ORTEC®

Detective

HPGe-Based Portable Nuclide Identifier

Introducing the *ORTEC* Detective
The ONLY HPGe-Based Portable Nuclide Identifier

POSITIVE IDENTIFICATION OF RADIOACTIVE MATERIALS

- Rapid, Simple and Reliable Classification of NORM, Medical, Industrial, Nuclear and Natural Isotopes via advanced algorithms
- Search and Identify Modes, including dose rate
- 20x Improvement in Resolution (selectivity) compared to identifiers based on NaI
- Portable, battery operated instrument
- Ready to use at all times, straight from docking station
- Digital spectrometer electronics
- A definitive portable answer to the detection of illicit trafficking
- HPGe detector cooled by miniature, high-reliability mechanical cooler that operates from battery, line power or from 12 V DC
- Performance enhanced by digital noise filter[1]
- Detector element encapsulated in high reliability, low loss, all-metal seal cryostat
- Proprietary identification software

[1]Patent Pending

The aftermath of the tragic events of 9-11 resulted in an urgent need for many types of improved portable instrumentation to fight illicit trafficking of nuclear materials in a variety of scenarios.

A successful instrument must overcome at least two major technical obstacles. One is SENSITIVITY, lack of which can give rise to failures to find nuclear material (so called false negatives). A second is SELECTIVITY, which leads to the so-called innocent alarm or false positive situation, in which a benign radioactive signature is misinterpreted as being a threat. A failure of the first type leads to failure to detect illicit trafficking, whereas a failure of the second type leads to unnecessary disruption at check points such as a port or airport. These are tough problems to deal with in the front-line position, especially with a portable instrument. Independent testing has shown that room temperature detectors such as NaI or CZT are incapable of providing rapid, reliable and clear results without having to rely on a high-resolution (HPGe) auxiliary analysis facility.[2,3]

Examples of common substances, which can produce innocent alarms, are:

- Potassium nitrate fertilizers
- Granite or marble
- Vegetable produce
- Camera lenses
- Thoriated tungsten welding rods
- Lantern mantles
- Porcelain bathroom fixtures
- Ceramic tile
- Kitty litter
- Medical isotopes

Recent experience shows 90% of innocent alarms at airports are due to medical isotopes in the bodies of travelers, while in cargo freight, the major problem is caused by natural emitters. The false negative issue is demonstrated by the spectra superimposed in Figure 1. The dominant isotope is medical radioiodine, but the blue spectrum from a detector with poor resolution (selectivity) gives no evidence of the presence of the plutonium which is easily seen with a high resolution detector.

With a low-resolution NaI detector, it is possible to miss a nuclear material such as plutonium, because of the presence of an innocent isotope such as medical iodine. Intermediate-resolution detectors such as CZT are not able to solve the problem because their small size and low efficiency make them impractical. The low efficiency gives unreasonably long measurement times to "clear" a suspect case. Moreover their inferior resolution to HPGe means they are still more easily "fooled" than a HPGe detector.

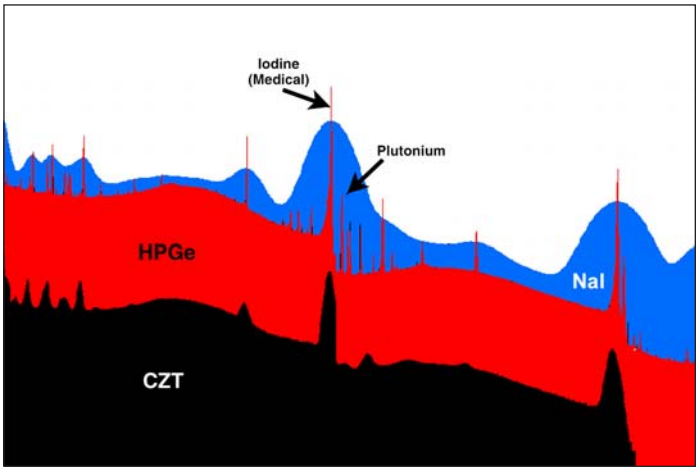

Figure 1.

Enter the Detective!

The Detective is a new kind of portable, nuclide identifier. By incorporating a HPGe detector for the first time in such an instrument, ORTEC has "raised the bar." The Detective can make an unequivocal determination, without the need for expert human intervention. For interdiction situations; this means you have:

- FEWER FALSE NEGATIVES
- FEWER FALSE POSITIVES
- "EXPERT LEVEL" DETERMINATIONS WITHOUT AN EXPERT

[2]ITRAP final report concluded that no tested instrument could fulfill the IAEA minimum requirements concerning Isotope Identification, Results Section 5.5 Point 3, FINAL REPORT ITRAP, ARC Seibersdorf.

[3]See LANL Reports LA-UR-03-4020 “Evaluation of Commercial Detectors” and LA-UR-03-2742 "Evaluation of Handheld Isotope Identifiers" J.M. Blackadar et al. All were NaI or CZT devices, and in 443 measurements the false positive plus false negative rate exceeded 60% of the total results. Available on ORTEC website at www.ortec-online.com/papers/reprints.htm#Homeland.

Detective Specifications at a Glance

The Detective Portable Nuclide Identifier (based on gamma-ray emissions only) provides the following functions:

SEARCH: Scanning mode for location of radioactive sources, with audio alert using an external earpiece.

IDENTIFY: Proprietary scheme[4] for identification and classification of radionuclides such as:

Industrial: Including, but not limited to ^{57}Co, ^{60}Co, ^{133}Ba, ^{137}Cs, ^{192}Ir, ^{241}Am, ^{75}Se

Medical: Including, but not limited to ^{18}F, ^{67}Ga, ^{99m}Tc, ^{111}In, ^{123}I, ^{131}I, ^{133}Xe, ^{201}Tl

Natural (NORM): Including, but not limited to ^{40}K, ^{226}Ra, ^{232}Th, ^{238}U

Nuclear: Including, but not limited to ^{233}U, ^{235}U, ^{237}Np, ^{239}Pu , ^{252}Cf

These classifications are based on an internal, fixed library according to ANSI N42.34. Customized libraries for specific applications can be supplied by special order.

DOSE Rate: Gamma Dose Rate is monitored by an internal compensated GM tube. Visual overrange indication and continuous audible alarm at dose rates >10,000 µSv/h.

Detective in Use

Figure 2 shows the operator keypad. Dedicated buttons are provided for simple search and identify operation.

Figure 3 shows the main operator screen. Gamma count rate and dose rate are displayed continuously, numerically and in bar graph form. The battery life remaining is also displayed.

When the search button is pressed, the display in Figure 4 appears. This shows a scrollng "strip chart" display of total count rate versus time, for your search operations. Instantaneous count rate and dose rate are also displayed.

When the Identify (ID) button is pressed, a screen like Figure 5 appears.

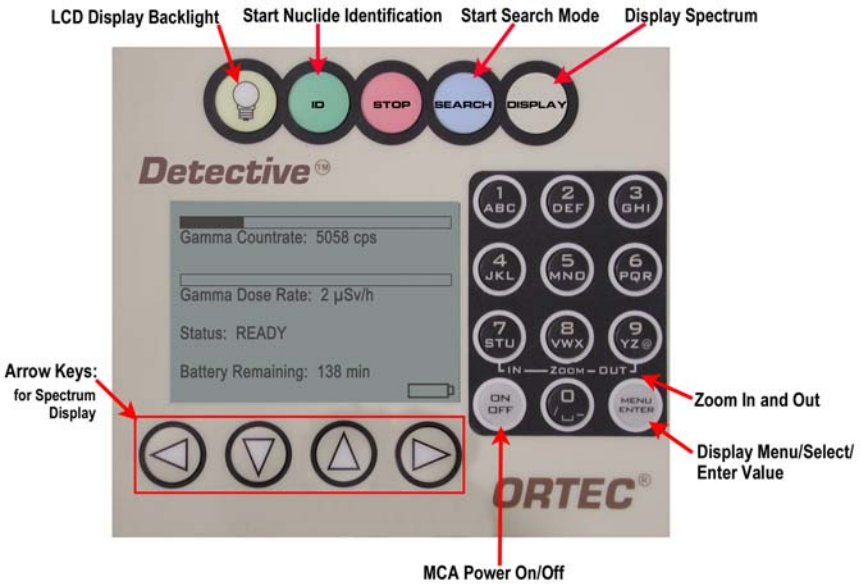

Figure 2.

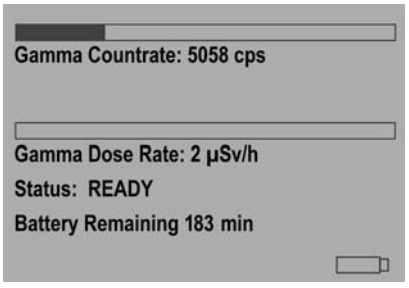

Figure 3.

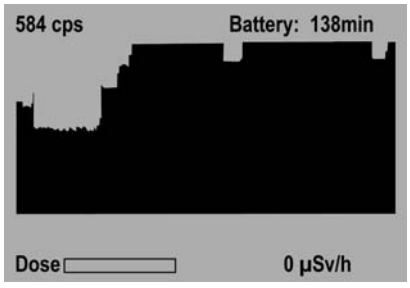

Figure 4.

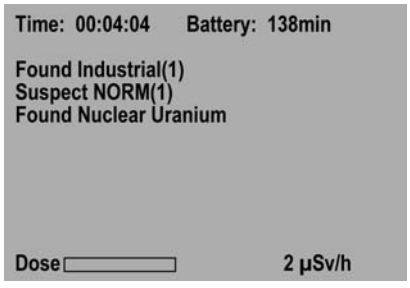

Figure 5.

[4]TL-01754-03 and TL-01753-03 Technology Transfer from LLNL.

Unlike other identifiers in which the instrument counts for a pre-set number of seconds and then attempts an identification, Detective is a "real time" identifier. Immediately after the ID button is pressed, Detective begins to identify. While the current standards, such as ANSI 42.34 call for identification to take place in one or two minutes, Detective typically reports in a much shorter period, in some cases less than 1 second.

"Suspected" nuclides are indicated if the statistical accuracy is not adequate; with more time, this tentative identification will often change from "suspected" to "found". This dynamic process is halted at any time by pressing STOP.

In Figure 5, one industrial and one nuclear isotope (uranium) have been identified, a natural isotope is suspected, and with more time, other nuclides might be identified.

Help Messages may appear on the main screen to assist the operator, such as:

"consistent with background, keep counting"
"Count Rate consistent with background"
"elevated radiation field"
"possible beta emitter"
"Possible nuclear material"
"Medical - positron emitter"

The form of the primary ID messages is:

"Found CLASS(#)" or "Suspect CLASS(#)"

where CLASS =
Medical
Industrial
NORM
Bremsstrahlung
Other

And "#" is the number of nuclides of that class identified.

In compliance with the IAEA, nuclear materials and Th-bearing NORM get special treatment. Possible messages include:

"Found nuclear uranium"
"Found nuclear plutonium"
"Found nuclear neptunium"
"Found NORM-Th"

A single button push takes the operator from the identify screen of Figure 5 to the screen in Figure 6 where the identity of the found nuclides is listed. Again, nuclear materials receive special treatment.

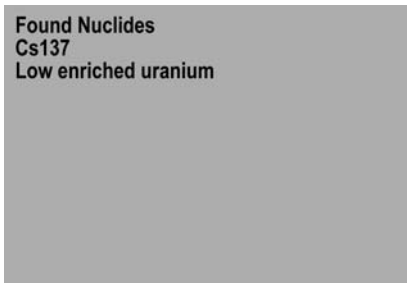

Figure 6.

If uranium has been detected, possible messages include:

"Highly enriched uranium"
"Depleted uranium"
"Low enriched uranium"
"Natural uranium"
"Elevated uranium concentration"

Similarly, for plutonium, and depending on the nature of the sample, shielding and the counting statistics, the following may appear:

"Count for >5 minutes for Weapons/Reactor Grade"

Followed by:

"Pu"
"Reactor Grade Pu"

or alternatively

"Pu"
"Weapons Grade Pu"

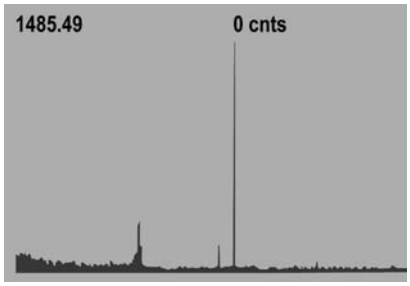

Figure 7.

You can also display the actual radionuclide spectrum, and manipulate the screen display (e.g., vertical scale, zoom) like a conventional multichannel analyzer. (Figure 7.)

Calibration Check

The Detective is supplied pre-calibrated from the factory. The advanced digital electronics and detector are very stable giving a constant peak position. A very simple procedure is used to verify and update the factory calibration. A small ^{137}Cs source is used, which can be installed in the docking station for use while recharging. The manual calibration check procedure is shown in Figures 8, 9, and 10.

When on the docking station, the detective continually recalibrates, meaning that when it says "READY", it is READY for you to use.

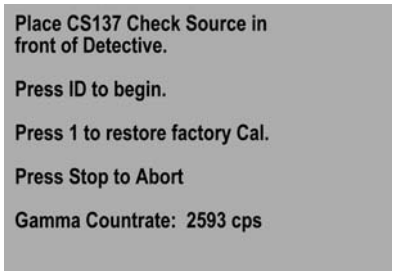

Figure 8.

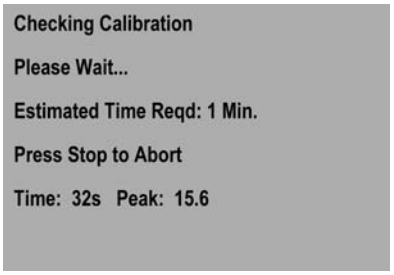

Figure 9.

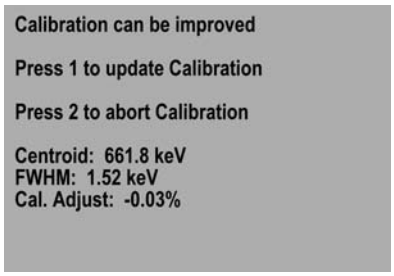

Figure 10.

Detective Power Sources

The Detective will go where you go. It draws power from a variety of sources. Designed for continuous operation, the miniature Stirling cooler has a very long operational life. (Design life exceeds 5 years continuous operation.) For initial cool down from ambient temperature, the Detective is placed on the supplied docking station. It takes less than 12 hours to cool to operating temperature, once cold, sustaining the Detective requires only a few tens of watts. The internal batteries have an operation life of more than 3 hours before additional power support is needed. The optional battery belt can be used to extend the operating time without limit. An automobile adaptor is supplied to provide charging through the docking station and support while in transit. For mains use, the docking station is supplied with a mains supply.

Performance

An interesting insight into the anticipated performance for SINGLE nuclides as seen in Figure 11.

The figure shows comparative data from seven portable nuclide identifier systems[3] and the Detective. The Detective is the only instrument using HPGe. The other instruments use NaI or CZT for the detector.

The X-axis in the figure is energy and the Y-axis is the quantity Efficiency/SQRT (Resolution) measured under similar conditions for each instrument. This quantity is a "figure of merit" relating to the detection limit of each instrument for a single nuclide. It represents the speed with which a positive identification is made, and the reliability of that identification.

The energy regions marked as LOW, MEDIUM, and HIGH are taken from Reference 5. It is clear from the "sharp" spectrum of Figure 1 which represents a medical-plutonium mixture and the relative sensitivities shown in Figure 11 that the Detective will have vastly superior sensitivity and resistance to innocent alarms, false positives and false negatives in comparison to all other hand held nuclide identifiers.

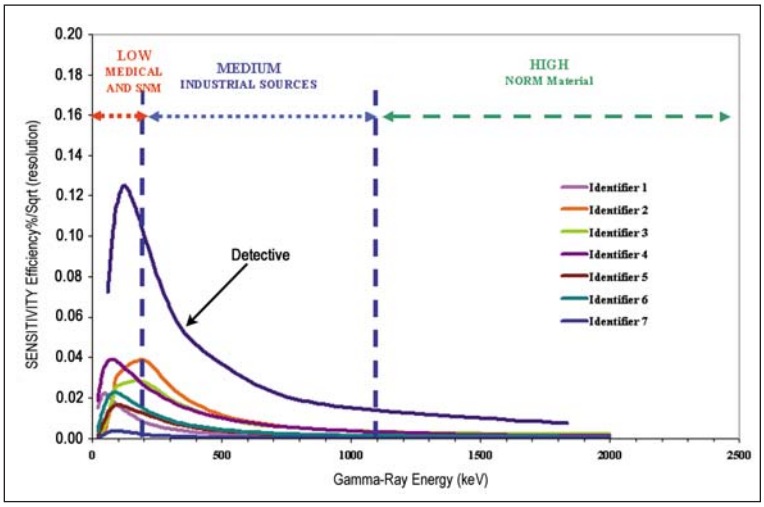

Figure 11.

[5]"The Application of Gamma Spectrometric Techniques with Plastic Scintillators for the Suppression of "Innocent Alarms" in Border Monitoring for Nuclear and other Radioactive Materials," K.E. Duftschmid, Technical University Graz, Austria, World Customs Exhibition and Forum, Budapest, Sept, 2003. Available on ORTEC website at www.ortec-online.com/papers/reprints.htm#Homeland.

Gamma-Ray Identification Performance Data for Uranium and Plutonium (typical values based on data obtained from actual measurements by ORTEC personnel)

Single Sources

Unless otherwise stated, these data were taken at a standard dose rate from the source of 500 nSv/h measured with a calibrated dose rate meter at the instrument detector face. When an absorber was present the dose rate at the detector was measured THROUGH the absorber.

Unshielded and Shielded Uranium: DU, U-NAT, LEU, HEU
The time to identify as uranium, either unshielded or shielded by up to 5 mm steel, is less than 5 sec. For LEU and HEU samples, the type ("LEU" or "HEU") is also reported in less than 5 sec. LEU and HEU samples shielded by 1.6 mm lead are identified as uranium in less than 5 sec.

Unshielded and Shielded Plutonium: Weapons Grade (WG), Reactor Grade (RG) (~60–93% Pu-239)
Time to identify as Pu, unshielded or shielded by up to 5 mm steel or 10 mm lead: <40 seconds for all types of Pu (with Cd filter if high Am content). For WG Pu the type "WG Pu" is also reported in less than 100 sec.

Mixtures

In all cases, the mixture consists of 500 nSv/h of the "mask" nuclide, added to the specified quantity of uranium or plutonium. The "dose ratio threshold" is defined to be the standard 500 nSv/h dose rate from the mask in ratio to the smallest dose rate from U or Pu detectable in the time stated.

Uranium at 500 nSv/h in the presence of Cs-137 or Co-57 mask (unshielded)
Time to identify as uranium <5 sec. For LEU and HEU, the type ("LEU" or "HEU") is also reported in <5 sec.

Uranium Dose ratio threshold for 60 second measurement in the presence of Cs-137 or Co-57 mask
>7:1 for identification as uranium unshielded, >3:1 shielded 5 mm steel
>2:1 for reporting as LEU or HEU unshielded, >1.5:1 shielded 5 mm steel

Plutonium at 500 nSv/h in the presence of Ba-133 mask
Time to identify as Pu <60 sec, unshielded or shielded by 5 mm steel or 10 mm lead. Identified type as RG Pu or WG Pu in <300 sec.

Plutonium Dose ratio threshold for 5 minute measurement in the presence of Ba-133 mask
>6:1 for identification as Pu unshielded, >4:1 shielded by 5 mm steel or 10 mm lead
>1:1 for reporting as WG Pu or RG Pu unshielded or shielded by 5 mm steel or 10 mm steel (with Cd filter if high Am content)

Specifications

OPERATION MODES

SEARCH
Scanning mode for location of radioactive sources, with audio alert using an external ear piece.

5 speed settings.

IDENTIFY
Proprietary scheme for identification and classification of radionuclides as:

Industrial: Including, but not limited to ^{57}Co, ^{60}Co, ^{133}Ba, ^{137}Cs, ^{192}Ir, ^{241}Am, ^{75}Se

Medical: Including, but not limited to ^{18}F, ^{67}Ga, ^{99m}Tc, ^{111}In, ^{123}I, ^{131}I, ^{133}Xe, ^{201}Tl

Natural (NORM): Including, but not limited to ^{40}K, ^{226}Ra, ^{232}Th, ^{238}U

Nuclear: Including, but not limited to ^{233}U, ^{235}U, ^{237}Np, ^{239}Pu , ^{252}Cf

These classifications are based on an internal, fixed library according to ANSI N42.34. Customized libraries for specific applications can be supplied by special order.

Dose Rate
Visual overrange indication and continuous audible alarm at dose rates >10,000 µSv/h.

DETECTORS

Internal HPGe Detector
Dimensions: 50 mm diameter x 30 mm deep nominal.

Coaxial construction.

P-type high-purity germanium.

Cooler: Hymatic SAX101-002 high reliability, low power Stirling Cooler. Cooler design life >5 years continuous running. Dual piston design, 1 W nominal lift at 100°K.

Digital Noise Suppression: "LFR Filter." ORTEC Patent Pending.

Gamma Dose Rate Detector
Detective uses two detectors to determine the gamma dose rate over a wide range from <0.05 µSv/h to >10,000 µSv/h, a dose-rate range of ~6 decades. For low dose rates, below ~20 µSv/h, the dose rate is determined from the Ge detector spectrum. For dose rates above this value, an internal compensated GM tube is used. Detective switches between the two automatically. Accuracy: dose rates up to 10 µSv/h. Uncertainty: ~≤50% to +100 %. Over-range indication and continuous alarm at does rates >10,000 µSv/h.

DIGITAL MCA AND DATA PROCESSOR

Display: 240 x 160 pixel backlit LCD.

Keypad: 21 numeric and function keys. Dedicated large single key for initiation of ID, Search and MCA display modes.

- Simple to use menu operation
- Digital MCA with internal storage of multiple spectral data
- Maximum number of stored spectra >40.
- 8k Channel Conversion gain.
- Monitoring of vital system functions:
  - Instrument Battery life remaining
  - System DC voltages
  - Detector Bias for both HPGe and GM
  - HPGe Crystal Temperature

Instrument is supplied factory pre-calibrated and adjusted. A recalibration function allows correct performance to be verified and adjusted using a small ^{137}Cs source.

DETECTIVE DISPLAYS AND MENUS

Main Screen

Gamma Count Rate Bar Graph 20 kcps full scale. Should the count rate exceed 20 kcps, bar is completely black and the rate line flashes.

Dose Rate Bar Graph 10 mSv/hr full scale, flashes on overrange.

Status Lines:

WARNING!! High Dose Rate — Displayed when Dose rate exceeds 10 mSv/hr

Detector is Warm — Displayed when crystal temperature is above working limit

Bias Supply Error — Displayed if any power supply is bad

WARNING!! Low Battery

Pressing Search starts a search mode acquisition

Pressing ID starts an identify operation

Pressing Backlight turns the light on or off

Pressing Display brings up the spectral display

Pressing Menu brings up the Main Menu

Search
Search starts when the "Search" button is pressed on the keypad. In search mode, a "strip chart" is drawn across the screen showing count rate vs. time on a log scale. 5 speed settings are available. If dose rate is beyond the maximum, the bar is black and flashes. The data may be saved.

Identify
When ID is pressed, data is cleared and acquisition starts.

Nuclides are divided into 5 basic types (Nuclear, Industrial, Medical, Natural, and Other).

Pressing Menu goes to the following options:
1 - **View Found Nuclides** returns confirmed identified nuclides
2 - **View Suspected Nuclides**
3 - **View Top Lines** returns the "Top 10 List"
4 - **Save** Saves the spectrum

Display brings up the spectral display. The spectrum may be manipulated via the arrow keys and various accelerator keys for cursor movement. Energy and channel contents are displayed with the spectrum.

Main Menu
1 - Administration Menu
2 - Calibrate
3 - Audio Settings
4 - View Diagnostic Status

1 - Administration Menu
Password Protected. Once verified, the spectrum screen is shown. Spectrum may be manipulated with Arrow keys and via zoom and jump "hot keys".

The Administration Menu has the following items:
1 - View Status
2 - General Settings
3 - Change Clicker Sensitivity
4 - Store & Retrieve Spectra
5 - Cooler Settings
6 - Search Mode Settings
7 - Change Dose Units
8 - Auto-Calibration Setup
9 - Exit Administrator Mode

2 - Calibrate
Calibrate looks for the ^{137}Cs peak in a range of 650 keV–680 keV. Once the peak is located, and there are at least 1000 counts in the peak (net area), a new fine gain is calculated. This is executed automatically when on the docking station.

3 - Audio Settings
Allows setting various parameters associated with the speaker and headphone.

4 - View Diagnostic Status

Reports instrument status, for example:

+12V	OK
–12V	OK
+3.3V	OK
Detector Temp	
Body Temp	OK
Cold Tip Temp	OK
Cooler Drive	OK
HV Volt	OK

PHYSICAL SPECIFICATIONS

Maximum Overall Dimensions (including handle, Ge detector endcap and shock absorbers) : 31.75 cm L x 16 cm W x 32 cm H (12.5” L x 6.3” W x 12.6” H)

Weight 23.3 lb (10.6 kg)

Internal Battery Life >3 hours at 25°C when HPGe detector is cold. Battery lifetime may be extended indefinitely by the use of external battery packs which are available in "battery belt" formats.

Input Power 10 to 17 V DC 30 W or from battery or auto-sensing Mains powered Battery Charger.
External Power DC In and Charge In. MS3112E12-10-s or Bendix PT02E-12-10S connector.

Temperature
Operation Range: –15°C to +50°C
Relative Humidity: <90% at 35°C, non-condensing

Communications Ports
USB 1.1 connection provided at the rear panel, protected by dust cover

External Earphone Jack, protected by dust cover

Communication Software
The Detective is a member of the ORTEC *CONNECTIONS* family. Remote control and data download, even over a network, is achieved simply, by the use of ORTEC *CONNECTIONS* products such as MAESTRO-32 MCA Emulation software.

Cool Down Time
The high reliability cooler is designed for continuous operation. Between making measurements the unit is powered from a DC supply, car battery or other high capacity device. The cooler life is expected to exceed 50,000 hours continuous operation. Initial cool down time depends on ambient temperature, but is typically <12 hours at 25°C.

Ordering Information

Model	Description
Detective	Detective HPGe Identifier. Includes docking station, universal mains supply, and automobile cable.
DET-CAL-CS	Internal Calibration Check Source. Cs-137, 37000 Bq, 1 µCi. Not included with Detective, must be ordered separately. Supplied at no charge. Proof of appropriate licensing must be supplied at time of order.

Options
A separate data sheet covering Detective Options and accessories is available on request.

Software for Detective

Detective is fully supported by the latest versions of the highly successful MAESTRO-32 MCA Emulator as well as the well-known ORTEC Gamma Spectroscopy Packages such as GammaVision-32 for generalized HPGe spectrum analysis, PC/FRAM and MGAHI for Pu and U isotopic ratio analysis and ISOPlus for in-situ waste assay analysis.

The integral USB connection in the Detective hardware provides full PC control, real-time live MCA display, fast data transfer of single and multiple spectra to the PC, and full ORTEC *CONNECTIONS* network support. Separate brochures are available on request.

PLEASE NOTE: MAESTRO-32 (A65-B32) is NOT supplied as part of the Detective. It must be ordered separately.

Specifications subject to change
061504

ORTEC®

800-251-9750 • www.ortec-online.com
info@ortec-online.com • Fax (865) 483-0396
801 South Illinois Ave., Oak Ridge, TN 37831-0895 U.S.A. • (865) 482-4411
For International Office Locations, Visit Our Website

AMETEK ADVANCED MEASUREMENT TECHNOLOGY