Edition 2.0

RADIOACTIVITY MEASUREMENT EQUIPMENT

MIRION TECHNOLOGIES (CANBERRA) KK

MIRION
TECHNOLOGIES

To our customers

Mirion Technologies is a world-leading company in radiation measurement and nuclear related services with a track record of over 60 years.

Our organization is comprised of over 2,300 talented professionals, passionate about delivering world-class products, services, and solutions in the world of radiation detection, protection and measurement. In partnership with our customers in nuclear power plants, military and civil defense agencies, hospitals, universities, national labs, and other specialized industries, Mirion Technologies strives to deliver cutting-edge products and services that constantly evolve based on the changing needs of our customers.

Company Profile

Mirion Technologies (Canberra) KK is a subsidiary of Mirion Technologies, Inc. and our mission is to provide Mirion's products and expertise to the Japanese market while meeting Japan unique requirements. In addition of products, our offering includes a large range of services as well as custom software development. In recent years, we have successfully developed tailor-made solutions and Measurement & Expertise services, meeting the needs of the evolving Japanese market. This was achievable thanks to the combination of Mirion's worldwide expertise and domestic capabilities including partnerships.

商 号	ミリオンテクノロジーズ・キャンベラ株式会社
英文名	Mirion Technologies (Canberra) KK
本 社	東京都台東区浅草橋 4-19-8 浅草橋ビル
設 立	平成 14 年 4 月1 日

Webサイト
www.mirion.com
www.canberra.com/jp （日本語）

本冊子に記載されている「キャンベラ社」、Canberra（社）」という表現は、すべて Mirion Technologies (Canberra), Inc. を指しています

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Section 1

RADIOLOGICAL COUNTING LABS

In the laboratory count room, Canberra™ time-tested software packages, teamed with a full complement of innovative detectors and signal processing electronics, offer customers sophistication with simplicity. The *Apex®* family of lab productivity suite including Apex-Gamma™ for gamma spectroscopy, Apex-Alpha™ for alpha spectroscopy and Apex-Alpha/Beta™ for alpha/beta counting software is designed to handle the workload of a busy lab.

Apex software serves as the user and management interface for the counting systems. It automatically ensures that routine QA checks are performed and automatically keeps records of all system activities – sample counts, calibrations, QA checks – as well as when they were performed and by whom. Unique database facilities make it simple to retrieve and review data – even years after the measurement – to respond to questions or legal challenges.

Alpha Analyst™ Integrated Alpha Spectrometer

Series 6LB™ Automatic Low Background Alpha/Beta Counting System

ISOCS™ and LabSOCS™ Calibration Software bring a new level of capabilities to gamma sample analysis by eliminating the need for traditional calibration sources during the efficiency calibration process. In addition to the monetary savings from not having to purchase, track or dispose of numerous calibration sources, the ISOCS and LabSOCS calibrations also save time in the field and laboratory respectively.

High Purity Germanium Detectors

Gross Alpha/Beta Counting

Automatic Gas Flow Counting Systems

Series 6LB™ Automatic Low Background Alpha/Beta Counting System

Features are:

- New and innovative 50 or 100 sample automatic changer system
- High performance 5.7 cm (2.25 in.) gas flow detector
- Integrated 7 in. touch screen display for information and control
- Interchangeable 50 and 100 sample Lock and Load stacks
- Complete front access – all critical components slide forward out of the shield
- Gasless guard detector – extends P-10 tank life to more than a year
- Automatic gas monitoring and conservation system
- Integrated self-diagnostics and environmental monitoring for temperature, humidity and barometric pressure
- USB Communication protocol to Apex-Alpha/Beta computer

Series 5 LB5500™ Large Area Automatic Low Background Alpha/Beta Counting System

Features are:

- Ultra-low background counting system (Alpha ≤ 0.3 cpm, Beta ≤ 3.5 cpm)
- High performance 12.7 cm gas flow detector with ultra-thin window 80 µg/cm^2
- Fifty planchet sample changer
- Gas Stat digital gas conservation and monitoring system
- Coded positive sample carrier identification
- Optional external bar code reader

Apex-Alpha/Beta™ Counting Productivity Software

Features are:

- Control and Analysis software for most gas-flow alpha/beta counters
- Compatible with LB4200, LB4100™, Mini20™, IN20™, Series 6LB and Series 5 systems
- Feature by feature replacement for Eclipse™ software
- Express Count for immediate counting with no sample data pre-entry
- Calibration and QC Sequences

- Automated Plateau and Region of Interest setup
- Unattended Calibration on Changer Systems

Manual Gas Flow Counting Systems

LB4200™ Multi-Detector Low Background Alpha/Beta Counting System

Features are:

- Manual drawer-based system for counting up to 16 samples at the same time
- Designed for counting multiple samples with long count times that are not practical for single detector counters
- Up to four 5.7 cm (2.25 in.) or 3.1 cm (1.25 in.) detectors or one 12.7 cm (5 in.) detector per counting drawer
- Configurable and upgradeable from one to four counting drawers
- High performance gas flow detectors with ultra-thin windows
- Gas Conservation and Monitoring System for maximum gas cylinder life
- Full front detector access without lifting lead shielding
- Small footprint and modular design for easy upgrading
- Independent detector start/stop

Gasless Counting Systems

iSeries™ Gasless Alpha/Beta Counting Systems

Common Features are:

- Includes PIPS® silicon gasless detector
- Automatically identifies and compensates for radon, thoron and progeny interference in air filters
- Can be used for other types of samples without radon/thoron compensation
- NiMH battery power for 6+ hours of continuous operation
- No computer required for operation – simple front panel controls
- Compatible with iLink™ iSeries Communications Software

iSolo® Portable Gasless Alpha/Beta Counting System

Unique Features are:

- Portable, manual, single-sample alpha/beta counter
- Compatible with sample diameters from 25 to 101 mm
- Various shielding and guard detector options to minimize background

iMatic™ Gasless Automatic Alpha/Beta Counting System

Unique Features are:

- Automatic sample changer with 50 or 100 sample capacity
- Compatible with sample diameters from 25 to 60 mm
- Molded low background shielding, 10 cm (4 in.) thick

Detector Selection

When measuring the energy of radiation, it is most effective depending on the type of radiation. You must select the correct detector.

Various types of detectors are available.

The main types of radiation detectors are the following:

- Planar silicon α / β detector
- Silicon (lithium) detector
- Scintillation detector
- Germanium detector

These detectors have more resolution and depend on the type of radiation and the purpose of the experiment. Optimum specifications are determined by efficiency requirements.

Planar silicon α / β detector (PIPS)

Detector with ion implantation electrode on Si wafer, beta ray, alpha ray, used for energy measurement of charged particles such as proton beams.

Silicon (lithium) detector

This detector was developed for X-ray energy analysis. Normal measurement energy range is about 300 eV to 50 keV. It has the best energy resolution among detectors and is often used for X-ray fluorescence analysis it is used.

Scintillation detector

Before the advent of detectors using silicon and germanium semiconductors, this detector was widely used as a radiation measurement detector. Easy to handle. The main features are simple, low price and high detection efficiency. NaI(Tl) crystal is mainly used.

Germanium detector

At present, germanium crystals are produced with very high purity. Various high-purity Ge detectors such as coaxial type, planar type, and well type are manufactured. The energy resolution is excellent, so scans over a wide energy range are possible.

It is used for nuclear physics experiments, radionuclide analysis, and environmental radioactivity analysis.

To obtain high energy resolution, liquid nitrogen and electricity (pulse tube type) use with cooling.

Reaction between radioactivity and detector

When radiation enters the detector, the charge depends on the amount of radiation energy made. Evaluate the energy value of radiation by measuring this amount of charge.

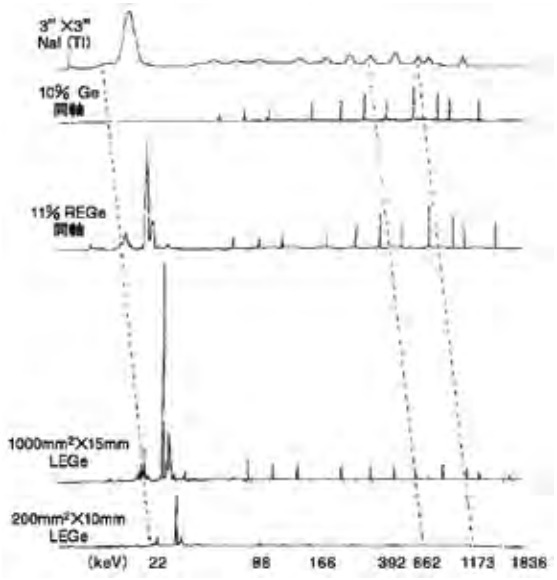
This reaction can be broadly divided into the following three categories.

1. Photoelectric effect
2. Compton scattering
3. Electron pair generation

This phenomenon is caused by scintillation detectors, silicon detectors, germanium detectors, and is a common reaction that occurs in the container.

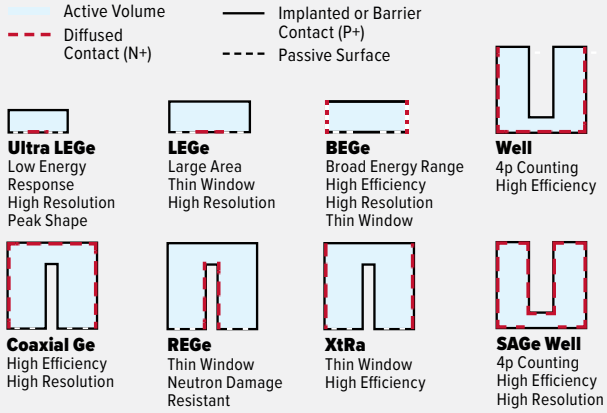
The measured data or spectrum includes the above three phenomena. However, it is the photoelectric effect of a) that determines the energy of the incident radiation. It is a peak by Compton scattering in part of the spectrum. The Electron pair production is represented on the spectrum as a 511 keV photoelectric effect peak. From the figure below, depending on the detector, (1) energy range that can be measured, difference in detection efficiency depending on the ruby value, (3) energy peak shape, (4) adjacent confirmation that the state of separation from the peak is clearly expressed on the spectrum.

Example of spectrum measurement by detector type

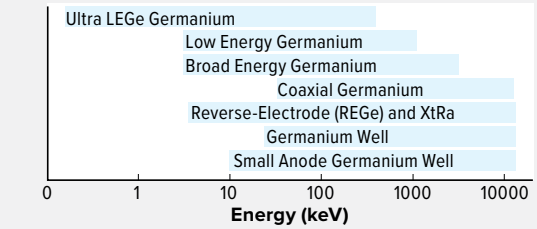


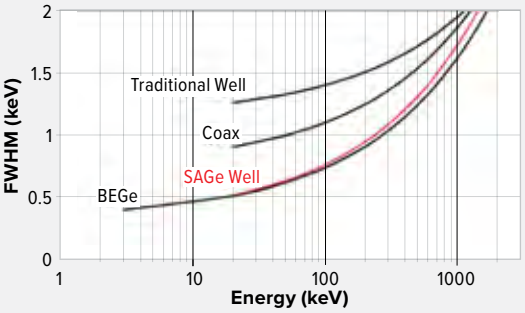
Gamma Spectroscopy

Structure Code:



Detector Type:

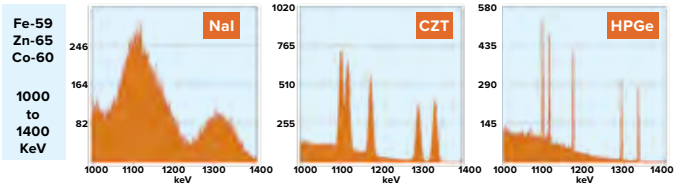




High Purity Germanium (HPGe) Detector Overview

- Wide variety of HPGe detector types and efficiencies are available:
  - SEGe™ Standard Electrode Coaxial – P-type
  - REGe™ Reverse Electrode Coaxial – N-type
  - XtRa™ Extended Range Coaxial
  - BEGe™ Broad Energy
  - LEGe™ Low Energy
  - U-LEGe™ Ultra-Low Energy
  - SAGe™ Well Small Anode Well
  - Germanium (Well)

- HPGe is the best available detector technology for analysis of complex gamma spectra
  - Below are spectra from three common types of gamma detectors: NaI(Tl), Cadmium zinc telluride (CZT) and HPGe
  - HPGe offers superior peak resolution performance compared to all other detector technologies
  - Broader peaks are harder to segregate from each other



- Conventional liquid nitrogen (LN_2) cryostats are available for all applications
  - **Laboratory** – Vertical or Horizontal with 30-liter or smaller Dewars
  - **Portable** – All-attitude MAC and Big MAC Cryostats
  - **Electrically-cooled** or hybrid electric/LN_2 cooled cryostats also available
- Ultra Low Background (ULB) for HPGe detectors is possible with special cryostat materials and a Remote Detector Chamber (RDC) to separate the preamplifier from detector crystal
  - Vertical configuration (shown)
  - U-Style configuration (see 737 Shield)

The iPA™ Intelligent Preamplifier

Since April 2017, all HPGe detectors with RC-feedback have been shipping with the iPA Intelligent Preamplifier, making key detector parameter data available 24/7 through the built-in USB port.

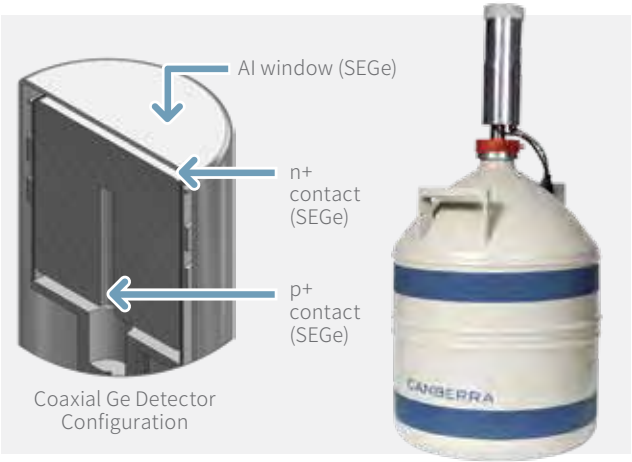
Gamma Spectroscopy
continued

Coaxial germanium detector (GC)

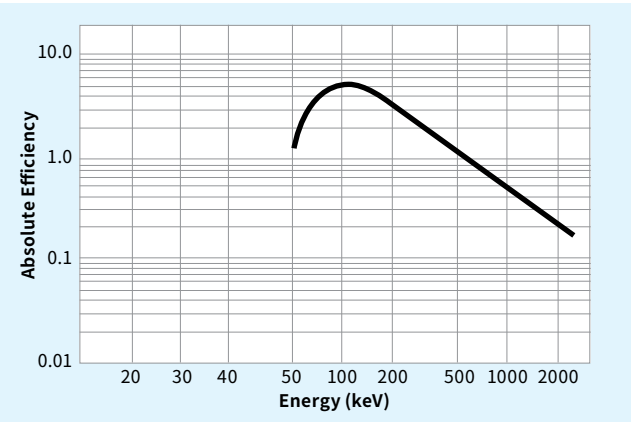
This detector uses a very pure germanium crystal as a detector in the form of a cylinder, and the best energy resolution can be obtained with a gamma-ray spectrometer. It is indispensable for qualitative quantitative analysis in environmental pollution, nuclear physics research, radiopharmaceutical purity test, etc.

Features are:

- Energy range from 40 keV to >10 MeV
- High resolution – good peak shape
- Excellent timing resolution
- High energy rate capability
- Equipped with Intelligent Preamplifier
- Diode FET protection
- Warm-up/HV shutdown
- USB 2.0 Serial Interface



Coaxial Ge Detector Configuration



Typical Absolute Efficiency Curve for 15% Detector (2.5 cm detector to source spacing)

Model Number	Typical Rel. Eff. (%) ≥	Full Width Half Max (FWHM) Resolution (keV)		Peak to Compton Ratio (P/C)	Peak Shape	Endcap diameter mm (in.)
		At 122 keV energy	At 1.3 MeV energy		FWTM/ FWHM	
GC0518	5	0.825	1.75	32	1.90	76 (3.0)
GC1018	10	0.825	1.75	40	1.90	76 (3.0)
GC1020	10	1.00	2.00	36	2.00	76 (3.0)
GC1518	15	0.825	1.80	46	1.90	76 (3.0)
GC1520	15	1.00	2.00	42	2.00	76 (3.0)
GC2018	20	0.850	1.80	50	1.90	76 (3.0)
GC2020	20	1.10	2.00	46	2.00	76 (3.0)
GC2518	25	0.850	1.80	54	1.90	76 (3.0)
GC2520	25	1.10	2.00	50	2.00	76 (3.0)
GC3018	30	0.875	1.80	58	1.90	76 (3.0)
GC3020	30	1.20	2.00	54	2.00	76 (3.0)
GC3518	35	0.875	1.80	60	1.90	76 (3.0)
GC3520	35	1.20	2.00	54	2.00	76 (3.0)
GC4018	40	0.875	1.80	62	1.90	76 (3.0)*
GC4020	40	1.20	2.00	56	2.00	76 (3.0)*
GC4518	45	0.900	1.80	63	1.90	83 (3.25)
GC4520	45	1.20	2.00	58	2.00	83 (3.25)
GC5019	50	0.950	1.90	64	1.90	83 (3.25)*
GC5021	50	1.20	2.10	58	2.00	83 (3.25)*
GC5519	55	1.00	1.90	64	1.90	89 (3.5)
GC5521	55	1.20	2.10	60	2.00	89 (3.5)
GC6019	60	1.00	1.90	66	1.90	89 (3.5)
GC6022	60	1.25	2.20	60	2.00	89 (3.5)
GC6520	65	1.00	1.95	68	1.90	89 (3.5)
GC6522	65	1.25	2.20	62	2.00	89 (3.5)
GC7020	70	1.00	2.00	70	1.90	89 (3.5)*
GC7022	70	1.25	2.20	64	2.00	89 (3.5)*
GC8020	80	1.10	2.00	72	1.90	95 (3.75)
GC8023	80	1.30	2.30	66	2.00	95 (3.75)
GC9020	90	1.10	2.00	78	1.90	95 (3.75)
GC9023	90	1.30	2.30	70	2.00	95 (3.75)
GC10020	100	1.20	2.00	78	1.90	95 (3.75)*
GC10023	100	1.40	2.30	70	2.00	95 (3.75)*
GC11021	110	1.20	2.10	78	1.90	102 (4.0)
GC11023	110	1.40	2.30	70	2.00	102 (4.0)
GC12021	120	1.30	2.10	78	1.90	102 (4.0)
GC12023	120	1.50	2.30	70	2.00	102 (4.0)
GC13021	130	1.30	2.10	80	1.95	108 (4.25)*
GC13023	130	1.50	2.30	74	2.00	108 (4.25)*
GC14022	140	1.30	2.20	80	1.95	108 (4.25)*
GC14024	140	1.50	2.40	74	2.00	108 (4.25)*
GC15022	150	1.30	2.20	80	1.95	108 (4.25)*
GC15024	150	1.50	2.40	74	2.00	108 (4.25)*

* Due to variations in crystal size endcap diameter may be larger. For guaranteed endcap diameter or custom specifications and hardware customization consult factory.

Model Number	Typical Rel. Eff. (%) ≥	Full Width Half MaR (FWHM) Resolution (keV)		Peak to Compton Ratio (P/C)	Peak Shape	Endcap diameter mm (in.)
		At 122 keV energy	At 1.3 MeV energy		FWTM/ FWHM	
GR1018	10	0.825	1.8	38	1.90	76 (3.0)
GR1020	10	1.00	2.00	34	2.00	76 (3.0)
GR1518	15	0.825	1.8	44	1.90	76 (3.0)
GR1520	15	1.00	2.0	40	2.00	76 (3.0)
GR2018	20	0.850	1.8	50	1.90	76 (3.0)
GR2020	20	1.10	2.0	46	2.00	76 (3.0)
GR2519	25	0.850	1.9	54	1.90	76 (3.0)
GR2521	25	1.10	2.1	50	2.00	76 (3.0)
GR3019	30	0.875	1.9	56	1.90	76 (3.0)
GR3021	30	1.20	2.1	52	2.00	76 (3.0)
GR3519	35	0.925	1.9	56	1.90	76 (3.0)
GR3521	35	1.20	2.1	52	2.00	76 (3.0)
GR4020	40	0.925	2.0	56	1.90	76 (3.0)*
GR4022	40	1.20	2.2	52	2.00	76 (3.0)*
GR4520	45	0.950	2.0	58	1.90	83 (3.25)
GR4522	45	1.20	2.2	54	2.00	83 (3.25)
GR5021	50	1.00	2.1	58	1.90	83 (3.25)*
GR5023	50	1.20	2.3	54	2.00	83 (3.25)*
GR5522	55	1.10	2.1	60	2.00	89 (3.5)
GR5524	55	1.25	2.3	54	2.10	89 (3.5)
GR6022	60	1.10	2.2	60	2.00	89 (3.5)
GR6024	60	1.25	2.4	54	2.10	89 (3.5)
GR6523	65	1.20	2.3	60	2.00	89 (3.5)
GR6525	65	1.30	2.5	54	2.10	89 (3.5)
GR7023	70	1.20	2.3	60	2.00	89 (3.5)*
GR7025	70	1.30	2.5	54	2.10	89 (3.5)*
GR8023	80	1.20	2.3	60	2.00	95 (3.75)
GR8025	80	1.30	2.5	56	2.10	95 (3.75)
GR9023	90	1.20	2.3	60	2.00	95 (3.75)
GR9025	90	1.30	2.5	56	2.10	95 (3.75)
GR10024	100	1.30	2.4	60	2.00	95 (3.75)*
GR10026	100	1.40	2.6	56	2.10	95 (3.75)*

* Due to variations in crystal size endcap diameter may be larger. For guaranteed endcap diameter or custom specifications and hardware customization consult factory.

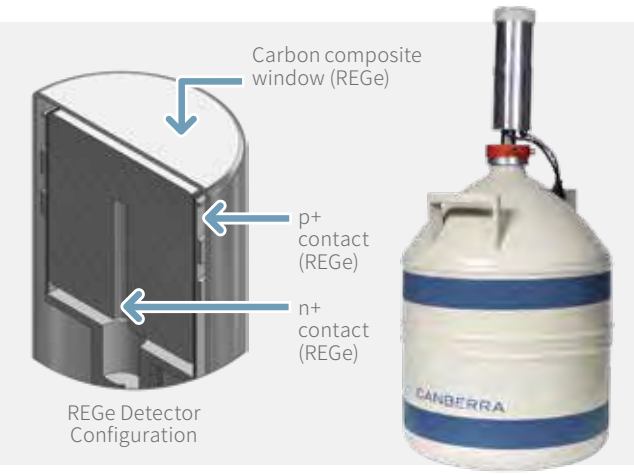
Wide energy band germanium detector - N type (GR)

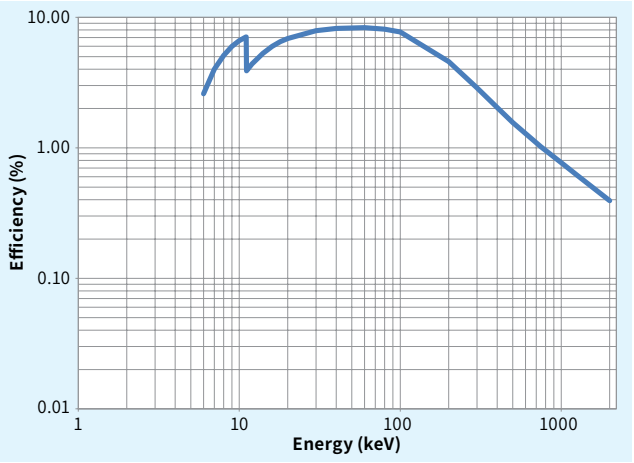
The reverse electrode detector uses N-type germanium crystals manufactured under strict quality control by Mirion. This detector has the electrode arrangement reversed to that of a normal germanium detector, P + electrode.

(Boron) is arranged on the incident surface, and N + electrode (Li) is arranged on the back surface. As a result, the response at low energy is improved and the resistance to radiation damage caused by neutrons and charged particle beams is increasing.

Features are:

- Spectroscopy from 3 keV to >10 MeV
- Ultra-thin ion implanted contacts
- Radiation damage resistant
- Excellent timing resolution
- High energy rate capability
- Equipped with Intelligent Preamplifier
- Diode FET protection
- Warm-up/HV shutdown
- USB 2.0 Serial Interface





Typical Absolute Efficiency Curve for 15% REGe Detector with Carbon window with 2.5 cm detector to source spacing

Gamma Spectroscopy
continued

Broad energy germanium detector (BE)

Mirion BEGe Broad Energy Germanium detectors range from about 3 keV and can measure energy up to 3 MeV. The low-energy resolution realizes the same high resolution as the LEGe detector, and the high-energy resolution realizes the high resolution of the coaxial detector.

The BEGe detector is characterized by high efficiency for actual sample measurements in the energy range below about 1 MeV, which is most important for gamma ray analysis. Traditionally, the relative efficiency of coaxial Ge detectors has been measured and defined with a ^{60}Co point source. However, much of the efficiency in actual measurements is different from this definition of relative efficiency. The graph on the right is a comparison of a coaxial detector and a BEGe detector with the same relative efficiency of 60% or more. BEGe detectors are highly efficient in the critical energy range of actual measurements.

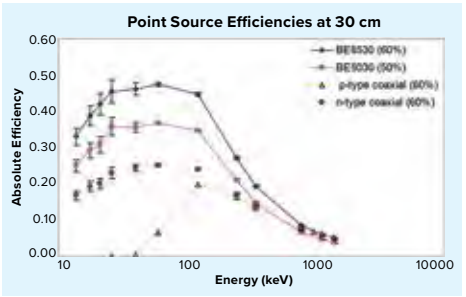
The BEGe detector also has high energy cosmic rays and Since ^{40}K, ^{208}Tl of natural radiation is transmitted, a low background is achieved compared to a coaxial Ge detector.

型番	有効面積 (cm²)	厚 (mm)	効率* (%) ≧	分解能 (FWHM) (keV)			エンドキャップ径 mm (in.)
				5.9 keV	122 keV	1332 keV	
BE2020	20	20	9	0.35	0.65	1.80	76 (3.0)
BE2820	28	20	13	0.40	0.70	1.90	82 (3.25)
BE2825	28	25	18	0.40	0.70	1.90	82 (3.25)
BE2825P	28	25	18	0.35	0.65	1.80	82 (3.25)
BE3820	38	20	20	0.45	0.75	1.90	89 (3.50)
BE3825	38	25	26	0.45	0.72	1.90	89 (3.50)
BE3825P	38	25	26	0.40	0.65	1.80	89 (3.50)
BE3830	38	30	34	0.45	0.72	1.90	89 (3.50)
BE3830P	38	30	34	0.40	0.65	1.80	89 (3.50)
BE5025	50	25	37	0.50	0.75	2.00	102 (4.0)
BE5030	50	30	48	0.475	0.72	2.00	102 (4.0)
BE5030P	50	30	48	0.425	0.675	1.80	102 (4.0)
BE6530	65	30	60	0.50	0.75	2.00	114 (4.5)

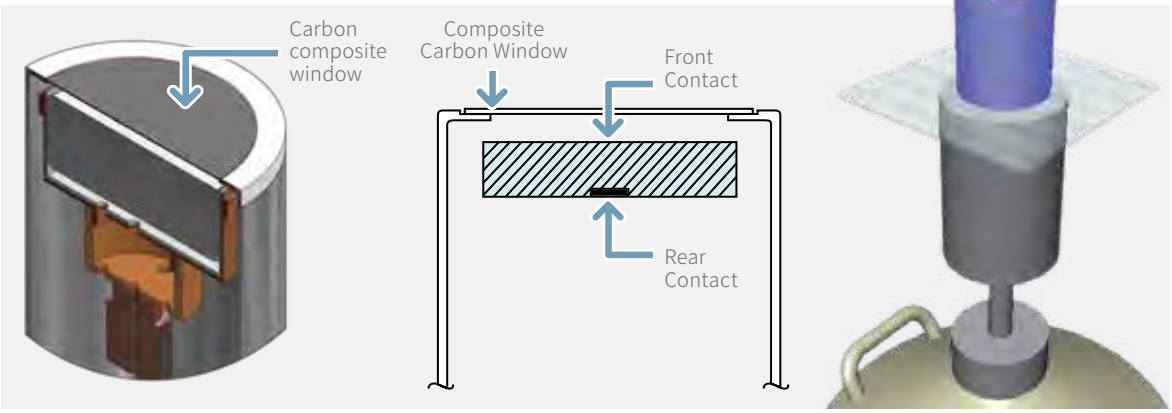
* It is not a guaranteed value but a reference value.

Features are:

- Energy range from 3 keV to 3 MeV combining advantages of Low Energy and Coaxial HPGe detectors (Maximum effective area 6500 mm²)
- Efficiency and energy resolution optimized for 3 keV to 662 keV region where most tightly-grouped peaks of interest are located
- Flat crystals offer optimum efficiencies for samples counted close to the detector
- Lower Compton continuum at lower energies resulting in much better MDA
- Detector of choice for Actinide Lung Counting
- Thin window
- High resolution in low energy range
- High resolution in high energy range
- Standardized geometry



Absolute Efficiency vs. Energy comparison for BE6530, BE5030, GC6020 (p-type coaxial) and GR6022 (n-type coaxial) detectors



型番	効率 (%) ≧	分解能 (FWHM) (keV)		ピーク/コンプトン比 (P/C)	ピーク形状	エンドキャップ径 mm (in.)
		122 keV	1332 keV		FWTM/FWHM	
GX1018	10	0.825	1.75	40	1.90	76 (3.0)
GX1020	10	1.00	2.00	36	2.00	76 (3.0)
GX1518	15	0.825	1.80	46	1.90	76 (3.0)
GX1520	15	1.00	2.00	42	2.00	76 (3.0)
GX2018	20	0.850	1.80	50	1.90	76 (3.0)
GX2020	20	1.10	2.00	46	2.00	76 (3.0)
GX2518	25	0.850	1.80	54	1.90	76 (3.0)
GX2520	25	1.10	2.00	50	2.00	76 (3.0)
GX3018	30	0.875	1.80	58	1.90	76 (3.0)
GX3020	30	1.20	2.00	54	2.00	76 (3.0)
GX3518	35	0.875	1.80	60	1.90	76 (3.0)
GX3520	35	1.20	2.00	54	2.00	76 (3.0)
GX4018	40	0.875	1.80	62	1.90	76 (3.0)*
GX4020	40	1.20	2.00	56	2.00	76 (3.0)*
GX4518	45	0.900	1.80	63	1.90	83 (3.25)
GX4520	45	1.20	2.00	58	2.00	83 (3.25)
GX5019	50	0.950	1.90	64	1.90	83 (3.25)*
GX5021	50	1.20	2.10	58	2.00	83 (3.25)*
GX5519	55	1.00	1.90	64	1.90	89 (3.5)
GX5521	55	1.20	2.10	60	2.00	89 (3.5)
GX6019	60	1.00	1.90	66	1.90	89 (3.5)
GX6022	60	1.25	2.20	60	2.00	89 (3.5)
GX6520	65	1.00	1.95	68	1.90	89 (3.5)
GX6522	65	1.25	2.20	62	2.00	89 (3.5)
GX7020	70	1.00	2.00	70	1.90	89 (3.5)*
GX7022	70	1.25	2.20	64	2.00	89 (3.5)*
GX8020	80	1.10	2.00	72	1.90	95 (3.75)
GX8023	80	1.30	2.30	66	2.00	95 (3.75)
GX9020	90	1.10	2.00	78	1.90	95 (3.75)
GX9023	90	1.30	2.30	70	2.00	95 (3.75)
GX10020	100	1.20	2.00	78	1.90	95 (3.75)*
GX10023	100	1.40	2.30	70	2.00	95 (3.75)*
GX11021	110	1.20	2.10	78	1.90	102 (4.0)
GX11023	110	1.40	2.30	70	2.00	102 (4.0)
GX12021	120	1.30	2.10	78	1.90	102 (4.0)
GX12023	120	1.50	2.30	70	2.00	102 (4.0)

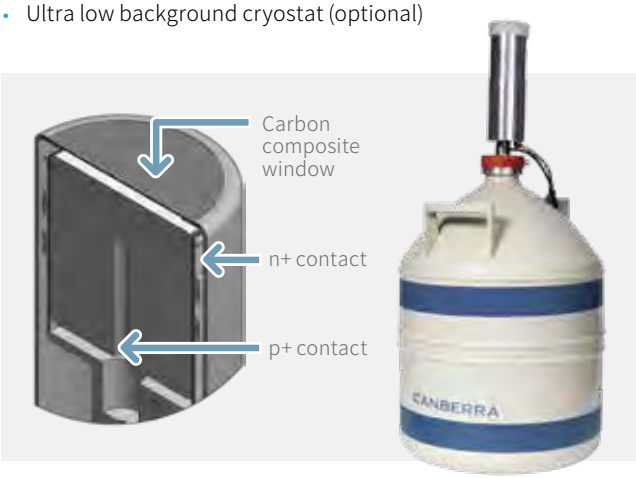
* Depending on the crystal dimensions, the endcap diameter may be larger than indicated.

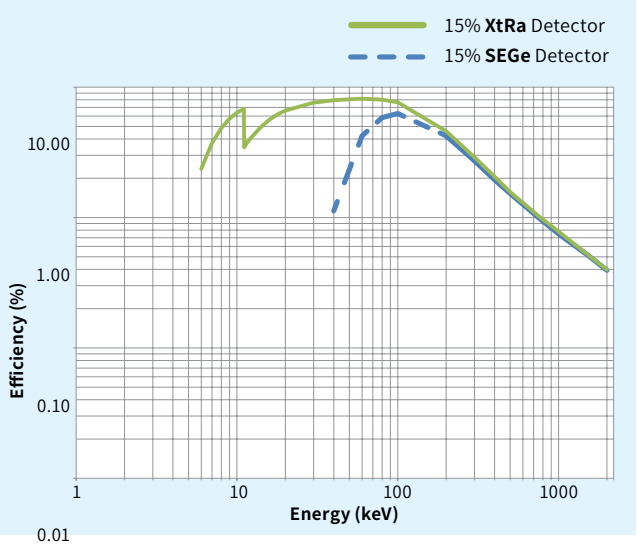
Wide energy band germanium detector – P type (GX)

The Mirion XtRa Ge detector has a very thin contact with a specially processed incident surface of a coaxial P-type Ge crystal. This thin contact provides a wide detection range with a detection range of about 3 keV to about 10 MeV.

Features are:

- Low energy X-rays and high energy γ-rays can be detected
- The incident window uses beryllium or carbon composite
- Uses P-type coaxial Ge crystal
- Ultra low background cryostat (optional)





Typical Efficiency curves comparing XtRa unit with a Carbon Composite window and a SEGe unit with detector-source spacing of 2.5 cm

Gamma Spectroscopy
continued

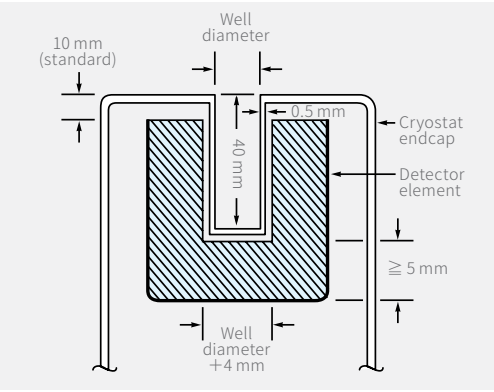
Well type germanium detector (GCW)

Well Ge detectors can perform energy analysis with maximum efficiency on small samples. The detection part of the well-type Ge detector is formed in a well type (well/blind hole). The sample installed inside is counted in almost all directions (4π), and extremely high counting efficiency is achieved. The Al thickness that protects the detector (well) is 0.5 mm, and the ion-implanted contact or surface barrier contact that forms the outside of the element (crystal) is negligibly thin compared to 0.5 mm Al, so well-type Ge detection has a good low energy response.

Standard well size is diameter: 10/16 mm, depth: 40 mm, but we can supply special Ge-type well detectors.

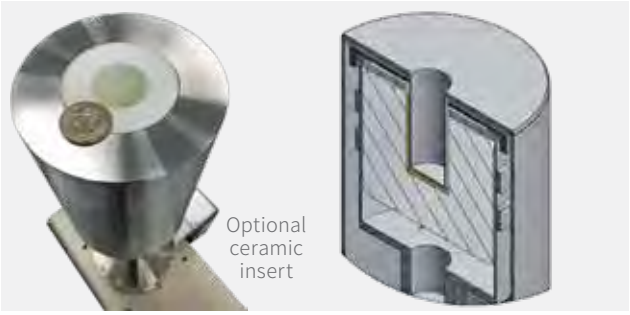
Features are:

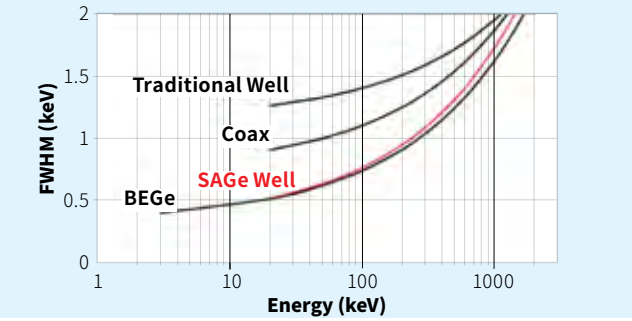
- High efficiency (near 4π counting geometry)
- Wide energy range
- Various well sizes
- Ultra low background cryostat (optional)



型番	効率(%)	ウェル径 (mm)	容量 (cc)	分解能	
				FWHM 1332 keV	FWHM 122 keV
GCW1521	15	10	90	2.1	1.1
GCW1522	15	16	100	2.2	1.3
GCW2021	20	10	110	2.1	1.1
GCW2022	20	16	120	2.2	1.3
GCW2521	25	10	130	2.1	1.2
GCW2523	25	16	140	2.3	1.4
GCW3021	30	10	150	2.1	1.2
GCW3023	30	16	160	2.3	1.4
GCW3521	35	10	170	2.1	1.2
GCW3523	35	16	180	2.3	1.4
GCW4021	40	10	190	2.1	1.2
GCW4023	40	16	200	2.3	1.4
GCW5021	50	10	260	2.1	1.2
GCW5023	50	16	260	2.3	1.4
GCW6021	60	10	300	2.1	1.3
GCW6023	60	16	300	2.3	1.5
GCW7021	70	10	320	2.1	1.3
GCW7023	70	16	320	2.3	1.5
GCW8022	80	10	350	2.2	1.3
GCW8023	80	16	350	2.3	1.5
GCW9022	90	10	380	2.2	1.3
GCW9023	90	16	380	2.3	1.5
GCW10022	100	10	450	2.2	1.3
GCW10023	100	16	450	2.3	1.5

* Depending on the crystal dimensions, the endcap diameter may be larger than indicated.





型番	有効容積 (cc)	ウェル径 (mm)	ウェル長 (mm)	分解能		エンドキャップ径 (inch)
				FWHM 1332 keV	FWHM 122 keV	
GSW120	120	16	40	2.2	0.75	3.25
GSW200	200	16	40	2.2	0.75	3.5
GSW300	300	16	40	2.2	0.75	4.25
GSW425	425	16	40	2.2	0.75	4.5
GSW275L	275	28	40	2.2	0.75	4.25

Small anode well-type detector and energy resolution (FWHM) of general well-type detector and coaxial detector.

Small anode well-type germanium detector plus (SAGe Well+)

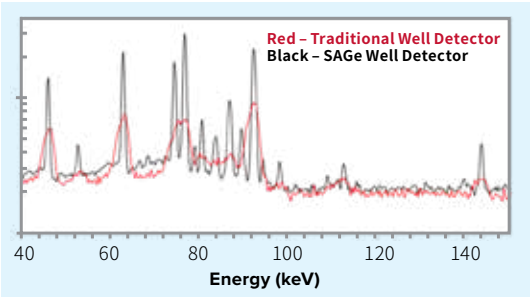
The Mirion SAGe Well Detector[1] combines excellent energy resolution at low and high energies with maximum efficiency for small samples. Like Traditional Well Detectors, the SAGe Well is fabricated with a blind hole, leaving at least 20 mm of active detector thickness at the bottom of the well. The counting geometry therefore approaches 4π.

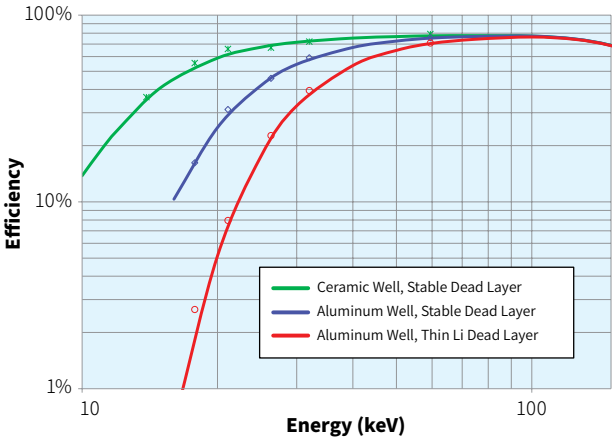
The low detector capacitance associated with the small anode technology (similar to what is used on the Mirion BEGe detectors) gives the SAGe Well superior low and medium-energy resolution performance compared to Traditional Well or Coaxial Detectors, as well as excellent resolution for higher energy gamma rays.

Features are:

- Blind well approaches 4π counting geometry yielding high absolute efficiency
- Superior resolution compared to Traditional Well Detectors at both low and high energies
- Larger well diameter (28 mm) available with the same excellent resolution as the standard (16 mm) well sizes
- Thin lithium diffused contact inside well allows spectroscopy from 20 keV up to 10 MeV
- Full LabSOCS characterization available, allowing True Coincidence Summing correction
- Equipped with Intelligent Preamplifier
- USB 2.0 Serial Interface

[1] US Patent 9,269,847 B2





Gamma Spectroscopy
continued

Low energy germanium detector (GL)

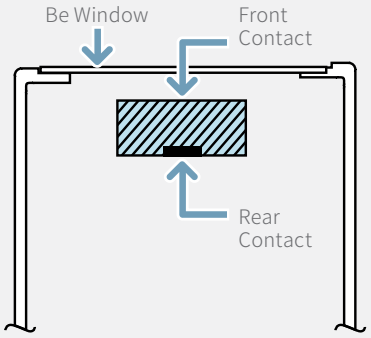
The LEGe type detector satisfies the highest energy resolution and detection efficiency in the middle range of the detection range of the Ultra LEGe type detector and the coaxial type detector. The detection area can be selected from the range of 0.5 cm^2 to 20 cm^2 and the detection thickness from 5 to 20 mm. The incident surface is a P (+) contact with a boron implant and has good low energy response, and Be is used for the incident window.

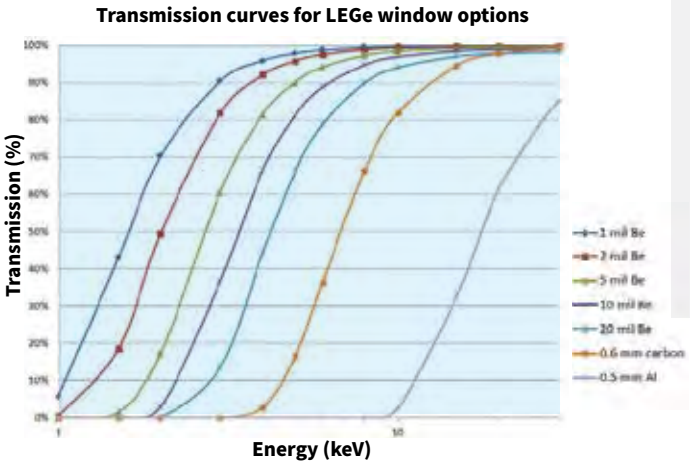
Features are:

- X-ray and γ-ray can be detected in a large area. (Maximum photosensitive area of 20 cm^2)
- An energy spectrum of 3 keV to 1 MeV can be obtained with high resolution
- The preamplifier uses a cooled FET to improve energy resolution
- Ultra low background cryostat (optional)

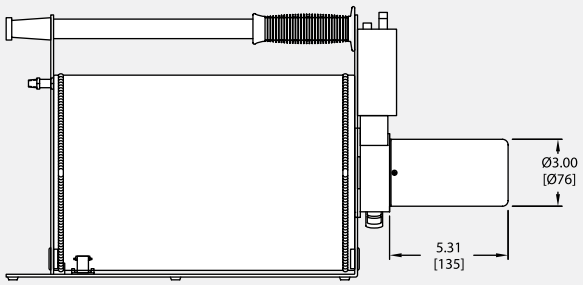
型番	有効面積 (mm^2)	厚 (mm)	窓厚mm (mils)	分解能 **		プリアンプタイプ
				FWHM 5.9 keV	FWHM 122 keV	
GL0055	50	5	0.025 (1)	145	500	I-TRP
GL0110	100	10	0.025 (1)	160	500	I-TRP
GL0210	200	10	0.15 (5)	195* (170)	520	RC*
GL0510	500	10	0.15 (5)	250	550	RC
GL0515	500	15	0.15 (5)	250	550	RC
GL1010	1000	10	0.5 (10)	300	620	RC
GL1015	1000	15	0.5 (10)	300	620	RC
GL2020	2000	20	0.5 (20)	400	680	RC

* An I-TRP preamplifier can be used as an option.
** Resolution (FWTM) ≤ 2 x Resolution (FWHM).

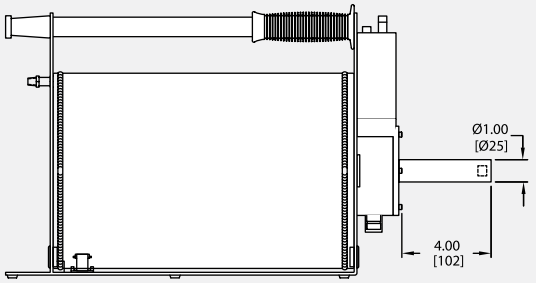




Comparison of low energy transmission for different available window

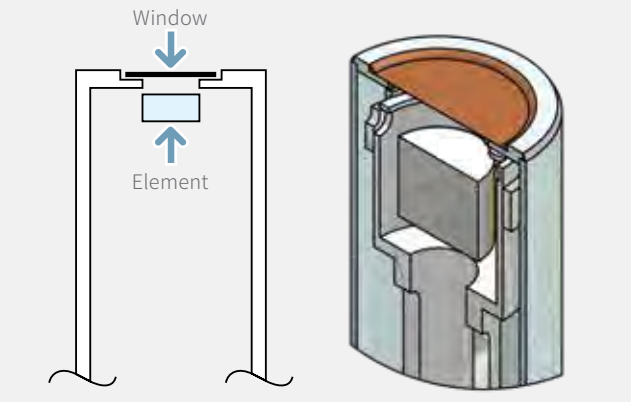


Example of GL2020 in Big Mac Cryostat
(Flanged version shown Slimline also available)



Example of GL0055 in Big Mac Cryostat

型番	有効面積 (mm²)	厚 (mm)	窓厚mm (mils)	分解能	
				FWHM 5.9 keV	FWHM 122 keV
GUL0035	30	5	0.025 (1)	140	550
GUL0055	50	5	0.025 (1)	140	550
GUL0110	100	10	0.025 (1)	150	550



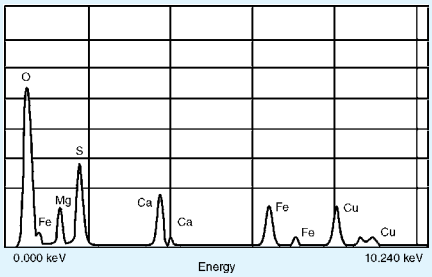
Germanium detector (GUL) for ultra-low energy

The GUL series ultra-low energy germanium detectors have expanded the detection range to a low energy of about 300 eV while achieving the resolution and peak-to-background ratio that were considered impossible to achieve with semiconductor detectors. In addition, the high energy efficiency of the high atomic number germanium detector is maintained. Therefore, a polymer window is available to fully exploit the performance of a wider energy range than the single photon detectors on the market. The polymer window allows higher efficiency in the extremely low energy range.

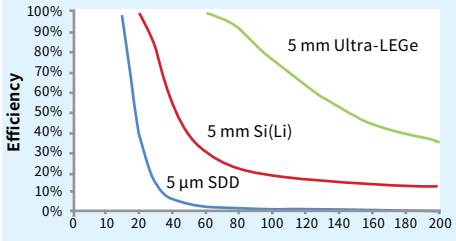
Features are:

- The energy range not available with conventional Si(Li) detectors can be obtained with pure germanium detectors
- An energy spectrum of about 300 eV to about 300 keV can be obtained with higher resolution than the Si(Li) detector
- An optional 0.4 µm thick polymer window is available
- Excellent resolution up to very high count rates
- Available standalone or in arrays
- For XRF, XAS (XAFS, EXAFS, XANES) and X-ray spectroscopy applications

Spectrum from NIST 2063 Thin Film Standard Glass

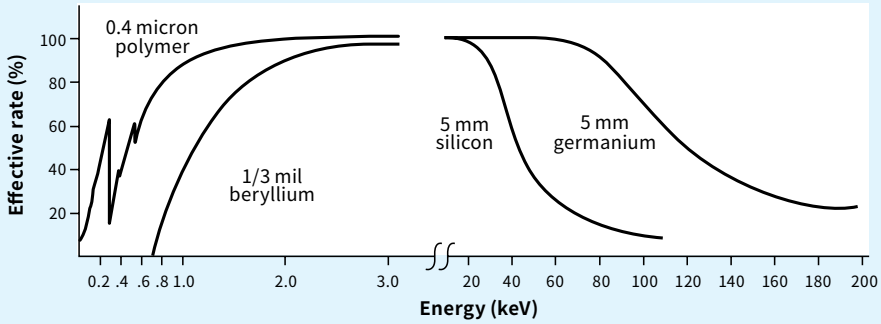


Comparison of high-energy efficiency – Germanium vs. Silicon



GUL detector (effective area 100 mm²) and windowless retractable cryostat (optional)

Window transmittance comparison-polymer vs. beryllium
Comparison of detector efficiency-germanium vs. silicon



Window options

BW-0.3	1/3 mil Be window (effective product 30 / 50 mm²)
PW-0.4 (V or H)	0.4 m polymer (For effective product 30 mm²)
PW-0.4 L (V or H)	0.4 m polymer (Effective product 50 mm², 100 mm²)

Cryostat option

7500	Vertical dipstick cryostat (30 mm)
7905-7.5	Horizontal integral (7.5 mm)
7906-7.5	Vertical integral (7.5 mm)
7905-R	Retractable
7905-WR	Windowless retractable
7905-BWR	Windowless retractable with bellows seal

End cap size: 25ϕ × 10 L (cm)

Gamma Spectroscopy
continued

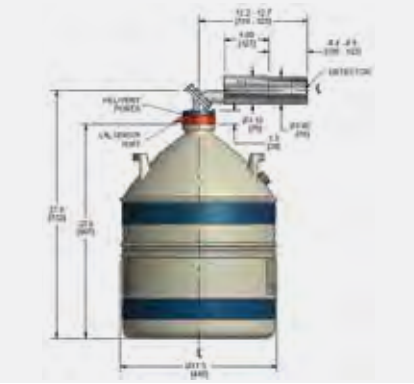
Slimline™ Type Cryostats

7500SL Vertical Dipstick in D-30 Dewar

7906-30SL Vertical Integral Cryostat

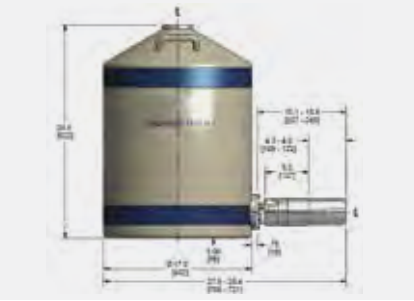
(also available in 7.5 and 15 liter version)

7600SL Horizontal Dipstick in D-30 Dewar



7500SL Vertical Dipstick in CCII-VD Hybrid Cryostat

7905-30SL Horizontal Integral Cryostat



(also available in 7.5 and 15 liter version)

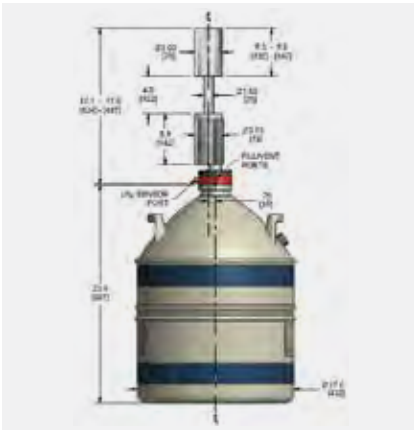
Remote Detector Chamber (RDC) option

The 7500SL vertical dipstick cryostat can be optionally equipped with an RDC remote detector chamber.

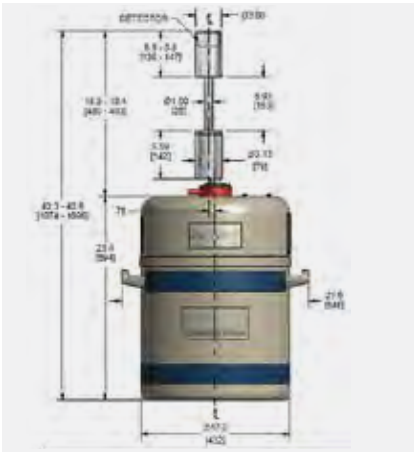
Typical RDC lengths are 2, 4, 6, 8, 10 inches. The figures below are an overview of the most common sizes, 4 inch and 6 inch RDC. RDC-4 is 747 and 767 suitable for lead shielding, RDC-6 is suitable for type 777 lead shielding.

- 7500SL-RDC-4 Vertical dipstick / RDC-4 (D-30 using Dewar)
- 7500SL-RDC-6 Vertical dipstick / RDC-6 (Using CCII-VD Cryo-Cycle II)

7500SL-RDC-4 Vertical Dipstick in D-30 Dewar



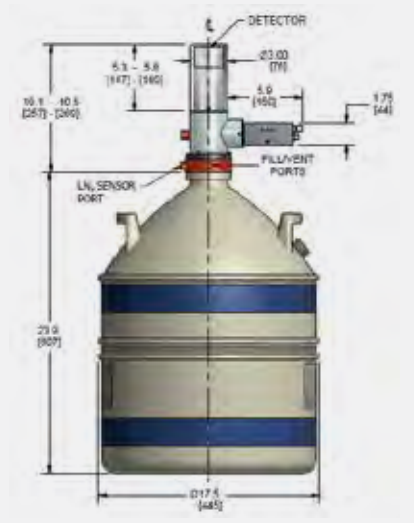
7500SL-RDC-6 Vertical Dipstick Cryostat in CCII-VD Hybrid Cryostat



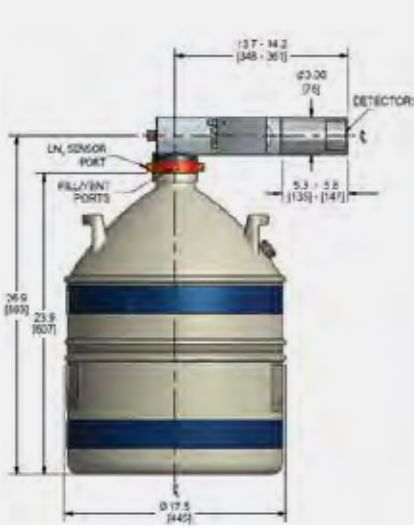
Flanged™ Cryostats Liquid Nitrogen Cryostat

The germanium detector is cooled with liquid nitrogen and requires a Dewar/cryostat. Mirion supplies a variety of Dewar/cryostat shapes for every experiment. When ordering detectors, select the optimal Dewar/cryostat from the diagram below. The unit of measurement in the figure is inches and (millimeters).

7500 Vertical Dipstick in D-30 Dewar



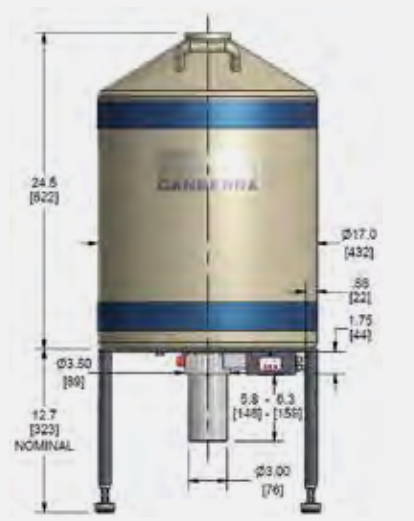
7600 Horizontal Dipstick in D-30 Dewar



7905-30 Horizontal Integral Cryostat

(also available in 7.5 and 15 liter version)

7906-30 Vertical Integral Cryostat

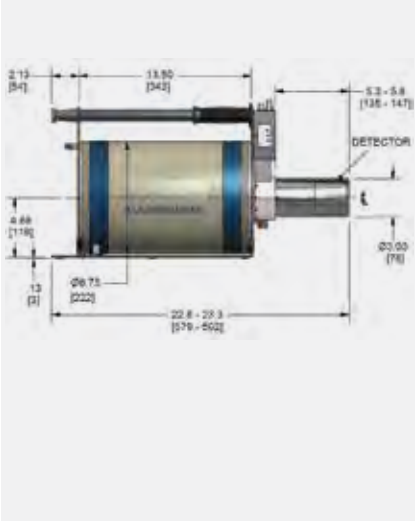


(also available in 7.5 and 15 liter version)

7935-2F Portable Multi-Attitude Cryostat

(2 liter MAC)

7935-7F Portable Multi-Attitude Cryostat

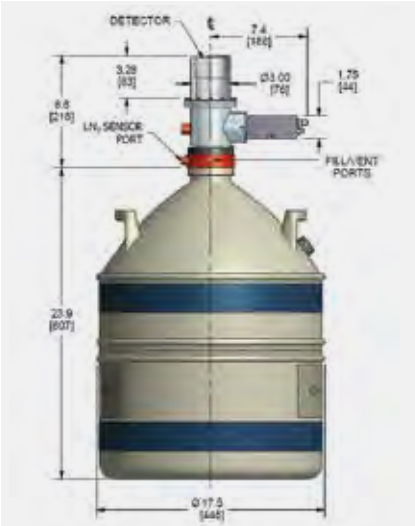


(7 liter Big MAC)

Gamma Spectroscopy
continued

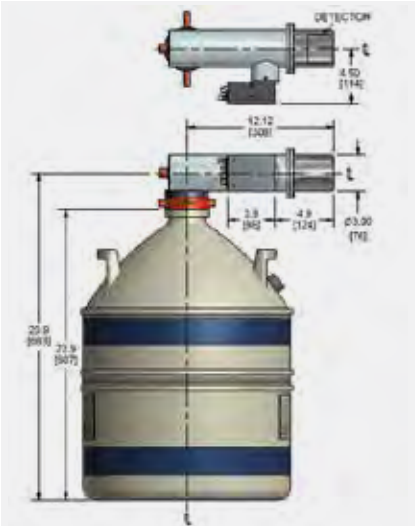
Metal seal flange type (3 inch (76 mm) diameter endcap only)

7500M Vertical Dipstick



(Available in D-30 Dewar or CCII-VD Hybrid Cryostat)

7600M Horizontal Dipstick



(Available in D-30 Dewar or CCII-HD Hybrid Cryostat)

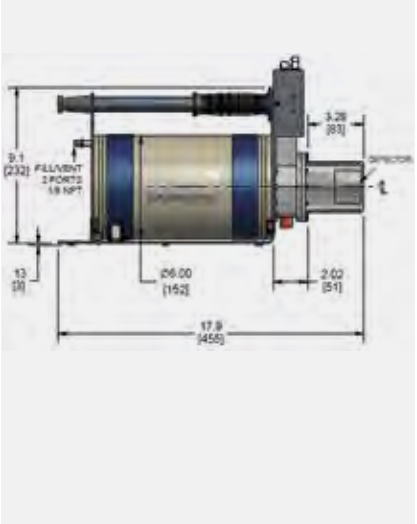
7905-30M Horizontal Integral Cryostat

(also available in 7.5 and 15 liter version)

7906-30M Vertical Integral Cryostat

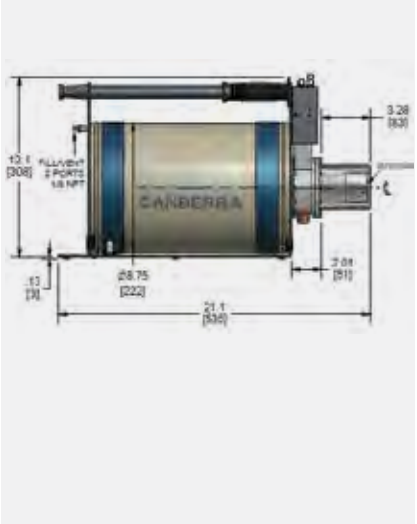
(also available in 7.5 and 15 liter version)

7935-2FM Portable Multi-Attitude Cryostat



(2 liter MAC)

7935-7FM Portable Multi-Attitude Cryostat



(7 liter Big MAC)

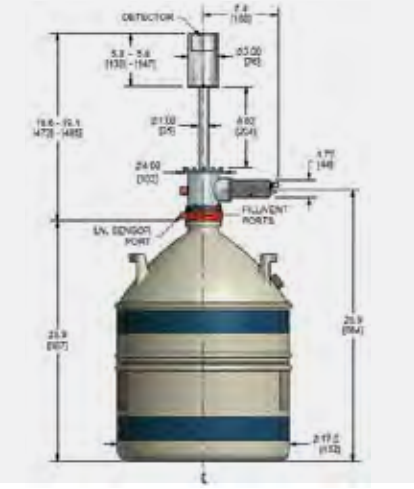
Remote Detector Chamber (RDC) option

All flanged cryostat models (with exception of the vertical integral downlooking Cryo-Cycle™ II cryostat, model CCII-VI) can be fitted with an RDC option. Standard lengths for RDC elements are 2, 4, 6, 8 and 10 inches. Below are a few examples of LN_2 or electrically cooled cryostat models including the RDC option. The flanged Big MAC and *Cryo-Pulse*® 5 Plus cryostat with RDC-4 are commonly used with in situ counting ISOCS™ systems.

CCII-HI-F-RDC-2 Horizontal Integral Hybrid Cryostat

(Use Cryo-Cycle II)

7500-RDC-8 Vertical Dipstick Cryostat in D-30 Dewar



(Uses D-30 Dewar)

7935-7F-RDC-4 Portable Multi-Attitude Cryostat

(7 liter Big MAC)

Pulse tube type liquid nitrogen evaporation prevention device

The pulse tube type liquid nitrogen evaporation prevention device was developed to reduce the number of times of replenishment of liquid nitrogen, which is troublesome compared to the Ge semiconductor detector cooled by conventional liquid nitrogen. The liquid nitrogen consumption of this equipment is less than about one liter per year. Therefore, it can be said that replenishment is virtually unnecessary. The equipment consists of a cold head (pulse tube type), compressor, controller and liquid nitrogen Dewar (16 L and 30 L types).

By using a pulse tube refrigerator with less vibration, mechanical vibration was suppressed as much as possible, and degradation of energy resolution was minimized. In the unlikely event that the power supply cannot be provided due to a power outage or the like, the liquid nitrogen in the Dewar will be used for about a week (16 L). Measurement can be continued for about two weeks (30 L), depending on detector size.

Gamma Spectroscopy
continued

MAC Portable Cryostat

Features are:

- Can be used in all directions
- Lightweight aluminum structure
- Long holding time
- Bias off function by temperature sensor

Overview

For applications requiring both portability and flexibility of use, the MAC (multi-attitude cryostat) is the answer. The unique fill and vent system employed by the MAC cryostat allows operation of the detector in any orientation without LN_2 spillage even when the Dewar is full. The small size, lightweight, and ruggedness of the unit permit use of the unit in field conditions. The slimline detector chamber allows the unit to be shielded very effectively for use in low-level counting applications.

The MAC detector consists of a Dewar having two fill and vent ports arranged so that one of the ports is the vent, regardless of the Dewar's orientation. This allows the Dewar to be operated in the horizontal position, vertically uplooking, or vertically downlooking, without loss of LN_2.

A single port version of the MAC and Big MAC cryostat is available on special order. This version has half the capacity and holding time of the standard product. A gravity-feed supply Dewar/stand is available for the single port cryostat. The single port cryostat is compatible with other brands, and it holds LN_2 in all orientations which may be important in some applications, e.g. for use in a submarine (see Mirion Model 7411).

The detector/preamp includes a sensor which provides a signal when the LN_2 is depleted. This output can be used to shut down the bias supply, to operate an alarm, or both.

The standard MAC unit features the Mirion Slimline Cryostat option in which a Mirion preamplifier is packaged behind the detector chamber within the confines of the 80 mm diameter snout. The Slimline cryostat allows the detector to be installed in a shield with very little difficulty and with efficient use of shielding material. The snout is long enough to reach through 10-15 cm of shielding material and still accommodate Marinelli beaker samples.

A flanged version of the MAC cryostat is also available. This version makes use of a conventional box-style preamplifier having bulkhead connectors (rather than pigtail connectors) and is somewhat more compact than the Slimline version.

The MAC unit comes with detachable carrying handle assembly. With the carrying handle assembly removed, there are no obstructions beyond the outer diameter of the Dewar, and the unit can be readily installed in other scientific apparatus such as whole body counters, scattering chambers or low-level counting systems.

Both manual and automatic refill systems are available for use with the MAC. Since the MAC has separate fill and vent ports, the LN_2 supply and the vent lines can be made gas tight, thus avoiding the hazards of cold N_2 or LN_2 to either personnel or adjacent equipment.

The MAC cryostat is available as an option with most of the High Purity Germanium detectors offered by Mirion. Consult the Mirion website for information on the wide variety of detectors that are available from Mirion.

MAC

- Weight: 5.1 kg (empty), 7.1 kg (when liquid nitrogen is full)
- Liquid nitrogen capacity: 2.5 liters
- Continuous use time: 2 days (for standard size detectors)
- Cooling time: 2 hours (approximate)
- Fill and Vent Ports: 3.2 mm (1/8 in.) NPT.

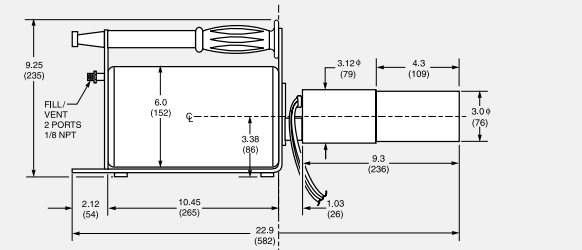
Big MAC

- Weight: 7.9 kg (empty), 13.6 kg (when liquid nitrogen is full)
- Liquid nitrogen capacity: 7.0 liters
- Continuous use time: 5 days (for standard size detectors)
- Cooling time: 2 hours (approximate)
- Fill and Vent Ports: 3.2 mm (1/8 in.) NPT.

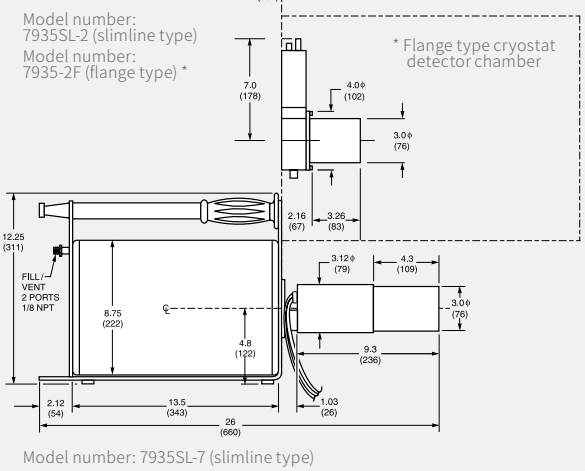
Rel. Efficiency (%)	Diameter in. (mm)
≤40	3.0 (76)
40-50	3.25 (83)
50-70	3.50 (89)
70-100	3.75 (95)
≥100	4.0 (102)

Option

- Model 7415 detector lift mechanism (for shield made by Mirion)



Model number:
7935SL-2 (slimline type)
Model number:
7935-2F (flange type) *



Model number: 7935SL-7 (slimline type)
Model number: 7935-7F (flange type)

Retractable™ Cryostat

Features are:

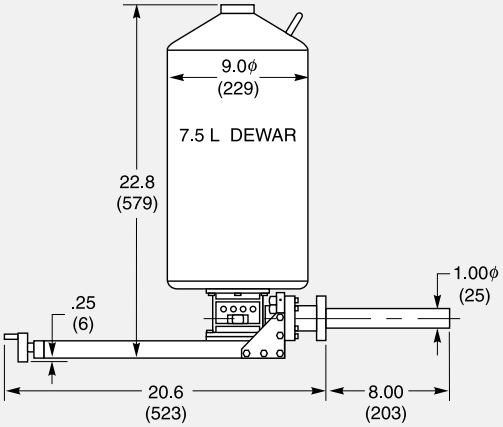
- Various geometry
- Windowless operation
- Robust design
- Use with Si(Li) detector and Ge detector
- UHV compatible (7905-BWR)

Overview

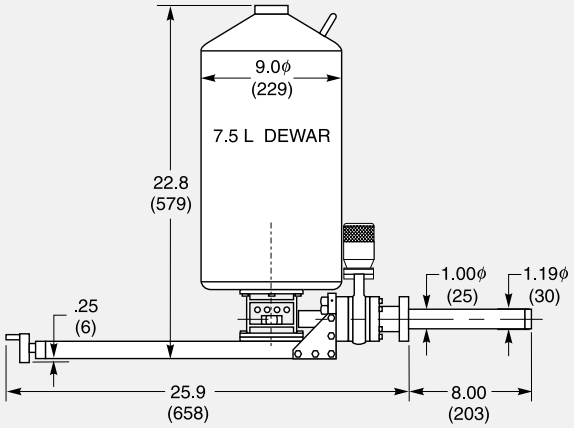
These retractable cryostats from Mirion are used with Si(Li), LEGe, and Ultra-LEGe detectors in x-ray applications. Retractable cryostats provide a means of moving the detector element in relation to the sample with both under vacuum. They also make it possible to operate the detector in windowless mode, i.e. without a window (absorber) between the detector element and the sample.

As with any detector that is not permanently sealed, care must be exercised in using windowless detectors to avoid contamination of the detector element. The vacuum chamber to which the detector is attached must be clean and dry and under good vacuum before the gate valve is opened. Under no circumstances is the detector to be exposed to the atmosphere while it is cold. Damage to detectors caused by contamination is not covered under warranty.

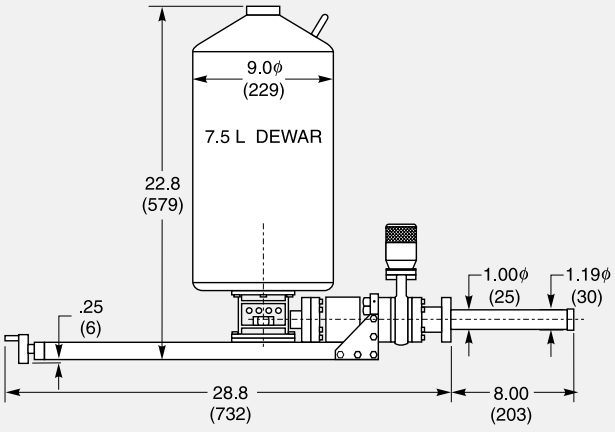
Model	Description
7905-R	Retractable unit with conventional window and sliding O-ring seal.
7905-WR	Windowless retractable unit with sliding O-ring seal.
7905-BWR	Windowless retractable unit with metal bellows seal.



Model 7905-R



Model 7905-WR



Model 7905-BWR

Gamma Spectroscopy
continued

U-Style™ Cryostat

Overview

Mirion U-Style cryostats have a vertically-oriented detector chamber located at the end of a horizontal arm extending from the side of the Dewar or cooler.

This configuration excludes the preamplifier and other hardware from the inner cavity of the lead shield and eliminates all line-of-sight streaming paths to the detector element. These features contribute significantly to the overall background reduction of the counting system.

The U-Style configuration has a lower center of gravity for the detector and shield as compared to a standard vertical configuration which may make it attractive for mobile applications as in trailer- or ISO container-based counting facilities. Additionally the U-style configuration allows installing the detector in systems where there is no room under the shield to place the Dewar or cooler.

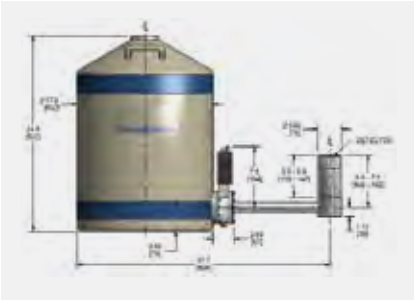
The standard length of the horizontal arm is 12 in. (305 mm) measured from the flange of the preamplifier service body to the detector center line. This length makes the U-style cryostat compatible with both 4 in. (102 mm) and 6 in. (152 mm) thick Mirion lead shields.

The standard configuration comes with a radial O-ring seal. A metal face seal is available as an option on detectors with a 3.0 in. (76 mm) diameter endcaps only. Metal seals are more rugged and, in general, provide a longer life time of the detector vacuum.

Endcap dimensions depend on detector size. The chart below shows the typical efficiency range vs. end-cap diameter. Endcap lengths are also greater for larger detectors. Consult the factory if endcap size is critical in your application.

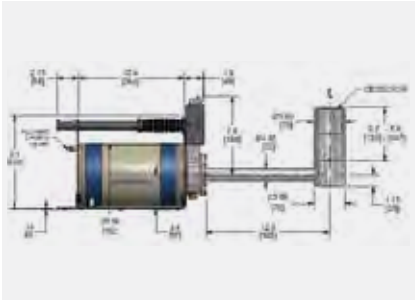
Rel. Efficiency (%)	Diameter in. (mm)
≤40	3.0 (76)
40-50	3.25 (83)
50-70	3.50 (89)
70-100	3.75 (95)
≥100	4.0 (102)

7905-30U Horizontal Integral Cryostat



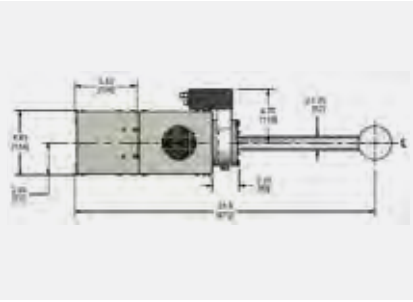
(also available in 7.5 and 15 liter version)

7935-2U Portable Multi-Attitude Cryostat



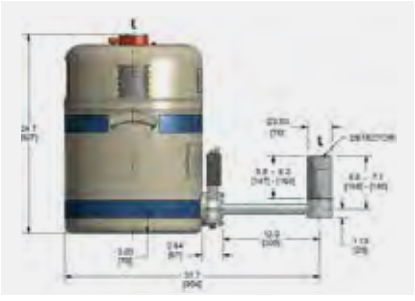
(2 liter MAC)

CP5-PLUS-U Electrically-Cooled Cryostat



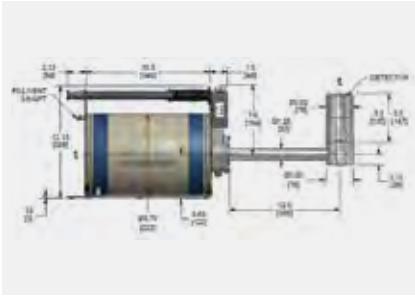
(top view – preamplifier can be oriented in other directions upon request)

CCII-HI-U Horizontal Integral Hybrid Cryostat



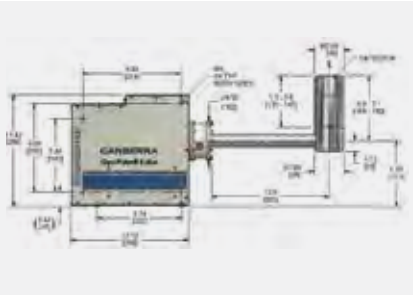
(also available in 7.5 and 15 liter version)

7935-7U Portable Multi-Attitude Cryostat



(7 liter Big MAC)

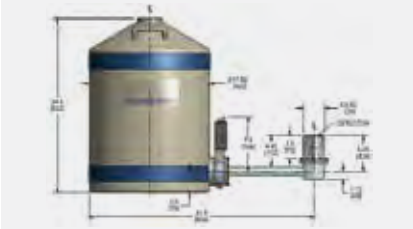
CP5-PLUS-U Electrically-Cooled Cryostat



(side view)

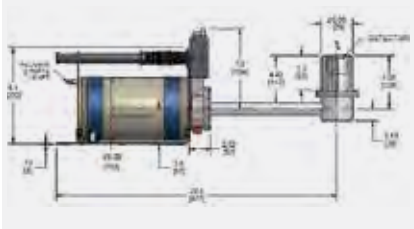
U-type with metal seal (3 inch (76 mm) diameter endcap only)

7905-30UM Horizontal Integral Cryostat



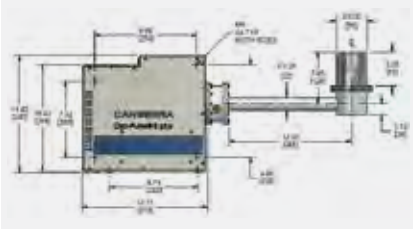
(also available in 7.5 and 15 liter version)

7935-2UM Portable Multi-Attitude Cryostat



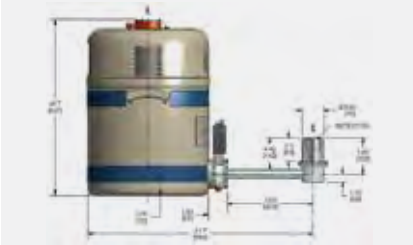
(2 liter MAC)

CP5-PLUS-UM Electrically-Cooled Cryostat

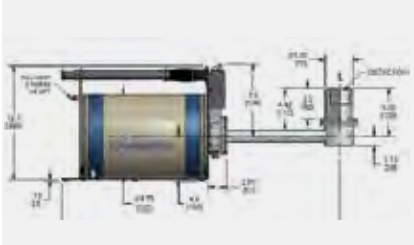


(side view)

CCII-HI-UM Horizontal Integral Hybrid Cryostat



7935-7UM Portable Multi-Attitude Cryostat



(7 liter Big MAC)

Ge semiconductor detector/liquid nitrogen accessory

Model 7170 LN_2 Level Gauge/Controller

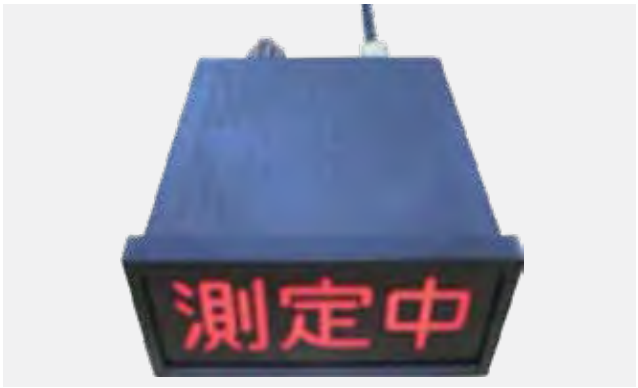
Features are:

- Color touch display
- RJ-45 and RS-232 outputs
- Level based valve control
- Configurable alarm setpoints
- Remote operation via Ethernet

Load cell weigh scale

Features are:

- The amount of liquid nitrogen in the semiconductor detector can be determined
- Load cell type weighing scale
- Only ultra-thin bases



Indicator during measurement

Features are:

- While the spectrum is being collected by the MCA, the “Measuring” text lights up in red
- Inform others that the device is in operation
- Reduces carelessness of accidentally opening the shield during measurement
- Can be installed in various boxes. Complies with IM standards
- Power cable and BNC cable included

Gamma Spectroscopy
continued

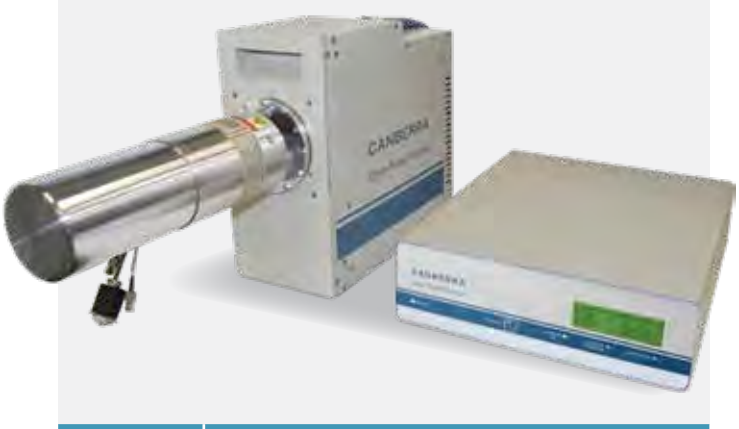
Electrically-Cooled Cryostats

High Purity Germanium Detectors must be maintained at cryogenic temperatures. Traditionally, this has been done by placing the detector assembly in a Dewar filled with liquid nitrogen (LN_2). The LN_2 must be replaced due to boil-off every week to two weeks which costs money and wastes valuable counting time. The *Cryo-Pulse* 5 Plus (CP5-Plus) and Cryo-Cycle II Cryostats described below eliminate the requirement to continually refill the Dewar but still keep the detector at LN_2 temperatures.

Cryo-Pulse® 5 Plus Compact Electric Cryostat

Features are:

- Electrically refrigerated cryostat with no LN_2 requirement
- Sealed system using non-CF4 non-flammable refrigerant
- Low power consumption
- Compact and lightweight – excellent for space-constrained areas
- Long-life cooler with 5 year warranty
- Low maintenance
- No compromise on performance specifications



型番	製品名
CP5-PLUS-SL	Slimline Cryo-Pulse 5 Plus Cryostat
CP5-PLUS-F	Flange Cryo-Pulse 5 Plus Cryostat

Cryo-Cycle™ II Hybrid Cryostat

Features are:

- Redundant electric/LN_2 cooling — recycles LN_2 gas boil-off into a 25-liter Dewar
- Built-in LN_2 supply provides immunity from power failure
- Low power consumption
- Convenient configuration – same space requirement as a standard 30-liter Dewar
- Long-life cooler with 5 year pro-rated warranty
- Low maintenance
- No compromise on performance specifications

型番	製品名
CCII-VD	Cryo-Cycle II 7500SL or 7500 compatible
CCII-HD	Cryo-Cycle II 7600SL or 7600 compatible
CCII-VI-SL	Cryo-Cycle II Vertical Integral Slimline Type
CCII-VI-F	Cryo-Cycle II Vertical Integral Flange Type
CCII-HI-SL	Cryo-Cycle II Horizontal Integral Slimline Type
CCII-HI-F	Cryo-Cycle II Horizontal Integral Flange Type
CCII-HI-U	Cryo-Cycle II Horizontal U-type Integral

Lead Shield

747 Top Opening Lead Shield

Features are:

- Four inch thick low-background lead shield
- Graded tin and copper liner
- Easy to use lever-actuated door
- Compact – 60 x 60 cm (2 x 2 ft) floor space
- Supports conventional 30-liter Dewar or Cryo-Cycle II Cryostat
- Cryo-Pulse 5 Plus Cryostat also supported with stand

767 Top and Front Opening Lead Shield

Features are:

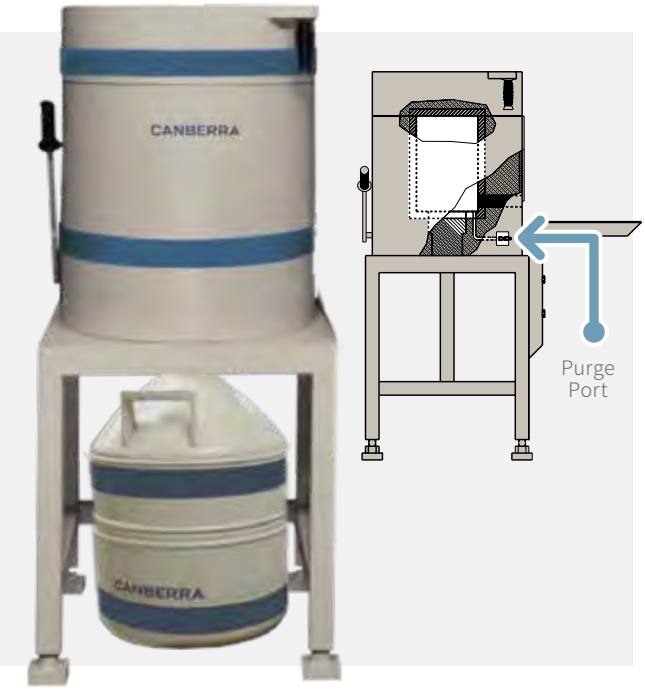
- Four inch thick low-background lead shield
- Graded tin and copper liner
- Full area front door and synchronized split top door
- Compact – 60 x 60 cm (2 x 2 ft) floor space
- Supports conventional 30-liter Dewar or Cryo-Cycle II Cryostat
- Cryo-Pulse 5 Plus Cryostat also supported with stand

Cryo-Cycle II Cryostat and Model 747 Lead Shield

Cryo-Pulse 5 Plus Cryostat and Model 747 Lead Shield

1 Radiological Counting Labs

Gamma Spectroscopy
continued



777 Ultra Low-Background Shield

Features are:

- 15 cm (6 in.) lead thickness
- Ultra low-background materials
- Versions for vertical or U-style cryostats
- Purge port for radon expulsion
- Supports conventional 30-liter Dewar or Cryo-Cycle II Cryostat
- Cryo-Pulse 5 Plus Cryostat also supported vertically with stand

737 U-Style Lead Shield

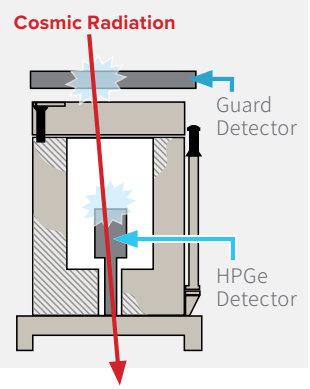
Features are:

- "No stream" design for U-style™ cryostat
- Low center of gravity
- Four-inch low background lead
- Graded tin and copper liner
- Easy detector installation
- Supports conventional 30-liter Dewar, Cryo-Cycle II or Cryo-Pulse 5 Plus Cryostat

CosmicGuard™ Cosmic Veto Background Reduction System

Features are:

- Performs Cosmic background reduction that can't be done with lead shielding alone
- Typical background reduction by 10 – 35% resulting in lower MDA's and count times
- Turnkey solution that can be added to new or existing HPGe detector/shield configurations
- Compatible with most standard HPGe Lead Shields – split or solid top
- Electronics for Veto Guard Detector built into detector module – no other signal processing electronics required
- Single cable connection to the acquisition PC or network hub
- Requires Lynx® Digital Signal Analyzer and Genie™ 2000 or Apex-Gamma™ software of current firmware/ software versions



Front open type lead shield

Features are:

- Can be transported in pieces (about several hundred kg each)

Specifications

- Inner volume: 250 x 350 mm (W x H) (shield part)
- Shielding configuration: SS400 = 10 mm Lead = 5 mm
  OFCU (Oxygen-free copper) = 5 mm
  Acrylic = 5 mm (Total shielding body = 120 mm)
- Shielding weight ~1,580 kg

The photo is for a vertical cryostat. Various specifications are available upon request. Please contact us for details.

Lead shield with sample changer

Features are:

- Because it is equipped with a sample changer, a large number of samples can be measured by PC control
- Can be transported in pieces (about several hundred kg each)

Specifications

- Lead thickness: 10 cm or more
- Lining: Oxygen-free copper, acrylic weight meter (including indicator) included
- Number of specimens: Please consult us
- Sample holder holding method: Fork type, chuck type (photo shows fork type)
- Sample feeding method: Turntable type, chain type (photo shows chain type)

The photo is for the U-type cryostat. Various specifications are available upon request, such as overall dimensions, sample size, and number of samples loaded. Please contact us for details.

Gamma Spectroscopy
continued

DSA-LX® Digital Signal Analyzer

The *DSA-LX* analyzer is a full featured 16K channel integrated Multichannel Analyzer based on advanced digital signal processing techniques (DSP). When paired with a computer running Genie 2000 software the *DSA-LX* unit becomes a complete spectroscopy workstation, capable of the highest quality acquisition and analysis. The instrument interfaces to existing detector technologies such as HPGe, NaI, Si(Li), CdTe or Cd(Zn)Te.

Features are:

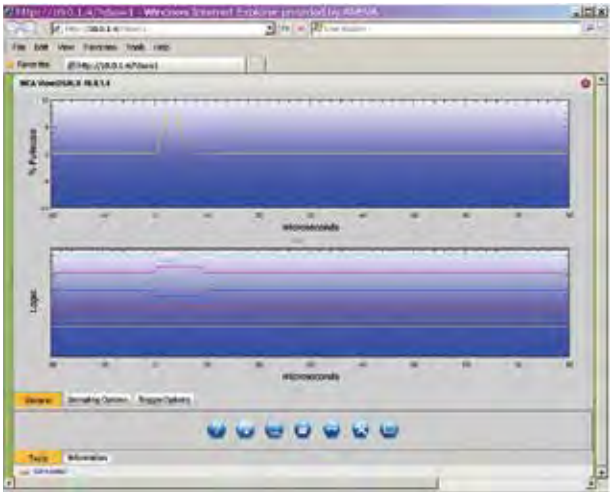
- Integrated desktop MCA based on Digital Signal Processing (DSP)
- Performs pulse height analysis (PHA) and/or multi-channel scaling (MCS)
- USB 2.0 interface allows simple connection to computer
- Web-based digital oscilloscope spectrum viewer and maintenance utility
- Advanced patented auto pole/zero, baseline restoration and digital stabilization capability
- Excellent count rate and temperature stability
- 16K channel memory, high voltage power supply, digital stabilizer, USB 2.0 interface
- Compact design (5.58 x 16.51 x 20.95 cm) (H x W x D)
- Digital oscilloscope
- Compatible with Genie 2000 Spectroscopy Software

Specifications:

- Data memory: 1-16K (PHA) ch, 2-16K (PHA) ch, 32-bit/ch
- Measurement mode: PHA, MCS
- Signal processing section DSP (digital signal processing) system integral nonlinearity: ± 0.025% or less
  - Differential nonlinearity: ± 1% or less
  - Gain drift: 35 ppm/°C or less Zero drift: 3 ppm/°C or less
  - Gain setting: Coarse adjustment x 2.0 to x 430.5 (adjustable in increments of 19%) Fine adjustment x 0.8 to x 1.2 (adjustable in increments of 0.004%)
  - Filter setting: Rise/fall time 0.2 µs to 38 µs Flat top 0 to 3 µs
- High-voltage power supply
  - RANGE 1: ± 200 to ± 1500 V (max. 1 mA) Ripple and Noise 5 mV or less (Peak to Peak)
  - RANGE 1: ± 1500 to 5000 V (maximum 1 µA) Ripple and Noise 10 mV or less (Peak to Peak)
- Data transfer control: USB method
- Other features
  - Power management setting: ON / OFF (switch on rear panel) Digital oscilloscope function
  - Pile-up rejection function Live time correction function Pole zero function shape
  - Dimensions: 5.58 x 16.51 x 20.95 cm (H x W x D)
  - Weight: 1451 g
- Usage environment
  - Temperature: -20 to 50 °C
  - Humidity: Up to 85% (no condensation)

Rear panel

Unit vertically mounted (stand included)



Digital Oscilloscope

Lynx® Advanced Digital Signal Analyzer

The *Lynx* DSA is the most advanced, full-featured Multichannel Analyzer ever offered. It is a 32k channel integrated signal analyzer based on advanced digital signal processing (DSP) techniques. When paired with the computer of choice, the *Lynx* unit becomes a complete spectroscopy workstation capable of the highest quality acquisition and analysis. The instrument supports a wide range of spectroscopy detector technologies such as HPGe, Si(Li), *PIPS*®, X-PIPS™, CdTe, Cd(Zn)Te and virtually all scintillation detectors used for gamma spectroscopy. It also supports the unique energy ranges of all these detectors from 1 keV on up.

Apex® Lab Productivity Suite shown with the *Lynx* Digital Signal Analyzer

Features are:

- Fully Integrated Multichannel Analyzer with 32k channel spectral memory, advanced signal processing filters, digital stabilizer, multi-trace oscilloscope and triple-range HVPS for all spectroscopy detector types
- Multiple counting modes: PHA, MCS, PHA & MCS simultaneous, Time-stamped List and Multispectral scaling
- Communication via Ethernet
- Web enabled set-up/ operation and compatible with Genie 2000 software
- Flexible hardware/ software controls for sample changers, external acquisition and MCS start/ stop, coincidence gating and auto pole/zero
- Software development kit (SDK) available for custom programming

Specifications:

- Signal processing
  - Integral nonlinearity: ± 0.025% or less
  - Differential nonlinearity: ± 1% or less
  - Gain drift: 35 ppm/°C or less (15 minutes after the start of operation)
  - Zero drift: 3 ppm/°C or less (15 minutes after the start of operation) 1 channel or less over temperature range (8k spectrum)
  - Overload recovery: within 1%
  - Pulse-to-resolution: 500 ns or more
  - Pile-up rejection
  - Live time correction
- Measurement mode
  - Even if the power is turned off, all device settings are maintained until the power is restored.
- PHA mode
  - Channel: 256, 512, 1024, 2048, 4096, 8192, Selectable from 16384 or 32768 channels
  - Preset: real time or live time
- MCS mode

The following measurement modes require SDK software separately. DUAL LOSS FREE COUNTING (Dual LFC) mode TIME STAMPED LIST mode

- MULTISPECTRUM SCALING (MSS) mode
- High voltage power supply
  - HVPS range 1: ± 200 to 1500 V @ 1 mA maximum
  - Ripple less than 5 mVp-p
  - Temperature fluctuation ± 50 ppm/°C or less
  - HVPS range 2: ± 1500 to 5000 V @ 1 µA maximum
  - Ripple 10 mVp-p or less Temperature fluctuation ± 50 ppm/°C or less
  - HVPS range 3: ± 200 V @ 100 nA maximum
  - Ripple 10 mVp-p or less temperature fluctuation ± 50 ppm/°C or less
- Dimensions/weight
  - Size: 8.9 x 21.3 x 27.4 cm (H x W x D)
  - Weight: 2.6 kg
- Operating environment
  - Operating temperature: 0 to 50 °C
  - Humidity: Up to 80% (no condensation)

Gamma Spectroscopy
continued

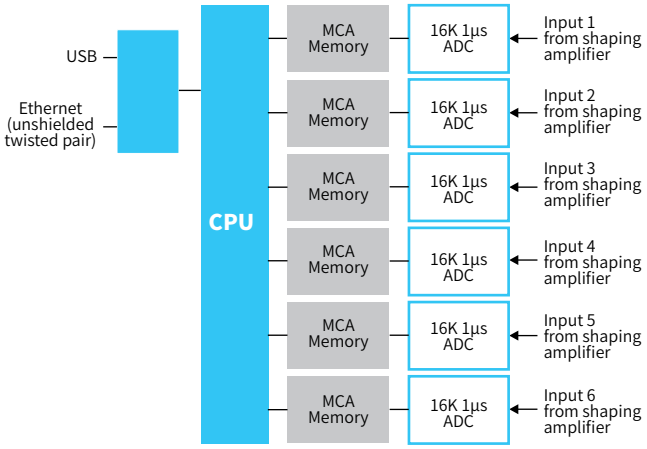
Multiport II™ Multichannel Analyzer

The Multiport II module is a double width NIM intended for use where existing amplifier and HVPS modules are to be combined with a high analog performance, low-cost ADC/MCA.

The Multiport II MCAs are suitable for use with a wide range of radiation detectors. Selecting a proper preamplifier, amplifier and high voltage power supply, makes the unit compatible with NaI(Tl), HPGe, SiLi, CdTe, ion implanted, plastic scintillation, BGO and other detector technologies. Modular NIM packaging makes it easy to reconfigure systems as needs change or as new technologies become available.

Features are:

- Up to six independent Multichannel Analyzers (in-the-field customer upgradable)
- Each MCA fully computer controlled
- 16K ADC, 1 µs fast fixed conversion time with linearization enhancement circuit for excellent non-linearity
- Fully buffered memory allowing simultaneous ADC memory write and spectrum transfer to host computer
- PHA and MCS acquisition modes
- Full I/O control (including sample changer)
- On-board data backup
- Suitable for HPGe, NaI(Tl), CdTe, *PIPS*, X-PIPS and other detector technologies
- Communications interface: Ethernet/USB
- Fully supported by Genie 2000 software



Specifications:

- ADC input: Unipolar or bipolar, 0 to + 10 V or 0 to + 5 V
- Logic input: mini-D I/O connector
  - XINPUT: External start/stop, sample changer input
  - XSUSPEND: Stop pulse processing, preset counter XDT: PUR dead time input
  - XMCSRESTART: MCS sweep advance input
  - XMCSADVANCE: External channel advance input
  - XMCSPULSE: MCS input
  - XCOINC: Coincidence, anti-coincidence input XREJ: Pile-up reject input
- Logic output: mini-D I/O connector
  - XOUTPUT: Sample changer advance output XSCA: SCA output
  - XLG: PUR linear gate output
  - XCOLLECTSTATUS: External collection status
  - 5 V: Output to external circuit; Max. 100 mA (per 7-pin I/O connector)
- Software control
  - ADC LLD: 0 to 100% full scale (4096 steps)
  - ADC ULD: 0 to 10% full scale (4096 steps)
  - ADC zero: ± 2.5% full scale (4096 steps)
  - ADC conversion gain: 256, 512, 1024, 2048, 4096, 8192, 16384
  - Communication: USB or USB/Ethernet
- Performance
  - Integral nonlinearity: ± 0.025% or less
  - Differential nonlinearity: ± 0.9% or less
  - Gain fluctuation: ± 0.005%/°C or less Zero drift: ± 0.005%/°C or less
  - Long-term stability: ± 0.005% or less Peak shift: ± 0.025%/°C or less
- Data memory
  - Memory size: 1-16K
  - ADC: 1 µs successive approximation ADC
- Dimensions
  - 2NIM width 6.86 x 22.12 cm
  - Weight: 1.36 kg

2100 Bin/Power Supply

Features are:

- NIM standard, IEC 801 compliant
- 150 W capability (96 W for Model 2000)
- 90-130 V or 193-260 V operation
- ±12 V at 3 A, ±24 V at 1.5 A, ±6 V at 10 A*
- With overload protection function
- With thermal protection circuit

* ±6 V supply provided only on the Model 2100

3102D™ 0-2 kV H.V. Power Supply

Features are:

- Output: ± 15 to ± 2000 V dc, 1 mA ± 1.5 to ± 200 V dc
- Ripple & Noise: 3 mVp-p or less
- Output stability: 0.01% or less/hr, 0.02% or less/8 hr
- Temperature coefficient: ± 50 ppm/°C (after 30 minutes warm-up)
- With overload and short-circuit protection
- Overload, inhibit and polarity are displayed with indicators
- Digital front panel meter with high voltage cutoff input

2026 Spectroscopy Amplifier

Features are:

- Gain: x 2.5 to x 1500
- Integral nonlinearity: 0.04%/°C or less
- Noise: 4.5 µV or less
- Gaussian and Triangular shaping
- Fine adjustment function
- Differential input possible
- Pile-up rejector function
- Live Time Corrector function
- Automatic baseline recovery and threshold functions

3106D™ 0-6 kV H.V. Power Supply

Features are:

- Output: ± 30 to ± 6000 V dc, 300 µA ± 3 to ± 600 V dc
- Ripple & Noise: 3 mVp-p or less (at 300 µA)
- Output stability: 0.01% or less/hr, 0.02% or less/8hr
- Temperature coefficient: ± 50 ppm/°C (after 30 minutes warm-up)
- With overload and short-circuit protection
- Overload, inhibit and polarity are displayed with indicators
- Digital front panel meter with high voltage cutoff input

Gamma Spectroscopy
continued

2018EB™ Silicon Detector Preamplifier

Features are:

- Low noise design: <3.0 keV (Si) at 0 pF
- High energy rate capability: up to 2 x 10^6 MeV per second
- FET input, diode protected
- Small size
- Capable of operating in a vacuum chamber

2004 Semiconductor Detector Preamplifier

Features are:

- Low noise design: 2.8 keV (C^s: 0 pF)
- High charge rate: Up to 4.5 x 10^6 MeV per second
- Integral nonlinearity: 0.02% or less (± 10 V output)
- Gain fluctuation: 0.01%/°C
- Charge sensitivity: 0.2 V/p^C or 1.0 V/p^C
- Internal selection
- Bias voltage: up to ± 2000 V dc
- Energy sensitivity: 9 mV/MeV (Si) or Internal selection at 45 mV/MeV
- FET input with diode protection

2005 Scintillation Preamplifier

Features are:

- Low noise design: 10^{-15} C rms or less
- High charge rate capacity: up to 9 µC/s (high count for rate applications)
- Integral nonlinearity: 0.02% or less (± 10V output)
- Gain fluctuation: 0.01%/°C
- Charge sensitivity: 4.5 V/pC or 22.7 mV/pC
- Internal selection
- Energy sensitivity: 9 mV/MeV (Si) or
- Selectable at 45 mV/MeV
- FET input with diode protection
- Rise time: 15 ns or less

2006 Proportional Counter Preamplifier

Features are:

- Low noise design: 350 ion pairs or less (C^s: 0 pF)
- High count rate design: 2 x 10^{-7} C/sec
- Integral nonlinearity: 0.02% or less (up to ± 10V output)
- Gain fluctuation: 0.01%/°C
- Charge sensitivity: 47 mV/M ion pair or 235 mV/M Internal selection with ion pair
- Bias voltage: up to ± 2000 V dc
- FET input with diode protection
- Rise time: 20 ns or less (C^s: 0 pF)

2007B™ Scintillation Preamplifier

Features are:

- Low power type: ± 12 V (15 mA)
- With high-pressure transient protection
- Integral nonlinearity: 0.04% or less (up to ± 10 V output)
- Gain fluctuation: 0.01%/°C
- Noise: 1.2 x 10^{-15} C rms
- Charge sensitivity: 4.5 mV/p^C
- Rise time: 20 ns or less

2007-2007P Photomultiplier Tube Base/Preamplifier

Features are:

- Connected to 14-pin photomultiplier tube (PMT)
- PMT bias voltage: up to 2k V dc
- Focus and gain control are independent
- Model 2007 has separate anode and dynode outputs
- Model 2007P combines tube base with low noise, charge sensitive preamplifier with HV transient protection

Osprey® Digital MCA Tube Base for Scintillation Spectrometry

Features are:

- All-in-one HVPS, preamplifier, and digital MCA
- Compatible with all standard 14-pin scintillation detectors, including NaI(Tl), $CeBr_3$ and $LaBr_3$(Ce)
- Optional temperature-stabilized* detectors
- USB 2.0 connection and Ethernet 10/100T (PoE) connection
- Three programmable general purpose I/O connectors
- PHA, MCS, SCA, MSS, List, and Time-stamped List modes
- Supported by Genie 2000 software and a software development kit (SDK) with examples
- Diagnostic web GUI
- Compatible with Model 727, 7F7 and TRACS™ shields

*US Patents 7,005,646 B1 and 7,049,508 B1

Osprey-Compatible Scintillation Detectors

Including:

- **802 Detector Family:** NaI(Tl) Scintillation Detectors
- **NAIS-2x2 Detector:** NaI(Tl) LED Temperature-Stabilized Scintillation Detector
- **NAIS-3x3 Detector:** NaI(Tl) LED Temperature-Stabilized Scintillation Detector
- **NAIS-3x5x16 Detector:** NaI(Tl) LED Temperature-Stabilized Scintillation Detector
- **LABR-1.5x1.5 Detector:** $LaBr_3$(Ce) Scintillation Detector
- **CEBRS-1.5x1.5 Detector:** $CeBr_3$ LED Temperature-Stabilized Scintillation Detector
- **CEBRS-2x2 Detector:** $CeBr_3$ LED Temperature-Stabilized Scintillation Detector

Features are:

- Standard NaI(Tl) Scintillation Detectors of various sizes with and without a well
- Temperature-Stabilized* NaI(Tl) Scintillation Detectors of various sizes including model compatible with the FASTSCAN™ Whole Body Counter
- $LaBr_3$(Ce) Scintillation Detector
- $CeBr_3$ Temperature-Stabilized* Scintillation Detectors
- Temperature-stabilized detectors only compatible with the Osprey Digital MCA Tube Base (3x5x16 also with Lynx DSA)
- ISOCS Characterization available or included with most detector models
- Choose the detector with the resolution, efficiency and background performance that best suits your application and budget

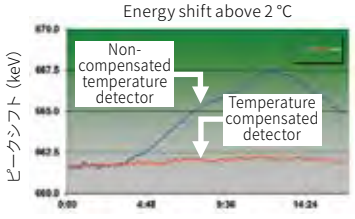
*US Patents 7,005,646 B1 and 7,049,508 B1

Comparison of Scintillation Detector Types

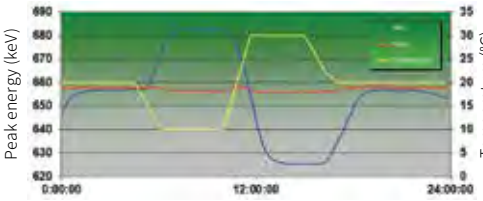
Property	NaI	$LaBr_3$	$CeBr_3$
Resolution at 662 keV (%)	7%	3 - 3.5%	4.3%
Efficiency	Standard	Above Standard *	Above Standard *
Internal Background	None	Low (La-138, Ac-227)	Very Low** (Ac-227)
Decay time (ns)	250	30	17
Temp. Stabilization Available	Yes	No	Yes
Cost	$ - $$	$$$	$$$ - $$$$

* Energy dependent - greatest difference from NaI at higher energies.

** Mirion offers only detectors meeting a premium low background specification.



Time: (hr: mm) Peak Shift Variation



Time: Figure 2: At 10 – 30 ° C Peak Shift Variation

Gamma Spectroscopy
continued

CZT In-Situ Super Compact Gamma Spectrometer

Features are:

- All-in-one detector, electronics and MCA
- Pre-set Gain, 1 cm^3 CZT solid state detector
- Miniaturized package: 25 x 25 x 63 mm, 60 g
- USB connection to PC for control and power
- Optional I/O ports for energy and timing outputs and gate inputs
- Interface to Genie 2000 software spectral analysis
- Optional Generic ISOCS characterization available
- Two cm thick tungsten shield with handle for any GR1 CZT Spectrometer
- Includes collimators (2 mm, 8 mm and 35 mm) and collimator lock tool
- ISXCZT-GR1 Generic ISOCS Characterization allows the GR1 unit to provide nuclide activities for in situ measurements
- Optional GR1-ACC Carrying Case with Tripod
- Case holds laptop PC, shield, collimators and tripod

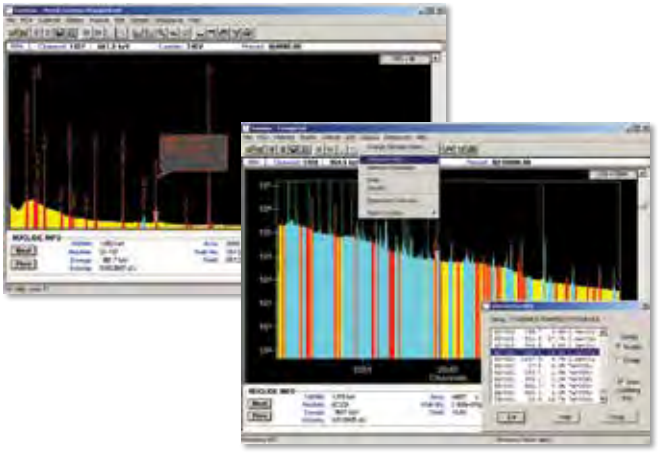
GR1 Family Variants	Resolution at 662 keV	USB	Gate Input	Timing Output	Energy Output
GR1	<2.5%	✓	–	–	–
GR1+	<2.0%	✓	–	–	–
GR1-A	<2.5%	✓	✓	✓	✓
GR1-A+	<2.0%	✓	✓	✓	✓

Software

S50XC Genie™ 2000 Spectroscopy Software Family

Genie 2000 software can easily build a network system at a low price with a personal computer and Ethernet. Genie 2000 software is fully multitasking. It is possible to count data from several detectors independently and simultaneously. The operation is completely independent. By using a network system, it is possible to manage several detectors away from the MCA main unit.

Genie 2000 basic software includes single-user single-input software and multi-user multi-input software. Select MCA from the "MCA Lineup" table on the right.



Features are:

- Integrated data acquisition and analysis software platform
- Independent support for over 250 detector inputs
- Networking for distributed MCA operation and centralized data management
- Comprehensive and flexible user programming capability
- Compatibility with our full MCA line
- Wide variety of layered software options available for specialized spectroscopy applications
- Interactive Spectral Analysis
- Nuclide identification and quantification
- Library Correlation NID peak locate with background compensation
- Interference correction and weighted mean activity calculations
- Patented* true coincidence (Cascade) summing correction

*US Patent 6,225,634 B1

S502C Genie 2000 Software

- Single-input spectroscopy software
- Low-priced software dedicated to single input

S500C Genie 2000 Software

- Multi-input spectroscopy software
- Measurement software that supports multiple inputs
- Multiple on the network
- Operator control of the MCA

Genie 2000 Analysis Software Option

- S501C Genie 2000 Gamma Ray Analysis Software
- S503C Genie 2000 Pro Count Software
- S505C Genie 2000 Quality Control (QA) Software
- S506C Genie 2000 Interactive Peak Fit Software
- S507C Genie 2000 MGA-U Software
- S508C Genie 2000 MGA software
- S509C Genie 2000 Alpha Analysis Software
- S560C Genie 2000 C Programming Library
- S561C Genie 2000 Batch Programming Support
- γ Explorer Environmental Radioactivity Analysis Program (Ministry of Education, Culture, Sports, Science and Technology 1992 version manual compliant)

MCA lineup

型番	製品名
DSA-LX	Digital signal analyzer (USB interface)
Lynx	Advanced Digital signal analyzer (Ethernet interface)
InSpector 2000	Portable multichannel analyzer
Multiport II	Multiport II multichannel analyzer (NIM type)
Osprey	Osprey Universal Digital MCA Tube Base (For scintillation detector)

Gamma Spectroscopy
continued

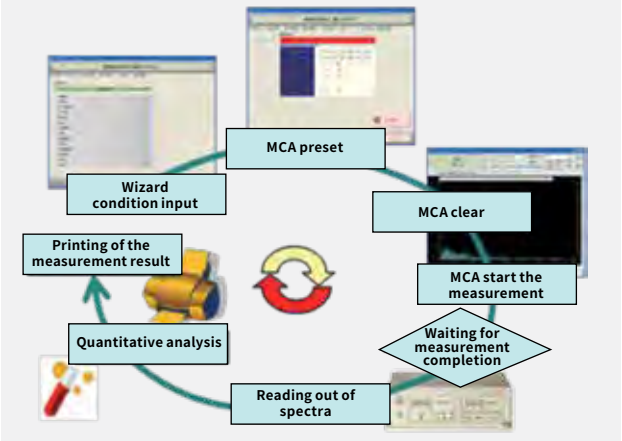
γ Explorer Software

γ Explorer software can perform analysis in compliance with the Ministry of Education, Culture, Sports, Science and Technology "Gamma-ray Spectrometry with Germanium Semiconductor Detector" (FY1992 version), including self-absorption correction and thumb effect correction.

It is designed not only to analyze γ-ray spectra but also to support customers' daily work (automated routine work and data aggregation).

This program can be used to operate all data from measured spectra on MCA, spectra recorded in files and databases, and calibration data to the nuclear data library.

Equipped with an "environmental gamma-ray analysis wizard" function that automatically assists from measurement to analysis and report output. Here, preset settings can be made based on detection limits that could only be determined after analysis. This more specific measurement such as "Measurement until Cs-137 reaches the detection limit of 0.1 Bq/L" is now possible.



* 1) Some MCA may not support 64-bit. Please contact us with questions.
* 2) The spectrum explorer with the γ-ray analysis option added is called γ explorer software.

Features are:

- High stability and high accuracy γ-ray spectrum analysis system in combination with digital MCA (Lynx/DSA-LX) units.
- The analysis method of the spectrum analysis software (γ Explorer) conforms to the "Gamma-ray Spectrometry with Germanium Semiconductor Detector" (FY1992 version, MEXT).
- The spectrum being measured by MCA or the spectrum recorded in a file or database can be analyzed simultaneously and in the same operation.

System configuration:

- Detection unit: Mirion germanium semiconductor detector
- MCA
  - Lynx/DSA-LX/Osprey instruments
  - InSpector™ series
  - Other Mirion MCA
- CPU
  - Japanese OS more than Windows 10 (64-bit)
  - Windows PC (Core-i3 2GHz equivalent or higher recommended)
  - 8 GB or more main memory
  - 500 GB or more HDD, or 256 GB or more SDD
  - Laser printer
- 19 inch or larger color display
- Software
  - Spectrum Explorer
  - γ-ray analysis program (optional)*2 γ-ray explorer
  - ISOCS calibration software (optional)
  - LabSOCS calibration software (optional)
  - Radioactivity level survey report program
  - In-situ analysis program
  - G(E) function method air dose analysis program (option)
  - Peel-off method air dose analysis program (optional)
- Response matrix method air dose analysis program (optional)
- Web-compatible environmental γ-ray nuclide analysis system
- Shielding calculation program by QAD
- Genie 2000 series software γ Explorer Software

γ Explorer Plus web-compatible environmental γ-ray nuclide analysis system

This is a γ explorer option for performing γ-ray nuclide analysis of environmental samples more efficiently with simpler operations. It can be operated from any computer on the network using web technology. The homepage input screen is designed to perform measurement analysis with simple and minimal input, and supports daily routine work. In addition, the input screen can be customized according to the customer's operation.

Features are:

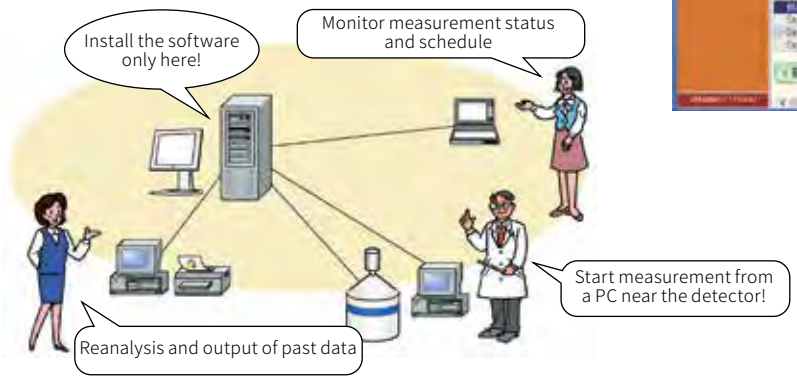
- Operation from any PC on the network is possible. Data can be confirmed and measurement status can be monitored even from a remote location.
- Easy operation from the homepage input screen.
- User-friendly program for those who are not familiar with γ-ray analysis or a PC.
- All data is managed in a database, which is very useful for searching and organizing data.
- Equipped for multiple time-repeated measurements, with a schedule measurement function for specified times. Sample changer is also available.
- Analysis result forms can be saved as electronic files, such as PDF.
- The analysis program and data handling identical to Gamma Explorer. In combination with γ Explorer, more detailed verification and adjustments are possible.
- The input screen and forms can be customized according to the customer's operational status. Custom software modifications are also available.
- Presets can be set based on detection limits that could only be determined after analysis. This makes it possible to perform more specific measurements such as "Measure until Cs-137 reaches the detection limit of 0.1 Bq / L."

System configuration:

- The following specifications are required for the web server PC

CPU

- Japanese OS more than Windows 10 (64-bit)
- Windows PC (Core-i3 2 GHz or equivalent recommended)
- 8 GB or more main memory

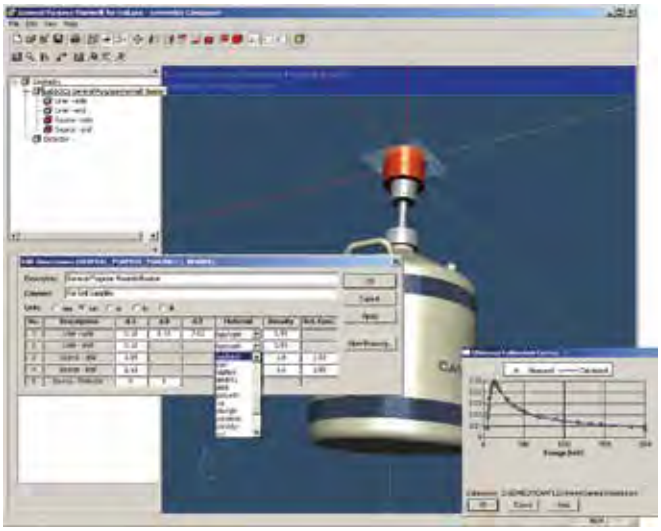


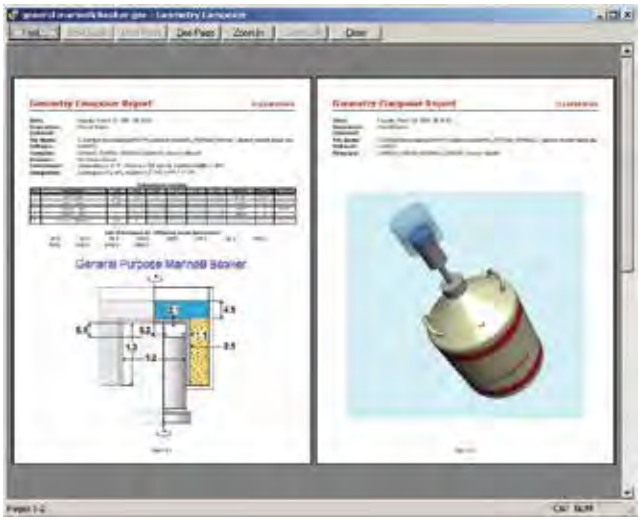
Gamma Spectroscopy
continued

Software
continued

S574C LabSOCS™ Calibration Software

The S574 LabSOCS (Laboratory Sourceless Calibration Software) mathematical efficiency calibration software brings a new level of capabilities to gamma sample assay in the laboratory by eliminating the need for radioactive sources for efficiency calibration. By combining the detector characterization produced with the MCNP modeling code, mathematical geometry templates, and a few physical sample parameters, the LabSOCS Calibration Software gives you the ability to produce accurate quantitative gamma assays of most any sample type and size.





Features are:

- Eliminates requirement for expensive radioactive efficiency source standards and their disposal
- Calibrations valid from zero distance to 500 meters (1640 ft) – more than would ever be needed in the count room
- Calibrations valid from 10 keV to 7000 keV and accurate to within a few percent
- Operates with any size or type of germanium detector which has been characterized
- Optimized for laboratory applications where complex shaped containers are used repetitively
- Includes model library of commonly available sample containers and tools to easily create custom models for other containers
- Compliant with 2009 U.S. NRC Regulatory Guide 1.21

System configuration:

DETECTOR

- Any Germanium, 2x2 NaI, 3x3 NaI, 1.5x1.5 $LaBr_3$ detector, characterized by Mirion. For each detector, order one of the following:
  - ISOXCAL – Characterization for a new Mirion HPGe detector.
  - ISOXCAL1 – Characterization of a previously ordered Mirion HPGe detector.
  - ISOXCAL2 – Characterization of a non-Mirion HPGe detector.
  - ISOXCALU – Re-characterization of a previously characterized HPGe detector.
  - ISXCLNA2 – Characterization for 802-2x2 NaI Detectors.
  - ISXCLNA3 – Characterization for 802-3x3 NaI Detectors.
  - ISXCLLA1.5 – Characterization for $LaBr_3$ 1.5x1.5 detector.
- Characterization is included with NAIS Stabilized NaI and CEBRS stabilized $CeBr_3$ detectors.

SPECTROSCOPY SYSTEM

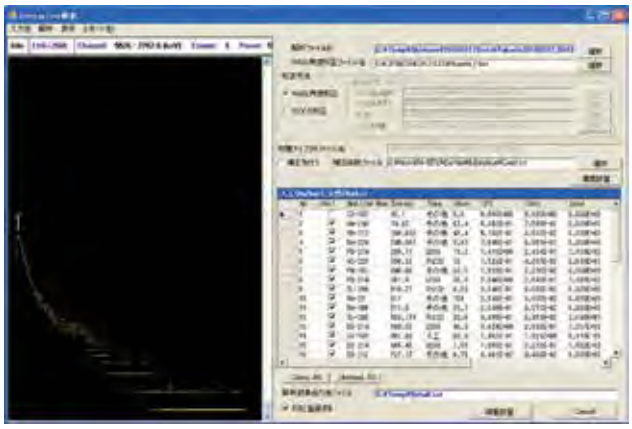
- Any Mirion PC-based MCA system running the following software as a minimum:
  - S500 – Genie 2000 Basic Spectroscopy Software, V3.2.
  - S501 – Genie 2000 Gamma Analysis Software, V3.2.
  - S574 – LabSOCS Calibration Software, V4.2.
- The PC should be a Pentium 2.0 GHz or better. For fast computations of large or highly attenuating geometries, a high-end PC is recommended.

HASL258 compliant in-situ analysis software

The analysis method performed by the in-situ analysis software air is the 2008 edition of “Germani.” In-situ measurement method using μm semiconductor detector. Also, the reference table for concentration and dose rate is the HASL-258, ICRU Rep.53 table. Either can be selected.

By ISOCS characterization, angle dependency, efficiency calibration source, calibration jig is not required. Of course, calibration with conventional radiation sources is also supported. Calculate Relaxation Length from the Sampling sample analysis results for each depth.

By using the ISOCS template, it is distributed exponentially in the depth direction. This makes it possible to evaluate the concentration and dose rate of nuclides more accurately.



A time series plot is standard

- Specify period, specify multiple nuclides
- Upper and lower split display
- Real-time plot function
- E-mail delivery function installed

Various map options are available

- Mesh level display
- Mesh bar graph display
- Contour display

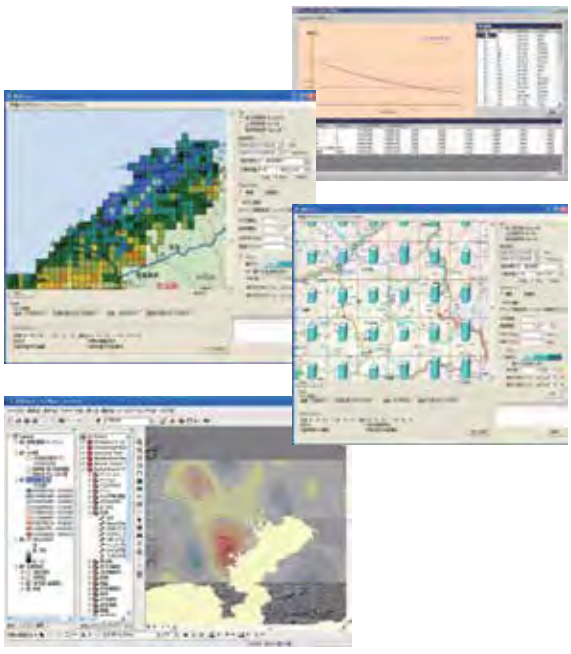
In-situ software for car bones and monitoring posts upon request. Customization is possible.

Aegis™ Transportable HPGe Spectrometer

ISOCS™ (In Situ Object Counting System) Shield Systems

Features are:

- Ministry of Education, Culture, Sports, Science and Technology (FY2008) “Insitu using germanium semiconductor detectors”
- Conforms to "Measurement method"
- HASL table / ICRU Rep.53 table can be selected
- ISOCS characterization enables angle-dependent calibration and efficiency calibration that do not require a radiation source
- Relaxation Length calculation function
- Time series plot function, database standard



System configuration:

Detection unit

- Germanium semiconductor detector manufactured by Mirion

MCA

- Lynx/DSA-LX instruments
- InSpector series

CPU

- Japanese OS more than Windows 10 (64-bit)
- Windows PC (Core-i3 2 GHz or higher recommended)
- 8 GB or more main memory
- 500 GB or more HDD, or 256 GB or more SDD

Laser printer

- 19 inch or larger color display

Software

- Map software (mesh display, contour display) option

Alpha Spectroscopy

Alpha Analyst™ Integrated Alpha Spectrometer

Features are:

- Completely integrated alpha spectroscopy instrument
- 100% computer controlled electronics and vacuum
- Automatic recoil suppression control
- Clean vent port to reduce moisture and contamination buildup in chambers
- Modular for ease of expansion in floor or bench top cabinets
- Connects directly to Ethernet network

PIPS® Passivated Implanted Planar Silicon Detectors

Planar Silicon Detector (PIPS-Passivated Implanted Planer Silicon Detector) is an innovative charged particle born from the latest semiconductor manufacturing technology.

Features are:

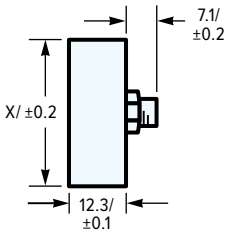
- Contacts are ion-implanted to form precise, thin, abrupt junctions for good alpha resolution
- Entrance window is stable and rugged – it can be cleaned readily and reliably with Propanol-2
- Standard detectors are bakeable to 100 °C – higher for special models (optional up to 200 °C)
- Leakage current is typically 1/8 to 1/100 of that of SSB and DJ detectors
- Low dead layer (window) thickness - less than 50 nm
- All junction edges are buried – no epoxy edge sealant is needed or used
- A450-18AM is, by far, the most popular model for alpha spectroscopy but other sizes are available

Outline of *PIPS* charged particle detector

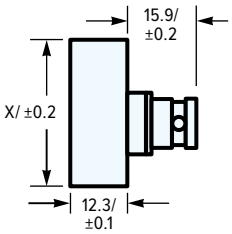
Mount and dimensions:

- The detection surface is located 1.0 mm behind each mount.

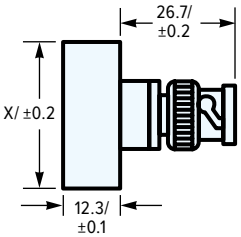
Axial mount
microdot connector
(Suffix – AM)



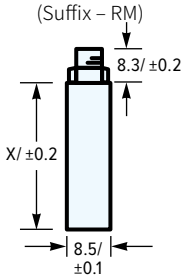
Axial mount
BNC connector (female)
(Suffix – AB)



Axial mount
BNC connector (male)
(Suffix – ABM)



Radial mount
microdot connector
(Suffix – RM)



Options:

- Cryogenic option (Prefix CY): up to -200 °C.
- Timing option (Prefix TM): A 20 nm aluminum layer is added to improve timing performance. See Data Sheet for applicable models.
- Bakeable option (Prefix BK): Baking up to 200 °C is possible (non-operating).

型番	製品名
Partially Depleted – PD series	Annular – ANFD series
Fully Depleted – FD series	Custom Design – CD series
Alpha – A series	X-PIPS – X-PIPS detector
CAM – CAM series	Single and Multi-element— SMEPS series

検出器サイズ (mm²)	有効直径 (mm)	コネクタタイプ	
		AM,AB,ABM,X (mm)	RM,X (mm)
25	5.7	16.7	19.4
50	8.0	16.7	19.4
100	11.3	23.6	26.1
150	13.8	23.6	26.1
200	16.0	28.6	31.6
300	19.5	28.6	31.6
450	23.9	32.0	34.8
490	25.0	33.4	N.A.
600	27.6	36.1	38.4
900	33.9	45.2	50.0
1200	39.1	48.8	53.0
1700	46.5	59.0	N.A.
2000	50.0	65.5	70.0
3000	61.8	76.2	80.0
5000	79.8	94.0	N.A.

Alpha Spectroscopy
continued

PIPS
continued

PD series partially depleted *PIPS* detector

The PD series of PD detectors finds widespread application in charged particle spectroscopy. The detection area can be selected from a range of 25 mm² to 5000 mm², and the depletion layer thickness can be selected from a range of 100 to 1000 µm.

Operating voltage typically is 40V/100 µm thickness detector, 60V/300 µm thickness detector, 100V/500 µm thickness detector, 350V/1000 µm thickness detector, respectively.

The PD detectors are normally supplied with an axial microdot connector, but can be ordered with other connectors (such as BNC). Please contact us if you require a special shaped package.

Specifications

PIPS 検出器:PD シリーズ									
空乏層厚	100 ミクロン厚			300 ミクロン厚			500 ミクロン厚		
有効面積 mm²	分解能 keV (FWHM)		型番	分解能 keV (FWHM)		型番	分解能 keV (FWHM)		型番
	α	β		α	β		α	β	
25	12	6	PD25-12-100AM	11	5	PD25-11-300AM	10	4	PD25-10-500AM
50	12	6	PD50-12-100AM	11	5	PD50-11-300AM †	11	5	PD50-11-500AM †
150	14	9	PD150-14-100AM	13	8	PD150-13-300AM †	12	7	PD150-12-500AM †
300	16	11	PD300-16-100AM	15	10	PD300-15-300AM †	14	9	PD300-14-500AM †
450	17	12	PD450-17-100AM	16	11	PD450-16-300AM †	15	10	PD450-15-500AM †
600	22	17	PD600-22-100AM	20	15	PD600-20-300AM	20	15	PD600-20-500AM
900	27	22	PD900-27-100AM	22	19	PD900-22-300AM	22	17	PD900-22-500AM
1200	35	30	PD1200-35-100AM	25	20	PD1200-25-300AM	26	21	PD1200-26-500AM
2000				40	35	PD2000-40-300AM	35	30	PD2000-35-500AM
3000				55	50	PD3000-55-300AM	50	45	PD3000-50-500AM
5000				80	75	PD5000-80-300AM	75	70	PD5000-75-500AM

PIPS 検出器：PD シリーズ				
有効面積 mm²	分解能 keV (FWHM)		空乏層厚 (µm)	型番
	α	β		
150	14	9	1000	PD150-14-1000AM
300	16	11	1000	PD300-16-1000AM

FD series fully depleted *PIPS* detector

The FD series of PIPS detectors are used in particle identification, detector telescopes and in other dE/dx measurements. Excellent thickness uniformity.

They are particularly good in thickness uniformity, 1 to 2 µm for small active areas and 2 to 4 µm for areas up to 900 mm².

The resolution is measured by injecting alpha particles from the rear contact (window thickness <150 nm).

Therefore, better resolution can be obtained by measuring from the front contact (window thickness <50 nm).

The connector is a radial (model number: suffix-RM) microdot connector.

Specifications

PIPS 検出器:PD シリーズ						
空乏層厚	100 ミクロン厚			300 ミクロン厚		
有効面積 mm²	分解能 keV (FWHM)		型番	分解能 keV (FWHM)		型番
	α	β		α	β	
50	14	6	FD50-14-300RM	14	6	FD50-15-500RM
150	15	8	FD150-15-300RM	15	8	FD150-16-500RM
300	18	11	FD300-18-300RM	17	10	FD300-17-500RM
450	18	12	FD450-18-300RM	19	14	FD450-19-500RM
600	22	16	FD600-22-300RM	22	15	FD600-22-500RM
900	24	17	FD900-24-300RM	24	17	FD900-24-500RM

The above resolution is obtained under the following conditions:
Alpha ray (^{241}Am) 5.486 MeV, shaping time 0.5 µs, using Mirion electronics

A Series Alpha *PIPS* detector

A detector developed for low background alpha spectroscopy. The thin window provides enhanced resolution with close detector-source spacing. The low leakage current minimizes peak shift with temperature variation. A-PIPS detectors are mounted in a low background package.

- Background: 0.05 count/hr/cm² (3 MeV to 8 MeV)
- Thinnest active thickness: > 140 µm (total absorption of <15 MeV alpha particles)
- Operating voltage: 40 V to 60 V (typical)

Specifications

アルファPIPS 検出器:A シリーズ			
有効面積 mm²	アルファ分解能 (FWHM) keV	バックグラウンド値 (カウント / 日)	型番
300	17	4	A300-17AM
450	18	6	A450-18AM
600	22	8	A600-22AM
900	25	12	A900-25AM
1200	32	16	A1200-32AM

The above resolution is obtained under the following conditions:
Alpha ray (^{241}Am) 5.486 MeV, shaping time 0.5 µs, using Mirion electronics

Annular *PIPS* detector

These detectors have a 4 mm diameter through hole.

Mount type is RM type only. Partial depletion layer (PD) and full depletion layer (FD) are available in 300 micron thickness.

Specifications

有効面積 (mm)		分解能keV (FWHM)		マウントサイズ mm²	型番
内径	外径	アルファ	ベータ		
5.5	19.5	20	15	300	ANFD300-20-300RM
5.5	19.5	18	14	300	ANPD300-18-300RM

CAM series CAM *PIPS* detector

The CAM PIPS detector is the best detector for alpha/beta particles in filters used in continuous air monitors.

Suitable for online and offline use. The CAM detector is coated with aluminum and varnish. The aluminum coating is light-tight and the varnish coating gives a mechanical protection. The total entrance window thickness is less than 1.5 µm equivalent silicon.

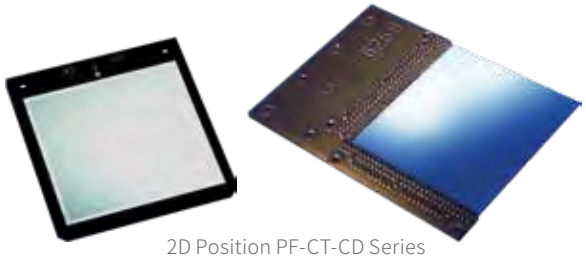
The CAM detector can operate at 15 to 24 V and does not require a high-voltage power supply.

Specifications

CAM シリーズ CAM PIPS 検出器					
有効面積 mm²	分解能 (keV)		検出器バイアス (Positive)	ベータ線スレッショルド (keV)	型番
	アルファ	ベータ			
300	36		15-24V	45	CAM 300AM
	33	15	70V		
450	38		15-24V	51	CAM 450AM
	34	17	70V		
490	39		15-24V	54	CAM 490AM
	35	18	70V		
600	42		15-24V	60	CAM 600AM
	37	20	70V		
900	45		15-24V	66	CAM 900AM
	39	22	70V		
1200	55		15-24V	75	CAM 1200AM
	45	25	70V		
1700	70		15-24V	90	CAM 1700AM
	55	30	70V		
2000	80		15-24V	110	CAM 2000AM
	65	37	70V		

Single/ Multi element *PIPS* detector (SMEPS)

The SMEPS detectors are standardized custom design detectors, available without a tooling charge. These detectors are generally mounted and wire bonded to an epoxy board.



2D Position PF-CT-CD Series

Features:

- Thin junction window: < 50 nm
- Ohmic window: < 1500 nm
- Standard 300 or 500 µm thickness
- Standard mounted on epoxy board
- 1D or 2D position information
- Simultaneous energy and position resolution

Options:

- Thin ohmic window: 150±25 nm
- Thickness 200 up to 1500 µm
- Can be mounted on customer board

1D Position PF-CT-CD Series

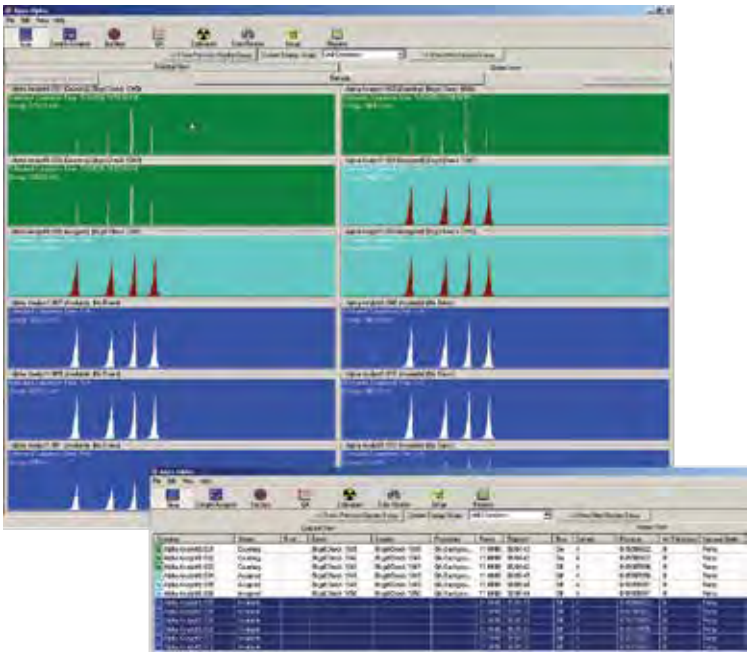
1 Radiological Counting Labs

Alpha Spectroscopy
continued

Apex-Alpha™ Alpha Spectroscopy Software Suite

Features are:

- Comprehensive operation and management software for the production-oriented alpha spectroscopy lab
- Supports manual alpha spectrometers and provides complete computer control of Alpha Analyst Spectrometer
- Distributed multi-user functionality for access to system resources from any client workstation
- Includes sample database that tracks batches of samples through log-in, counting and final data review/approval processes
- Intuitive tools for easy creation of sample batches with associated counting and analysis procedures
- Extensive quality assurance capability for scheduling of QA checks, failure identification and response and data trending
- Single screen data review and advanced reanalysis facilities
- Genie 2000 spectroscopy software core provides well established algorithms for analysis of spectral data



MIRION TECHNOLOGIES

Section 2

IN VIVO MEASUREMENT

Mirion is a leading worldwide supplier of whole body counters (including lung monitors). With the In-Vivo measurement system, subjects do not need to provide urine or stool samples for radiochemical analysis, but can take measurements only when they are in a designated location. The system also allows for a wide variety of systems and instrument configurations, from systems that quickly assess the intake of specific radionuclides to high-resolution scanning systems that provide location information for complex intake analysis. All systems can qualify and quantify radionuclides found in the body by gamma-ray spectroscopy.

Mobile whole body counter (Tottori Prefecture)

Argos™-3PAB (inside vehicle)

Example of mobile measuring device: Body surface contamination monitor and whole body counter installed in the truck

Features Common to Mirion In Vivo Counters:

- Shielded in all straight-line directions by 10 cm (4 in.) of low background steel
- Modular shield construction for easy assembly
- Rapid on-site analysis and presentation of results
- Full spectroscopy systems; not just gross count screening counters
- Flexibility and ease of operation through Apex-InVivo Whole Body Counting software
- Standalone Apex-InVivo workstations or networked client/server systems
- Extensive QA data collection program
- Mirion In-Vivo Counting Systems **can be installed in a fixed location or a mobile unit**. Systems mounted in vehicles can reduce operating costs by allowing measurements to be made wherever contamination needs to be monitored to assure the public's health and well-being.

Calibration at the whole body, lungs, gastrointestinal tract, and thyroid

Calibration for measurement is available for the whole body, lungs, gastrointestinal tract, and thyroid gland.

Worldwide standard for whole body counters

Mirion's whole body counter provides high-quality performance and functions backed by 500 units delivered, while operating easy-to-use software in a Japanese environment.

2 In Vivo Measurement

NaI detector for quick measurement of ingested nuclides

Furthermore, in the case of a vertical hall body counter, it is easy and quick to enter and exit the measurement position. In an emergency situation, it is important because a large number of people must be measured.

Ge semiconductor detector for precise measurement of ingested nuclides

Emergency contamination is caused by various radionuclides. Ge semiconductor detectors with excellent energy resolution are ideal for precise measurement of ingested nuclides.

Measurement with a Ge semiconductor detector is essential to distinguish and quantify Na-24 activated by neutron irradiation and K-40 in the body.

Software that enables qualitative and quantitative determination of unknown ingested nuclides

To perform qualitative and quantitative analysis of unknown nuclides, peak analysis such as automatic recognition (peak search) of obtained spectra and separation of complex peaks is important. Mirion's whole body counter software uses highly accurate analysis routines in the field of radiation to obtain precise analysis results.

FASTSCAN™ High Throughput Whole Body Counter

Features are:

- Processes 30-50 people per hour
- One minute count time for typical operation
- Two very large, 7.6 x 12.7 x 40.6 cm (3 x 5 x 16 in.), NaI(Tl) detectors
- Temperature-stabilized detectors available to eliminate spectral peak shifts
- 150 Bq (4 nCi) ^{60}Co LLD typical for personnel counts
- Vertical linear geometry for accuracy over a wide range of personnel sizes

Order information:

- Model 2250-L FASTSCAN with Lynx DSA, Non-Stabilized Detectors, Apex-InVivo Software
- Model 2250-LS FASTSCAN with Lynx DSA, Stabilized Detectors, Apex-InVivo Software

ACCUSCAN II™ Scanning, High Resolution, Germanium Whole Body Counter

Features are:

- High resolution, standup whole body counter
- Scanning detector mechanism accommodates one or two high purity germanium (HPGe) detectors
- Count times as low as five minutes
- Simultaneous energy and positional spectrum for accurate interpretation of data
- Available with LN_2 or electrically-cooled detectors

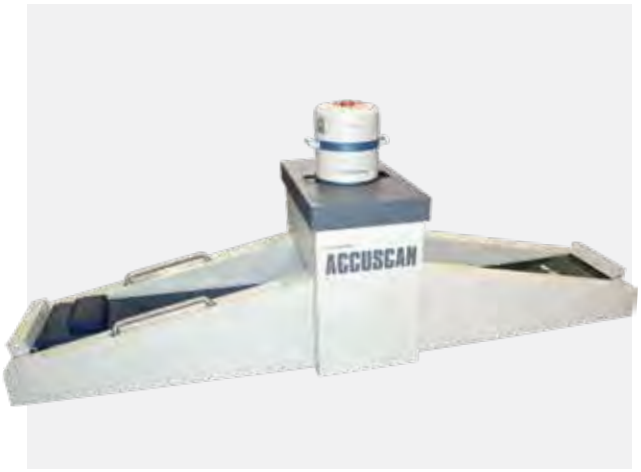
ACCUSCAN™ Scanning, Horizontal Bed Whole Body Counter

Features are:

- Horizontal, lie-down linear geometry whole body counter
- One 7.6 x 12.7 x 40.6 cm (3 x 5 x 16 in.) NaI detector (standard)
- Count times as low as five minutes
- Computer-controlled scanning bed
- Simultaneous energy and positional spectrum for accurate interpretation of data

Available Options:

- One or two HPGe detectors instead of NaI
- Two or three large NaI detectors
- Two HPGe detectors and two NaI detectors
- LN_2 or electrically-cooled HPGe detector



BABYSCAN™ (Exposure Measurement System for Infants)

Features are:

- Supports up to 130 cm from infants
- High sensitivity design: Detection limit (Cs-137, 134) 50 Bq/Body
- Measurement accuracy ± 10% (Block phantom)
- Measurement time about 4 minutes
- Lie down position for measurement. View of child for parents
- Lead-free
- Overall dimensions: 1.9 x 1.3 x 1.2 m (W x D x H)
- Shield: Thickness 10 cm Iron (bottom is 15 cm)
- Weight: 5700 kg approximately
- Detector: four large NaI(Tl), LED stabilization function (optional)
- Data processor: Full γ-ray spectrum copy function

2270 Actinide Lung Counter

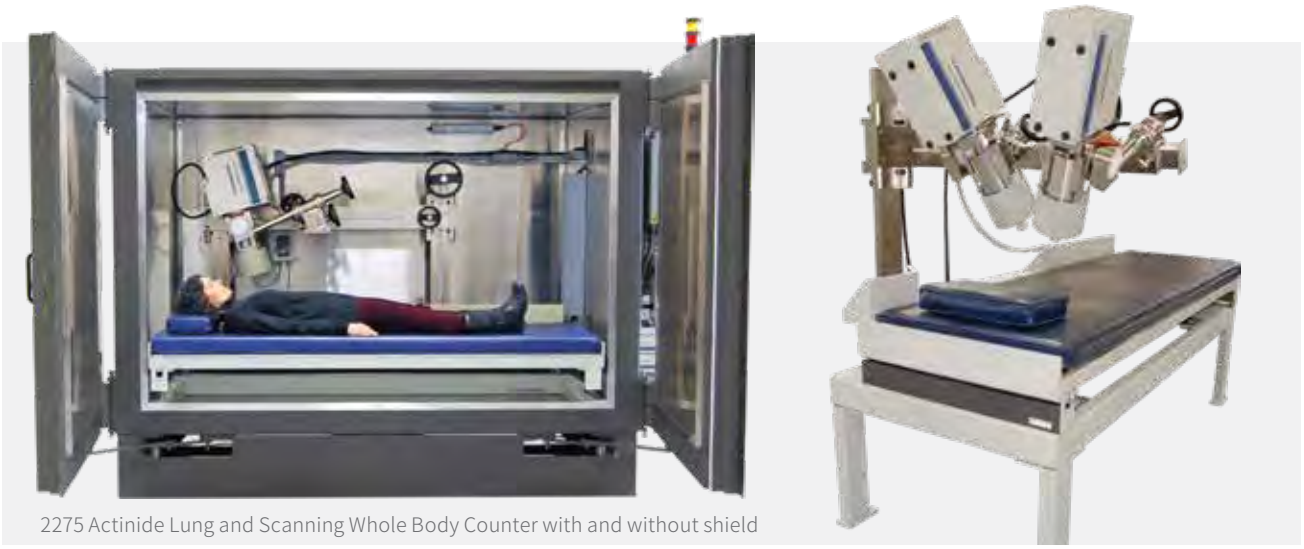
Features are:

- Detector positioner mechanism with six degrees of freedom
- Positioner accommodates BE6530 detectors
- Digital Signal Analyzers for high-resolution signal processing
- Comfortable reclining chair for subject positioning
- Flexibility and ease of operation with Apex-InVivo whole body counting software
- Extensive QA data collection program
- Lung counting software for automatic chest wall thickness correction
- Turnkey system delivered calibrated and ready to count

System Options and Upgrades for both Counters:

- 15 cm (6 in.) or 10 cm (4 in.) thick low-background steel shield
- The BE6530 with 6500 mm^2 area and 60% relative efficiency offers excellent minimum detectable activities (MDAs) and shorter counting times
- Cryo-Pulse 5 Plus electrically-refrigerated cryostat for use with BE6530

2 In Vivo Measurement



2275 Actinide Lung and Scanning Whole Body Counter with and without shield

2275 Actinide Lung and Scanning Whole Body Counter

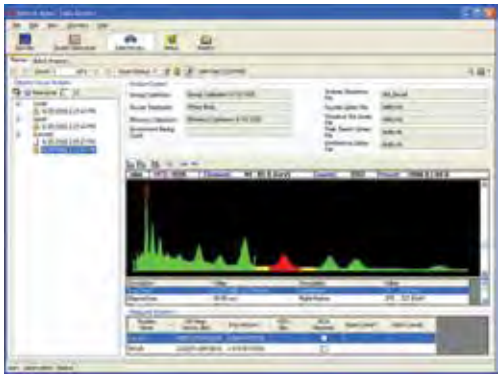
Features are:

- Lung detector positioner mechanism with six degrees of freedom
- Lung positioner accommodates BE6530 detectors
- Digital Signal Analyzers for high-resolution signal processing
- Sliding bed for easy subject/patient loading
- 7.6 x 12.7 x 40.6 cm (3 x 5 x 16 in.) scanning sodium iodide detector for whole body counting
- Flexibility and ease of operation with Apex-InVivo whole body counting software
- Extensive QA data collection program
- Lung counting option for automatic chest wall thickness correction
- Detector Anti-Compton Shields to reduce subject-generated background
- Turnkey system delivered calibrated and ready to count

Apex-InVivo™ Whole Body and Lung Counting Productivity Software

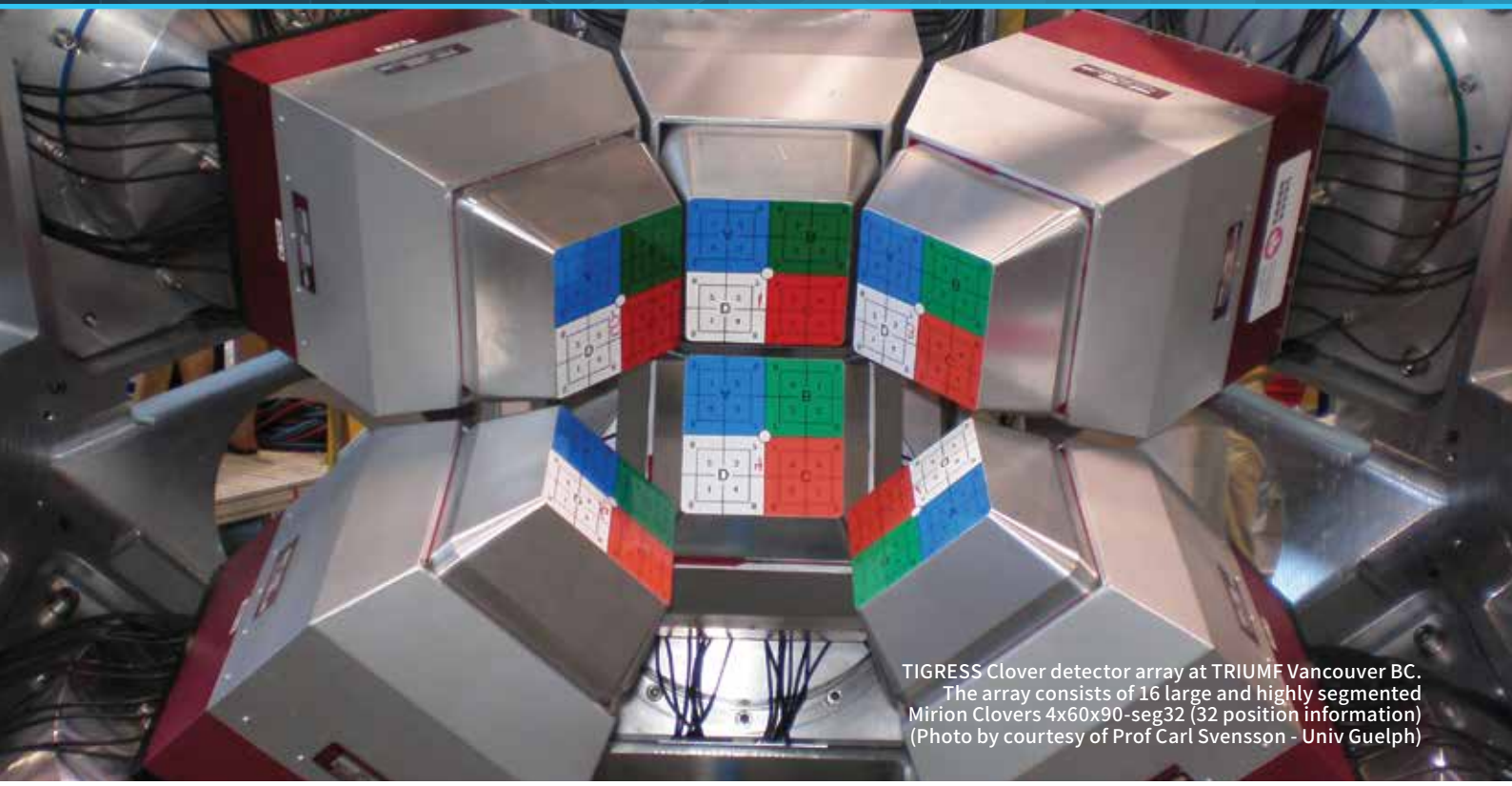
Features are:

- Comprehensive operation and management features for in vivo counting systems
- Distributed multi-user functionality provides access to counters from any client workstation
- Flexible calibration facilities including a verification report and calibrations that are automatically shared across different configurations
- Quality assurance facilities with enforced scheduling policies, and failure response option
- Advanced database features help manage all personnel count data, multiple analyses, and advanced search capabilities in key activities
- Live summed detector groups as well as multi-channel scaling (MCS) groups with defined energy ranges



Section 3

RESEARCH AND EDUCATION



TIGRESS Clover detector array at TRIUMF Vancouver BC. The array consists of 16 large and highly segmented Mirion Clovers 4x60x90-seg32 (32 position information) (Photo by courtesy of Prof Carl Svensson - Univ Guelph)

Mirion is built on 60 years of experience, in research, problem-solving and product development. We approach our work through a lens of curiosity and rigor, with a spirit that compels us to question and constantly drive innovation in our field.

Mirion is consisting of talented professionals highly skilled brainstorming together to create innovative solutions based on state-of -the-art technologies. But more than just product makers and problem solvers, we also committed to bring advanced detector technology to our customers to leverage unprecedented conditions for research and education market.

Mirion detectors and instrumentation have been used in industry, nuclear physic research, and even for space application in some of the world's leading industries, research institutes and prestigious Universities. A dedicated R&D structure allows us to deliver innovative nuclear detection systems based on a comprehensive exploration of all available and emerging technologies.

Detailed Nuclear Science Experiments with Digital Electronics Lab Manual and associated lab kits are also available to assist with hands-on exposure to fundamental and advanced topics of gamma-ray measurement and gamma spectroscopy in teaching and research laboratories.

Detectors such as the Passivated Implanted Planar Silicon variety are used in core products for alpha spectroscopy and alpha/beta counting. They also play critical roles in systems for XRF materials characterization, the space program and physics research.

High Purity Germanium (HPGe) detectors offer the unique blend of cutting-edge technology and proven reliability. From standard coaxial/planar detectors to sophisticated array detectors for scientific research and industrial applications – you can count on consistent quality, high technology and reliability. Electrically-cooled LN_2-free cryostats are available in most configurations as well as rigorous material selection for the detector hardware for specific applications or to reach ultimate levels of MDAs.

Mirion Digital Signal Processing products and spectroscopy software are at the heart of our gamma spectroscopy systems. These versatile technologies offer solutions that serve the most demanding requirements of the world's leading researchers and educators. They are not only the components with which the systems are built – but also the tools that are building the future of the nuclear industry.

HPGe Detector Configurations for Nuclear Physics Research

Euroball Clover Detector 4x50x70 a great detector success designed by Mirion in early 90s with more than 130 identical detectors delivered worldwide.

New COMPEX clover: the first electrical cooled Clover ever done with a special RDC cryostat designed for windowless operation. Four of these Clovers are currently in use at GSI in Germany as a decay box to study new exotic nuclides.

Clover Detectors Array of Four HPGe Detectors

Features are:

- Clover Array-Detector design is consisting of four special shaped Ge crystals for a close array – with or without segmentation of the individual crystals
- Excellent energy and timing resolution due to dedicated crystal quality and low electrical noise electronics
- 130% relative efficiency in addback mode with a Clover 4x50x70. More is achievable with bigger crystals.
- Can address applications where highest efficiency or MDAs are required
- Low background configurations available with specifically selected materials for their radio-purity
- Thin entrance window for extended energy range to low energy photons available on request.
- Optional electrical cryocooling for LN_2-free operation

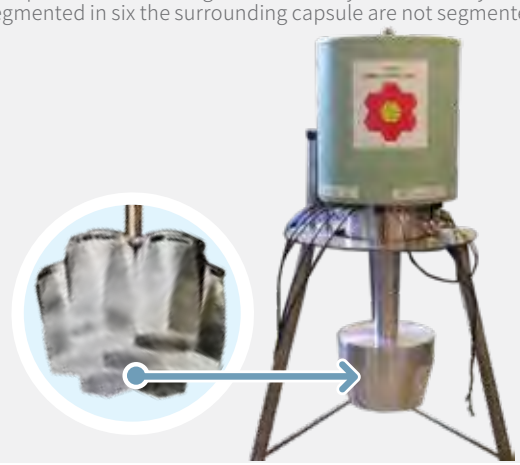
The GRETA detector consisting of 4 encapsulated HPGe crystals each segmented in 36.

Total number of channels per detector: 148

- 144 position
- 4 full volume channels

The Euroball Cluster detector is consisting of 7 encapsulated HPGe crystals. Mirion delivered 180+ individual capsules for Euroball Cluster detectors and Miniball at CERN.

The photo shows a design for JAEA: only the center crystal is segmented in six the surrounding capsule are not segmented.



High efficiency HPGe Array Solutions

Features are:

- Up to seven HPGe crystals in one cryostat
- Encapsulation techniques for a modular design easy to handle in case of maintenance.
- At request segmentation of the outer contact of the individual crystals
- Embedded low power and low noise preamplifiers with fast rise time.
- Special irregular hexagonal shape to accommodate a complete 4 PI detection ball consisting of only HPGe material where Veto scintillator detectors such as BGO/CSI are no longer needed due to the close HPGe array detector system.

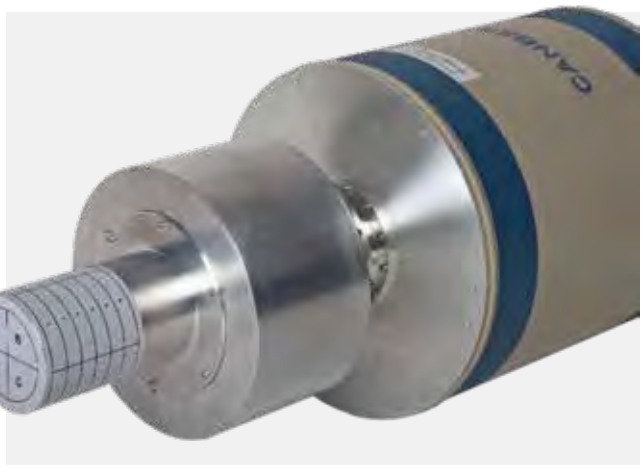
Segmented coaxial Ge detectors for position information

Features are:

- For gamma tracking, polarimetry, Doppler effect correction, ß decay suppression
- Longitudinal and transversal segmentation of the outer contact by photolithography (up to 36 segments), on various N-type crystal geometries
- No dead zone or absorbing material between segments
- Monolithic or multielement segmented detectors
- Reliable segmentation technology over three decades not sensitive to heat cycling nor neutron annealing operation in-situ.
- No measurable crosstalk effects
- Increased granularity of multi-detector systems
- Localization of the interaction and gamma-ray tracking capability through coincidence between internal core signal and segment contact signals.

Applications are:

- Nuclear physics:
  - Doppler effect correction
  - Multiple site energy deposit and ß decay suppression
  - Polarimetry
  - Tracking
- Compton cameras – gamma imager: Gamma-ray sources location
- Compton suppression



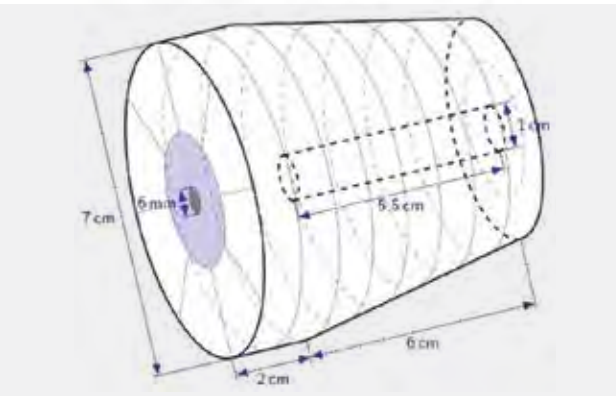
MSU “SeGA” system

CNS Ge array “GRAPE”

NEW: Inverted & Segment coaxial type Ge detector

Features are:

- Novel Germanium Detector technology for in-beam gamma-ray spectroscopy.
- Gamma-ray tracking for background suppression and multiple interaction analysis.
- Up to 20 segments including a central electrode (point contact) and surrounding segments as well inside the core.



HPGe Detector Configurations for Nuclear Physics Research

continued

Encapsulated Ge detectors

Features are:

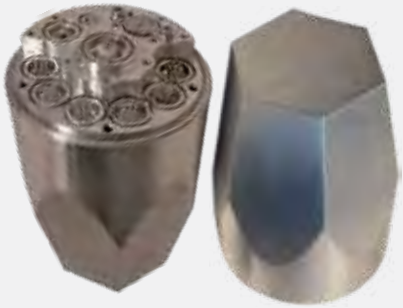
- For compact construction of multi-element detectors for gamma-ray applications
- For very large efficiency and solid angle coverage
- For high sensitivity and low detection limit gamma-ray spectroscopy even in harsh environments
- Easy annealing in standard ovens, without pumping, in case of radiation damages
- In situ annealing in space applications
- Long detector life time
- Large choice of shapes (pentagonal, hexagonal) for compact matrix assemblies
- Essential for complex cryostat development, particularly with segmented detectors
- Total reliability Ultra High Vacuum technology
- Easy detector handling and exchange

Applications are:

Such a detector is easy to use, reliable and robust. So, it may be used in a large range of scientific and industrial applications such as:

- Array of detectors for gamma spectroscopy (ex: MINIBALL, AGATA, GRETA nuclear physics experiments)
- Research laboratory
- Nuclear medicine
- Environmental measurements
- Industrial quality control
- Homeland Security
- Space experiments, thanks to its in situ regeneration capabilities after radiation damages (ex: INTEGRAL, MARS ODYSSEY, SELENE,...)
- Assistance to Engineers (ex: design of complex cryostats and/or multi-element detectors electronic)

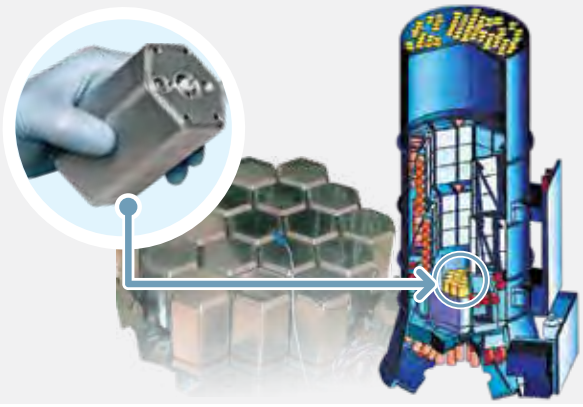
AGATA capsule: Irregular-hexagonal shaped, encapsulated HPGe crystal with outer contact segmented in 36 segments for position information.



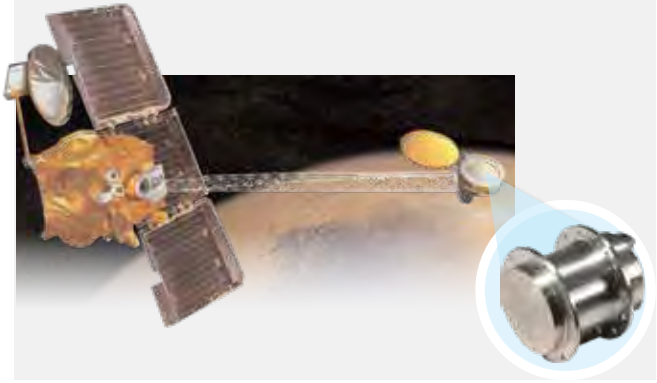
EuroBall cluster consisting of Regular-hexagonal shaped, encapsulated HPGe crystal. A segmented version: **MiniBall** at Isolde 'CERN' with 12 segments.

Selene (JAXA) Lunar orbiter mission "KAGUYA". Mission duration: one year. Encapsulated coaxial HPGe detector for the GRS. The GRS had an excellent energy resolution 20 times superior to those used in past lunar missions.

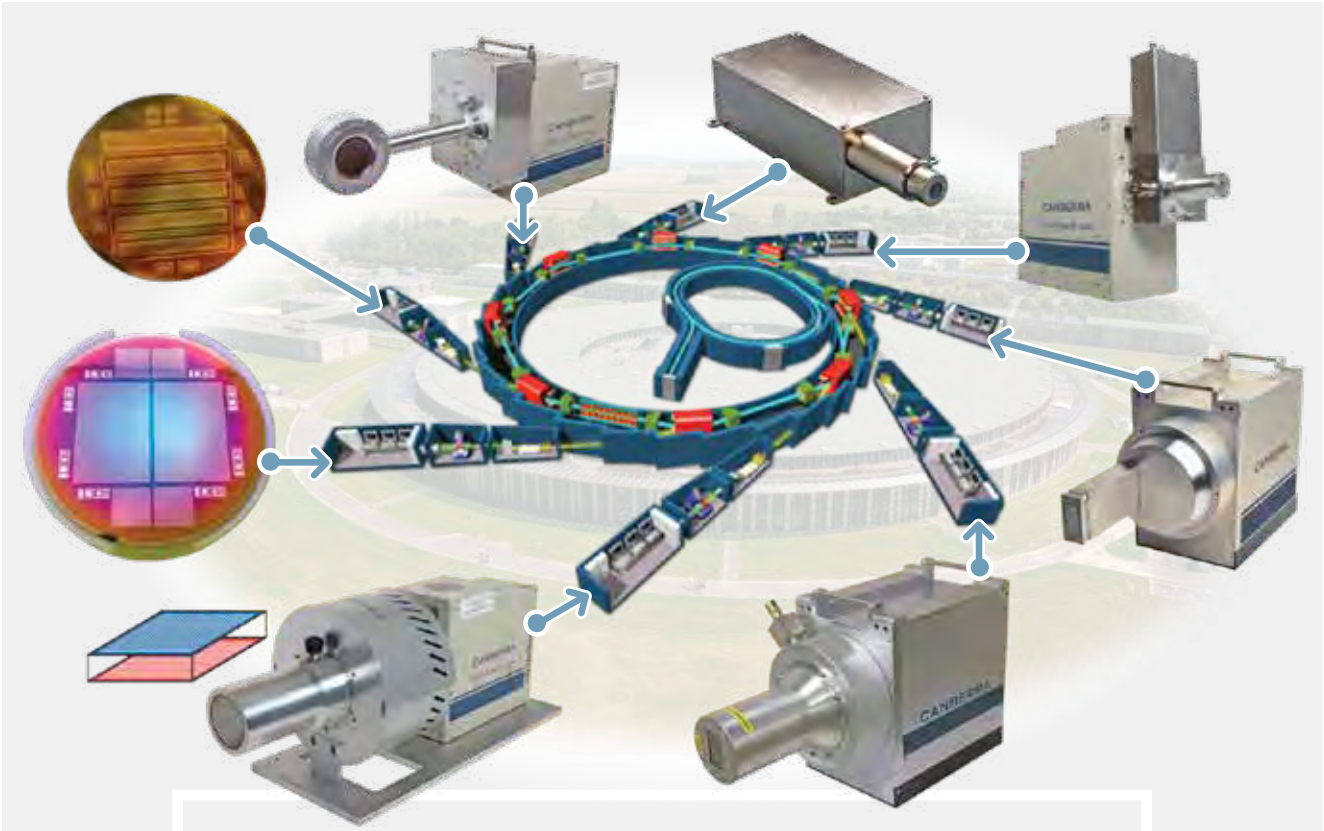
Integral SPI Project: Launched in 2002 to study the origin of gamma bursts in the universe. Compact array of 19 encapsulated coaxial HPGe detectors. Vibration level 50 g. Still in operation.



The Mars Odyssey Mission: Launched in 2002 to detect the presence of water (ice) on Mars by using (n,γ) reactions. Coaxial HPGe, N-type detector, titanium encapsulated. Vibration specifications 50 g. Still in operation.



Mirion's Detector Offer for Synchrotron Facilities



The Mirion's product portfolio for Synchrotron applications is split in two parts but both are using state-of-the-art technologies:

Spectroscopy detectors

- High Purity Germanium detectors (HPGe), single or multichannel
- Silicon: X-PIPS, Silicon drift diodes (SDD), single or multichannel

Imaging detectors

- Strip detectors
- Finely pixelated detectors

3 Research and Education

Mirion's detector offer for Synchrotron facilities.

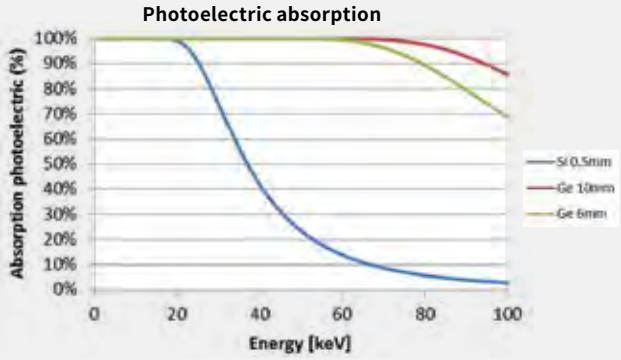
continued

Spectroscopy Detectors for Synchrotron Applications

When to choose SDD or HPGe?

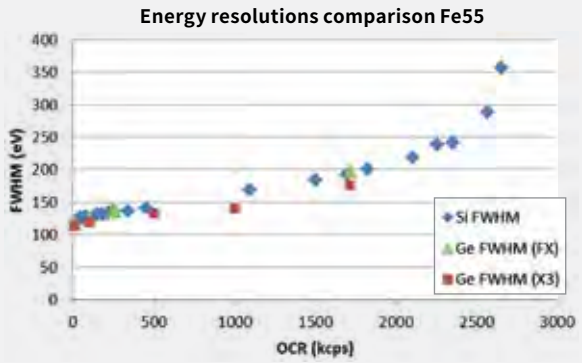
	SDD	New generation HPGe
Energy range	1 keV ÷ 20 keV (windowless 300 ev)	2 keV ÷ 200 keV (windowless 300 eV)
Energy resolution	Better below 3 keV Better above 1 Mcps	Better 3 keV ÷ 200 keV Better below 1 Mcps
Throughput	Same @ 6 keV	Same @ 6 keV
Peak to background	1 : 12000	1 : 1000 to 5000
Footprint	Smallest	Larger
Price	Lower	Higher
Fluorescence peak	1.7 keV	11 keV ...
Cooling time	Few minutes with Peltier Electrical cooling 2 to 4 hours	Electrical cooling 2 to 8 hours

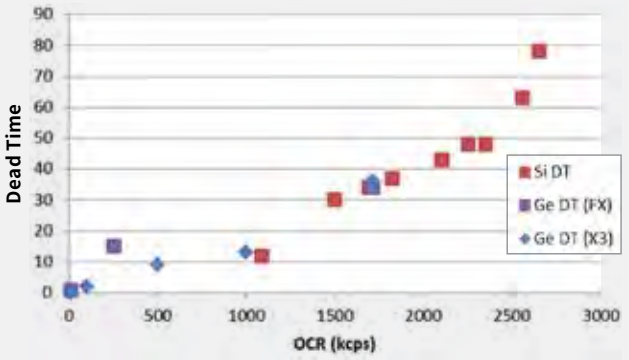
Details on material photon absorptions
NOTE: Thicker Ge are available



Comparisons of FWHM and dead time:

- SDD with FalconX,
- HPGe with FalconX and Xspress3 mini
  HPGe type EGX10-06 and SDD type SXD50

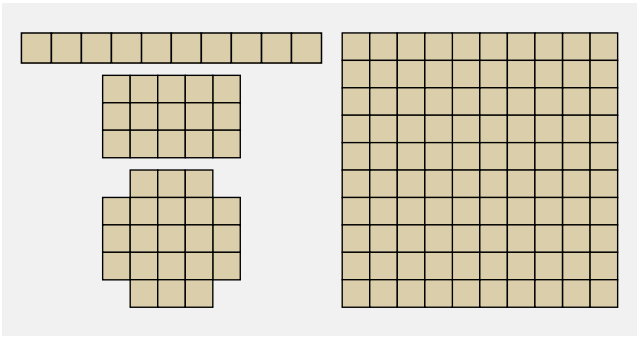




FX: measurement with FalconX (XIA)
X3: measurement with Xspress3 mini (Quantum)

HPGe Pixel detectors and discrete arrays

Example of Pixel layout:



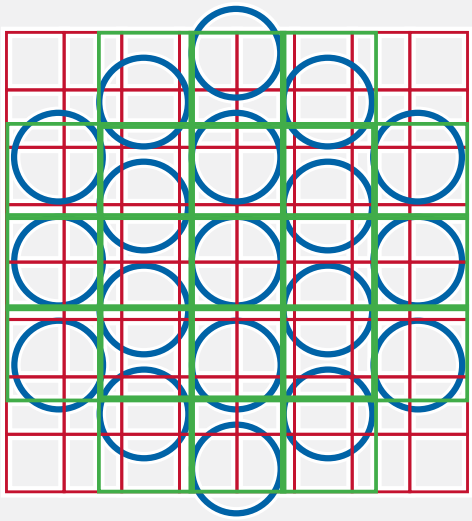
Pixel features:

- Typical Pixel size:
  - 5 x 5 mm = 25 mm²
  - 8 x 8 = 64 mm²
  - Consult Factory for other customized pixel sizes
    From: 3 - 4 - 5 - 9 - 16 - 25 - 36 - 64 up to 100 pixels

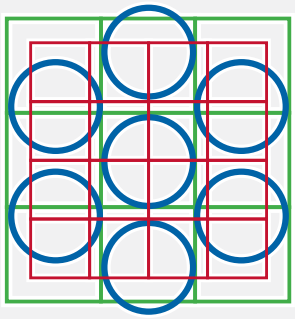
Main HPGe detector parameters for pixels and multielement arrays.

Detector parameter	Monolithic xtal slab	Discrete arrays
Energy resolution	Good	Best
Peak to background	Good	Best
Count rate capability	Good	Best
Number of channels	Up to 100	Limited to 32
Solid angle	Largest	
Energy range	2 : 200 keV	2 : 200 keV (down to 0.3 keV)
Charge sharing	Mitigated (collimator grid)	none

Packing ration comparison between:



- 50 mm² multielement (7 and 19 elements)
- 25 mm² pixels (16 and 64 elements)
- 64 mm² pixels (9 and 21 elements)



Mirion's detector offer for Synchrotron facilities.
continued

New Spectroscopy Detectors for improved performance

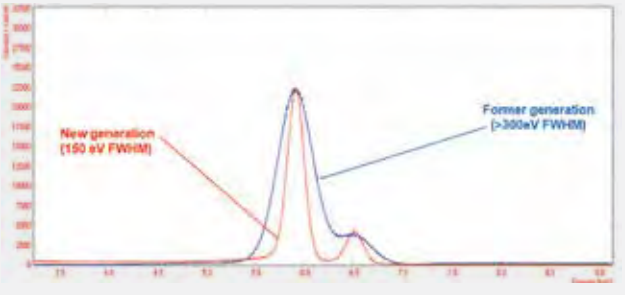
HPGe Pixel & discrete element with new ultimate performance

Features are:

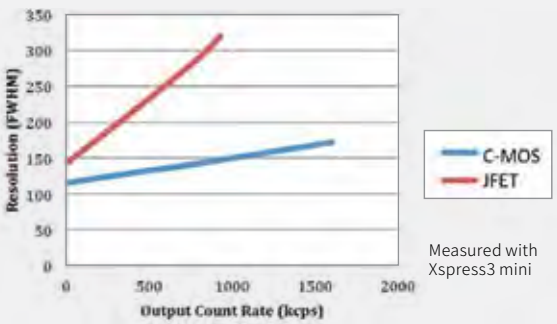
- Highly improved FWHM:
  - Novel ultra-low capacitance element configuration
  - Ultra-low noise cryogenic electronics: replacement of the former JFETs by new CMOS technology
  - Highly EMI immune design

Energy resolutions	Typical	Guaranteed
1,000 counts per second 6 µs shaping time	< 110 eV	< 130 eV
100,000 counts per second 0.5 µs shaping time	< 120 eV	< 145 eV
100,000 counts per second 0.1 µs shaping time	< 150 eV	< 170 eV
100,000,000 counts per second FalconX or Xspress3 mini	< 175 eV	< 190 eV

Example of 5x5 mm² pixel Fe55 0.1 µs Shaping 500 kcps



Mirion Ge rate/resolution



Measured with Xspress3 mini

New generation HPGe performances (detailed comparison)

60 keV (Am-241) resolution [eV] (Dead time)	
ICR [kcps]	Typical Guaranteed
9	323 (0.5%)
18	329 (1.2%)
72	343 (3%)

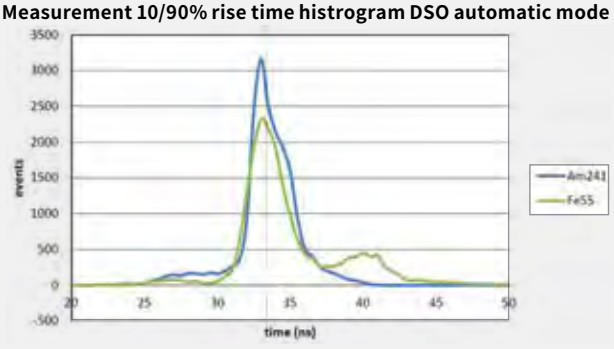
6 keV (Fe-55) resolution [eV] (Dead time)			
ICR [kcps]	XMAP	Xspress3 mini	FalconX
10	115 (9%)	113 (0%)	117 (1%)
100	135 150	118 (2%)	
300	132 (45%) 166 (19%)		136 (15%) 162 (7%)
500		132 (9%)	
1000		140 (13%)	
1700		175 (36%)	197 (34%)

Pixel detectors: new ultimate performances

Features are:

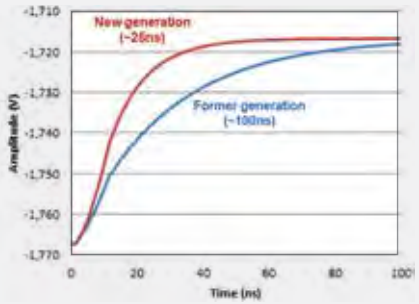
- Increased throughput: better electronics, smaller pixels, improved front end rise time
- Decreased dead time: faster data acquisition, faster pulse processing

Measurement 10/90% rise time histrogram DSO automatic mode



Overall faster pulse processing

Pulser



Faster electronics

Detectors for Diffraction & Imaging

Millimetric segmentation

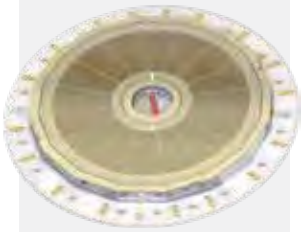
Features are:

- Similar designs as EXAFS detectors
- Single LEGe or U-LEGe unit
- Array of discrete elements
- Linear segmented pixel
- Strip detectors


Strip HPGe detector

Monoelement

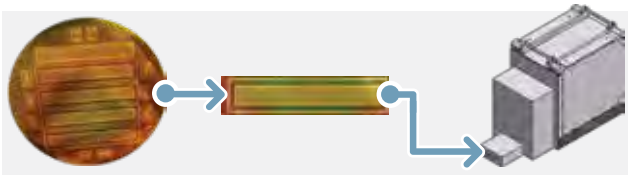
- All possible crystal arrangements:
  - Custom cryostat configuration and holders to fit the experiment hutch (press, etc.)
  - Segmented annular silicon detector for beam monitoring


Photodiodes for Beam Alignment

Micrometric segmentation

Features are:

- Strip detectors from wafer or crystal slabs depending on thickness



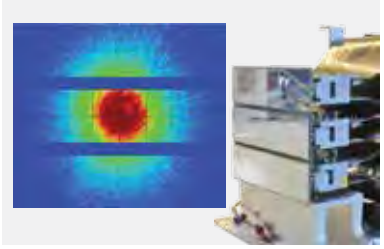
- Imaging beamline with Ge strip detectors
  - Example of medical beamline on humans and animals' organs (ESRF)

Length = 150 mm,
Width = 20 mm,
Thickness = 2 mm
864 Strips - 350µ pitch
FWHM - 1.3 keV at 60 keV

Elleaume & al

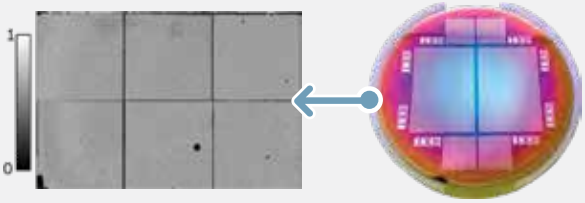

Tumor

- Silicon wafers for Medipix
  - 500 µm thickness
  - Pixel size 55 µm
  - E.g. 8 x 2 sensor gives 2048 x 512 pixels

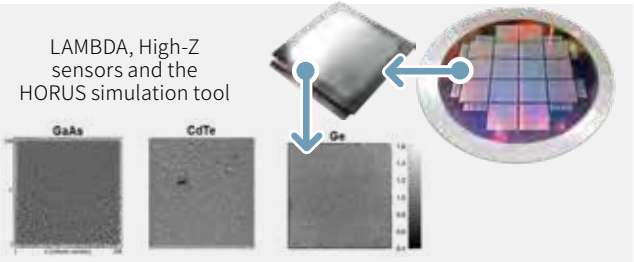


https://www.diamond.ac.uk/Science/Research/Detector/ExcaliburRX/Sensor-Module.html

- Ge wafers vs. other material:
  - High Z detectors based on latest available asics
  - High absorption efficiency compared to Si
  - 55 micron pixels and bump-bonding
  - Thin HPGe wafer (few hundreds µm)
  - Partnership with Medipix collaboration (HPGe supplier)
  - Better image quality than the other high Z materials (CdTe, CZT, GaAs)


Matrix of Ge chips available for larger area

LAMBDA, High-Z sensors and the HORUS simulation tool



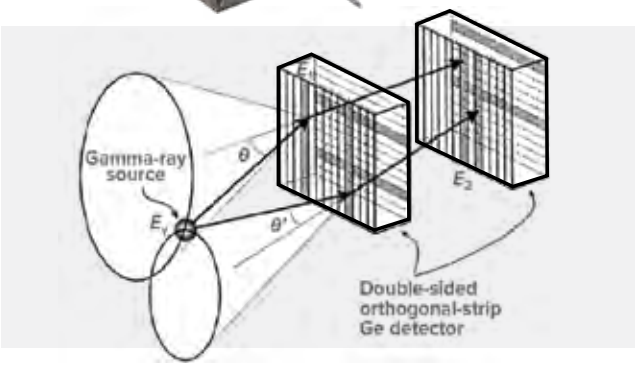
Mirion's detector offer for Synchrotron facilities.
continued

Detectors for Diffraction & Imaging

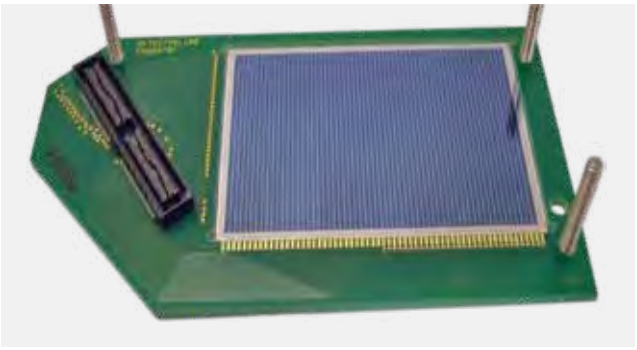
Double sided strip detectors (DSSD)

Features are:

- Example Ge DSSD detector:
  - Active area 60 x 60 mm^2
  - Thickness 20 mm;
  - Orthogonally strips on both sides 12X – 12Y
  - Energy resolution
    - < 2 keV @ 122keV
    - < 3 keV @ 1332keV
  - Transmission cryostat stackable with minimized distances Ge to Ge
  - Array Design available with two DSSD in a unique cryostat
  - Electrical cooling by Cryo-Pulse 5 Plus cryostat
  - All attitude cryostat



- Example Si DSSD detector:
  - Active area 60 x 60 mm^2 - 60 strips on both sides
  - Thickness up to 1 mm



Beam characterization with customized transmission detectors

Features are:

- Beam characterization with transmission detectors
  - Highly selected material for minimal fluorescence
  - Minimized backscatterered (front and rear windows, offset contacts…)
  - High count rate preamplifiers
  - Hyper pure Beryllium window
  - Customized RDC cryostat with user-friendly electrical cooler type Cryo-Pulse 5 Plus cryostat.

Electrical cooling for synchrotron applications

Features are:

- Highly integrated electric cooler and embedded electronics for smallest footprint
- Less maintenance required
- No risk of LN_2 refill oversight
- No need for LN_2 supply infrastructure
- No risk of burning for the user during LN_2 refill
- No risk of anoxia
- Low vibration level: identical performance if compared to LN_2 cooled detectors
- Highly reliable Pulse-Tube cryocoolers: demonstrated lifetime of 11 years
- All attitude
- Fan free version for nnanofocused beamlines with external water chiller circuit to collect preamplifier and cooler heat
- Very favorable total cost of ownership
- Low electrical power of 80-150 W easily supported by standard UPS.
- Electrical connection between the control/supply unit (CP5CO) and the cooler. Standard cable length 3 m.

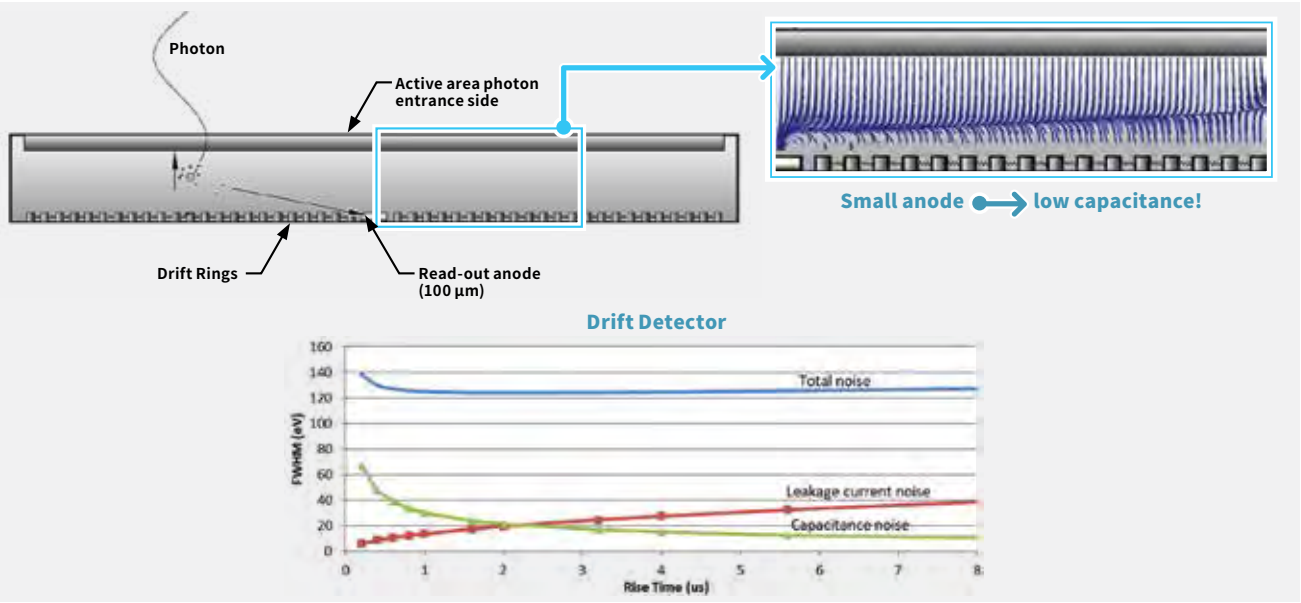
Monoelement

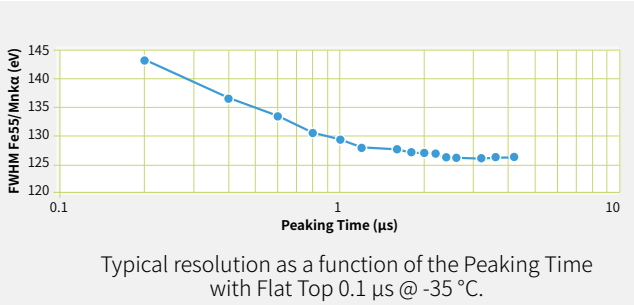
8-Element, electrical cooler with water chiller circuit

25 pixel

Focus on Silicon Detectors

X-PIPS Detectors single element





Typical resolution as a function of the Peaking Time with Flat Top 0.1 µs @ -35 °C.

Model: SXD15M-150-500 or SXD30M-150-500

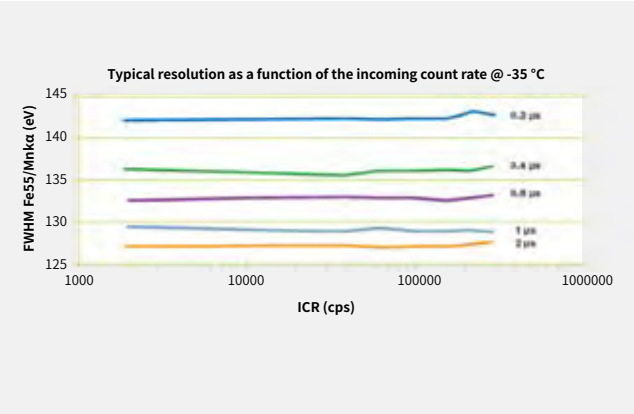
Application:

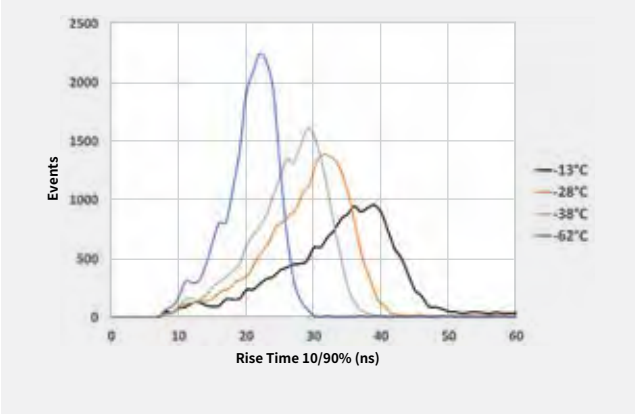
- Used mainly for XRF

Features are:

- Hermetically sealed detector element including: 15 or 30 mm² collimated, 500 µm thick
- On chip collimator
- Excellent resolution: typ.135 eV at 5.9 keV (CMOS based typ. 127 eV at 5.9 keV)
- Peak/Background: typ. 15 000
- Low noise FET or CMOS assembly
- HV bias supply
- Peltier cooler
- Be window, 12.5 µm
- Temperature controller
- Stable operation in changing ambient

Excellent linearity at higher count rates





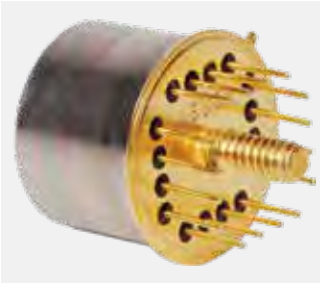
- Very good signal rise time
  - Signal rise time distributions from 10-25 ns with an average below 20 ns have been achieved
  - Dependent on temperature

X-PIPS Specifications (Active thickness 500 µm)

Model	Active area (mm^2)	Collimator	Front end electronics	PBT		Energy resolution FWHM (eV) *	
				Typical	Max	Typical *	Max *
SXD30M-150-500	30	multilayer	JFET	15000	> 12000	135	145
SXD15M-150-500	15	multilayer	JFET	15000	> 12000	135	145
SXD30M-500-CM-PA	30	multilayer	CMOS	15000	> 12000	127	132
SXD15M-500-CM-PA	15	multilayer	CMOS	15000	> 12000	127	132

Cooled to -35 °C
* @ optimum shaping time

SXD30M-150-500
X-PIPS™ Detector SDD



SXD15M-150-500-TO8
Silicon Drift Detector SDD

SXD30M-500-CM-PA
X-PIPS™ Detector SDD

SXD15M-500-CM-PA
X-PIPS™ Detector SDD

Focus on Silicon Detectors
continued

Multi-element drift detector

Features are:

- Array of 7 individual SDD's of 100 or 70 mm² (collimated to 80 or 50 mm²) and 500 µm thickness in a close-packed geometry.
- Typical energy resolution 127 eV at 5.9 keV
- Used in synchrotron applications
- Cryo-cooled
- CMOS preamplifier
- 1 mil Be window

Detector system includes:

- Preamplifiers
- HV power supply
- Temperature controller

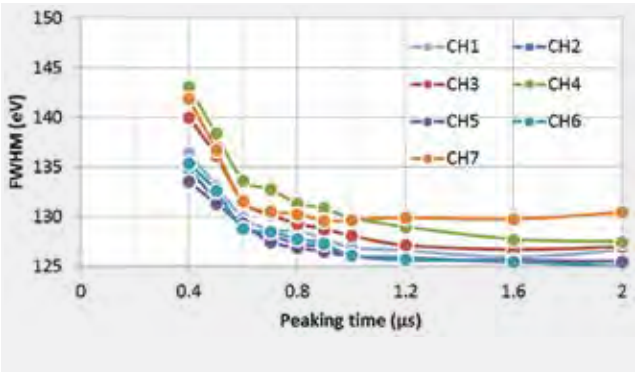
Mechanical design can be optimized to customer request.

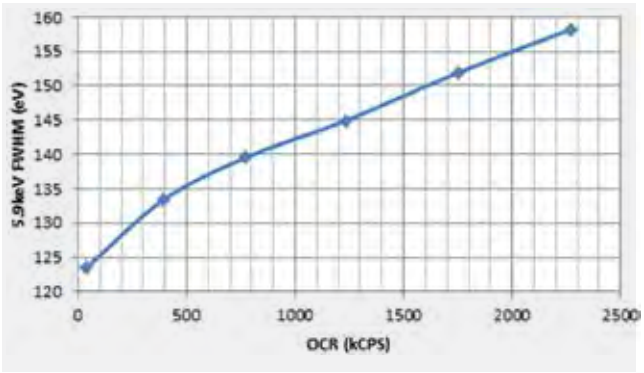
- Advantage of cryo-cooling: lower operating temperature possible which leads to
  - Better signal rise time
  - Better resolution at higher count rates

Straightforward assembly leads to:

- Maintenance and eventual repair made easier
- On-site maintenance of the vacuum possible

FWHM at 5.9 keV, 7-element detector, each segment 50 mm²





Optimum resolution of 125 eV achieved at 4 µs peaking time.
Resolution at the fasted peaking time (0.2 µs) were 139-146 eV.
Good resolution at higher count rates.

Si(Li) / Super Si(Li) X-ray detector

Features are:

- Ideal for X-ray spectroscopy from about 300 eV to 50 keV
- The incident window is made of beryllium to detect low energy X-rays
- Energy resolution 135 eV to 180 eV (FWHM at 5.9 keV)
- Cool and operate with liquid nitrogen

Overview:

This is a high-resolution X-ray detector using a silicon semiconductor. The measurement X-ray range is about 300 eV to about 50 keV. Used for X-ray fluorescence analysis, X-ray generator tube characteristic test, X-ray irradiation energy spectrum analysis, etc.

Specifications:

Si(Li) X-ray detector (SL)

Model number	Effective area (mm^2)	Crystal thickness (mm)	Resolution FWHM 5.9 keV
SL12145	12.5	2	145
SL12160	12.5	2	160
SL30155	30	3	155
SL30170	30	3	170
SL80165	80	5	165
SL80180	80	5	180

Super Si(Li) X-ray detector (SSL)

Model number	Effective area (mm^2)	Crystal thickness (mm)	Resolution FWHM 5.9 keV
SSL12135	12.5	2	135
SSL30145	30	3	145
SSL80155	80	5	155

- FWTM is guaranteed less than twice FWHM
- Super Si(Li) detector guarantees the above performance when using a spectroscopic amplifier with a 24 µs shaping time constant.

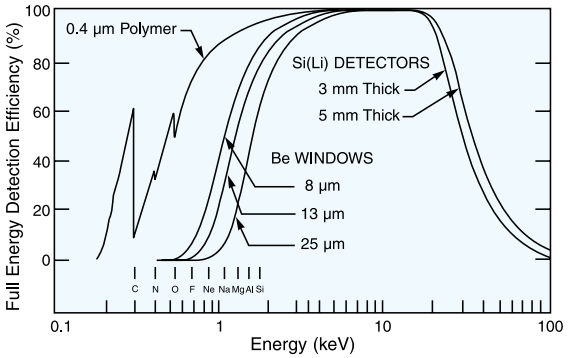
Window option

BW-0.3	8 µm beryllium (effective product 12.5, for 30 mm^2)
PW-0.4 (V or H)*	0.4 µm polymer (effective product 12.5, for 30 mm^2)
PW-0.4L (V or H)*	0.4 µm polymer (for effective area 80 mm^2)

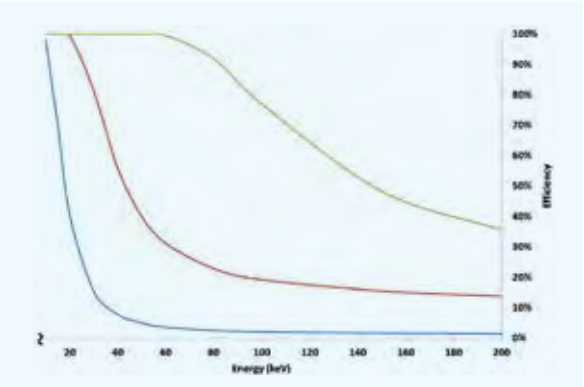
*Polymer windows are not light tight.

Cryostat option

7500M	Vertical dipstick cryostat (30 Dewar, metal seal)
7600M	Horizontal integral (30 Dewar, metal seal)
7905-7.5, 1.5, 30	Horizontal integral (7.5 Dewar, 1.5 Dewar, 30 Dewar)
7906-7.5, 1.5, 30	Horizontal integral (7.5 Dewar, 1.5 Dewar, 30 Dewar)
7935-2	Flange type MAC portable
7935-7	Big MAC Cryostat
7905-R	Retractable (7.5 Dewar)
7905-WR	Windowless Retractable (7.5 Dewar)
7905-BWR	Windowless retractable with bellows seal (7.5 Dewar)



Transmission curves for various types and thickness of windows. The polymer window curve does not show the effect of the support grid on overall efficiency



Comparison of high-energy efficiency Germanium vs. Silicon

Rugged Germanium Detector Solutions

A novel, ultra-compact, gamma spectroscopy detector for high count rates in confined spaces.

MicroGe with Supply Station, DSA-LX® MCA and Genie™ 2000 Software for Windows PC computer

MicroGe™ Ultra-compact HPGe detector

Features are:

- High count measurement in extreme environments
- Compact and lightweight portable Ge
- Can be used almost anywhere
- Thermal cycle free

Design:

- Small HPGe crystal
- Small electric cooling system (lightweight, short time cooling, power saving)
- Ultra-low noise electronics circuit
- System design options:
  - Collimator
  - Watertight housing
  - Custom mounting interface depending on the application
- Hardened vacuum allowing partial thermal cycles

Pelicase to ease any storage/transportation

Sealed Probe Breakthrough for Harsh Environments Requiring HPGe performance

Benefits are:

- Increase your survey productivity: shorter measurements, incomplete thermal cycling
- High mobility and small footprint
- Easy to clean and to decontaminate
- LN_2 free
- Submersible in sea water
- Highest energy resolution

Applications:

- Harsh conditions or contaminated environments
- Decontamination and Decommissioning
- Emergency response for safety and security
- Mining and well logging
- Underwater and oceanography

Examples of sealed probe applications:

Spent Fuel Pool Spectroscopy Application

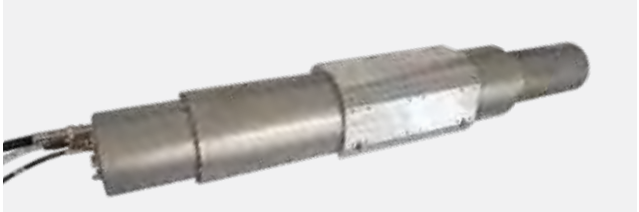
- Customized industrial solution
- Special shape to fit available footprint
- IP68 water tightness and decontaminable
- Specific interface
- Complete embedded Mirion solution
- ISOCS characterization

Under Water Applications

- Installation in a laboratory (water pumped from river and stored in tank)
- Antifouling and anti-corrosion coatings

Whole Body Counter for Mobile Lab

- Electrical cooled detectors for a mobile WBC system with new CL5 Cryo Electric cooler.
- The new CL5 cooler requires the same room as a Big MAC cryostat and is therefore adapted to the upgrade of an existing system with room constraints. CL5 cooler will accommodate high ambient temperature through a specific water cooling chiller.

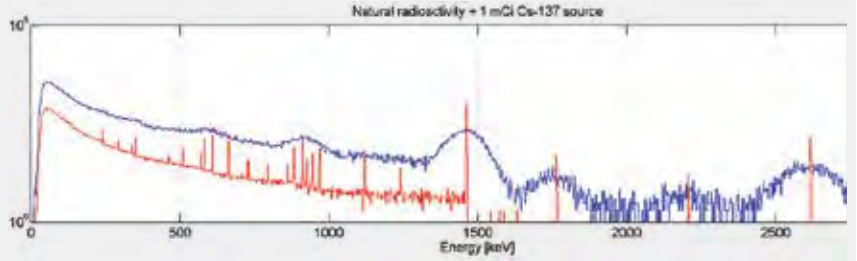


Antares: Deep Underwater Gamma-ray measurement - Project NuMerEnv

- HPGe detector used at 2500 m depth in the Mediterranean Sea for gamma spectroscopy complementary to the Cosmic Neutrino Experiment (Antares).
- Use of Mirion electrical cooler with a proven high reliability due to limited access twice a year. Dedicated design to combine gamma-ray transmission through Titanium pressure housing including Lynx Digital Signal Analyzer.

Rugged Germanium Detector Solutions
continued

Hardware overview of the Mirion airborne system consisting of two cabinets (detector and processing electronics)



Excellent energy resolution, see spectrum in red.
Usual scintillator detector spectrum, see spectrum in blue.

View of detector cap through a hole in aircraft cabin. Each colored circle shows the location of an individual coaxial detector within a common cryostat

Ground Contamination Spectroscopy Systems with HPGe Detectors

A novel, compact, gamma spectroscopy array detector for airborne survey with highest spectroscopy response.

Features are:

- High efficiency assembly with large detectors (modular size).
- Modular detector design for easy maintenance.
- Add-back enhanced efficiency up to 1300% at 1.33 MeV.
- Full embedded system with Electrical cooling and digital MCA.
- Typical MDA 50 µCi @100 m height at a 180 km/h speed for ^{137}Cs.

Mirion Specialty Ultra Low Background "S-ULB" detectors

The Mirion Technologies (Canberra™) product catalog is offering Ultra Low Background "ULB" detectors for more than four decades.

ULB detector performances can now be significantly enhanced by new technologies to address demanding nuclear physics research like astrophysics with ultimate level of background as required in deep underground labs for low radioactive environmental samples.

Below is a list of features for Canberra Specialty Ultra Low Background (S-ULB) HPGe detectors now available from Mirion Technologies:

- Ultimate Level of Background.
- Customized HPGe crystals and electronics.
- Tailored cryostat to fit special constraints.
- Electrical cooling as a proven and mature technology for underground HPGe detector labs.
- New array detector systems for unprecedented detection efficiency.
- Novel Small Anode (SAGe) detector technology.
- New Small Anode Well (SAGe Well) detector technology.
- Customized Well or true Well detectors for 4π detection geometry.
- Minimized exposure to cosmic radiation due to Mirion storage cave with 800 mwe overburden.

Below performance on ULB and S-ULB detectors could be disclosed thanks to the kind contribution of our customer very willing to share the information requiring up to many weeks of counting time per spectrum due to the very low level of radioactivity.

Background performance difference between ULB and S-ULB detector in Underground Lab conditions:

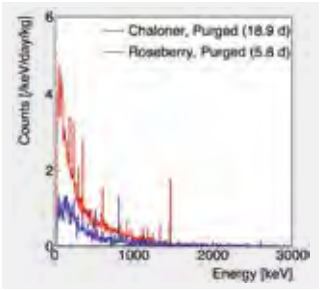
This table below from the deep underground Lab "Canfranc" ("LSC") in Spain provides the integral counts in ULB and S-ULB cryostats for a coaxial 400 cc P-type detector with "U" style type cryostat.

Integral counts on a 400cc P type detector	"Specialty" S-ULB (counts/kg/day)	"Specialty" S-ULB (counts/kg/day)
20-2700 keV	1932	190
40-2700 keV	689	179
60-2700 keV	641	165
100-2700 keV	598	143

By courtesy of Dr Iulian Bandac - LSC

Background performance difference of BEGe6530 detectors at Boulby UnderGround Screening Lab ("BUGS") in the UK with ULB and S-ULB cryostat grade assessment occurred in 2018:

- **Involved detectors:**
  - "Chaloner" nickname of a BEGe6530 with ULB cryostat (delivered in 2015).
  - "Roseberry" nickname of a BEGe6530 with S-ULB cryostat (delivered in fall 2017).
- Typical minimum activities (computed values) from the S-ULB detector at Boulby Underground Lab:
  - 210Pb < 0.7 mBq/kg
  - 234Th < 0.5 mBq/kg



NOTE: There is not an insignificant amount of Co^{58} (511 keV 810 keV 863 keV 1674 keV) and Co^{57} (122 keV 136 keV) in the S-ULB detector background spectra in blue shown above. This is just activation from being on the surface and it is something that will disappear with time due to the very short half life of Co^{58} (71 days) and Co^{57} (270 days).

Credit: 'STFC-Boulby Underground Laboratory' and the 'UCL, High Energy Physics Group'

During the LZ (Lux Zeplin) collaboration meeting Dr Cham Ghag from the University College London (UCL) compared the Mirion BEGe6530 detector in S-ULB cryostat with two world known reference detectors homemade specifically by MPI in Heidelberg for the Gran Sasso underground lab (LNGS) in Italy. It is important to highlight how close the Mirion S-ULB detector (called Roseberry) comes to the GATOR and GeMPI detectors recognized as world reference detectors, with respect to background performance.

Enery [keV]	Chain/nuclide	Counts/day		
		Gator	GeMPI	Roseberry
239	$^{232}Th/^{212}Pb$	<0.5	–	<0.3
911	$^{232}Th/^{228}Ac$	<0.5	<0.2	<0.3
352	$^{238}U/^{214}Pb$	0.7±0.3	<0.5	1.1±0.4
609	$^{238}U/^{214}Bi$	0.6±0.2	0.50±0.45	0.6±0.3
1120	$^{238}U/^{214}Bi$	0.3±0.1	–	<0.3
1765	$^{238}U/^{214}Bi$	0.08±0.06	–	<0.3
662	^{137}Cs	<0.5	–	<0.3
1173	^{60}Co	0.5±0.1	0.6±0.4	0.8±0.3
1332	^{60}Co	0.5±0.1	0.6±0.3	1.2±0.4
1461	^{40}K	0.5±0.1	0.6±0.4	0.5±0.3
2615	$^{232}Th/^{208}Tl$	0.2±0.1	–	<0.3

"Roseberry" is a nickname of a Mirion BEGe6530 with S-ULB cryostat (delivered in fall 2017)

"GATOR" (2010) and "GeMPI" (2005) are nicknames of 400 cc HPGe detectors with highly customized cryostat designed by MPI scientists in Heidelberg for the Gran Sasso underground Lab in Italy.

Credit: 'STFC-Boulby Underground Laboratory' and the 'UCL, High Energy Physics Group'

Mirion Specialty Ultra Low Background "S-ULB" detectors

continued

S-ULB detectors with ultimate background and without any compromise towards spectroscopy performance

- BEGe detector offer in S-ULB configuration :
  - Active large diameter 100 mm or more
  - Active thickness 40 mm or more
  - Thin entrance window not sensitive to heat cycling nor long term storage at room temperature.
  - iPA unit: intelligent room temperature preamplifier
  - S-ULB hardware for use in underground facilities.
  - Electrical cooling with Cryo-Pulse 5 Plus cryostat
  - LabSOCS Calibration Software characterization
  - High purity Aluminum or OFHC copper.

Example of a 1.2 kg BEGe detector in S-ULB configuration, delivered to IAEA MEL.

- FWHM 590 eV at 122 keV
- FWHM 1.65 keV at 1.33 MeV
- Relative efficiency 66%

Lead time four months after drawing approval.

Array detector with three PCGe detectors to be dipped in LAr

SAGe PCGe detectors

Underground nuclear scientific research demands Ge detectors with large active volume and low noise. For astroparticle and neutrino physics based on rare event search by direct interaction measurement within the Germanium crystal.

Electronic noise contributes significantly to the performance of a Ge detector and limits the overall energy resolution performance.

Mirion developed SAGe detectors in S-ULB configuration to offer:

- Large crystal sizes: 1.5 kg or larger
- Typical energy resolution 50 eV (FWHM with pulser).
- Energy threshold of about 150 eV.
- Complex assemblies of several detectors in S-ULB probes to be dipped directly in LN_2 or LAr.
- One or two preamplifiers per crystal (readout on both contacts for signal vetoing).
- Compact front cryostat without any flange for close veto detector operation.
- Electrical cooled SAGe for LN_2 free operation without any compromise on performance.

PCGe detector with readout preamplifiers on both detector contacts

PCGe detector with electrical cooling and customized copper cryostat

SAGe™ Well in S-ULB cryostat

S-ULB SAGe Well detector offer:

- Active volume > 250 cc – usefull well diameter 21 mm
- Active volume > 400 cc – usefull well diameter 21 mm

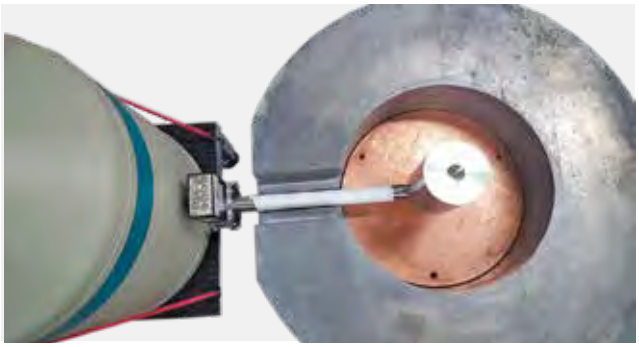
"U" style cryostat with LN_2 cooling (30 or 50 liter Dewar) or Cryo-Pulse 5 Plus cryostat

FWHM performance for S-ULB SAGe Well detectors:

- At 1.33 MeV: < 2.10 keV
- At 122 keV: < 750 eV

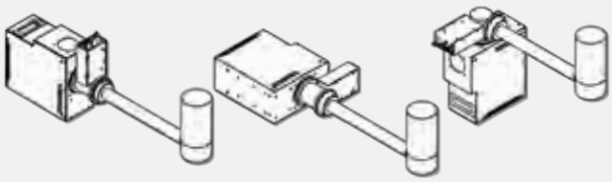
Measurement conditions:

- 1000 counts per second
- Gaussian shaping time 6-12 µs (analogue electronics) or Lynx Digital Signal Analyzer electronics



Electrically Cooled S-ULB detectors

Mirion is offering high reliable pulse tube cooler technology originally used in military and space applications and which has proven its value for germanium detectors. For Specialty Ultra Low background (S-ULB) systems it could demonstrate a very safe operation mandatory in underground labs and no compromise on detector performance even on high sensitive Well or SAGe detectors.



Several cryostat configurations and cooler position are possible to accommodate local constraints at a customer site. A "cap to cap" two-detector configuration is easily possible within the same lead shield.

Mirion Specialty Ultra Low Background "S-ULB" detectors

continued

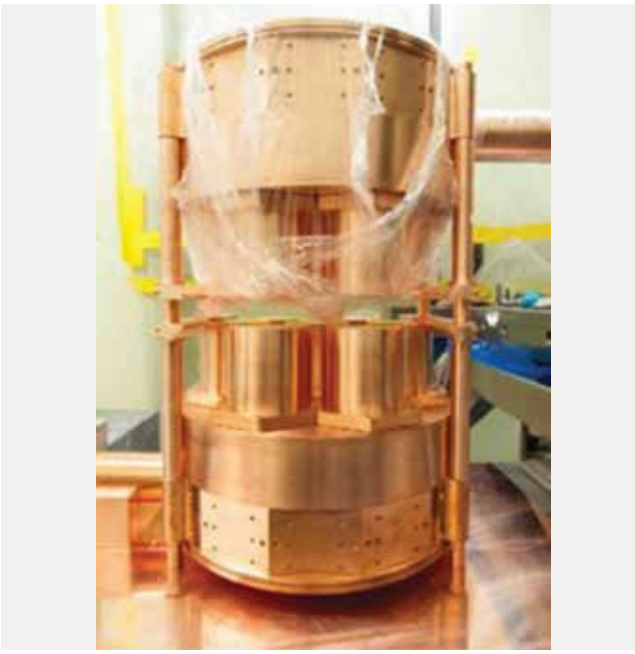


Photo courtesy of Prof YeongDuk Kim – IBS

Array S-ULB Detectors

Example of array detector system to increase drastically the MDA with a two detector system and a total of 14 HPGe crystals with highly selected materials.

Features are:

- 14 detector elements of 70% relative efficiency
- Global relative efficiency 980%
- High sensitivity measurement of U + Th contamination (see table below)

Applications are:

- Assay of MoO_3 enriched powder
- Rare decay exploration like ^{180m}Ta with T1/2 > 4,5 1016 years).

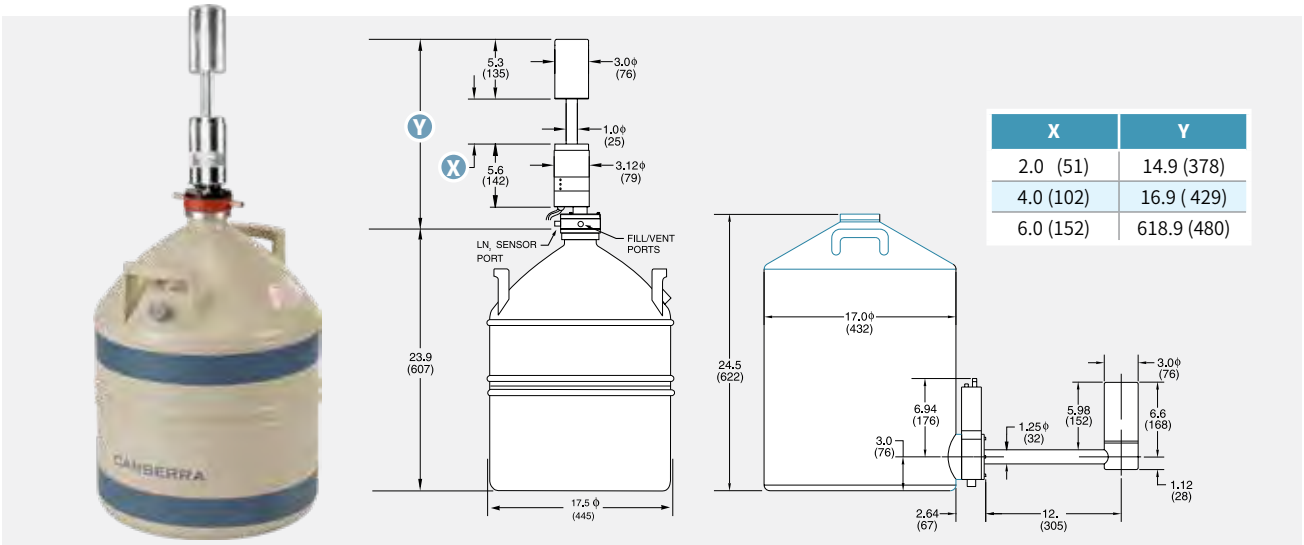
Isotopes		Peak(keV)	Efficiency (%)
^{232}Th	^{228}Ac	911	5.8
		968	5.5
	^{212}Pb	238	9.7
	^{212}Bi	727	6.8
	^{208}Tl	2616	2.0
		583	4.7
		860	4.7

Information by courtesy of Dr Elena Sala – IBS – published at LRT2017

Mirion is recognized by the scientific community as a world leader of array detectors. In the 1990s, Mirion developed the Clover detectors an array of four crystals closely packed and the Euroball cluster with seven encapsulated detectors. Mirion also has array detector solutions available to combine several HPGe crystals together in a special S-ULB cryostat compatible with underground labs constraints. The goal of the design shown above is to find an ideal arrangement for record efficiencies for exotic nuclide exploration of the decay schemes in the ideal conditions of an underground lab.

Lower 7-element detector

Upper 7-element detector



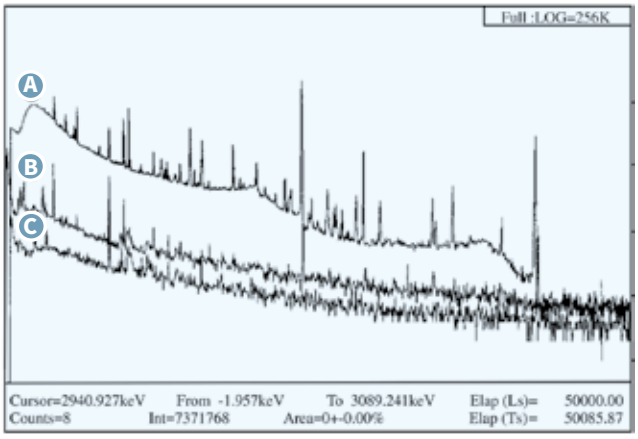
X	Y
2.0 (51)	14.9 (378)
4.0 (102)	16.9 (429)
6.0 (152)	618.9 (480)

ULB (Ultra Low Background) series

Extremely low background cryostat to be used at sea level, using carefully selected materials to provide a very low background environment.

Features are:

- Aluminum-99.999% guarantees thorium and uranium below 1 ppb
- Copper-99.99% (better than standard OFHC)
- Stainless steel Co-60 low content carefully selected
- We adopt composite carbon window of almost zero background
- Compatible with Mirion Ge detectors (GC, GR, GX, GL, GCW, GSW, BE)



Typical spectral values:

- A No shielding,
- B Standard cryostat (model number: 7500SL) and 10 cm thick lead shield (Model: 747),
- C Extremely low background cryostat (model number: 7915-30 ULB) and 15 cm thick ultra low background lead shielding (Model: 777)

Customized Software for Japan Market

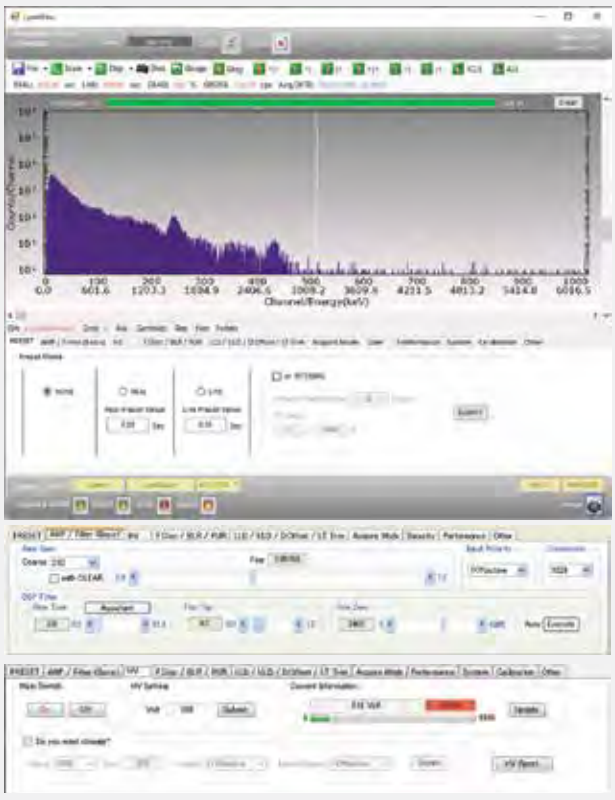
LynxNavi™ software for specialized measurements in Japan

Features are:

- Complete user interface for all functions of a high precision digital MCA
- Use a dedicated SDK independent of the Genie 2000 Gamma Analysis Software
- Designed for a variety of custom base applications
  - PHA spectral mode
  - MSS mode
  - DLFC mode (Lynx only)
  - LIST/TLIST mode

User interface for all functions of a high precision digital MCA:

It has a complete graphical user interface that allows you to operate all the features of the latest Mirion digital MCAs.



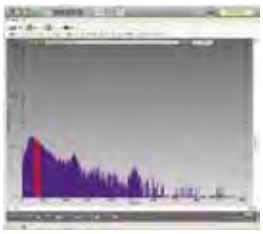
Use a dedicated SDK independent of the Genie 2000 Software:

A Genie 2000 software key was needed to communicate with the Genie 2000 MCA. This program uses a dedicated SDK and communicates directly with the MCA, so it is lightweight and allows for high-speed processing.

Various custom base applications:

Only the basic operations of intuitive measurements are implemented to form the basis for various custom programs.

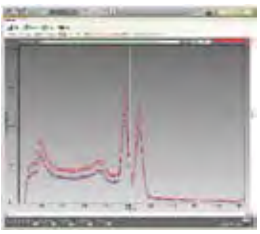
All measurement modes are available:



PHA mode

This is the most basic measurement mode.

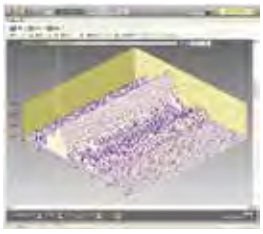
Can be used in a variety of custom programs. Repeated measurements can be taken and data can be automatically saved to a text file.



DLFC mode

This emulates the loss-free measurement mode based on the VPG (Virtual Pulse Generator) method.

The basic operation is the same as the PHA measurement mode, but the loss-free corrected spectrum (red) is displayed simultaneously with the normal PHA spectrum (blue). Therefore, you can visually observe the count components that are originally lost as dead time.



MSS mode

Real-time energy spectrum information is maintained and displayed in a time slice graph.

The changes in counting that occur at very small times can be observed as an energy spectrum, rather than simply as gross counting.

LIST/TLIST mode

It can be observed sequentially as an ADC event. It is also possible to observe ADC events with time of occurrence information.

The spectrum is not displayed during LIST/TLIST mode observation, and events are sequentially displayed at the bottom of the screen. It is possible to save the event to a file at any time by pressing the Capture button.

IN SITU MEASUREMENT

Sealed HPGe Probe for LN_2-free operation in harsh environments

Specialty Ruggedized HPGe Detectors

Features are:

- Hardened design, shock and vibration resistant
- Adapted cooling devices (electrical coolers)
- Encapsulation techniques allowing easy exchange of each individual detector when mounted in arrays
- Waterproof design for outdoor use
- Dedicated shapes and materials for cryostats (hexagonal cutting, titanium lightweight capsules, telescope mount, etc.)
- Ultra-high vacuum for best reliability and thermal cycle-free operation

NaI or HPGe test
Enclose the container
(Completely waterproof)

Shield probe (waterproof NaI detector)

Features are:

- MDA 1 Bq/L (3600 seconds)
- 160 mm diameter, 7 kg
- Completely waterproof
- For underwater measurement of wells, pools, ponds, swamps, lakes, dams, seas, etc.
- Real monitoring of gamma-ray count rate and energy spectrum (Cs-134, Cs-137)
- No installation required, ready for use
- Lead shielding unnecessary
- Cost effective

ISOXSHLD™ In Situ Object Counting System

Features are:

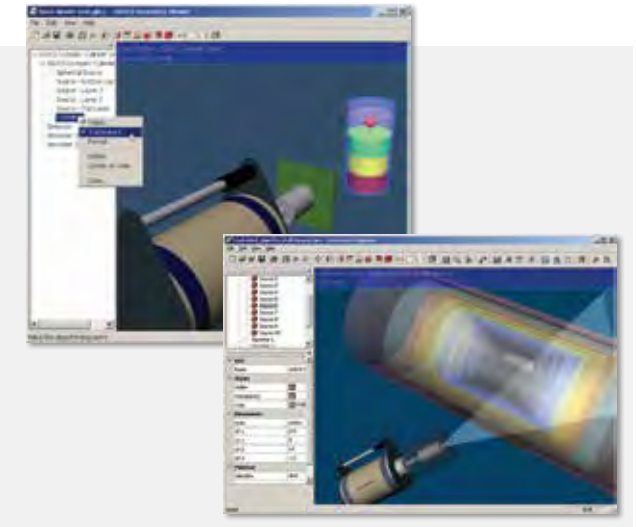
- Portable Germanium detector shield system for in situ assays
- Includes 25 mm and 50 mm thick lead shields
- Reduces interfering 1000 keV radiation by a factor of 7.5 (25 mm) and 60 (50 mm)
- Modular design for easy handling
- Includes 30°, 90°, and 180° collimators (each thickness) plus solid end caps for background measurements
- Includes a rear shield set (requires RDC option on detector)
- Wheeled mounting stand with brakes for ease in moving the shield from one sample to the next
- Large wheels for easy movement: 40 cm (16 in.) at rear, 20 cm (8 in.) in front
- Upper and lower detector mounting positions, with 180° detector rotation at either location
- Easy to assemble and to change detector positions
- Built-in laser aiming device
- Components from 25 mm and 50 mm shields may be combined to build a sample counting chamber

4 In Situ Measurement

Aegis™ Transportable HPGe Spectrometer

Features are:

- Integrated solution combining a thermal cycle-free HPGe detector system, MCA and electronics platform
- Portable and battery-powered with choice of electrically-cooled HPGe detector:
  - Detector options: BE5030, GX40 and GC40 with or without RDC-6 Remote Detector Chamber
  - RDC-6 is compatible with ISOXSHLD Cart
  - RDC-6 is also compatible with standard laboratory lead shields
- Built-in GPS and dual, hot-swappable batteries
- Operation from -20 °C to 50 °C without cooling fans
- IP65-rated enclosure enabling operation in harsh environments
- Access to system through web browser
- Web UI allows:
  - Setup, diagnostics and maintenance
  - Spectrum viewing
  - Firmware updates
  - User account and network management
- Genie 2000 software used for data acquisition and analysis
- ISOCS characterization is available which allows radionuclide activities to be calculated for complicated geometries



S573C ISOCS™ Calibration Software

Features are:

- Eliminates the cost of purchasing, tracking, and disposing of radioactive standards
- No radioactive efficiency source standards needed for accurate efficiency calibrations
- Calibrations valid from 10 to 7000 keV
- Calibrations valid from detector face out to 500 meters
- Sample size can be point-like, or up to 500 meters in size
- Advanced Collimator designs include liners and back shielding
- Calibrations accurate at any angle from detector, not just on center line
- Operates with germanium, scintillation and CZT detectors characterized by Mirion
- Ideal for In Situ applications, where large and various sample types are often encountered
- 3D visualization speeds geometry creation and error identification
- Uncertainty Estimator and Assay Planning tool
- Custom templates can be provided to meet special application needs
- Multi-Efficiency program allows creation of compound efficiencies for multiple detectors, multiple locations or multiple sources
- Compliant with 2009 U.S. NRC Regulatory Guide 1.21

InSpector™ 2000 DSP Portable Spectroscopy Workstation

Features are:

- Full featured portable MCA based on Digital Signal Processing (DSP) technologies
- 16k Channel conversion gain/ spectrum memory
- PHA and MCS modes supported
- Ultra small, ultra lightweight package
- Accommodates a wide dynamic range of count rates, minimal loss of spectrum resolution
- 10 hour HPGe battery life (12 hour NaI)
- Fast USB and highly optimized RS-232 host interfaces supported
- Digital oscilloscope to assist with setup

SPIR-Ace™ RID with the GenieXPort™ Application

Features are:

- SPIR-Ace Radionuclide Identification Device (RID) with GenieXPort application for Genie compatibility
- Ultra-fast and accurate compact identifier
- Simple operation with versatile alarm modes
- Automatic sourceless gain stabilization
- Radiological performance exceeds current standards for RIIDs and RIDs
- Live data transmission and reachback capability
- Optional alpha/beta probe and integrated neutron detection
- Battery life: 4.5 to 15 hours, depending on display use
- Onboard GPS for trajectory and mapping
- Remote display and control via web browser

Each SPIR-SPEC™ package includes:

- SPIR-Ace Radionuclide Identification Device
- GenieXPort application providing compatibility with Genie 2000 software for proven activity determination and reporting
- Generic ISOCS characterization of the SPIR-Ace detector
- Preloaded efficiency calibrations for easy nuclide quantification

- Use ISOCS software to create efficiency calibrations for unique geometries that can be loaded to the SPIR-Ace device as well

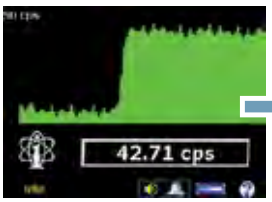
InSpector™ 1000: Hand-held Radionuclide Identifier

Features are:

- High-sensitivity, stabilized* NaI or LaBr probe for a factor of two** better resolution
- Highly sophisticated identification algorithms to maximize positive ID and minimize false ID
- High resolution color touch display for best visibility in any light condition – darkness to bright sunlight
- Detachable probe allows for close survey of possible sources while still viewing instrument
- Built-in remote data transfer
- Compatible with laboratory software for more detailed analysis

* US Patents 7,005,646B1 and 7,049,598
** Compared at 661 keV

Monitor



Locate

Identify and Quantify

4 In Situ Measurement

TRACS™ Transportable Radiation Analysis Counting System

Features are:

- Complete and mobile gamma counting system
- Assembly in less than 10 minutes without tools
- Each item weighs less than 9.1 kg (20 lb); can be transported in a car
- Minimum 1.3 cm (0.5 in.) stainless steel shielding
- Includes Osprey Digital Tube Base and can be used with a variety of standard or temperature-stabilized 2x2 and 1.5x1.5 scintillation detectors
- Includes Camera and GPS and for recording sample images and measurement location
- Operated with Genie-FieldPro software for ease of sample counting and automated analysis by field users

- Automated sample data export to Apex-Gamma System for remote expert review

Genie-FieldPro™ Gamma Spectroscopy Sample Counting Software

Features are:

- Simplified user interface for gamma sample counting by non-experts
- Uses powerful and familiar Genie 2000 analysis algorithms
- Sample count time and analysis automated by user selection of sample size and matrix
- Automated “Clear” or “Above action limit” results report generation
- Single click operation for background check and calibration check
- Automated sample data export to Apex-Gamma System for remote expert review
- Color-coded calibration check and background check status

- Calibration check and background check failure/ overdue lockout
- Count-to-MDA acquisition option
- Can be used with any scintillation detector that is compatible with the Osprey Digital Tube Base
- Optional Camera and GPS integration
- Standard part of TRACS Transportable Radiation Analysis Counting system

Ampo monitor (AMPOSAFE™) Radioactivity measuring device for ampo

Features are:

- Measurement lower limit: 25 Bq/kg or less
- Screening level: 70 Bq/kg or more *
- Measurement time: Minimum 80 seconds **

* Applicable when precision measurement (measurement time extension mode) is used

** Varies depending on the concentration, combination, and type of soot

- Non-destructive inspection formula (no sample extraction required)
- Optimized for each persimmon type, such as Hachiya
- Individual measurement (per tray, per bowl), per box measurement
- Applicable to foods other than Anpo porridge

FOODSAFE™ (food safe) agricultural products radioactivity measurement system

Features are:

- Non-destructive inspection
- Radioactivity measurement in 30 kg rice bag
- Easy operation (start, stop, display results by color, can be installed anywhere)
- Operating temperature in harsh environments
  -10 °C ～ + 50 °C
  Humidity <90%, ambient radioactivity <2 µSv/h
- Applicable to fruit such as peaches, apples and pears
- Shield: 10 cm thick iron
- Detector: High efficiency, large sodium iodide (NaI) detector adoption

Section 5

WASTE MANAGEMENT AND CRITICALITY SYSTEMS

Integrated Crate Interrogation System

Waste disposal is a major concern, whether a facility is operational and routinely generating radioactive wastes or closed and undergoing decontamination and decommissioning (D&D). The ability to accurately measure and characterize the nature of radioactive waste is critical to minimize associated costs and environmental impact.

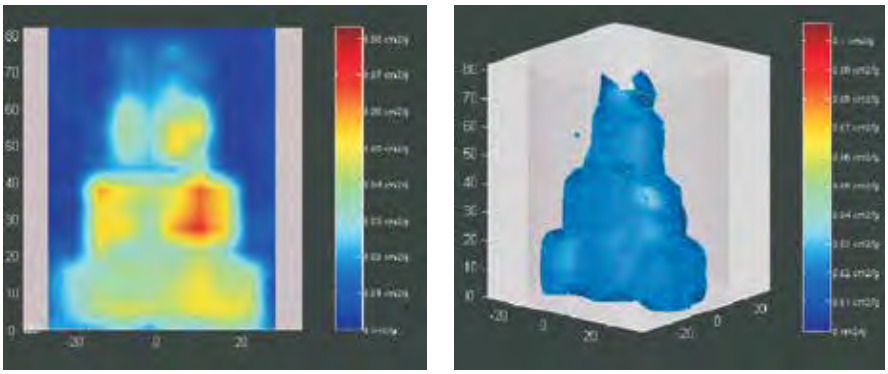
By working closely with nuclear facilities and regulatory agencies worldwide, Mirion has developed an advanced family of assay systems that can effectively measure materials in the widest variety of matrices and container geometries. In fact, Mirion has designed, built and operated waste assay systems for many years. This wealth of experience goes into all systems offered now and in the future.

For systematic waste characterization and disposal, a system including one or more Germanium detectors is recommended. Systems of this type include WM2100, WM2200 and WM2900 Series gamma scanners for drum or small boxed wastes. The WM2500 Series Gamma Box and Container Assay System is appropriate for measuring large volumes of low to moderately contaminated material, such as debris from D&D operations, in a short amount of time.

Additionally, the Hybrid K-Edge/XRF Analyzer is used by the safeguards community for routine special nuclear material inspections. All these systems offer excellent sensitivity along with simple, operation and built-in record keeping.

The systems themselves are offered by the Mirion Detection and Measurement Division which include spectroscopy building blocks such as detectors, MCAs and Genie 2000/ISOCS software originate from Mirion. All items are integrated, tested and calibrated as a system before shipment.

Mirion can offer standard or customized solutions for performing gamma, neutron or gamma and neutron waste or safeguards measurements to suit any application. The systems described in this section are just a few examples.



NDA 2000 Non-Destructive Assay Software and WM2900 Drum Scan

5 Waste Management and Special Systems

WM2100 Series Q2™ Qualitative and Quantitative Gamma Waste Assay System

Features are:

- Provides qualitative and quantitative gamma assays for waste in 208 L (55 gal) drums or similar sized boxes
- Sensitivity better than 370 Bq (10 nCi) for 208 liter (55 gal) drums
- Factory calibrated for turnkey operation, and includes QA check source and holder
- Low background 10 cm (4 in.) steel shield
- Automatic weighing system for matrix attenuation corrections due to sample density
- PC-based control and analysis system featuring the user-friendly Mirion NDA 2000™ Waste Assay Software package

Auto Q2™ Low Level Waste Assay System

Features are:

- Complete quantitative gamma analysis for fission/activation products or TRU radionuclides
- Multiple large coaxial or broad energy detectors for optimal performance
- PC-based control and analysis system featuring the user-friendly Mirion NDA 2000 Waste Assay Software package
- ^{239}Pu detection levels <1 mg
- Container sizes up to 208 L (55 gal); optional up to 400 L
- PLC-based electromechanical control system with optional capabilities including:
  - Automatic weighing system
  - Automatic attenuators
  - Automated conveyor system

WM2500 Series Modular Gamma Box and Container Assay Systems

Features are:

- Performs full gamma spectroscopy and accurately characterizes containers of waste
- Saves time and labor by assaying waste in a large container or its shipping container
- Modular design can be configured for samples from B-25 (1 x 1 x 3 m^3) boxes through ISO shipping containers
- Fully assays a B-25 box in 30 min. and an ISO container in 2-3 hours
- 0.01 Bq/g (0.3 pCi/g) typical detection limit for a B-25 box
- Available with manual, powered, or automatic conveyor systems for sample handling
- PC-based control and analysis system featuring the user-friendly Mirion NDA 2000 Waste Assay Software package

WM2900 Series Tomographic Gamma Scanner

Features are:

- Most accurate gamma measurement available for waste drums
- Optimal measurement range is for gram quantities of plutonium or uranium
- Available in manual, semi-automated, and fully automated modes
- Options available for high activity measurements up to 1.0 Sv/h (100 R/h)
- Interactive graphics package provides color plots of hot spots in container
- PC-based control and analysis system featuring the user-friendly Mirion NDA 2000 Waste Assay Software package

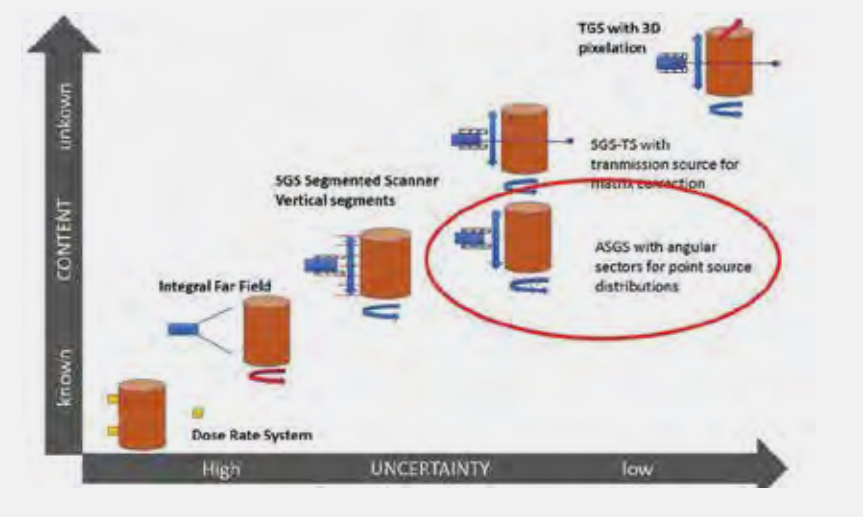
WM2200 Series Segmented Gamma Scanner

Features are:

- Accurate quantification of gamma emitting waste
- Multiple correction techniques for matrix attenuation
- Self-absorption correction algorithms for lump correction
- Calculates Pu and U isotopics using optional MGA™ software code
- High activity versions available for surface dose rates up to 1.0 Sv/h (100 R/h)
- PC-based control and analysis system featuring the user-friendly Mirion NDA 2000 Waste Assay Software package

WM2200 Series Segmented Assay System

SGS™ Standard Segmented Gamma Scanner



ASGS Advanced Sectorial Gamma Scanning

Features are:

- Advanced segment gamma scan system Advanced SGS
- Special algorithm for measuring heterogeneous waste with high accuracy is adopted

ICIS™ Integrated Crate Interrogation System

Features are:

- TRU waste applications for large containers
- System is comprised of a BSGS™ Box Segmented Gamma Scanner providing high resolution gamma spectroscopy, and a BNAS™ Box Neutron Assay System providing passive neutron counting capability, each mounted in its own separate ISO container
- Gamma and neutron assay results are combined to provide an integrated result using the NDA 2000 software multi-modality
- The system can handle crates in sizes up to and including the SLB-2™ Standard Large Box-2 system which has approximate inner dimensions of 2.6 x 1.6 x 1.7 m (L x W x H)
- The system can also be fully calibrated for smaller containers if desired

TRUCKSCAN™ System for soil sorting

Multi-sacks Activity Measurement System using standard trucks.

Features are:

- Fast and accurate measurements: measurement time of 90 seconds for each truck
- Total Measurement Uncertainty (TMU) of the system less than 20% at one standard deviation (SD)
- TRUCKSCAN system can handle flexible volume of each truck. 4-10 sacks per truck
- Measurement speed and accuracy drastically reduce cost and waste volumes

WM2400 Series Large Capacity Decontamination Counter

Features are:

- Decontamination waste including insulation, iron pipes, electric wires, concrete, etc. measurement
- Automatic determination of clean or contaminated
- Automatic operation, high processing capacity
- Large specimen size – 1 m^3 (250 gal)
- Energy and concentration calibration
- Ge detector or NaI(Tl) scintillation detector
- Sample concentration correction by software
- Association of gamma emitters and non-gamma emitters by waste type

IWAS™ Integrated Waste Assay System

The gamma-ray assay system is based on the Q2 concept. Two or more High Resolution Germanium Detectors are mounted on retractable stands that allow the detectors to be inserted into the shield assembly during the passive neutron assay. System can provide plutonium isotopics for very small sources in waste containers. In addition the system can determine other actinides such as ^{235}U, ^{238}U, ^{237}Np, and ^{241}Am.

Features are:

- Transuranic waste facilities
- Combines Multiple Assay Techniques
- 200 liter (55 gal) drums and 320 liter (85 gal) Over-Packs
- MDAs of less than 30 nCi/g
- 27% Efficiency for ^{240}Pu fission neutrons
- 2.8% Active Mode Detection Efficiency
- 10^8 neutron/second Zetatron
- Cosmic-ray rejection algorithm system
- Combined neutron and gamma detection and analysis

Power Cabinet | Processing Cabinet | Alarm Cabinet

CAAS-3S™ Criticality Accident Alarm System (CAAS)

Features are:

- Neutron-only, gamma-only or combined detection capability
- Completely redundant architecture at all system levels
- Response time less than 300 ms per criticality standards
- Multiple zone coverage - 10 zones with 2 out of 3, or 8 zones with 2 out of 4 voting logic
- Continuous state-of-health monitoring on each detector
- Remote supervision
- Qualified under real criticality situations at CALIBAN and PROSPERO reactors of the French Atomic Energy Commission (CEA)
- Complies with the IEC 60860 (2014), ISO 7753 (1987) and ANSI/ANS-8.3 (1997)
- Designed to comply with SIL2 IEC61511

Key Benefits:

- Low false alarm rates
- Negligible operational interruption
- Low maintenance requirements and minimal facility downtime
- Adaptability to various accidents, shielding, legacy installations and regulations through both gamma and neutron detection
- Post-accident monitoring capabilities

Key Design Criteria:

- Reliability
- Response time
- Fault/Failure warning
- Seismic tolerance
- Minimization of false alarms

Applications:

- Fuel Cycle Facilities including enrichment, fabrication, and reprocessing
- Research & Military applications
- Waste & Storage applications

Dependability:

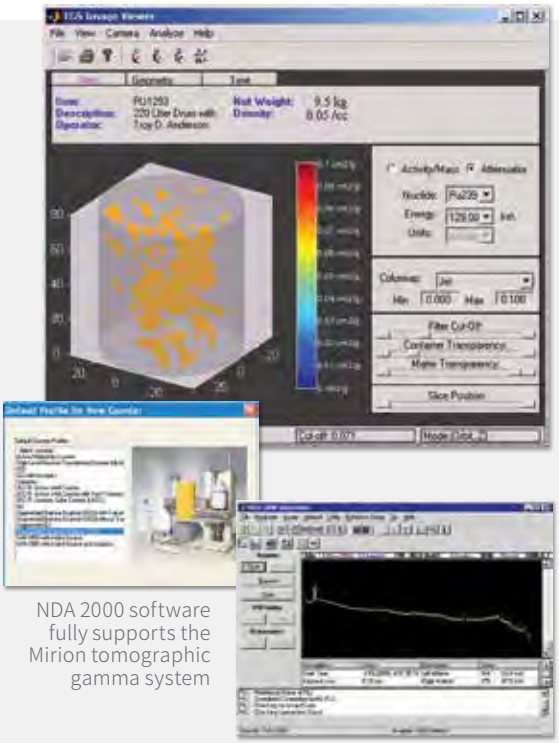
- The CAAS-3S unit is a next generation system based on operational excellence established over forty years. The new design is based on the highly reliable analog signal chain used in the probe design for the previous EDAC-2 and later EDAC-21 products which have had successful safety records and very low false alarm rates. This new system addresses the next several decades of facility operation.

NDA 2000™ Non-Destructive Assay Software

NDA 2000 software is designed to be a complete acquisition, analysis and archival package for use with all Mirion gamma waste assay systems and neutron counters. The software offers fully integrated gamma and neutron analysis for either combined or sequential assay operations and is based on the Genie 2000 Spectroscopy Software Suite providing ease and flexibility of operation. Various counter arrangements, detector arrangements, analysis sequences, hardware control, and reports can be generated from the standard software.

Features are:

- **Data Review -** Customer editable report formats
- **ISOCS integration** - Supports neutron and gamma assay systems — both separate and integrated systems
- Supports all Mirion safeguards and waste assay systems
- Based on Genie 2000 software
- Provides full control of data acquisition electronics
- Controls automated assay system operation
- Menu structure for ease of operation
- Includes automated evaluation of different measurement modalities
- Multi-level password control



NDA 2000 software fully supports the Mirion tomographic gamma system

MGA™ Multi-Group Analysis Software

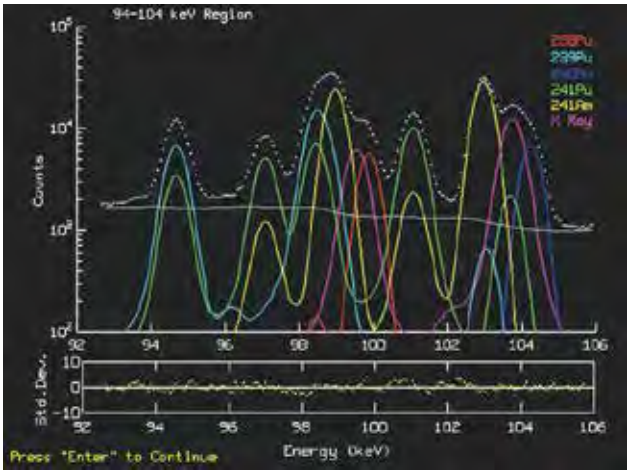
Features are:

- Analyzes the abundance ratio (and weight ratio) of plutonium isotopes
- No calibration required
  - In the case of 4K channel spectrum with a low energy detector, the gain is adjusted to about 0.075 keV/ch.
  - No need for efficiency calibration for sample density/thickness or container properties
- Incorporates advanced peak fitting and multiple deconvolution algorithms for improved accuracy in complex isotope mixture samples
- In addition to Pu, other actinides such as U-235, U-238, Np-237, Am-241 are also analyzed
- Analysis is possible regardless of sample shape/size/composition
- Analyze time-tested samples from fresh samples
- Less than 1% accuracy for short-term measurement and analysis (for safeguard)
- Analysis of U/Pu abundance ratio for MOX samples
- Built into Mirion waste/ safeguard measuring equipment for advanced analysis with minimal operation
- Analysis in either 1 or 2 detector mode
- Built-in “Waste” and “Unusual Isotopics” analysis modes
  - Analysis with insufficient spectrum
- Used in routine measurements at many institutions (IAEA, Euratom)

MGA-U™ Multi-Group Uranium Analysis Software

Features are:

- Analyzing the abundance ratio of uranium isotopes
- Built-in concentration meter mode



SAFEGUARDS ANALYSIS SYSTEMS

Mirion's mostly neutron-only system solutions (some can be used for both Safeguards and Waste measurements) have been developed and are supported by our staff who offer extensive and diverse experience in this field. We are committed to providing the best technologies for the ever-changing demands related to safeguarding nuclear materials.

Mirion has a variety of research and technology transfers with well-known laboratories and institutions. We have developed and provided systems for more accurate measurement of various forms of nuclear material.

Neutron Safeguards Analysis Systems

JCC-12™ Inventory Sample Neutron Coincidence Counter INVS

Features are:

- Authorized for routine inspection use by the International Atomic Energy Agency (IAEA) as the INVS, the Inventory Sample Coincidence Counter
- Designed for passive neutron coincidence assay of plutonium
- High counting efficiency — 35%
- Variable sample cavity size
- Fast Amptek Electronics
- Sixteen ^{3}He detectors
- Transportable
- Optional transport container

JCC-13™/JCC-14™ Sample Inventory Coincidence Counters

Features are:

- Authorized for routine inspection use as the INVS, Inventory Sample Coincidence Counter
- Designed for passive neutron assay of plutonium
- High counting efficiency – 42%
- Variable sample cavity size
- Fast Amptek electronics
- Eighteen ^{3}He detectors
- Transportable
- Optional transport container

JCC-31™ High Level Neutron Coincidence Counter

Features are:

- Designed for passive neutron coincidence assay of plutonium
- Eighteen ^{3}He detectors
- Fast Amptek electronics
- Transportable for inspections at multiple sites
- Optional transport container

6 Safeguards analysis systems

Neutron Waste Analysis System
continued

JCC-51™ Active Well Neutron Coincidence Counter

Features are:

- Designed for active neutron interrogation of uranium
- Variable sample cavity size
- Fast Amptek electronics
- Forty-two ^{3}He detectors
- Passive counting of plutonium when the AmLi sources are removed
- Optional transport container

JCC-61™/JCC-62™ Universal Fast Breeder Reactor Subassembly Counters

Features are:

- Authorized for routine inspection use by the International Atomic Energy Agency (IAEA) as the Universal Fast Breeder Counter (UFBC)
- Designed for passive neutron measurement of plutonium in fast breeder reactor fuel subassemblies
- Fast Amptek electronics
- Twelve ^{3}He detectors
- Transportable

LEMC™ Large Epi-Thermal Multiplicity Counter

Features are:

- Designed for quantitative passive neutron analysis
- High Efficiency: >50% for ^{240}Pu spontaneous fission neutrons
- Fast Die-Away Time: 24 µs
- Improved measurement precision
- Large Sample Cavity accommodates samples up to 40 L
- Fast Amptek electronics
- Low deadtime: 41 ns
- Internal De-randomizing Board
- Operated using JSR-14™ shift registers
- Available with NDA 2000 software

JCC-71™/JCC-72™/JCC-73™ Neutron Coincidence Collars

Features are:

- Designed for neutron coincidence measurement of uranium in PWR, BWR and CANDU fuel assemblies, or plutonium in MOX fuel assemblies
- Variable sample cavity size (Model JCC-71 unit)
- Fast Amptek electronics
- ^{3}He detectors
- Transportable
- Optional transport container
- Authorized for routine inspection use by the International Atomic Energy Agency (IAEA) as the Uranium Neutron Collar (UNCL and UNCL II)

JCC-71 Collar (Passive) JCC-72 Collar (Active) JCC-73 Collar (Active)

PSMC-01™ Plutonium Scrap Multiplicity Counter

Features are:

- High efficiency: >50% for ^{240}Pu spontaneous fission neutrons
- Die-away time: 50 µs
- Uniform axial response profile
- Sample Cavity 19.7 x 41 cm (7.8 x 16.1 in.) (D x H)
- Custom pre-amplifier electronics for fast-processing and low-noise
- Operated using Mirion JSR-14 and JSR-15™ shift registers
- Includes internal de-randomizing board
- Available with NDA 2000 software
- Higher efficiency versions available (greater than 60%)

JCC-41™ Flat-Squared Neutron Coincidence Counter

Features are:

- Well-type neutron coincidence counter for in-plant applications
- Special design features give uniform spatial response axially over the sample cavity
- Relatively insensitive to sample matrix effects
- Relatively flat neutron energy response
- Twenty-four ^{3}He detectors
- Fast Amptek electronics
- Large (61 x 24 cm) sample cavity
- Exterior neutron shielding
- Unit's high efficiency (>22%) provides high counting rates and good precision
- Response is better than 28 counts/sec per gram ^{240}Pu (a 1000 second counting time gives a precision of 2.4% for 0.06 gram ^{240}Pu)*

* Menlove, H.O., Palmer, R., Eccleston, G.W., and Ensslin, N. (1989). Flat-Squared Counter Design and Operation Manual. Report LA-11635. Los Alamos, New Mexico: Los Alamos National Laboratory.

WCAS™ Waste Crate Assay System

Features are:

- Combines multiple assay techniques
  - Passive neutron multiplicity coincidence counting
  - High resolution isotopic gamma-ray analysis
- Crate sizes up to 1660 L (1.4 x 1.4 x 1.2 m)
- Scalable to larger containers
- Fully automated operation and analysis
- 18% efficiency for ^{240}Pu fission neutrons
- MDAs of less than 6 mg ^{240}Pu
- Multiple HRGS detectors
- ^{252}Cf Add-A-Source moderator correction
- NDA 2000 Non-Destructive Analysis Software

6 Safeguards analysis systems

Neutron Waste Analysis System
continued

WM3100 HENC™ High Efficiency Passive Neutron Counter

Features are:

- 208 L (55 gal) drum counter
- >30% efficiency
- <0.7 cps coincidence background at sea level
- MDAs of less than 20 nCi/g
- Automated loading and unloading
- Add-A-Source correction
- Coincidence or multiplicity counting

WM3210 Passive/Active Neutron Cf-252 Shuffler™ System

Features are:

- Unique ^{252}Cf Shuffler mechanism for both Active and Passive neutro coincidence counting of 200 L drums
- Active mode sensitivity[1], 1000 second count time:
  - Fast neutrons: 300 mg ^{235}U
  - Thermal neutrons: 3 mg ^{235}U
- Passive mode sensitivity[1], 1000 second count time: 4 mg ^{240}Pu
- Rugged mechanical design for in-plant use
- Fast Teleflex source shuffling mechanism with 400 ms transfer time
- Three rpm turntable for barrel rotation
- Sixty-four ^{3}He tubes for 17.5% detection efficiency
- PC-based control and analysis system

[1] Los Alamos National Laboratory Application Note The ^{252}Californium Shuffler, March, 1990.

WM3400 Passive Neutron Slab Counter

Features are:

- Designed for passive neutron go/no-go measurement of plutonium in 200 L (55 gal) drums
- Drum positioner on front of polyethylene body for repeatable positioning of counter
- Fast Amptek electronics
- Six ^{3}He detectors
- Transportable

WM3500 Curved Passive Neutron Slab Counters

Features are:

- Designed for quantitative passive neutron analysis
- Suitable for go/no-go measurement of plutonium
- Flexibility geometry for assay of pails, drums or large objects
- Expandable – additional slabs can be connected to improve performance with large samples
- Fast Amptek electronics
- High efficiency >19%
- Sensitivity – detection levels of <50 mg W.G. Pu
- All HDPE moderator enclosed in stainless steel skins
- Transportable
- Free standing detector assemblies
- Operated using JSR-12™ shift registers
- Available with NDA 2000 software

Gamma Ray and/or Neutron Waste Analysis Systems

PIMS PuO_2 detection system

Features are:

- PuO_2 canister verification system
- Simultaneous processing of passive neutron coincidence counting and gamma-ray isotope ratio measurement
- Verification of up to five plutonium in stainless steel canister
- Abundance of plutonium isotopes and fission products by MGA analysis code
- Ge detector position control by computer and manual
- Telescope Ge detector (For a single cryostat, a 12% efficient coaxial Ge detector and incorporating a low energy Ge detector)
- Neutron measurement with twelve ^3He detectors

HKED™ Hybrid K-Edge/ XRF Analyzer

Features are:

- Used for routine inspections by the international safeguards community
- Non-destructive, on-site analysis of heavy elements in a wide variety of materials, including highly radioactive samples
- Analysis for several elements simultaneously
- No sample preparation required
- Only 2 mL of the sample material is needed
- Precision typically better than 0.5%
- Typical assay time of 5 to 20 minutes
- Hybrid K-Edge software offers fully integrated operation, measurement, calibration and analysis capability for HKED systems
- Capable of analyzing U:Pu 1:1 MOX (high concentration – generalized KED analysis)

Other Instrumentation Products and Systems

* Portable Multichannel Analyzer With NaI Detector (IAEA/SG-NDA 5)
** Portable Multichannel Analyzer With HPGe Detector (IAEA/SG-NDA 13)

IMCA InSpector Multichannel Analyzer

Features are:

- Provides measurement/confirmation of uranium enrichment using the enrichment meter technique
- Based on Brookhaven/Los Alamos designs for use by the IAEA
- Provides complete functionality of IAEA PMCN* and PMCG** procedures
- ^{239}Pu detection levels <1 mg
- Available with following detector types:
  - ^{241}Am seeded NaI(Tl) detector (both characterized and uncharacterized for temperature drift)
  - Normal NaI(Tl) detectors
  - HPGe detectors
- Available in general user or special IAEA format

JSR-15 rack-mounted version

JSR-15™ Handheld Multiplicity Register (HHMR)

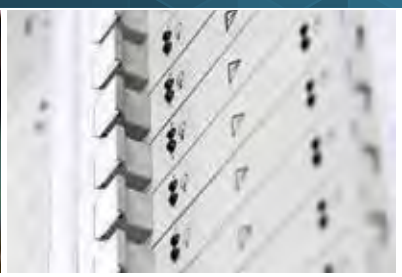
Features are:

- Fast clock rate for high count-rate applications (>10 times that of pre-existing instruments)
- 512 channel histogram of multiplicity data
- Battery-operated with extended battery life
- Compact size and lightweight for greater portability
- USB communications
- Both TTL and differential input options
- Compatible with the INCC (IAEA Neutron Coincidence Counting) and NDA 2000 software packages
- Multi-Instrument Collect (MIC) compatible
- Applications include: Nuclear Safeguards, Process Monitoring, Nuclear Waste Assay
- Complies with current EU directive for CE marking and current FCC(UL)/CSA 61010-1 directives for NRTL certification

MIRION TECHNOLOGIES

Section 7

RADIATION MONITORING SOLUTIONS

SUSTAINABLE, RUGGED SYSTEMS COMPLIANT TO THE MOST RIGOROUS STANDARDS AROUND THE WORLD

Control and reactor protection

- In-core & out-of-core Control (neutron flux channels)
- Boron meters

Barrier Monitoring

- Primary circuit/water monitoring
- Spectrum analysis monitors
- Steam generator tube rupture monitoring

Effluent Release Monitoring

- Alpha and Beta particulates monitors
- Iodine monitors
- Noble Gas monitors
- Tritium monitors
- Stack monitors
- Liquid monitors

Area Monitoring

- Dose rate measurement
- Post-accident contamination monitoring

Operational measurement

- Irradiation monitoring in pipes, sleeves and drums

Effluent Release Monitoring

iCAM MF (Moving Filter) monitor

Standard iCAM monitor on trolley

Standard iCAM monitor on bench

Standard iCAM monitor on wall mount

iCAM™ Alpha/Beta Particulate in Air Monitor

Features are:

- For environmental monitoring or stack/duct discharge monitoring
- Simultaneous alpha and beta particulate monitoring in one instrument
- Alpha measurement range: $1E^{-3}$ to $9E^{3}$ Bq/m^3 (1 hour averaging)
- Beta measuring range: 1 to 3.6E5 Bq/m^3 (1 hour averaging)
- Lowest false alarm rates due to unique radon compensation algorithms
- Dynamic gamma compensation
- Rapid response to accidental releases – typical 5 DAC-hr alpha alarm in five minutes
- Rugged construction and high reliability
- Comprehensive I/O facilities (RS-232 and RS-485, 4–20 mA, 4 x relays, etc.)
- Card mounted changeable filter for ease of handling or filter roll with automatic filter advance for long term unattended operation (up to six months)
- Mobile/portable/wall mount systems available

iCAM/MF Moving Filter Head for iCAM Monitor

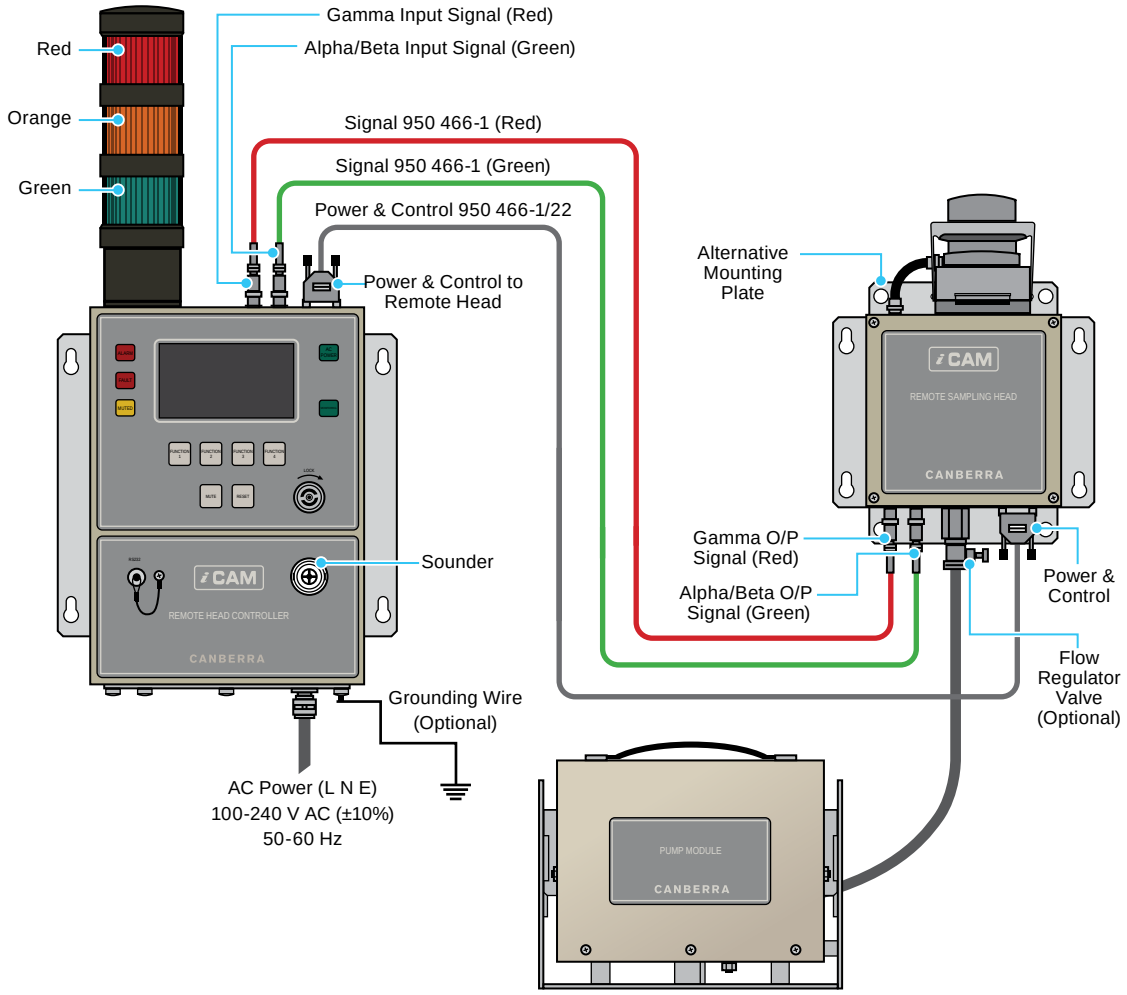
Features are:

- Automatic filter change mechanism
- Up to six months autonomous operation
- Retrofittable to existing iCAM monitors
- Automatically detected and configured

Photo by courtesy of TEPCO

iCAM/RH – Remote head

(Available with fix and moving filter head)



Effluent Release Monitoring
continued

ABPM 201S™ Seismic Alpha Beta Particulate Monitor

The ABPM 201S monitor has been developed to sample air extracted from ventilation ducts or stacks. A double silicon detector performs the gamma compensation and a radial fin grid limits the scattering of the alpha particles (static compensation) which facilitates the compensation of the radon and thoron solid progenies by the processing algorithms (dynamic compensation). Operating costs are minimized by the autonomous operation through automatic filter advance management.

Features are:

- Measurement range:
  - Alpha: 10^{-2} to 3.7 10^{6} Bq/m^3
  - Beta: 1 to 3.7 10^{6} Bq/m^3
- Energy range:
  - Alpha: 2 MeV to 10 MeV
  - Beta: 80 keV to 2.5 MeV
  - Gamma: 80 keV to 2.5 MeV
- Temperature range: -5 °C to +55 °C
- Flow rate: 35 l/min

Standards :

- Nuclear: IEC60761
- Environmental: IEC/IEEE 60780-323, RG 1.97
- Seismic: IEC60980, IEEE344
- EMC: 2014/30/EU and 2014/35/EU, EPRI 102323, MIL STD 461, IEC61000-6-2 and IEC61000-6-4

IM 201S™ and IM 201M™ Iodine Monitors

Continuously measuring the gamma volumetric activity of radioactive iodine sample, in both molecular and organic forms contained in air drawn from stacks, ventilation ducts or working areas. Can withstand seismic conditions for the 201S version. An NaI scintillation detector faces the activated charcoal cartridge in which radioactive iodine is trapped. The proximity of the detector and the cartridge, enclose within a 4 π/5 cm (4 π/2 in.) lead shielding, serves to optimize detection efficiency.

A radioactive ^{241}Am source built into the NaI scintillator allows compensation of temperature and aging related drifts. The spectrometry capability, based on a 1024-channel spectrum analysis, allows radio iodine isotope localization.

Features are:

- Detector: 1.25 x 1 in. NaI(Tl) scintillator + PMT
- Measurement range : 3.7 to 3.7 10^{+6} Bq/m^3
- Energy range: 100 keV to 3 MeV
- Normal temperature: +5 °C to +40 °C (+41 °F to +104 °F)
- Temperature limit: -5 °C to +55 °C (+23 °F to +131 °F)
- Standards
  - Nuclear: IEC60761
  - EMC: 2014/30/EU and 2014/35/EU, IEC61000-6-2 and IEC61000-6-4

NGM 203S™ Seismic High Range Noble Gas Monitor

Designed for accident and post-accident conditions.

Features are:

- Durable detector without any electronic or radiation degraded component
- 1E qualification and embedded safety related software
- RG 1.97 and IEC60951 compliance
- Available under 10 CFR 50 App. B, ASME NQA-1 and IEC61226 programs for safety related application
- Detector: flow-through ionization chamber (CHMC01)
- Sensitive volume: 100 ml (100 cc)
- Energy range: 5 keV to 3 MeV
- Typical measurement range (for RG 1.97 applications)
  - ^{85}Kr: 4 10^{+6} to 10^{+16} Bq/m^3
  - ^{133}Xe: 10^{+6} to 3.7 10^{+15} Bq/m^3
- Typical measurement range (for IEC60951 applications):
  - ^{85}Kr: 4 10^{+6} to 5.55 10^{+15} Bq/m^3
  - ^{133}Xe: 10^{+6} to 1.85 10^{+15} Bq/m^3
- Standards
  - Nuclear: IEC60951, RG 1.97
  - Environmental: IEC60780, IEEE323
  - Seismic: IEC60980, IEEE344
  - EMC: 2014/30/EU and 2014/35/EU, EPRI 102323, RG1.180, IEC61000-6-2 and IEC61000-6-4

NGM 209M™ Mobile Low Range Noble Gas Monitor

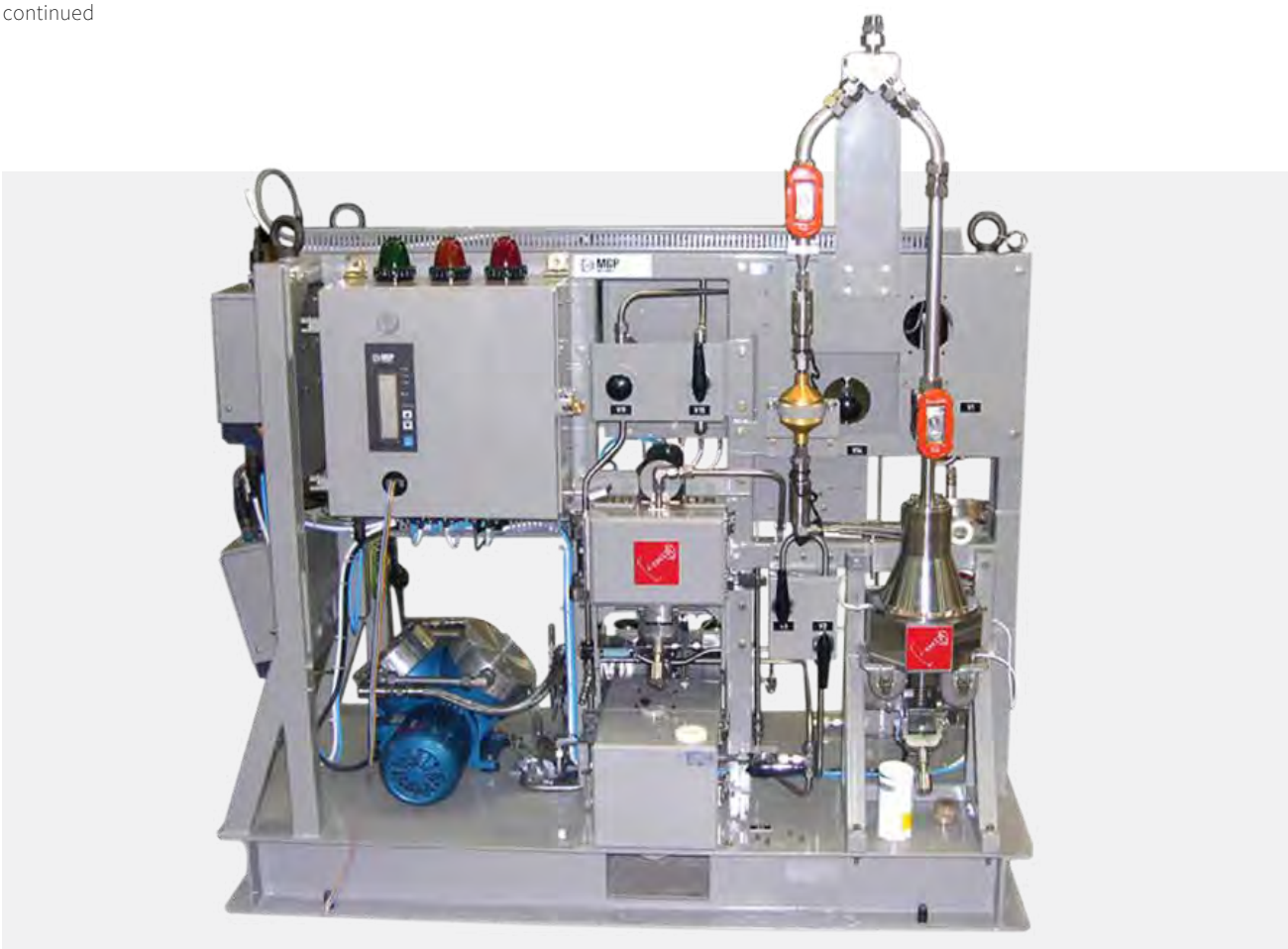
Monitoring air in working areas, discharge stacks or ventilation ducts. The dual silicon diode detector integrated in a 4 π/3 cm (4 π/1.18 in.) lead shielded sample volume guarantees high reliability of the measurements. The first silicon diode detects the beta/gamma radiation from sample volume and the gamma ambient radiation (background). The second one detects gamma radiation from the sample volume and the gamma ambient radiation. This allows noble gas beta measurement with dynamic gamma compensation by the processing algorithms.

Features are:

- Measurement range :
  - ^{85}Kr: 10^{+3} to 3.7 10^{+9} Bq/m^3
  - ^{133}Xe: 10^{+3} to 10^{+10} Bq/m^3
- Energy windows: 80 keV to 420 keV
- Detector: dual large area silicon
- Sampling chamber: 76 ml (76 cc)
- Energy range: 80 keV to 2.5 MeV
- Standards
  - Nuclear: IEC60761-1 and IEC60761-3
  - EMC: EMC: 2014/30/EU and 2014/35/EU, IEC61000-6-2 and IEC61000-6-4

Effluent Release Monitoring

continued



PING 206S™ Seismic Particulate, Iodine and Noble Gas Monitor

Continuously measuring the particulate, iodine and noble gas volumetric activities in stacks, ventilation ducts or working areas. Can withstand seismic conditions. Allows dynamic compensation of radon and thoron progenies.

Features are:

- Particulate (ABPM 201)
  - Radiation detected: alpha, beta and gamma
  - Detector: dual large area silicon (PIPS detector)
  - Filter type: FSLW
  - Typical energy windows:
    - Alpha: 2 MeV to 10 MeV
    - Beta: 80 keV to 2.5 MeV
    - Gamma: 80 keV to 2.5 MeV
  - Typical measurement range:
    - Alpha: 10^{-2} to 3.7 10^{+6} Bq/m^3 (2.7 10^{-13} to 10^{-4} µCi/cc)
    - Beta: 1 to 3.7 10^{+6} Bq/m^3 (2.7 10^{-11} to 10^{-4} µCi/cc)
- Iodine (IM 201):
  - Radiation detected: gamma
  - Detector: 1.25 x 1 in. NaI(TI) scintillator + PMT (SG/NAI 1.25 x 1 in.)
  - Iodine cartridge: 57.7 mm (2.27 in.)
  - Energy range: 100 keV to 3 MeV
  - Typical energy window: 314 - 414 keV (^{131}I, Eγ 364.5 keV) 1024-channel spectrum
  - Typical measurement range: 3.7 to 3.7 10^{+6} Bq/m^3 (10^{-10} to 10^{-4} µCi/cc)
- Noble gas (NGM 204):
  - Radiation detected: beta and gamma
  - Detector: dual large area silicon (PIPS detector)
  - Sampling chamber: 300 ml (300 cc)
  - Typical energy windows: Beta: 80 keV to 2.5 MeV
  - Gamma: 80 keV to 2.5 MeV
  - Typical measurement range:
    - ^{85}Kr: 3.7 10^{+4} to 3.7 10^{+14} Bq/m^3 (10-6 to 10^{+4} µCi/cc)
    - ^{133}Xe: 3.7 10^{+4} to 1.8 10^{+13} Bq/m^3 (10^{-6} to 5 10^{+2} µCi/cc)
- Standards :
  - Nuclear: IEC60761-1-2-3-4
  - Environmental: RG 1.97, IEC/IEEE 60780-323
  - Seismic: IEC60980, IEEE344
  - EMC: 2014/30/EU and 2014/35/EU, EPRI 102323, RG1.180, IEC61000-6-2 and IEC61000-6-4

Tritium Monitors

βionix™ Portable Tritium Monitor

The portable β ionix monitor is intended for the real-time Tritium activity monitoring and other Beta emitters in ambient air. Due to its very high sensitivity, its ergonomics and its reliability, the β ionix portable monitor provides the radiation levels to your teams on decommissioning, construction, process controls, surveillance of premises, etc.

Ready for use, the portable monitor offers the most advanced features, such as: graphical presentation, archiving of data, the postponement of the alarms, etc.

	βionix 3 – MES Manual gamma compensation	**βionix 3 – CMP** Automatic gamma compensation
Measurement range	2.5 kBq/m³ to 2.5 TBq/m³	7 kBq/m³ to 7 TBq/m³
Limit of detection	12.5 kBq/m³	25 kBq/m³
Precision	5% of the reading ± 15 kBq/m³	5% of the reading ±35 kBq/m³
Stability	25 kBq/m³/year	50 kBq/m³/year
Zero offset	±15 kBq/m³	±35 kBq/m³
Noise	±12.5 kBq/m³	±25 kBq/m³
Response time	< 60 sec to 90% of full scale	< 75 sec to 90 % of full scale
Influence of temperature	0.3%/°C of the reading from 8 to 38 °C	0.3 %/°C of the reading from 8 to 38 °C
Volume	660 cc	2 x 300 cc

Mionix™ Mobile Tritium Detector

The mobile tritium Mionix detector is used for real-time monitoring of tritium levels and other ambient beta gases in the air. Mionix detector assures radioprotection for your teams continuously during decommissioning or as a temporary replacement of a fixed monitor.

Features are:

- Measurement range
  - Tritium: 5 kBq/m³ ~ 2.7 GBq/m³
  - Krypton: 600 Bq/m³ ~ 0.3 GBq/m³
  - Radon: 8 Bq/m³ ~ 4.17 MBq/m³
- Accuracy: 5% ± 5 kBq/m³
- Stability: 10 kBq/m³/year
- Response time: 90% of the final value within 60 seconds

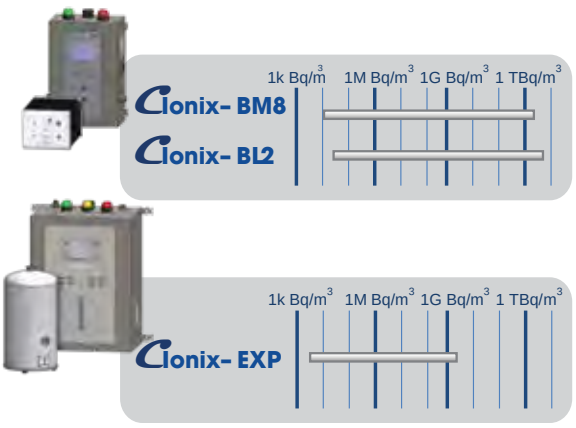
Tritium Monitors
continued

Cionix™ Installed Tritium Monitor

Installed tritium monitor is used to measure continuous activity of Tritium and other β emitters in a gas for all applications of workplace monitoring, decommissioning, stack release or other applications.

Features are:

- Limit of detection of tritium: 5 kBq/m³ (EXP)
- Response time: below 60 seconds
- Stability: 20 kBq/m³/an (BM8), 5 kBq/m³ (EXP)
- Noise: ±15 kBq/m³ (BM8), ±5 kBq/m³ (EXP)
- Precision: 5% of the measured value ±15 kBq/m³ (BM8), 5% of the measured value ±5 kBq/m³ (EXP)



Measurement range for Tritium

HT ionix™ Tritium Bubblers

The range of HT ionix bubblers consists of trappers intended for monitoring levels of concentration of atmospheric tritium HTO (vapor) form and HT (gas).

Features are:

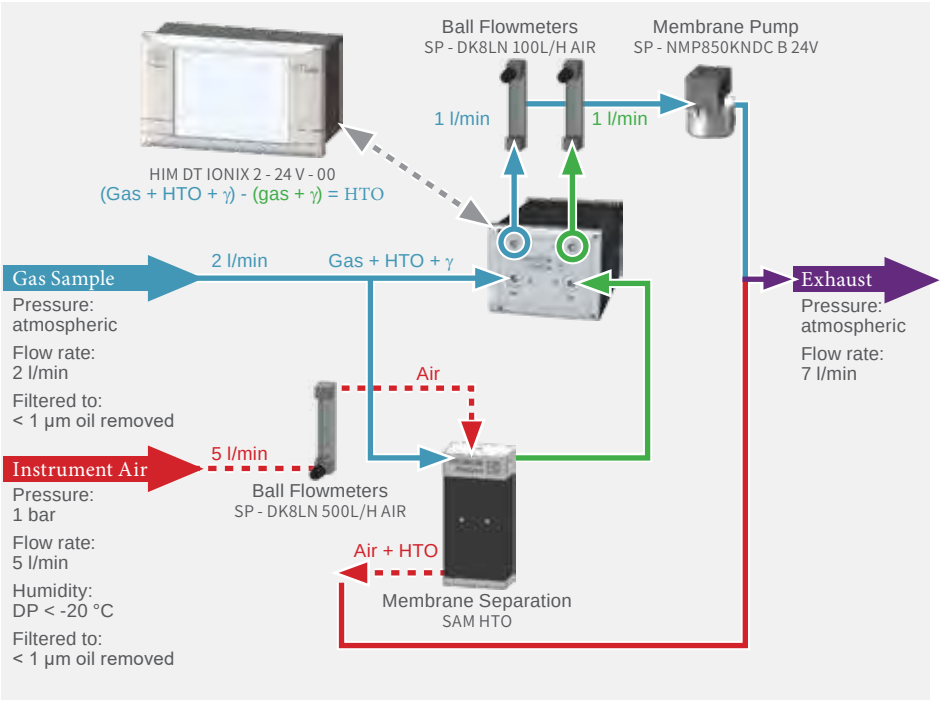
- High trapping efficiency : HT & HTO → > 95%
- For stacks, ventilation systems, surveillance of premises or even environmental applications.
- Simple and robust :
  - Intuitive to use
  - Color touch screen
  - Fast and easy set up
  - No undesirable condensation
  - Leaks detected in real time
  - Limited liquid loss (dedicated technology to follow the dew point)

Cionix™ BLH Installed Tritium Oxide (HTO) Monitor

C ionix monitor– BL2 - HTO is designed to measure continuously the level of Tritium Oxide (HTO) activity in the presence of other β emitting gases including noble gases, for all applications of workplace monitoring, decommissioning, stack release or other applications.

Features are:

- Measurement range: 4 kBq/m³ to 4 TBq/m³
- Limit of detection: 40 kBq/m³
- Detection of puffs in 1 minute from 100 kBq/m³
- Precision: 5% of the measured value ±40 kBq/m³
- Stability: 40 kBq/m³/year



Monitors for Process Control

Sensitive

- Tritium LOD: 5 kBq/m³
- Volume: 4/8 l
- Applications:
  - Exhausts
  - Measurement, Environnemental Protection

Wide range

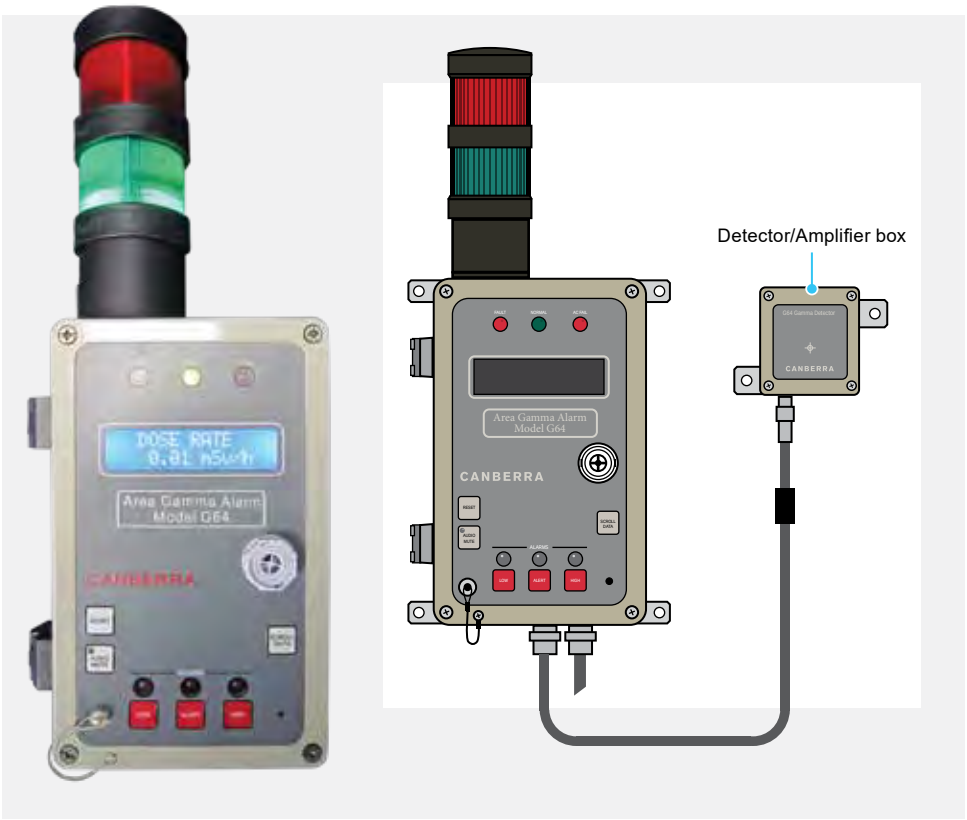
- Tritium LOD: 15/50 kBq/m³
- Volume: 660/180 cc
- Applications:
  - Radioprotection
  - Nuclear Power

High activities

- Tritium LOD: 50 kBq/m³
- Volume: 10/500 cc
- Applications:
  - Nuclear Power
  - Process control

Area Monitoring

G64™ Area Gamma Monitor



Features are:

- Wide range area gamma monitor 0.1 µ Sv/h to 100 m Sv/h (10 µR/h –10 R/h)
- Options for remote detector, high range ion chamber detector to 100 Sv/h (10K R/h), NaI scintillator and ionization chamber.
- Interlock operation built in
- Compact, rugged industrial construction
- High reliability
- Comprehensive I/O facilities (RS-232 and RS-485, 4–20 mA, relays, etc.)

GIM 204K™ Very Wide Range Gamma Area Monitor

Monitoring dose rate in nuclear facilities for personnel exposure or for process monitoring. It has been developed to monitor dose rate or equivalent dose rate in nuclear facilities for personnel exposure as well as for process monitoring. This monitor is available in many versions: with or without display, integral or remote detector, dose rate or equivalent dose rate, fixed or portable, etc.

Features are:

- Detector: silicon (SG/Si(R)11 for Sv/h or SG/Si(R)21 for Gy/h)
- Energy range: 60 keV to 3 MeV
- Typical measurement range (according to IEC60532): 10^{-6} to 100 Gy/h or Sv/h (10^{-4} to 10^{+4} rad/h or rem/h)
- TID
  - Detector: 500 Gy
  - LP(D)U³: 100 Gy
- Normal temperature: +5 °C to +40 °C (+41 °F to +104 °F)
- Temperature limit
  - Processing unit: -5 °C to +55 °C (+23 °F to +131 °F)
  - Detector: -20 °C to +55 °C (-4 °F to +131 °F)

Designed to meet the requirements set forth by nuclear standards: IEC 60532

- Environmental: IEC/IEEE 60780-323
- Seismic: IEEE 344 and IEC 60980
- EMC: 2014/30/EU and 2014/35/EU, EPRI 102323, RG1.180, IEC 61000-6-2 and IEC 61000-6-4

GIM 201K™ Low Range Gamma Area Monitor

Low range gamma area monitor is developed to monitor absorbed equivalent dose rate in nuclear facilities or laboratories for personnel exposure. The ionization chamber made of high density polyethylene allows the measure of short duration pulsed radiation fields when halogenated and/or material activation is an issue.

Features are:

- Measurement range: 10^{-6} to 10 Sv/h
- Energy range: 50 keV to 7 MeV
- Normal temperature range: +5 °C to +40 °C
- TID:
  - Detector: 10^{+5} Gy
  - LP(D)U³: 100 Gy
- Protection index:
  - Processing unit and detector: IP65 and IK07
- Up to 150 meters (492 ft) between detector and processing unit
- Standards:
  - Nuclear: IEC 60532
  - Environmental: IEC/IEEE 60780-323
  - Seismic: IEEE 344 and IEC 60980
  - EMC: 2014/30/EU and 2014/35/EU, EPRI 102323, RG 1.180, IEC 61000-6-2 and IEC 61000-6-4

GIM 203K™ Wide Range Gamma Area Monitor

Continuous monitoring of gamma dose rate under harsh or post-accident environmental conditions. Particularly useful for monitoring the dose rate inside containment and in the reactor building during and after mild and severe accidents under harsh operating conditions.

Features are:

- Measurement range: 10^{-6} to 10^{3} Sv/h
- Energy range: 80 keV to 7 MeV
- TID
  - Detector: 2 10^{+6} Gy
  - LP(D)U³: 100 Gy
- Protection index:
  - Processing unit: IP65 and IK07
  - Detector: IP67 and IK07
- Detector: -5 °C to up to +135 °C
- LOCA profile (detector):
  - +165 °C (329 °F) during 12 hours
  - +225 °C (437 °F) during 2 seconds
  - 7 bars abs. during 12 hours
  - Tested under saturated steam conditions
  - Resistant to chemical spray
- Designed to meet the requirements set forth by the IEC 60951-1&3 _ IEC 60532 standard and by the USA RG 1.97
- Seismic: IEEE 344 and IEC 60980
- EMC: 2014/30/EU and 2014/35/EU, EPRI 102323, RG1.18, IEC 61000-6-2 and IEC 61000-6-4
- For safety related applications class 1E, this monitor has been qualified in accordance with IEEE 323, IEC 60780, IEEE 344 and IEC 60980 standards

Area Monitoring
continued

GIM 206K™ High Range Gamma Area Monitor

Continuously monitoring dose rate under harsh or post-accident environmental conditions. This monitor is designed to meet the requirements set forth by the IEC 60951 standard and by the USA RG 1.97. It is typically used for monitoring high dose rate range during and after mild and severe accidents in nuclear facilities under harsh operating conditions.

Features are:

- Typical operational and measurement range (by default): 10^{-3} to 10^{+5} Gy/h
- Measurement capability: 10^{-4} to 10^{+5} Gy/h
- Energy range: 60 keV to 7 MeV
- TID
  - Detector: 2 10^{+6} Gy
  - LP(D)U³: 100 Gy
- Detector: -5 °C to up to +135 °C
- LOCA profile (detector):
  - +165 °C (329 °F) during 12 hours
  - +225 °C (437 °F) during 2 seconds
  - 7 bars abs. during 12 hours
  - Tested under saturated steam conditions
  - Resistant to chemical spray
- Designed to meet the requirements set forth by the IEC 60951-1&3 _ IEC 60532 standard and by the USA RG 1.97
- For safety related applications class 1E, this monitor has been qualified in accordance with IEEE 323, IEC 60780, IEEE 344 and IEC 60980 standards.

NIM 201K™ Neutron Irradiation Dose Rate Monitor

Monitoring in real time the neutron equivalent dose rate. It provides operational dose rate in units of H*(10) derived from neutron fluence according to ICRU 57 recommendations. The helium-3 proportional counter (cylindrical tube) placed inside a polyethylene sphere detects thermal and fast neutrons. Its large energy range, associated with modular design makes it efficient, reliable and very sensitive. It is used effectively in nuclear reactors, subcritical stacks, neutron generators, irradiators and in accelerator facilities.

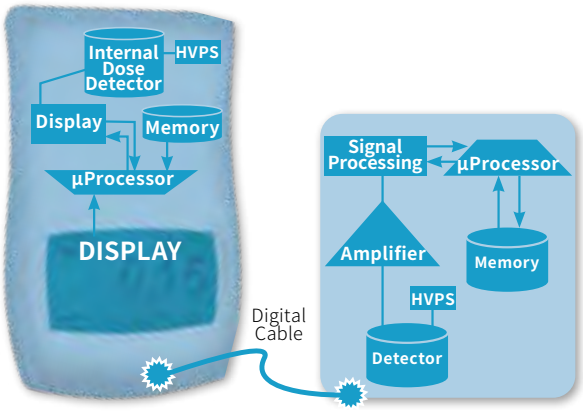
Features are:

- Measurement range (according to IEC 61322): 10^{-6} to 0.1 Sv/h (10^{-4} to 10 rem/h)
- Measurement capability: 10^{-7} to 0.3 Sv/h
- Standards
  - Nuclear: IEC 61322, IEC 61005
  - EMC: 2014/30/EU and 2014/35/EU, IEC 61000-6-2 and IEC 61000-6-4

PORTABLE RADIATION MEASUREMENT

Miron offers dose rate and survey meters for a wide range of users and probes to suit many applications. Generally, health physics users like to invest in one particular instrument so training and expertise can be maximized. Mirion offers handheld instruments for all levels of users, from the technician performing a specific task on site to the highly knowledgeable health physicist. These instruments are focused on particular applications and can be used either as handheld, semi fixed or fixed devices.

With the CSP™ Smart Probe approach, the instrument is selected to match the situation specifics, taking into account that any CSP probe will always be compatible.



CSP and CSPS™ (Canberra Smart Probes Software) shown with the Colibri® and RDS-31™ survey meter

The Mirion CSP™ (Mirion Canberra Smart Probes)

Features are:

- More instruments are available in the field
- Considerably less calibration and set-up time
- 100% compatibility with all CSP compatible instruments
- Reduced total cost of ownership and daily workload
- Reduced need for paper and log books
- Improved accuracy of data transcription

CSP-PL™ CSP Communication Software

Features are:

- Windows based software development kit that allows for integration of CSP probes with a customer's own software application
- Combined with CSP-COM network interfaces, the CSP-PL Programming Libraries allow the user to create a network of CSP probes and to monitor their outputs via a computer

CSP-COM™ CSP Network Interfaces

Features are:

- Enhances CSP probe connectivity by adding Bluetooth® and Ethernet, network interfaces
- Allows unattended remote measurement and monitoring with CSP probes
- Models available for hardwired or wireless connections

The Bluetooth® word mark and logos are registered trademarks owned by Bluetooth SIG, Inc.

Dose-Rate and Survey Meters

RDS-31™ Wearable and Robust Survey Meter

Features are:

- Dose-rate equivalent up to 100 mSv/h (10 rem/h)
- Dual simultaneous Alpha/Beta display with Gamma dose rate
- Scaler/timer to improve MDA (compatible with Easy-Count™ instrument)
- Rugged and waterproof
- Clip and vibrator for hands-free use
- Very long battery life up to 1000 hours
- Connection to external CSP probes
- Contacts for external power with cradle for charging NIHM batteries

Radiagem™ 2000 Meter

Features are:

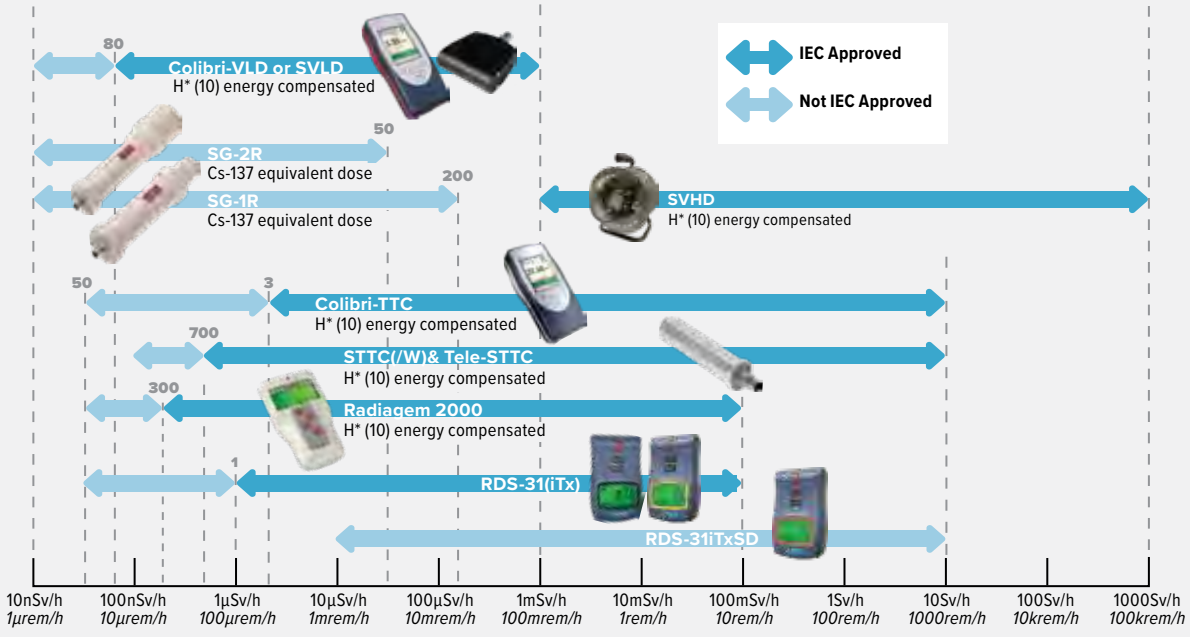
- Measurement of H*(10) ambient dose equivalent rate up to 100 mSv/h
- Easy-to-read and backlit analog bar graph and digital display
- Visual and audible alarms on dose rate and integrated dose equivalent
- External probes for remote measurements, dose rate and surface contamination
- Date stamped data-logging (1000 points in probe memory and 1000 points in Radiagem memory)
- Scaler/timer mode in data-logging
- Lightweight, waterproof and easy to decontaminate
- Rugged and easy to use

RDS-31iTx™ and RDS-31iTxSD™ Telemetry Survey Meter

Features are:

- Dose-rate equivalent up to 100 mSv/h (10 rem/h) with (iTx) and up to 10 Sv/h (1000 rem/h) with (iTxSD)
- Telemetry via WRM2™ communication: 2.4 GHz ISM for Europe and 900 MHz ISM for USA
- Dual simultaneous Alpha/Beta display with Gamma dose rate
- Scaler/timer to improve MDA
- Rugged and waterproof
- Clip and vibrator for hands-free use
- Very long battery life up to 1000 hours
- Connection to external CSP probes
- Contacts for external power with cradle for charging NiHM batteries

Dose rate equivalent measurement ranges

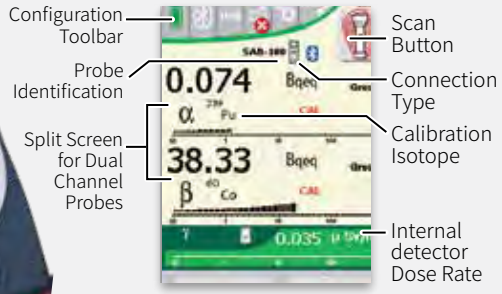


Colibri® Handheld Communication ALARA Platform

Features are:

- Embedded dose detector: VLD for low dose-rate (Red) or TTC for wide range (Grey)
- Mapping application with GPS or barcode reader
- Wired connection for up to eight probes
- Dual simultaneous Alpha and Beta reading with SAB probes

Colibri-TTC Meter Colibri-VLD Meter



AVIOR®-2 and MIP-2™ Digital Desktop or wall mounted Frisker/Integrator

Features are:

- Rugged and simple to use with dedicated buttons
- Scaler/timer to improve MDA (compatible with Easy-Count instrument)
- Back-up built-in rechargeable battery for up to 70 hours
- Dual probe inputs (MIP-2 unit is compatible with previous Nardeux probes with second connector)
- Dual Alpha/Beta display for each input (up to four channel displayed simultaneously)
- Manual or automatic background deduction
- Specific hand/foot mode with body detection

8 Portable Radiation Measurement

Dose-Rate and Survey Meters
continued

CSP-Navi Handy Survey Meter

Features are:

- Easy operation by touch panel
- Shock-resistant SSD terminal
- Quick alarm setting
- One touch transition of Dose rate/Count rate
- Automatic acquisition of calibration for the dose rate conversion
- Photographs by web camera with corresponding white light/night vision
- Standard installation of data logging function

For the efficient decontamination!

Diagram representation of the process.
Contact us for details.

- Area monitoring application: CSP-Navi system
- CSP-Navi system was developed for Japan
- CSP-Navi system displays the measurement data clearly, which is provided along the automatic recording data by barcode

iPIX™ Ultra Portable Gamma-Ray Imaging System

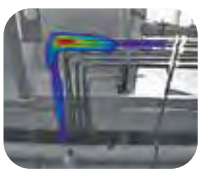
iPIX unit is a unique gamma imager that quickly locates and identifies low level radioactive sources from a distance while estimating the dose rate at the measurement point in real time.

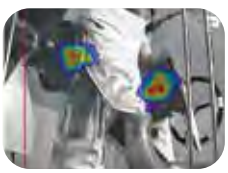
Features are:

- Graphically shows dose rate estimate of hot spots on field-of-view image
- Real-time acquisition and display
- Sensitive for energies down to 30 keV
- Small size and weight for ultra-portability
- Simple and intuitive user interface
- Improves worker safety while reducing dose/time budget
- Rugged industrial design for harsh environments - IP65
- Battery, Power over Ethernet (POE) or AC-powered
- Optional remote-controlled pan/tilt kit

iPIX-NID full option shown

Optional remote-controlled pan/tilt kit





UltraRadiac™-Plus Personal Radiation Monitor

Features are:

- Easy to operate by personnel in firefighting or “HAZMAT” protective gear
- Extremely rugged, metal housing
- Accurate dose measurements with high dose rate protection
- Large, easy-to-read back-lit LCD display
- Audible, visual and vibrating alarms
- Unique “stay time” display shows time remaining for the highest level of individual health and safety
- Configuration by push button or integrated software
- Uses standard AAA batteries; optional rechargeable batteries

BABYLINE 81 Ionization Chamber Survey Meter

Features are:

- Measurement of the absorbed dose rate in six ranges: from 10 µGy/h to 1000 mGy/h and of the absorbed dose in five ranges: from 10 µGy to 100 mGy
- Uniform response from 18 keV to 2 MeV
- 515 cm^3 air ionization chamber with 7 mg/cm^2 tissue equivalent wall and 300 mg/cm^2 removable cap
- Produced under CEA (French Atomic Energy Commission) license
- CTHIR 005 qualification

Top display enables hands-free visual alarm assessment

AccuRad™ PRD Personal Radiation Detector

Features are:

- Sensitive detection for homeland security, law enforcement, and site protection
- Alarms at 0.5 µSv/h within two seconds
- VBS: Authenticates true alarms in variable backgrounds
- Energy range: 25 keV to 3 MeV; detects all radionuclides of concern
- Wide range of measurement and personal protection alarms for emergency response applications
- Energy compensated dose and dose equivalent rate measurements up to 10 Sv/h, accuracy +/-20%
- Compact, body worn device: 200 g, 108 x 61 x 36 mm, clip
- Two AA batteries for more than 900 hours of continuous operation
- Robust: -20 °C to 60 °C, Drop of 1.5 m on concrete, IP67 (dust and 1 m water immersion)
- Bluetooth Low Energy with Near Field Communications (NFC) pairing to smartphone
- Smartphone App available on Google Play Store and Apple Store
- USB type C

SN-D-2 on tripod

SN-D-2™ Neutron Dose Probe

Features are:

- Neutron H*(10) Dose Equivalent Rate
- Complies with public limits control
- Belongs to CSP family
- Calibration via PC
- Easy to carry
- Excellent fit of IEC 61005 and ICRP-74 starting from thermal energy

8 Portable Radiation Measurement

Dose-Rate and Survey Meters
continued

STTC and STTC-W Wide Range Probe

Features are:

- Wide range Gamma dose rate from background up to 10 Sv/h (1000 R/h) with one detector only
- Time-to-Count technology delivers prolonged detector life
- STTC-W waterproof version with 20 m (65 ft) cable on a reel

Tele-STTC™ Wide Range Gamma Telescopic Probe

Features are:

- Wide range Gamma dose rate from background up to 10 Sv/h (1000 R/h) with one detector only
- Time-to-Count technology delivers prolonged detector life
- All extension up to 4.09 meters with available cradles for Radiagem, RDS-31 or *Colibri* units
- Lightweight carbon fiber pole with variable segments locking mechanism

STHF-R™ Ultra High Flux Gamma Probe

Features are:

- Dose-rate equivalent up to 1000 Sv/h (100 000 rem/h)
- Waterproof with 50 meter cable on a reel
- High cumulative dose capability up to 5 kSv with remote electronics
- Compatible with Radiagem™ 2000 Personal Portable Dose Rate and Survey Meter only

Telepole II™ Telescopic Radiation Survey Meter

Features are:

- Color coded display featuring large easy to read digits
- Simultaneous display of external and internal detectors
- Simple multi-layered menu for quick selection of command
- WRM2 communication
- Integrated BT alarm communication:
  - Vibrating Bracelet
  - Earphone
- Aluminum 11 ft Pole with quarter turn positive locking mechanism
- Built-in LED for dark areas being surveyed
- Interchangeable “smart” detector capabilities
- Long battery life (85 hours)
- IP-65 rated meter

CSP™ Smart Contamination Probe Range

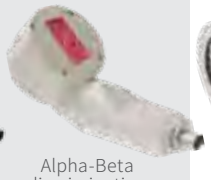
15 cm²

SABG-15+™
GM Pancake

Multi-purpose contamination probe

α β γ

SPAB-15™
***PIPS*® Detector**



Alpha-Beta discrimination in high Gamma background

α/β

20 cm²

SA-20-2™
ZnS Scintillator

SB-20™
Plastic Scintillator

Contamination check in high Gamma background

α or β

32 cm²

SA-32™
ZnS Scintillator

SB-32™
Plastic Scintillator

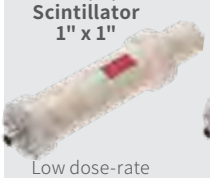
SAB-32™
Plastic/ZnS Phoswich

Personal Alpha or Beta contamination probe

α or β or α/β

Gamma Scintillator

SG-1R™
NaI(Tl) Scintillator 1" x 1"



Low dose-rate and Gamma contamination probe

γ

SG-2R™
NaI(Tl) Scintillator 2" x 2"

Very low dose-rate and Gamma contamination probe

γ

SX-2R™
NaI(Tl) Scintillator 1.5" x 3mm

Low energy Gamma and Alpha contamination check in humid environment

α x γ

Large Area

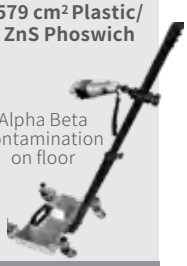
SAB-250™
250 cm² Plastic/ ZnS Phoswich

Large area Alpha Beta frisking or hand contamination check

SABP-525™
525 cm² Plastic/ ZnS Phoswich

Alpha Beta contamination on foot

SABS-579™
579 cm² Plastic/ ZnS Phoswich

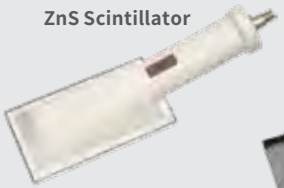


Alpha Beta contamination on floor

α β

100 cm²

SA-100™
ZnS Scintillator



Large area Alpha contamination check

α

SB-100™
Plastic Scintillator

Large area Beta contamination check

β

SAB(G)-100™
Plastic/ZnS Phoswich

Alpha/Beta discrimination on large contamination area and personal frisking

α/β (γ)

Neutron

SN-S™
Moderated Helium 3 Tube

Neutron presence detection

η rate

SN-D™
Moderated Helium 3 Tube

Neutron dose equivalent rate

η dose

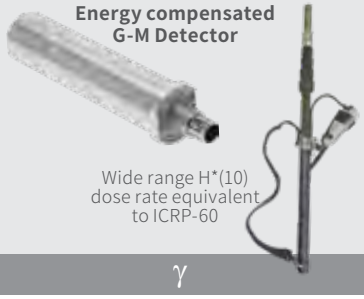
1 Cable Fits ALL

Dose Equivalent Rate

SVLD™
Energy Compensated CsI(Tl)

Very low H*(10) dose equivalent rate probe for public working area checks

STTC™ TELE-STTC™
Energy compensated G-M Detector



Wide range H*(10) dose rate equivalent to ICRP-60

SVHD™
Silicon diode

Very high dose rate probe for fuel control

γ

Electronic Dosimetry

SOR-R™ Electronic Dosimeter

The SOR/R Electronic Dosimeter was specifically designed to meet the needs of various applications with one product. The SOR/R dosimeter is qualified in accordance with current military and civil standards. The SOR line exceeds some of the standards currently in use in order to account for harsh operational environments.

Features are:

- The SOR dosimeter line is built upon two basic versions:
- The SOR/T for tactical (gamma and neutron) and residual/ambient gamma measurements the SOR/R for residual/ambient gamma measurements
- Assignable electronic dosimeters
- Waterproof, light and small
- Rugged for battlefield use
- Hand free communication, pass-by exchange
- Data communication through clothing layers

DMC 3000™ Personal Electronic Dosimeter

The DMC 3000 dosimeter features a unique, high contrast and back-lit LCD display, enhanced alarms (audible, visual, and vibration alerting), high EMI and RF Immunity and long battery life.

Features are:

NUCLEAR

- Display Units: mSv, µSv, or mrem
- Measurement Range (Dose): 0.01 mrem (0.1 µSv) to 1000 rem (10 Sv)
- Measurement Range (Dose Rate): 0.01 mrem/h (0.1 µSv/h) to 1000 rem/h (10 Sv/h)
- Energy Range (X-ray and Gamma): 15 keV to 7 MeV
- Energy Response: ± 20% (typically 10% from 16 keV to 7 MeV)

ELECTRICAL

- Power Supply: Standard AAA (LR03) 1.5 V alkaline battery
- Battery Life: 2500 hr continuous run

OPERATIONAL

- Display: Large LCD with high quality white back-lighting eight alpha-numeric digit display
- Audible Alarm: Loud speaker (>85 db)
- Visual: Super bright forward facing alarm LED along with alarm and information LEDs on top
- Shock, vibration and drop resistant (1.5 meters on concrete)

MECHANICAL

- Dimensions: 3.4 x 2.2 x 0.8 in. (86 x 56 x 21 mm) without clip
- Weight (alkaline battery and clip): <2.9 oz (84 g)

Add-on Modules for DCM 3000 Dosimeter:

Beta Module Hp(0.07)

The Beta Module combines with the DMC 3000 dosimeter to measure the Hp(0.07) shallow dose radiation at a wide range of energy levels.

Neutron Module Hp(10)

The Neutron Module combines with the DMC 3000 dosimeter to measure Neutron radiation at a wide range of energy levels.

Telemetry Module

The Telemetry Module combines with the DMC 3000 dosimeter to transmit the radiological data (accumulated dose, dose rate and alarm status) to other WRM2™ Telemetry System components (Base Station, Repeater, etc.)

CONTAMINATION AND CLEARANCE

Argos-5 Monitor

Argos-5 Configuration
25 Detectors

Argos™-5PB Gasless
Whole Body Contamination Monitors for β Detection

Argos™-5PBG Gasless
Whole Body Contamination Monitors for β/γ Detection

Argos™-5PAB Gasless
Whole Body Contamination Monitors for α/β Detection

Argos-5 Gasless (TPS family) Models:

- **818001** Argos-5PB, 2-Step Whole Body Monitor
  - Twenty-five (25) Model TPS-B-579 TPS Plastic Scintillator detectors, 579 cm^2
- **Argos-5PBG***, 2-Step Whole Body Monitor
  - Twenty-five (25) Model TPS-BG-579 TPS Plastic Scintillator detectors, 579 cm^2
- **Argos-5PAB**, 2-Step Whole Body Monitor
  - Twenty-five (25) Model TPS-AB-579 TPS Plastic Scintillator detectors, 579 cm^2

* — Requires CURTAINPB Front Curtain Lead Kit

Argos-3 Monitor

Argos-3 Configuration
18 Detectors

Argos™-3PB Gasless
Whole Body Contamination Monitors for β Detection

Argos™-3PBG Gasless
Whole Body Contamination Monitors for β/γ Detection

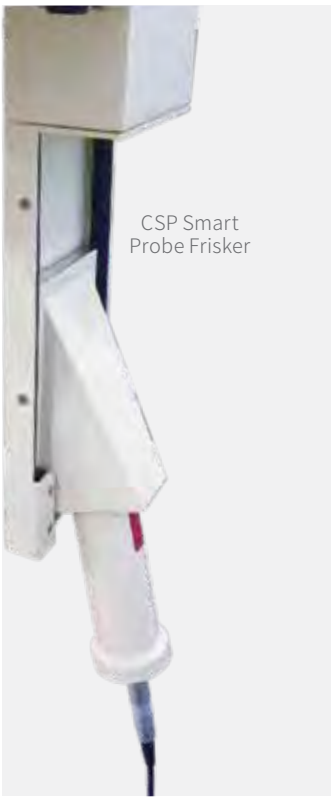
Argos™-3PAB Gasless
Whole Body Contamination Monitors for α/β Detection

Argos-3 Gasless (TPS family) Models:

- **7062324** Argos-3PB, 2-Step Whole Body Monitor
  - Eighteen (18) Model TPS-B-579 Thin Plastic Scintillator detectors, 579 cm^2
- **Argos-3PBG***, 2-Step Whole Body Monitor
  - Eighteen (18) Model TPS-BG-579 Thin Plastic Scintillator detectors, 579 cm^2
- **Argos-3PAB**, 2-Step Whole Body Monitor
  - Eighteen (18) Model TPS-AB-579 Thin Plastic Scintillator detectors, 579 cm^2

Sirius™-5 Hand, Cuff and Foot Surface Contamination Monitor

Sirius-5 monitor provides thorough and reliable detection of external contamination on the hands and feet of personnel working in nuclear environments. Depending on your monitoring needs, Sirius monitors are designed to use either plastic scintillator (TPS) gasless detectors or patented* gas flow proportional detectors (LFP-579). The Sirius-5 Hand, Cuff and Foot monitor meets the need for a robust, industrial-strength contamination control product. It is designed for the high-throughput, demanding applications found in the nuclear industry – nuclear power plants, fuel cycle facilities, nuclear waste facilities and D&D operations.



CSP Smart Probe Frisker

Sirius-5AB hand/cuff/foot monitor for alpha/beta contamination:
- Six (6) large area low flow gas proportional LFP-579 detectors
- 1 step process for hands

Sirius-5PB hand/cuff/foot monitor for beta contamination:
- Six (6) large area gasless TPS detectors
- 1 step process for hands

Sirius-5PBG hand/cuff/foot monitor for beta/gamma contamination:
- Six (6) large area gasless TPS detectors
- 1 step process for hands

Sirius-5PAB hand/cuff/foot monitor for alpha/beta contamination:
- Six (6) large area gasless TPS detectors
- 1 step process for hands

Features are:

MECHANICAL
- Cabinet:
  - Steel with rugged powder coat finish for column and top, stainless steel base and foot pan cover provide for ease of decontamination and minimum maintenance
  - Dimensions for any of the Sirius-5 models is approximately: 33.5 x 70.6 x 36.2 in. (78.0 x 179.3 x 91.9 cm) (W x H x D)
  - Approximate weights are (with no options installed)
- Model Weight:
  - Sirius-5AB 275.0 lb (125.0 kg)
  - Sirius-5PB /PAB/PBG 298.8 lb (135.8 kg)

* Patent US 7,470,913 B1 High Efficiency and High Homogeneity Large-Area Gas-Filled Detectors

ENVIRONMENTAL
- Temperature Range:
  - Operating Temperature (meets IEC 61098): 0-40 °C (32-104 °F)
  - Storage: 0-50 °C (32-122 °F)
- Relative Humidity:
  - Operating (per IEC 61098): ≤85% non-condensing at 35 °C (95 °F) maximum
  - Storage: ≤95% non-condensing
- Power Requirements:
  - 220 V ac/50 Hz/1.0 A or 110 V ac/60 Hz/2.0 A mains ~10 ft (3 m). IEC standard cable (supplied; other cables are available; specify special cable requirements; contact local Mirion affiliate) for further information

POWER CONSUMPTION
- 110 VA

CERTIFICATIONS
- IEC 61098 compliant
- ISO 11929:2010 compliant

Cronos® Gamma Object/Tool Contamination Monitors

The *Cronos* Gamma Object/Tool Monitors are extremely sensitive instruments used to detect radioactivity from small articles such as notebooks, keys, tools, hard hats, and other miscellaneous objects to detecting gamma radiation in/on articles such as waste bags, tools, briefcases, hard hats, and other miscellaneous objects. Measurements which ensure that objects have no detectable radioactivity can result in significant cost savings in waste processing and/or storage.

43 LITERS

Cronos®-1PBG Beta/Gamma Object/Tool Monitor

The *Cronos*-1PBG Beta/Gamma Object/Tool Monitor is an extremely sensitive instrument to detect beta and gamma emitting radioactive contamination on small objects such as notebooks, keys, tools, hard hats, and other items which can be placed in the counting chamber. Short count times and high efficiency make the *Cronos*-1PBG monitor, the ideal tool for the implementation of the "Empty Pocket" policy in your facility.

Features are:

NUCLEAR

- Twelve 14.6 x 6.7 x 2.3 in. (37.2 x 17.0 x 5.8 cm) thin plastic scintillation (TPS-BG-579) detectors with built-in photomultiplier tubes
- Total detector volume 23.4 L (0.83 cu.ft)

OPERATIONAL

- Display Screen: 10.4 in. (~264 mm) touch screen LCD display integrated in top of unit (second display kit optionally available for exit side)

ELECTRICAL

- 220 V ac / 50 Hz / 1.0 A or 110 V AC / 60 Hz / 2.0 A mains
- Maximum power consumption is 95 VA
- ~10 ft (3 m) IEC standard power cable supplied

MECHANICAL

- Unit with No Lead: 600 lb (272 kg)

Cronos-1 Gamma Object/Tool Monitor

43 LITERS

Cronos-4 Gamma Object/Tool Monitor

129 LITERS

Cronos-11 Gamma Object/Tool Monitor

345 LITERS

9 Contamination and Clearance

Cronos Gamma Object/Tool Contamination Monitors

continued

Cronos Gamma Object/Tool Monitor Features:

		Cronos-1 Monitor	Cronos-4 Monitor	Cronos-11 Monitor
Radiological : Time to reach MDA	Calculated count times for MDA = 83 Bq (5000 dpm) 80 nSv/h background, 1" lead shielding, α = 0.15% and 1-β = 97.5% confidence intervals.	**6 Detector Configuration** For ^{137}Cs: 24 seconds For ^{60}Co: 6 seconds **4 Detector Configuration** For ^{137}Cs: 35 seconds For ^{60}Co: 9 seconds	**6 Detector Configuration** For ^{137}Cs: 48 seconds For ^{60}Co: 10 seconds	**6 Detector Configuration** For ^{137}Cs: 130 seconds For ^{60}Co: 22 seconds
Detectors		• For doors and main unit: six 38.7 x 33.2 x 5.1 cm (15 x 13 x 2 in.) plastic scintillators with built-in photomultiplier tubes. • Detector volume for main unit detectors (four total) 25.5 L (0.90 cu. ft.). • Detector volume for main unit and Optional door detectors (six total) 38.2 L (1.4 cu. ft).	• For doors and main unit: six 45.7 x 45.7 x 5.1 cm (18 x 18 x 2 in.) plastic scintillators with built-in photomultiplier tubes. • 65.1 L (2.3 cu. ft) total detector volume.	• For doors: two 61 x 61 x 5.1 cm (24 x 24 x 2 in.) plastic scintillators with built-in photomultiplier tubes. • For main unit: four 61 x 74.9 x 5.1 cm (24 x 29.5 x 2 in.), plastic scintillators with built-in photomultiplier tubes. • 130.5 L (4.6 cu. ft) total detector volume.
Mechanical: Internal Dimensions	Width x Depth x Height	34.1 cm (13.4 in.) x 36.5 cm (14.4 in.) x 34.5 cm (13.6 in.)	46.5 cm (18.3 in.) x 57.9 cm (22.8 in.) x 47.8 cm (18.8 in.)	63.5 cm (25.0 in.) x 87.2 cm (34.3 in.) x 62.4 cm (24.6 in.)
	Internal Volume	~42.9 L (1.5 cu. ft)	~128.7 L (4.5 cu. ft)	~345.5L (12.2 cu. ft)
	Overall Width	60.0 cm (23.6 in.)	73.2 cm (28.8 in.)	88.4 cm (34.8 in.)
	Overall Depth	73.1 cm (28.8 in.) for body and door handles	95.2 cm (37.5 in.) for body and door handles	124.4 cm (49.0 in.) for body and door handles
	Overall Height (Flush with bottom of casters or flush with bottom of the leveling feet)	With Standard Leveling Feet 96.3 cm (37.9 in.) With Optional Casters 100.4 cm (39.5 in.)	129.1 cm (50.8 in.)	145.7 cm (57.4 in.)
	Door Thickness	7.0 cm (2.7 in.)	7.0 cm (2.7 in.)	7.0 cm (2.7 in.)
Weight	Unit with No Lead	260 kg (573 lb)	445 kg (981 lb)	563 kg (1241 lb)
	Lead (1 layer)	416 kg (917 lb)	751 kg (1656 lb)	1264 kg (2787 lb)
	Lead (2 layers)	832 kg (1834 lb)	1503 kg (3314 lb)	2529 kg (5575 lb)
	Total (with 1 layer of lead)	683 kg (1506 lb)	1207 kg (2661 lb)	1841 kg (4059 lb)
	Total (with 2 layers of lead)	1099 kg (2423 lb)	1958 kg (4317 lb)	3105 kg (6845 lb)
Power Requirements:	220 V ac/50 Hz/1 Amp or 110 V ac/60 Hz/2 Amp mains 3 m (~10 ft) IEC standard cable (supplied; specify and special cable requirements on order).			
Certification:	IEC 61098 compliant and ISO 11929:2010 compliant.			
Environmental: Temperature	Operating temperature range 0 to +45 °C (+32 to +113 °F).			
Humidity	85% non-condensing.			

MiniSentry™ 2 Transportable Gamma Portal Monitor

The MiniSentry 2 portal monitor provides screening of pedestrians or vehicles for gamma radiation. It is designed to be quickly set up and operated with very little training or expertise in radiation detection technology. This portable system is well-suitable for emergency scenarios and security applications.

Features are:

- Gamma portal monitor for rapid deployment and emergency response
- Quick and easy setup with automatic start-up and operation
- Simple clean/contaminated status indicator
- Very little training or expertise in radiation detection needed
- Weight less than 46 kg (101 lb)
- Suitable for indoor and outdoor operation in adverse weather conditions (IP54, -25 °C to 50 °C)
- Three different measurement modes available (walk-through, enter-wait, count-rate)
- Powered by battery (up to 65 hours autonomy[1]), USB or 110/240 V
- Possibility for connection of additional CSP probe (for example: α/β frisker SAB-100 probe or SN-S neutron probe)
- Many options and accessories available
- Detection of 1 µCi ^{137}Cs (according to FEMA-REP-21)
- Based on high sensitivity plastic scintillation detectors with 2 x 5.3 L active volume
- Wide energy range: 30 keV – 2 MeV compliant with FEMA-REP-21 as well as IEC 62244[2]

[1] - with optional battery extension module

[2] - compliance to IEC 62244 standard with minor limitations

GEM™-5: Gamma Exit/Entrance Contamination Monitor

Mirion's highly sensitive GEM-5 gamma exit monitor provides power plants and nuclear facilities the very latest gamma detection capability to monitor pedestrians leaving areas of potential radioactive contamination. Operation of the monitor is straightforward and reliability is assured with both audible and visual aids to support monitoring activities. The easy to view color LCD screen provides visual cues and readily displays contaminated areas. Additionally, users are guided through the monitor with a voice annunciator, which provides clear voice prompts necessary for dependable unassisted operation during normal conditions. Access to the installed computer is through a single convenient panel on the front of the monitor. The computer includes built-in USB and LAN ports, and is located inside a lockable door. The GEM-5 monitor is rugged, reliable and extremely easy to use.

Features are:

- Rugged and reliable for high traffic areas
- Configuration of eight large plastic scintillators (three on each side, one on each top and bottom)
- Continuous automatic background subtraction function
- Sensitivity: ^{60}Co / ^{137}Cs
  - 830 Bq/1850 Bq (walking mode)
  - 555 Bq/830 Bq (Stop mode 4 seconds)
  - 370 Bq/370 Bq (two-stage mode)
- 2.5 cm (1 in.) thick lead shield on both sides
- A lead shield with a thickness of 2.5 cm (1 in.) can be added to both sides and top and bottom respectively (optional)
- Touch screen PC, voice prompt for multiple languages
- Based on Windows 10 IoT
- Similarly, the manufacturer's best software is used.
- Total detector volume: 86,196 cm^3
- Total detector area: 16,968 cm^2
- IEC 61098 compliant
- Gaussian/Baisian statistics based algorithm (Compliant with ISO 11929: 2010 standard)

Mirion at your service

QUALITY POLICY

1 Achieve high level of customer satisfaction by complying with requirements

Mirion Technologies (Canberra) KK will do their best to offer high-level products and services to meet the applicable legal and regulatory requirements, and customer requirements and expectations.

2 Setting and working on quality targets

Mirion Technologies (Canberra) KK has established “Quality Targets” and “Achievement Plans” to ensure the above item 1 and all employees will work towards achieving them. We also regularly review quality objectives to ensure their effectiveness.

3 Continuous improvement of the effectiveness of the quality management system

Mirion Technologies (Canberra) KK will endeavor to continually improve the effectiveness of the quality management system in order to ensure item 1 above.

4 Thorough on-site principles

Employees at Mirion Technologies (Canberra) KK are aware of the impact of their work on the quality of our products and services, and strive to continually improve and innovate business processes.

TERMS AND CONDITIONS

Our terms and conditions follow the Regular transaction guidelines of Mirion Technologies (Canberra) KK.
For details, please visit our website: **http://www.canberra.com/jp/ terms.asp**

CERTIFICATION

Our quality management system conforms to ISO 9001:2015

ISO 9001 Certified
12 100 49792 TMS

SERVICES

M&E: MEASUREMENT SERVICE & EXPERTISE

PARTNERSHIPS FOR MORE EFFICIENT AND COST-EFFECTIVE NUCLEAR MEASUREMENTS

Expertise:

- Mirion Technlogies (Canberra) KK provides development of custom measuring solutions, Technical and feasibility studies to assist in waste management and D&D strategies, as well as NDA system design.

Onsite Measurement:

- Services and Characterization Reports: Large range of onsite services from dose rate and gamma imaging surveys to complex gamma spectroscopy measurements using ISOCS calibrations or other modelization codes.

M&E services provided by Mirion Technologies (Canberra) are proven by enriched experiences and achievements in nuclear facilities around the world. For more information, please refer to our “Decontamination & Decommissioning” brochure to view case studies achieved with the global collaboration of Japan and M&E expertise.

AFTER SERVICE

All products arriving from a factory in another country follow consistent performance and quality check procedures. In addition to services, Mirion continues to work on the design, software, and production of total measurement systems, striving to deliver safe and easy-to-use products.

Receiving/Shipment inspection

All products pass acceptance qualifications and shipping inspection by our Engineering department, prior to delivery to our customers.

Annual maintenance

Our products come with a standard warranty. Optional contracts are available to customers such as, annual maintenance for system products.

Periodic inspection

Optional periodic inspection plans are available for routine inspections, such as for germanium semiconductor detectors and FASTSCAN body counters.

Please contact our sales department for details:
Tokyo head office: TEL 03-5835-5402
Osaka sales office: TEL 06-4806-5662

Repair

Support teams are available to help provide information and answer questions about our products. If you need assistance, please contact our Engineering department at TEL 03-5835-5404. We offer pickup for portable products requiring repair, and can provide on-site repairs for larger systems.

MAINTENANCE PLAN

The Ministry of Health, Labor and Welfare recommends periodic inspections of measuring equipment, and the Ministry of Education, Culture, Sports, Science and Technology manual recommends inspections at least once a year. Mirion also recommends inspection and calibration once a year to ensure the reliability of analysis results.

Germanium detector	
Ge Regular maintenance	Regular calibration maintenance
On-call service	Customer support is available! For assistance call: TEL: 03-5835-5402
Add-on service	Several optional services are available
Preventive maintenance	For long-term product maintenance
Ge Regular maintenance + Ge Preventive maintenance	Diverse plans to meet all your needs!
Ge Safety Support (Regular inspection + maintenance) *For the purchase after 2011	Full support for all your needs Discounts for transfer and continuous support packages
Ge Full Support (Regular inspection + maintenance + preventive maintenance) *For purchases after 2011	Regular maintenance with preventive action plan Discount offer for continuous support package
FASTSCAN	
FASTSCAN Regular maintenance	Regular calibration maintenance
On-call service	Customer support is available! For assistance call: TEL: 03-5835-5402
Add-on service	Several optional services are available

For more information, please check our website or contact us at TEL: 03-5835-5402.

Who we are, where to find us

Mirion Technologies is a leading provider of innovative products, systems and services related to the measurement, detection and monitoring of radiation.

The company delivers high quality, state-of-the-art solutions that constantly evolve to meet the changing needs of its customers.

With the addition of the Canberra™ brand in 2016, Mirion® expanded its portfolio and the breadth of its expertise to bring a new standard of solutions to the market. Every member of the Mirion team is focused on enhancing the customer experience by delivering superior products, exceptional service and unsurpassed support.

MIRION AT YOUR SERVICE

Headquarters

- Mirion Worldwide HQ – San Ramon, CA

International Offices

- Please visit the website for a complete listing.

Sales Offices

- Mirion sales and service capability exists in virtually every country in the world.

Local contacts

Headquarters

〒111-0053 Asakusabashi Blg, 4-19-8, Asakusabashi, Taito-ku, Tokyo

TEL: 03-5835-5402
FAX: 03-5835-5403

Service

TEL: 03-5835-5404
FAX: 03-5835-5403

E-mail

Sales: jp-sales@mirion.com
Service: jp-support@mirion.com

Osaka office

TEL: 06-4806-5662
FAX: 06-4806-5663

Fukushima office

TEL: 024-597-7517
FAX: 024-597-7518

For details, please visit our website: **www.mirion.com/jp**

ISO 9001 Certified
12 100 49792 TMS

Mirion Technologies (Canberra) KK quality management system conforms to ISO 9001:2015

MIRION TECHNOLOGIES

www.mirion.com/jp

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