. Scaling is done with the leftmost scale and the right side beyond the highest channel address is displayed blank. The "-" and "+" keys are used to move the horizontal coordinates at any time when there is no other conflict.

The [Secondary Menu] trace/TRACE menu options are as follows:

Option	Name	Function	Notes
CLEAR	Clear Spectrogram	After pressing the key, a second confirmation dialog box appears	
PAUSE	Pause Accumulation	Press once to pause the spectrum accumulation, the display changes to START, press again to start accumulation, the display changes to PAUSE.	Indicated by symbols on the display
LIN/LOG	Vertical axis setting	Switch vertical axis in liner and log mode	
BACK	Return	Return to mode main menu	

This clear operation only affects the energy spectrum, not the dose rate or accumulated dose. If the single channel site is full, accumulation is suspended and the status bar indicates Channel Overflow.

The [Secondary Menu] advance/ADV menu options are as follows:

Option	Name	Function	Notes
Optimization/OPTIM	Measurement optimization	Press to turn on, After turn on it will display as OPTIM OFF	
Background cancelling/DBKG	Enable radiation background cancelling	Press to enable. After enable it will display as BKG OFF	
Save Background/BKG	Save current background	Save current measurement as background	
BACK	Return	Return to mode main menu	

When Deduct Background is turned on, the stored background is used as the basis for proportional deduction from the spectrum, but the dose rate and accumulated dose are not affected. This operation does not clear the accumulated energy spectrum data, if you need to clear it, you should operate Clear in the trace menu.

If the total count of the current spectrum is more than 100kC after pressing the Save background option, it will prompt on the secondary confirmation dialogue box that the old data will be overwritten and display the options of Confirm/OK and Cancel/CANCEL; if the total count is less than 100kC, it will prompt that the total count is insufficient and cannot be set as the background, so please continue to accumulate it and try again.
Before collecting the background, clear the spectrogram first, then place the instrument in an undisturbed place to accumulate enough counts, then press the Save Background button to record it.

（2）、DOSE Menu

[First level menu] In dose priority mode, the top level menu is the DOSE menu:

Option	Name	Function	Notes
MARKER	Cursor	Enter the cursor control menu after pressing the key	With subordinate menu
SCALE	Coordinate setting	Set the type of coordinates and their size	With subordinate menu
CLEAR	Clear data	Clear dose rate measurement after Press and confirm	
LOG	vertical coordinate	Switch vertical coordinate between Linear and Log	

KC761 runs records in the background in all modes, whether it is a dose curve or an accumulated dose, and only displays them in dose priority mode. Switching from another mode to dose priority mode displays the history instead of updating it from scratch.
The dose priority mode still runs the energy spectrum analysis in the background and compensates for energy or equivalent accordingly.

The [Secondary Menu] Cursor/MARKER menu options are as follows:

Option	Name	Function	Notes
NextPeak	Peak Find	Find the peak in the display area from left to right	
LPEAK	Move cursor left	Search for the next peak to the left of the current cursor position	Long press to move continuously
RPEAK	Move cursor right	Search for the next peak to the right of the current cursor position	Long press to move continuously
BACK	Back	Return to mode main menu	

If there are no other conflicts, the -+ keys on the keyboard are used to move the curve at any time. The curve is moved up to the old and new ends. If no move operation is performed for 30 seconds, the right edge is automatically restored to the latest refresh state. Users who need to stay in a non-up-to-date position for a long time for a closer look should first pause the refresh in the Clear menu.

The [Secondary Menu] SCALE menu options are as follows:

Option	Name	Function	Notes
ZoomOut	Zoom Out Curve	Increase the time span and make the graph smaller	
ZoomIn	Zoom In Curve	Decrease the time span and make the graph bigger	
BACK	Return	Return to mode main menu	

New data is poured in from the right side and old data leaves from the left side. The data missing due to intermittent work in the power saving mode or shutdown in the middle of use is uniformly

4.3.2、FUNC Menu

The FUNC menu has more content and is displayed in a list. At the bottom of the FUNC menu list, the soft menu shows two options, ENTER and BACK.

The FUNC menu has a cursor that uses the reverse color to indicate the position. Press ENTER to activate the setup item and press “-” and “+” to adjust the options. If the item has a dedicated setup page, jump to the setup page.

The FUNC menu uses a scrolling list, with scrolling driven by the cursor, and the position of the cursor is temporarily stored when you leave the FUNC menu.

The contents of the FUNC menu are listed in the following table.

Menu Item	Name	Function
Language	Language Setting	Toggle between English and Chinese. The language of the menu name is mutually exclusive with the actual activation language.
Communication	Communication setting	
Bluetooth switch	Enable Bluetooth	
Ethernet switch	Enable Ethernet	
Ethernet config	Config the ethernet setting	
Local IP Config	IP	Setting IP address
Local Gateway Config	Gateway	Setting Gateway address
Local Subnet Mask	Subnet mask	Setting Subnet mask
Local TCP/IP Port Number	Local Port Setting	Setting Port number of KC761x
Cloud	Settings for cloud connection	Config cloud data connection for KC761x
Transmit switch	Enable cloud transmission	Enable or disable cloud function
Service add	Cloud address setting	Config the cloud service address
Secret key	Cloud key setting	Setting cloud connection keys
DATE and TIME	Time setting	
Sound and Light		
Global volume		Adjusting the volume Loud, low, off
Key BEEP Switch	Button sound setting	
Count BEEP Switch	Particle count setting	
Earphone Switch	Headphone output enable	3.5mm headphone output enable
Count LED Switch	Count LED enable	Enable LED blink
Power Save		
Auto Power Save Mode	Enable power saving	Only one of the two functions can be selected. Trns off the display or
Auto Power Off mode	Enable auto power off	

		switching off after a set period of time.
APS Time Delay	Waiting time to enable APS mode	1~600 minutes
APO Time Delay	Waiting time to enable APO mode	1~600 minutes
ALARM	Alarm function settings	
γ Alarm Setting	Gamma alarm threshold	CPS and Dose Rate threshold
Neu Alarm Setting	Neutron alarm threshold	CPS and Dose Rate threshold
PIN Alarm Setting	PIN sensor alarm threshold	CPS and Dose Rate threshold
Total Dose Alarm		Total Dose Rate alarm threshold
Reset Alarm to Default		Rest the Alarm Setting
Radiation Sensor Select	Select sensors	Same as hold MODE button
Unit Select	Setting measurement unit	Config separately for different sensor
Quantities and units of radiations	Setting radiation units	Including Gy, rad, R, Sv,rem
Pressure or Altitude		Selection of barometric pressure or altitude display
Advance		Advance settings
Sensor Correction		
Gamma Sensor Correction		User calibration for CsI sensor
Neutron Sensor Correction		Setting neutron identification parameters
PIN Sensor Correction		Setting energy scale for Alpha radiation
Smooth window	Set the window length for the average dose rate or Cps	1 to 300s range, works for average dose rate/Cps of all interfaces
Waveform Out	Pulse output settings	Enable pulse output and setting output sensor
Auto Storage	Configure storage functions	Set up automatic storage
Device information		
RESET	Reset instrument	Includes restoring the factory, clearing the accumulated dose, etc.
Firmware upgrade		

Three options are included in the RESET/RESET menu: Clear Accumulated Dose, Restore Factory Settings, and Exit. Password for clear accumulated dose is 7601,and Device Reset password is 9527.

With the improvement of functions, each menu may have a large adjustment. Due to the limitation of printing lot, it may not be updated in the manual in time, so please refer to the actual product.

4.4、Other matters to be clarified

(1) The energy spectrometer may receive radiation above the upper energy limit, at which time counts will still be generated and the energy will accumulate to a number of channel sites near the highest. Therefore, the peak on the far right of the spectrum(Ch1600~Ch2047) is the sum of all pulses above its energy reading, and the peak position is not real.

(2) Scintillation detectors can respond to higher energy β-rays, β-ray can also produce bremsstrahlung and measures as a continuous spectrum. When testing, attention should be paid to the interference of β radiation.

(3) The PIN detector has a little sensitivity to γ-rays. β-rays can also cause bremsstrahlung and be received by the PIN detector. When testing for β rays, be aware of interference from γ rays. The PIN sensor has a thin depletion layer which β-rays can easily pass through without obtaining the full energy. Therefore, it is not possible to fully measure the energy spectrum of the β-rays and show a low energy spectrum.

Alpha-ray spectrum measured by PIN sensor can use to compare the energy of alpha-ray.

4.5、Usage Tips

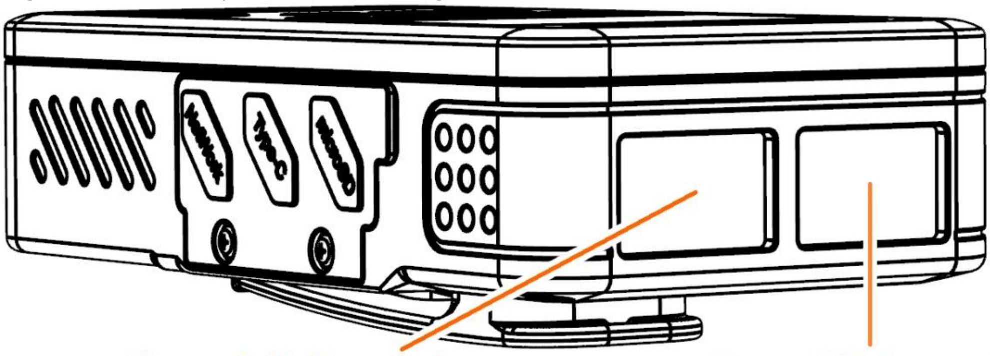
This section notes tips for use, and newer versions of the user manual may include more content.

4.5.1、Optimal incidence direction and distance

This device can be installed three sensors. The γ ray scintillation detector should be used in the left sensor slot, Neutron sensor can only be installed at right slot.

Although scintillation detectors are sensitive to rays in all directions, rays incident in the long axis direction give better energy resolution and peak-to-concept ratio.

The thickness of the housing at the window is much thinner than elsewhere, which facilitates the transmission of low-energy X rays. For the neutron detector (optional), the moderator is on the side near the window. The scintillator in the neutron detector is a thin ^{6}Li glass, and the direction of incidence of neutrons should maximise the use of the cross-sectional area of the lithium glass, i.e. from a direction parallel to the long axis of the instrument. PIN detector has metal shielding, only in the direction perpendicular to the back of the instrument housing surface with a window, only that direction of the α and β rays can reach the semiconductor surface. α and β rays need to be shot through the window of the housing in order to avoid being blocked by the housing.

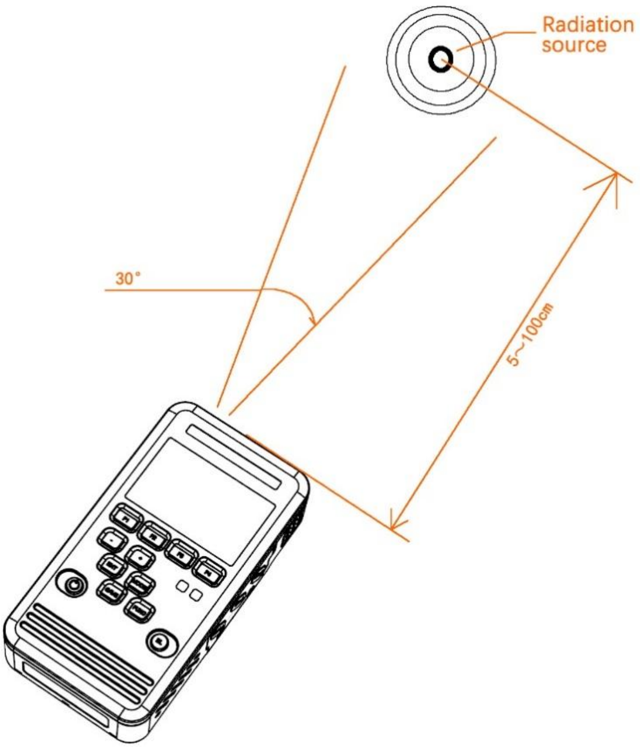


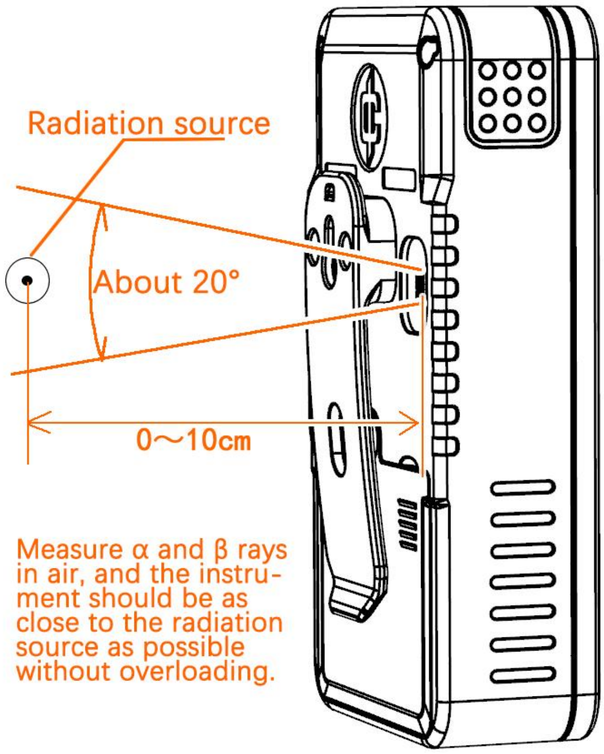
The best direction of incidence is shown in the figure below. The left figure is suitable for detecting γ rays(also for neutron sensor that move to right window), and the right figure is suitable for detecting α and β rays.

The sensor's count rate, or dose rate reading, is for the optimal direction of incidence only, and deviation from the recommended direction will magnify the error.

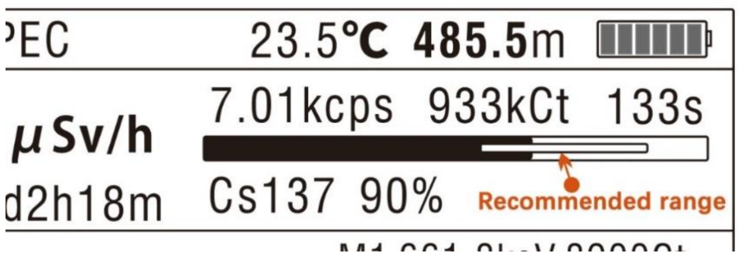
Neutron sensor readings are also related to the moderator, which should be added between the source and the sensor window, usually a polyethylene plastic 5 to 10 cm thick, or a human thigh.

ℹ Unless measuring neutrons or absolutely necessary, avoid placing objects, especially metals or metal-containing minerals, between the source and the instrument. Metals or minerals should also be kept away from the source to prevent luminescence.





The distance between the radiation source and the instrument should be as close as possible without exceeding 10kcps. In the energy spectrum priority mode, the instrument will use the length of the light column to indicate the radiation intensity, you can adjust the distance between the instrument and the radiation source, so that the light column is located in the recommended range. The recommended range is only considered from the perspective of rapid measurement, if it is lower than the recommended range, it will not affect the measurement.



If the radiation source is weak and requires longer measurements, which in some cases (e.g. analysis of natural rocks) may take up to several days, attention should be paid to the stability of the power supply and timely storage of data to avoid any accidents.

4.5.2、Find unknown sources

Sometimes it is not clear where the source is located and a search is required.

The KC761x does not have a search mode. The so-called search mode essentially cancels the smoothing and updates the count rate in real time as much as possible. This can be achieved through proper software configuration. When searching for an unknown source, the length of time can be appropriately reduced in the FUNC-Advanced-Sensor Max Smoothing Window setting, e.g. set to 6 seconds. At the same time, set it to play all pulse sounds.

Whatever the source, it follows the pattern of large near and small far. The instrument can be moved in all directions to observe changes in the count rate or dose rate readings and listen to the count click. For observation purposes, it is recommended to use the dose-first mode. If the reading becomes significantly larger after moving to a certain direction, the source is most likely to come from that direction. If it is not convenient to get close to the source, you can also observe the direction of the significant decrease in reading, its opposite direction is the direction of the source.

For α and β-rays, the directionality of the sensor can be used for directional measurements. The optimal direction of incidence of the PIN sensor is also the sensitive direction.

For X rays or γ-rays, the instrument is sensitive to radiation from any direction, and the optimal direction of incidence indicates only the ideal direction for measuring the energy spectrum and dose rate.

For low-energy γ-rays, because the scintillator is not spherical, rays coming from the side will pass through a larger cross-sectional area and the count rate may be slightly higher than the optimal incidence direction. For high-energy rays, rays coming from the side will penetrate the sensor more and the direction is not obvious. Therefore, do not judge the direction of incoming γ-rays by rotating the angle of the instrument.

The sensitive direction of the neutron sensor is similar to the scintillation sensor. The direction is not obvious due to the randomness of the neutron scattering direction.

Shielding panels as well as bodies can also be used to shield the rays and provide directionality, but are not always effective for neutron sources. To reduce fluorescence, copper shielding should be used.

The dose rate and the distance from the source are squarely decreasing. Moving the instrument in the direction of the source, the distance to the source can be initially estimated based on the trend of the dose rate becoming larger or decreasing.

4.5.3、Protecting the quality of energy spectra

In order to improve the spectrum measurement, the following techniques should be observed in addition to the direction and distance.

(1) The measured source should be as bare as possible, without unnecessary blocking, especially with heavier metal blocking.There should also be no metals or minerals containing high atomic number elements near the measured source, it will bring deterioration due to scattering and luminous. If a lead box is to be used, a larger volume should be used to keep the source away from the lead.

(2) For the lower activity of minerals, powders, etc., rather extend the measurement time, but also to avoid relying on increasing the number to improve the activity. The smaller and thinner the source, the better, as long as the radiation is above background. This is because the source itself blocks the rays it produces, changing the energy spectrum distribution.

(3) Keep the temperature as constant as possible during the measurement. The instrument will inevitably drift slightly in energy, and if the temperature changes during the measurement, the spectral peaks will broaden due to the drift, which will deteriorate the resolution. If the temperature changes rapidly, the only way is to shorten the measurement time.

5、Maintenance

This product does not normally require special care, but there are still some issues that need attention in order to keep the instrument in good condition.

5.1、Stability of the energy scale and calibration

As described in Chapter 1, the spectrometer corresponds photons through flash, photoelectric conversion, charge-voltage conversion, pulse shaping, and analog-to-digital conversion. A performance drift in any of these will affect the channel (peak position) of the spectral lines, i.e., the accuracy of the energy scale.

For the instability incurred by the electric components, KC761 has taken compensation and stabilization design and its effect has become smaller. However, variations in optical coupling between scintillators, spectrum-stabilizing LEDs and silicon photomultiplier arrays are difficult to predict and compensate for. Sensors are semi-airtight components, and when the external atmospheric pressure or temperature changes rapidly, there will be a small change in the internal stress. After a long time there will be accumulated effect the light coupling.

Therefore, KC761 should not be stored or operated in a place where the temperature or air pressure fluctuates frequently and rapidly. Nor should the sensor be crushed or subjected to strong vibrations.

The energy scale should be calibrated at least once a year after the instrument has been commissioned, and every three months for the first six months. If it is subjected to violent impacts, drops, etc., it should be calibrated before use. The CsI sensor can be check with back ground ^{40}K ^{137}Cs or other more clearly characterized sources. If the deviation exceeds the specified technical performance, it can be corrected using FUNC-Advance-Sensor Correction menu or returned to the manufacturer for calibration if necessary.

If there is only one known source, e.g. ^{137}Cs, then only the energy scaling would be set. Measure the known source with the instrument and read the peak energy use maker peak find function. Divide the known energy of that source by the energy read to get the scaling factor. Enter this factor into the instrument as a percentage. Each sensor needs to be tested and entered separately. To minimize errors, the energy of the known source should be located as close as possible to the 500 keV to 1.5 MeV range.

If there are two known sources, the intercepts, or translations, of the lines they form can be found. For example, if one source has a known energy of 59 keV (named m) and a measured energy of 68 keV (named n), and the other source has a known energy of 662 keV (j) and a measured energy of 608 keV (k), the scaling factor (Ez) and the translation value (Eo) are calculated according to the following formula:

$$E_z = \frac{j-m}{k-n} = \frac{662-59}{608-68} \approx 1.117$$

$$E_o = m - nE_z = 59 - 68 \times 1.117 = -16.956$$

In the case of two known sources, one of them should try to be in the low-energy range of 50 to 300 keV, while the other should try to be in the high-energy range of 500 keV to 1.5 MeV, and the energy gap between them should not be too small. When this condition is met, revisions can also be made using nuclides with at least two peaks that are far apart, e.g., using thorium oxide (^{232}Th). ^{137}Cs can be used with KC761x, a low-energy peak of ^{137}Cs (sources requiring a plastic shell).

Also can be done using the ^{40}K peak in the natural background radiation. The ^{40}K peak is usually seen by accumulating for 12 hours and using Optimization 2 (Trace-Advanced-OPTIM, do not set DBKG). Measurement of potassium salts such as potassium chloride allows the 40K peak to be seen within 1 hour.

Using two peak revisions, the accuracy was close to that of sending it back to the factory for calibration. We will release an calibration method using 5 points for advanced user, it will release in other manual.

5.2、Use of batteries

The instrument uses three AA batteries in series with a rated operating voltage of 4.5V. Considering that the user may also use NiMH or LiFe dry cell batteries, the actual design is available in the voltage range of 3.0V to

6.0V (1V to 2V/cell).

The low voltage alarm point is set at 3.2V, and the protection shutdown point is set at the lowest available voltage of 3V.

When the battery voltage is lower than the protection point, the automatic shutdown prompt will be displayed and the buzzer will beep one long time every minute. If there is no operation, it will shut down after 30 minutes, and re-timer if there is operation.

Auto Power Off Tips Menu

Option	Name	Function	Notes
DELAY	Delayed shutdown	Stop prompting for shutdown within 30 minutes after key press	
IMMED	Immediate shutdown	Shutdown after key press	
BACK	Return	Exit low battery prompt menu, equivalent to DELAY	

It is not known what batteries the user has fitted, so the user must install good quality genuine batteries and take management measures according to the characteristics of the batteries fitted. Leaking batteries can damage the instrument and are not covered by warranty.

⚠ The KC761x has a charging function. In order to avoid danger caused by accidental charging, it is prohibited to use any lithium batteries, including rechargeable lithium batteries that simulate the function of a AA dry cell battery.

⚠ When using AA non-rechargeable dry cell batteries, the external power supply can be turned on only for a short period of time (<30min). Prolonged charging of dry cell batteries may be dangerous. Remove the batteries if the external power supply is to be used permanently.

If the instrument is not used for a long time, the battery should be removed. The instrument still has a weak power consumption in the off state, which will increase the risk of battery leakage.

ℹ When replacing the battery, it is recommended to replace the power supply with USB or POE to maintain continuous timing.

If the instrument is freeze, it can be restarted by hold POWER button for 5s or removing and installing the battery.

If the backlight brightness is erratic, usually the battery contact is poor, use rough paper to wipe the electrode and spring surface of the battery compartment.

ℹ Before storing data (SAVE button) operation, please check the battery power and try to use external power supply. Since writing to a TF card consumes a lot of power, if the battery is close to being exhausted or the contact is poor, the moment you press the store button may cause the voltage to drop, resulting in data loss.

5.3、Use of External Power Supply

Due to the sensitive circuitry inside the instrument, although strict voltage regulation measures have been applied, it is still necessary to make requirements for the quality of the external power supply.

When using USB power supply, you should use a good performance power adapter, whose ripple should not be greater than 0.5%, and conduct high-frequency interference to be small. Poor quality chargers will interfere with the normal operation of the instrument.

When using POE power supply, attention should be paid to the line lightning protection, it is recommended to use the network cable with shielding layer, and the shielding layer is properly grounded. POE power quality should also pay attention to avoid the conduction of high-frequency interference.

KC761x turns on the charging function by default. The instrument starts charging the battery immediately after connecting to the external power supply. Prolonged charging of dry batteries may result in leakage, so use NiMH rechargeable batteries if external power is frequently connected.

When batteries are installed, the auto power-up start function is disabled and cannot be restarted remotely by cut off the power supply. If used as a fixed sensor, the battery should be removed.

5.4、Other Notes

(1) The instrument should be maintained intact and avoid working with faults. When in doubt about the performance, it should be calibrated in time; the shell and its accessories can be ordered from the manufacturer if they

are defective.

(2) Wipe the shell with clean water, do not use alcohol or other organic solvents. Be careful to avoid dirt into the crevices of the keyboard.

(3) If the instrument is drenched with water, it should be dried with an absorbent material first, and then shake out the water in the keyboard and speaker holes in the direction of the front panel. Do not open the rubber protection plug before wiping dry. When water is inside the rubber or on the window, it should be wiped dry in time, and do not force the rubber to close, so as not to press water into the inside of the instrument.

(4) The screen cover is reinforced glass, if broken, there will be sharp fragments, need to beware of scratches. Glass cannot be replaced alone, if damaged, the front cover assembly should be replaced.

(5) When removing and installing the battery cover, you need to use a large force, beware of plastic corners to cut your fingers.

(6) The instrument contains a very sensitive amplifier circuit, so please keep away from electromagnetic radiation. When implementing important tests, make sure that the distance from cell phones, walkie-talkies and other sources of radiation is more than 0.5 meters. Avoid carrying it in the same pocket as a cell phone, and do not hang it on the same side of your body with a walkie-talkie.

ℹ When the count is suspected to be abnormal, attention should be paid to exclude the possibility of surrounding electromagnetic field interference.

ℹ When using an AC power adapter, the adapter should allow the output to be grounded and grounded at one end. Some switching power supplies (e.g. USB chargers) have common mode voltage ripple of up to tens of volts at the output. This voltage ripple can cause interference by way of local capacitance to ground, causing the instrument to respond incorrectly when near metal, or the human body.

(7) Store in a cool, dry place.

[End of text]

NOTES

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