FRANK LABORATORY OF NEUTRON PHYSICS

In 2009, the FLNP scientific programme was realized under five research themes of the JINR Plan for Scientific Research and International Scientific and Technical Cooperation and was aimed at obtaining new results in condensed matter physics (theme 04-4-1069-2009/2011 «Investigations of Nanosystems and Novel Materials by Neutron Scattering Methods» headed by V. L. Aksenov, A. M. Balagurov and D. P. Kozlenko) and neutron nuclear physics (theme 06-4-1036-2001/2010 «Nuclear Physics with Neutrons — Fundamental and Applied Investigations» headed by V. N. Shvetsov and Yu. N. Kopatch). To effect scientific research, work to develop and modernize the FLNP basic facility, the IBR-2 (theme 07-4-0851-87/2010 «Upgrade of the IBR-2 Complex» headed by A. V. Belushkin and A. V. Vinogradov) as well as the IBR-2 spectrometry and computation complex (theme 04-4-1075-2009/2011 «Novel Development and Creation of Equipment for IBR-2M Spectrometers Complex» headed by V. I. Prikhodko and S. A. Kulikov) continued.

This report contains a brief account of 2009 scientific results. The FLNP Annual Report for 2009 will give a more detailed account of the results in 2009.

CONDENSED MATTER PHYSICS

In view of the IBR-2 reactor shutdown for reconstruction, the scientific and experimental work of the personnel of the Department of Neutron Investigations of Condensed Matter was carried out in neutron and synchrotron centres in Russia and abroad under the existing cooperation agreements and in accordance with the accepted beam time application proposals. The work on the IBR-2 reactor was conducted according to the plan of the modernization programme for the spectrometers.

Scientific Results. Neutron diffraction studies of the atomic and magnetic structure of 314-cobaltites $Sr_3 3YCo_4O_{10.5+\delta}$, wherein A-positions are perfectly ordered, have been continued. For these compounds it has been revealed that Co atoms occupying different positions in a unit cell have different magnetic moment magnitudes correlating with the oxygen surrounding of the atom. The compounds with different oxygen contents have been found to have AFM structure of G-type without any sign of the presence of the ferromagnetic component of the moment [1]. In 2009, the compounds with partial substitution of Ca for Sr, namely, $Sr_{0.75-x}Ca_xY_{0.25}CoO_{3-y}$ with $x \approx 0.30$ and $y \approx 0.35$ were studied, for which from indirect data some evidence was found for the partial stabilization of ferromagnetism due to the effect of Ca on the charge state of Co. To test this model, on the HRPT diffractometer (PSI), neutron diffraction spectra were obtained in the temperature range from 1.5 to 300 K. The preliminary analysis showed the presence of magnetic phase transition at $T \approx 260$ K with the appearance of the AFM structure and a possible small FM component.

The studies of high-pressure effects on the crystal and magnetic structures of complex anion-deficient cobalt oxides have been continued in a wide temperature range. In the $Sr_{0.7}Y_{0.3}CoO_{2.62}$ compound a pressure-induced change in the spin configuration for Co^{3+} ions has been revealed, which results in a modification of the symmetry of the antiferromagnetic state [2].

The structural characteristics of optically active nanostructured materials ($95GeO_2$–$5Eu_2O_3$,

$94.9GeO_2$–$5Eu_2O_3$–0.1Ag and $99.9GeO_2$–0.1Ag) annealed in air at $T = 900°C$ have been investigated by small-angle neutron scattering and X-ray diffraction. It has been found that a considerable change in the relative intensity of luminescence excitation bands of Eu^{3+}ions by doping with Ag correlates with a decrease in the characteristic sizes of polydisperse clusters formed during annealing (Fig. 1).

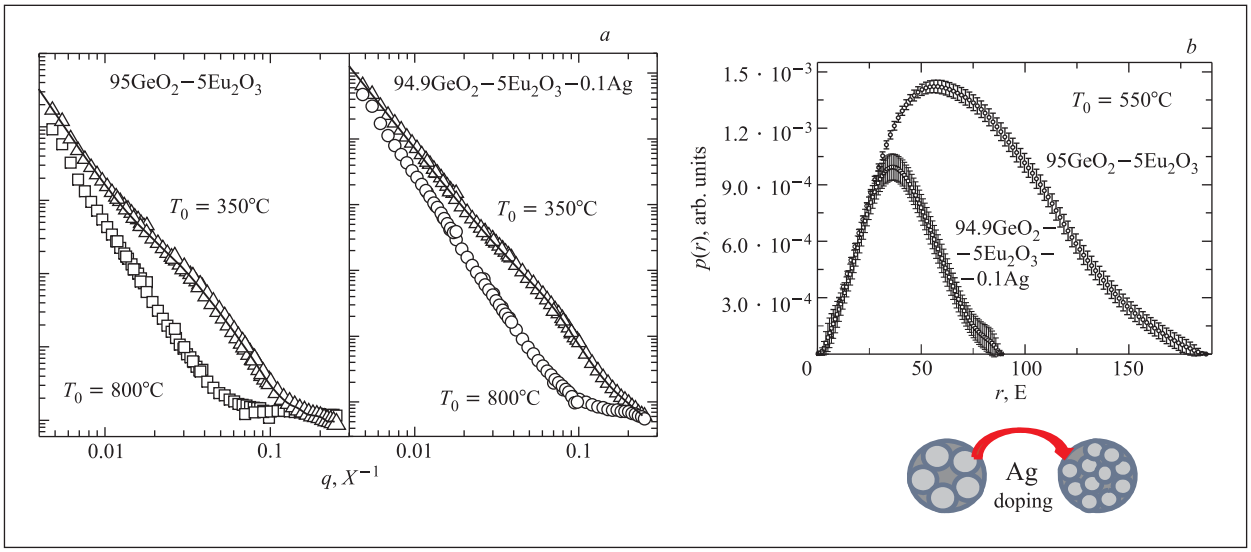

Fig. 1. *a*) Experimental and theoretical curves of small-angle neutron scattering of xerogels $95GeO_2$–$5Eu_2O_3$ and $94.9GeO_2$–$5Eu_2O_3$–0.1Ag for annealing temperatures 350 and 500°C. *b*) Distribution function of intermediate aggregates sizes for xerogels $94.9GeO_2$–$5Eu_2O_3$–0.1Ag and $95GeO_2$–$5Eu_2O_3$ for annealing temperatures 550°C

Complex investigations of the size regulation effect for magnetite nanoparticles in ferrofluids with nonpolar organic carriers and stabilization by monocarboxylic acids have been completed. The studies have been performed using the static magnetization analysis, transmission electron microscopy, diffraction and small-angle scattering of synchrotron radiation and small-angle scattering of polarized neutrons. It has been confirmed that the replacement of nonsaturated oleic acid (C_{18}) used in the classical stabilization procedure with saturated acids from a series of lauric (C_{12}), myristic (C_{14}), palmitic (C_{16}), stearic (C_{18}) acids results in a decrease in the effective size of stabilized magnetite [3].

The structure of the aggregates of nanodiamond particles (detonation) dispersed into polar liquids (water, DMSO) by a special wet milling procedure has been determined with the use of small-angle neutron scattering. The size and fractal characteristics of the aggregates, as well as the structural features of the nanodiamond particles (size, surface character), have been obtained. The analysis of the structure factor as a function of the number of particles points to the cluster interpenetration upon concentrating dispersions. The contrast variation with the use of mixtures of protonated and deuterated solvents allowed one to determine the mean density of the particles composing the cluster, and thus to conclude about the existence of a nondiamond component on the nanodiamond surface [4].

The micellization of sodium dodecyl(sulfophenoxy) benzene sulfonate and nonyl benzene deca(ethylene oxide) has been investigated in neutral and alkaline electrolyte solutions of different concentrations by small-angle neutron scattering. The micelles formed in the solutions have been found to possess a cylindrical (ellipsoid) shape. The characteristic sizes of the micelles have been determined as functions of surfactant and added electrolyte concentrations. The correlation of the data obtained with the geometry of track nanopores and the dynamics of their etching in surfactant-containing solutions has been revealed, and the model of the influence of surfactants on the formation of pores with specific geometry has been developed [5].

The experimental investigations concerning the problem of coexistence of ferromagnetism (F) and superconductivity (S) have been continued. The magnetic state of the Fe/V bilayer has been studied using a neutron wave resonator MgO/V/Cu. The behaviour of the bilayer in reality corresponded to the behaviour of a three-layer F/F–S/S structure in which the intermediate F–S layer was a mixture of vanadium and iron atoms. The direct and inverse proximity effects were observed. The direct effect consisting in the appearance of the superconducting order in ferromagnetic F–S manifested itself at the transition of the vanadium layer (S) into the superconducting state ($T = T_c$) as a decrease in the magnetization vector and its approach to the direction of the external magnetic field. The inverse proximity effect, i.e., the appearance of ferromagnetic order in the superconductor F–S, was observed at a temperature of $0.6T_c$ and involved an increase in the magnetiza-

tion vector and its deviation from the direction of the magnetic field [6].

The X-ray diffraction technique was applied to study water solutions of multilayer vesicles of multicomponent membranes modeling the mucous membranes of the human oral cavity (Oral Stratum Corneum, OSC) and the membranes comprising the mixture sphingomyelin/dipalmitoylphosphatidylcholine/dipalmitoylphosphatidylethanolamine (SM/DPPC/DPPE). The systems of the SM/DPPC/DPPE mixture (mass ratios of 1/1/1, 1/2/1) are characterized by a lamellar structure. As the mass fraction of DPPE increases, a part of the lipid forms a separate lamellar phase ($d \sim 56$ Å) and a reverse hexogonal phase ($a \sim 56$ Å).

Using the neutron diffraction data, the texture of special steels, graphite, zirconium niobate (various processes of manufacturing) has been determined. The crystallite orientation distribution function (ODF) has been determined; the simulation of volume elastic properties of these constructional materials has been performed. It has been shown that the austenitic facing of the VVER-1000 reactor vessel has a sharp radial texture (rotation of grains around the normal to the steel plane (002)), which results in a complex distribution of residual stresses in it, and in this case the minimal values of the Young modulus are attained in the direction of the normal to the surface of the reactor vessel.

The investigations of texture and internal stresses of rock samples from the Central Alpes (Switzerland) in the region of the Gotthard Base Tunnel have been carried out. The obtained results are important to estimate the influence of the tunnel excavation work on the geomechanical conditions of the mountain ranges surrounding the tunnel.

The inelastic neutron scattering method has been applied to study vibrational spectra of hexane and isomers of hexanol. The theoretical simulation of the vibrational spectra using the density functional theory has been performed. It has been found that to describe the dynamics of hydroxyl groups, the formation of hydrogen bonds between hexanol molecules should be taken into account.

Instrument Developments. The manufacturing of the head part of the mirror vacuum neutron guide has been completed and its installation on beam 6b of the IBR-2M reactor has been carried out within the framework of realization of the project of construction of the DN-6 diffractometer for microsample investigations. The manufacturing of a vacuum casing for the tail part of the neutron guide was continued. The designing of a gas position-sensitive detector has started.

The manufacturing, vacuum testing and installation of the head part of the GRAINS reflectometer on the reactor have been completed. The manufacturing of the rail support and the casing for the beam-forming system has started. The components of the given system (variable slits, beam-deflecting mirrors) have been tested. The technical documentation on the manufacturing of a mechanical drum chopper has been prepared.

A schematic design of a new backscattering detector for the HRFD diffractometer has been developed on the basis of ZnS-elements. The solid angle of the new detector is ~ 10 times that of the available detector, which will make it possible to significantly improve conditions for conducting structural experiments on HRFD.

NEUTRON NUCLEAR PHYSICS

The physical startup of the first stage of the IREN facility has been carried out at JINR FLNP. The IREN first stage includes one section of the electron accelerator and a nonmultiplying tungsten target. The achieved parameters are: peak electron beam current — 2.0 A; electron energy — 30 MeV; pulse width — 100 ns; repetition rate — 25 Hz; integral neutron yield — $(3{-}5) \cdot 10^{10}$ s^{-1}. The indicated parameters already make it possible to carry out experiments, which require high energy resolution in the energy range from fractions of eV to hundreds of eV [7].

The investigations of P-odd secondary particle emission asymmetry in the reactions of polarized cold neutrons and light nuclei of ^{6}Li and ^{10}B have been continued. The measurements are carried out at ILL (Grenoble) in an effort to study neutral weak currents in nucleon–nucleon interactions. At present, the results are as follows: the triton emission asymmetry in the $^6\mathrm{Li}(n,\alpha)^3\mathrm{H}$ reaction is $\alpha^{^6\mathrm{Li}}_{P\text{-odd}} = -(8.8 \pm 2.1) \cdot 10^{-8}$; the γ-ray emission asymmetry in the nuclear reaction $^{10}\mathrm{B}(n,\alpha)^7\mathrm{Li}^* \to \gamma \to {}^7\mathrm{Li(g.s.)}$ is $\alpha^{^{10}\mathrm{B}}_{P\text{-odd}} = +(0.8 \pm 3.9) \cdot 10^{-8}$. Using these values in the framework of the cluster model, the weak neutral current constant was estimated to be $f_\pi^{^6\mathrm{Li}} \leqslant 1.1 \cdot 10^{-7}$ and $f_\pi^{^{10}\mathrm{B}} \leqslant 2.4 \cdot 10^{-7}$ (at 90% confidence level). Both these values contradict «the best» DDH value $f_\pi^{\mathrm{DDH}} = 4.6 \cdot 10^{-7}$.

In October–November, 2009, a new experiment to measure $\alpha^{^{10}\mathrm{B}}_{P\text{-odd}}$ was conducted. The 50-day measurement was carried out on the polarized cold neutron beam at ILL. The main difference between this experiment and the previous ones is the improved geometry: earlier a boron target had been right in the air in the neutron beam in front of the detectors, in the last experiment it was placed in the helium-filled neutron guide. That made it possible to reduce the background and to improve the precision ($1.8 \cdot 10^{-8}$ instead of $3.9 \cdot 10^{-8}$). A «zero»-experiment was performed as well [8].

On the cold neutron beam at ILL, the FLNP specialists in collaboration with the French scientists have measured the concentration of hydrogen atoms in diamond nanopowder before and after degassing, total scattering cross section for hydrogen (not removed by degassing) and its temperature dependence. The concentration was found using the measurement of relative flux intensity of characteristic γ quanta in the $n(p,d)\gamma$ reaction from the samples under study and a polyethylene sample. It has been revealed that the amount of hydrogen in the nanopowder before and after degassing can be expressed by the ratios C_8H and $C_{15}H$, respectively. The total scattering cross section for a hydrogen atom in the degassed powder is ~ 120 b. The variation of this cross section as the temperature changes from 500 to 80 K does not exceed 3%. Thus, an increase in the reflection probability from a powder of diamond nanoparticles, which is of interest as a reflector for very cold neutrons, is possible either by removing/replacing hydrogen or by suppressing the channel of inelastic losses by cooling the powder to liquid helium temperatures. The measurement of the reflection probability in this case is possible, for example, by deep cooling of a trap of very cold neutrons [9].

The investigations of the (n,p), (n,α) reactions induced by fast neutrons have been continued. The experiments are carried out at the Van de Graaf accelerator EG-5 at JINR FLNP (Dubna) and EG-4.5 of the Institute of Heavy Ion Physics of Peking University (Beijing, China) in collaboration with the University of Lodz (Poland), the National University of Mongolia (Ulaanbaatar, Mongolia), and the Oak Ridge National Laboratory (USA). Data on neutron reactions with emission of charged particles induced by fast neutrons are of much interest both for the creation of constructional materials in nuclear power engineering and for studying mechanisms of nuclear reactions and determining the parameters of an optical potential. Within the framework of joint investigations at the EG-4.5 accelerator of the Institute of Heavy Ion Physics of Peking University (Beijing, China), the measurements of the parameters of the ^{143}Nd$(n,\alpha)^{140}$Ce and ^{95}Mo$(n,\alpha)^{92}$Zr reactions at $E_n = 4.0$, 5.0 and 6.0 MeV and the ^{147}Sm$(n,\alpha)^{144}$Nd reaction at $E_n = 5.0$ and 6.0 MeV have been carried out. The energy spectra of charged particles have been obtained. The data treatment and theoretical calculations were completed in 2009. The experimental data were compared with the available data, evaluations and model calculations. It should be pointed out that the analysis of new data on fast neutron cross sections was performed along with the analysis of the available data on these reactions induced by resonance neutrons [10].

In 2009, in the FLNP Neutron Activation Analysis Sector the RFBR–Romania project «Geochronology and Retrospective Study of Pollution of Unconsolidated Sediments from Oxygenated and Anoxic Territories of the Western Black Sea» was completed. The results of the performed investigations were printed in five scientific publications in international peer-reviewed journals, two of which being of special interest for geology. In 2009, the State Prize of the Government of the Republic of Macedonia was awarded to the research work conducted in the NAA sector in collaboration with the Macedonian specialists on the creation of the geochemical Atlas of one of the environmentally unsound areas in Macedonia [11–13].

The dependence of electrical characteristics of SiCN films on silicon substrate produced using the plasma-enhanced chemical vapor deposition (PECVD) technique on their chemical composition has been studied. The concentration of silicon, nitrogen and carbon in the films was measured using the Rutherford backscattering technique. The concentration of hydrogen in the films and their thickness were determined by recoil proton technique on the helium ion beam of the EG-5 electrostatic generator. The possibility of accurate determination of concentration of all elements in the three-element film was realized through the application of simultaneous measurements of the Rutherford backscattering and recoil proton spectra [14].

NEUTRON SOURCES

The IBR-2 Pulsed Reactor. In 2009 the following works on the IBR-2 modernization were performed:

• Installation of the reactor vessel at its work site and of in-vessel components. Loading of dummy fuel assembly cartridges into the reactor core;

• Installation of the movable reflector MR-3 in the operative position;

• Replacement of a cold trap for purifying sodium coolant in loop «A» of the second reactor cooling circuit;

• Installation of stationary reflectors and water moderators on the trolleys of the rolling shields;

• Installation of executive mechanisms and control units of the reactor;

• Manufacturing and installation of an additional storage facility for the IBR-2 used fuel in the reactor hall;

• Installation of equipment of the cryogenic helium refrigerator KGU-700/15 and helium pipelines between the cryogenic refrigerator and the rolling shields.

Activities Still in Progress According to the Plan

• Installation and stage-by-stage adjustment of the operator console on the main control panel of the reactor;

• Installation and adjustment of communications and power electrical equipment of the reliable power supply system, of the power supply system of the standby control board and the heaters of the IBR-2M cooling circuits from the standby power supply system;

• Installation of equipment and switching lines of the technological parameters control system (TPCS) and the automatic safety and control system (ASCS-12R);

• Preparation to the filling of the reactor cooling circuits with a liquid sodium coolant;

• Manufacturing of a cryogenic moderator for beams 7–11 (CM 202);

• Installation of an experimental stand for testing transportation modes of mesitylene balls to the cryogenic moderator.

IREN Facility. In accordance with the decision of the JINR Directorate to realize the IREN project in several stages, the construction of the electron accelerator and the nonmultiplying neutron-producing target complex has been completed. Since the beginning of 2009 the carrying out of experimental investigations on the newly constructed source has been started.

NOVEL DEVELOPMENT AND CONSTRUCTION OF EQUIPMENT FOR IBR-2M SPECTROMETERS COMPLEX

Cryogenic Moderators. The conceptual design, development of technical documentation, manufacturing and mounting of the main parts of a full-scale stand of the technological system of the cryogenic moderator (CM) have been accomplished. The stand is a full-scale model of the future CM system with a copy of the CM camera, technological system and the system for delivery of mesitylene beads. The stand cooling system comprises two coolant loops connected by a heat exchanger. In the first coolant loop, helium is driven by a helium blower through the heat exchanger and the CM chamber. In the second coolant loop, helium is forced through the heat exchanger by a helium refrigerator (500 W, 15 K). As a result of simultaneous operation of the helium refrigerator and the helium blower in the CM chamber the required temperature is achieved and mesitylene beads are transported by the flow of gaseous helium from the charging device to the CM chamber.

In the FLNP Department of Spectrometers Complex, a special integrated control system for monitoring different parameters of the stand and the respective software complex have been developed. The system includes various sensors (15 pieces altogether), a gas blower motor drive controller and a controller of the step motor of the dispenser of balls into the system. The system makes it possible to control the main parameters of the moderator stand:

• transport of balls through a pneumatic conveying pipe (controlled by an original method based on gas-dynamic effects);

• filling of the moderator chamber with beads (monitored with a web-camera through quartz glasses);

• gas flow rate;

• pressure and temperature of helium.

At present, the manufacturing of the elements of the stand has been completed and the process of assembling and testing has started.

Test Beam. The technical project of construction of a test beam on channel 13 of IBR-2M has been developed, the assignments for development of the channel equipment units have been given to the Design Department. The design specification for a biological shield has been prepared as well.

Neutron Beam-Forming Systems. In cooperation with the German institutes and PNPI (Gatchina) within the framework of the project aimed at constructing curved mirror neutron guides for the EPSILON and SKAT spectrometers on beam 7p of the IBR-2 reactor, the work to design and manufacture mechanical and optical units of the neutron guides was continued. In particular, the designs of a vacuum system and a background shield of the EPSILON and SKAT spectrometers and of a docking part of the neutron guide of the NERA-PR spectrometer have been developed, the documentation has been worked out and the manufacturing of the disk background chopper and three drum λ-choppers is nearing completion.

The reconstruction of the supporting column of IBR-2 in bldg. 117 and a biological shield of the head part of beam 7 to accommodate three neutron guides on the channel has been completed. The equipment from the embedded pipe of the ring corridor wall has been dismantled. In NPO «Atom» the posts and beam-positioning support pillars of the neutron guide head part have been produced. In JSC «Komtrast» the manufacturing of 92 vacuum casings for the curved neutron guides for the EPSILON and SKAT spectrometers is in progress. At present, the assembly of the head part (splitter) of beam 7 and the adjustment of mechanical units of the choppers have started.

Cryogenic Stand. A test cryostat for work with closed cycle cryocoolers has been developed. The manufacturing of a control panel of the helium circulation system for additional refrigerators that can be placed in this cryostat is in progress. The cryogenic stand is used to test and adjust cryogenic systems. At present, the modernization of the cryostat for the inelastic neutron scattering spectrometer (beam 7b, IBR-2) is under way.

The cryostat shaft (70 mm in diameter) allows for fast cold sample change. The expected final temperature is 4.5 K.

Development of Control Systems of Choppers. At FLNP the control system of choppers based on the VFAS1-series variable-frequency electric drives from Toshiba has been developed, manufactured and debugged for the disk background chopper and three drum λ-choppers of the EPSILON, SKAT and NERA-PR spectrometers. The control system of choppers based on microcontrollers with CAN interface has been developed. As a result, control over each chopper is exerted by a computer of the respective spectrometer. The performed development work and tests have demonstrated the possibility of using variable-frequency VFAS1 drives and control systems to replace outdated EKT2 on the choppers of other IBR-2M spectrometers.

Calculations of Spectrometers. Calculations of neutron spectra and optimization of beam geometry from moderator to sample for the EPSILON–SKAT spectrometer (beam 7a) have been completed. This will allow the neutron flux at the sample position to be increased by 20–30%. Preliminary calculations for beam 10 (GRAINS) have been made as well. The simulation of the instrument and its elements has been performed and recommendations to increase the neutron flux have been given. Two new modules for the VITESS software package have been developed.

Detectors. The anode and cathode electrodes have been manufactured, the position-sensitive detector for the GRAINS spectrometer has been assembled and filled with a gas mixture. The tests of the detector and the measurement of its characteristics have been carried out on beam 5 of the IR-8 reactor in the RRC «Kurchatov Institute». A series of measurements with pin-hole and slit cadmium masks has been made at various values of anode voltage and different levels of discrimination of input signals. The PSD counting characteristics were measured with the pin-hole and slit exposure of the detector. Optimum operating modes of the detector were chosen and its main characteristics were measured. Also, the profiles of beam 5 of the IR-8 reactor and the IREN facility were obtained.

A new high-speed neutron counter with a peak load of up to $3 \cdot 10^6$ s^{-1} has been developed. The counter is a rectangular parallelepiped made of duraluminium of dimensions $250 \times 80 \times 40$ mm and with internal working volume $150 \times 30 \times 20$ mm. The anode is a multiwire frame coupled to the common electrode brought out through a vacuum connector outside. The pressure-optimized mixture of ^{3}He and CF_4 is used as a working gas. The DAQ electronics, PC interface and the software for the counter have been developed as well. The counter has been tested on the SuperADAM reflectometer (ILL, Grenoble, France).

The development of a new ring-shaped multisection MWPC-based detector for the DN-6 diffractometer has started. At the first stage it is proposed that one ring-shaped detector be constructed and installed at a scattering angle of $90°$. The advantages of the new ring-shaped gas multisection detector as compared to the previously used ring-shaped detector based on SNM-17 gas counters are: large size of the detector working volume will allow the count rate of scattered neutrons to be increased several times; shared working volume makes it possible to have practically the same efficiency for all sections; rectangular geometry of counting sections should improve the homogeneity of detection efficiency; smaller sizes of «dead zones» of the detector.

Electronics, Computing. The requirements specifications have been approved and the development of electronic blocks for acquisition and accumulation of raw data on the EPSILON, HRFD and DN-6 diffractometers has been started. These diffractometers will employ different detector systems, but the common feature, which all of them share, is that all these systems can be considered as a set of point detectors with fixed spatial geometry. This makes it possible to design identical (from the viewpoint of hardware) electronic blocks, in which all functions and parameters are realized on the level of microprograms, which are executed in FPGA of the respective block.

A new test programme has been developed and a high-speed DAQ block for 1D and 2D MWPC detectors with delay line readout has been tested. The test programme is a basis for creation of a standard interface to the Sonix + software package.

In 2009, new equipment of external communication channels for 10 Gbit/s operation was installed in the JINR local area network. This, in its turn, requires partial replacement of the existing switching equipment in the central and peripheral segments of the FLNP network. The analysis of possible changes in the network architecture and of characteristics of the equipment available in the market has been made with due regard for prospects of further evolution of the network. In view of limited financing it has been decided to purchase one intellectual multilevel router of WS-3560 series and a limited set of communication modules. The respective contract is in the realization stage. After this equipment is tested, it will be installed in one of the IBR-2M experimental halls.

A schedule for conducting maintenance work on the IBR-2 spectrometers according to which the modernization and repair of electronic equipment and the preparation of the spectrometers to the reactor startup will be carried out. This work is already in progress on four spectrometers.

Two scientific schools for advanced training of young scientists were organized at the Frank Laboratory of Neutron Physics in 2009: the II Advanced Courses of CIS Countries for young researchers, PhD students and graduate students on modern methods in investigations of nanosystems and materials «Synchrotron and Neutron Investigation of Nanosystems» (SYN-NANO-2009) (June 28 – July 13, 2009, Moscow–Dubna) and the all-Russian Neutron School for Young Scientists and Students «Modern Neutron Diffraction Studies: Interdisciplinary Research of Nanosystems and Materials» (October 12–20, 2009, Dubna). These schools continued the tradition of the FLNP schools for young scientists devoted to the fundamental and applied aspects of neutron research in the fields of condensed-matter physics, materials science and related topics.

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