MIRION TECHNOLOGIES

Clover™ Detectors

Four Coaxial Germanium Detectors

EUROBALL type Clover detector 4x50x70

KEY FEATURES

- High photopeak efficiency in 'add-back' mode
- High efficiency in 4π geometry (well type configuration)
- Excellent energy resolution
- Excellent timing response
- Optional position information (segmentation can reduce Doppler broadening)
- Reduced vulnerability to neutron damages
- Good sensitivity to gamma ray polarization
- Easy maintenance
- Optional: low background materials, electrical cooling, extended energy range

APPLICATIONS

- Nuclear Physics
- Polarization measurements
- Health Physics (well type CLOVER detector)
- Any application where the highest efficiency is required without compromises on energy or timing resolution

The first CLOVER detector was initially developed in France by Canberra™ in the frame of the EUROGAM collaboration. The original design consisted of a close arrangement of four n type germanium detectors like a 4-leaf clover. This configuration drastically improves the total system efficiency and compensates for the still limited relative efficiency of conventional n type crystals. Well over 200 Mirion CLOVER detectors are currently in operation worldwide. Although CLOVER detectors should be considered as specialty detectors or scientific instruments, they are highly reliable, allowing for routine maintenance to be performed by customers on-site. As is evidence: the first EUROBALL CLOVERS delivered in 1992 are still in operation.

DESCRIPTION

In the CLOVER detector assembly, the crystals are held on a minimized crystal holder to reduce the quantity of material surrounding the crystals and to improve peak to background ratio. With this principle Mirion is offering an optimized amount of HPGe material within the cap.

Moreover, crystals are packed very closely together to improve the add-back factor. The maximum gap between two adjacent crystals is ≤0.7 mm without any absorbent material along the whole crystal length that will absorb more than 1% of 20 keV gamma rays.

The four crystals are mounted in a common cryostat with a tapered or regular square shaped end cap.

Distance between end cap and crystals has been reduced to a very minimum to improve the solid angle and efficiency of any veto detector (BGO) which can surround the CLOVER cap. Also so called back catcher cryostats are available for given CLOVER types where a dedicated BGO detector can be installed at the rear of the cap.

A major advantage of a CLOVER detector consists of its high absorption efficiency: results are not only four times those obtained with a single crystal but, as crystals are mounted without any additional absorbing material, the full energy of a photon Compton scattered and absorbed in a second (or even a third) crystal can be determined. The full energy peak can be obtained by summing ("add-back") the energies deposited in the N segments firing.

The "Add-back" efficiency is then superior to the sum of the four individual efficiencies.

Clover Detectors

In the EUROGAM CLOVER detectors (dia. = 50 mm, L = 70 mm), the mean relative efficiency of each crystal is between 21 and 22%, whereas the total relative efficiency in “add-back” mode is between 130 and 140%. See Duchene et Al NIM A432-1999-90.

The energy resolution of the four shaped crystals is typically less than 2.1 keV at 1.33 MeV and 1.05 keV at 122 keV. In add-back mode, the energy resolution is still excellent: 2.3 keV at 1.33 MeV.

Similar resolutions have been obtained with larger CLOVER detectors.

Specification sheets for different detector sizes with or without segments in EUROBALL type cryostats or back catcher cryostats are available upon request.

The arrangement of several small n type crystals induces other benefits in comparison with a large single crystal:

- Reduction of the crystal opening angle permits a Doppler broadening reduction. Segmentation of the outer contact (available on some CLOVER type detectors) can also permit to further reduce Doppler broadening).
- Sensitivity to neutron damages is also reduced by using n-type HPGe crystals.
- The timing response of each individual crystal, measured with a ^{60}Co source in coincidence with a small BaF2 scintillator, is very good. Average FWHM is 5 to 6 ns and FWTM/FWHM is about 3.0 for a 50 keV energy threshold and a DFC delay of 30 ns.
- The CLOVER detectors can also be used as polarimeters due to the presence of four crystals.

The Mirion CLOVER detector portfolio has regularly been improved over the 15 last years; first by increasing the total CLOVER efficiency with the use of crystals of larger volume, then by improving the granularity of the detector to enhance the resolving power.

Granularity qualifies the number of independent cells constituting the detector. The first CLOVER detectors had a granularity of four crystals. A 2 or 4 fold longitudinal crystal segmentation drastically increases that granularity.

Such detectors allow a major reduction of gamma ray broadening due to Doppler effect. Moreover, the use of internal and external contacts of the crystal (in case of detector segmentation) gives interaction position information:

- Vertically and transversally by analyzing signals induced by the mirror charge to further increase the granularity.
- Radially, by making pulse shape analysis.

Accurate location of the interaction points allows not only reduction of Doppler broadening, but also gamma ray tracking in the detector.

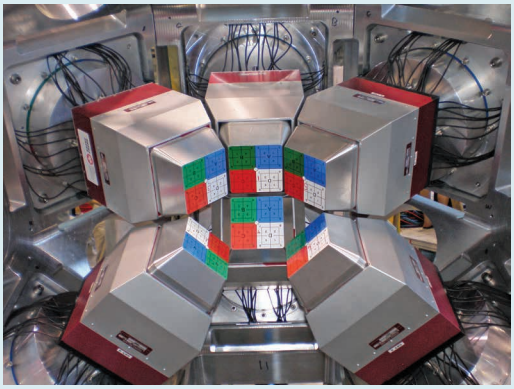
Moreover, the maintenance of such tools has been simplified for the users: easy access to the cooled input stage of the charge sensitive preamplifier to replace the field effect transistor (FET). Mirion can offer training to enable on site maintenance. Also preamplifier cards are available. All Clover detectors have motherboards inside the preamplifier enclosure where the preamplifier cards and alarm cards are connected.

CLOVER detector Dewars are small and allow:

- Compact arrangement covering nearly 4π.
- Positioning in all directions without significant temperature change.
- Full 1-day LN_2 holding time.

Other Clover detectors have been designed, such as ”well type” for example, allowing measurement of large samples with an angular coverage of almost 4π.

TIGRESS Clover detector 4x60x90-seg32 with BGO



TIGRESS Clover detector array with BGO

EXOGAM type Clover detector 4x60x90-seg16 with back catcher cryostat

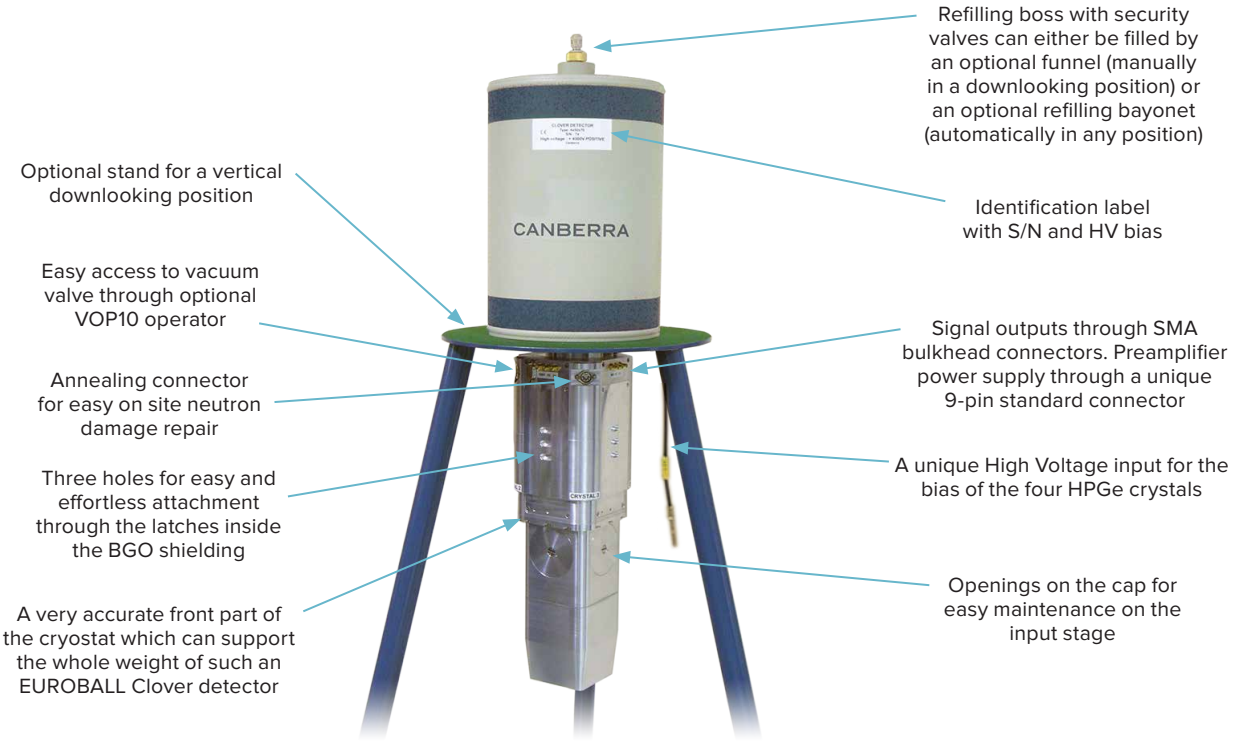
Courtesy of Pr Svensson – Univ Guelph

PROJECT EXAMPLES

Below are some examples of Clover detectors, developed using HPGe crystals with various sizes:

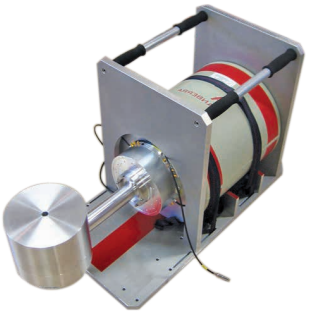
4x diameter in mm x length in mm (total of HPGe material), name of the experiment.

- Clover 4x50x70 (~3 kg) EUROGAM – EUROBALL – CLARA – AFRODITE – INGABALL.
- Clover 4x50x80 (~3.3 kg) CLARION.
- Clover 4x60x60 (~3.6 kg).
- Clover 4x60x90 (~5.4 kg) EXOGAM – TIGRESS – GRIFFIN.
- Clover 4x70x70 (~5.7 kg).
- Clover 4x80x90 (~9.6 kg).
- Clover 4x70x140 (~11.5 kg) VEGA.



Mirion EUROBALL Clover detector 4x50x70 offers unique features for user friendly handling

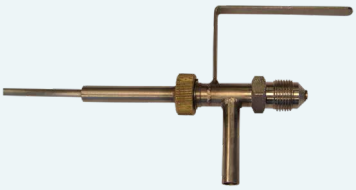
4 CLOVER detector HPGe crystals, with a dedicated shape to build a high efficient array like a compact detection cube



True Well Clover detector 4x80x90

ACCESSORIES FOR CLOVER DETECTORS AVAILABLE AS OPTIONS:

NRK-200 neutron damage repair kit



Refilling bayonet for automatic pressurized refilling

VOP10 pumping sleeve

Cable set (power supply – signal – high voltage)

Storage box (not a transportation box)

Stand for vertical downlooking position

LN_2 filling funnel for manual filling in vertical position

ISO 9001 SYSTEM CERTIFIED MERIDEN CT SMYRNA GA OAK RIDGE TN CONCORD ON

CANBERRA