**POSTER REPORTS (DLNP)**

**V. Belov**

**Event reconstruction and background estimation of DANSS experiment**

We report the approach to the DANSS data analysis strategy. The structure of registered events is described. The signature of various types of events (inverse beta-decay, muons, radioactive sources, accidental coincidences and others) and corresponding criteria of selection is demonstrated. The examples of obtained distributions with selection efficiency is illustrated.

**J. A. Dadakhanov, A. Marinova, A. Baimukhanova, N. Mirzayev, D. Karaivanov,**

**F. Roesch, D.V. Filosofov**

**Sorption of a number of metals on ion-exchange resins in acetic acid solutions**

Ion exchange resins are used in diverse areas of chemistry, biology, medicine, and in different technological applications. Therefore the behavior of large number of elements in water solutions of acetic acid in the high concentration range has been previously observed on ion exchange. There are a lot of studies for sorption of significant number of elements. However, it appears that for a lot of elements (e.g., Th, Hf, Zr, Ti, Ac, Ra) the sorption data for cation exchange and anion exchange resins with acetic acid solutions is very little or nonexistent. In the present study the concentration limits of acetic acid were expanded and the distribution coefficients on Ion-exchange resin for elements with valences from II to VI were determined. We also studied the elements distribution coefficients with different mixtures of acetic acid and ammonium acetate as eluting solution. The accumulated data from this research could be used for the creation of better separation methods and purification of elements.

**S. V. Fateev**

**The updated version of the Brundibar program for mathematical processing of discrete experimental spectrum of low-energy electrons**

The main problem of computer codes for mathematical processing of discrete experimental spectrums of low-energy electrons is a correctly simulation of spectrometer response function (SRF). The SRF in the Brundibar code takes from the measured spectrum or is constructed by using of measured line shapes. In the poster report the updated version of this program is presented. Features of the updated version consist of the following:

* operational stability under the Windows 7 operating systems and above;
* the changed user's interface allowing to carry out extraction of the individual line from the experimental spectrum by means of the Brundibar code;
* evaluation of the electronic lines which are in area of the complex background.

The updated version of the Brundibar code was tested on experimental spectrums of low-energy electrons measured on an electrostatic spectrometer ESA-50.

**Nikita Gorshkov**

**The optical module of the Baikal-GVD neutrino telescope**

The Baikal-GVD neutrino telescope in Lake Baikal is intended for studying astrophysical neutrino fluxes by recording the Cherenkov radiation of the secondary muons and showers generated in neutrino interactions. The first stage of Baikal-GVD will be equipped with about 2300 optical modules. Each of these optical modules consists of a large area photomultiplier R7081-100 made by Hamamatsu Photonics and its associated electronics housed in a pressure resistant glass sphere. We describe the design of the optical module, the front-end electronics and the laboratory characterization and calibration before deployment.

**E. S. Kurakina**

**Application of Perturbed Angular Correlation (PAC) studies on the after-affects of radiopharmaceutical precursors**

One of the key challenges in the field of Nuclear Medicine is stability of the isotope-chelating agent system. After-effects of the radioactive decay can be a cause for isotope to come out of the complex. Perturbed angular correlation (PAC) of γ-rays appeared to be effective technique in studying this system.111In as widely used diagnostic imaging agent in the field of Nuclear Medicine is also suitable isotope for PAC spectroscopy. On the other hand, some of the rare earth elements are promising to be used in the treatment of tumors. 177Lu is already proved to be very effective for target therapy of metastatic prostate cancer. Since Eu PAC isotopes have appropriate half-life for the long research, the results upon the stability of radioactive complex can be useful for the other lanthanides due to similar properties.

In present work, four radionuclides 111In, 111mCd, 152Eu, 154Eu are investigated with chelating agent 10-4 M diethylenetriaminepentaacetic acid (DTPA) at different pH values under the same conditions. Stability constants of the complexes were determined. Herein we aim to present the after-effects, which play a major role in application of the isotope-chelator system as precursors of the radiopharmaceuticals.

**Genko Marinov, M. Milanova, D. V. Filosofov**

**Separation and Purification of REE with the use of chromatographic methods**

Rare earth elements (REE) are of great interest for modern science, industry and medicine. More often than not they should be in pure form for their application. On the other hand, there are other elements like Ac(III), needed in pure form and the REE appear as contaminates.

In the research for the separation of REE a way to purify them from Ta and Hf after proton irradiation of Ta target was researched. For this purpose, a system with cation exchange resin and UTEVA resin was implemented. Another sub area was the separation of REE from proton irradiated Th target and purification of Ac(III) for which DN resin is tested. The separation of Ac (III) from REE always presents a challenge and great interest due to their similar properties. Following the receipt of the pure mixture of REE the separation of individual REE was researched using a modified method for the separation of individual REE with the help of cation exchange resin and α – hydroxyisobutyric acid

**Atanaska Marinova**

Utilization of (p,4n) reaction potential for medical isotopes production with medium energy protons: radionuclide generator 90Mo→90Nb

Utilization of protons with medium energies (50-70 MeV) for production of medical radionuclides have become a very attractive option whit recent grout commercial availability of medium energy cyclotrons. In this work, we demonstrated proof-of-principle production of the 90Mo/90Nb system by irradiation of natural niobium target with medium energy protons. Two step separation was performed for efficient purification of 90Mo from bulk niobium mass. Two generators systems based on TEVA and WBEC were tested and showed potential for use for 90Mo/90Nb generator. Production and separation of 90Mo was performed as potential source of 90Nb for PET imaging.

**N. Mirzayev**

**Purification and synthesis of ammonium salts used in low-background studies and nuclear medicine**

The development of new technologies and modern scientific research have led to a serious increase in the value of ultrapure substances. The key to successful low-background experiments is the use of materials and samples that are very pure in relation to possible radioactive impurities. Ultrapure substances are especially needed in nuclear medicine. Ammonium salts can be used as fluxes in the soldering of devices operating under low background conditions, and are also the basis for the synthesis of a number of substances used in nuclear medicine.

The poster is devoted to the description of the procedure for the synthesis of pure ammonium salts (for example, NH4Cl). The purity is achieved by three factors: a) a specially selected procedure for synthesis from the gas phase, b) using pure initial components (acids), and c) using vessels from specially selected materials. To purify acids, the distillation method is used at temperatures below the boiling point. All processes are carried out in a specially equipped clean room. The purity of obtained samples was determined by inductively coupled plasma mass spectroscopy (ICP-MS) and nuclear spectroscopy.

The distribution coefficients of more than fifty elements in solutions of NH4Cl on DOWEX 50W-X8 resin were identified for first time.

**Dmitrii Ponomarev**

**Sensitive neutron detection method using iodine-containing scintillators**

This work explains a new, highly sensitive method for the detection of neutrons, which uses the T1/2=845ns delay in the decay of 128Iat the 137.8 keV energy level, resulting from the capture of thermal neutrons by iodine nuclei in NaI and CsI scintillation detectors. The use of delayed coincidence techniques with a several *μ*s delay time window for delayed events allows for the highly effective discrimination of neutron events from any existing background signals. A comparison of ambient neutron measurements between those identified through the suggested method from a cylindrical, Ø 63 mm × 63 mm NaI(Tl) scintillator and those from a low background proportional 3He counter experimentally demonstrates the efficacy of this neutron detection method. The proposed method can provide low-background experiments, using NaI or CsI, with measurements of the rate and stability of incoming neutron flux to a greater accuracy than 10-8 n cm-2 s-1.

**А.V. Rakhimov**

**Purification and analysis of macro quantities of selenium-82 for the study of double beta-decay**

82Se is one of the most suitable isotope for the study of rare processes: double beta-decay and searching of neutrinoless double beta decay (the Demonstrator of the SuperNEMO project). The purified selenium should be radiopure and highly dispersive for the preparation of thin spectrometric foil of selenium.

Purification of selenium from natural radioactive trace radionuclides of 232Th, 238U, 226,228Ra, 227Ac and 40К and analysis of materials (chemical reagents, polyethylene and other construction materials) are curried out at the scientific experimental department of nuclear spectroscopy and radiochemistry of DLNP JINR in collaboration with the members of LSM.

A purification technique of selenium from the above-mentioned tracers has been developed. It is based on cation exchange chromatographic separation. Further, a technique has been developed in order to obtain elemental selenium using selenous acid (H2SeO3) reduction with sulfur dioxide. The purification and reduction of 2.5 kg of enriched selenium (82Se) has been done on the basis of these both techniques.

The purity of materials (initial and purified selenium, water, nitric acid, polyethylene) has been determined with inductively coupled plasma atomic emission and mass spectroscopies (ICP-AES/MS), neutron activation analysis (NAA) and the measurements with HPGe- and BiPo-spectrometers in low background conditions. The results of measurements of 82Se radio-purity are 228Th = 92 µBq/kg and 226Ra <763 µBq/kg.

**Nadezda Rumyantseva**

**Pulse shape discrimination in novel germanium detectors of GERDA experiment**

The GERDA (GERmanium Detector Array) experiment, located at the Laboratori Nazionali del Gran Sasso (LNGS) of INFN in Italy, searches for the neutrinoless double beta (0νββ) decay of 76Ge. GERDA operates bare germanium detectors enriched in Ge76 directly immersed in liquid argon, which acts as a cooling medium and at the same time as a shield against external radioactivity. Recent results of GERDA Phase II show that the unprecedented background index of 10−3 cts/(keV·kg·yr) is successfully achieved. This implies that the experiment will stay background-free up to design exposure of 100 kg·yr. One of the main feature, which helped to reach such background level, is superior pulse shape discrimination capability of our novel detectors.

**Bair Shaybonov**

**Data management and processing system for Baikal-GVD neutrino telescope**

The Baikal-GVD neutrino telescope is being constructed in lake Baikal. The robust Baikal Analysis and Reconstruction Software (BARS) has been developed to convert raw data into physics results. To provide a stable and continuous analysis of all the data an automatic data processing using database is developed. The flexibility of the concept makes it easy to add new steps at any point of the analysis chain. The software is ROOT based collection of C++ classes driven by a central event loop. Now the basic algorithms have been implemented in the system such as event building, signal extraction, background rejection and simple reconstruction.

**E. Shevchik**

**Active background suppression using argon scintillation for the GERDA phase II and the LEGEND experiment.**

The liquid argon veto system (LAr veto) is a detector system aimed to detect argon scintillations in the vicinity of the Ge detector array of GERDA experiment. The goal is to reject background events in the Ge detectors caused by γ background from natural decay chains and α or β decays near/on detector surface. A low background LAr veto instrumentation has been installed for Phase II and the intended background index of ~10⁻³ cts/(keV•kg•yr) has been confirmed.

Ultimate goal for next generation LEGEND experiment phase I is upgrade of existing GERDA infrastructure up to 200 kg HP-Ge with background reduction up to 5 times relatively to GERDA experiment. Therefore, it`s necessary to update the liquid argon fiber shroud system to improve operation stability, constructive materials radiopurity and new Ge detector array design compability.

**Temerbulatova N**

**The study of ferrites with a spinel structure (CoFe2O4, NiFe2O4, ZnFe2O4) and titanium and scandium oxides by the method of perturbed angular γγ correlations.**

In recent years, the problem associated with wastewater disposal is becoming very urgent. One of the promising cleaning methods is based on the decomposition of organic contaminants under the influence of sunlight using photocatalysts. Photocatalysts based on ferrites with a spinel structure (ferrospinels) and some oxides (TiO2, Sc2O3) are considered suitable (sufficiently cheap). Therefore, in order to increase the effectiveness of the application, a lot of work is performed to shift their absorption region from the near ultraviolet to the visible region of the spectrum by adding alloying elements.

The poster report is devoted to the investigation of hyperfine interaction (and its temperature dependence) between the doping elements and the sample matrix (oxide, ferrospinel) by perturbed angular γγ-correlations (γγ-PAC).

The γγ-PAC method is based on the implanting of a radioactive isotope into the sample (the probe core is 44Ti, 111In, 140La, 172Lu), the decay of which is accompanied by the emission of cascade γ-quanta. The angular distribution of the emitted cascade γ quanta provides information on the hyperfine fields (magnetic and electric) with which the sample affects the embedded nuclei.

Samples were synthesized by co-precipitation. The isotopes used (44Ti, 111In, 140La, 172Lu) were obtained by irradiated targets (Cu, Sb, Ta) with protons on the LNP Phasotron of JINR and separated by ion exchange chromatography.

**POSTER REPORTS (FLNP)**

**D. N. Grozdanov, N. A. Fedorov, F. А. Aliev, V. M. Bystritski, Yu. N. Kopach, I. N. Ruskov, P. V. Sedyshev, V. R. Skoy, V. N. Shvetsov**

**The use of resonance neutron method of the analysis of isotope composition for searching of palladium in elements of the “Proton” rocket engine.**

JINR FLNP pulsed resonance neutron source IREN, based on an electron accelerator with a non-multiplying neutron-producing target, and neutron time-of-flight (ToF) technique can be used for determining the elemental and isotopic composition of samples by characteristic neutron capture gamma-ray resonances. The cross section for the interaction of neutrons with matter in the neutron energy region from eV to hundreds of keV has a pronounced resonance structure, and the position of the neutron capture gamma-ray resonances, as well as their intensity (the area under the resonance) are unique for each element, which makes it possible to identify different elements, as well as their isotopes with high accuracy.

The sensitivity of the method is different for different elements and depends on a number of factors (the presence of resonances in the required neutron energy region, the resonance neutron cross section, the presence of background resonances from other elements in the same region, etc.). The penetrating ability of neutrons is quite high; therefore, the method allows analyzing rather massive samples and does not require their preliminary preparation, cutting, etc.

Palladium is one of those elements for which the resonance method works well enough, because very strong resonances are observed for this element in the energy range up to 100 eV (where the sensitivity of the method is high), which makes it possible to determine the presence of palladium even in very small amounts. In the experiment, the elements of the gas generator of the engine of the second and third stages of the “Proton” heavy rocket, including soldering with a significant amount of palladium, were investigated. The presence of palladium in these elements is an indicator of a violation of the technological process of manufacturing the engine, which can lead to an accident. For the detection of palladium in the samples provided by Roscosmos, they were placed in a neutron beam inside the "Romashka" scintillation spectrometer consisting of 24 NaI(Tl) crystals. The results of the experiment are presented.

1. **I. Frank, G. V. Kulin, M. A. Zakharov, S. V. Goryunov**

**Enhancing of the efficiency of the energy transfer to neutrons during diffraction by a moving grating.**

Recently, multiwave dynamical theory of neutron diffraction by a moving grating was developed [1]. A phase grating moving across the neutron beam can act as a quantum modulator of neutron wave transforming the spectrum of transmitted neutrons. As a result, the spectrum is characterized by a discrete set of energies. The efficiency of the neutron energy transfer is directly defined by amplitudes of diffraction orders. Theory predicts that at a certain height of the grating profile a significant suppression of the zero-order diffraction may occur. At the same time the intensity of the lines of orders increases. Experiment was performed at the PF2 source of ILL. The resulting spectra if diffracted UCNs were measured using time-of-flight Fourier diffractometer [2]. Two diffraction gratings with different depth of the grating profile were used. The results of the experiment were compared with the results of numerical simulation. Finally the experimental results were found in a good agreement with theoretical predictions.

[1] Bushuev V. A., Frank A.I., Kulin G.V., Jetp 122 (1) (2016) 32.

[2] G.V. Kulin, A.I. Frank, S.V. Goryunov, et al. 2016 Nucl. Instr. and Meth. A 819 67.

**D. Wang, I. N. Ruskov, Yu. N. Kopatch, and D. N. Grozdanov**

A New Single-pixel Gamma Camera

Gamma cameras have been widely used in the nuclear industry to measure the spatial distribution of gamma sources. Usually a gamma camera is based on the coded aperture imaging technique. And a position sensitive detector is employed to record the gamma flux after the coded aperture. It is still not easy to achieve good spatial and energy resolution simultaneously. In this research we developed a new gamma camera, in which only one BGO scintillation detector is used. This camera takes the advantage of a variable coded aperture. The coded aperture pattern changes randomly after each measurement. Two radioactive sources, 137Cs and 60Co, were used in experiments to test the camera. The results show that with this camera we can obtain clear spatial distributions of 137Cs and 60Co gamma-sources within 24 measurements.

**F. Aliev, V.M. Bystritsky, N.A. Fedorov,D.N. Grozdanov, C. Hramko, Y.N. Kopach, I.N. Ruskov, V.R. Skoy, V.M. Slepnev, D. Wang, N.I. Zamyatin, E.V. Zubarev**

**Neutron beam profilometer on the base of double-sided silicon strip detectors.**

At present, in the Joint Institute for Nuclear Research (JINR), Dubna, Russia, in the frame of project TANGRA (TAgged Neutron and Gamma RAys), are conducted experiments to study the process of inelastic scattering of fast neutrons with the nuclei of various substances.

The build TANGRA-facility allows to obtain precise information about the angular and energy distributions of gamma-rays resulting from the inelastic scattering of 14.1 MeV neutrons on complex nuclei.

As source of neutrons, we used a portable neutron generator ING-27 (En=14.1 MeV), designed and created by VNIIA (Moscow) with an embedded double-sided 64-pixel silicon (gallium arsenide) alpha-particle detector, by means of which 64 independent tagged neutron beams are formed.

Tagging of neutrons is done by registration of the alpha particle, produced in the binary reaction d + t → (α + n), which is emitted in direction almost opposite to that of the neutron.

To obtain correct information about the characteristics of the process of inelastic neutron scattering on nuclei, it is necessary to know the parameters of all 64 tagged neutron beams with good accuracy.

To solve this problem, we have developed and created a two-coordinate position-sensitive silicon detector of fast neutron (profilometer), by means of which we measured the characteristics of all the 64 tagged neutron beams.

In this paper we give a description of the design of profilometer and present the results from the measurements of profiles of 64 tagged neutron beams formed by ING-27.

**Zinicovscaia, Nikita Yushin, E. Rodlovskaya, M. Frontasyeva, Inna Kamanina**

**Biosorption of lead ions by cyanobacteria *Spirulina platensis*: kinetics, equilibrium and thermodynamic study**

The potential use of dry *Spirulina platensis* biomass to remove lead ions from aqueous solution was studied. Effects of various parameters such as contact time, temperature, dosage of biosorbent, initial pH, and initial concentration of lead were investigated in the batch adsorption mode. The highest lead removal of 5.7 mg/g was obtained at pH 5, biomass dosage of 0.5 g, initial lead concentration of 60 mg/L. The Langmuir and Freundlich models fit the experimental data (R2>0.99), while the kinetic data was best described using the pseudo second-order kinetic model (R2>0.99). FTIR spectra indicated that lead removal takes place through binding to OH, C=O and P=O groups. Lead was efficiently recovered from biomass by mineral acids, while using CH3COOH and NaOH as eluents the biomass maintained high biosorption capacity during three cycles. This study demonstrates the potential of using *Spirulina platensis* as biosorbent to remove lead from model solutions as well as industrial wastewater.

**Chaligava Omari, S. Shetekauri, T. Shetekauri, A. Kvlividze, T. Kalabegishvili,**

**E.I. Kirkesali, M.V. Frontasyeva, O.E. Chepurchenko**

**Atmospheric Deposition Study of Major and Trace Elements by The Moss Biomonitoring Technique in Georgia: 2014 – 2016**

Results of 2014-2016 moss biomonitoring of atmospheric deposition of major and trace elements in Georgia are reported. Overall, during these surveys, 111 moss samples were collected, covering nearly the whole country. The sampling was performed in compliance of the UNECE ICP Vegetation guidelines. The concentrations of 39 elements (Na, Mg, Al, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Zn, As, Se, Br, Sr, Zr, Mo, Pb, Sb, I, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Hf, Ta, W, Au, Th, U) were determined by epithermal Neutron activation analysis (ENAA), while the concentrations of Cu, Cd and Pb were determined by atomic absorption spectrometry (AAS). Multivariate statistics was applied to find any association of chemical elements and to characterize the sources of elements detected in the samples, which mostly are associated with mineral dust, industrial or vehicle emissions. Micro-analysis of moss samples collected in the highlands of Georgia showed the presence of clastic, anthropogenic, as well as cosmogenic particles. For graphical data presentation, GIS tools were used.

**Mardyban E.V.**

**Phase transition in heavy nuclei**

Bogoliubov Laboratory of Theoretical Physics

We investigate the stabilization of octupole deformation with angular momentum for heavy nuclei. The parity splitting for 240Pu and 226Ra nuclei are calculated. The critical angular momenta, which describes the phase transitions from octupole vibrational mode at low angular momentum to the stable octupole deformation at high angular momentum, are defined. The results are compared with the experimental data.