



Semiconductor detectors



& Nuclear Electronics for Radiation Measurements







History





Baltic Scientific Instruments was established in 1994 on the basis of Riga Research and Development Institute for Radio-Isotope Apparatus (RNIIRP, est.1966), which belonged to Ministry for Atomic Energy.

In 2003 the company has entered the group of BRUKER companies and in 2007 has change the name to Bruker Baltic. In June, 2010 the company has bought out its shares from Bruker AXS and returned its name Baltic Scientific Instruments (BSI).





OUR PARTNERS

International Atomic Energy Agency (IAEA)

Nuclear Power Plants (Russia, Ukrain, Lithuania, France, Germany, Spain, Finland, Italy, India, China, South Korea, Pakistan, Japan.....)

Environmental & Food Control Organizations

Industrial Customers, both OEM and direct

Numerous Universities & Research Institutes

Space Research Institutes (ESA, NASA, CEA Saclay, Danish SRI, Italian SRI, Russian SRI, China SRI.....)



HPGe Si Detectors and Electronics CdZnTe Scintilators



SiLi Detectors Cooled by LN₂



- Sensitive area 10 ...500 mm² customized geometries available
- Excellent energy resolution
- Any spatial orientation
- Thin Be or polymer windows
- Customized Dewar vessels
- Data acquisition software





SiLi Peltier Cooled Detectors





- Sensitive area 10 ...100 mm2 customized geometries available
- Resolution 160eV @ 5.9keV
- Closed system
 no liquid nitrogen
 - no external cooling water
- Any spatial orientation
- Thin Be or polymer windows
- Data acquisition software



SiLi Detectors used in X-ray Diffractometry



Alpha Detectors





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Pu-238, Pu-239, U-233 spectrum

 The detectors can operate without hermetization

- Relatively thin dead layer (less than 500 Å)
- High solidity entrance window
- Possibility working in vacuum
- Possibility of annealing the detectors up to 100 °C
- The detectors can be supplied with BNC or MICRODOT connectors.
- The detectors are produced with open window and with metalized window.

Alpha Spectrometers





Modifications available:

- 1 channel
- 2 channels
- 8 channels
- 12 channels



CZT Detectors





CZT Large Volume Detectors CZT/500S

Spectrometric Detection Probe SDP310/Z

CdZnTe Micro Spectrometer



APPLICATION

Gamma-radiation spectroscopy Environmental monitoring Nuclear power plants Monitoring of nuclear material flow Home land security

FEATURES

Very compact Changeable CdZnTe detectors Digital pulse processing High energy resolution High efficiency High count rate capability USB powered Minimal power requirements Easy-to-use



- High spectrometric performance from pixel to pixel
- Imaging in medicine and industry
- Space research applications









16x16 pixel detector based on crystal 15x15x10 mm³

Pixel Detector

CdZnTe Co-planar Grid Detectors







- State of the art performance:
 - volume 15 x15 x10 mm³;
 - energy resolution 1.7 % at 662 keV (¹³⁷Cs)
- Application: Safeguard in nuclear industry

Tomographic system based on CdZnTe detectors









Gamma Spectrometers All-In-One

based on Nal, LaBr₃, CeBr₃, Srl₂ crystals

BALTIC SCIENTIFIC INSTRUMENTS

micro

X

CE

Gamma Spectrometer combines scintillation crystal of different sizes, a photomultiplier tube, a high voltage power supply, a preamplifier and a multi-channel analyzer module from within one rugged housing.

Available with following detector dimensions: 51mm x 51mm (2" x 2"); 63mm x 63mm (2.5" x 2.5"); 76mm x 76mm (3" x 3").



Gamma–, beta- and alpha - spectrometer – radiometer TRIO

Gamma-, beta- and alpha – spectrometer TRIO is intended for measuring energy distribution of gamma- and beta radiation, identify gamma-emitting radionuclides, and also for measuring the activity (specific and volumetric activity) naturalradionuclides ²²⁶Ra, ²³²Th, ⁴⁰K, ²²²Rn, and technogenic radionuclides (¹³⁷Cs, ¹³⁴Cs, ⁶⁰Co, ^{99m}Tc, ⁹⁰Sr and etc.) in the soil samples, rocks, vegetation, water, food, wood, building materials, chemical industry materials, alloys, scrap metal and other technological products. Also it is used for measuring gross specific activity of beta- and alpha- emitting radionuclides in water.





Mobile Radiation Monitor GammaCART

GammaCART is designed to measure gamma radiation energy distribution, identify gamma emitting radionuclides, as well as calculate specific and surface activity of gamma emitting radionuclides under conditions of their natural occurrence and at nuclear industry premises





Gamma and X-ray HPGe Detectors Cooled by LN₂



- Customized Dewar vessels
- Excellent energy resolution
- Data acquisition software

Avaialble:

Coaxial

• Efficiency 10...160%

Planar

Sensitive area – 20 …5000 mm²



Gamma HPGe Detectors Cooled by LN₂ (X series)



Energy range from 5 keV to 10 MeV.

Excellent energy resolution.

Relative registration efficiency from 10% to 160 %.

Thin input window made of Beryllium or Carbon windows



Well-type Gamma-ray Detectors





Energy range from 20 keV to 10 MeV

Relative registration efficiency: from 15% to 60% and higher.

Well diameter: 10 mm – 20 mm.

Well depth: 40 mm - 60 mm.

Energy resolution: at 122 keV –1.2 keV, at 1.33 MeV –2.2 keV.

BALTIC SCIENTIFIC INSTRUMENTS

Laboratory HPGe Spectrometer with shield for Radionuclide Analysis



- Radionuclide monitoring of environmental and biological objects, materials and food
- Detection limit for ¹³⁷Cs 0.5 Bq/kg
- Low level of instrumental background
 - Less than 400 pulses per 24 hours



Automated Spectrometers







Waste Assay Monitor Hercules 200





Waste Assay Monitor Hercules 200





Waste Assay Monitor Hercules 400/RC



Industrial Systems

Automated System for Specific Water Activity Monitoring in Water Reservoirs





- high sensitivity of radionuclide activity detection
- full autonomy of measurement station
- data transfer via radio channel or cable channel into the point of information receiving, processing and archiving
- operation simplicity and system high reliability

Industrial Systems

Automated Spectrometers for Radionuclide Analysis of Liquid and Gaseous Flows





Automated Spectrometers for Radionuclide Analysis of Liquid and Gaseous Flows



DEFINISTRUMENTS

HPGe Hand Held Spectrometer NitroSPEC





APPLICATION

- Customs and Homeland security
- Environmental monitoring
- Waste Management
- Nuclear Industry
- Nuclear Medicine
- First Response

ADVANTAGES

- Minimal weight and size,
- Ready for operation in 1 hour,
- autonomous operating time up to 20 hours,
- Simple and cheap in maintenance and service,
- Really competitive price.

HPGe Hand Held Spectrometer HandSPEC (electrically cooled)





APPLICATION

- Customs and Homeland security
- Environmental monitoring
- Waste Management
- Nuclear Industry
- Nuclear Medicine
- First Response

FEATURES

- Integrated solution with HPGe detector, MCA, power supply, etc.
- No Liquid Nitrogen needed
- Long autonomous operation time up to 6 hours
- Really portable device
- Good energy resolution provided by Pulse tube application
- Rugged and designed for outdoor use in wide range of temperature and humidity

Mobile System

HPGe Mobile Spectrometer for Field Application





Optimal size and weight for mobile application

Placed on a trolley with Lead shield set

Minimal time to reach the operating temperature after LN2 filling

Simplicity of operating and servicing the device



Electricooling system

MODULE

FEATURES and ADVANTAGES

- Possibility to install any BSI detector;
- Cooling time not more than 4 hours;
- Small dimensions (about 380 x 250 x 250 mm);
- Long continuous running (without stops);
- Integrated system for detector temperature stabilization
- Operational temperature: -10 °C +50 °C
- Spectrometric parameters not worse comparing with liquid nitrogen cooling systems.







Laboratory HPGe Spectrometer with shield and Electrical Cooling

HPGe Spectrometer with Hybrid Cooling





Spectrometer "BOSON"

FEATURES and ADVANTAGES

- Smaller dimensions (170 x 90 x 180 mm);
- Fully digital control;
- Multifunctional status indicator;
- Increased capacity up to 32 768;
- Increased range of amplifying coefficients;
- More communication ports: RS-232, USB, Ethernet;
- HV Power supply with various variations: from 0 to + 5 kV (for semiconductor detectors), from 0 to \pm 2 kV (for photoel. multiplier);
- Amplifier Power Supply \pm 12 V and \pm 24 V;
- Spectrometer Power Supply from 9 to 18 V (allowing to use auto accumulator);
- 4 shaping time constants with ballistic inaccuracy correction;
- It is possible to use with various types of preamplifiers (resistive and pulse feedback);
- Energy range span up to 1000 times (from 3 KeV up to 3 MeV).



negative

0

N

HV1 ON

HV2 ON

STATUS

ACQUIRE

Polarity

nhibit Polarity

SOFTWARE



- EffMaker simulation without measurements;
- Quality Assurance system (allowing to assess the detector health);
- Conforming with ISO 11929 (allowing to calculate MDA, MDC);
- Language pack (software localization for various languages);



Deep-water Gamma-ray Spectrometer





Gamma-radiation from radionuclides in monitoring of the sea bed for objects from marine accidents, submarine storage of radioactive wastes, search of lost nuclear charges, inspection of radionuclide migration, etc.

- Long-duration independent data collection at great depth (up to 3000m)
- Storage of gamma-spectra during unlimited time
- Package includes special data processing software

In-situ Automated Spectrometers for Radionuclide Analysis in Natural Water Reservoirs







HPGe Spectrometer for Orbiter







Flowing HPGe Detection Unit

FEATURES

- Efficient control of radionuclide materials with low activity
- 4π geometry measurements
- Efficiency registration dozens times higher

Industrial Systems



Flowing HPGe Detection Unit



Absolute efficiency registration comparison curves

Industrial Systems

Borehole Gamma Spectrometer





• Determination of underground orientation of transuranium ores in their natural beddings (headings, mines, boreholes);

• High precision gamma-spectrometry of radionuclides at inspection of sea bed, water sealed mines, water filled boreholes, radionuclide migration in groundwater;

• Gamma-spectrometry at neutronactivation method of substance analysis.

Our experience in Ultra Low-Background technique with HPGe spectrometers



1. Institute for Nuclear Research, Kiev, Ukraine

Underground laboratory in Solotvino Cave

2. V. G. Khlopin Radium Institute, St. Petersburg, Russia

Underground laboratory in Metro ("Gostiny Dvor" station) 120 meters water equiv.

- **3. National Research Centre "Kurchatov Institute", Moscow**, Russia *Multi-crystal HPGe detector with active shield*
- **4. Institute of Theoretical and Experimental Physics, Moscow, Russia** HPGe detectors for GEMMA experiments at Kalinin NPP, 70 meters water equiv.
- 5. Joint Institute for Nuclear Research, Dubna, Russia

HPGe spectrometers for research applications

6. Joint Research Centre of EU, Institute for Ref. Materials and Measurements, Geel, Belgium

Underground laboratory in HADES

7. CEA Saclay, Gif-sur-Yvette, France

Edelweiss experiment - Black matter search project

- 8. Max-Planck-Institut für Kernphysik, Heidelberg, Germany Black matter search project
- 9. Tsinghua University, Beijing, China Black matter search project

Storage and transportation of HPGe

- 1. Transportation by road or other surface methods
- 2. Storage in water or paraffin shield with Cadmium box inside
- 3. Time minimization for HPGe detector fabrication





Radon. Transportation of HPGe crystals in hermetic boxes in dry nitrogen atmosphere - Edelweiss experiment









- 1. Storage of crystals in dry nitrogen atmosphere
- 2. Transportation of crystals by surface freight

In hermetic boxes in dry nitrogen atmosphere to prevent precipitation of radon on the surfaces of crystals



Assembly of the Detectors



Proper cleaning of crystal surfaces is performed, high-purity acids are used.

Assembly of the detector takes place in a dry box in nitrogen atmosphere to prevent contamination of surfaces with dust or radon.



Design of Ultra-Low Background HPGe Detectors



- Typically a "U-type" cryostat
- Remote preamplifier outside of the Pb shielding
- Sorption pump (Zeolite) outside of the Pb shielding
- FET with low background design
- Electrolytic copper screen
- Electron-beam welding



Materials for Low-Background Cryostats



- HPGe crystal
- High-purity Lithium and Nickel for contacts
- High-purity AI for end-cap and crystal holder (AISi 1%, grade 5N5, U + Th < 1 ppb)
- Electrolytic Copper (OFE-OK) for coldfinger parts
- Materials analysis on radiopurity
- High-purity acids are used for etching
- Deionized water is used for cleaning
- Soldering is minimized
- Number of screws and washers from stainless steel is minimized (checked for radiopurity)



Radiopurity measurements in underground laboratory by means of ultra-low background HPGe detectors



Radionuclide	Sapphires	FET assembly on standard substrate	FET assembly on low-background substrate				
	mBq/kg	mBq/assembly	mBq/assembly				
²³⁸ U	< 21	19±5	< 2				
²³⁵ U	< 3.3	n.a.	< 0.8				
²²⁶ Ra	< 6.5	16±2	0.28±0.25				
²²⁸ Ra	< 10	25±1	< 0.9				
²²⁸ Th	< 4	26±1	< 0.8				
²¹⁰ Pb	< 25	68±37	24±8				
⁴⁰ K	< 30	5±3	< 5.6				
^{6O} Co	< 3.3	n.a.	n.a.				
¹³⁷ Cs	< 3	n.a.	< 0.23				
⁷ Be	n.a.*	n.a.	< 2				
⁵⁴ Mn	n.a.	n.a.	< 0.8				
n.a. – peak detected, but detection limit is not calculated							

Quality of HPGe Detector





Background spectrum of 160% efficiency HPGe detector:

- Low background cryostat in passive lead shield without Cu liner.
- Measuring time: real 41 942 seconds; live: 41 931 seconds.
- Energy resolution 950 eV at 122 keV; and 1970 eV at 1.332 MeV.

GEMMA I – Detector and shield

GEMMA – <u>G</u>ermanium <u>E</u>xperiment on measurement of <u>M</u>agnetic <u>M</u>oment of <u>A</u>ntineutrino



HPGe detector parameters:

- P-type coaxial
- Dimensions: 70 x 70 mm (d x h)
- Relative registration efficiency: 70%
- Energy resolution:
 - < 900 eV at 122 keV
 - < 1.9 keV at 1.33 MeV

Shield parameters:

Passive elements

- 25 cm of Pb
- 5 cm of Cu
- Active elements
- Nal scintillation detectors assembly
- Plastic scintillation detector on the top



GEMMA II – Design and Parameters

Design:

- 1. Crystals are installed facing each other
- 2. Ring-type Sapphire insulator
- 3. Copper holder with thickness of 30 mm
- 4. Crystal holder is supported by thermal bridge
- 5. Copper cold finger
- 6. Fluoroplastic centering rim
- 7. Thin copper screen is intended for cold transfer to upper crystal
- 8. Thin AI cup produced from single high-purity AI piece.

Double-crystal detector parameters:

- Crystals dimensions 80 x 120 mm (d x h)
- Relative registration efficiency of each detector:150%
- Energy resolution
 - < 900 eV at 122 keV
 - < 2.0 keV at 1.33 MeV
- Possibility to operate in coincidence mode



Ultra-Low Background Detector – Design and Parameters (JRC, Geel)

Design:

1. End cap, detector holder and cold finger parts are made from electrolytic copper

- 2. Sapphire parts, screws, FET are tested on radioactivity, selected
- 3. Inverted U-type cryostat with extended arm

4. Sorbent is placed in horizontal arm in order to be located outside passive shield chamber upper crystal

Detector parameters:

- Crystal dimensions 80 x 70 mm (d x h)
- Relative registration efficiency: 85%
- Energy resolution:
 - ~ 850 eV at 122 keV
 - ~1.85 keV at 1.33 MeV



Ultra-Low Background Detector in JRC, Geel







Ultra Low Background HPGe Detector





Assembling of multicrystal HPGe Detectors





Inverted-Coax HPGe Detectors





Specification sheet HPGe coaxial detector GWD - 6022 Serial N: 2522-17



- 1.Operating voltage: +3000V
- 2.Detector characteristics:
- 3.Measurement conditions:
 - 1.Spectrum analyzer: *Hybrid, BSI Ltd., shaping time =6 us*
 - 2.Software *SpectraLineGP*

Energy:	122keV (Co-57)	1332keV(Co-60)
Measured FWHM in eV:	665	1883
FWTM/ FWHM	-	1.99



Inverted-Coax HPGe Detectors







Five detectors characterized in Europe specifically for LEGEND

- Three commercial SAGe detectors from CANBERRA(?)
 - Yoann Kermaïdic (MPIK)
 - Three detectors, masses 1.4, 2.7, and 2.9 kg
 - Good PSA, 5.5 6.1% SEP for 90% DEP acceptance
 - Good to acceptable resolution (2.6, 3.1, and 3.1 keV FWHM at 2614 keV)
- Prototype from ORTEC
 - Yoann Kermaïdic (MPIK)
 - 1.6 kg, 76 mm diameter, 66 mm long, no taper
 - 2.5 keV FWHM at 2614 keV
 - PSA: 5.9% SEP for 90% DEP acceptance
- Prototype from Baltic Scientific (Crystal from UMICORE)
 - Tommaso Comellato (TUM)
 - 1.7 kg, 78 mm diameter, 63 mm long, no taper
 - 2.5 keV FWHM at 2614 keV
 - PSA: 4.6% SEP for 90% DEP acceptance

David Radford

2017 International Germanium Detector Technology Workshop LBNL December 2017

GWD - 6023 Serial No 2661 – 18

MODANE



GwD-6023 1

8025,686

443 Live:

Loading:

6656

753.690 Real:

7168

768.700 Dead: 1.95% Channel: 7292 Counts:

Channe

7 Energy:

1210.62 FW:

1.69



DEFINISTRUMENTS



Segmented HPGe Detectors







Crystals Processing













Photolithography













Thank you for your attention!

www.bsi.lv