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AUTOMATION OF REACTOR NEUTRON ACTIVATION ANALYSIS

Павлов С. С., Дмитриев А. Ю., Фронтасьева М. В. Д18-2013-87
Автоматизация реакторного нейтронного активационного анализа

Сообщается о состоянии дел по созданию программного комплекса, предназначенного для автоматизации НАА на реакторе ИБР-2 ЛНФ ОИЯИ (Дубна). Согласно решениям, принятым на координационном совещании МАГАТЭ в Делфте 27–31 августа 2012 г., отсутствующее в настоящее время устройство смены образцов (sample changer) для НАА будет изготовлено и установлено в соответствии с особенностями радиоаналитического комплекса РЕГАТА на реакторе ИБР-2. Представлены конструкционные детали устройства смены образцов. Программное обеспечение для работы с этим устройством состоит из двух частей. Первая часть представляет собой пользовательский интерфейс, а вторая является программой для управления устройством смены образцов. Вторая часть будет создана после установки этого устройства.

Работа выполнена в Лаборатории нейтронной физики им. И. М. Франка ОИЯИ.

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Pavlov S. S., Dmitriev A. Yu., Frontasyeva M. V. D18-2013-87
Automation of Reactor Neutron Activation Analysis

The present status of the development of a software package designed for automation of NAA at the IBR-2 reactor of FLNP, JINR, Dubna, is reported. Following decisions adopted at the CRP Meeting in Delft, August 27–31, 2012, the missing tool — a sample changer — will be installed for NAA in compliance with the peculiar features of the radioanalytical laboratory REGATA at the IBR-2 reactor. The details of the design are presented. The software for operation with the sample changer consists of two parts. The first part is a user interface and the second one is a program to control the sample changer. The second part will be developed after installing the tool.

The investigation has been performed at the Frank Laboratory of Neutron Physics, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna, 2013

1. INTRODUCTION

At the Joint Institute for Nuclear Research, neutron activation analysis (NAA) is carried out using the installation REGATA at the IBR-2 reactor of the Frank Laboratory of Neutron Physics [1]. The most important tasks in performing NAA are to improve the quality of analysis and the quantity of performed investigations.

In the framework of international programs in the field of life sciences and materials science at the REGATA facility the mass analysis of a large number of samples is performed that requires organization of labeling, storage and recording of analyzed samples, irradiations, measurements and processing of the γ spectra of induced activity, as well as systematization of the results of analysis. Large sets of samples of vegetation, soil, foodstuffs, microorganisms used in bionanotechnology, and other materials have to be recorded, properly stored, prepared for irradiation, and all phases of the analysis have to be registered.

To a large extent, these tasks are realized while ensuring the fullest possible automation of work. Therefore, the main objective of this project is to increase the level of automation of performed investigations. The initial phase of the development of software for automation of the NAA at the IBR-2 reactor of FLNP is reflected in [2, 3].

Improving the quality and quantity of research will be achieved through:

— automation of data input for analysis;

— use of programmable QC procedures in the analysis;

— rapid statistical analysis of the results and QC/QA procedures;

— automation of measurements of spectra using devices of automatic sample changer;

— automation of the process of calculating the concentrations, storage of the results of analysis and reporting;

— fast check of all phases of analysis and search for any information on NAA from any computer of the Department of NAA & AR.

The purposes mentioned above can be implemented through:

— development of a principally new software using databases of performed investigations;

— development and use of automatic sample changer during measurements of spectra;

— development and manufacture of new pneumatic control electronics for irradiation of samples, replacing the outdated pneumatic components of installation;

— carrying out studies of radiation resistance of new materials for the manufacture of a new type of packaging material and containers for long irradiation exposures;

— development and manufacture of devices for holding containers with samples after long irradiation exposures.

2. PROGRAM PACKAGE

2.1. Block Diagram of the Software. In 2013 development of the software package using the databases has been continued. Block diagram of the software to automate the NAA at the IBR-2 reactor is shown in Fig. 1.

2.2. Database Diagram. The database diagram is presented in Fig. 2. Program modules in solid lines are already developed and used. Those in dashed lines are in progress.

2.3. Main Database Window. Figure 3 shows the main window of the database interface, by means of which one can insert and check information about customers and received samples, used CRM and neutron flux monitors and check their residual amount, as well as data on all steps of the NAA: receiving,

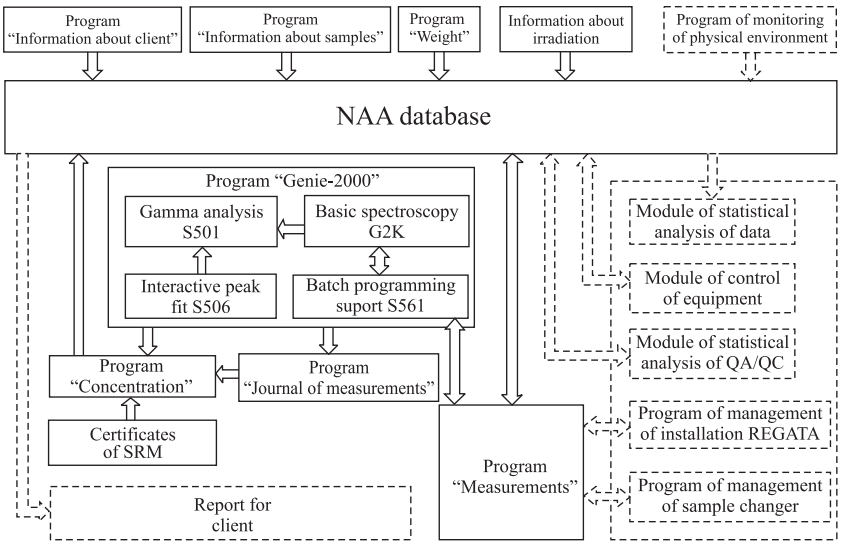

Fig. 1. Block diagram of the software

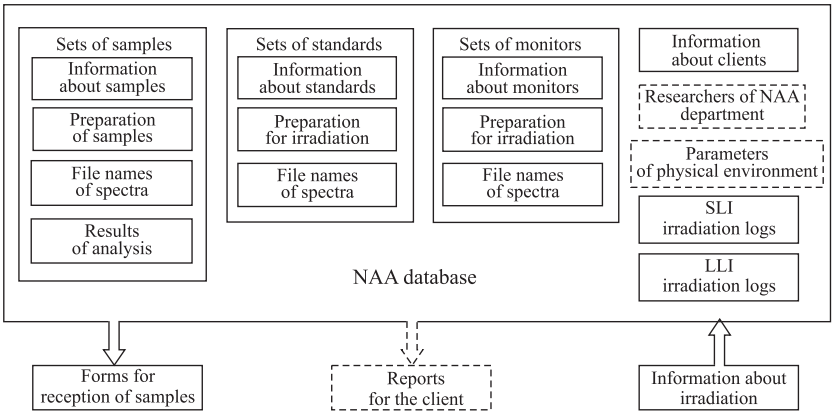

Fig. 2. The database diagram

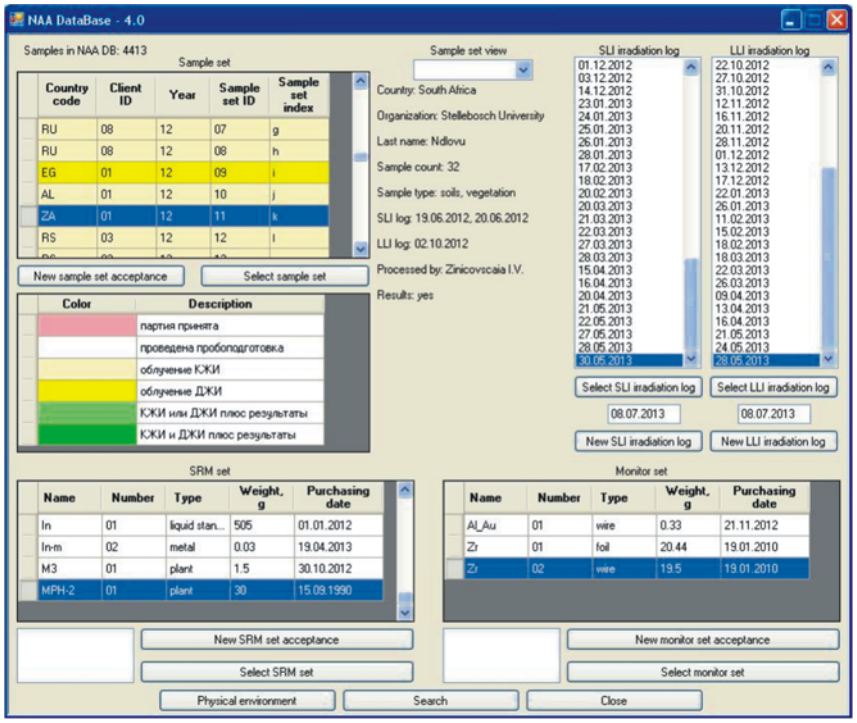

Fig. 3. Main database window

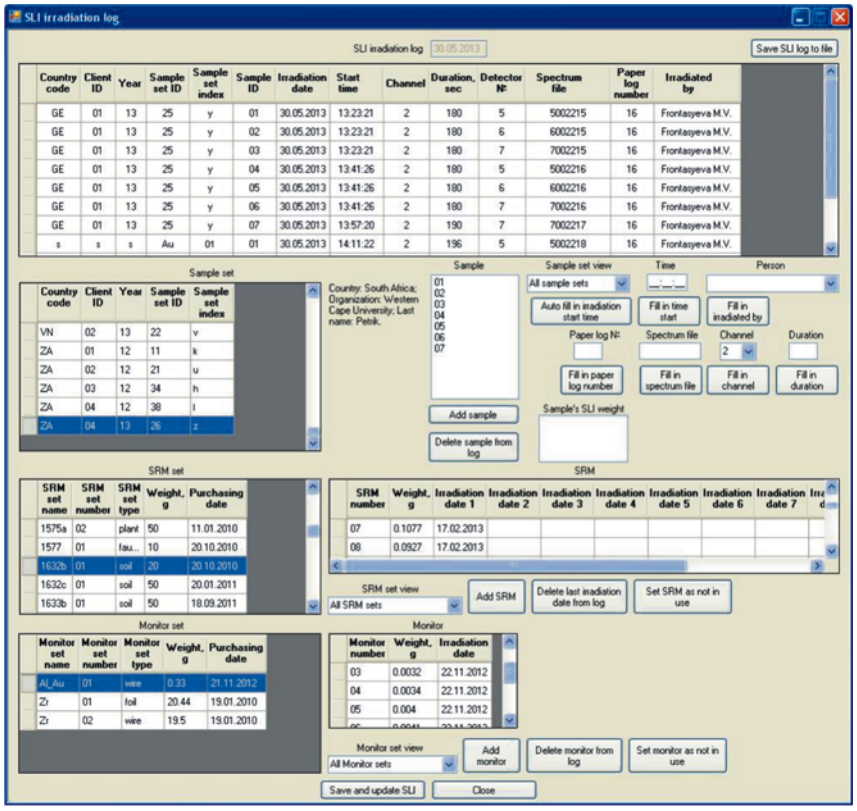

Fig. 4. Journal of irradiations for determination of short-lived isotopes

sample preparation, irradiation, processing the results and carrying out statistical analysis of the results obtained.

For example, from the journal of irradiations for determination of short-lived isotopes (Fig. 4) one can learn all the necessary parameters for the analysis on irradiations and the names of the spectra for each sample, standard or monitor.

Currently, most of the software has an interface in Russian, so other types of windows are not given in this report.

All the changes and additions will be made and their interfaces will be able to select the language.

2.4. Program "Concentration". Automation of calculation of concentrations of element in the samples based on the results of analysis of the spectra of samples, standards, and monitors is achieved by using the program "Concentration", the main window of which is shown in Fig. 5.

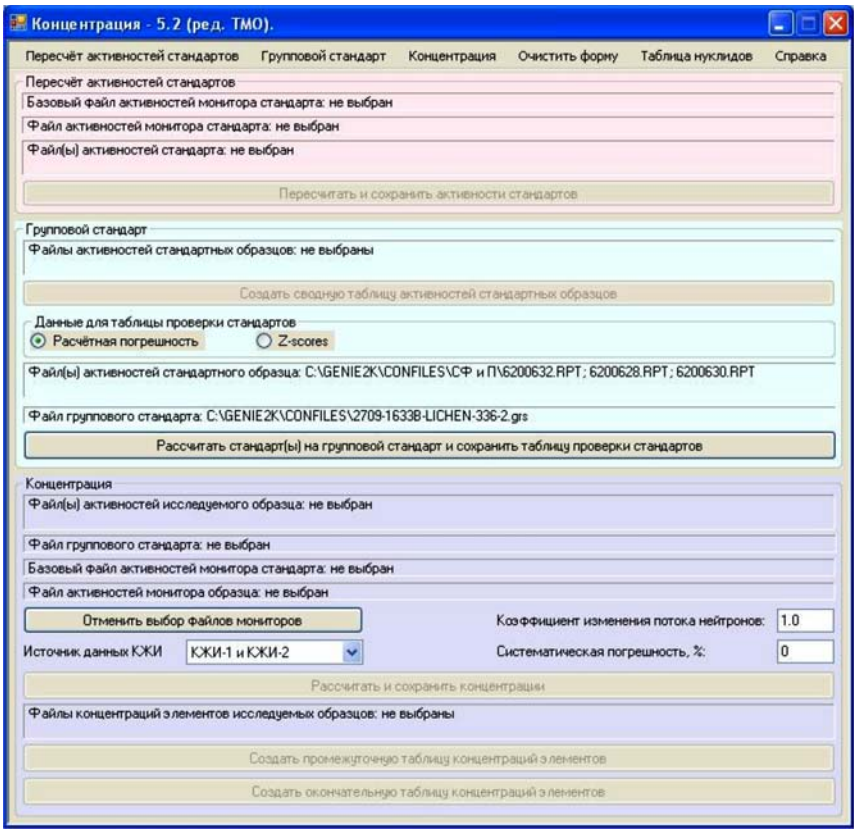

Fig. 5. Main window of the program “Concentration”

This program allows one:

— to make a correction of activity of isotopes in the samples and standards using the neutron flux monitors;

— to make a group standard using several irradiated CRMs;

— to check the compiled group standard calculating the concentration of elements in each of the standards through the group standard and making the resulting table;

— to calculate the concentration of elements in the samples using the group standard;

— to compile an intermediate table of results and to check the results by creating graphs based on the elemental concentrations obtained from different measurements and concentrations of correlated elements in the samples (Fig. 6);

— to compile the final table and to save it into the database.

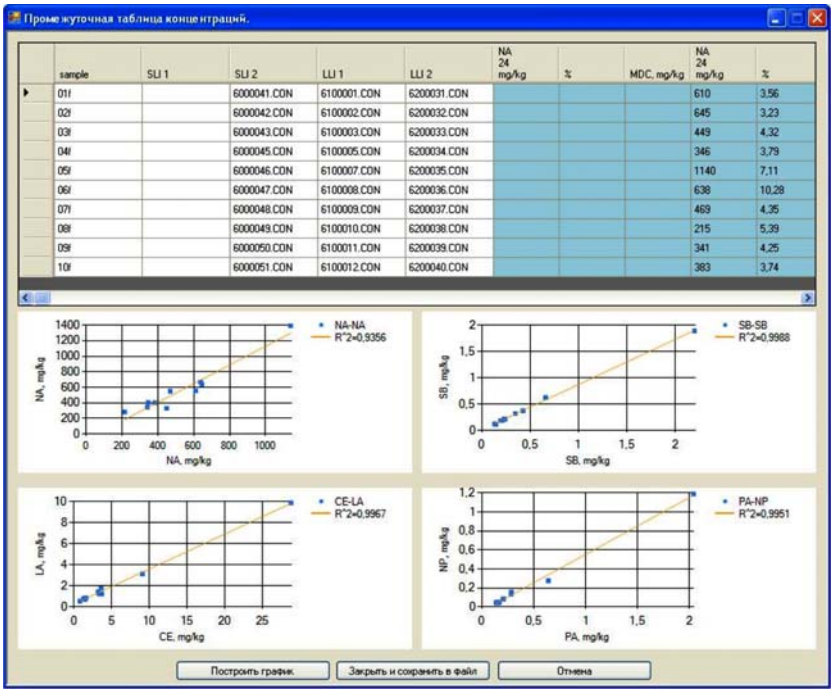

Fig. 6. Intermediate table of results

3. SAMPLE CHANGER

A special device has been developed to automate change of samples on the detectors. The samples to be measured are pre-installed in a rotating disk with 40 cells for containers. Transportation of containers from disk to the detector and back will be carried out using a commercial device produced by company DriveSet M202A (Figs. 7 and 8), which is composed of linear modules for horizontal and vertical transportation in three dimensions and the control electronics, including the control of a rotating disk with samples. The control module allows one to set the sample at any height above the detector and to check the state of the system over all the three dimensions by means of the absolute encoders. The manufacturing of such three modules of linear transportation is in progress.

The purchased package includes libraries for OS Windows, necessary for developing the existing program to control the devices and measurements of spectra.

Discs and stands for the samples are manufactured in the laboratory workshops (drawings are developed and transferred to the workshops). The contract for the purchase of lead shielding is in progress.

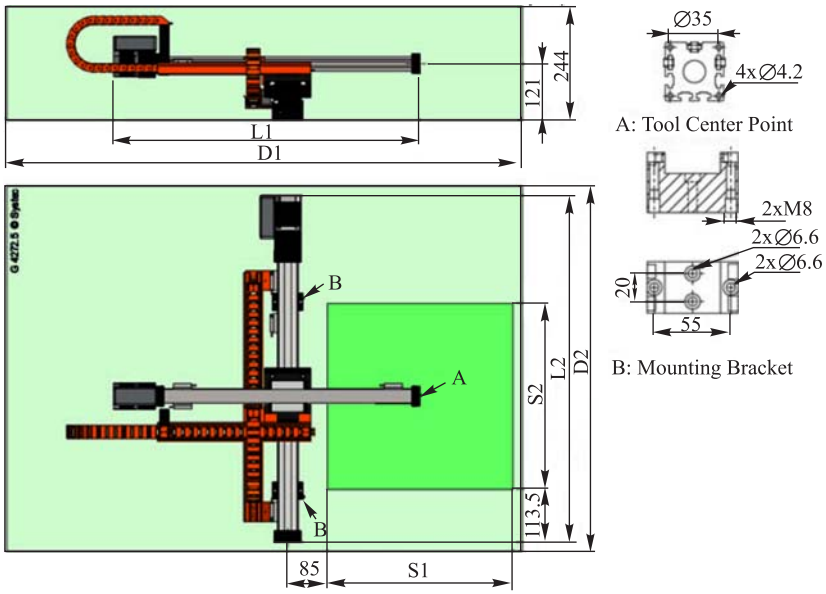

Fig. 7. General view of DriveSet M202A

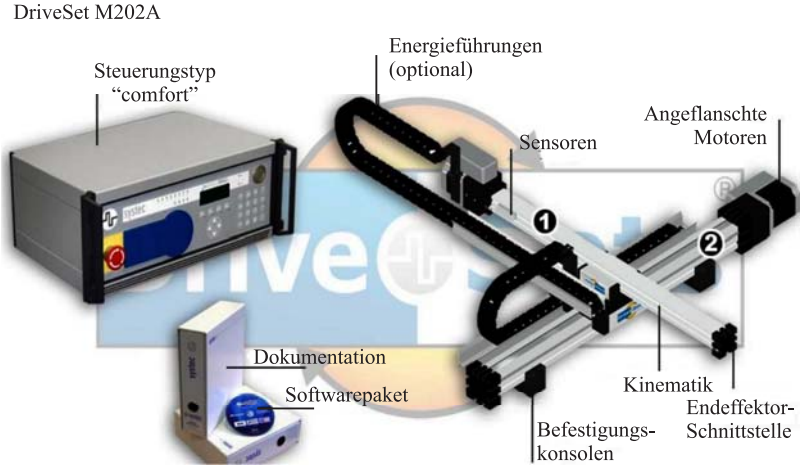

Fig. 8. Module of linear transportation by firm DriveSet

4. PROGRAM TO CONTROL DEVICES AND MEASUREMENT OF SPECTRA

All the necessary data for calculation of the concentrations are taken from the database and from the corresponding files; they are written automatically in the fields of the program and in the spectra. Information on the results of the measurements is automatically stored in the database (Fig. 9).

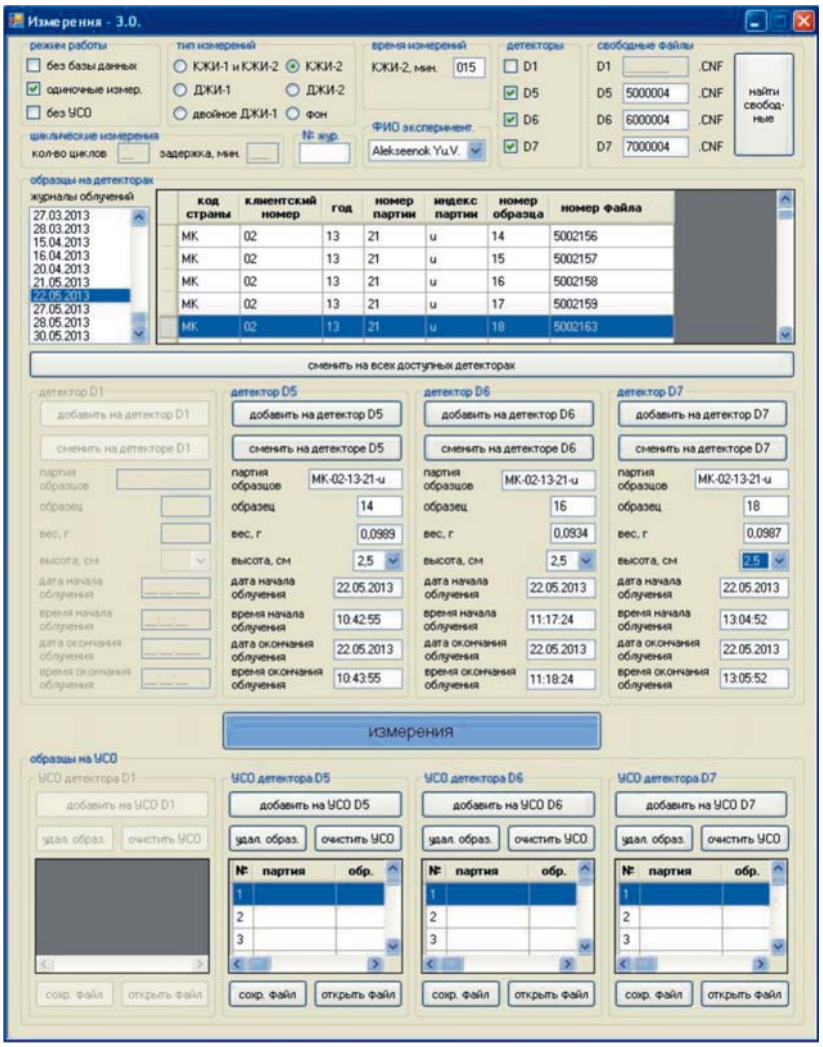

Fig. 9. Window of the program to control the devices and measurement of spectra

After installing the sample changers, in the process of their maintenance, it will be necessary to add to the program the codes to control the devices and to check their status.

At present the program is used without devices for automatic changing of samples.

5. TASKS OF THE PROJECT FOR 2014

1. To continue developing the software for the integrated automation of the NAA. To develop a database for atomic absorption spectrometry (AAS). The spectrometer is being set up.

2. To assemble and maintain three sample changers in the radioanalytical laboratory REGATA at the IBR-2 reactor provided with the program to control the devices and measurement of spectra.

3. To replace the outdated pneumatic components of the pneumatic system for irradiation of the samples; to develop new electronics to control the pneumatic system of the REGATA installation.

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