Shielded NaI(Tl) γ-ray Spectrometer with High-Precision Spectrum Analysis

The shielded γ-ray spectrometer of Dr. Westmeier GmbH employs a NaI(Tl) or other scintillation detector with good resolution inside a very good shielding. Systems with specialised detectors are also available. The system operates with integrated software for the control of multichannel analyzer hardware, acquisition of data and high-precision analysis of spectra. The spectrum analysis program SODIGAM employs our new algorithms and strategies which allow, among others, the quantification of small activities, even after relatively short measuring times.

Typical areas of application of the spectrometer are:
- Contamination of foodstuff for humans and animals
- Contamination of raw and processed material
- Import control measurements at boarders and ports
- On-line control during smelting processes (mostly iron or aluminum)
- Applications of Safeguards Inspections and CTBTO
- Activity measurements in nuclear medicine (solid samples and water from decay systems) as well as release measurements
- Control of composition and purity of radionuclides in nuclear medicine (formerly called „well-counter")
- Release measurement of material from decommissioning
- Determination of activities and activity gradients in Research and Development

Hardware

Components of our shielded NaI(Tl) γ-ray spectrometer are presented in the following. For detailed explanations and more information please contact us through e-mail (info@westmeier.com) or by phone +49 (0)6424 923 000 or by FAX +49 (0)6424 923 002.


3"x3" NaI(Tl) detector with integrated photomultiplier and very strong µ-metal shield (0.63 mm thick) against external magnetic fields. All components are hermetically sealed in an aluminium housing (optional SS housing). The Al-thickness around the detector crystal is 0.5 mm; the inner reflector layer consists of Teflon.

Multichannel analyzer (MCA) model "bMCA" with HV-generator, Amplifier/Shaper, flash-ADC and up to 4k (4096 channels) spectrum length.

The unit connects via USB or Ethernet (PoE) to the PC.

bMCA is a digital system with a 25 MHz 12-bit flash-ADC, suitable for high count-rates over 80000 cps.
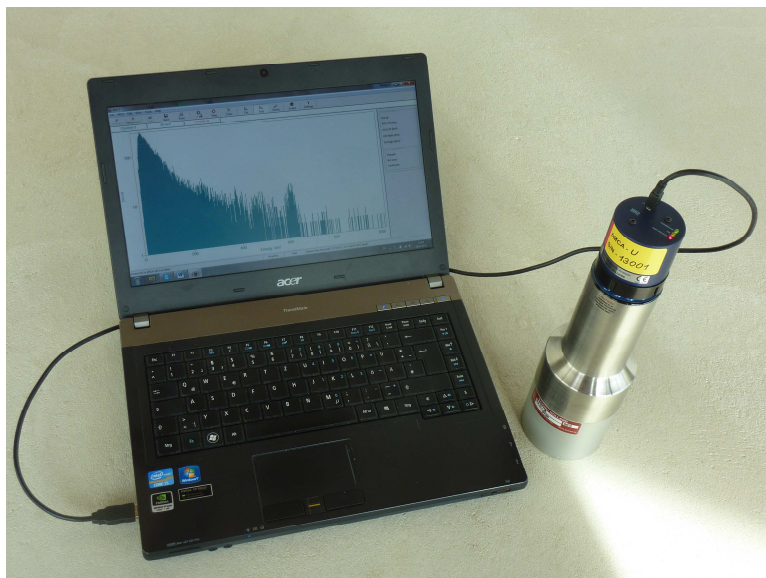
The basic operating unit for the multichannel analyzer consists of a desktop PC with monitor, keyboard and mouse or, as shown in the picture, of a Notebook. An optional Laser Printer can be attached for immediate documentation.

For protection and security the system can be housed in a RITTAL 19" cabinet or equivalent. A window in the upper part allows control of the monitor. An extendable drawer in the middle of the cabinet holds keyboard and mouse for the desktop PC.

Background radiation is suppressed through a lead shield having thickness of 50 mm or more of very low-activity lead. The inner space of the lead castle is sufficient for a 1-liter Marinelli beaker or up to 2-liter standard beakers. An optimised sample geometry, i.e. highest count-rate, is achieved with a 1-Liter Marinelli beaker.

When using standard beakers or dishes as containers the diameter of the sample container should not significantly exceed the diameter of the detector crystal (≤ 76mm).

The lead castle has an easy-going top cover of 50 mm thickness; the total weight inclusive of the steel-table is approx. 420 kg.

Software for operation of the spectrometer

Well adapted software is used for the operation of bMCA plug-on multichannel analyzer hardware as well as for data acquisition and spectrum administration.

The bMCA program is used for operation of bMCA-U and bMCA-E multichannel analyzers. The program contains all options for set-up of the analog and digital electronics:
- positive high voltage up to 1500 Volts
- pre-amplifier
- digital amplifier / shaper
- 25 MHz flash ADC
- 4096-channel spectrum storage

Moreover bMCA controls storage and administration of measured spectra, makes data display on the screen, simple energy calibration and it allows definition of regions for integrating overview-analyses.

The quantitative analysis of measured spectra is made with the SODIGAM program for high-precision analysis of scintillator spectra (NaI(Tl), LaBr$_3$(Ce), CeBr3, CsI, CZT, … others) and of X-ray spectra from proportional counters. SODIGAM is a Windows® program, which is designed to work with any multichannel analyzer hardware. SODIGAM knows spectrum formats from almost all current hardware systems and it can read and analyze the spectra.

The most important highlights about SODIGAM are compiled on the following pages.

SODIGAM provides two basically different spectrum analysis modes:

- The graphics-oriented manual mode is used for calibrations and library operations such as creation of application libraries, deletion or addition of nuclides or editing of γ-ray lines or other data. Moreover, the user can perform controlled analyses of peaks or regions. For a "hand-analysis" the user marks a region, optionally defines peaks and transfers this information to the fit-program for quantitative least-squares analysis. Hand-analysis of peaks or regions serves primarily the purpose to get acquainted with the program and to build confidence in its performance. Moreover, hand-analysis is used in preparation of Batch-files for automatic analyses of new kinds of spectra. This analysis mode was in particular developed for education and training. It shows details of the fit like e.g. measured data as a histogram, the exact course of the baseline, individual peak functions, sum of all peak functions plus baseline, and numerical results (peak-positions in channels and energy, peak-areas, full widths at half maximum, fit variable, quality info). In the hand-analysis mode one can repeat analyses trying various combinations of peaks or different starting values of other parameters.

- In the automatic Batch-mode each analysis is made on the basis of instructions in predefined instruction files (Batch-files). All instructions that shall be used for spectrum analysis are written in the file in the sequential order of desired operation. The instructions are defined using a very simple meta-language of SODIGAM which is called CODEWORD. All CODEWORDs are easily understood as mnemonics and they can have up to three associated numerical parameters. For example: the CODEWORD "CALC 500 800" will perform an automatic analysis of the spectrum from channel 500 to channel 800, and the CODEWORD "CALC 500 800 1" will perform an automatic analysis of the spectrum from 500 keV to 800 keV.

The Batch-file logic of SODIGAM can be used in two different ways:
1 – one can start Batch-files in the manual mode and test the course and results of analyses. It is possible to start another Batch-file from the first one, thus one can generate very complicated and complex analysis sequences.
2 – one can generate a Procedure in which all reference files that are needed for quantitative analysis like e.g. efficiency, external background peaks, energy calibration, project library and others are defined together with a Batch-file which contains all CODEWORDs for the desired analysis. When the Procedure is started one just defines the sample mass and SODIGAM goes ahead with the complete analysis (one-click analysis). The result of analysis is shown on screen and always also stored in an ASCII file (.TXT) in the same directory where the spectrum file is located.

There are various possibilities how one can handle the results on screen:
- print out on the attached laser-jet for immediate documentation
- print out and thus store as .PDF file
- back-up storage on another medium (e.g. jump-drive, floppy, network drive)
- delete and ignore the information

In this way a seamless documentation of each analysis is guaranteed. When several analyses are made from the same spectrum, SODIGAM will increment the resulting ASCII filename from .001 to .999 and none of the first 1000 analyses will go lost.

Preparation and Course of a Measurement

Before each sample measurement one should test proper function of the multichannel analyzer with a short measurement of a known source. When the peak appears in an unexpected position of the spectrum one might have to change gain or HV, when no counts at all appear something is seriously wrong (in most cases HV is missing) and one must identify the error. We are glad to support you via telephone with error identification.

Fill your sample container (Marinelli, Beaker, Dish …) from the master container exactly to the mark for which you have an efficiency calibration; in a Marinelli beaker this is the slim line just below the lid of the beaker. Wipe the container or dry it properly in order to avoid contamination of the detector. If the risk of contamination is prevalent it is advisable to cover the detector head with a thin plastic bag which is frequently exchanged. Place the container carefully on top of the detector and avoid any shock or pressure on the end-cap. The aluminum in the end-cap is only 0.5 mm thin; any damage of the aluminum shell will irreversibly destroy the hygroscopic NaI crystal.

Attention! To insert the 1-liter Marinelli beaker into the standard lead castle or to remove it hold the beaker with crossed hands.

Close the top cover of the lead castle, define the desired measuring time and start the measurement. When measurement is finished or statistical precision is sufficiently good start spectrum analysis with clicks onto **Compute – Spectrum analysis: Marinelli**, define the sample mass in the Procedure window and start analysis. You can delete (close) the results, transfer it to the printer or store it as .PDF file. At any rate, one copy of the results will be stored together with the spectrum as an ASCII (.TXT) file and no result will go lost. After each measurement the radioactive sample must be poured back into the master container or a collection device. Marinelli beakers can be rinsed with weakly acidic water (pH 4), dried and re-used immediately. If there is some considerable contamination with ^{131}I the beaker is stored and can be re-used after three months decay time.

Easy-to-use software – Made in Germany

SODIGAM

Highlights of SODIGAM software for high-precision analysis of scintillator spectra:

SODIGAM, software for the high-precision analysis of gamma-ray spectra from scintillation detectors such as e.g. NaI(Tl), BGO, CsI, $LaBr_3(Ce)$ (BrilLanCe), $CeBr_3$ or of X-ray spectra from Proportional Counters.

The 32-bit WINDOWS program is available in English, German and French; languages are on-line switched. SODIGAM provides an unlimited cost-free update service.

SODIGAM provides various analysis options for different applications:
- Fully automatic spectrum analysis (overview mode)
- User controlled analysis of peaks (hand analysis, educational mode)
- Batch file operation without user intervention (automatic routine analysis mode)
- Procedure mode analysis for selectable standard analysis procedures (lab production mode)

SODIGAM contains all options needed for quantitative spectrum analysis and nuclide assignment:
- Selectable sensitivity in units of detection limits
- FWHM function definition from measured peaks
- Intrinsic FWHM function for NaI(Tl), $LaBr_3(Ce)$ and $CeBr_3$ spectra
- Nonlinear energy calibration function
- Efficiency via intrinsic function or polynomials (one to nine coefficients)
- Consideration of external background interferences with uncertainties
- Extensive master library with all nuclides having $T_{1/2}$ over 10 seconds
- Application libraries generated through excerpting
- Library data can be edited (no warranty)
- Decay correction (collection time, waiting time, during measurement) and interference correction
- Multiplet deconvolution of up to 28 peaks
- Physical peak-shape description
- Physical shape of baseline under peaks
- Fuzzy-logic applied for various tasks
- Very stable LSQ-fit <u>without</u> matrix inversion

SODIGAM provides many I/O options:
- Six levels of increasing printout length
- Storage of all results in a protocol file, ready for editing to needs
- Reads spectra from essentially all commercial MCAs
- Writes spectra as ASCII files
- Very detailed display of baseline, fitted functions and sum-function
- Graphic images can be stored as Windows Meta File (spectrum and fits)
- 15 units for activity (e.g. Bq, Bq/kg, Bq/l, Bq/m^3, ...)
- Calculus window for calibration functions
- Detection limits, decision threshold etc. according to KTA 1503.1 and DIN/ISO 11929
- Statistical calculations with uncertainties (Weighted mean, +, -, * and /)
- Freely selectable colour scheme of graphics window
- Five user levels with password protection (for industrial and routine analysis applications)
- HARDLOCK software protection unit

SODIGAM comes with extensive documentation:
- Manual describing all commands
- Short manual for fast start-up
- .PDF manual files on CD or stick (Jump drive)
- Unlimited cost-free update service
- Telephone hotline service during daily working hours

For more information: info@Westmeier.com or telephone +49 6424 923 000

When the analyzed activity is below 5 Bq/l of ^{131}I the contents of the master container can be released to the public sewage system. The limiting activity for uncontrolled release of ^{131}I is defined in the German StrlSchV (Radiation Protection Regulation) Anlage III, Table 1 as 2 kBq/l; however, this value does not apply for release from controlled areas such as a decay system in nuclear medicine. According to Supplement VII (§§ 29 and 47 StrlSchV) the maximum permitted activity concentration must not exceed 5 Bq/l of ^{131}I when released from a controlled area. If the total amount of annually released water from the decay system is below 10^5 m^3/year the maximum activity concentration must not exceed 50 Bq/l. This latter limiting value is not accepted by all authorities.

Service and Repair

We recommend an annual service of all commercially used systems which were provided by us; we will remind you in written form when the time for service is due. The main focus is on the technical state of the detector and electronics but we will also clean the system, check voltages and other system properties, check and when necessary correct calibrations, provide software updates at no cost and, when desired, make a complete backup of last year's data. Small repairs will be made immediately during service after informing the user. Moreover, each system is inspected and tested according to DGUV V3; we grant the inspection sticker for the system when no faults have been found. An extensive service report is sent to the user (maybe indicating developing problems or recommendations for action) as well as the inspection protocol according to DGUV V3.

In case of faulty operation or system breakdown we provide Spot-Service and repair with typically 3 days reaction time (plus maybe extra time to procure spare parts).

Updates of our own software are provided free of charge and configured for your application during each service provided that the new version contains relevant modifications that are useful for the application.

We can be reached during normal working hours from 8:00 hours until 17:00 hours for any help, question, support and consultation via telephone, as well as 24/7/12 by FAX and Mail.

When something in your spectrum or analysis printout looks strange or you are not sure of the results, send us the spectrum and printout as attachment to your mail. We will judge the spectrum, check the analysis, consult you properly and solve your problem.

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