Manufactured by TechnoAP Co., Ltd.

Digital Positron Annihilation Lifetime Measurement System

LIFETIME, CDB and AMOC

Bring it all into one

version 1.4

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1. Equipment features

Digital signal processing using rewritable LSI (FPGA)

Real-time positron lifetime measurement is possible based on the DSP algorithm in which the hardware functions of analog electronic circuits are converted into software.

High efficiency digital measurement

Measurement accuracy and reproducibility of measurement are improved by software processing of the digitally quantized detection signal. Eliminates signal deterioration caused by electronic circuits and improves reliability. As before, real-time processing by sequential analysis is performed, and offline processing of positron lifetime histogram analysis is also possible with the list mode that stores primary waveform data.

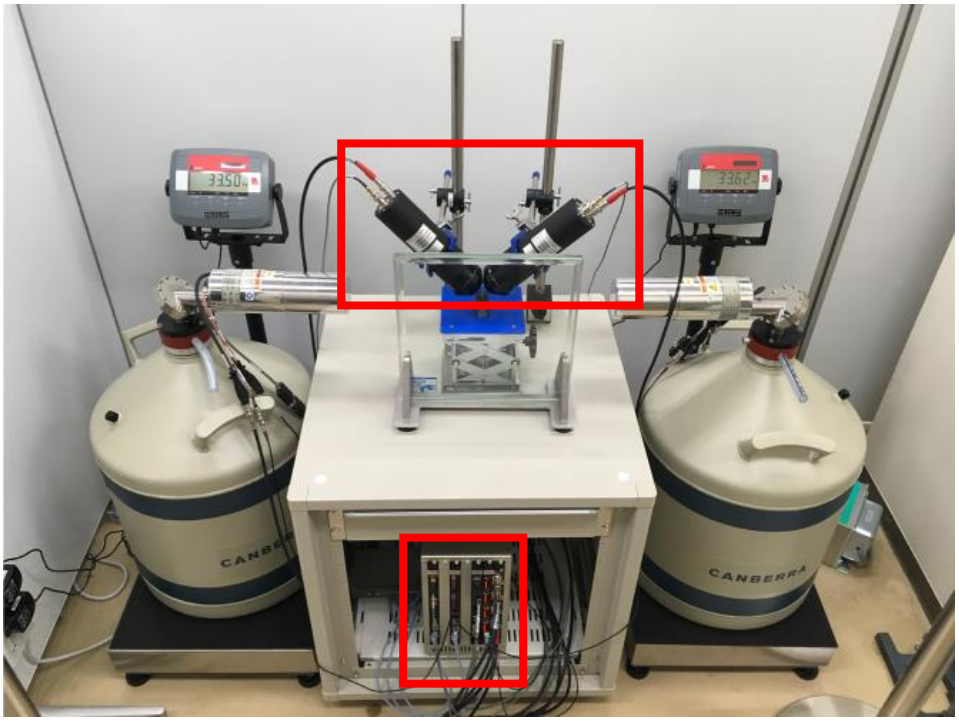


Photo 1. Experiment using our measurement equipment
(Parts surrounded by red line: our products)

The measurement board and power supply board required for positron annihilation lifetime measurement used in the measurement of vacancy-type defects in semiconductors in the materials field, etc., have been combined into one rack to form one device.

Equipped with 4 CH. high voltage power supply module and 4 CH. preamplifier power supply modules for BaF_2 scintillation detector and HPGe semiconductor detector. The settings for each module and the reading of the data are performed via the network from the application software for the positron annihilation lifetime measurement device installed on the computer.

In the positron annihilation lifetime measurement (LIFETIME), high-speed pulse signals from two BaF_2 (barium fluoride) scintillator detectors are input to a time analysis spectrum board to calculate the positron annihilation lifetime.

In positron annihilation Coincidence Doppler Broadening (CDB), the coincidence of signals from two HPGe semiconductor detectors is obtained, and a two-dimensional histogram is generated from each peak value.

Furthermore, by combining these modules, it is possible to measure Age-MOmentum Correlation (AMOC), which takes the correlation between life and momentum.

Photo 2. Compact and highly efficient digital measuring device
Height: 32cm, Width: 17cm, Depth: 40cm

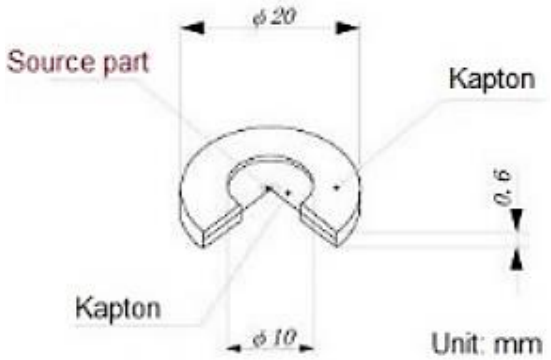
2. Positron source and Samples

In the positron lifetime method for bulk materials, the positron source is sandwiched between two target samples, and the time difference between the gamma rays generated together with the positrons and the annihilated gamma rays from the sample is accumulated over one million times, and the average positron lifetime is measured. It takes about an hour and a half to get 1 million counts, depending on the measurement environment.

2-1. Positron source

Photo 3. Thin film positron source Na-22

The isotope is sandwiched between Kapton (7.5 μm thick polyimide film).
A Kapton component appears around 380 ps when analyzing data.
Positrons are emitted in almost 4π directions.



Specifications

Nuclide	Na-22
Product code	NA351
Radioactivity standard	1MBq (+0, -30%)

This source is sealed with a thin film, so it has a structure that is vulnerable to impact.
Do not touch the source window directly to avoid damage.
This product is a sealed source that is not subject to laws and regulations.

Provider: Japan Isotope Association
https://www.jrias.or.jp/e/

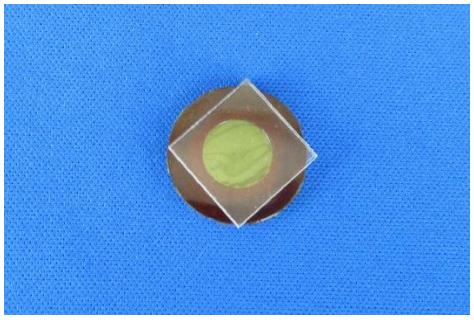


Photo 4. Figure sandwiching the source with reference material
(photographed from above)

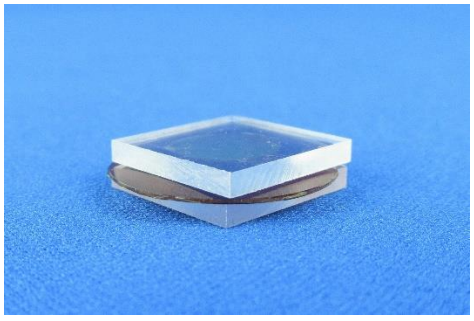


Photo 5. Figure sandwiching the source with reference material
(photographed from the side)

Please contact us if you are considering purchasing this item.

2-2. Standard samples

Vacancy defect measurement

Base material	Positron lifetime (ps)	Reference number
Silicon	220.6 ±6.2 (214.4 – 226.8)	NMIJ CRM 5606-a
Stainless steel (SUS)	106.2 ±6.2 (0.1036 – 0.1084)	NMIJ RM 5607-a

Ultrafine vacancy defect measurement

Base material	o-Ps (ortho-positronium) lifetime (ns)	Reference number
Quartz glass (Silica)	1.62 ±0.05 (1.57 – 1.67)	NMIJ CRM 5601-a
Polycarbonate (PC)	2.10 ± 0.05 (2.05 - 2.15)	NMIJ CRM 5602-a

Photo 6. Standard material Polycarbonate (PC)

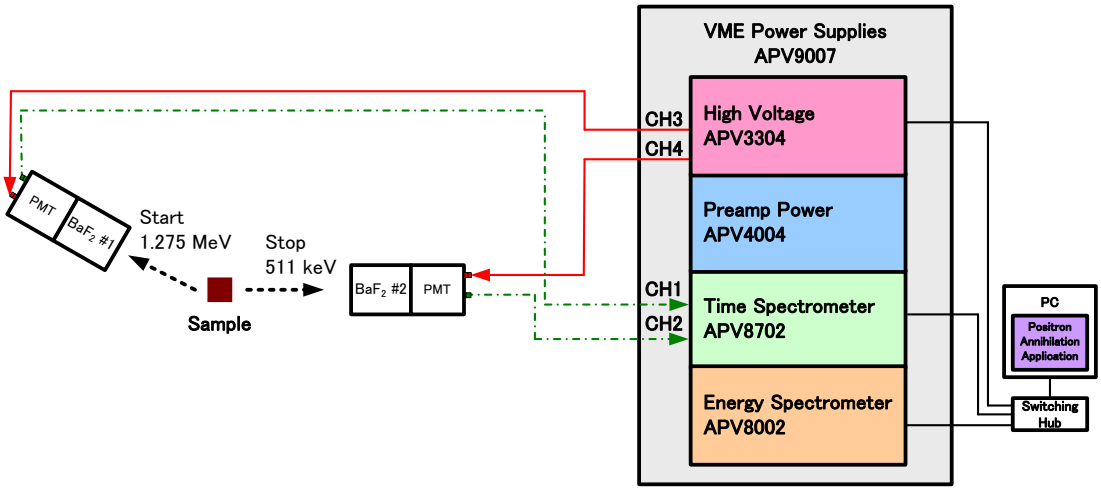
Provider: General Science Corporation or Shibayama Scientific Co., Ltd.
https://shibayama.co.jp/14/index1.html

Please contact us if you are considering purchasing this item.

3-1. Measurement mode

3-1-1. LIFETIME mode

Lifetime (LT) mode is a mode in which two BaF_2 scintillation detectors are measured at the same time, the time difference between the rise of the two waveforms is taken, and positron lifetime measurement is performed.



Configuration diagram

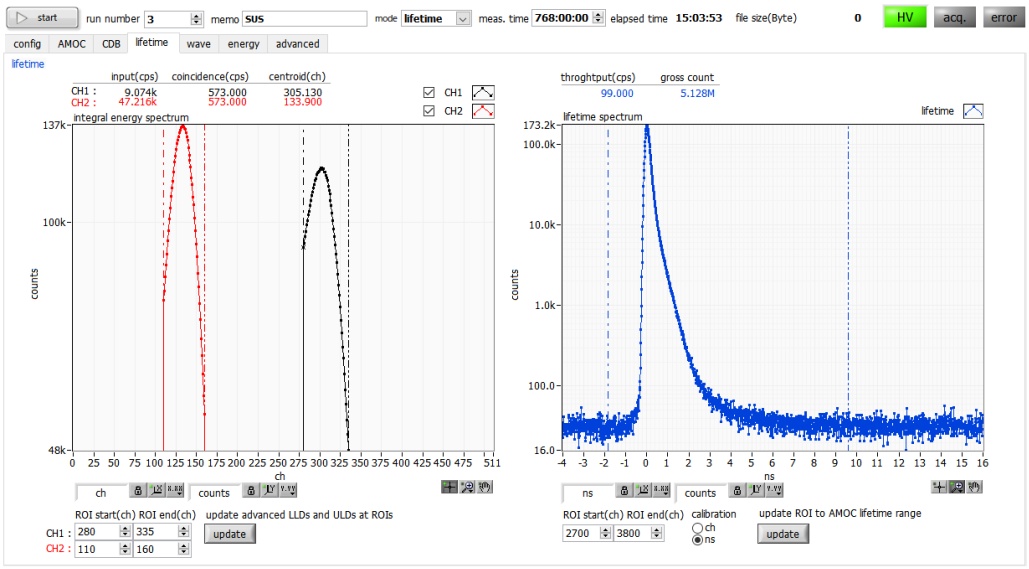
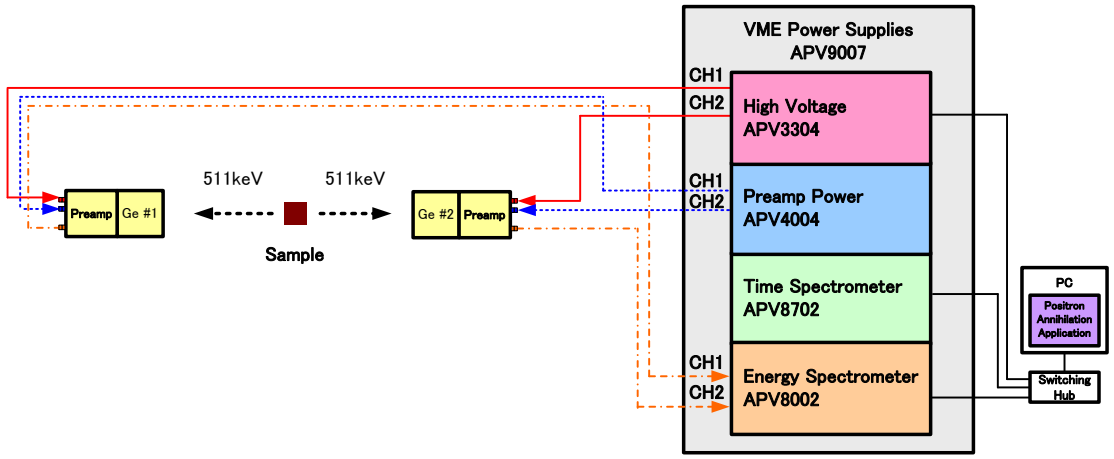


Photo 7. Measurement window with developed by TechnoAP Co., Ltd. application software CH1 1275keV peak (Black line), CH2 511keV peak (Red line), Lifetime spectrum (Blue line)

3-1-2. CDB mode

CDB (Coincidence Doppler Broadening) mode is a mode that takes coincidence counts of two Ge semiconductor detectors, takes each crest value, measures positron annihilation coincidence counting Doppler broadening.



Configuration diagram

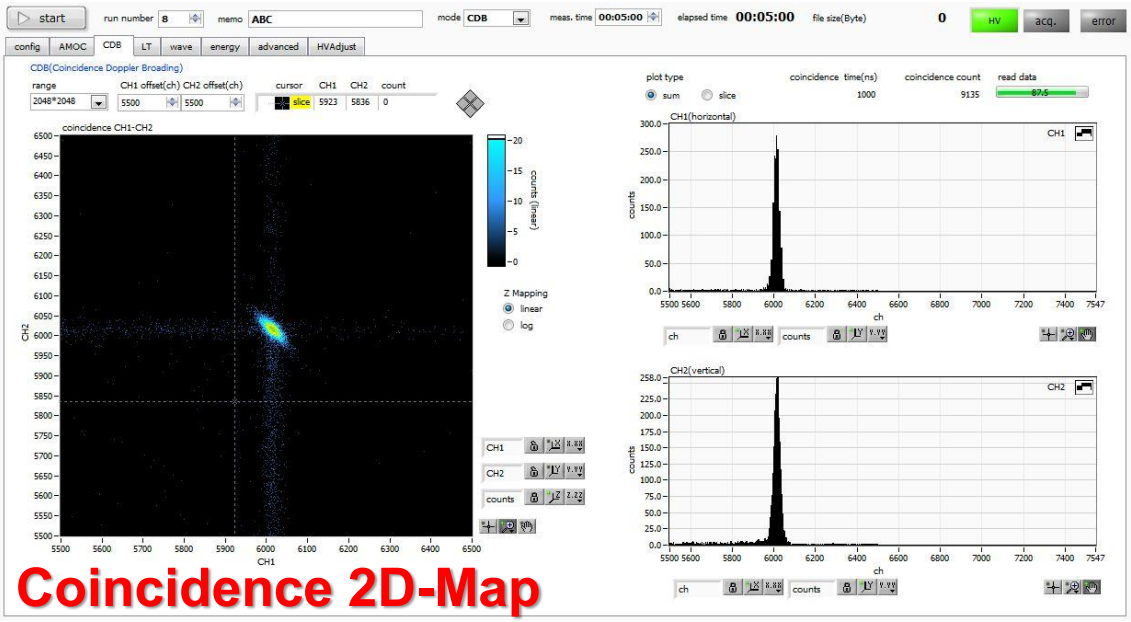
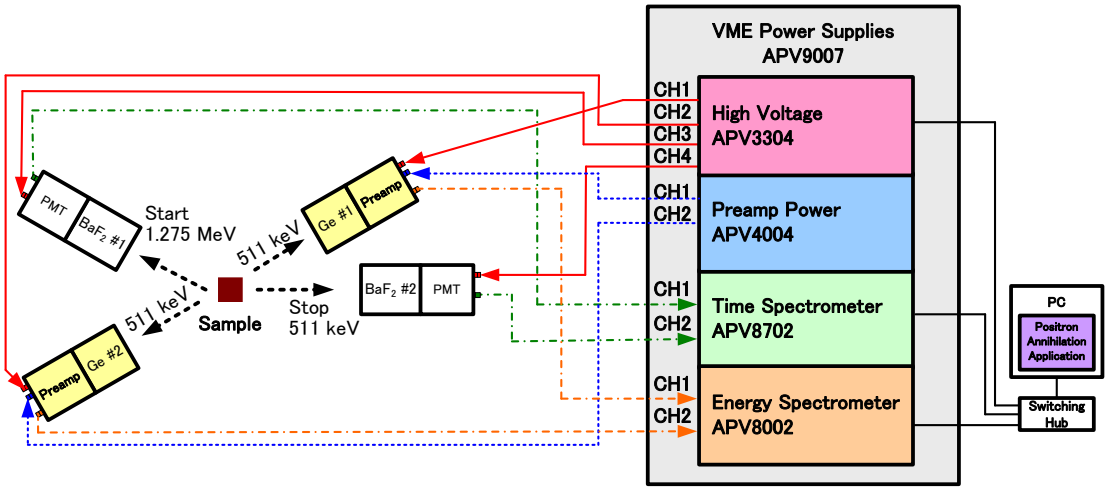


Photo 8. Measurement window with developed by TechnoAP Co., Ltd. application software

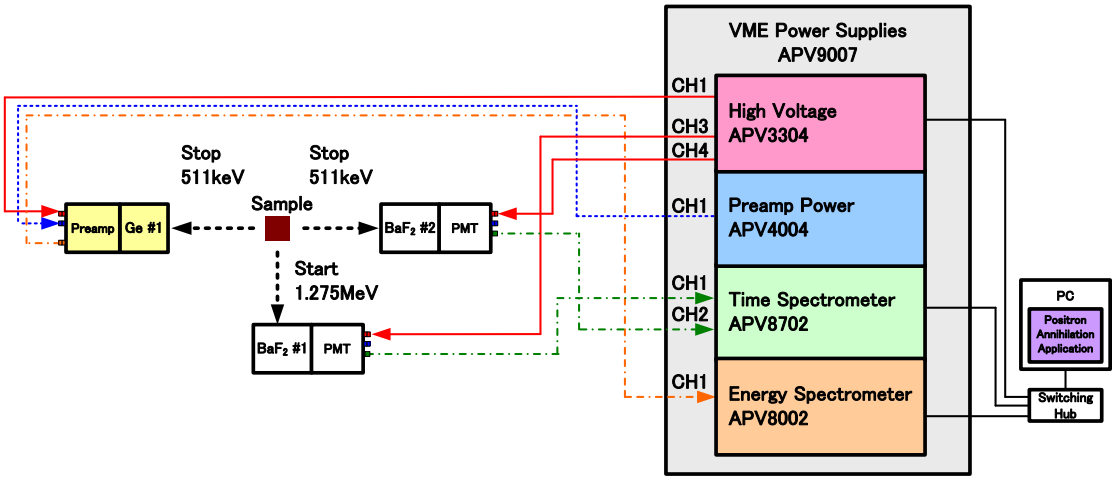
3-1-3. CDB & LIFETIME mode



Configuration diagram

3-1-4. AMOC mode

AMOC mode is a mode to measure positron lifetime-momentum correlation by taking coincidence counts of two BaF_2 scintillation detectors and one Ge semiconductor detector.



Configuration diagram

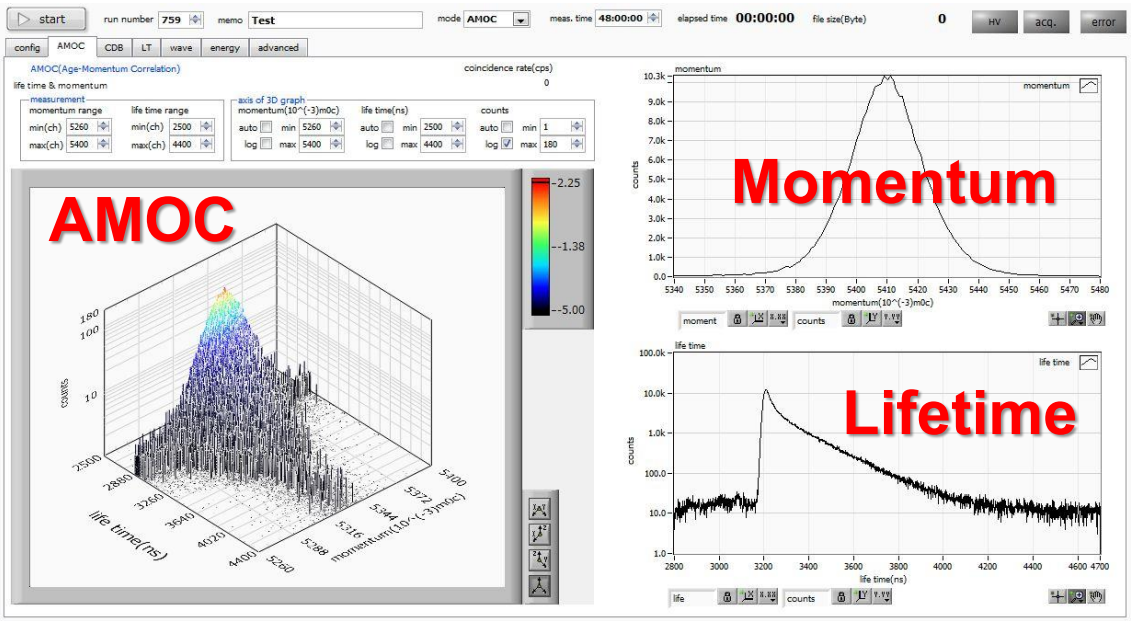


Photo 9. Measurement window with developed by TechnoAP Co., Ltd. application software

3-2. Data Analysis

The acquired data is analyzed using dedicated software, PALS fit3. This software is verified on Windows 7, 8 and 10.

To be able to run this program, a license key is required. To obtain it for first time, please contact to Dr. Morten Eldrup (Department of Energy Conversion and Storage, Technical University of Denmark, Phone: +45-4677-5728, E-mail: palsfit@risoe.dtu.dk)

Please check the details from the link below.
http://palsfit.dk/

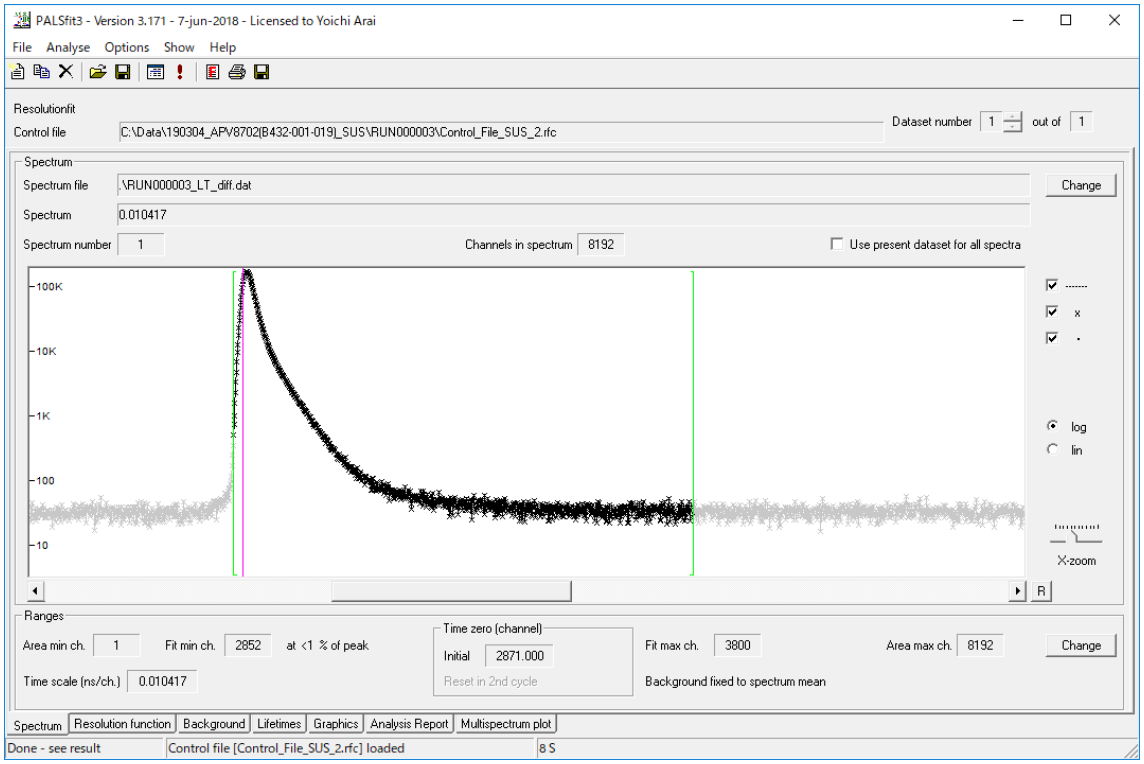


Photo 10. Window of analysis software (PALS fit3)

```
Resolution function:

FWHM (ns)             :      0.1673
Std deviations        :      0.0002

Intensities (%)       :    100.0000

Shifts (ns)           :      0.0000
Std deviations        :       fixed
-------------------------------------------------------------------------
Lifetime components:  Stainless steel     Kapton

Lifetimes (ns)        :      0.1070     0.3802     1.7191
Std deviations        :      0.0003     0.0018     0.0785

Intensities (%)       :     74.7765    24.7128     0.5107
Std deviations        :      0.1630     0.1457     0.0313
-------------------------------------------------------------------------
Background (Counts/channel)    :     32.4129
```

Photo 11. Analysis results of stainless steel (positron lifetime 0.1062 ns ± 2.4)

4. Equipment configuration

4-1. LIFETIME・CDB・AMOC measurement

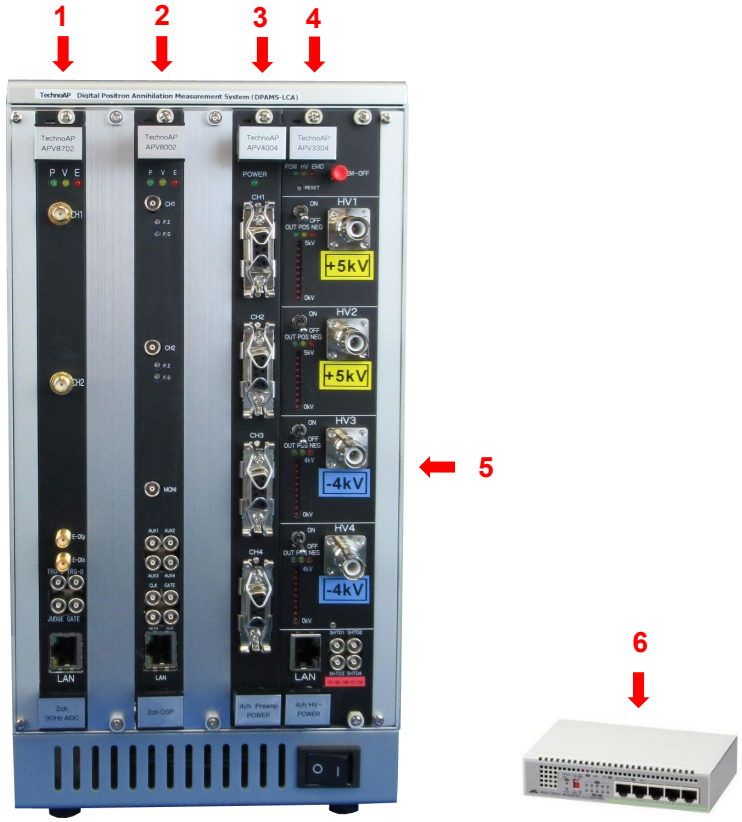


Photo 12. Model: DPAMS-LCA

Please check the details from the link below

http://www.techno-ap.com/seihin_pa_e.html

Product Catalog

http://www.techno-ap.com/img/cat_dpalms-lca_e.pdf

No.	Function	Specifications	Model
1	Positron Lifetime spectrometer	ADC: 3 GHz, 2 Ch., 8-bit Signal cable with SMA connectors, Length: 3 Meters (2 pcs)	APV8702
2	2 dimensions wave height analysis	ADC: 100 MHz, 2 Ch., 16-bit With coincidence function	APV8002C
3	Preamplifier power supply	4 Ch. with D-sub9 pin connector	APV4004
4	High voltage power supply	2 Ch., + 5 kV for HPGe detectors 2 Ch., -4 kV for BaF_2 detectors High voltage cable with SHV connectors, Length: 3 Meters (4 pcs) Bias shutdown cable with BNC connectors, Length: 3 Meters (1 pc)	APV3304
5	VME powered crate	7 slots for VME6U AC 100 / 240 V Dimensions: 166.5 × 310.5 × 399 mm Weight: 6.5 kg	APV9007
6	Switching hub	5 ports LAN cable with category C, Length: 1 Meter (5 pcs)	AT-GS910/5
7	Software	Device control and Measurement for LIFETIME, CDB, ENERGY (Single) and AMOC	APP-LCA

The following items are not included in this device, but please consult us if you need them.

1. Computer for device control and operation (desktop type / notebook type)
2. Data analysis software (PALS fit3, etc.)
3. Thin film positron beam source (Na-22)
4. Germanium semiconductor detector
5. AC power strip with filter
6. Experimental environment equipment (lab bench, stand, lab jack, shield lead glass etc.)
7. Conversion adapter (BNC － LEMO connector or BNC - SMA connector)
8. Weigh scale (for germanium semiconductor detector)
9. Cryogen jet and Siebel vessel for liquid nitrogen
10. Transportation costs, installation costs, etc.

4-2. LIFETIME measurement (Stand-alone type)

Photo 13. Model: APU8702

Height: 6 cm, Width: 30cm, Depth: 34cm, Weight: 3.3 kg

No.	Function	Specifications	Model
1	Positron Lifetime spectrometer	ADC: 3 GHz, 2 Ch., 8-bit Signal cable with SMA connectors, Length: 3 Meters (2 pcs) Communication I/F: Ethernet (TCP/IP) Equipment control and data acquisition program included	APU8702

4-3. Operation Methods

We already uploaded a video on YouTube about the operation method of the positron lifetime measurement system manufactured by us.

Adjustment method of lifetime mode
https://www.youtube.com/watch?v=fkVUPkth4ZM

Adjustment method of waveform offset
https://www.youtube.com/watch?v=N_ggAzBovPo

Adjustment method of APV8002 (DSP, Digital Signal Processing, 2CH)
https://www.youtube.com/watch?v=UIA2B2w4A0w

Method of applying high voltage power supply using APV3304
https://www.youtube.com/watch?v=qo9zbphQsug

5. Detectors

5-1. Scintillation detector (BaF_2 crystal + photomultiplier tube)

5-1-1. Cylindrical type

Photo 14. Model: XBF110

Photo 15. Back of detector

Specifications

Crystal size	Φ 28 mm × L 20 mm
Connectors	SHV: High voltage power supply (-HV) BNC: Anode output (SIG) BNC: Dynode output (DY)
Applied voltage	Maximum rating: -3000 V Absolute rating: -3500 V
PMT	H3378-51 manufactured by Hamamatsu Photonics K. K.
Outer diameter	Φ 65 mm × 221 mm *without connectors
Weight	650 g

Product Catalog: http://www.techno-ap.com/img/XBF110_e.pdf

5-1-2. Truncated cone type

Photo 16. Model: XBF464015

Photo 17. Crystal cover

Specifications

Crystal size	Φ 46 mm × Φ 40 mm x L 15 mm
Connectors	SHV: High voltage power supply (-HV) BNC: Anode output (SIG) BNC: Dynode output (DY)
Applied voltage	Maximum rating: -3000 V Absolute rating: -3500 V
PMT	H3378-51 manufactured by Hamamatsu Photonics K. K.
Outer diameter	Φ 64 mm × 240 mm *without connectors
Weight	684 g

Product Catalog

http://www.techno-ap.com/img/XBF464025_XBF464015_e.pdf

5-1-3. Truncated cone type

Photo 18. Model: XBF464025

Photo 19. Crystal cover

Specifications

Crystal size	Φ 46 mm × Φ 40 mm x L 25 mm
Connectors	SHV: High voltage power supply (-HV) BNC: Anode output (SIG) BNC: Dynode output (DY)
Applied voltage	Maximum rating: -3000 V Absolute rating: -3500 V
PMT	H3378-51 manufactured by Hamamatsu Photonics K. K.
Outer diameter	Φ 64 mm × 250 mm *without connectors
Weight	763 g

Product Catalog

http://www.techno-ap.com/img/XBF464025_XBF464015_e.pdf

5-2. Semiconductor detector

5-2-1. HPGe detector

We recommend that you purchase the HPGe detector yourself.

The products that are often used with our equipment are:

Manufacture: Mirion Technologies, Inc. (CANBERRA)
Model: GC4018-7600SL
Horizontal Cryostat (Dipstick type)

This is an image. See also the photo on page 3 of this brochure.

Specification

Efficiency (%)	Resolution (FWHM)		Peak / Compton	Peak form	End cap diameter mm (in.)
≧ 40	122 keV	1332 keV		FWTM / FWHM	
	0.925	1.8	62	1.90	76 (3.0)

Liquid nitrogen (30 L) should be replenished approximately every two weeks.

Please check the details from the link below.
https://www.mirion.com/products/germanium-detectors

6. Our clients

6-1. Domestic

Research facility name	Website
Chiba University Graduate School of Science and Engineering, Instrumentation Chemistry Laboratory	http://chem.tf.chiba-u.jp/gacb11/
National Institute of Advanced Industrial Science and Technology Nanostructured Materials Evaluation Research Group	https://unit.aist.go.jp/mcml/index.html
Kyoto University Graduate School of Engineering, Department of Nuclear Engineering	https://www.ne.t.kyoto-u.ac.jp/ja
Kyoto University Institute of Multidisciplinary Nuclear Science Particle Beam Basic Properties Research Division	https://www.rri.kyoto-u.ac.jp/
The University of Shiga Prefecture School of Engineering, Material Science	https://www.usp.ac.jp/english/
Tohoku University Metal Materials Research Laboratory	http://www.imr.tohoku.ac.jp/
Tokyo Gakugei University Natural Sciences Wide Area Studies Environmental Science	http://www.u-gakugei.ac.jp/
University of Tsukuba Graduate School of Mathematical Sciences	http://www.pas.tsukuba.ac.jp/

In addition to the above, our system has been introduced to Japanese steelworks manufacturers and private companies.

6-2. Overseas

Research facility name	Website
Heilongjiang Provincial Academy of Sciences (Harbin, China)	https://www.has.ac.cn/
Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH) (Magrele, Romania)	http://www.nipne.ro/
Idaho National Laboratory (Idaho, USA)	https://inl.gov/
Joint Institute for Nuclear Research, Dubna Institute (Moscow, Russia)	http://www.jinr.ru/main-en/
The Commonwealth Scientific and Industrial Research Organization (Canberra, Australia)	https://www.csiro.au/
The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences (IFJ-PAN) (Krakow, Poland)	https://www.ifj.edu.pl/
Tomsk Polytechnic University (Moscow, Russia)	https://tpu.ru/
University of Science and Technology of China (Hefei, China)	https://www.ustc.edu.cn/

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