Encapsulated Detectors

Encapsulated Germanium Detectors for Gamma Measurements

Features

- 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

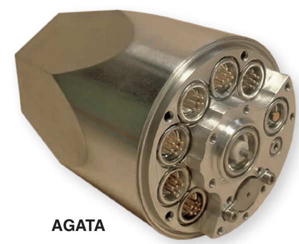
Such a detector is easy-to-use, reliable and robust. So, it may be used in a large range of scientific and industrial applications such as:

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

Description

ENCAPSULATION TECHNIQUES

Mounting and operation of **several detectors** in a common vacuum with minimum spacing between consecutive elements makes a real challenge. Encapsulation techniques have been developed to minimize such problems. Placing each encapsulated detector into the vacuum in an individual aluminium cap makes it possible to separate the vacuum of each detector from the cryogenic vacuum shared by all detectors. Encapsulation drastically enhances the germanium detector **reliability**. This technology is key for many applications, particularly in space, and especially if associated with Ultra High Vacuum. Encapsulated germanium detectors may be easily handled by the users. They may be stored, exchanged or rearranged and be adapted to various applications with different types of cryostats.



AGATA

A capsule may be **regenerated** many times and can be thermally annealed in an ordinary oven from neutron or proton radiation damages, without pumping. The life time of such a detector may be estimated to a minimum of seven years without service. But in reality it is much more: The first EUROBALL capsules were delivered in 1992 and are all still in operation. Encapsulated detectors hardness enables a **wide application range**, such as part of the payload of nacelles, space launchers, etc...

Compact arrays may be designed. The capsules manufactured for EUROBALL offer a typical wall thickness of 0.7 mm with a distance between cap and crystal of only 0.7 mm. These encapsulated detectors may be in contact with one another offering a 3 mm distance between consecutive crystals and a 1.4 mm total aluminium wall thickness.

For better follow-up of scientific progress, some segmented crystals have been encapsulated to offer high **granularity**, in addition to the previous advantages.

The detector granularity qualifies the number of independent cells constituting this detector. Such detectors allow a significant reduction or gamma ray broadening due to the Doppler effect.

Moreover, the use of internal and external contacts of the crystal provides information on the interacting **position**:

- Vertically and transversally, by analyzing signals induced by mirror charges.
- Radially by making a pulse shape analysis.

Accurate localization of the interaction points allows not only reduction of the Doppler effect broadening, but also gamma ray tracking.

Encapsulated Detectors

In addition to these benefits, the segmented detector encapsulation allows the design of complex cryostats, thus signal optimization which is of much interest for pulse shape analysis.

The feasibility of the germanium detector encapsulation was studied in the frame of a collaboration between CANBERRA, the Jülich research center and the University of Cologne in Germany.

NUCLEAR PHYSIC APPLICATIONS

EUROBALL:

- A EUROBALL capsule and CLUSTER array for EUROBALL (seven encapsulated HPGe detectors).
- Hexagonal tapering – 70 mm (diameter); 78 mm (height).
- FWHM resolution: <2.3 keV.
- Efficiency: >55%.
- Aluminum wall thickness: 0.7 mm.
- Cap-to-Ge distance: 0.7 mm.
- Add-back efficiency: about 600%.
- More than 150 units delivered.

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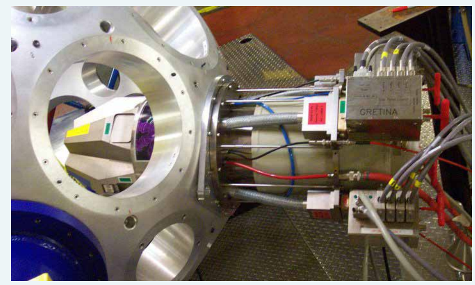
AGATA:

By courtesy of AGATA collaboration

- AGATA detector and the AGATA demonstrator at Laboratori Nazionali di Legnaro consisting of the first five triplet detectors.
- Hexagonal tapering – 80 mm (diameter) 90 mm (height) – outer contact segmented in 36.
- FWHM resolution: <2.35 keV.
- Efficiency: >80%.
- Alu wall thickness: 0.7 mm.
- Cap-to-Ge distance: 0.7 mm.
- Total encapsulated detectors of the AGATA project: 180 capsules.

GRETA:



By courtesy of the GRETA collaboration.

- GRETA detector consisting of four encapsulated detectors each with 80 mm (diameter) – 90 mm (height) – outer contact segmented in 36.
- The GRETA will consist of 30 quartet detectors which represents a total of 120 capsules.

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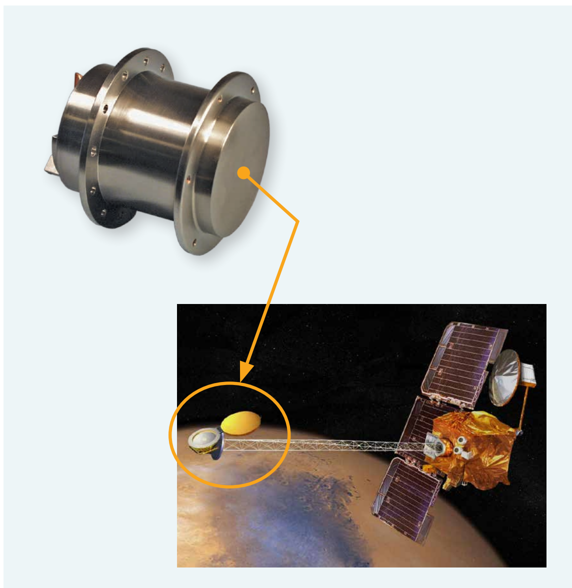
SPACE APPLICATIONS

The Mars Odyssey Mission

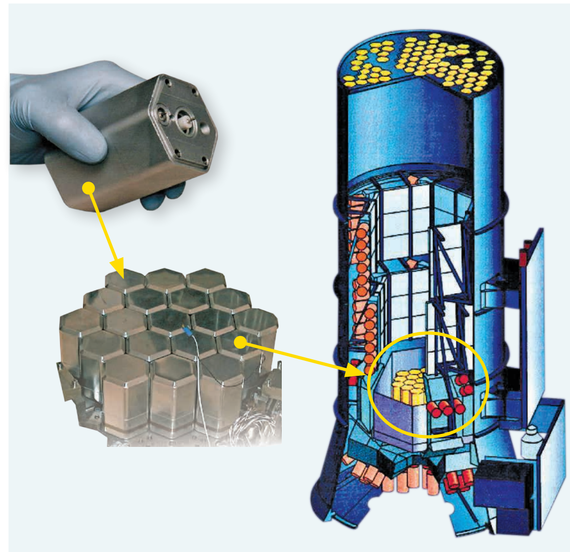
This mission consisted of putting a satellite into orbit to detect the presence of water (ice) on the Mars planet by using (n,γ) reactions.



DETECTOR TYPE:

- Coaxial HPGe, N Type, titanium encapsulated, relative efficiency 50%.
- Encapsulation offers sealed ultra-high vacuum conditions, therefore long live and possibility to anneal the detector from radiation damage without pumping or opening to the spatial environment.
- The technology developed offers light weight sensors, a very important criterion for spatial devices. The use of titanium is another important asset: aluminum would conflict with gamma rays of interest.

SPI INTEGRAL Spectrometer:



- Launched on October 2002.
- An array of 19 encapsulated Ge detectors.
- All still in operation.
- Relative efficiency 40% each.
- Crystal to crystal gap: 3.5 mm.

SELENE:

- Lunar orbiter mission.
- Encapsulated coaxial HPGe detector.
- 60% efficiency.

CE

ISO 9001 SYSTEM CERTIFIED

CANBERRA