
MIRION
TECHNOLOGIES

Detection & Measurement Division

High Purity Germanium Detectors for in-situ Gamma Spectroscopy

ANIMMA 2021

7-142

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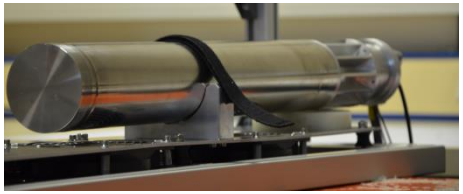
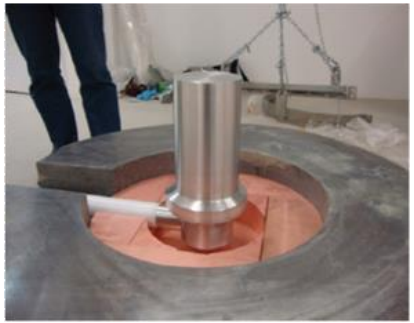
MIRION Detection and Measurement Division

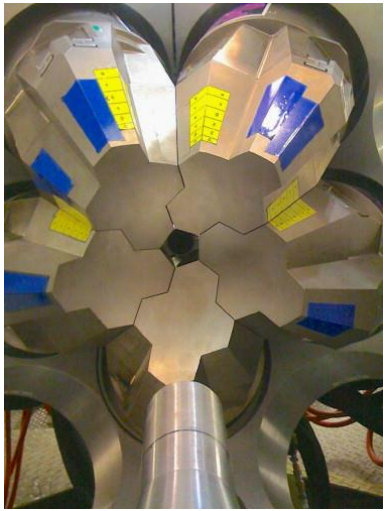
- **Detection & Measurement Division (DMD)** offers radiation measurement, personnel protection, advanced safety and search, and decontamination and decommissioning solutions for a variety of worldwide applications

Specialty HPGe solutions



- Lingolsheim site, France: More than 50 years in expertise manufacturing HPGe detectors from standards to specialty solution
- Covering several fields of application
  - Fundamuntal Nuclear research
  - Ultra-low contamination counting labs
  - XRF
  - OEM solutions
  - In-situ spectroscopy
  - Space applications





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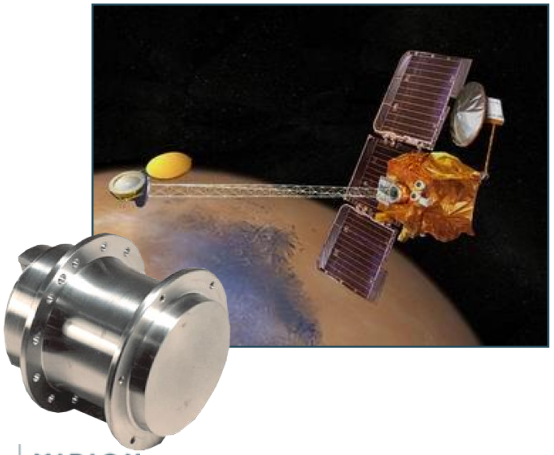
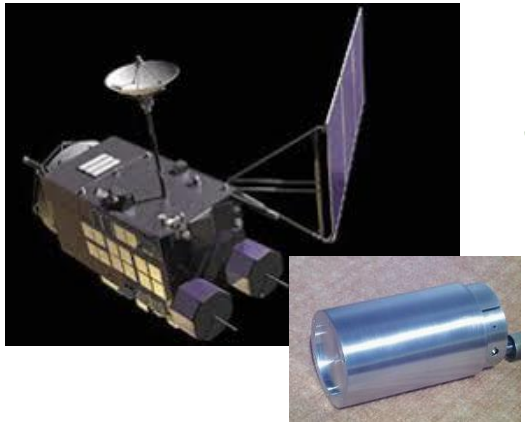
Long experience in rough-motion proof detectors for space applications

- MIRION has been involved in several space mission in the last decades, using HPGe encapsulation technology
- Bringing **Reliability** and **Ruggedness** together with **unmatched nuclide identification** through HPGe grade gamma-ray spectroscopy

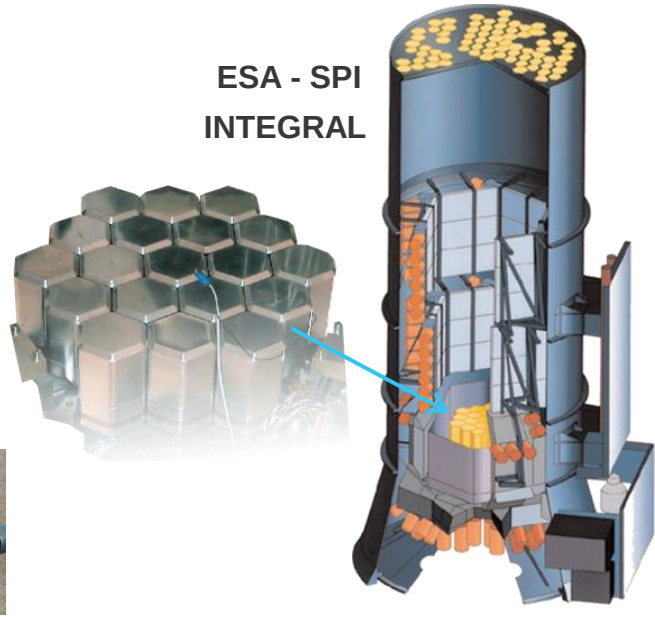
NASA - MARS ODYSSEY Project



JAXA - SELENE Project



ESA - SPI INTEGRAL



LN2-free solution: electrical cooling

Addressing LN2-free solution

- For decades MIRION pioneered the use of electrical cooling with HPGe detectors
- The technology is mature and deployed with all types of detectors, even complex, not making any compromise with detector performances
  - Multi-element detectors
  - Segmented HPGe detectors

Nuclear research

Standard detectors

Synchrotron
X-ray applications

Gamma-ray imaging

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Towards portable / embedded solutions

Portable solutions

- Merging rugged detectors and electrical cooling
- Clearing the path towards new applications

Rugged HPGe technology

Electrical cooling

Portable spectrometer

Custom solution

Optimized system

Sealed probe for Harsh environment

Harsh environment

- Sealed probe to bring gamma-ray spectrometry in difficult environment:
  - Through-hole measurement
  - Contaminated area
  - Humid areas
  - Limited space
- Streamline design
  - Connexion to a power supply station though rugged umbilical cable
- Performances
  - 20% rel. eff. Crystal
  - 1.2 keV @ 122 keV
  - 2.2 keV @ 1332 keV

Underwater Spectroscopy: Application Example

Under Water Applications

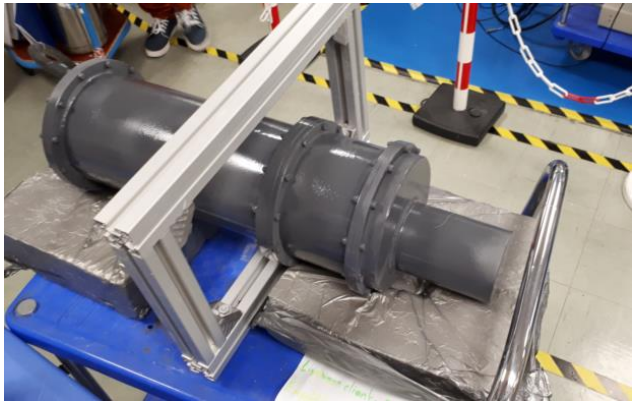
- River/Seabed or laboratory spectroscopy

Antifouling and anticorrosion coatings

Composite watertight cable

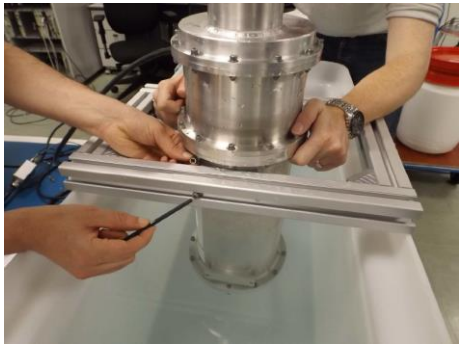
Sealed version for underwater measurement

Assessment in a laboratory (water pumped from river and stored in tank) before installation



Under Water Applications

- Detector performances at 4µs - 1kcps
  - FWHM at 1,33MeV : measured 1.67keV
  - FWHM at 122keV : measured 0.87keV
  - Relative efficiency : measured 27%
  - FWTM/FWHM : 1.86
  - FWFM/FWHM : 2.45
- Higher efficiency available
  - 40% – 70% – 100% relative efficiency



Survey: Airborne system
Extra Large Germanium Spectrometer

Airborne Spectrometer

- Airplane/Helicopter embedded system for large area spectral survey and monitoring
- 7 close-packed, large-efficiency crystals inside a unique, electrically-cooled cryostat
  - 1100% relative efficiency
  - Using add-back (summing energies between crystals) to enhance photopeek efficiency
- Complete system, 2 plugs required:
  - power supply
  - computer conexion
- Custom solution to synchronize gamma-ray spectra analysis with 2D mapping

µGe
Miniature Germanium Spectrometer

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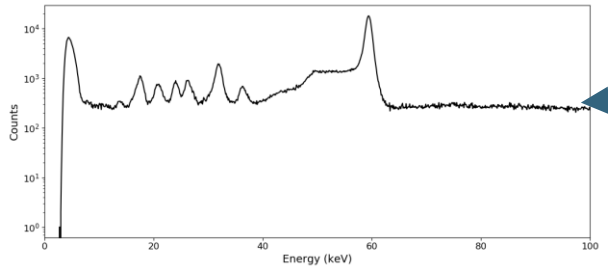
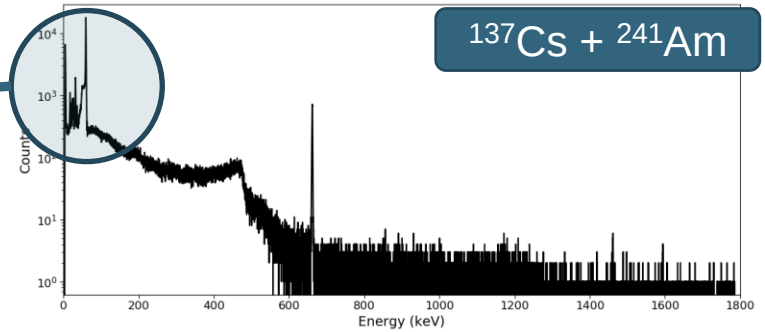
Miniature Germanium Spectrometer : µGe

- **Description:**
  - Compact and lightweight HPGe spectrometer
  - Fast cool down time
  - Suited for high flux environment

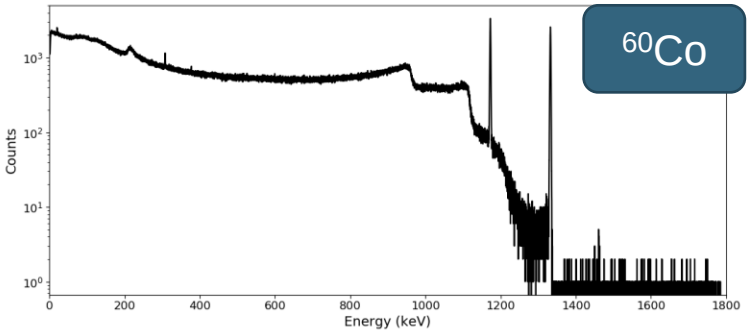
- **Characteristics**
  - Small HPGe sensor: 10x10 mm
  - Low power consumption
  - Embedded analog electronic

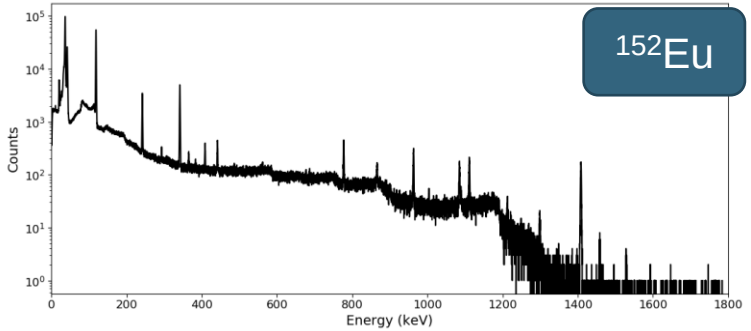
- **New paradigm for HPGe detectors**
  - Open the way towards new applications

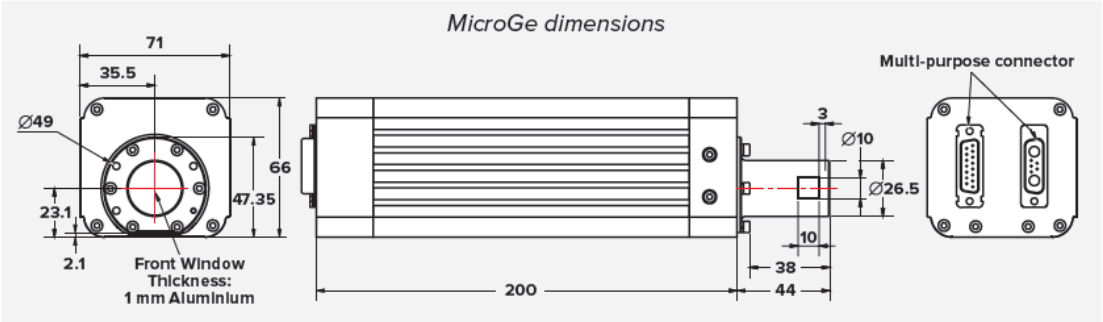




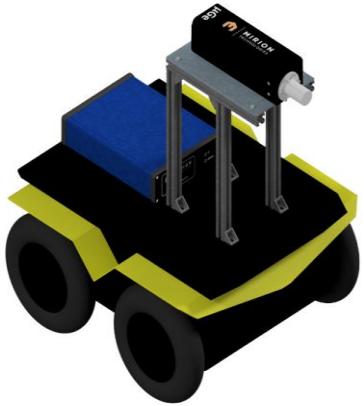
- **1.6 keV FWHM @ 662 keV**
  - 0,25% FWHM @ 662 keV
  - To be compared with 2% (13 keV) FWHM for 10x10mm RTSD detector
- **< 1.0 keV FWHM @ 122 keV**







Miniature Germanium Spectrometer : µGe



Parameter	Value
HPGe crystal	0.1 % relative efficiency (10mm diameter x 10mm long)
Overall dimensions for housing	200 mm x 71 mm x 66 mm (without cable and without cap)
Probe weight	1.5 kg
Housing	Aluminum
Cooling	Fully automatic electrical cryocooler (no LN_2)
Power consumption	< 10 W (20 W during cooling phase)
Time to reach temperature of operation	<30 minutes
Energy resolutions (typical)	1.0 keV @ 122 keV
2µs Gaussian shaping time	1.6 keV @ 662 keV
Count rate : 1kcps	2.2 keV @ 1332 keV
Count rate capability	> 10^5 counts per second @ 662 keV Customized collimator could be provided for high flux environment.
Preamplifier	Included in the probe housing Resistive feedback Gain 200 mV/MeV (adjustable on request)
Alarm card	For automatic HV shutdown
Typical high voltage	<1000 V (negative)
Connections	Two bulkhead connectors to interface signal processing and power supplies. Connectors and cables can be customized on request.
Cable length	10 m maximum (can be adjusted on request)

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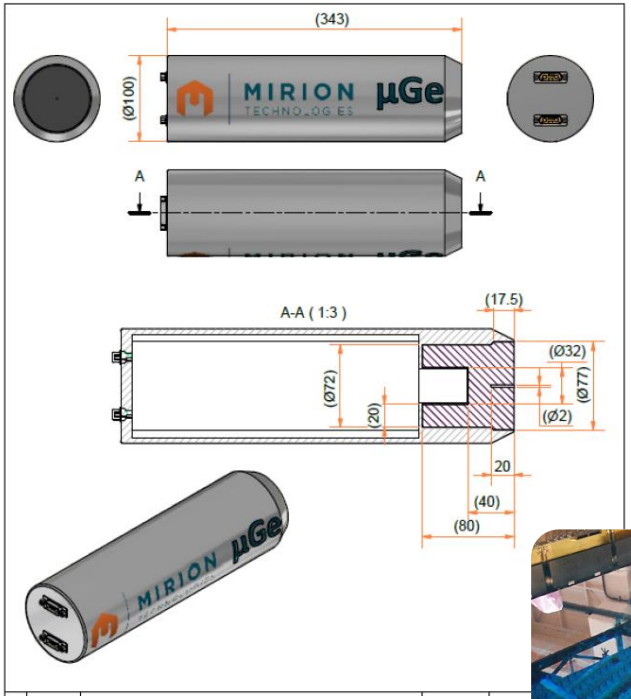
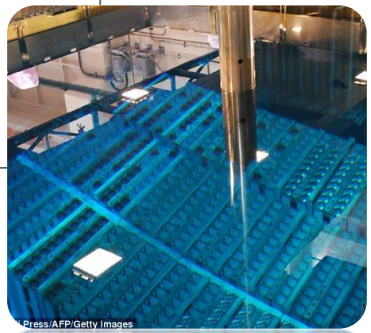
Ongoing µGe upgrade : **watertight version**

- Watertight housing
  - Easy decontamination
  - Submarine
  - Optionnal collimator for very high flux
- Performances maintained inside 60°C environnement: allowing to be used inside hot pools for monitoring





Ongoing µGe upgrade : **Low energy version**

- Using X-ray detector technologies inside µGe housing
  - Ultime resolution FWHM
    - < 0.2 keV @ 6 keV
    - < 0.4 keV @ 60 keV
  - Ultra high count rates (up to several Mcts/s)
  - Thin entrance window (Beryllium)

- New applications to assess
  - Embedded/in-situ XRF for high Z elements
  - Fuel enrichment trough low energy X/gamma measurement at high count rate

Conclusion

- Using latest cryocooler and rugged HPGe technology to bring laboratory grade gamma-ray spectroscopy on the field
- Large panel of HPGe solution for in-situ environnement
  - Harsh environnement
  - Submarine
  - Airborne
- Custom solutions available to fit specific needs
- µGe, latest innovation, is a game-changer for several application:
  - Bringing portable and immediate availability for gamma-ray spectroscopy
  - Naturally adapted for very high flux
  - Low profile