SpectraLineHandy – the Multipurpose Gamma-Spectrometry Software Package for Nuclear and Radioactive Materials Control with HPGe, CZT, LaBr(Cl) – Detectors.

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LABORATORY
of spectrometry
and radiometry

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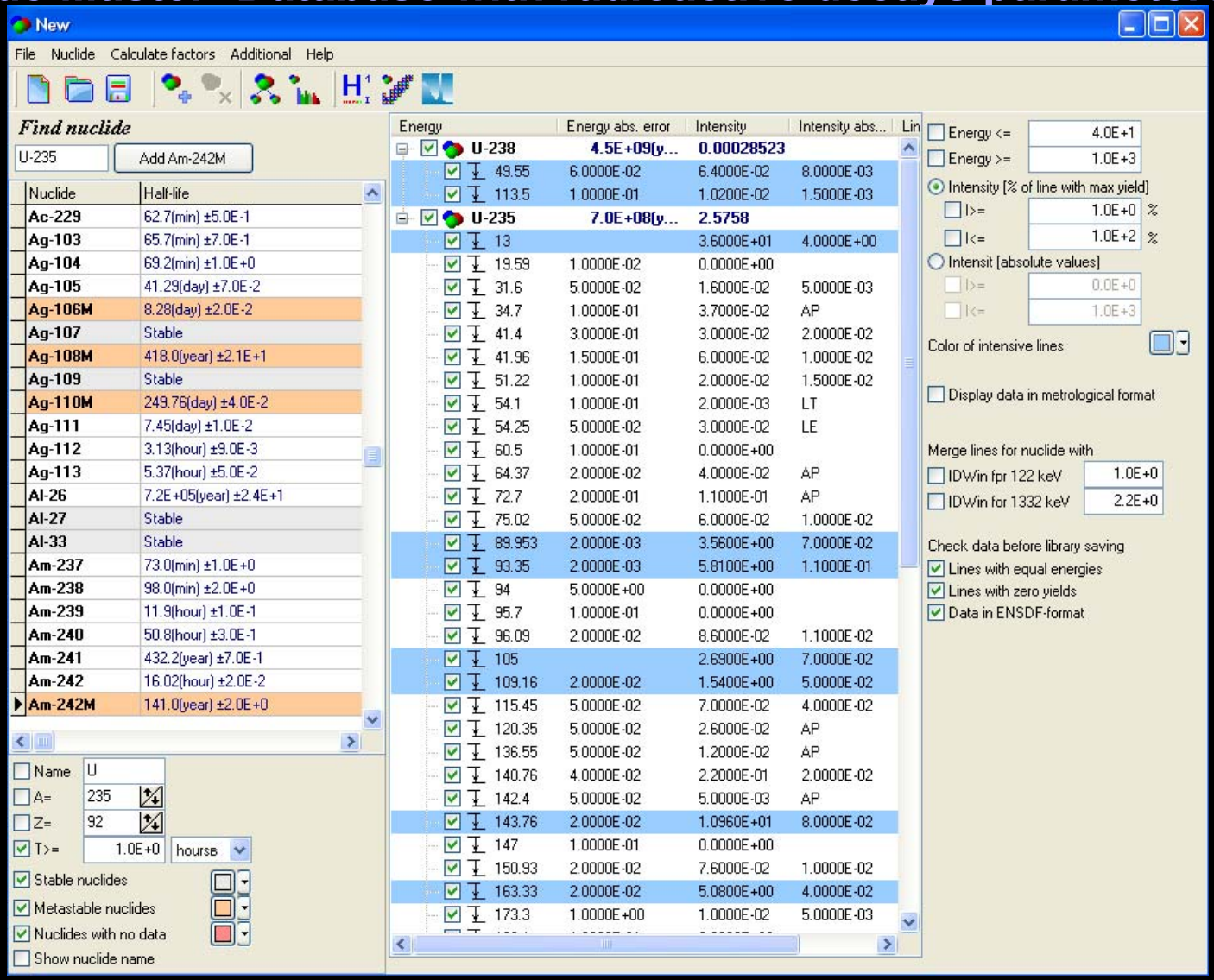
The main activity of LSRM Ltd. is the development of software, methodical and metrology for ionizing radiation measurements:

- Software packages for α-, β- и γ-radiation semiconductor and scintillation spectrometers:
  - The certified measurements
  - Detection and identification of the fissionable and radioactive materials
  - Radiation monitoring
- Our own methodologies for measurements
- Databases with radioactive decay parameters
- Our own algorithms and methods for calculation of ionizing radiation characteristics, including modeling of gamma spectra of various detectors

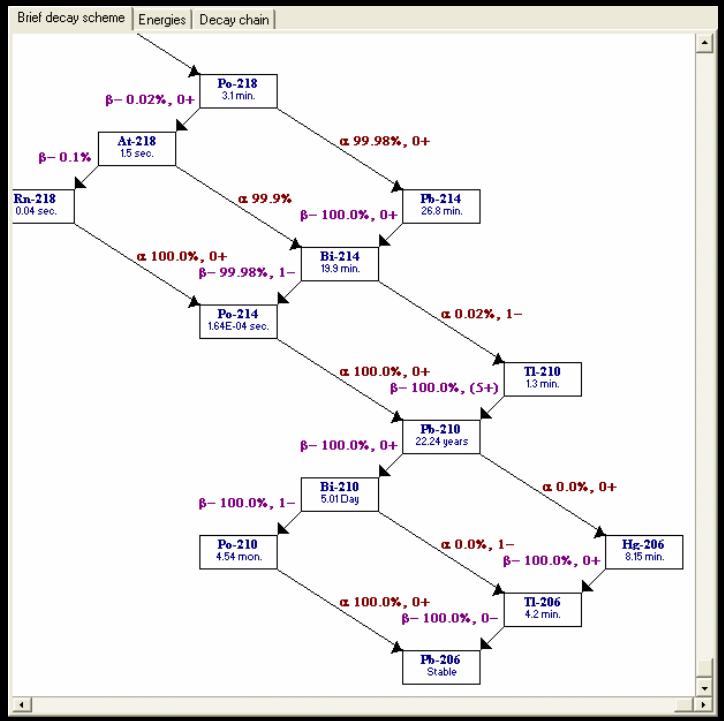
Nuclide Master- Database with radioactive decays parameters



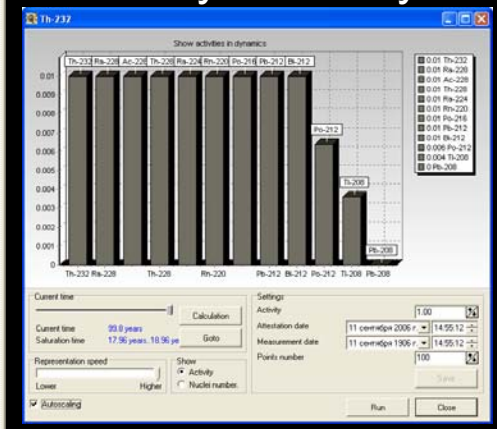
Nuclide Master- Database with radioactive decays parameters

with user-friendly GUI

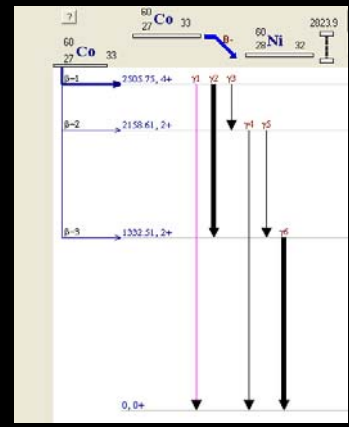
viewing of the decay chain

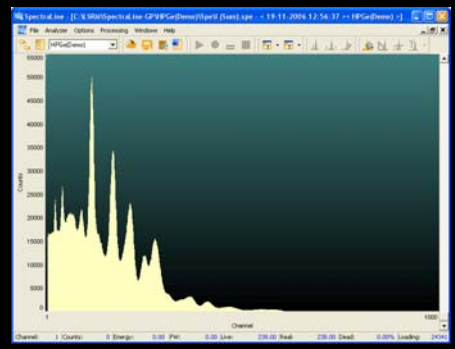


display a change of the nuclides activity by a decay chain dynamically



viewing of decay schemes of the required nuclide





generation of gamma-spectra

GammaLab – integrated system of nuclear data, computation applications and spectra processing programs for gamma spectrometry experiments modeling and emulation

The system models the measurements with semiconductor and scintillation spectrometers. **Monte-Carlo** method, evaluated nuclear structure data files ENSDF and cross sections are used for calculation. The following aspects are taken into consideration:

- radionuclides mixture and activity,
- shipping container,
- position of detector and source,
- radioactive background,
- hardware influence (peaks widening and shift, errors depending on the loading etc.)

GammaLab

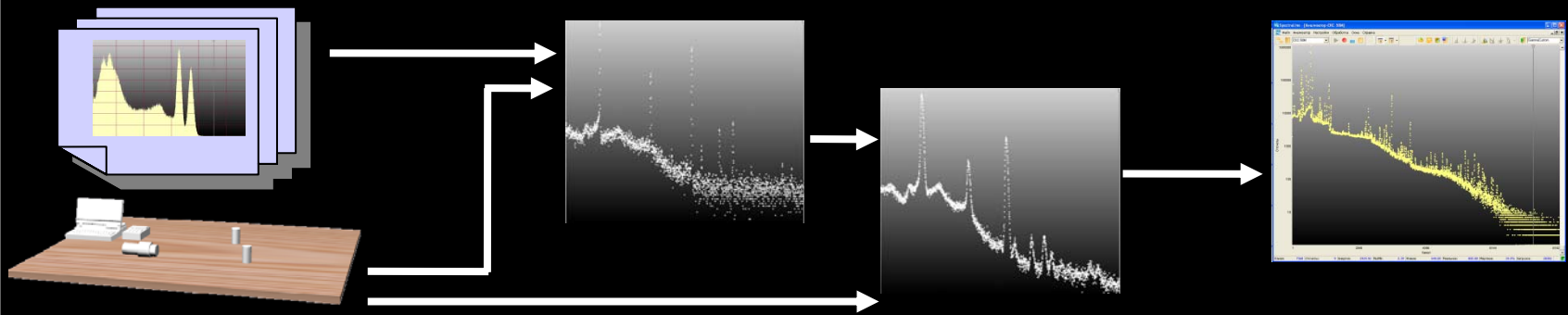
Sources and Hardware Modelling

Databases with nuclear information → Interface application for models parameters → Databases with models

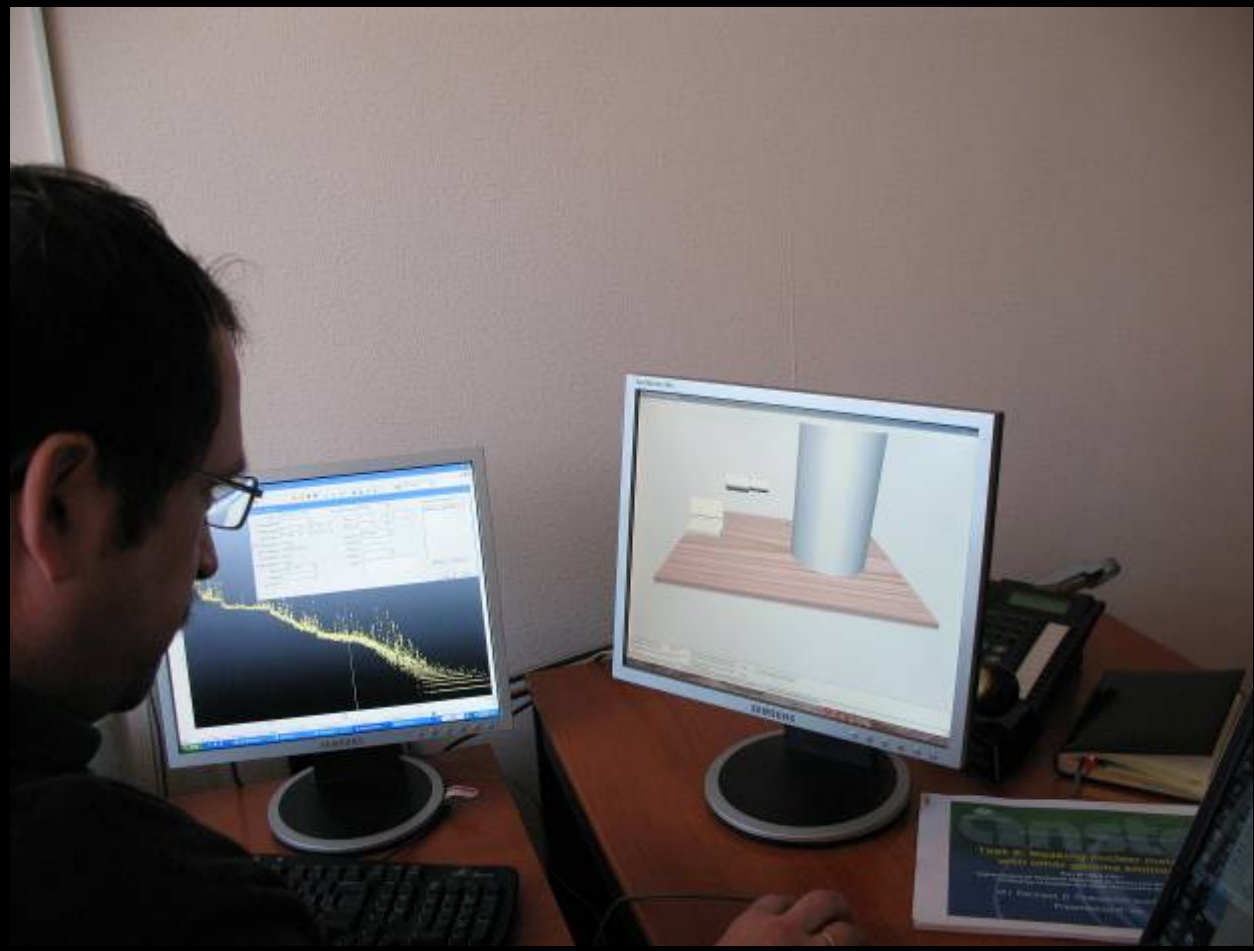
Calculation of Spectra Templates for Sources with the Required Radionuclides Mixture

Detector response function → Detector response matrix → Hardware quasi-spectra of monoenergies → Hardware spectrum template

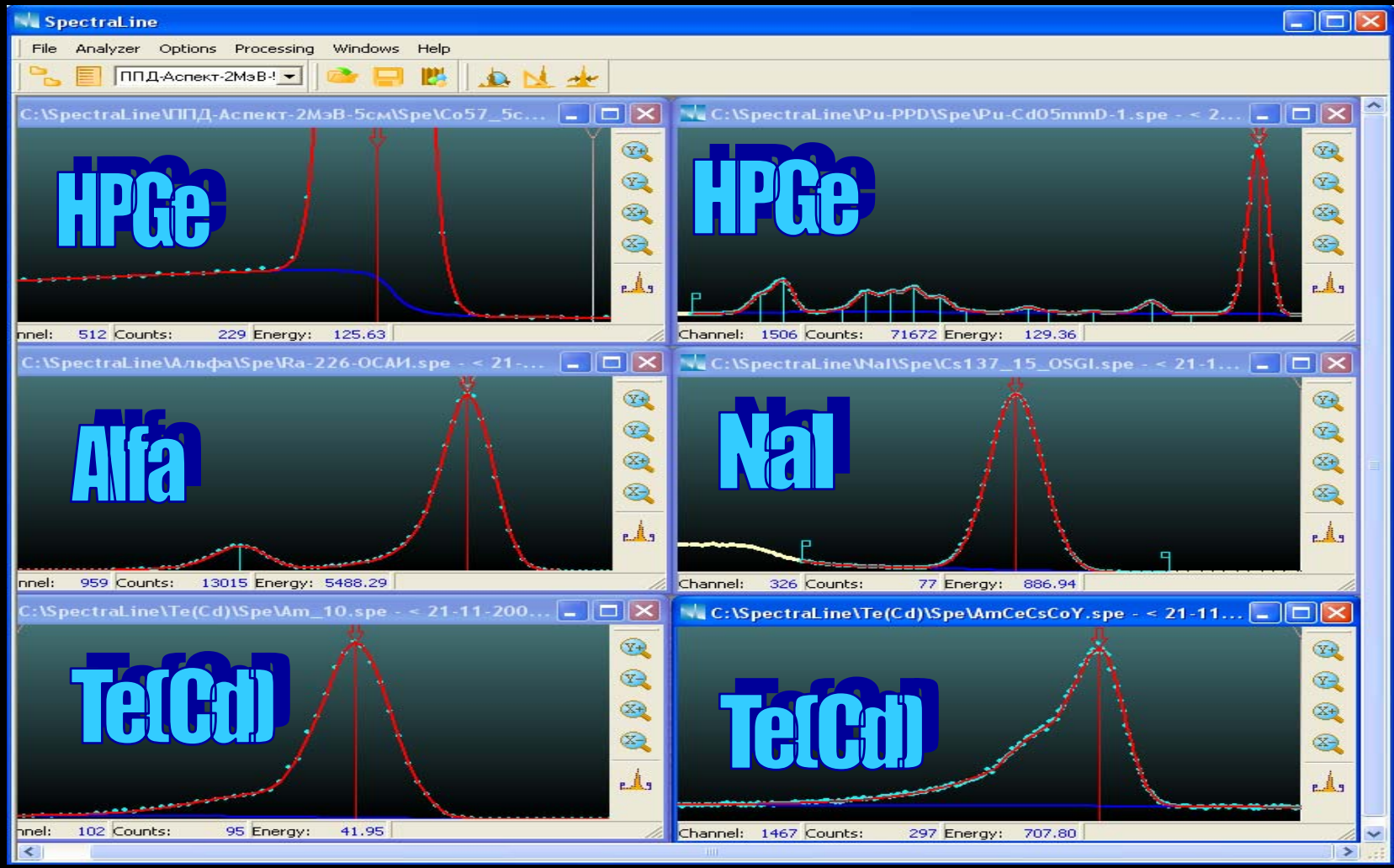
Spectra Emulation in the Real-time Operation Mode, Using Processing Software



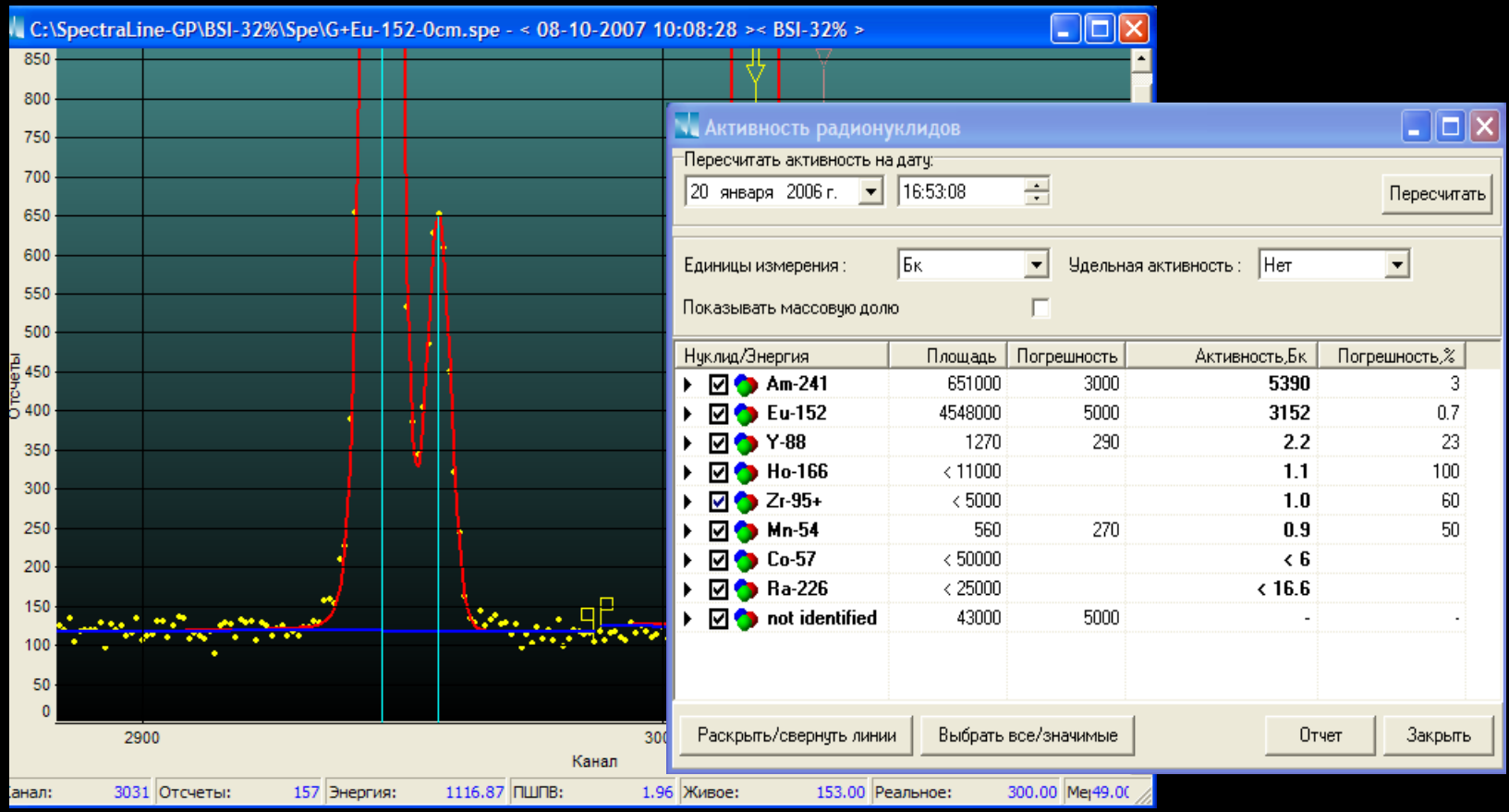
«Trainer»- software package is used to obtain practical experience for customs inspection of fissionable and radioactive materials .



SpectraLine – Software Products Family for Linear Spectra Processing

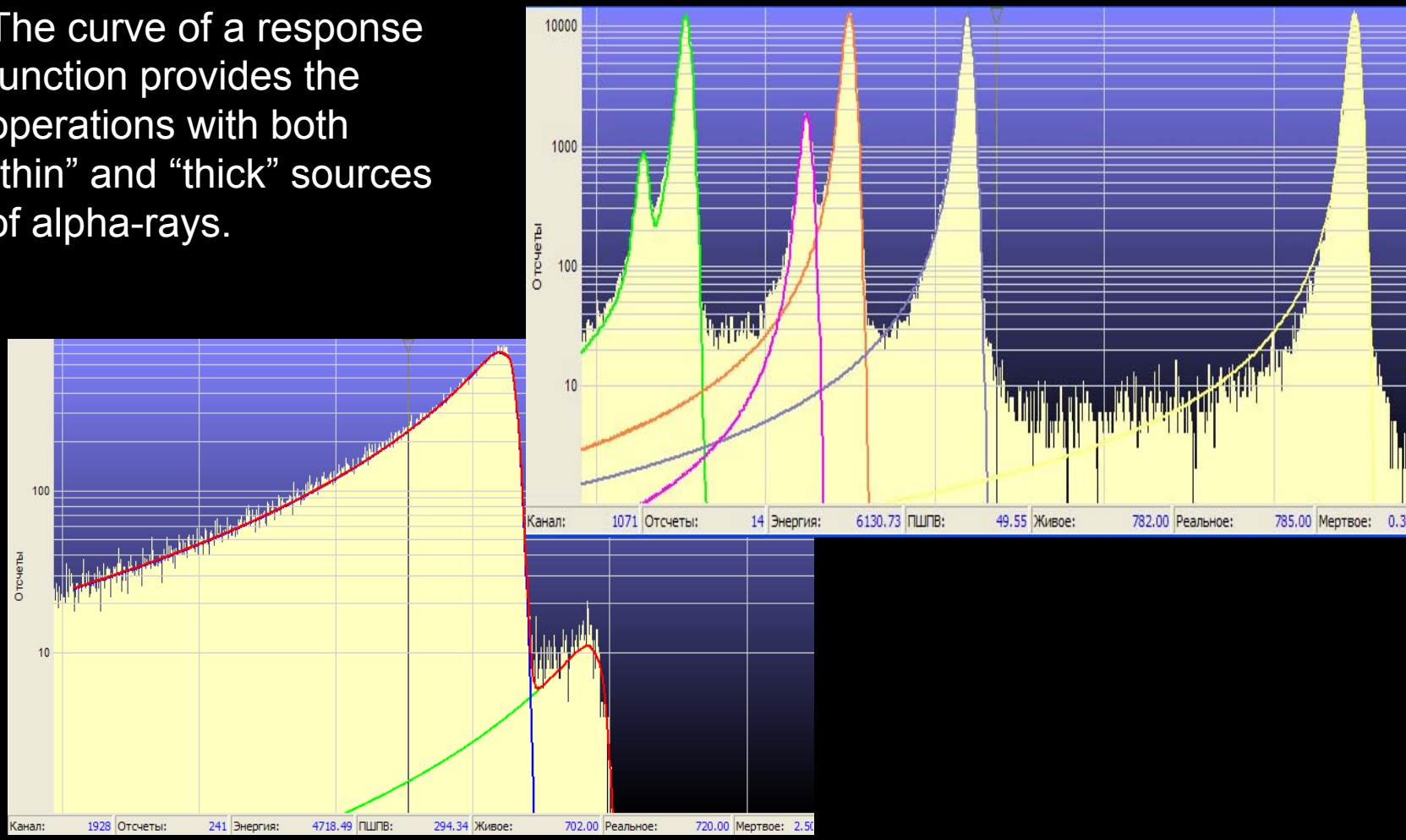


SpectraLineGP - Precision Processing of Gamma Spectra Collected by HPGe-Detectors. Identification and Activity Calculation.

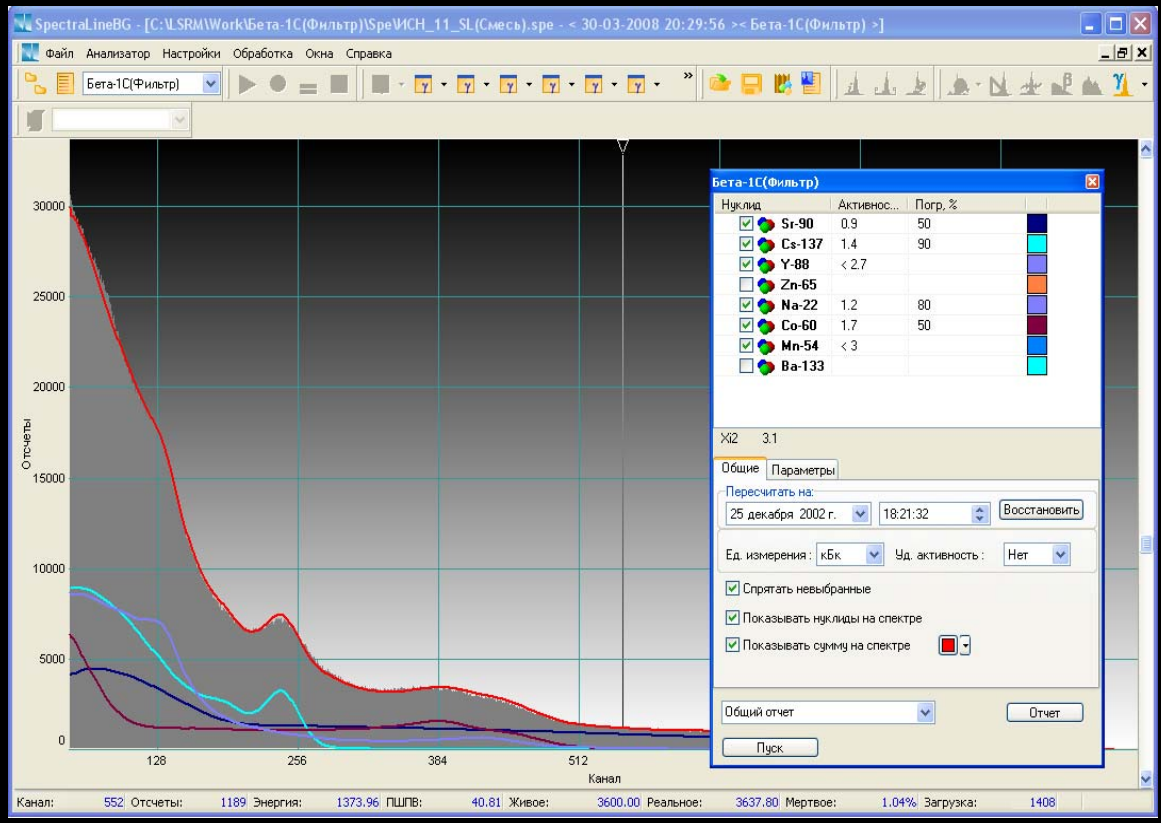


SpectraLineADA- Alpha Spectra Processing.

The curve of a response function provides the operations with both “thin” and “thick” sources of alpha-rays.



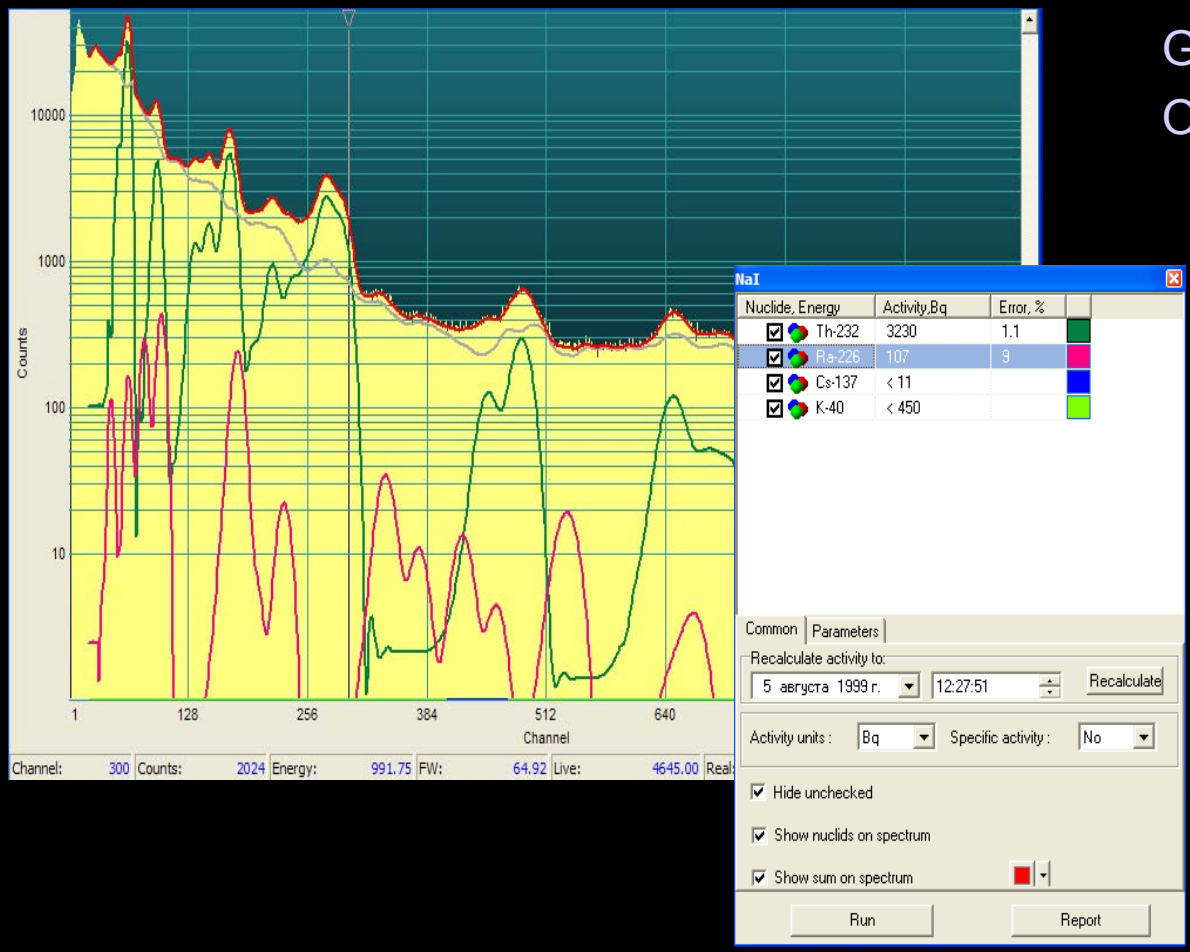
SpectraLineBG - Beta – and Scintillation Gamma Spectrometry



Beta spectrometry

Activity calculation by reference spectra method

SpectraLineBG - Beta – and Scintillation Gamma Spectrometry



Gamma spectrometry

Our own method of activity calculation -

quasi- **reference spectra method**

SpectraLineHandy

Spectrometric Analysis with HPGe, NaI, LaBr (Cl), CdTe - Gamma-ray Spectrometers.

- Identification and activity calculation of the sources in shipping containers
- Determination of uranium concentration
- Isotope analysis of plutonium samples

14900 - Development and Test of Field Useable Software for the Analysis of Gamma Spectra of Seized Sources

Field and remote use expert system for reachback support to law enforcement officers performing radiation monitoring at borders or in a country

What is Meant by the Term "Multipurpose"?

- Operations with detectors of different types, with both low and high resolution, and with analyzers of different manufacturers
- Solving of various tasks, which use spectrometric methods of analysis
- Possible adaptation of the software for realization of new measurement methods

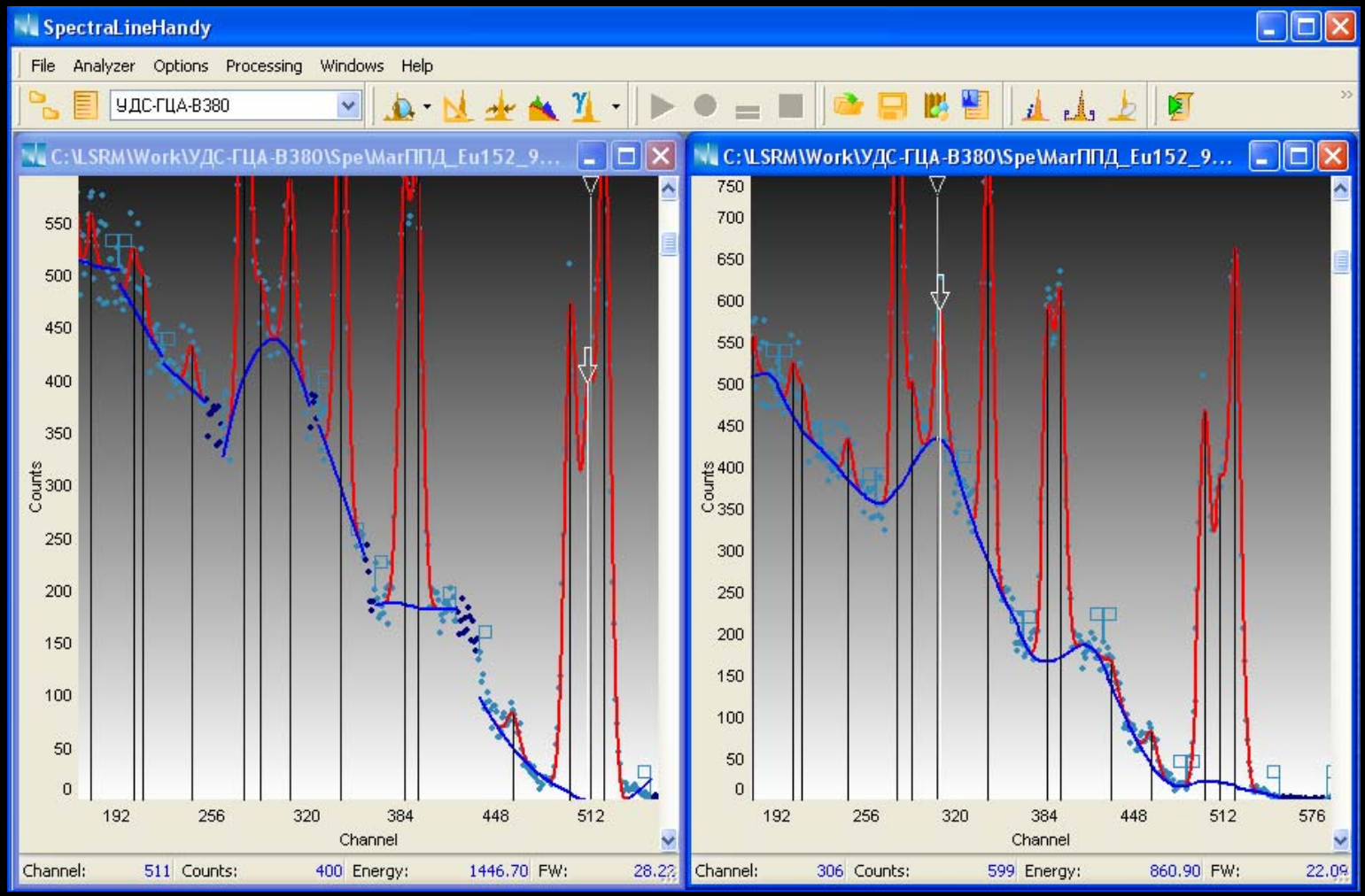
This Multifunctionality is Provided by

- A wide variety of spectra processing algorithms
- Software architecture and flexible interface
- Modern updatable nuclear data

Algorithms

- Calibration procedures, including calibrations by
  - energy
  - resolution
  - peak shape (including X-ray and annihilation peaks)
  - registration efficiency (with break on the bound of absorption)
- Several fitting procedures. The most effective one is done by all spectra lines simultaneously using the intensities ratio of every nuclide and their uncertainties, including
  - Peaks areas uncertainty
  - Registration efficiency uncertainty
  - Uncertainty of the table lines yields
  - Absorption uncertainty in the source material
- When the spectrum intervals are fitted, the influence of peaks in neighbor intervals and the influence of background continuity on the intervals boundaries (if they don't intersect) are taking into consideration. This way helps one to describe the background by a polynomial with low degree.
- Several procedures of identification and activity calculation

Algorithms - «sewing» of spectrum interval



Software Architecture and Interface

- Modular approach – the dynamically linked DLL – modules
  - Conjunction with hardware
  - Methods of activity calculation
  - Realization of measurement methods
  - Connection to databases
- Parameters configuration
- Processing scenarios
  - Calibration commands
  - Loading of the informative zones
  - Parameters calculation – peaks search, fitting, activity etc.
  - Requirements analysis

Nuclear Data

- Radioactive decay information on the basis of ENSDF-file
- Data on photons cross section based on XCOM.

SpectraLineHandy adaptation for determination of isotopic composition of uranium and plutonium samples

- Calibration by energy and resolution
- Peak shape calibration – consideration of X-ray peaks shape
- Calibration by relative registration efficiency (by the measured sample)
- Approximation of spectrum informative intervals
- Calculation of relative activities and mass fractions of isotopes

Uranium-Planar.lsc

- clear
- search(3)
- $idwin=1
- encalibr(1,0, U-Calibr0.lib , U.cen,1)
- reset(idwin)
- clear
- xraypatterns([89.957 94.000 92.282 90.00 93.357 87.000 94.654 100.000 95.863 90.000 98.434 110.000])
- loadzones(U-Calibr.zon)
- encalibr(2,0, U-Calibr.lib , \U.cen,1)
- clear
- loadzones(C:\Lsrm\Work\U-HPGe-Planar\Data\U-Eff.zon)
- recalibrate(0.001,[94.654 98.434 143.760 185.715 205.31])
- clear
- loadzones(Planar.zon)
- activity(AllZonesSew)
- showwindow(activityinfo)

Source Code Verification

International Workshop on Gamma Evaluation Codes for Plutonium and Uranium Isotope Abundance Measurements by High-Resolution Gamma Spectrometry: Current Status and Future Challenges

Institute for Transuranium Elements, Karlsruhe
November 14 – 16, 2005

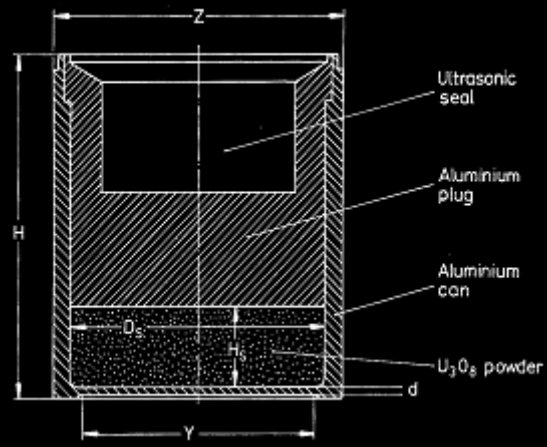
STUDY OF THE MGAU APPLICABILITY TO ACCURATE ISOTOPIC CHARACTERIZATION OF URANIUM SAMPLES

Andrey Berlizov and Volodymyr Tryshyn

Institute for Nuclear Research
National Academy of Sciences of Ukraine

Standard Reference Material SRM 969

Material: U_3O_8 powder, m = 200 g, ρ = 2.5 g/cm^3;
Externals: Z = 80 mm, H = 90 mm;
Sample volume: D_S = 70 mm, H_S = 20.8 mm;
Al window thickness: d = 2 mm.



Isotope	Reference sample, mass %				
	031	071	194	295	446
^{234}U	0.0020(2)	0.0052(2)	0.0171(2)	0.0279(4)	0.0359(3)
^{235}U	0.3166(2)	0.7119(5)	1.9420(14)	2.9492(21)	4.4623(32)
^{236}U	0.0146(3)	<0.00002	0.0003(1)	0.0033(2)	0.0068(2)
^{238}U	99.6668(4)	99.2828(4)	98.0406(18)	97.0196(29)	95.4950(32)

Certified Reference Material CRM 146

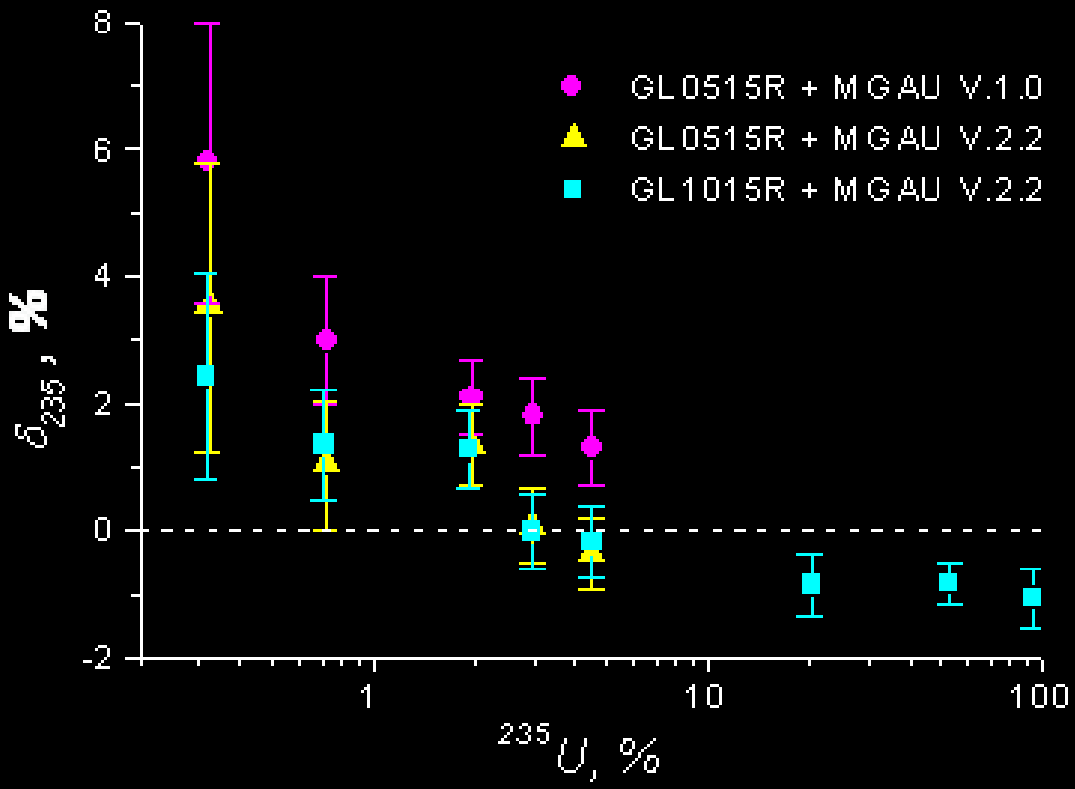
Material: U_3O_8 powder, m = 230 g, ρ = 3.78 g/cm^3;
Externals: Z = 80 mm, H = 90 mm;
Sample volume: D_S = 70 mm, H_S = 15.8 mm;
Al window thickness: d = 2 mm.

Isotope	Reference sample, mass %		
	20	52	93
^{234}U	0.1486 (2)	0.3718(5)	0.9800(15)
^{235}U	20.107 (10)	52.488(21)	93.1703(3)
^{236}U	0.1973(6)	0.2645(3)	0.2937(12)
^{238}U	79.547(10)	46.876(21)	5.5559(26)

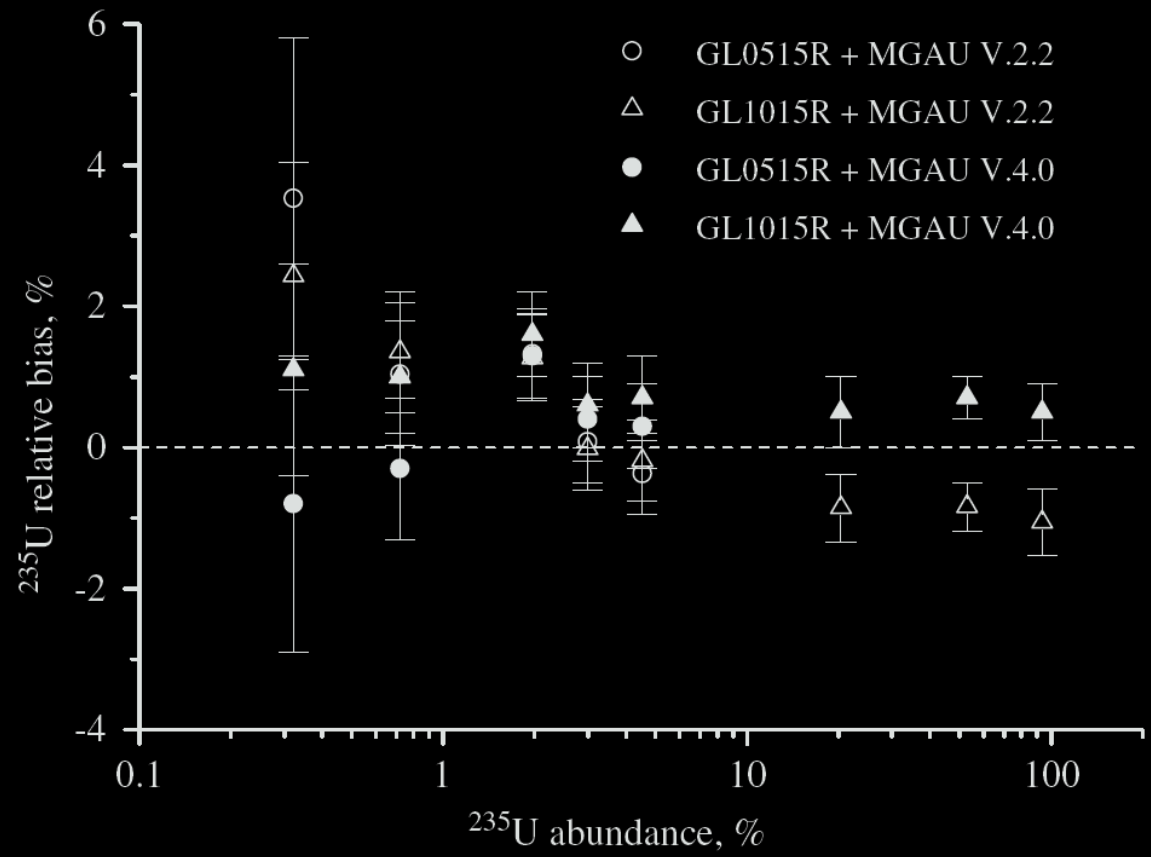
Hardware

- Detector - LEGe GL0515R, S=500 mm2 d=15 mm, input window – 0.5 mm Al.
- InSpector Portable Spectroscopy Workstation, Model 1200UPU.
- MGAU V.1.0 V2.2 uranium isotopic software.

Certified Reference Material
CRM 146 & SRM 969

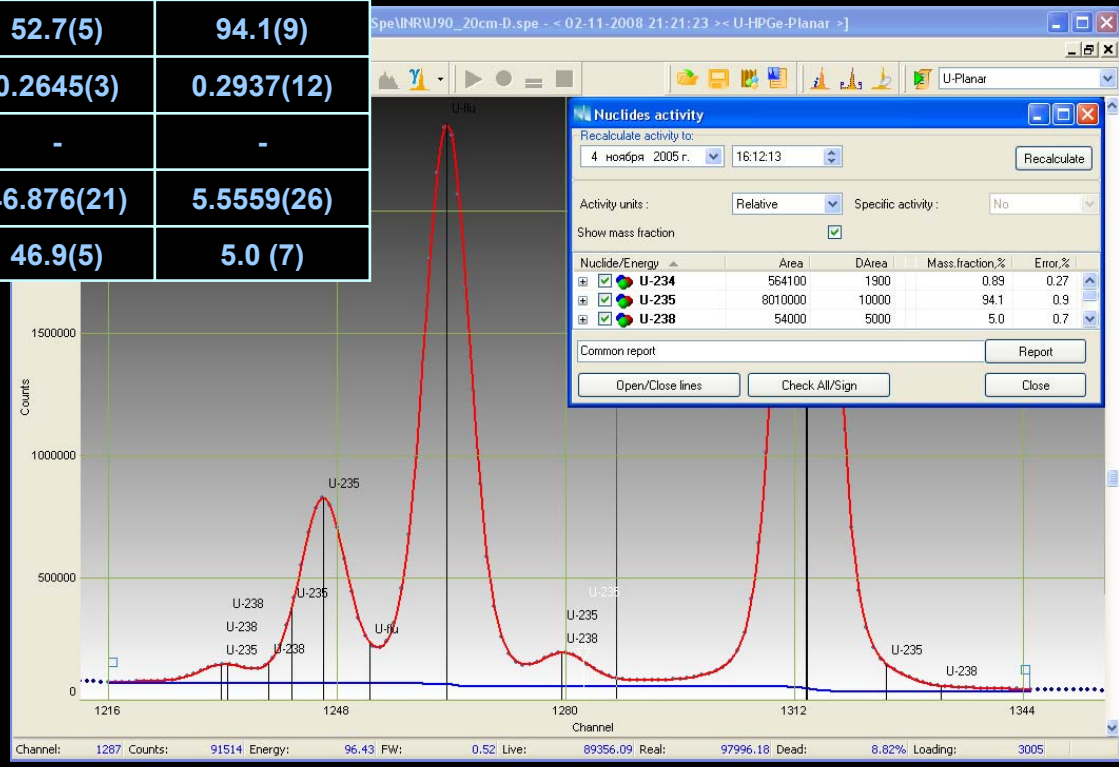


Certified Reference Material CRM 146 & SRM 969



Certified Reference Material CRM 146

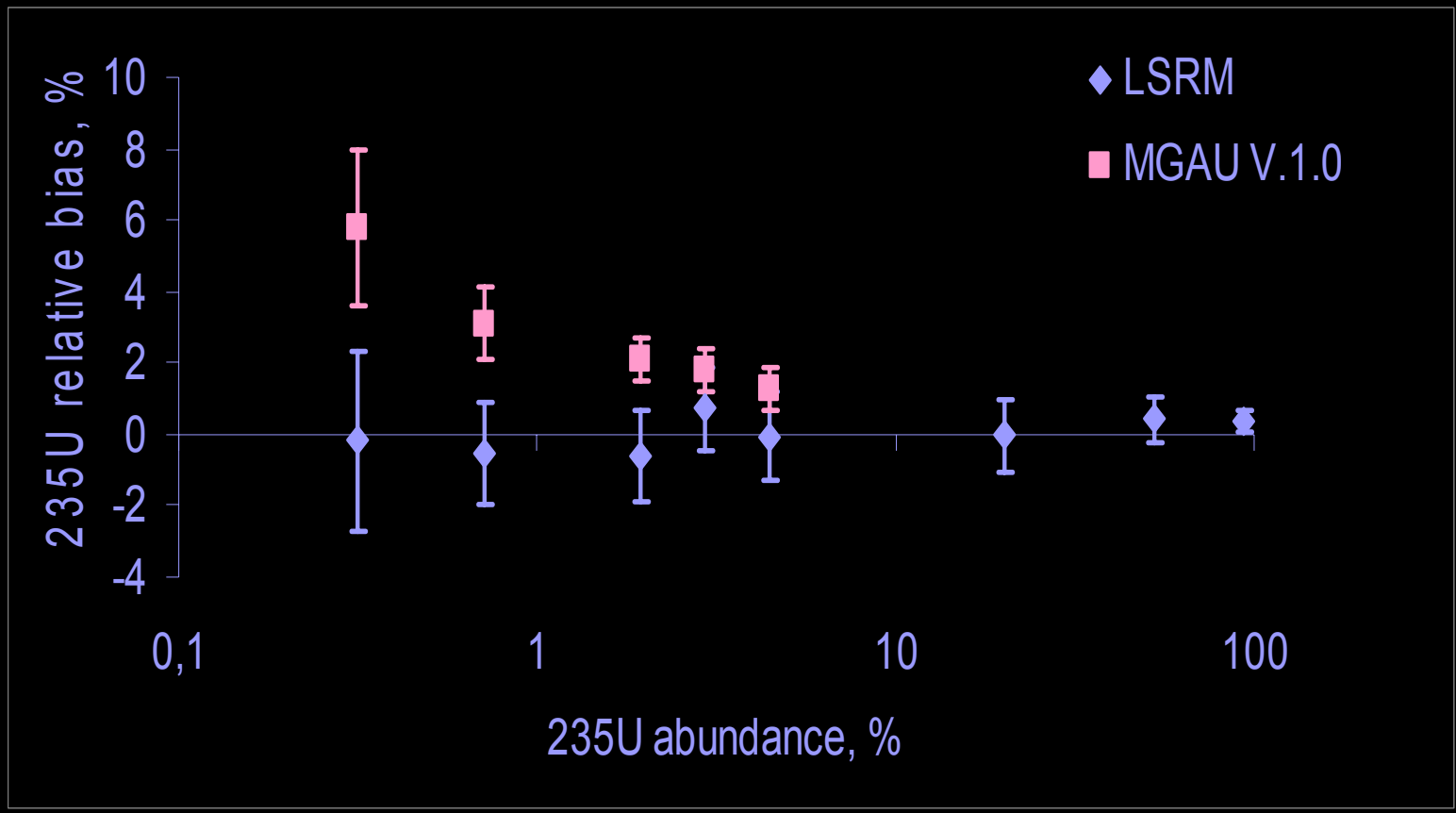
Isotope		Reference sample, mass %		
		20	52	93
^{234}U	Reference	0.1486 (2)	0.3718(5)	0.9800(15)
	Lsrm	0.138(21)	0.35(5)	0.89 (27)
^{235}U	Reference	20.107 (10)	52.488(21)	93.1703(3)
	Lsrm	20.18 (22)	52.7(5)	94.1(9)
^{236}U	Reference	0.1973(6)	0.2645(3)	0.2937(12)
	Lsrm	-	-	-
^{238}U	Reference	79.547(10)	46.876(21)	5.5559(26)
	Lsrm	79.68(22)	46.9(5)	5.0 (7)



Standard Reference Material SRM 969

Isotope		Reference sample, mass %				
		031	071	194	295	446
^{234}U	Reference	0.0020(2)	0.0052(2)	0.0171(2)	0.0279(4)	0.0359(3)
	Lsrm	0.0016(4)	0.0049(8)	0.0160(24)	0.026(4)	0.033(5)
^{235}U	Reference	0.3166(2)	0.7119(5)	1.9420(14)	2.9492(21)	4.4623(32)
	Lsrm	0.308(9)	0.702(14)	1.941(29)	2.95(4)	4.49(6)
^{236}U	Reference	0.0146(3)	<0.00002	0.0003(1)	0.0033(2)	0.0068(2)
	Lsrm	-	-	-	-	-
^{238}U	Reference	99.6668(4)	99.2828(4)	98.0406(18)	97.0196(29)	95.4950(32)
	Lsrm	99.690(9)	99.293(14)	98.043(29)	97.03(4)	95.48(6)

Certified Reference Material CRM 146 & SRM 969



U reference spectra from LNHB and LLNL

http://www.nucleide.org/spectres.htm

Accueil LNHB | Remonter | Sommaire LNHB | Dosimétrie | Radioactivité

Laboratoire National Henri Becquerel

Uranium spectra

LLNL spectra (all files ASCII format)	LNHB spectra					
	Coaxial detector (all files ASCII format) (all files CHN format)		CZT detector (all files ASCII format) (all files CHN format)		Planar detector (all files ASCII format) (all files CHN format)	
125v003.asc	G-125VC.ASC	G-125vc.chn	C-125.asc	C-125.chn	X-125VC.ASC	X-125vc.chn
15411001.asc	G-125VD.ASC	G-125vd.chn	C-1541.ASC	C-1541.chn	X-125VD.ASC	X-125vd.chn
15411002.asc	G-125VE.ASC	G-125ve.chn	C-1542.ASC	C-1542.chn	X-125VE.ASC	X-125ve.chn
15411003.asc	G-1541C.ASC	G-1541c.chn	C-1613.ASC	C-1613.chn	X-1541C.ASC	X-1541c.chn
15411004.asc	G-1541D.ASC	G-1541d.chn	C-1614.ASC	C-1614.chn	X-1541D.ASC	X-1541d.chn
1542-001.asc	G-1541E.ASC	G-1541e.chn	C-R1.ASC	C-r1.chn	X-1541E.ASC	X-1541e.chn
1542-002.asc	G-1542C.ASC	G-1542c.chn	C-R2.ASC	C-r2.chn	X-1542C.ASC	X-1542c.chn
1542-003.asc	G-1542D.ASC	G-1542d.chn	C-R3.ASC	C-r3.chn	X-1542D.ASC	X-1542d.chn
1542-004.asc	G-1542E.ASC	G-1542e.chn	C-R4.ASC	C-r4.chn	X-1542E.ASC	X-1542e.chn
1542-005.asc	G-1613C.ASC	G-1613c.chn	C-R5.ASC	C-r5.chn	X-1613C.ASC	X-1613c.chn
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U0_017.ASC	G-X2CC.ASC	G-x2cc.chn			X-X3CC.ASC	X-x3cc.chn
U0_483.ASC	G-X2D.ASC	G-x2d.chn			X-X3D.ASC	X-x3d.chn
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g295001.asc	G-Y2EE.ASC	G-y2ee.chn			X-Y2EE.ASC	X-y2ee.chn
g295002.asc						
g295003.asc						

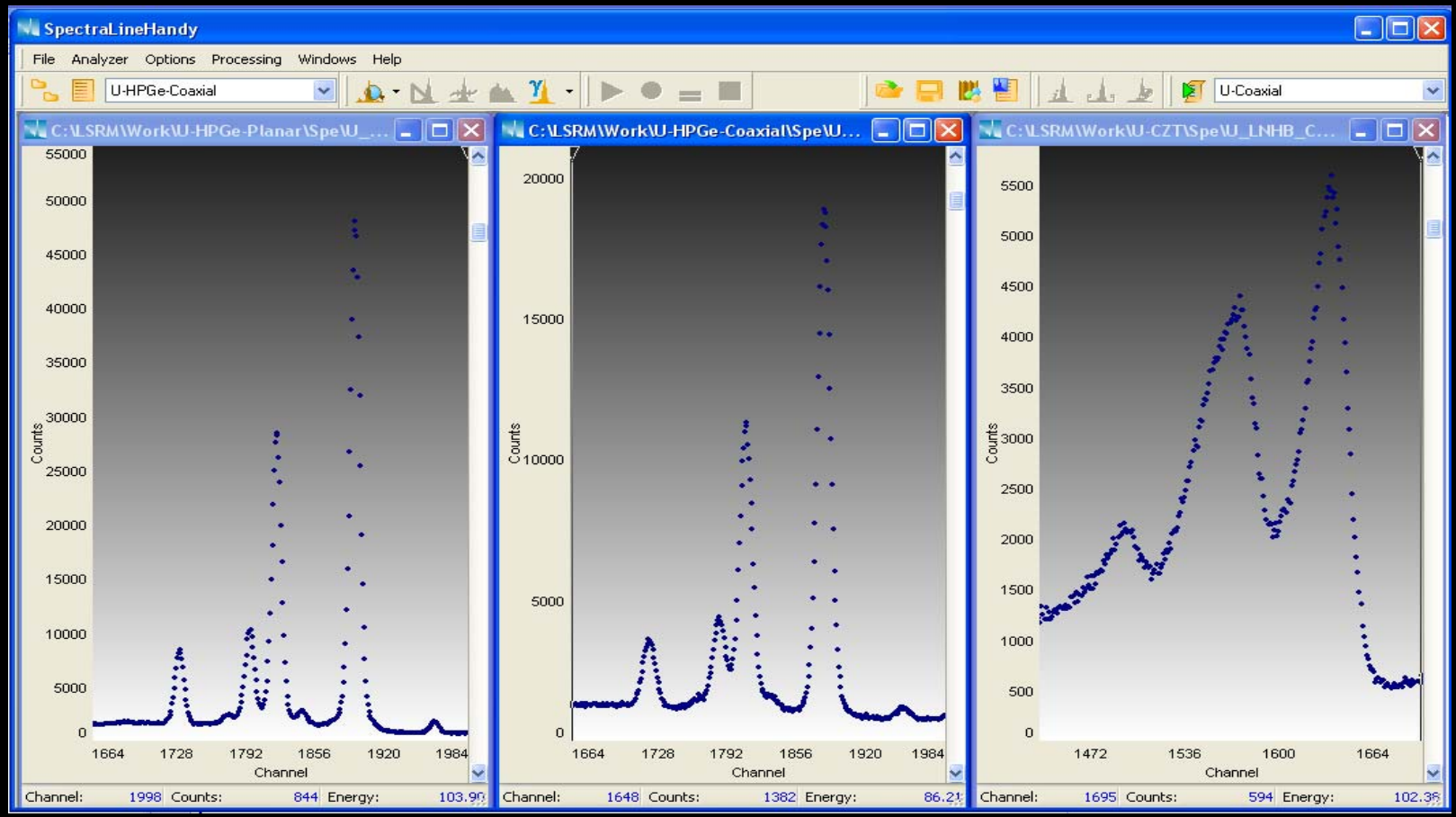
U reference spectra from LNHB and LLNL

http://www.nucleide.org/spectres.htm

HPGe-Planar
FWHM at 122 keV: 0.52 keV

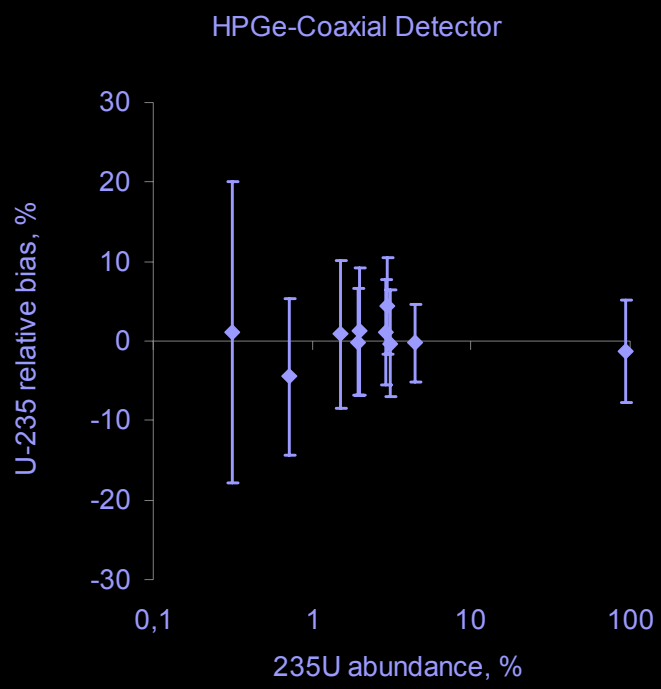
HPGe-Coaxial
0.71 keV

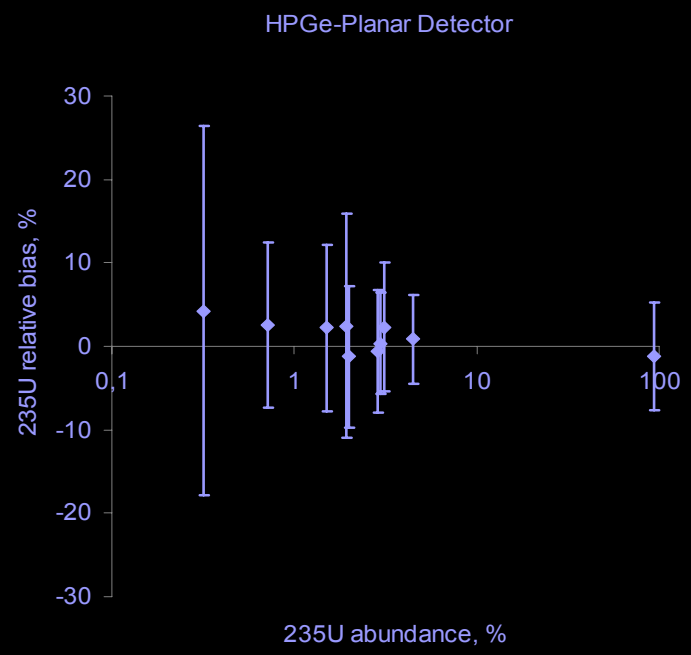
CZT
1.95 keV



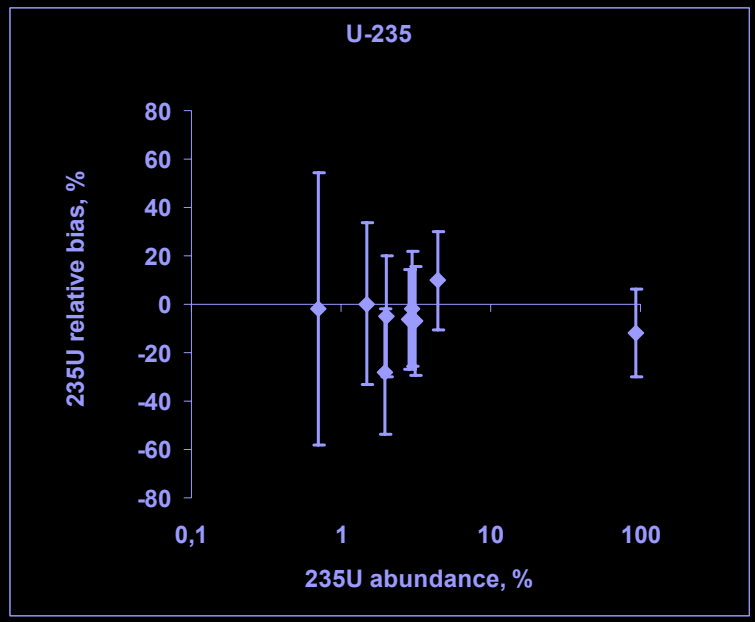
U reference spectra from LNHB and LLNL

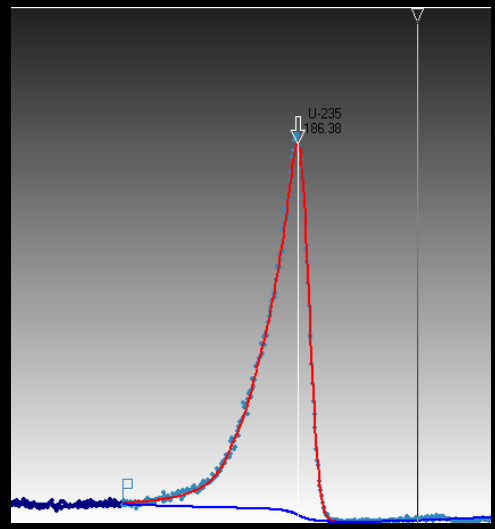
http://www.nucleide.org/spectres.htm

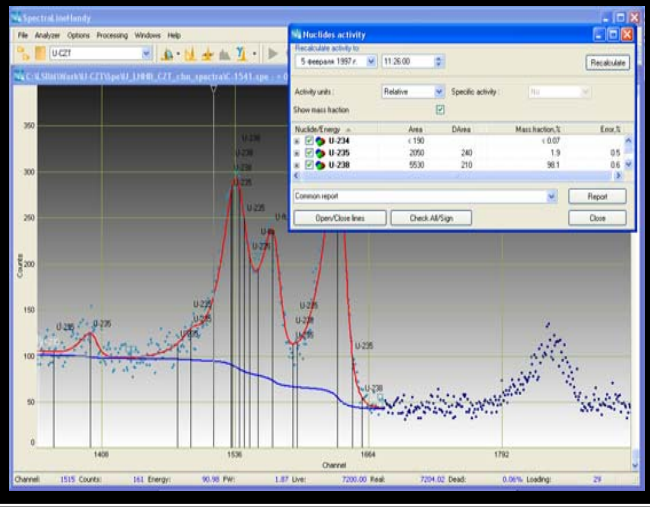


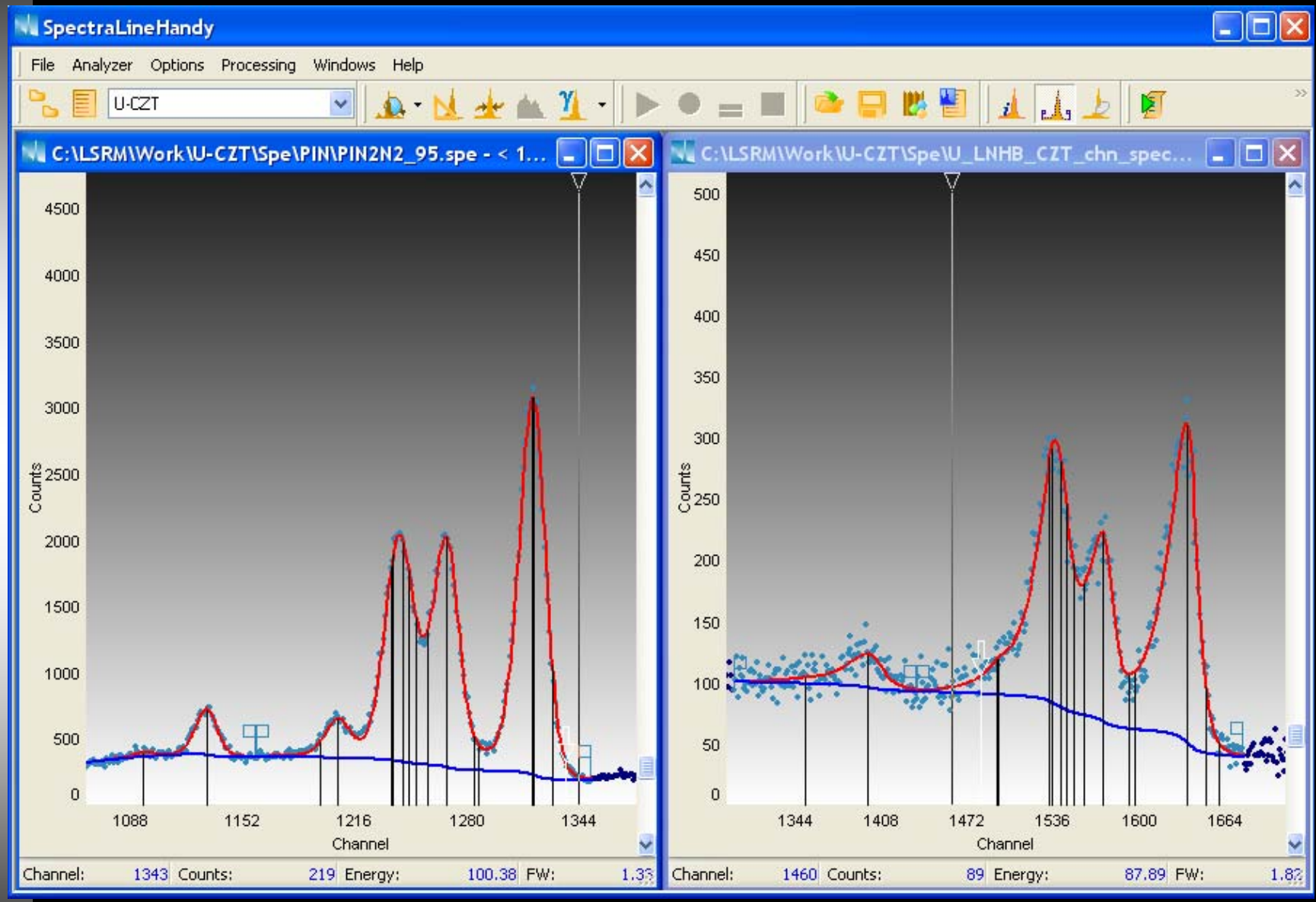


U reference spectra from LNHB CZT-detector







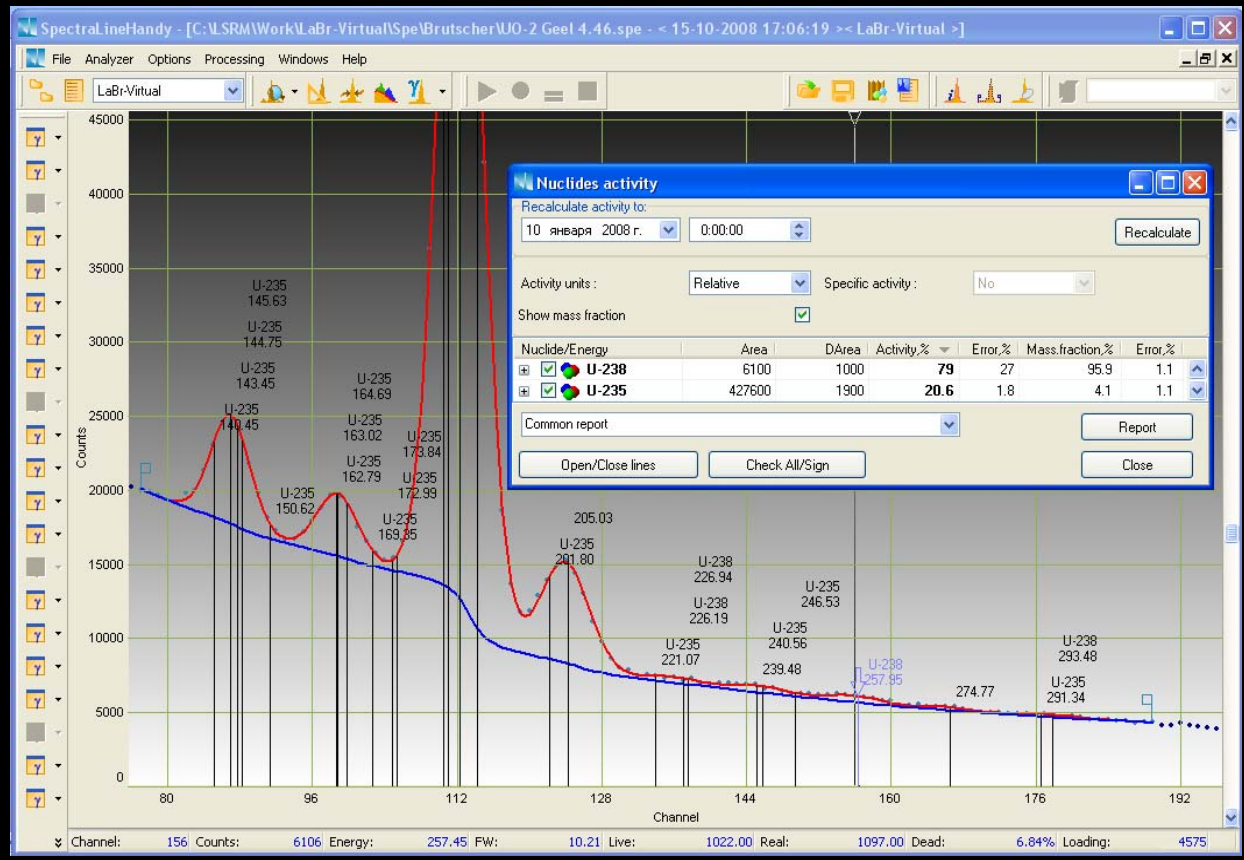

SpectraLineHandy
File Analyzer Options Processing Windows Help
U-CZT
C:\LSRM\Work\U-CZT\Spe\PIN\PIN2N2_95.spe - < 1...
Counts
Channel
1088 1152 1216 1280 1344
Channel: 1343 Counts: 219 Energy: 100.38 FW: 1.33
C:\LSRM\Work\U-CZT\Spe\U_LNHB_CZT_chn_spec...
Counts
Channel
1344 1408 1472 1536 1600 1664
Channel: 1460 Counts: 89 Energy: 87.89 FW: 1.82

LaBr3 -2x2”

122 кэВ FWHM: 6.1%
661 кэВ FWHM: 2.7%

^{235}U

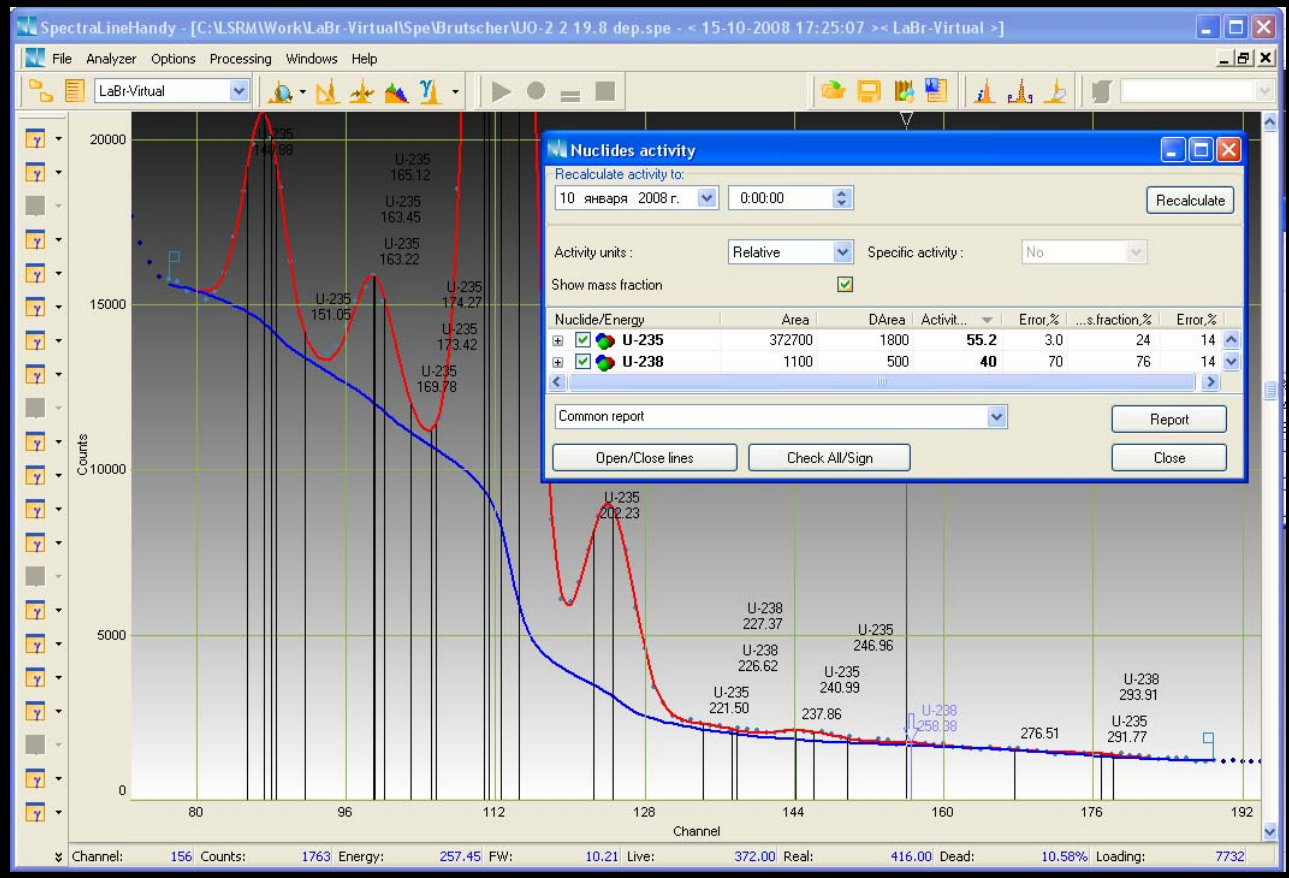
Passport - 4.46%
Measurement - 4.1+/-1.1 %



LaBr3 -2x2”

^{235}U

Passport - 19.8%
Measurement 24+/-14 %

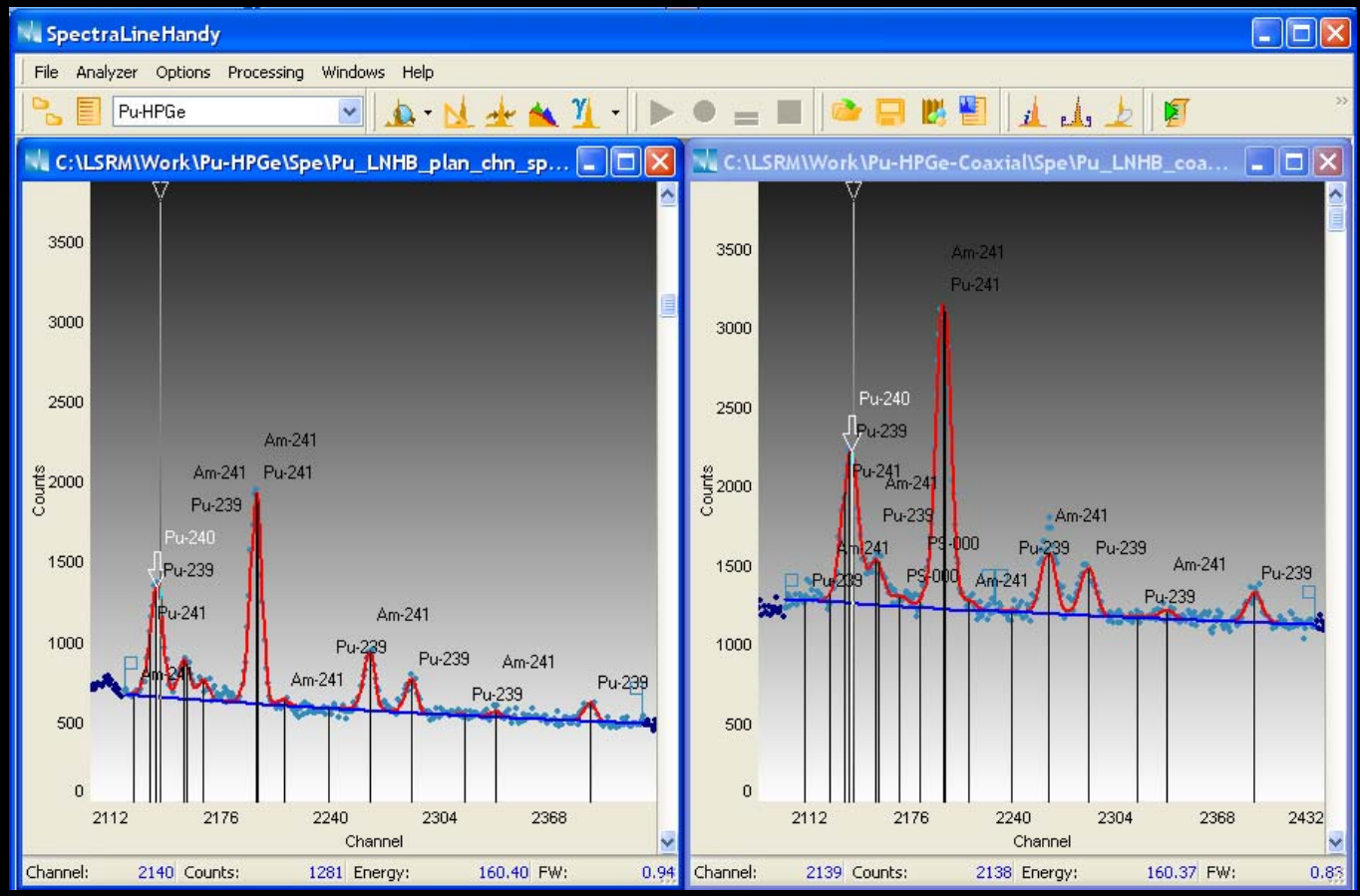


Pu reference spectra from LNHB

http://www.nucleide.org/spectres.htm

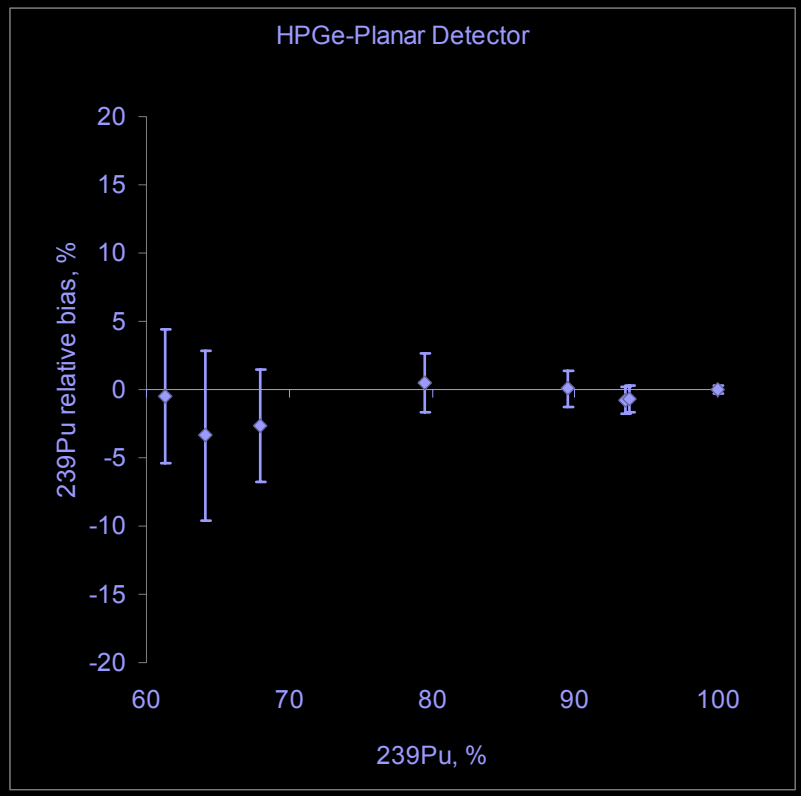
HPGe-Planar
FWHM at 122 keV: 0.52 keV

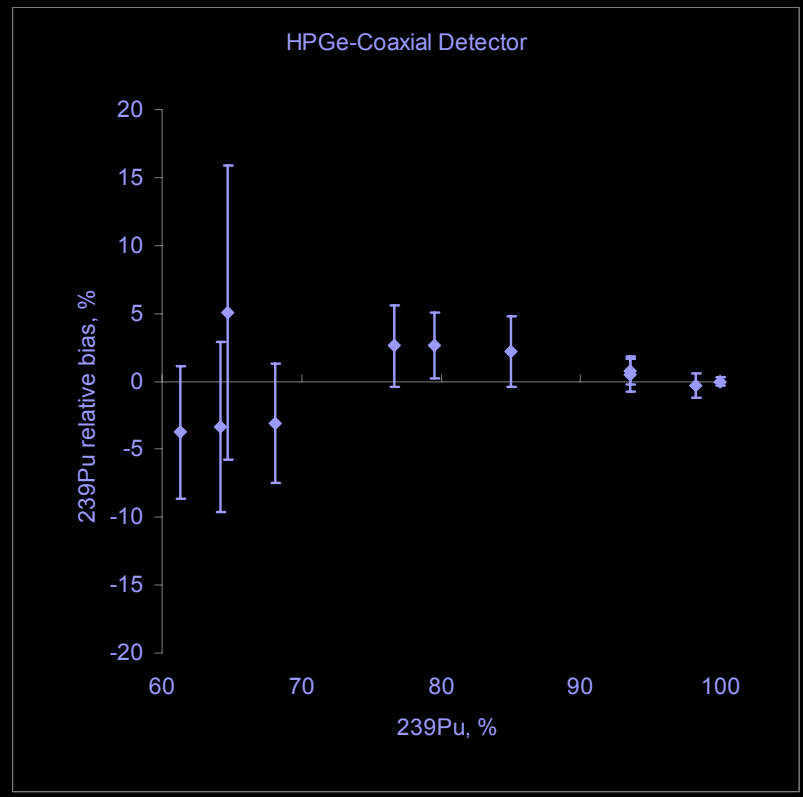
HPGe-Coaxial
0.71 keV



Pu reference spectra from LNHB

http://www.nucleide.org/spectres.htm

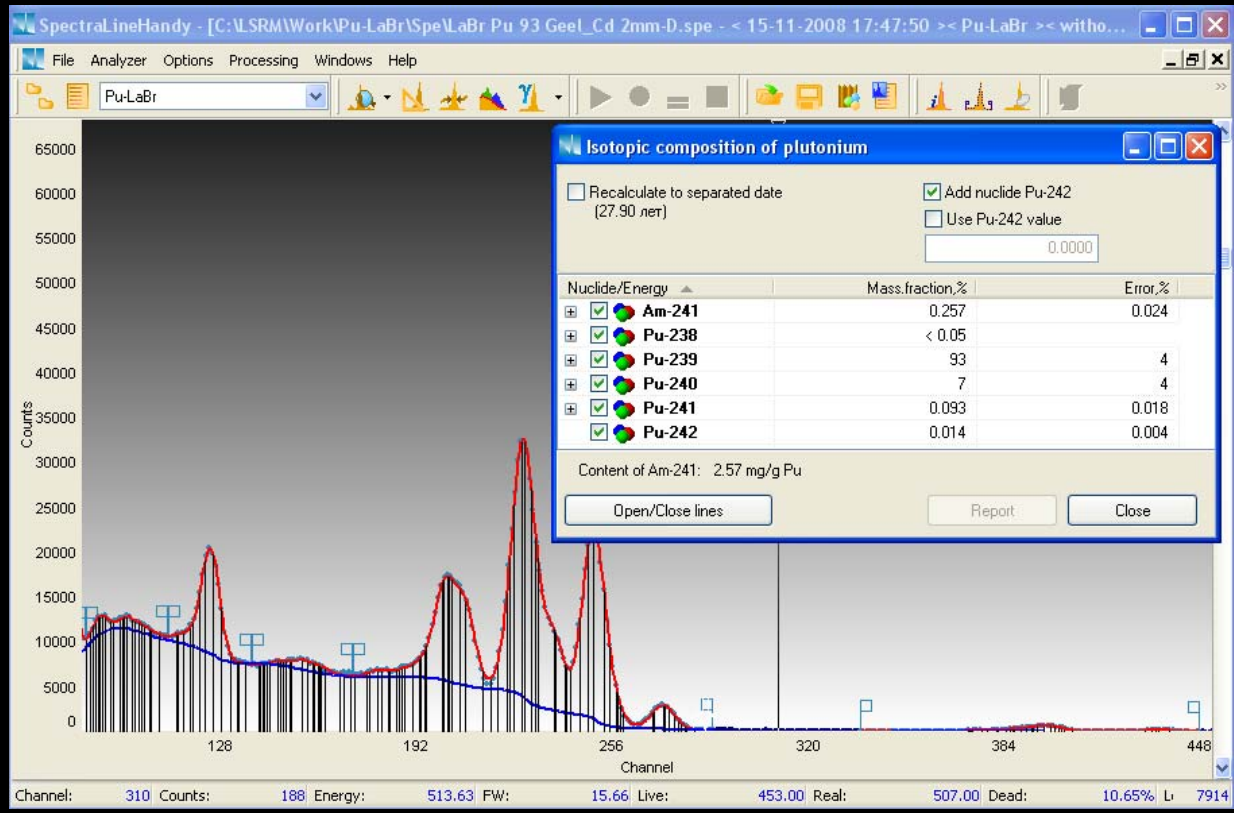




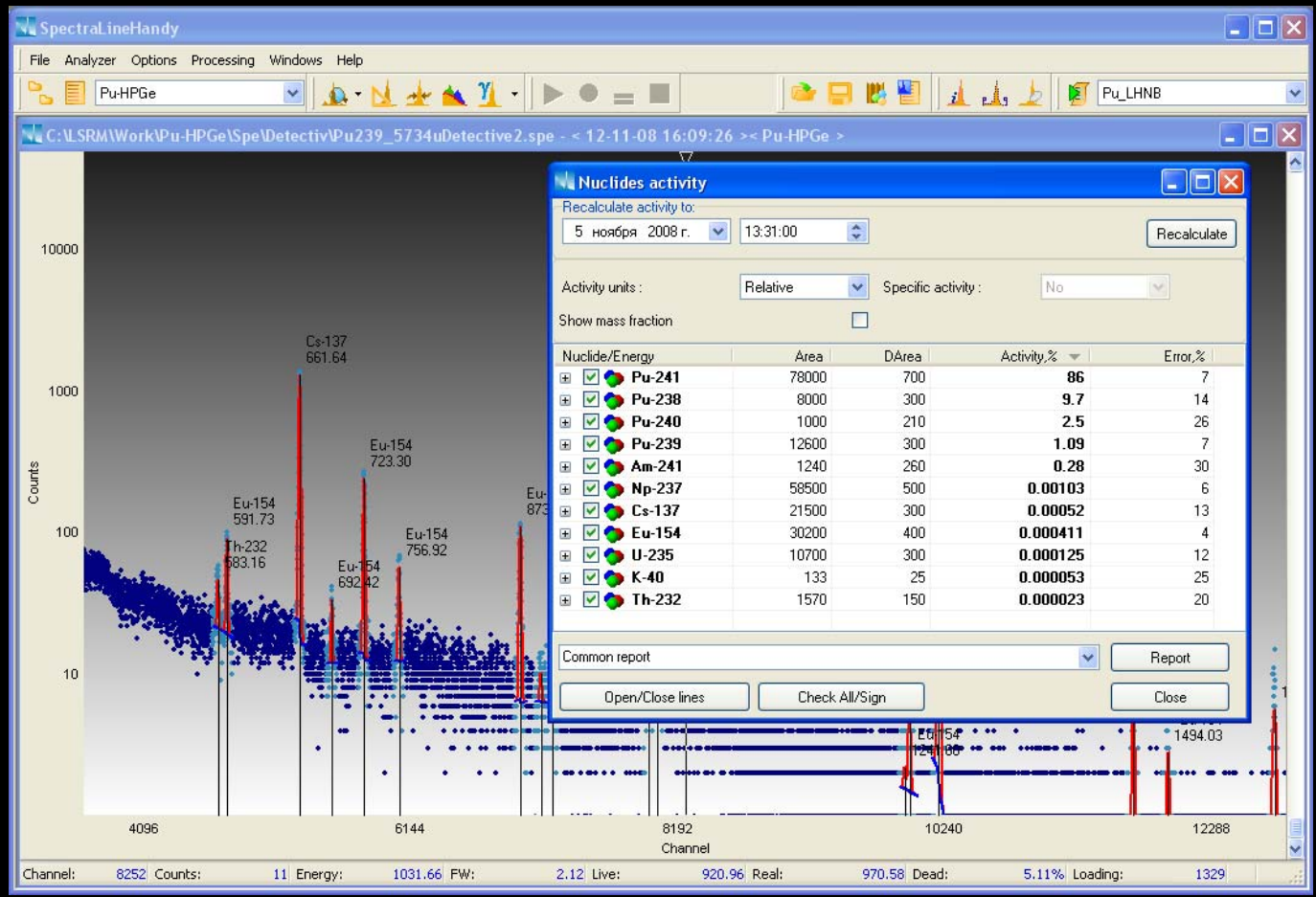
LaBr3 -2x2”

^{239}Pu

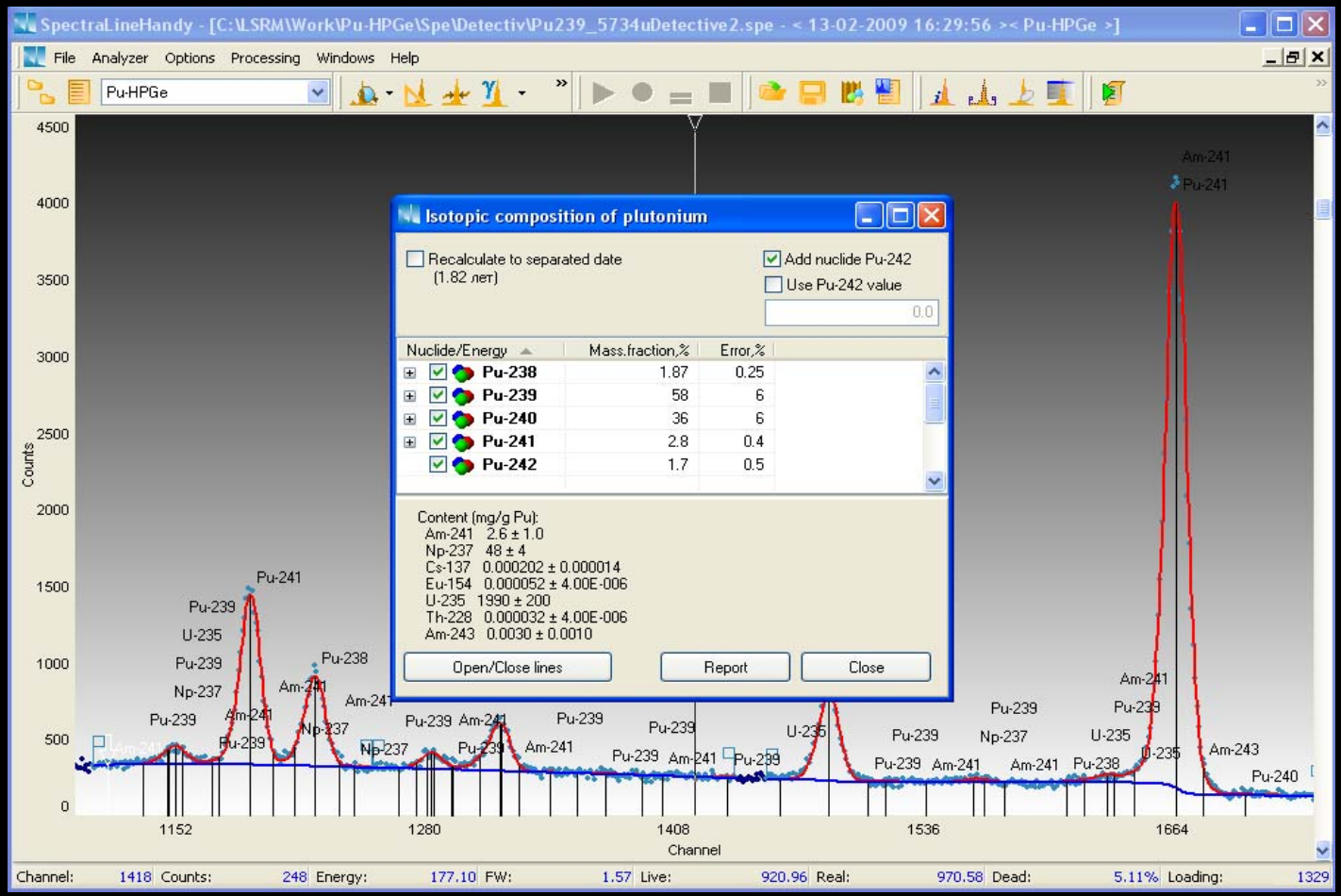
Passport - 93%
Measurement 93+/-4 %



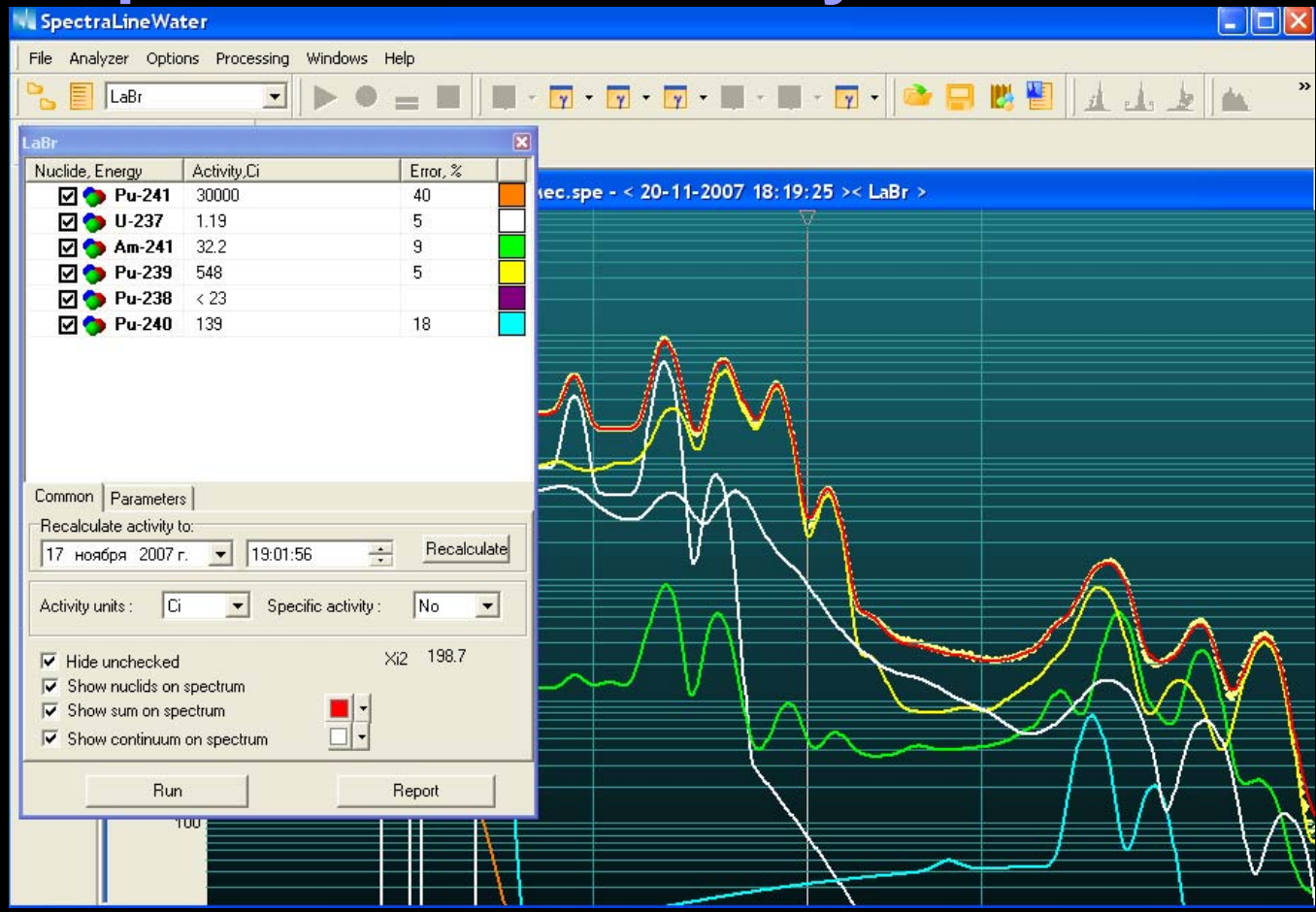
MicroDetective: FHWM at 122keV =1.5 keV



MicroDetective : Low-energy Spectrum Interval



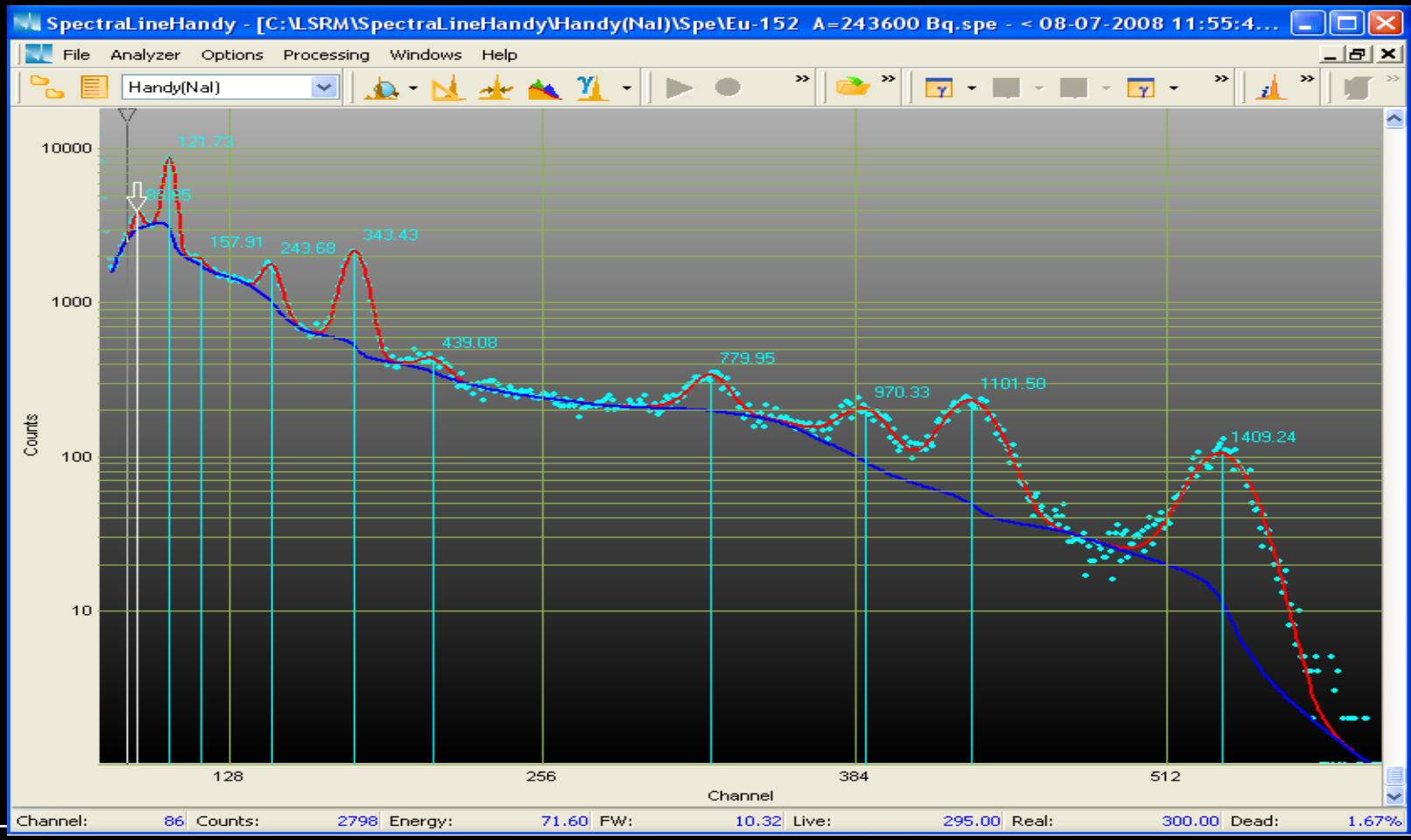
SpectraLineHandy - Plutonium Isotopic Composition Measured by LaBr-3 Detector.



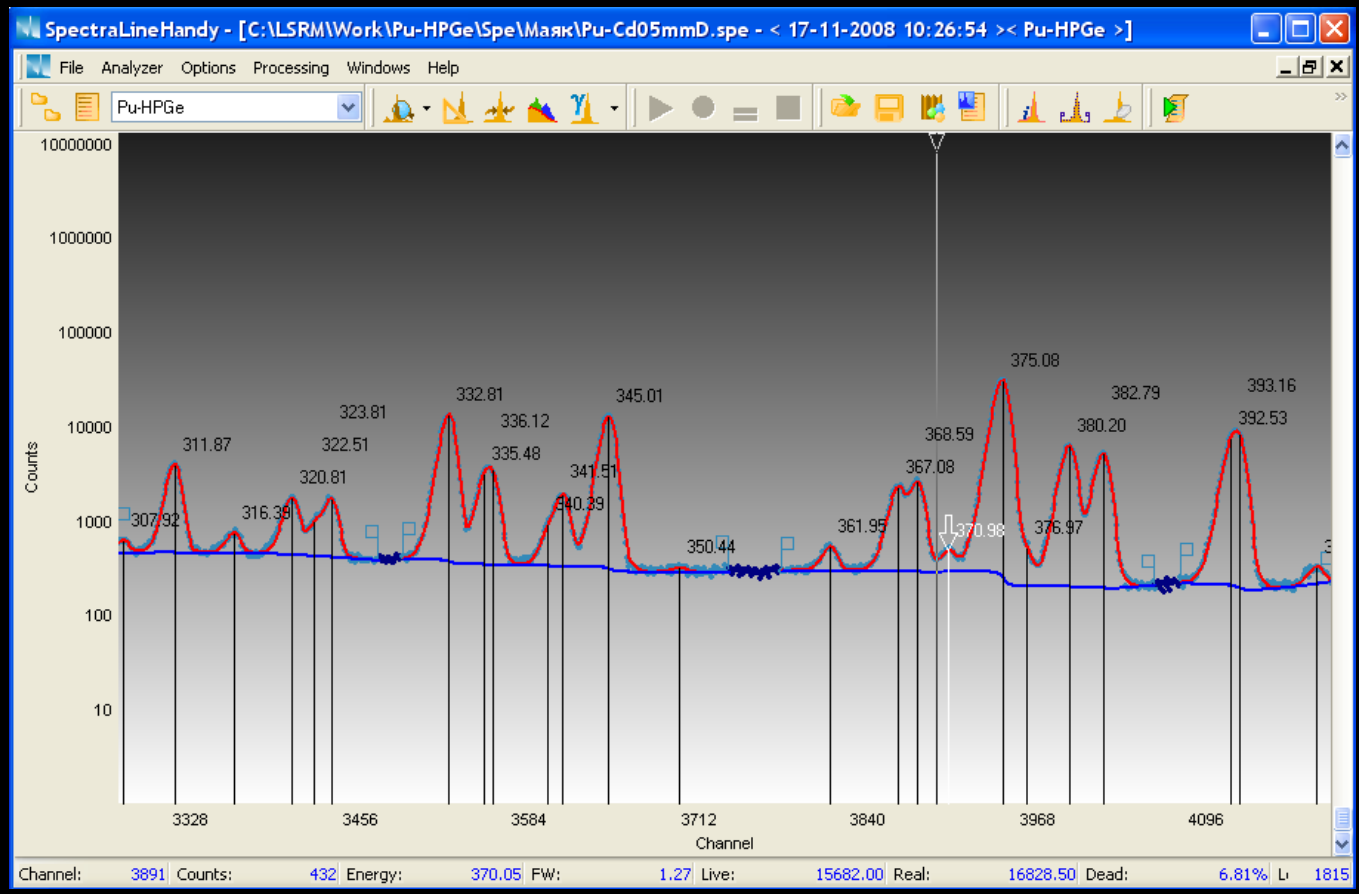
Identification Steps

- The peaks search in the spectrum and the fitting of the spectrum intervals
- Comparison of energy values of the found peaks with the peaks of radionuclides in the user nuclides library, which are the most important for spectrum description, and preparation of the table of nuclides, which can be in the measured sample
- Marking the peaks of all possible nuclides, which are important for spectrum description.
- Re-marking of the spectrum intervals and new fitting of spectrum. Calculation of activity of all nuclides and analysis of their importance for the description of this spectrum.

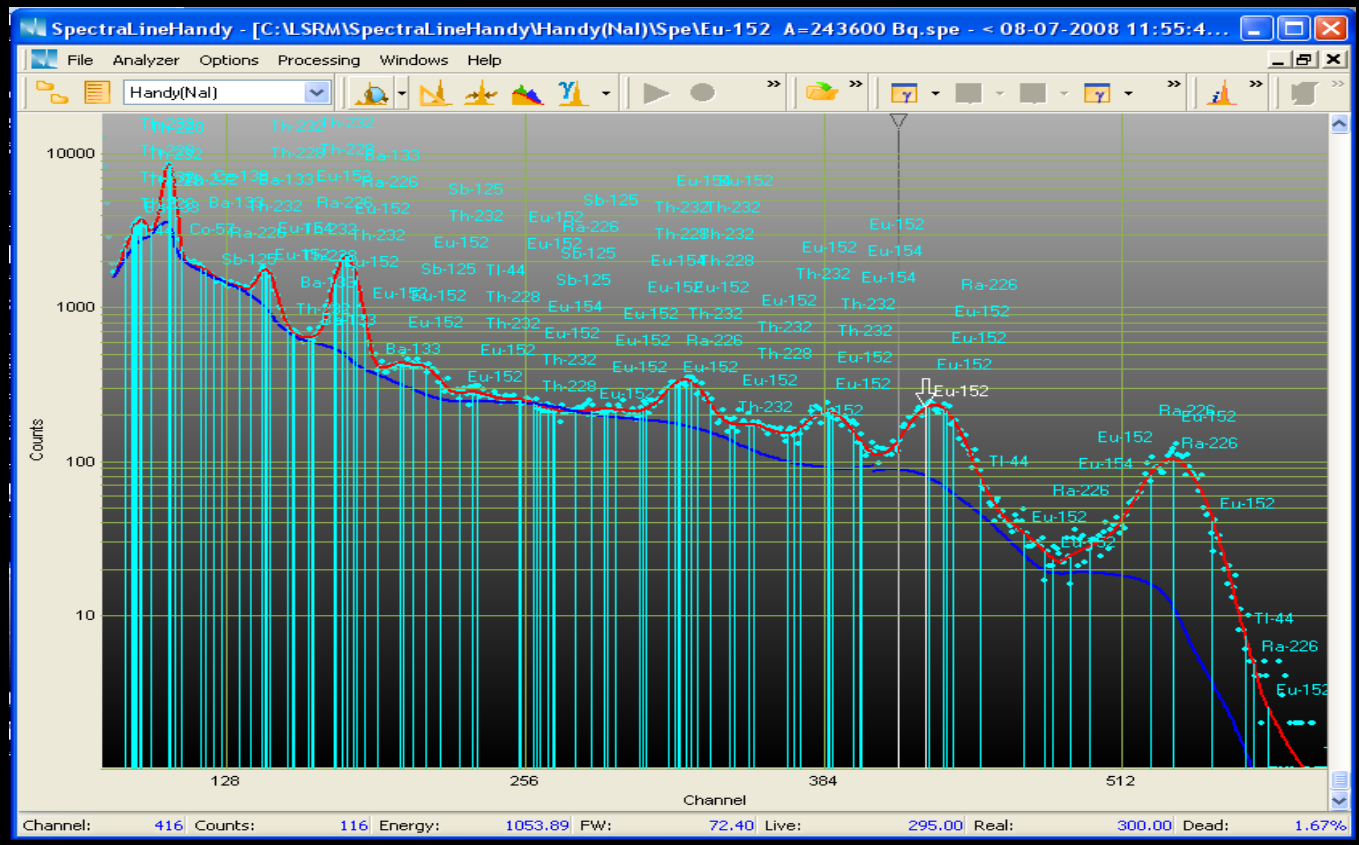
Peaks Search



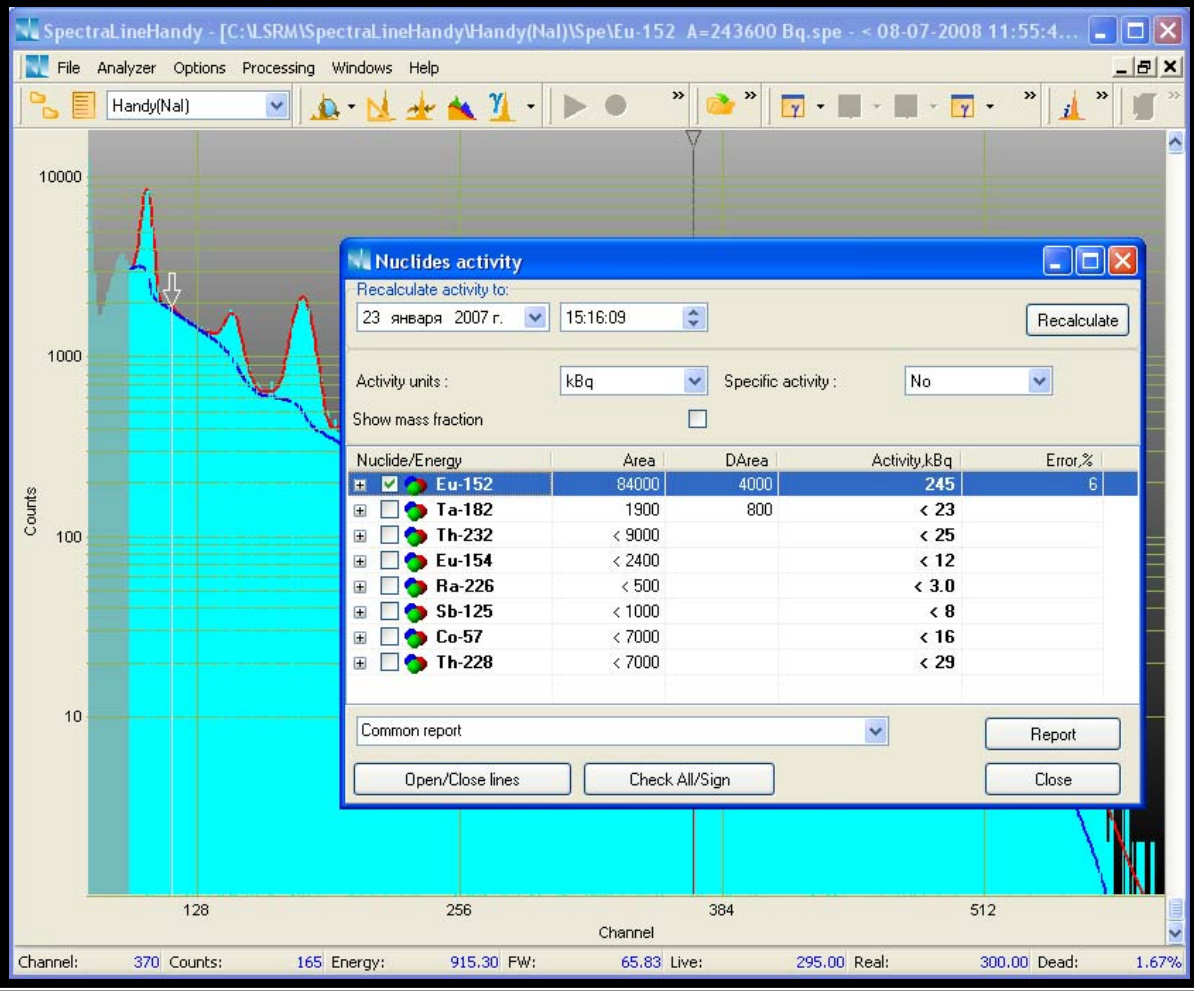
Peaks Search Procedure – Multiplets Separation



Estimation of Activity of all Probable Nuclides



Estimation of Activity of all Probable Nuclides



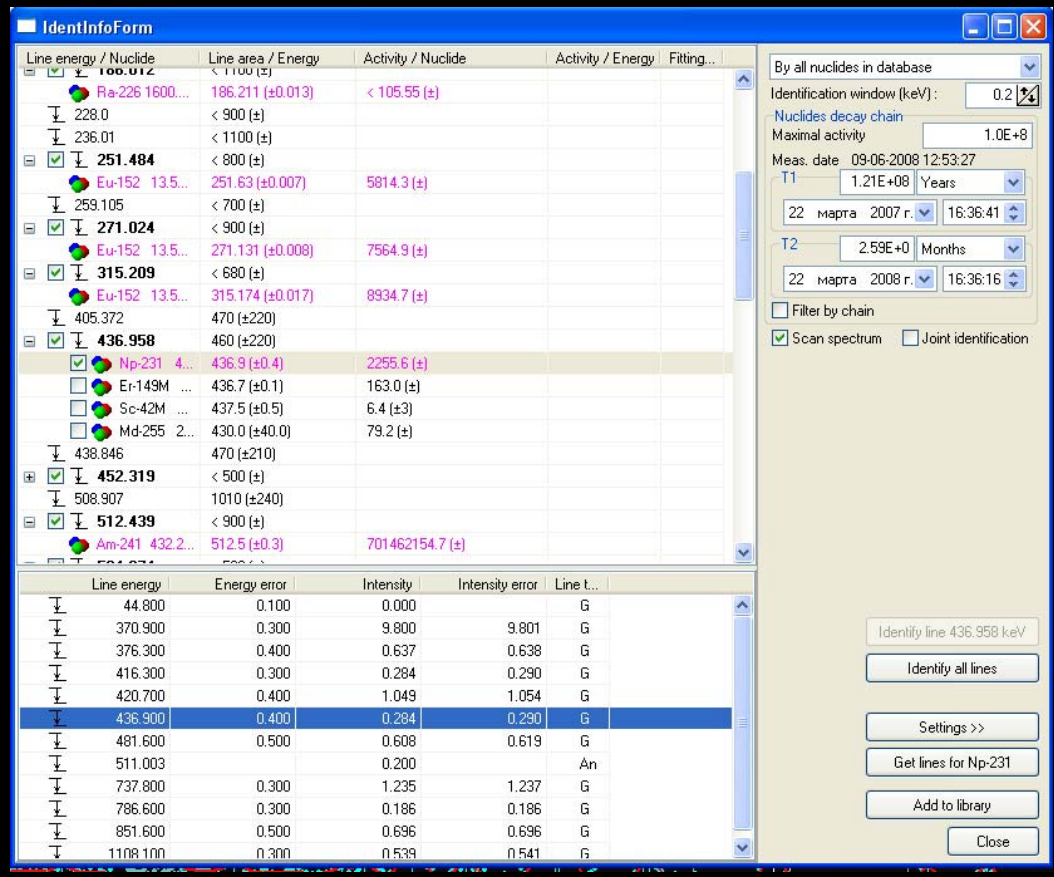
The Requirements for Successful Identification

- Data for all assumed nuclides from the sample should be in the nuclides library
- Correct energy calibration
- Agreement between parameters of the shipping container, used for calculation, and real values

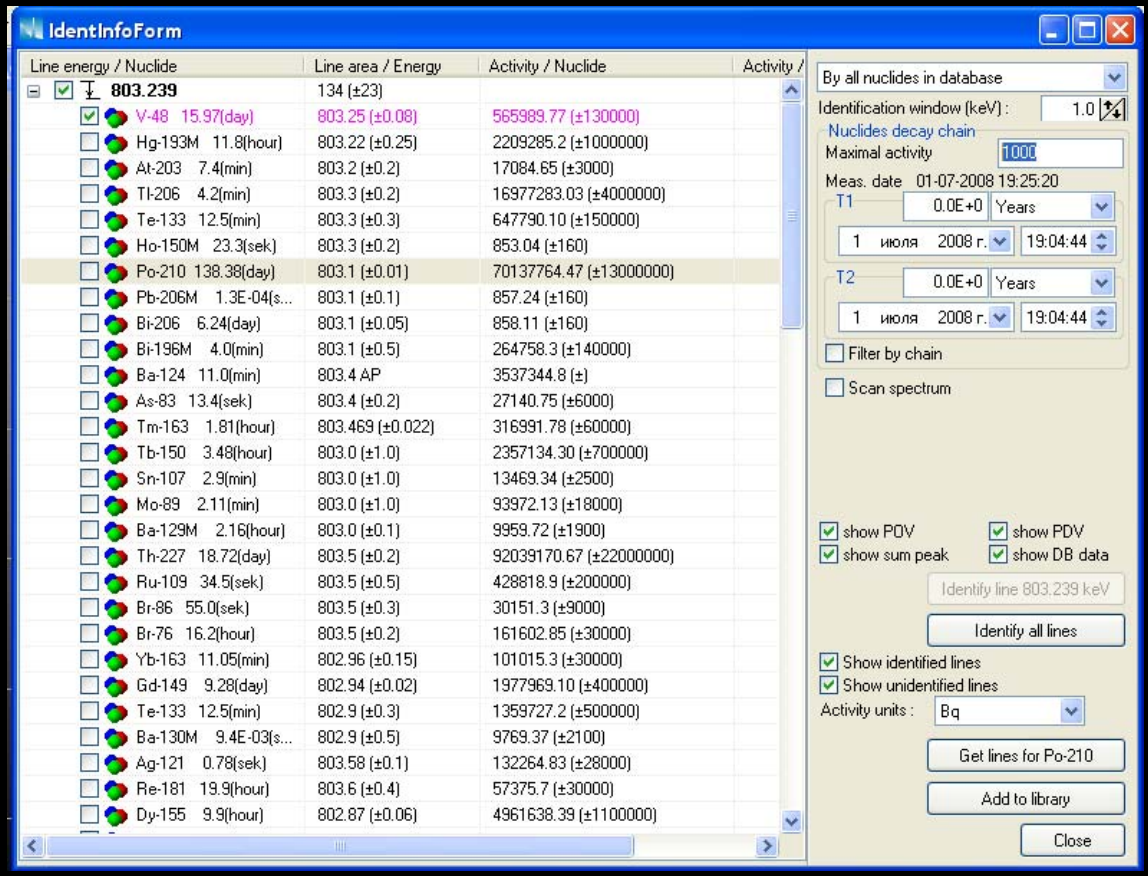
Extension of Nuclides Library

- By the list of identified nuclides
- By a selected nuclides list
- By nuclides database

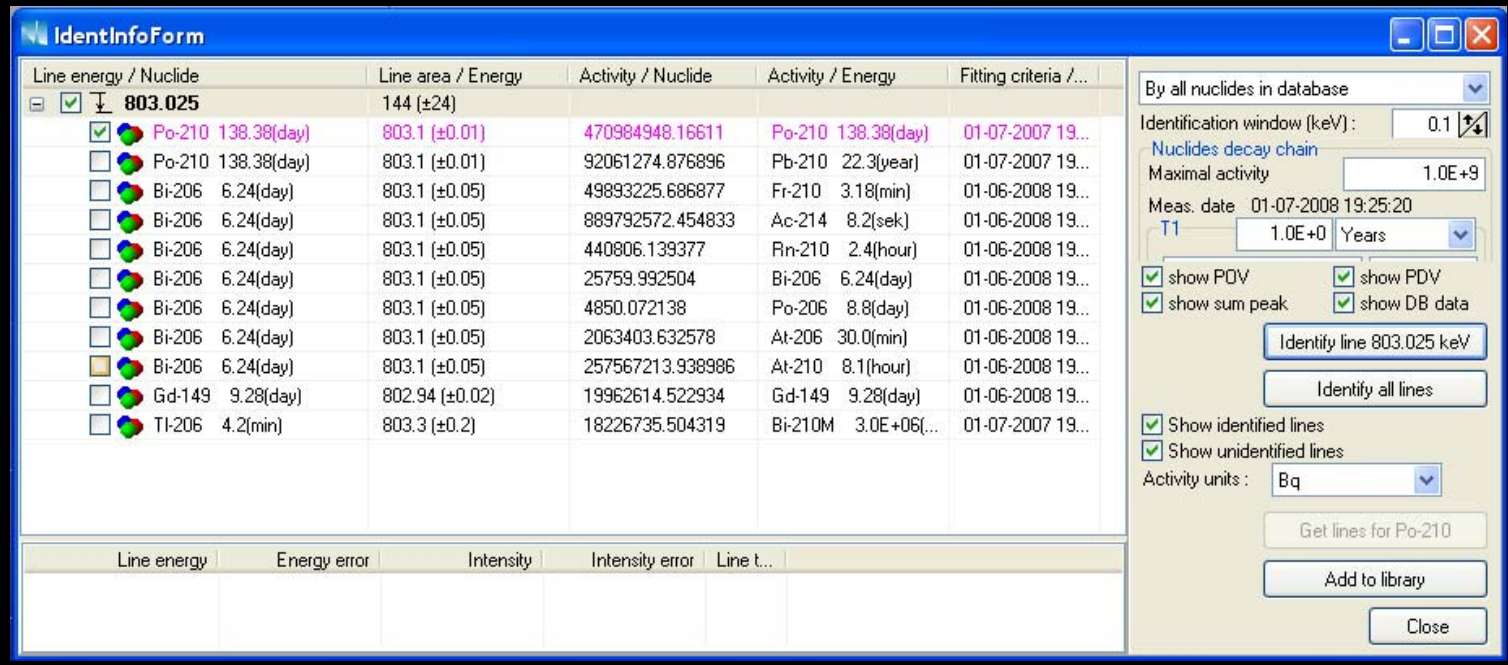
By the List of Identified Nuclides



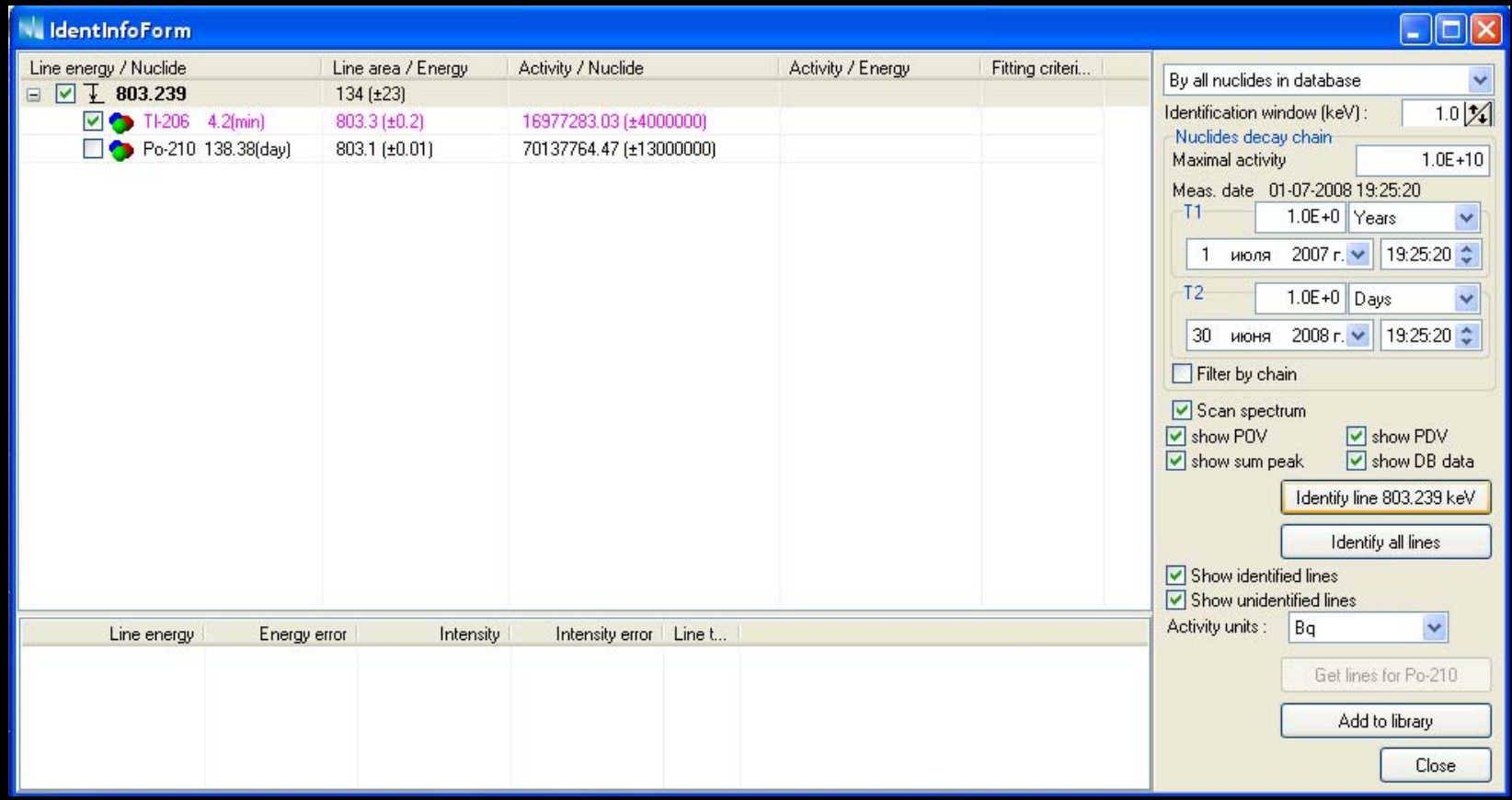
Extension of Nuclides Library
Filter by Energy



Extension of Nuclides Library
Filter by Half-life Period

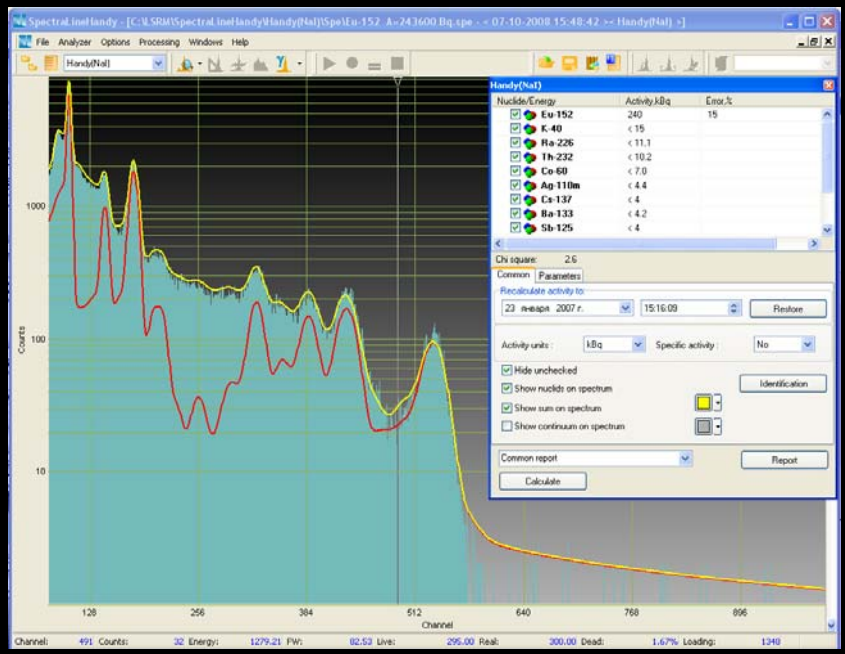


Extension of Nuclides Library
Filter by Spectrum

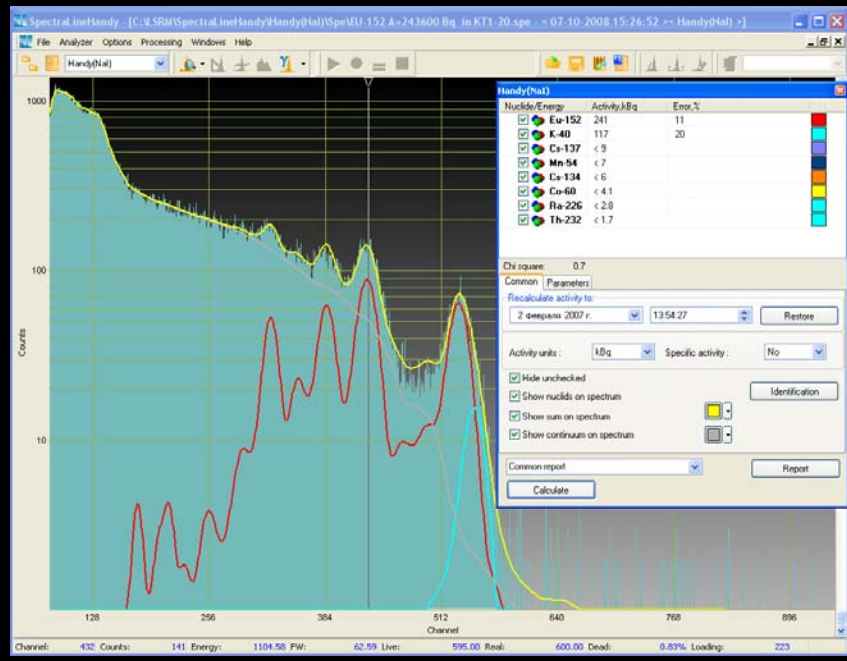


“Quasi- Reference Spectra” Method for Spectrometers with Low Resolution

Spectrum of Eu-152 point source measured with NaI-detector



Eu-152 in container KT1-20, measured with NaI-detector



Our Software Nowadays

- Peaks search procedures with high functionality
- Procedures of identification and activity calculation using intensities ratio and absorption in the container material
- Software with comprehensive data: database of nuclides with their decay chains, database with cross sections of material-radiation interaction

Software Development

Methodological and algorithmic tasks

- Limitation of nuclides library, nuclides classification depending on their co-presence
- Using information about available nuclides to restore calibration, analyze absorption etc.
- Development of procedures for estimation of radiation absorption based on the approximate information about matrix or container properties

Technical tasks

- Duplication of mouse functions by shortcut keys
- Support of the main spectra formats

LABORATORY
of spectrometry
and radiometry

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Thank you for your kind attention!