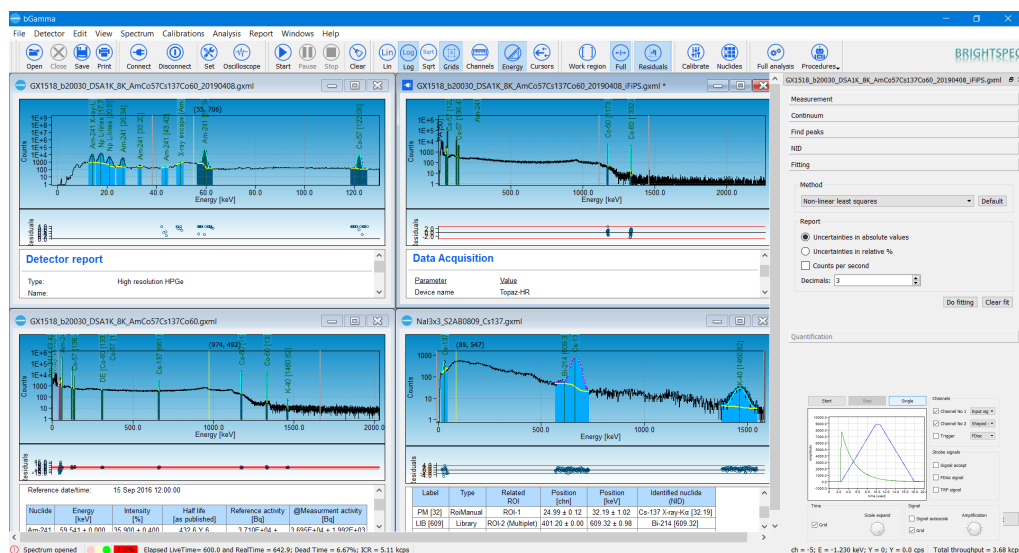# TECHNICAL SPECIFICATIONS

bGamma Software Package

INTRODUCTION

The analysis of the energy spectra resulting from any radioactive sample and recorded with a nuclear radiation detection system is still a very critical step in gamma-ray spectrometry due to its complexity, e.g. large amount of interference between radionuclide emissions, presence of spectrum artifacts (sum and escape peaks), complex continuum, correct radionuclide identification and quantification of its activity independently of the measurement geometry or sample characteristics among many others.

bGamma software is a general purpose, comprehensive and extensive software package for gamma-ray spectrum analysis and radionuclide identification and quantification.

bGamma software can analyze any recorded gamma-ray spectrum independently of the detector, geometry or sample used. bGamma, provides all the necessary tools and functionality for performing the detailed analysis of complex gamma-ray spectra and the corresponding radionuclide quantification from the given sample.

In particular the software allows to:

- Connect and control the hardware for correct data acquisition
- Controls and visualizes the data acquisition
- Imports spectra from other file-formats
- Energy, shape and efficiency calibration for the gamma-ray spectra
- Automatic peak search and peak class identification (singlets, multiplets)
- ROI analysis and calculations
- Fitting of the experimental data to mathematical models, including background subtraction, peak interference correction, etc.
- Nuclide identification with separation from possible spectrum artifacts and structures
- Radionuclide activity and MDA calculations

All of above in a very simple and yet powerful way. The modern graphical user interface (GUI) makes spectrum visualization and analysis very intuitive and provides an important "visual" feedback of the analysis results.

bGamma software is a multi-document software allowing you to analyzed multiple-spectra at the same time and/or acquire data from several connected detectors.

The large quantity and variety of calculation algorithms implemented into bGamma allows you to analyze a broad range of gamma-ray spectra independently of the detector used, e.g. from high-resolution Ge spectra to medium resolution scintillator spectra from $LaBr_3$ or the vastly-used NaI(Tl).

bGamma software runs seamlessly on MS Windows® , Linux™or macOS® .

FEATURES

- Controls data acquisition and setup detector-MCA
- Implements different automatic peak search methods
- Provides several methods for peaks' continuum evaluation and subtraction
- Automatic and/or manual ROI insertion. Region of interest (ROI) calculations.
- Energy and shape calibrations using comprehensive data input with visual interaction and feedback
- Easy to perform and yet powerful efficiency calibration, with single or dual polynomial fit and user-defined cross-over point.
- Implements several spectrum analysis fitting methods, including **Bayesian fitting**. This wide choice of analysis methods warranties the success and/or suitability of spectrum analysis for any kind of gamma-ray spectrum and analysis needs
- Fitting and mathematical model parameters are at hand for their quick changes and optimization
- Superb graphical user interface (GUI) that can be set to user's preferences. Multiple and interactive peaks coloring and labels
- Advanced spectrum cursors (multiple-cursors) showing satellite or spectrum artifacts
- Multi-document design with full data synchronization
- Great traceability, saving all information into XML-formatted files (*.gxml)
- Import spectrum from other formats. E.g. Ortec (*.chn) and Canberra (*.cnf) files
- Customizable analysis reports, including fully colored and HTML-formatted tables
- Quantification via different methods
- MDA calculations via three methods: ISO 11929, KTA and Currie (standard) methods, with meaningful and flagged data table reports
- Embedded full radionuclide library based on internationally well-know and maintained "NuDat" nuclear data files
- The software is multi-platform and runs seamlessly under MS Windows®, macOS® or Linux™

BRIGHTSPEC

HARDWARE CONTROL

- Connect to any BrightSpec device

- Setup and control data acquisition via device control widget

- Incorporates a two-channel digital oscilloscope for signal inspection and device's troubleshooting

FILES

- bGamma uses ASCII XML -structured files as data storage format into files.

- Nearly all spectral data, acquisition parameters, spectrum analysis settings and results are stored into files, providing great data review capabilities.

- Still you can import spectral data stored into different file formats, such as: IAEA *.spe, Canberra *.cnf, Ortec *.chn and ANSI N42.42

CALIBRATIONS

- Provision of multiple methods for energy and peak shape calibrations.

- Calibrations are perform using interactive and visual displays which shows fitted calibration functions, residual plots, experimental points with their uncertainties, etc.

- Input data covariances are taken into consideration when calculating any calibration function.

DATA ACQUISITION AND HARDWARE CONTROL

Using bGamma software you can connect to **any BrightSpec device,** set it up and perform data acquisition. The connection dialog will automatically search for available devices in your PC or network for connection.

The parameters of each individual device are properly shown using its device control widget.

The widget will automatically detect the device's capabilities and enable/disable the corresponding controls. Using the device control you can manage any hardware parameter from the basic ones to the most sophisticated and dedicated ones. The settings can be conveniently stored into or load from a file.

The software incorporates a dedicated toolbar for hardware control and data acquisition. It also provides a two-channel digital oscilloscope. Using this tool you can review the electronic pulses, fine-tune your device's settings and/or troubleshoot any potential problem.

FILES

bGamma stores nearly all spectrum information and analysis results into files. This way provides an outstanding method for data traceability and review. bGamma application uses XML-based ASCII formatted files; which warranties fast data parsing and fast individual data component location while still preserves the human readability and can be easily imported into other data concentration systems, such as large databases.

In bGamma you can easily import spectral files stored into other file formats, such as:

- IAEA ASCII-formatted, *.SPE files

- TXT, generic text files

- Canberra binary, *.CNF files with no need of VDM or runtime libraries to be present on local PC.

- ORTEC binary, *.CHN files

- And N42.42 xml-based files (including latest 2012 revision)

> Import Canberra binary files (*.cnf) directly into bGamma with no need of the VDM nor the Canberra's run-time libraries to be installed in your PC
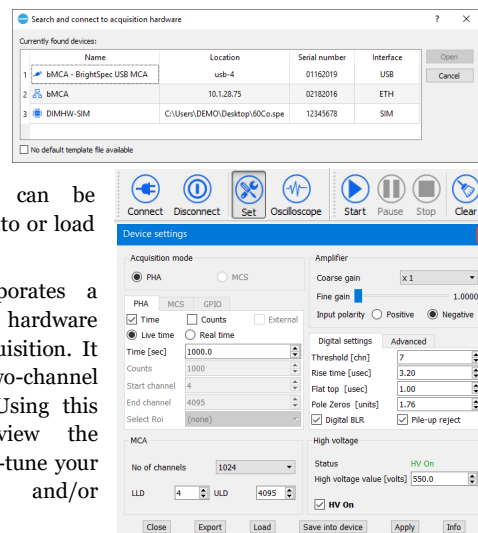
CALIBRATIONS

bGamma provides the necessary tools and functionalities to perform spectrum energy calibration, shape calibration and photon efficiency calibration.
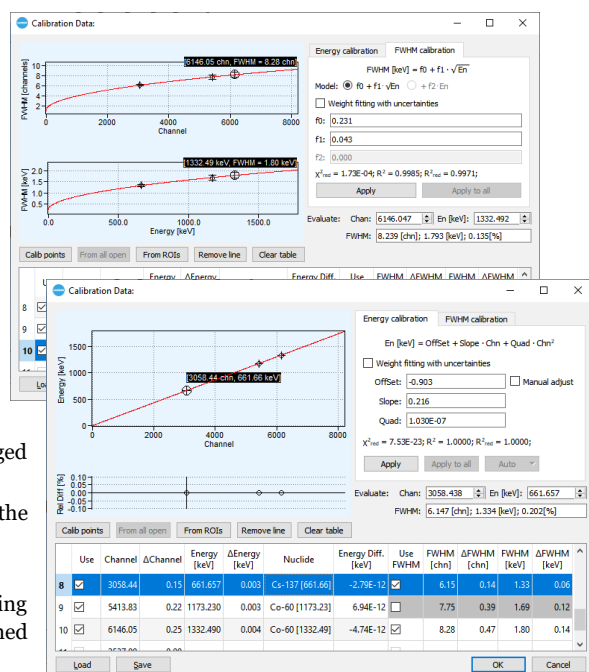
Energy and shape calibration

Many methods and ways to perform an energy and shape calibration.

- Simple energy calibration using spectrum plot cursor and one point (or peak).

- Using several calibration points and interactions with currently marked ROIs in the spectrum

- Automatic with a radiation library input, tagged radiations or single nuclide radiations

- "Manually and visually adjusted" to match the obtained energy spectrum

- Editing the calibration coefficients

Each calibration has its dedicated plot showing experimental points, their uncertainties, obtained calibration curve and differential residual plot.

Efficiency calibration

Uses a polynomial fit to the Ln(E).

Provision of graphical plots containing experimental points and their uncertainties and fitted polynomial curve. The plot includes a cursor with explicit calibration point (nuclide emission) label for better guidance.

> Experimental points' uncertainties and their covariance are taken into consideration for efficiency curve calculation

Residuals plot with calculated uncertainties.

Includes both a fit to a single polynomial function or a fit to two independent polynomial functions with a user-selectable cross-over point.

Efficiency calibration polynomials are fitted dynamically while the user is changing the input data and/or the mathematical model.

Obtained curve is given with statistical results parameters, such as χ^2, R^2 and $R^2_{reduced}$

The algorithm checks for correctness and applicability of the efficiency calculation conditions (e.g. same detector, geometry, etc.).

An evaluation toolbox is provided for evaluating an efficiency value at currently obtained polynomial fit.

Can import experimental points from Canberra LabSOCS/ISOCS™ as well as from generic Monte Carlo calculation codes.

OUTSTANDING GRAPHICAL USER INTERFACE

The program has been designed with a very rich, complete and powerful graphical user interface.

Nearly any action on the spectrum analysis can be reviewed through a "visual feedback".

Every graphical component is automatically updated to show the specifics of the currently selected spectrum. All the computational results (ROI computations, peaks' fitting, activity results) can be displayed into dynamically updated tables. The table's contents can be easily selected.

All the graphical components can be shown/hidden or set to the user's preferences; creating a convenient, attractive and yet powerful spectrum analysis dashboard. Among many, the following GUI features are highlighted :

- Display of spectrum analysis fitting residuals
- Individual and distinctly display of each peak fitting component (multi-peaks in ROI, continuum, total peak fit, etc.)
- Color distinction in dependence of ROI/peaks categories and/or method of their creation
- Use of context menu commands for most commonly used spectrum analysis operations or dynamically changed context menu in dependence of the spectrum plot or spectrum analysis situation
- All graphical components and spectrum plot can be set to the user's preferences
- Spectrum zoom in and out with easy sliding commands and auto-scales
- Spectrum plot scales on different units. X-axis (energy and channels) and for Y-axis (counts or cps) in Linear, Logarithmic or Square-root scales
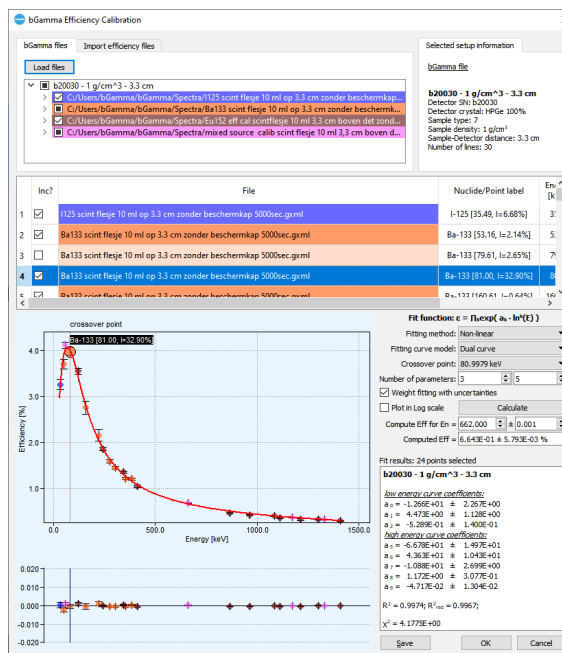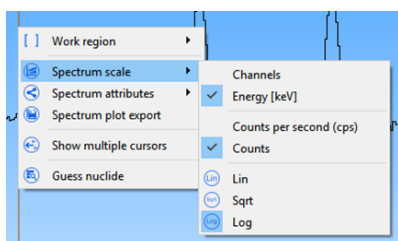
> bGamma provides a powerful GUI for immediate and visual spectrum analysis feedback, easy analysis operations and yet visually attractive

BRIGHTSPEC
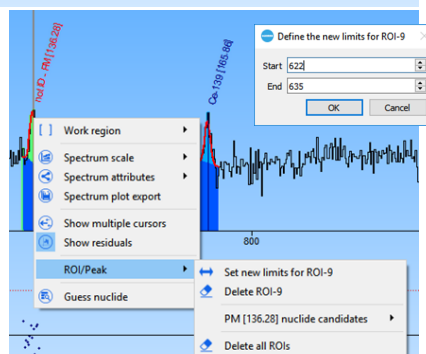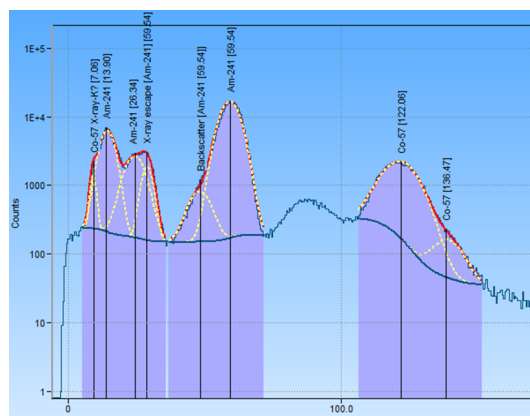
- Use of dynamically created context menu

- Implement toolbars and floating docking windows for displaying numerical and graphical data

SPECTRUM ANALYSIS

- Powerful spectrum analysis methods

- Seven peak search methods

- Four spectrum/peak continuum models

- Three peak's spectrum fitting methods, including "**Bayesian fitting**"

- All peak fitting data results can be visualized and updated dynamically

ACTIVITIES AND MDA

- Activity calculations per peaks or per nuclides

- Reporting of "Weighted activity"

- Report radionuclide activity in different units and normalized to sample weight or volume

- Provision of multiple methods for minimum detectable activity (MDA), such as:

  I. According to ISO-11929 standard (including 2010 revision)

  II. KTA

  III. Currie or traditional method

- MDA report results with clear flag indications

GRAPHICAL INTERFACE (CONT.)

- Peak's pop-up balloon label with peaks computation results

- Display of "multiple-cursors". This feature shows the different possible spectrum artifacts (like single or double escape peaks, sum peaks, X-ray escape peaks, Compton edges, etc.). from the current spectrum plot position. The spectrum artifacts to be displayed can be selected from the program's preferences.

- View of computational results into dynamically updated data tables

- Use of docking and floating windows, which provides easy access to spectrum analysis model parameters.

> bGamma implements three peak's fitting methods, including "**Bayesian fitting**" a peak's fitting model that does not depends much of the peak's shape calibration

Among many others.

SPECTRUM ANALYSIS

bGamma software offers a large amount of methods and calculation engines for the spectrum analysis; allowing to practically analyzed any recorded spectral data independently of its detector type, sample characteristics and used geometry.

There are:

- seven peak search methods

- four mathematical models for spectrum /peaks continuum

- Three peak fitting algorithm which includes "Bayesian fitting", a novel peak's data fitting that does not requires of input of peak shape calibrations.

ACTIVITY AND MDA CALCULATIONS

Radionuclide activity calculations can be performed per peaks, but also per nuclide. They can be normalized to sample weight or sample volume.
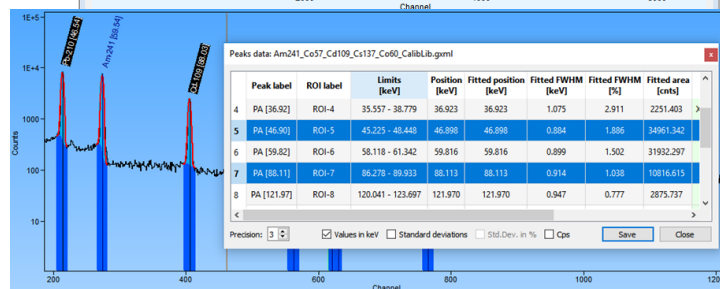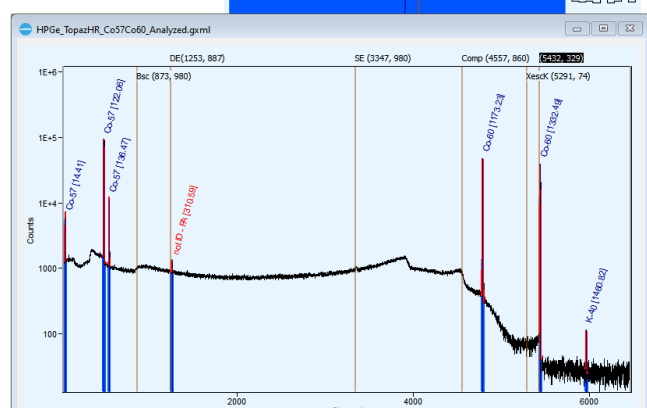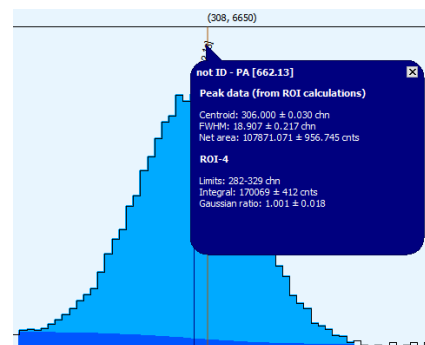
Activities can be reported using several radioactivity units.

MDA calculations can be done via three selectable method:

- According to ISO-11929 (including revision 2010)

- KTA

- Currie (standard method)

In the case of ISO-11929, comprehensive data table are reported with clear indications of decision levels.

Additionally, MDA calculations on the current spectrum can be done against a different (secondary) set of nuclear radiations or nuclear library.
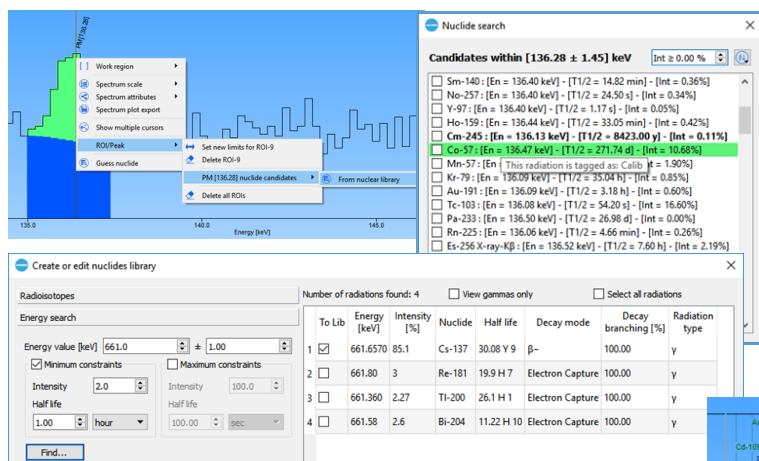
NUCLIDE LIBRARY

In bGamma the traditional concept of "nuclear library" is unnecessary. All the radiations from nuclear decays are embedded into the program and easily and very fast accessible; thanks to a novel data handle technique implemented into the program.

> bGamma embeds the entire nuclear decay radiations library

This data handling method allows access to any library nuclear radiation with no noticeable delay and from any part or step of the spectrum analysis.

bGamma embeds data from the well-know, maintained and evaluated nuclear data library NuDat [1]

This approach improves the recognition of any radiation present into the spectrum as well as any step of the spectrum analysis (e.g. energy calibration, efficiency calibration, nuclide identification, etc.).

It also allow to perform novel spectrum analysis functionalities like:

- Online and extensive library radiation search
- Use of "tagged" radiations
- Perform a generic (Ctrl+F) search from any where in the spectrum
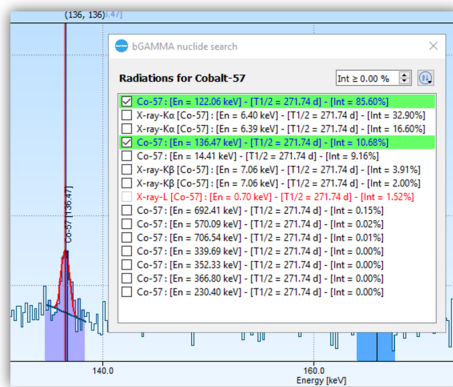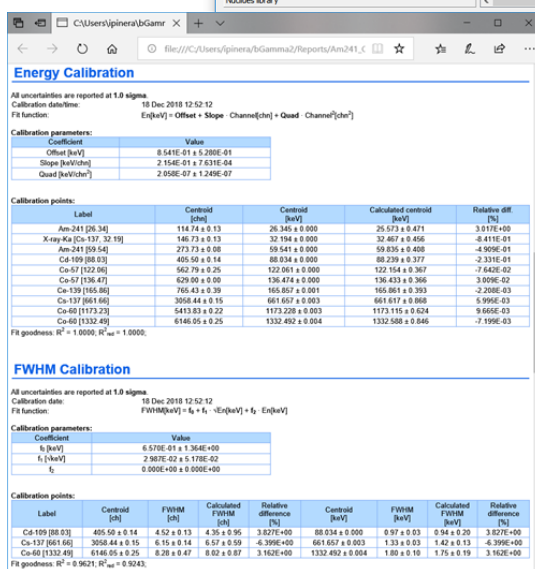- Implements peak "guessing"

And much more.

REPORTING

bGamma employs rich, colorful HTML-based reports that includes graphical data and numerical tables. Statistically doubtful data results are flagged and colored in dependence of their criticality. Each spectrum/document has its own individual report displayed in the spectrum report panel.

Reports contents and layout can be changed to user's preferences using the report template editor. Report templates are based on plain HTML-based commands and scripts.

Reports can be saved as HTML or PDF documents.

NUCLEAR LIBRARY

- Fast data handling techniques allows the inlusion of the entire decay data radiations into the software. Providing fast access to any nuclear radiation from any part of the program or step of the spectrum analysis
- bGamma uses NuDat[1] data files as provider of decay radiation library information
- Provides advance techniques as generic "CTRL+F" for radiation search or "guess nuclide"
- Nuclide radiations can be "tagged" and quickly recalled at any time or step

[1] see NuDat citation and disclosure notes at the end of this document

REPORTS

- HTML-based reports
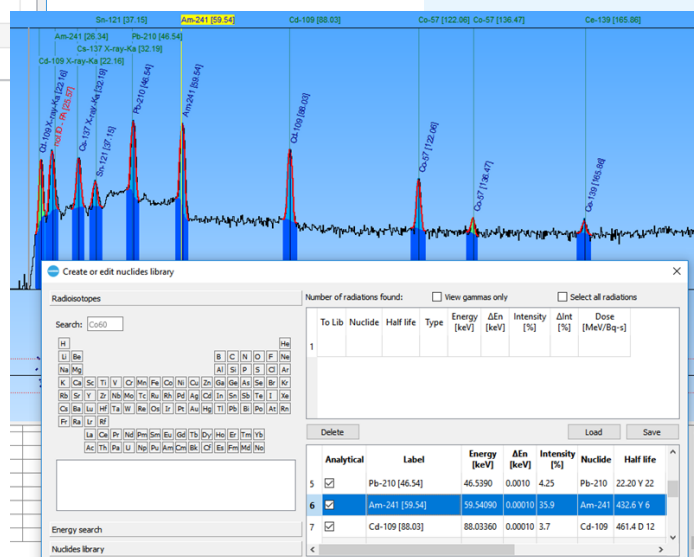
- Each spectrum has its own individual report
- Reports are rich formatted using colors, data tables and inclusion of graphical plots
- Create user defined reports using HTML coding and report templates/blocks
- Data results are colored if results are statistically doubtful
- Reports can be saved into HTML or PDF files

BGAMMA OPTIONAL PACKAGES OR ADDITIONS

In addition to the standardly distributed bGamma software package the following modules or software extensions are available for purchase, as well.

Option	Description
Procedures	Performs guided spectrum analysis, including data acquisition.
File Batch Analysis	Performs spectrum analysis according to pre-defined models or templates on a large amount of data files.
Files Browser	Extracts and plots data and spectrum analysis results from bGamma files.
Quality Assurance / Quality Control	Performs scheduled or predefined spectrum acquisition and analysis for assuring the normal functionality of the gamma-ray spectrometer or sample analysis methodology.
User Management Control	Limits the operational capabilities of bGamma software in accordance of user's privileges. Keeps user's actions trailing records. Provides "administration" review for logbook records.
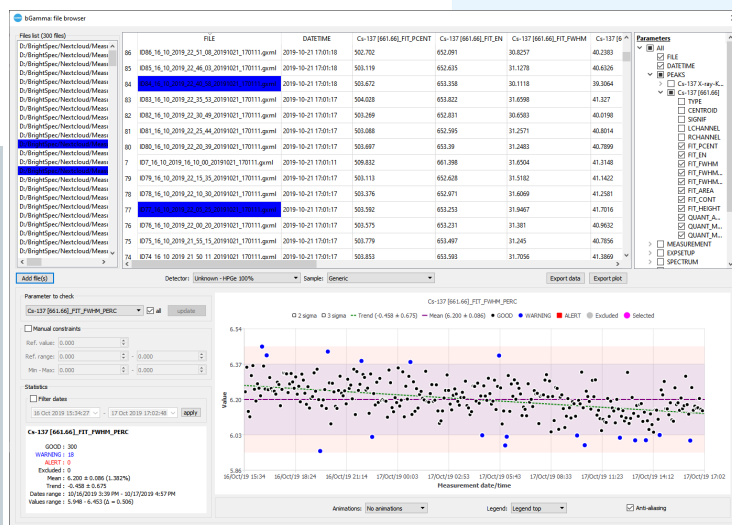
ORDERING INFORMATION

1. bGAMMA/1 application software. Single input license. Standard option. Allows to establish connection to a single detector/spectrometer.
2. bGAMMA/2 application software: Double input license. Allows to establish concurrently connection to two (2) spectrometers at the same time.
3. bGAMMA/M(4) application software: Multi-input license

Optional
1. bGAMMA/Procedures. Includes "Procedures" option
2. bGAMMA/File Batch. Includes File Batch Analysis and "Files browser" options
3. bGAMMA/QA. Includes "QA/QC", "Procedures" and "Files Browser" options.
4. bGAMMA/Files Browser. Includes "Files browser" option.
5. bGAMMA/User Management. Includes "User Management" option

Please check your representative or BrightSpec office for updates on this product and/or new options.

REQUIREMENTS

bGamma is a multiplatform software and runs seamlessly on the following OS:

- Microsoft Windows XP™, Windows 7™ ,Windows 8™ and Windows 10™
  ⇒ 32-bit or 64-bit processors
- mac OS®™
- Linux® OS
  ⇒ Both ARM and x86 processors

However, the corresponding software installer must be requested and/or download. Please specify your base OS when ordering this or any updates for this product.

ADDITIONAL INFORMATION

The bGAMMA software product line includes the "bGAMMA/SDK" (Software development kit), which are offered as separate product. Please contact us for more details on ordering "bGAMMA/SDK" and its license options.