2014

JOINT INSTITUTE FOR NUCLEAR RESEARCH

Joint Institute for Nuclear Research

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JINR MEMBER STATES

Republic of Armenia
Republic of Azerbaijan
Republic of Belarus
Republic of Bulgaria
Republic of Cuba
Czech Republic
Georgia
Republic of Kazakhstan
Democratic People's Republic of Korea
Republic of Moldova
Mongolia
Republic of Poland
Romania
Russian Federation
Slovak Republic
Ukraine
Republic of Uzbekistan
Socialist Republic of Vietnam

AGREEMENTS ON GOVERNMENTAL LEVEL ARE SIGNED WITH THE FOLLOWING STATES:

Arab Republic of Egypt
Federal Republic of Germany
Republic of Hungary
Italian Republic
Republic of Serbia
Republic of South Africa

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INTRODUCTION

The year 2014 became quite fruitful for the Joint Institute in a number of most important trends. The November session of the Committee of Plenipotentiaries of the Governments of JINR Member States highly appreciated the scientific significance and long-term benefits of the projects that involve our international community, as well as ambitious efforts to achieve bright scientific results and widen international scientific cooperation.

In 2014, the JINR flagship project to develop the superconducting collider of heavy ions NICA entered the intense implementation phase. Key elements of the complex cryogenic system are now in production, and a new injector has been manufactured. The production of superconducting magnets for the NICA project booster and the FAIR project synchrotron (Darmstadt) was started using the unique technology developed at JINR. The development of unique scientific equipment is conducted in close partnership with JINR Member States.

For the first time the Nuclotron operated in the mode of two parallel users. The circulation of the coasting (structureless) beam was provided at two consequent flat-tops (plateaus) of the magnetic field, for experiments at the internal target and in slow beam extraction.

The first operation of the new stand heavy ion source KRION-6T was performed at the Nuclotron accelerator complex. Optimization of the source and linac LU-20 regimes was provided for generation of ion species. Ar ions were accelerated and delivered to users for physics experiments.

The activities on the DRIBs complex, as well as on the development of the key element of this project — the Factory of Superheavy Elements, were also very successful. The project as a whole and its basic element, the new cyclotron DC-280, are implemented on the highest technological level that will provide in future the leading position of the Institute in heavy ion physics research.

In 2014, in experiments on the study of properties of superheavy elements near the island of stability, in the fission reaction of ^{48}Ca with target nuclei of ^{239}Pu and ^{240}Pu, new neutron-deficient isotopes ^{284}Fl and ^{285}Fl were first synthesized.

In 2014, within the framework of the User Programme, 150 received proposals were admitted from different countries for implementation in experiments in physics, materials science, chemistry, geology, biology and biophysics, and applied sciences. A neutron radiography and tomography station was constructed, where first results were obtained in the studies of internal structure of various objects: technological, engineering, paleontological, geophysical, and other ones.

In 2014, the modernization of the IREN facility and its building was continued. Successful testing of the new modulators of klystrons for this facility was conducted.

In theoretical physics the following results can be regarded significant: a new effect of decoupling the directed flux of charged pions, kaons, protons, and antiprotons was predicted in the asymmetric system Cu + Au at non-central collisions with the energy $\sqrt{s_{NN}} = 200$ GeV. It was shown that decoupling, as a function of the transverse momentum, characterizes the electromagnetic response of the early non-equilibrium phase of hadron matter that appears in relativistic collisions of heavy ions.

For the first time the quantum electrodynamics corrections at order $m_e\alpha^7$ for a three-body Coulomb system were obtained, which led to the record 10-fold improvement for the transition energies of the hydrogen molecular ion and the antiprotonic helium. It allowed one to achieve a fractional precision of $1.5 \cdot 10^{-11}$ in determination of the electron-to-proton mass ratio.

As part of the neutrino programme, actively developed at JINR, the first stage of the construction of the giga-ton deep underwater telescope BAIKAL-GVD was started in Lake Baikal. It will become a new research base of JINR to study the neutron flux from astrophysical objects.

The solar neutrino flux from the *pp* reaction was measured in real time at the Borexino detector with active participation of JINR physicists. The result is in good agreement with the Standard Solar Model, which confirms the phenomenon of neutrino oscillations.

The BES-III collaboration (IHEP CAS, China), which includes a JINR group, announced an interesting result — observation of charmonium-like resonances $Z_c(3900)$.

This experiment found new decay modes of the charged states $Z_c^{\pm}$ and a neutral particle $Z_c^0(4020)$ that is supposed to be an isospin partner of the charged state $Z_c^{\pm}(4025)$. The tau-lepton mass was measured, and its accuracy is almost as good as that of all previous measurements taken together.

In the field of information technologies, a new grid and cloud services simulation for NICA accelerator complex data storage and processing system was developed by JINR specialists.

The heterogeneous computing cluster HybriLIT was launched. Being an effective component of the Multifunctional Centre for Storage, Processing and Analysis of Data, it is much in demand for the solution of resource-intensive tasks that arise in research at JINR.

In the framework of a new trend developed at JINR — astrobiology, which attracts the scientific world's attention, research was continued on the synthesis of chemical compounds from formamide under exposure to radiations with different linear energy transfer. Synthesis reactions occurred under irradiation with accelerated protons and ^{11}B and ^{12}C ions in the presence of catalysts obtained from meteorites of different classes. Examples of all molecule classes necessary for the origination of life on Earth were produced: carboxylic acids, amino acids, sugars, nucleic bases, nucleosides, and other complex compounds. These studies bring closer the solution to the problem of the origin of life. The experiments were conducted in collaboration with Italian scientific groups.

In cooperation with specialists of the Universities of Naples and Udine (Italy), JINR radiobiologists completed the initial stage of research on the radioprotective properties of a new radioprotector synthesized in the University of Naples. In animals irradiated with 170-MeV protons the radioprotector was introduced that showed its effective protective influence on the animals' organisms.

In 2014, 422 students and postgraduate students of the basic chairs of MSU, MIPT, MIREA, "Dubna" University, and universities of JINR Member States were trained at the University Centre (UC). JINR postgraduate courses were attended by 37 people. In 2014, the Summer Student Practice in JINR Fields of Research was held in three stages for 140 people.

One of the first-priority and very important tasks for the Institute and its Member States is education of high-skilled engineers. Two new structures were organized at the JINR UC: a scientific and engineering team, and a department of educational programme development.

In 2014, the leaders of the Institute paid much attention to the development of contacts both with JINR Member States and with the countries that display their interest in cooperation with JINR. Representative delegations of China, India, Argentina, Japan, and France visited JINR in 2014. Memoranda on cooperation and contracts were signed; the exchange of scientists and specialists became more active. In December, Dubna hosted a large scientific forum on issues of participation of Chinese organizations in Russian mega-science projects and Russia's involvement in similar projects in China. The forum was attended by representatives of the RF Ministry of Science and Education, the Chinese Ministry of Science and Technology, scientific centres of Russia, China, Germany, Poland, Italy, and Egypt.

In 2014, CERN and JINR took important decisions on mutual granting of the Observer status: for JINR in the CERN Council and for CERN in the Committee of Plenipotentiaries of the Governments of the JINR Member States. JINR has also obtained an opportunity to have its representative in the Expert Committee of the Nuclear Physics European Collaboration Committee (NuPECC).

It is gratifying to note that Russia, as a member state and simultaneously the state of JINR location, acts as the guarantor of the sustainable development of JINR, despite a very complicated economic situation. This firm attitude of the government of Russia is a good example for other JINR Member States.

One of good events of the year was the victory of the staff member of JINR's Laboratory of Theoretical Physics A. Bednyakov in the contest for the right to get the RF President grant with the state support of young scientists and candidates of science, in the field "Physics and Astronomy". The leading scientific school of Academician D. Shirkov obtained the right to conclude a state contract for the RF President grant to support leading scientific schools in the field "Physics and Astronomy".

Regretfully, among sad bereavements, the scientific community of JINR had a grievous loss in 2014. On 24 September Vladimir Kadyshevsky, an outstanding Russian scientist, a theoretical physicist, RAS Academician, Scientific Leader of JINR and JINR Director in 1992–2005, passed away. In the memory of his colleagues he will remain a true scientist and a very compassionate friend.

The fifth year of the Seven-Year Plan of the Development of JINR was completed. Looking back, we see how much we have done and clearly understand the tasks in store. To achieve them, we need not only strong qualifications, but also the skill to concentrate on major goals in science, education and innovation, as well as in improvement of scientific and social infrastructure that is indispensable for further progress.

Only one year is left until the 60th birthday of "our home on the Volga", as our colleagues from Member States who have worked in Dubna for many years often call the Institute. We start preparations for this jubilee and realize that the significant anniversary of the establishment of JINR should ensure its prestige in the world scientific community and greater consolidation of all generations of staff members to achieve our mutual goals. We look forward to new achievements and are aware of the pre-requisites to accomplish all we plan.

V. Matveev
Director
Joint Institute for Nuclear Research

2014

GOVERNING AND ADVISORY BODIES OF JINR

ACTIVITIES OF JINR GOVERNING AND ADVISORY BODIES

SESSIONS OF THE JINR COMMITTEE OF PLENIPOTENTIARIES

A regular spring session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held on 25–26 March. It was chaired by the representative of the Russian Federation, L. Ogorodova.

The Committee of Plenipotentiaries (CP) considered the report "Recommendations of the 115th session of the JINR Scientific Council (February 2014). Results of JINR activities in 2013" presented by JINR Director V. Matveev. The CP took note of the recommendations of the 115th session of the JINR Scientific Council as well as of the information presented by the JINR Directorate on the implementation of the JINR Plan for Research and International Cooperation in 2013 and on the plans for JINR activities in 2014. The Committee supported the initiative of the JINR Directorate, endorsed by the Scientific Council, to consolidate the programme of neutrino physics and astroparticle physics. It commissioned the JINR Directorate to present to the Scientific Council and the Committee of Plenipotentiaries a long-term plan for implementing this programme with regard to the external and extrabudgetary sources of funding.

The CP welcomed the contacts being developed between JINR and European bodies such as ESFRI and its Strategy Working Group on Physical Science and Engineering. It supported the initiative of the Scientific Council to approach the CERN Council with a suggestion for a reciprocal arrangement to establish observership of JINR at CERN and of CERN at JINR. This would further promote and intensify the cooperation between these two international organizations.

The CP supported the activities to develop educational facilities based on the existing equipment at JINR, recommending for this purpose the establishment of a scientific and engineering unit housed by the University Centre. This would create additional conditions for implementing advanced educational programmes to train scientific and technical personnel for research centres of the Member States and JINR.

Based on the report "Execution of the JINR budget in 2013" presented by S. Dotsenko, Chief Accountant of JINR, the CP took note of the information presented. It resolved to hold a meeting of the Working Group concerning the principles for a new methodology for calculating the Member States' contributions to the JINR budget, until November 2014 and with the participation of the Chairman of the Finance Committee.

The CP deferred a decision concerning the Member States' arrears, which occurred in 2002–2003, until the adoption of a new methodology for calculating contributions in 2015, due to the risk of further excessive financial load on a number of states in arrears.

In accordance with the JINR Charter, the CP suspended receiving new specialists at JINR, being sent to work by the Plenipotentiary of the Democratic People's Republic of Korea and by the Plenipotentiary of the Republic of Uzbekistan, due to the multiannual financial arrears of these Member States in contributing to the JINR budget.

With a view to a better consistency in preparation for the next fiscal year, the CP recommended that the Plenipotentiaries of the Governments of the Member States conclude agreements with the JINR Directorate for the next fiscal year not later than November of the preceding year.

Regarding the report "Results of the meeting of the JINR Finance Committee held on 21–22 March 2014" presented by S. Kulhánek, Chairman of the Finance Committee, the CP approved the Protocol of this meeting and JINR's report on the execution of the budget for the year 2013 in expenditure amounting to US$127 011.7 thousand and in income amounting to US$139 948.2 thousand.

The CP approved the proposed text of the "Regulation for the Internal Audit of JINR", taking into account the recommendations received from the Working Group, the Finance Committee and the Committee of Plenipotentiaries, and authorized the JINR Director to approve the "Regulation for the Procurement Activities of JINR" and to make the necessary arrangements for bringing this Regulation into force. The Committee commissioned the JINR Directorate to continue effort towards improving the documents which regulate the financial activities of JINR and to submit them at the meeting of the Finance Committee in November 2014.

As proposed by Director V. Matveev and based on the results of voting, the CP appointed G. Trubnikov as Vice-Director of JINR for the term of office of the JINR Director, until 31 December 2016.

The CP took note of the information on the dissolution of the investment agreement between JINR and the OJSC "RUSNANO", which was concluded on 20 September 2010, concerning the implementation of the project "Expansion of production of multi-purpose detectors for identification of a wide range of substances based on tagged neutron technology". It also endorsed the withdrawal of JINR from the LLC "Neutron Technologies" and recommended that the JINR Directorate negotiate the possibility for the Institute to return its share in immovable property, which was contributed to the authorized capital of the company at its establishment.

Regarding the report "Scientific infrastructure of JINR in the field of research with heavy-ion beams: Status and prospects" presented by JINR Vice-Director G. Trubnikov, the CP endorsed the proposed long-term strategic programme of research with heavy-ion beams at JINR. It also recognized the progress in implementing the NICA and DRIBs-III projects. The Committee supported the Directorate in its adherence to the approved schedules for the implementation of the projects and to the priorities based on the recommendations of the Programme Advisory Committees and the Scientific Council, as well as in its compliance with the resource allocation format over the research fields presented.

The CP also heard a report "Neutron physics and astrophysics at JINR" presented by V. Bednyakov, Director of the Dzhelepov Laboratory of Nuclear Problems, and information on JINR's participation in the UN Convention on Long-Range Transboundary Air Pollution presented by M. Frontasyeva, Head of an FLNP Sector.

A regular autumn session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held on 21–22 November. It was chaired by the Plenipotentiary of the Government of the Republic of Bulgaria, L. Kostov.

The Committee of Plenipotentiaries expressed condolences to the JINR staff over the loss of Professor V. Kadyshevsky, the Scientific Leader of JINR and its Director during 1992–2005, who made an outstanding contribution to the successful operation and development of JINR based on broad international cooperation.

The CP considered the report "Recommendations of the 116th session of the JINR Scientific Council (September 2014). Brief overview of the results of JINR activities in 2014 and plans for 2015" presented by JINR Director V. Matveev. The CP approved the recommendations of the 115th and 116th sessions of the Scientific Council as well as the JINR Topical Plan of Research and International Cooperation for 2015.

The Committee recognized the achievements of the JINR international staff in implementing the plans for research and international cooperation endorsed by the Scientific Council and in meeting the goals of the Seven-Year Plan for the Development of JINR. These include a number of important results produced in 2014 in world-class fundamental physics research, in particular: the contribution to the experimental measurements, with record precision in the Borexino international project (LNGS, INFN), of the solar *pp*-neutrino flux, confirming the predictions of the Standard Solar Model and the phenomenon of neutrino oscillation; the synthesis of the neutron-deficient isotopes ^{284}Fl and ^{285}Fl in the fusion of ^{48}Ca with the target nuclei ^{239}Pu and ^{240}Pu, accomplished for the first time; the successful implementation of the technology of ion-beam stochastic cooling at the Nuclotron-M; the construction and launching of a facility for manufacturing and testing superconducting magnets for the NICA booster and for the FAIR synchrotron (Darmstadt, Germany); the new results achieved in condensed matter studies using neutron scattering methods; the development of novel nuclear-physics approaches to astrobiology problems and issues of the origin of life on Earth.

The CP supported the Directorate's efforts to establish strong scientific links with Chinese, Indian, Latin American, and other scientific organizations and research centres which express their intention to join the Institute's research programmes.

The CP expressed appreciation to the CERN Council for its decision to grant JINR the status of Observer in this largest international organization and for its readiness to accept the status of Observer at JINR.

The CP noted the effective results of the newly established internal audit service at JINR, which has made it possible to develop ways to improve the executive discipline and economic performance in the audited subdivisions; endorsed the actions taken by the JINR Directorate towards introduction of modern methods and tools for procurement, recommending further improving the documents regulating JINR's financial activities; and welcomed the plans of the JINR Directorate to develop a programme to improve the structure of JINR and its management system.

The Committee endorsed the efforts undertaken by the JINR University Centre (UC) to establish a scientific and engineering team at the UC with a view to developing educational and practical programmes for training

scientific and technical personnel for JINR laboratories and research centres in Member States.

The CP commissioned the JINR Directorate to prepare a Plan of Activities for the 60th anniversary of the founding of JINR to be celebrated in the Member States and in the countries with which the Institute has agreements on international scientific and technological cooperation.

The CP supported the request of the VBLHEP Directorate, endorsed by the participants of the international symposium "The 70th Anniversary of the Discovery of Phase-Stability Principle" (Dubna, 10–15 November 2014), to name the square in front of Building 3 on the site of this Laboratory after V. Veksler.

The Committee congratulated Professor L. Kostov on the award by the Scientific Council of the title "Honorary Doctor of JINR", in recognition of his outstanding contribution to the development of science and the education of young scientists.

Based on the report "Draft budget of JINR for the year 2015, draft contributions of the Member States for the years 2016, 2017, and 2018" presented by S. Dotsenko, Chief Accountant of JINR, the Committee approved the JINR budget for the year 2015 with the total expenditure amounting to US$180.86 million as well as the contributions of the Member States for the year 2015. The Committee determined the provisional volume of the JINR budget in income and expenditure for 2016 amounting to US$207.53 million, for 2017 — US$212.58 million, and for 2018 — US$217.82 million. It also adopted the provisional sums of the Member States' contributions and of arrears payments for 2016, 2017, and 2018.

The Committee allowed the JINR Directorate to index the salary and tariff parts of the compensation package of the staff members, taking into account the possibilities afforded by the JINR budget in 2015, in accordance with the JINR Collective Bargaining Agreement for 2014–2017.

The CP endorsed the proposal of the Republic of Belarus for JINR to address the governments of the Member States which are members of the Customs Union of the Republic of Belarus, the Republic of Kazakhstan and of the Russian Federation, and the authorities of the Customs Union directly with a request to include JINR in the list of organizations for which a preferential VAT rate is applied.

Based on the report "Results of the audit of the JINR financial and economic activities for the year 2013" presented by A. Sedyshev, Director of the company "MS-Audit", and the recommendations of the Finance Committee, the CP approved the auditors' report for 2013.

Regarding the report "Results of the meeting of the JINR Finance Committee held on 18–19 November 2014" presented by S. Kulhánek, Chairman of the Finance Committee, the CP approved the Protocol of this meeting and JINR's report on the execution of the budget for the year 2013 in expenditure amounting to US$127 011.7 thousand, with the summary account as of 01.01.2014 being US$665 022.0 thousand.

The CP set up a Working Group under the CP Chairman for financial issues, composed of representatives of the Republic of Belarus, the Republic of Bulgaria, the Czech Republic, Georgia, the Republic of Kazakhstan, the Republic of Poland, and the Russian Federation.

As recommended by the Finance Committee, the CP took the principles of the new methodology as a basis for calculating the scale of the Member States' contributions to the JINR budget. It commissioned the JINR Directorate and the Working Group to prepare the final version of this methodology for approval by the CP in March 2015.

Based on the information concerning by-election to membership of the JINR Scientific Council presented by JINR Chief Scientific Secretary N. Russakovich, the CP accepted the resignation from membership of Professor G. Piragino (University of Turin, Italy) and thanked him for his successful work as member of the Scientific Council. It elected Professor A. Maggiora (INFN, Turin, Italy) as a new member of the Scientific Council.

Regarding the information "Prospects for the development of JINR's relationships with CERN and with the European Union's science policy bodies" presented by N. Russakovich, the CP took note of the information about the decision taken by the CERN Council to grant JINR the status of Observer. The CP granted the European Organization for Nuclear Research the status of Observer at the Committee of Plenipotentiaries of the Governments of the JINR Member States and invited a representative of CERN to attend the next CP session in March 2015 and the subsequent sessions.

The CP welcomed the decision of NuPECC, an Expert Committee of the European Science Foundation, to include a representative of JINR in this committee, emphasizing that JINR's participation in NuPECC activities will undoubtedly contribute to the integration of the JINR basic facilities into the pan-European research infrastructure.

The CP addressed the Plenipotentiaries of the JINR Member States which are members of the European Union with a request to organize, through representatives of their countries in the European Strategy Forum on Research Infrastructures (ESFRI), the submission and support of the inclusion of the NICA project in the renewed European Roadmap for Research Infrastructures.

Regarding the information "Prospects for the involvement of new countries to JINR" presented by D. Kamanin, Deputy Head of the JINR Science Organization and International Cooperation Office, the CP supported the Directorate's efforts to attract Brazil, China, France, India as well as Tajikistan to take part in JINR based on agreements with their governments.

The CP heard the report "Prospects for the realization of the JINR Neutrino Programme" presented by V. Bednyakov, Director of DLNP, and the information regarding the European Union's project in Romania "Extreme Light Infrastructure — Nuclear Physics" presented by N.-V. Zamfir, Plenipotentiary of the Government of Romania, and thanked the speakers for their interesting and informative presentations.

SESSIONS OF THE JINR SCIENTIFIC COUNCIL

The 115th session of the JINR Scientific Council took place on 20–21 February. It was chaired by JINR Vice-Director R. Lednický and Professor M. Waligórski of the H. Niewodniczański Institute of Nuclear Physics and Oncology Centre (Kraków, Poland).

JINR Chief Scientific Secretary N. Russakovich informed the Scientific Council about the decisions of the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States (November 2013), about the major results achieved by JINR in 2013, and about the activities planned for 2014.

In their reports, Vice-Director M. Itkis outlined the prospects for research in the field of heavy-ion physics and VBLHEP Director V. Kekelidze presented the prospects for dense baryonic matter research at Nuclotron–NICA: BM@N and MPD projects. FLNP Director V. Shvetsov spoke about the current state of the detector systems for nuclear physics with neutrons at FLNP.

The Scientific Council heard the following invited reports: "Unsolved problems of neutrino physics and astrophysics and the potential of the experiment on Baikal" presented by V. Rubakov and "From one-carbon atom compounds to spontaneous generation of RNA. Which source of energy?" presented by E. Di Mauro.

The recommendations of the Programme Advisory Committees were reported by I. Tserruya (PAC for Particle Physics), W. Greiner (PAC for Nuclear Physics), and P. Alekseev (PAC for Condensed Matter Physics).

The appointments of Deputy Directors of DLNP and FLNP were endorsed at the session. Proposals for the award of the title "Honorary Doctor of JINR" were presented by the Directorate. The B. Pontecorvo Prize and diplomas to the winners of JINR prizes for the year 2013 were awarded.

The Scientific Council heard the best reports by young scientists which had been recommended by the PACs.

Resolution. General Considerations. The Scientific Council took note of the information about the decisions of the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States (November 2013) presented by Chief Scientific Secretary N. Russakovich. It was pleased to note the substantial progress in implementing the Seven-Year Plan for the Development of JINR (2010–2016), which concerns, in particular, the preparatory work at the NICA site, the civil engineering for the building of the Factory of Superheavy Elements, and the commissioning of new advanced spectrometers at the IBR-2 facility. The Scientific Council concurred with the request of the Committee of Plenipotentiaries addressed to the JINR Directorate to start work on long-term planning for JINR until the year 2020.

The Scientific Council welcomed the initiative of the JINR Directorate, supported by the PAC for Particle Physics and the PAC for Nuclear Physics, to evaluate and consolidate the programme of neutrino and astroparticle physics at JINR (especially in view of the two in-house flagship large projects — the Baikal neutrino observatory and the Kalinin nuclear reactor neutrino experiments), and recommended inviting leading world experts to take part in this evaluation process.

The Scientific Council highly appreciated the excellent collaboration between the FAIR project and the corresponding NICA project in the field of relativistic heavy-ion collisions.

The Scientific Council noted with satisfaction the contacts being developed between JINR and European bodies such as ESFRI and its Strategy Working Group on Physical Science and Engineering in which JINR has received observer status. Being convinced that observership of JINR at CERN and of CERN at JINR would further promote and intensify the cooperation between these two international organizations, the Scientific Council recommended that the JINR Directorate approach the CERN Council with a suggestion for such a reciprocal arrangement.

Recommendations on Reported Activities. The Scientific Council took note of the report "Prospects for research in the field of heavy-ion physics" presented by Vice-Director M. Itkis. It strongly supported the plans for the realization of the DRIBs-III project, including the construction of the Factory of Superheavy Elements and new experimental set-ups, and for the proposed research programme to study superheavy elements and light exotic nuclei. Expecting that the time scale of the DRIBs-III project would be respected, the Scientific Council recommended that the JINR Directorate and the Committee of Plenipotentiaries take the necessary steps to achieve this important project.

The Scientific Council took note of the report "Prospects for dense baryonic matter research at Nuclo-

tron–NICA: BM@N and MPD projects" presented by VBLHEP Director V. Kekelidze. It highly appreciated the progress in preparing the research programme in this field and in developing the experimental instruments, and emphasized the priority for implementing these projects.

The Scientific Council took note of the report "Current state of the detector systems for nuclear physics with neutrons at FLNP" presented by FLNP Director V. Shvetsov. It recognized the significance of the scientific results produced in the field of nuclear physics with neutrons and recommended further development of advanced instrumentation in order to maintain the positions achieved.

Recommendations in Connection with the PACs. The Scientific Council concurred with the recommendations made by the PACs at their January 2014 meetings as was reported at this session by Professors I. Tserruya, W. Greiner, and P. Alekseev.

Particle Physics Issues. The Scientific Council noted the PAC's comments concerning the reports presented by the Directors of VBLHEP, DLNP, and LIT. Particularly:

— The Scientific Council recognized the high quality of the scientific research being performed by VBLHEP groups and supported the efforts of the VBLHEP management for enhanced involvement of the staff in the research programme of the Nuclotron–NICA accelerator complex, while maintaining a balanced but visible participation in external experiments.

— The Scientific Council recognized the importance of the neutrino physics and astrophysics research programmes carried out at DLNP. It requested the JINR Directorate to consider having all neutrino physics–related proposals discussed in a single PAC or alternatively having regular joint meetings of the PAC for Particle Physics and the PAC for Nuclear Physics to assess the priorities for the JINR neutrino physics programme. This recommendation holds in particular to take a decision about the participation in the new projects NOvA and COMET proposed by the PAC for Particle Physics and by the PAC for Nuclear Physics, respectively.

— The Scientific Council supported the efforts of the LIT management in the concentration of human and material resources to best meet the fundamental interests of JINR and its Member States. For the computational services provided by LIT personnel to other JINR groups, the LIT Directorate was requested to clarify its strategy on how to distribute its resources, which research areas to enter, and eventually how to make the clients participate in covering the costs for this support.

The Scientific Council appreciated further improvements achieved in the Nuclotron operation as demonstrated in Run 48, welcoming the beginning of site preparation for the NICA building construction work. It noted with satisfaction that the Nuclotron–NICA Machine Advisory Committee was pleased with the progress achieved by the Nuclotron–NICA team and by the proposed solutions to address the multiple challenges ahead.

The Scientific Council noted the progress concerning the BM@N project. It requested a report from the BM@N team with its detailed staging and a detailed concept of the tracking system suitable for Au beams. It also urged the BM@N team and the Laboratory management to establish the DAC for BM@N and to increase significantly the JINR manpower involved in BM@N.

The Scientific Council appreciated the progress in constructing, manufacturing, and testing prototypes for the MPD detector systems achieved in 2013, as well as progress in the preparation of the MPD technical project. It urged the MPD and NICA managements to focus their efforts on completing contracts for the two critical items — manufacturing of the magnet and construction of the collider. It also encouraged continuation of the efforts in shaping the NICA scientific programme, focusing on quantitative assessment of the proposed measurements in close cooperation with the MPD, BM@N, and CBM@FAIR teams. The Scientific Council thanked the members of the MPD Detector Advisory Committee for their review of the project realization and recommended continuation of this activity.

Nuclear Physics Issues. The Scientific Council was pleased with the continuation of the experiments with extracted beams and in the IREN target hall. Neutron spectra from the gallium production target have been experimentally measured. Work on the detailed technical project of the accelerating structure of IREN and an implementation of nonmultiplying neutron-producing target made from natural uranium are in progress. These activities have not been finalized yet, the next milestone to be prepared for the next meeting of the PAC in June 2014.

The Scientific Council appreciated the FLNR group's work on the DRIBs-III project, noting with satisfaction that the implementation of this project and the work related to the development of the DC-280 cyclotron, construction of new and upgrade of existing physics instruments (ACCULINNA-2 and VASSILISSA–GABRIELLA separators, Gals, and others) generally proceeded according to the Seven-Year Plan for the Development of JINR. In order to bring the implementation of the theme "Accelerator Complex of Ion Beams of Stable and Radioactive Nuclides (DRIBs-III)" into accordance with the Seven-Year Plan, the Scientific Council recommended extending this theme for two more years with first priority. At the same time the Scientific Council acknowledged that the construction of a new FLNR experimental hall was falling behind schedule and recommended that the JINR and FLNR Directorates take the necessary steps to meet the deadlines for commissioning

GOVERNING AND ADVISORY BODIES OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

COMMITTEE OF PLENIPOTENTIARIES OF THE GOVERNMENTS OF THE JINR MEMBER STATES

Republic of Armenia	– S. Harutyunyan
Republic of Azerbaijan	– N. Mamedov
Republic of Belarus	– A. Shumilin
Republic of Bulgaria	– L. Kostov
Republic of Cuba	– F. C. Diaz-Balart
Czech Republic	– J. Dobeš
Georgia	– A. Khvedelidze
Republic of Kazakhstan	– K. Kadyrzhanov
D. P. Republic of Korea	– Li Je Sen
Republic of Moldova	– I. Tighineanu
Mongolia	– S. Davaa
Republic of Poland	– M. Waligórski
Romania	– N.-V. Zamfir
Russian Federation	– D. Livanov
Slovak Republic	– S. Dubnička
Ukraine	– B. Grynyov
Republic of Uzbekistan	– Not appointed
Socialist Republic of Vietnam	– Le Hong Khiem

Finance Committee

One representative of each JINR Member State

SCIENTIFIC COUNCIL

Chairman: V. Matveev
Co-Chairman: M. Waligórski (Republic of Poland)
Scientific Secretary: N. Russakovich

O. Abdinov	– Azerbaijan
T. Baatar	– Mongolia
C. Borcea	– Romania
M. Budzyński	– Poland
L. Cifarelli	– Italy
A. Dubničková	– Slovakia
M. Eliashvili	– Georgia
P. Fré	– Italy
S. Galès	– France
N. Giokaris	– Greece
B. Grynyov	– Ukraine
A. Harrison	– UK
M. Hnatič	– Slovakia
P. Jenni	– Switzerland
M. Jeżabek	– Poland
V. Kadyshevsky	– Russia
E. Kenzhin	– Kazakhstan
G. Khuukhenkhuu	– Mongolia
S. Kilin	– Belarus
Kim Son Hyok	– Democratic People's Republic of Korea
M. Kovalchuk	– Russia
G. Kulipanov	– Russia
V. Matveev	– Russia
J. Mnich	– Germany
D. Nagy	– Hungary
Nguyen Manh Shat	– Vietnam
I. Padrón Diaz	– Cuba
G. Piragino	– Italy
G. Poghosyan	– Armenia
S. Pospišil	– Czech Republic
I. Povar	– Moldova
E. Rabinovici	– Israel
V. Rubakov	– Russia
K. Rusek	– Poland
B. Sharkov	– Russia
N. Shumeiko	– Belarus
A. Skrinsky	– Russia
P. Spillantini	– Italy
M. Spiro	– France
H. Stöcker	– Germany
Ch. Stoyanov	– Bulgaria
Gh. Stratan	– Romania
V. Strazhev	– Belarus
N. Tonchev	– Bulgaria
Tran Duc Thiep	– Vietnam
M. Waligórski	– Poland
I. Wilhelm	– Czech Republic
A. Zagorodny	– Ukraine
G. Zinovjev	– Ukraine

Programme Advisory Committee for Particle Physics

Chairperson: I. Tserruya (Israel)
Scientific Secretary: A. Cheplakov

Programme Advisory Committee for Nuclear Physics

Chairperson: W. Greiner (Germany)
Scientific Secretary: N. Skobelev

Programme Advisory Committee for Condensed Matter Physics

Chairperson: V. Kantser (Moldova)
Scientific Secretary: O. Belov

INTERNAL ORGANIZATION OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

DIRECTORATE

Director V. Matveev
Vice-Director M. Itkis
Vice-Director R. Lednický
Vice-Director G. Trubnikov
Chief Scientific Secretary N. Russakovich
Chief Engineer G. Shirkov

Bogoliubov Laboratory of Theoretical Physics

Director V. Voronov

Research in
– symmetry properties of elementary particles
– field theory structures
– interactions of elementary particles
– theory of atomic nuclei
– theory of condensed matter

Frank Laboratory of Neutron Physics

Director V. Shvetsov

Research in
– nuclei by neutron spectroscopy methods
– fundamental properties of neutrons
– atomic structure and dynamics of solids and liquids
– high-temperature superconductivity
– reactions on light nuclei
– materials by neutron scattering, neutron activation analysis and neutron radiography methods
– dynamic characteristics of the pulsed reactor IBR-2

Veksler and Baldin Laboratory of High Energy Physics

Director V. Kekelidze

Research in
– structure of nucleons
– strong interactions of particles
– resonance phenomena in particle interactions
– electromagnetic interactions
– relativistic nuclear physics
– particle acceleration techniques
– interactions of multicharged ions in a wide energy range

Laboratory of Information Technologies

Director V. Korenkov

Research in
– provision of operation and development of the JINR computing and networking infrastructure
– optimal usage of international computer networks and information systems
– modern methods of computer physics, development of standard software

Dzhelepov Laboratory of Nuclear Problems

Director V. Bednyakov

Research in
– strong, weak and electromagnetic interactions of particles, particle structure
– nuclear structure
– nuclear spectroscopy
– mesoatomic and mesomolecular processes
– particle acceleration techniques
– radiobiology

Laboratory of Radiation Biology

Director E. Krasavin

Research in
– radiation genetics and radiobiology
– photo radiobiology and molecular biophysics systems
– radiation protection physics

Flerov Laboratory of Nuclear Reactions

Director S. Dmitriev

Research in
– properties of heavy elements, fusion and fission of complex nuclei, cluster radioactivity, reactions on an isomer hafnium target
– reactions with beams of radioactive nuclei, structure of neutron-rich light nuclei, nonequilibrium processes
– interactions of heavy ions with condensed matter
– particle acceleration techniques

University Centre

Director S. Pakuliak

Directions of activities:
– senior students' education
– JINR postgraduate courses
– school students' education
– staff training and retraining
– organization of schools and practice courses in JINR research trends

Central Services

– central scientific and information departments
– administrative and economic units
– manufacturing units

the Factory of Superheavy Elements, which is a key project of the Seven-Year Plan for the Development of JINR.

The Scientific Council supported the approval of the new project "Design and development of the tagged neutron method for elemental analysis and nuclear reaction studies" (project TANGRA) aimed at developing the tagged neutron method, which is already successfully used in applied research for detection of hazardous substances.

Condensed Matter Physics Issues. The Scientific Council highly appreciated the stable operation of the IBR-2 facility, which is providing experiments with extracted neutron beams, and emphasized the importance of implementing the programme of regular physics experiments in accordance with the user policy and the relevance of disseminating the obtained results in order to highlight the capabilities of the updated facilities. Noting the successful operation of the FLNP User Programme at the spectrometer complex of the IBR-2 facility and the increased number of high-quality experiments performed, the Scientific Council concurred with the PAC that the implementation of this programme should remain one of the major activities of FLNP in 2014.

The Scientific Council noted the progress in upgrading the FLNP instrumentation. In particular, it appreciated the commissioning and first experiments carried out with the GRAINS reflectometer, and welcomed the intention to include it in the User Programme. The Scientific Council also noted the efforts being taken to modernize the YuMO spectrometer and the increasing number of proposals on investigations based on small-angle neutron scattering.

The Scientific Council welcomed the increased number of high-quality results produced in the various fields of applied research and presented as scientific reports at the PAC meeting.

Reports by Young Scientists. The Scientific Council appreciated the following reports by young scientists, which were selected by the PACs for presentation at this session: "Study of the magnetic structure of $HoCo_2$ and $ErCo_2$ compounds at high pressures", "Study of hyperon and antihyperon production in deep inelastic muon scattering", "Study of the processes of fusion-fission and of evaporation residue formation within the knowledge base on low-energy nuclear physics", and thanked the speakers: A. Rutkauskas, N. Rossiyskaya, and A. Karpov.

Memberships of the PACs. The Scientific Council deeply regretted the loss of Professor N. Janeva, a prominent Bulgarian expert in the fields of nuclear physics with neutrons and nuclear waste transmutation. It highly appreciated her great contributions to the PAC for Nuclear Physics as a member since 1994 and Chairperson during 2006–2007.

The Scientific Council also deeply regretted the loss of Professor V. Petrov, a prominent Russian expert in the fields of space research, radiation safety, and radiobiology. It highly appreciated his great contributions to the PAC for Condensed Matter Physics as a member since 2005.

As proposed by the JINR Directorate, the Scientific Council appointed for a term of three years:

— Professors P. Hristov (CERN, Geneva, Switzerland) and J. Pluta (Warsaw University of Technology, Poland) as new members of the PAC for Particle Physics;

— Professors L. Avramov (Institute of Electronics, Sofia, Bulgaria), L. Dubrovinsky (Bayerisches Geoinstitut, Bayreuth, Germany), and R. Saladino (Tuscia University, Viterbo, Italy) as new members of the PAC for Condensed Matter Physics;

— Professor Guinyun Kim (Kyungpook National University, Daegu, South Korea) as a new member of the PAC for Nuclear Physics.

The Scientific Council thanked the outgoing members Professors J. Dobeš and A. Steuwer for their successful work as members of the PAC for Nuclear Physics and the PAC for Condensed Matter Physics, respectively.

Scientific Reports. The Scientific Council highly appreciated the scientific reports: "Unsolved problems of neutrino physics and astrophysics, and the potential of the experiment on Baikal" presented by Professor V. Rubakov, "From one-carbon atom compounds to spontaneous generation of RNA. Which source of energy?" presented by Professor E. Di Mauro, and thanked the speakers for their excellent presentations.

Awards and Prizes. The Scientific Council endorsed the proposal of the JINR Directorate to award the title "Honorary Doctor of JINR" to Professors S. Enkhbat (Mongolia), L. Kostov (Bulgaria), and R. Maier (Germany), in recognition of their outstanding contributions to the advancement of science and the education of young scientists.

The Scientific Council approved the Jury's recommendations on the JINR prizes for 2013 in the annual scientific research competition in the fields of theoretical physics, experimental physics, physics instruments and methods, and applied physics.

The Scientific Council congratulated Professor L. Maiani (Sapienza University of Rome, Italy) on the award of the 2013 B. Pontecorvo Prize for his outstanding contributions to elementary particle physics, in particular, to weak interaction physics and neutrino physics. The Scientific Council thanked Professor L. Maiani for his inspired presentation.

Appointment of Deputy Directors of JINR Laboratories. The Scientific Council endorsed the appointment of V. Glagolev and D. Naumov as Deputy Directors of the Dzhelepov Laboratory of Neutron Physics,

and N. Kučerka as Deputy Director of the Frank Laboratory of Neutron Physics, until the completion of the terms of office of the directors of their respective laboratories.

The 116th session of the JINR Scientific Council took place on 25–26 September. It was chaired by JINR Director V. Matveev and Professor M. Waligórski of the H. Niewodniczański Institute of Nuclear Physics and Oncology Centre (Kraków, Poland).

The Scientific Council paid tribute to Professor Vladimir Kadyshevsky, an outstanding theoretical physicist and the Scientific Leader of JINR. As Director of JINR during 1992–2005, he made a great contribution to the successful operation and development of the Joint Institute for Nuclear Research based on broad international cooperation. V. Kadyshevsky was a true advocate of fundamental science, strongly believing in the role of science in bringing nations together. It was thanks to his efforts that this Scientific Council of JINR became truly international, composed not only of representatives of the JINR Member States but also of scientists from leading research centres of other countries collaborating with JINR. His extraordinary dedication to science, amiable and kind attitude to people will be sorely missed.

V. Matveev informed the Scientific Council about the progress in implementing the recommendations of its 115th session and of the decisions of the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States (March 2014).

The Scientific Council heard reports: "Progress of research in the field of neutrino physics and astrophysics" presented by DLNP Director V. Bednyakov, "Progress of construction of a Factory of Superheavy Elements" presented by FLNR Director S. Dmitriev, "User policy of the Laboratory of Information Technologies" presented by LIT Director V. Korenkov, and "Status of the BM@N project" presented by VBLHEP Leading Researcher M. Kapishin.

The recommendations of the Programme Advisory Committees were reported by I. Tserruya (PAC for Particle Physics), W. Greiner (PAC for Nuclear Physics), and O. Belov (PAC for Condensed Matter Physics).

The Scientific Council heard the scientific report "High-energy heavy-ion collisions: Status and prospects of the study of hot and dense hadronic matter" presented by Professor J. Schukraft (CERN). It also heard the best reports by young scientists which had been recommended by the PACs.

V. Matveev presented the Directorate's proposals for the award of the title "Honorary Doctor of JINR". The V. Dzhelepov Prize was awarded, and diplomas to the winners of JINR prizes for the year 2013 were presented.

Election of the Directors of VBLHEP and LRB took place at the session, and vacancies of positions in the directorates of JINR laboratories were announced.

Resolution. General Considerations. The Scientific Council appreciated the progress in implementing the recommendations of its 115th session and the decisions of the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States (March 2014) as presented in the report by JINR Director V. Matveev.

The Scientific Council was pleased to note the good progress in implementing the Seven-Year Plan for the Development of JINR (2010–2016). At the same time it appealed to the JINR Directorate to pay continuous attention to the working schedule of the SHE factory, where the accumulated delay is already about a year as compared to the original planning. Even more attention should be paid to the NICA complex, which is now ready for starting the civil engineering and ordering valuable equipment for the MPD experiment. The issue of consolidation of financial and human resources is of primary importance here. Ways of attracting resources additional to the JINR budget, including long-term loans, should be carefully investigated.

The Scientific Council supported the efforts of the JINR Directorate to develop a strong scientific network with Chinese, Indian, and Latin American authorities and research centres, welcoming their intention to join the JINR scientific programme and to contribute to the JINR infrastructure.

The Scientific Council was pleased to get the news from the CERN Council about approval of mutual observership of JINR at CERN and of CERN at JINR, which will further promote and intensify the cooperation between CERN and JINR.

Recommendations on Reported Activities. The Scientific Council took note of the report "Progress of research in the field of neutrino physics and astrophysics" presented by DLNP Director V. Bednyakov. It appreciated the events which had been organized by the JINR and DLNP Directorates: the joint session of the PACs for Particle Physics and Nuclear Physics for the assessment of the JINR Neutrino Physics Programme and the meeting of the Scientific Advisory Committee for the Baikal Experiment with its important recommendations and new international participants of the experiment. These meetings were conducted in order to implement the recommendations of the 115th session of the Scientific Council concerning international expertise and consolidation of the JINR Neutrino Programme, and the determination of prospects for JINR's new basic facility — the GVD neutrino telescope in Lake Baikal.

The Scientific Council was pleased to note the readiness of the joint JINR–INR RAS team of the Baikal experiment to complete deployment of the first cluster of GVD ("Dubna cluster") in 2015 and to put it into operation. It welcomed DLNP's recent achievements with the DANSS experiment at the Kalinin Nuclear Power Plant, expecting the first interesting results in 2015. The Scientific Council recommended that the JINR Directorate

support the future implementation of the JINR Neutrino Programme with the resource requirements for the next 3–5 years.

The Scientific Council took note of the report "Progress of construction of a Factory of Superheavy Elements (SHE)" presented by FLNR Director S. Dmitriev. It commended the efforts being undertaken by JINR to build the SHE factory, noting, in particular, that completion of work related to construction of elements of the DC-280 cyclotron was currently coming to the forefront and that construction of the experimental hall of the SHE factory had recently been accelerated. The Scientific Council recommended that the JINR and FLNR Directorates continue to work towards the elimination of the construction delay in order to meet the schedule adopted under the Seven-Year Plan for the Development of JINR.

The Scientific Council took note of the report "User policy of the Laboratory of Information Technologies" presented by LIT Director V. Korenkov and supported the efforts of LIT aimed at creating a first-class IT facility to meet the present and future challenges of JINR.

The Scientific Council took note of the report "Status of the BM@N project" presented by VBLHEP Leading Researcher M. Kapishin and supported the plan for implementing the project. The Scientific Council welcomed the establishment of a management team for the project and of a Detector Advisory Committee (DAC), whose first working meeting with the BM@N team took place at JINR on 24 June 2014, and requested a report from this DAC at the next session.

Recommendations in Connection with the PACs. The Scientific Council concurred with the recommendations made by the PACs at their June 2014 meetings as reported at this session by I. Tserruya, Chairperson of the PAC for Particle Physics (through teleconference), W. Greiner, Chairperson of the PAC for Nuclear Physics, and by O. Belov, Scientific Secretary of the PAC for Condensed Matter Physics.

Particle Physics Issues. The Scientific Council recognized the progress achieved by the VBLHEP towards implementation of the Nuclotron–NICA project, in particular: the beginning of production of superconducting magnets for the NICA and FAIR projects, the progress with the KRION-6T heavy-ion source and the source of polarized particles, the preparations for the assembly of the new heavy-ion Linac expected to be fully delivered by June 2015, and the ongoing efforts towards finalizing the construction documents for the NICA collider building in order to sign the contract with the general contractor.

The Scientific Council appreciated the successful completion of the R&D for the preparation of the technical projects for the MPD main subsystems. It also noted the progress towards preparation of the BM@N project.

The Scientific Council welcomed the presentation of the Letter of Intent "Spin physics experiments at NICA–SPD with polarized proton and deuteron beams" and the first steps toward the formation of an international collaboration around the SPD experiment, which is regarded as an essential part of the NICA research programme. The NICA–SPD team was encouraged to prepare a full proposal.

The Scientific Council supported the PAC's recommendations on the continuation of ongoing projects and new activities as outlined in the PAC report.

The Scientific Council highly appreciated the success of the CERN–JINR Teacher Programme Collaboration and supported the proposal to extend this educational programme.

Nuclear Physics Issues. The Scientific Council highly appreciated the results of investigations conducted by the FLNR staff under the theme "Synthesis and Properties of Nuclei at Stability Limits", which concern, in particular, the synthesis of element 117 and experimental work confirming the discoveries of elements 113 and 115; investigation of chemical properties of element 113; study of fission and quasi-fission mechanisms, as well as production of neutron-rich nuclei in multi-nucleon transfer reactions; research of the structure of light nuclei ^{10}He, ^{6}Be beyond the limits of nuclear stability; theoretical studies of nuclear structure and nuclear reaction mechanisms. The Scientific Council supported the PAC's recommendation on the extension of this theme for two more years (2015–2016), with first priority, in order to harmonize it with the Seven-Year Plan for the Development of JINR.

Common Issues. The Scientific Council endorsed the results of the joint session of the PAC for Particle Physics and the PAC for Nuclear Physics for the assessment of the JINR Neutrino Physics Programme, which was held on 26 June 2014. The Scientific Council supported the PACs' recommendations to the DLNP Directorate to accelerate its efforts towards concentration of resources in selected directions and to prioritize all the neutrino projects in which JINR is involved according to the following criteria: (i) scientific merit and discovery potential, (ii) resources involved (manpower and finances), (iii) visibility of JINR participation, (iv) competitiveness and timeliness with other international projects.

As far as the Baikal experiment is concerned, the Scientific Council supported the continuation of the project evaluation regarding science, feasibility, cost, construction issues, milestones as well as synergies and competition with existing and planned international projects.

Condensed Matter Physics Issues. The Scientific Council appreciated the efforts being undertaken by the FLNP staff to further develop the IBR-2 facility and to upgrade the spectrometers. In particular, it noted the results of beam characteristics measurements following

the modernization of the IBR-2 reactor, the advancing of new techniques for the pulsed neutron sources, and a wide range of new research topics useful for developing the experimental capabilities of the spectrometer complex.

The Scientific Council supported the activities planned within the new themes "Development of Experimental Facilities for Condensed Matter Investigations with Beams of the IBR-2" and "Investigations of Condensed Matter by Modern Neutron Scattering Methods", and within the new projects "Development of PTH sample environment system for the DN-12 diffractometer at the IBR-2 facility" and "Isotope-identifying neutron reflectometry at the IBR-2 facility" proposed for implementation in 2015–2017.

The Scientific Council supported the PAC's recommendations on the extension of the themes "Research on the Biological Effect of Heavy Charged Particles with Different Energies" and "Multimodal Platform for Raman and Nonlinear Optical Microscopy and Microspectroscopy for Condensed Matter Studies" for 2015–2017 and the opening of the corresponding projects. The Scientific Council welcomed continuation of studies within the theme "Radiation Effects and Physical Basis of Nanotechnology, Radioanalytical and Radioisotope Investigations at the FLNR Accelerators" for 2015–2016 and the opening of the new theme and project "Novel Semiconductor Detectors for Fundamental and Applied Research" for 2015–2017.

Reports by Young Scientists. The Scientific Council noted with interest the following reports by young scientists, which were selected by the PACs for presentation at this session: "The NA48/2 experiment at CERN", "Production of doubly magic nucleus ^{100}Sn in fusion reactions via particle and cluster emission channels", and "Meteorites as catalysts of the prebiotic synthesis of biomolecules from formamide under radiation exposure". The Scientific Council thanked the speakers: A. Korotkova, Sh. Kalandarov, and M. Kapralov, respectively, for their excellent presentations, welcoming similar reports in the future.

Memberships of the PACs. As proposed by the JINR Directorate, the Scientific Council appointed M. Dubničkova (Comenius University, Bratislava, Slovakia) and T. Perring (RAL, Didcot, United Kingdom) as new members of the PAC for Condensed Matter Physics for a term of three years. The Scientific Council thanked the outgoing member V. Lisý (University of Košice, Slovakia) for his successful work as member of this PAC.

Awards. The Scientific Council congratulated Professors S. Enkhbat and R. Maier on the award of the title "Honorary Doctor of JINR". The Scientific Council endorsed the proposal of the JINR Directorate to award the title "Honorary Doctor of JINR" to Professors B. Sharkov (Russia), Gh. Stratan (Romania), and Tran Thanh Van (Vietnam/France), in recognition of their outstanding contributions to the advancement of science and the education of young scientists.

The award of the V. Dzhelepov Prize took place at the session. The Jury had conferred it upon JINR scientists V. Bystritsky, V. Kadyshevsky, and M. Sapozhnikov for their series of papers "Application of Nuclear Physics Methods for the Identification of Complex Chemical Substances".

The Scientific Council congratulated the laureates of the JINR prizes for 2013 — winners of the annual scientific research competition in the fields of theoretical physics, experimental physics, physics instruments and methods, and applied physics.

The Scientific Council congratulated JINR on being awarded a commemorative medal for its long-term cooperation with the Comenius University in Bratislava, on the occasion of the 95th anniversary of this University. The medal was received from the Plenipotentiary of the Government of Slovakia to JINR, S. Dubnička.

The Scientific Council congratulated Professor I. Golutvin on being awarded the P. Cherenkov Prize of the Russian Academy of Sciences for his outstanding contribution to the success of the CMS experiment at CERN as leader of the RDMS CMS collaboration.

Election and Announcement of Vacancies in the Directorates of JINR Laboratories. The Scientific Council elected V. Kekelidze as Director of the Veksler and Baldin Laboratory of High Energy Physics and E. Krasavin as Director of the Laboratory of Radiation Biology, each for a term of five years. It also announced the vacancies of the positions of Deputy Directors of VBLHEP and LRB. The endorsement of the appointment for these positions will take place at the 117th session of the Scientific Council.

MEETINGS OF THE JINR FINANCE COMMITTEE

A meeting of the JINR Finance Committee was held on 21–22 March. It was chaired by S. Kulhánek, a representative of the Czech Republic.

The Finance Committee considered the report "Recommendations of the 115th session of the JINR Scientific Council (February 2013). Results of JINR activities in 2013" presented by JINR Director V. Matveev, and appreciated highly the results produced by the JINR international staff in 2013.

The Finance Committee noted the substantial progress in implementing the Seven-Year Plan for the Development of JINR (2010–2016), which concerns, in particular, the preparatory work at the NICA site, the

civil engineering for the building of the Factory of Superheavy Elements, and the commissioning of new advanced spectrometers at the IBR-2 facility. At the same time the Committee expressed its concern that the construction of a new FLNR experimental hall was falling behind schedule, which was noted in the recommendations of the 115th session of the Scientific Council. It also emphasized the importance of the timely preparation of a contract for the construction of the NICA collider.

Regarding the report "Execution of the JINR budget in 2013" presented by S. Dotsenko, Chief Accountant of JINR, the Finance Committee recommended that the CP take note of the information on the execution of the budget in 2013 in expenditure — US$127 011.7 thousand and in income — US$139 948.2 thousand.

The Finance Committee informed the Committee of Plenipotentiaries (CP) about the results of voting on the cancellation of arrears of a number of Member States which occurred during 2002–2003 as well as on the postponement of a decision concerning the Member States' arrears for this period until a new methodology has been adopted for calculating contributions. Pursuant to the JINR Charter, the Finance Committee recommended that the CP suspend receiving new specialists at JINR, being sent to work by the Plenipotentiary of the Government of the Democratic People's Republic of Korea and by the Plenipotentiary of the Government of the Republic of Uzbekistan, due to the multiannual financial arrears of these Member States in contributing to the JINR budget.

Regarding the report on the Draft Regulation for the Internal Audit of JINR presented by N. Kalinin, Head of the JINR Internal Audit Service, the Finance Committee recommended that the CP approve the proposed text, taking into account the recommendations received from the Working Group.

Regarding the report on the Draft Regulation for the Procurement Activities of JINR presented by E. Bosin, Adviser to the JINR Director, the Finance Committee recommended that the CP authorize the JINR Director to approve the proposed text and make the necessary arrangements for bringing this Regulation into force. The Committee commissioned the Directorate to continue effort towards improving the documents which regulate the financial activities of JINR and to submit them at the meeting of the Finance Committee in November 2014.

The Finance Committee agreed with the proposal concerning the withdrawal of JINR from the LLC "Neutron Technologies" and recommended that the JINR Director negotiate the procedure for the Institute to return its share in immovable property, which was contributed to the authorized capital of the company at its establishment.

Regarding the report "Development of the JINR Educational Programme" presented by S. Pakulyak, Director of the JINR UC, the Finance Committee supported the activities to develop educational facilities based on the existing equipment at JINR, which would create additional conditions for implementing advanced educational programmes to train scientific and technical personnel for research centres of the Member States and JINR.

The Finance Committee also heard a report "Construction of a facility for the assembly and tests of superconducting magnets for the NICA and FAIR projects" presented by S. Kostromin, Head of a VBLHEP Department.

A meeting of the JINR Finance Committee was held on 18–19 November. It was chaired by S. Kulhánek, a representative of the Czech Republic.

The Finance Committee heard the report "Recommendations of the 116th session of the JINR Scientific Council (September 2014). Brief overview of the results of JINR activities in 2014 and plans for 2015" presented by JINR Director V. Matveev.

The Finance Committee noted the significant progress in implementing the Seven-Year Plan for the Development of JINR (2010–2016), the positive results of the efforts taken by the Directorate to overcome the delay in building the Factory of Superheavy Elements as compared to the initial plan, as well as to consolidate the financial, material, and human resources on the construction of the NICA complex. The Committee appreciated the work of the newly established internal audit service at JINR, which has made it possible to develop ways to improve the executive discipline and economic performance in the audited subdivisions; endorsed the actions taken by the JINR Directorate towards introduction of modern methods and tools for procurement, noting the need to continue work to further improve the documents regulating JINR's financial activities; welcomed the plans of the JINR Directorate to develop a programme to improve the structure of JINR and its management system, noting the important role of the JINR Science and Technology Council in this process; and endorsed the efforts undertaken by the JINR University Centre (UC) to establish a scientific and engineering team at the UC with a view to developing educational and practical programmes for training scientific and technical personnel for JINR laboratories and research centres in Member States.

The Finance Committee took note of the information on the progress in constructing the NICA complex, endorsed the conclusions on the submitted draft contracts of the preparatory period, as well as the Directorate's proposal to consider for approval the signing of a general contractor agreement for NICA construction using electronic communications in accordance with the financial regulations.

Based on the report "Draft budget of JINR for the year 2015, draft contributions of the Member States for the years 2016, 2017, and 2018" presented

by S. Dotsenko, Chief Accountant of JINR, the Finance Committee recommended that the Committee of Plenipotentiaries (CP) approve the JINR budget for the year 2015 with the total expenditure amounting to US$180.86 million as well as the contributions of the Member States for the year 2015; determine the provisional volume of the JINR budget in income and expenditure for 2016 amounting to US$207.53 million, for 2017 — US$212.58 million, and for 2018 — US$217.82 million; adopt the provisional sums of the Member States' contributions and of arrears payments for 2016, 2017, and 2018. The Finance Committee also recommended that the CP allow the JINR Directorate to index the salary and tariff parts of the compensation package of the staff members, taking into account the possibilities afforded by the JINR budget in 2015, in accordance with the JINR Collective Bargaining Agreement for 2014–2017.

Regarding the report "Methodology for calculating the scale of Member States' contributions to the JINR budget" presented by JINR Vice-Director G. Trubnikov, the Finance Committee resolved to bring to the attention of the CP the results of voting concerning the principles of the new methodology for calculating the scale of contributions. It recommended that the CP adopt the following principles proposed by the Working Group:

— with a view to ensuring the financial stability of JINR, the new methodology shall preserve the existing (as of 2014) share of the contribution of the Russian Federation in the total amount of contributions of all the Member States to the JINR budget;

— the amount of annual contributions of all the Member States shall be determined by the CP;

— the contributions of all the Member States, except the Russian Federation, shall be determined on the basis of the GDP scale averaged over three years;

— in order to avoid sharp fluctuations in contributions of the Member States, a ten-year transition period shall be applied beginning in 2017, during which the contributions of all the Member States, except the Russian Federation, shall be determined along with a uniform decrease of the current fixed scale (beginning from 90% in 2017 down to 0% in 2026) and with a uniform increase in the share by the new scale (beginning from 10% in 2017 up to 100% in 2026); also, in order to avoid too rapid growth of the Member States' contributions, a limit of 30% shall be applied for the annual growth of contributions;

— the contribution of a new Member State shall be calculated with account taken of its averaged GDP, based on a predetermined amount of the Member States' contributions; in so doing the contribution of a new Member State shall increase the JINR budget by the amount of the given contribution, while the absolute values of the Member States' contributions shall not change and the percentage shares of the contributions in the new budget of JINR shall be redistributed accordingly;

— a maximum limit for contributions of the Member States, except for the host country of JINR, shall be applied amounting to 20% of the amount of the Member States' contributions;

— in the event of withdrawal or expulsion of a Member State from JINR, the shares of the Member States' contributions shall be revised by the CP.

The Finance Committee recommended that the CP use the following rule: the contribution of a Member State of the Institute should be no less than the direct costs for the personnel sent to JINR by its Plenipotentiary; also, 2017 should be regarded as the first year for the application of the new methodology.

The Finance Committee recommended that the CP set up a Working Group under the CP Chairman for financial issues, composed of representatives of the Republic of Belarus, the Republic of Bulgaria, the Czech Republic, Georgia, the Republic of Kazakhstan, the Republic of Poland, and the Russian Federation, and that it commission the JINR Directorate and the Working Group to prepare the new methodology for calculating the scale of contributions based on the aforesaid principles for approval by the CP in March 2015.

Based on the report "Results of the audit of the JINR financial and economic activities for the year 2013" presented by A. Sedyshev, Director of the company "MS-Audit", the Finance Committee recommended that the CP approve the auditors' report for 2013 and JINR's report on the execution of the budget for the year 2013 in expenditure amounting to US$127 011.7 thousand, with the summary account as of 01.01.2014 being US$665 022.0 thousand.

The Finance Committee heard with interest the report "JINR accelerators as an effective tool for addressing issues of fundamental and space radiobiology" presented by LRB Leading Researcher A. Boreyko.

MEETINGS OF THE JINR PROGRAMME ADVISORY COMMITTEES

The 39th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 20–21 January. It was chaired by Professor V. Kantser.

The Chairperson presented an overview of the PAC report, delivered at the session of the JINR Scientific Council in September 2013, concerning the implementation of the recommendations of the previous PAC meeting. JINR Vice Director M. Itkis informed the PAC about the Resolution of the 114th session of the Scientific Council and about the decisions of the JINR Committee of Plenipotentiaries.

The PAC heard with interest a report on implementation of the programme of physics experiments with extracted neutron beams and on the main results of experimental operation of the cryogenic moderator. It was pleased to note that the IBR-2 facility operates steadily at a power of 2 MW, providing experiments with extracted beams in accordance with the plan, including experiments using the CM-202 cryogenic moderator for neutron channels 7–11. The PAC emphasized the particular relevance of the research being conducted for the construction of a complex of cryogenic moderators and for the development of new equipment important for safe operation of the reactor, in particular of the MR-3R reserve movable reflector, and considered it necessary to ensure full support for these activities. It also noted the importance of implementing the programme of regular physics experiments in accordance with the user policy and of continuing the commissioning of upgraded physics instruments on extracted neutron beams lines. In this regard, the PAC underlined the importance of disseminating the best obtained results in order to highlight the possibilities of new updated facilities and considered it useful to organize proposal calls each quarter and schools with special subsections for potential users of the IBR-2 facility.

The PAC was informed about the results of realization of the FLNP User Programme in 2013. Recognizing the successful operation of this programme at the spectrometer complex of the modernized IBR-2 reactor, the increased total number of the experiments performed, and the high quality of the scientific results obtained, the PAC recommended that the implementation of the User Programme at IBR-2 spectrometers should remain one of the major activities of FLNP in 2014. In order to increase the visibility of scientific research at IBR-2, the PAC also suggested organizing meetings for users and extending information about new facilities available at the Laboratory's web page.

Taking into account the information about the commissioning and first experiments carried out at the GRAINS reflectometer under the thermal and cold regimes of the moderator, the PAC appreciated the beginning of experimental measurements with this set-up and supported further efforts to improve the background conditions at the instrument and to develop the user control interface. The PAC expects the GRAINS reflectometer to be included into the User Programme in the third quarter of the current year.

The PAC heard a report on the status of the YuMO spectrometer. It noted the significant progress achieved in modification of the YuMO spectrometer, and supported the ongoing upgrade of this instrument aimed at achieving improved physical parameters of the spectrometer and at increased number of experiments to be performed in compliance with the current user policy, given the constantly increasing need for investigations based on small-angle neutron scattering. The PAC noted the complementary support coming from LIT in developing this spectrometer. It recommended giving special attention to the adaptation of the spectrometer for the planned implementation of the cold moderator. It also suggested that the extension of spectrometer possibilities related to planned launch of the new-type position-sensitive detector and its installation into a two-detector system, which had already demonstrated its high effectiveness, should remain another priority within the upgrade programme for this spectrometer.

The PAC heard with interest the following scientific reports by invited experts: "Frontiers in crystallography research under extreme conditions" by L. Dubrovinsky and "Modern trends in neutron scattering applications for biology" by N. Kučerka. It also noted two other reports in the field of practical application and extension of radiation research: "In-situ neutron diffraction analysis of charging/discharging processes in Li-ion batteries at the IBR-2 pulsed reactor" by I. Bobrikov and "Implementation of behavioural effects of radiation" by A. Bazyan. The PAC appreciated the progress of investigations in the field of CARS microscopy presented in the high-quality reports "Up conversion luminescence in oxyfluoride nano-glassceramics" by G. Arzumanyan and "Raman spectroscopy for fundamental and applied studies in biomedicine" by V. Gordeliy. The PAC looks forward to hearing new scientific results of JINR researchers at its future meetings.

The PAC was informed about the international scientific school for young scientists and students "Modern Neutron Scattering" (Dubna, 28 October – 1 November 2013). It appreciated the quality of the scientific programme and the results of the school, and recommended its further annual organization.

The PAC considered the poster presentations by FLNP and LIT young scientists and selected the poster "Study of the magnetic structure of $HoCo_2$ and $ErCo_2$ compounds at high pressures" presented by A. Rutkauskas as the best one at this session. Two other high-quality posters were noted: "Molecular dynamics simulation of human lactoferrin apoprotein" (by R. Erhan) and "High pressure diffractometer DN-6: Current state" (by E. Lukin).

The members of the PAC for Condensed Matter Physics commemorated Professor V. Petrov, a member of this PAC during 2005–2013, who had significantly contributed to the work of its meetings by his high-quality expertise in the fields of radiobiology, space research, and life sciences in general.

The 40th meeting of the Programme Advisory Committee for Particle Physics was held on 27–28 January. It was chaired by Professor I. Tserruya.

JINR Vice-Director R. Lednický informed the PAC about the Resolution of the 114th session of the JINR Scientific Council (September 2013) and about the decisions of the JINR Committee of Plenipotentiaries (November 2013).

The PAC heard with interest the reports presented by the directors of LIT, DLNP, and VBLHEP on the scientific activities and future developments in their laboratories.

The PAC welcomed the efforts of the LIT management in the concentration of human and material resources to best meet the fundamental interests of JINR and its Member States, and secure a long-term future for the Laboratory. As for the experts support and LIT's participation in research programmes not linked to the JINR IT infrastructure, the PAC requested the LIT Directorate to clarify its strategy on how to distribute its resources, which research areas to enter, and eventually how to make the clients participate in covering the costs for this support.

The PAC recognized the importance of the neutrino physics and astrophysics research programmes being carried out at DLNP, proposing that this should be emphasized in the updated Seven-Year Plan for the Development of JINR. The PAC asked the JINR Directorate to consider having all neutrino physics–related proposals discussed in one single PAC or at a joint meeting of the PAC for Particle Physics and the PAC for Nuclear Physics to commonly assess the neutrino physics programme at JINR.

The PAC was pleased to note the high quality of the scientific research being performed by VBLHEP groups and supported the efforts of the Laboratory management for enhanced involvement of the staff in the research programme of the Nuclotron–NICA accelerator complex, while maintaining a balanced participation in external experiments.

The PAC appreciated the further improvements achieved in the Nuclotron operation as demonstrated in Run 48, noting with satisfaction that the Nuclotron–NICA Machine Advisory Committee was pleased with the progress achieved by the Nuclotron–NICA team. The Committee welcomed the beginning of the site preparation for the NICA building construction work.

The PAC noted the progress concerning the BM@N project and requested a report with its detailed staging and a detailed concept of the tracking system suitable for Au beams. It also urged the BM@N team and the Laboratory management to considerably increase the JINR manpower involved in BM@N.

The PAC noted with interest the results of the meeting of an international expert team held in Dubna in October 2013, which were summarized in a paper entitled the "NICA Priorities", and recommended continuation of the work, focusing on a quantitative assessment of proposed measurements in close cooperation with the MPD and BM@N teams.

The PAC appreciated the progress in manufacturing and testing of prototypes for the MPD detector systems achieved in 2013, and also the progress in preparing the MPD technical project. It urged the MPD and NICA managements to focus their efforts on completion of the contracts for two critical items — manufacturing of the magnet and construction of the collider. The PAC thanked the members of the MPD Detector Advisory Committee for their review of the project realization and recommended continuation of this activity.

The PAC recommended approval of JINR's participation in the new project NOvA (Fermilab, USA).

The PAC appreciated the report "Vacuum stability in the Standard Model: Three-loop analysis" presented by A. Bednyakov.

The PAC noted with interest the poster presentations in particle physics by young scientists from DLNP and VBLHEP. It selected the poster "Study of hyperon and antihyperon production in deep inelastic muon scattering" presented by N. Rossiyskaya to be reported at the session of the Scientific Council in February 2014.

The 39th meeting of the Programme Advisory Committee for Nuclear Physics was held on 30–31 January. It was chaired by Professor W. Greiner.

The Chairperson of the PAC presented an overview of the implementation of the recommendations taken at the previous meeting. JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 114th session of the Scientific Council (September 2013) and about the decisions of the Committee of Plenipotentiaries (November 2013).

The PAC heard a report on the further development of the IREN facility. It recommended that the FLNP Directorate complete the Critical Design Review of the second stage of the accelerator and of nonmultiplying uranium target and present it at the next meeting.

The PAC heard a report on the upgrade of the VASSILISSA separator and on the results of first test measurements. It emphasized that the upgraded set-up is of great interest to the international scientific community, expressing confidence that the realization of the FLNR scientific programme presented at previous PAC meetings would be successful.

The PAC took note of the report on the theme "Accelerator Complex of Ion Beams of Stable and Radioactive Nuclides (DRIBs-III)" and highly appreciated the FLNR group's work on the DRIBs-III project. It noted with satisfaction that the implementation of this project and the work related to the development of the DC-280 cyclotron, construction of new and upgrade of existing physics instruments (ACCULINNA-2 separator, VASSILISSA–GABRIELLA, and others) generally proceed according to the Seven-Year Plan for the Development of JINR. At the same time the PAC stated with concern that the construction of a new FLNR experimental hall was falling behind the schedule. It recommended extending the original DRIBs-III due date for two more years and continuing work on the theme with first priority. It was also recommended that the JINR and FLNR Directorates take the necessary steps to meet the deadlines for commissioning the Factory

of Superheavy Elements, which is a key project of the Seven-Year Plan.

The PAC heard with interest the proposal for a new project "Design and development of the tagged neutron method for elemental analysis and nuclear reaction studies" (project TANGRA). Noting that the set-up, which is being constructed in the framework of the project, would be unique for JINR, the PAC recommended approval of TANGRA for implementation in 2014–2016 and allocation of the requested funding as presented in the schedule of work.

The PAC heard a proposal for JINR's participation in the project "Experimental search for coherent neutrinoless $\mu-e$ conversion at J-PARC" (project COMET) and noted the fundamental importance of searching for lepton flavor violation with the highest possible sensitivity. The PAC identified this project as having fundamental physics importance and recommended approval of the participation in it in 2014–2016, with first priority.

The PAC heard the scientific reports: "Investigation of charged particle emission reactions induced by fast neutrons" by Yu. Gledenov and "Fusion at near and sub-barrier energies with quantum diffusion approach" by G. Adamian.

The PAC was pleased with the presentations of new results and proposals by young scientists in the field of nuclear and heavy-ion physics research. The best posters have been selected: "Study of the processes of fusion-fission and evaporation residue formation within the knowledge base on low-energy nuclear physics" by A. Karpov and "Properties of quasi-fission in dependence on the reaction entrance channel" by G. Knyazheva. The PAC recommended that the report by A. Karpov be presented at the session of the Scientific Council in February 2014.

The members of the Programme Advisory Committee for Nuclear Physics commemorated Professor N. Janeva who had served extremely successfully in this PAC as a member and Chairperson for a long period of time.

The 40th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 23–24 June. It was chaired by Professor V. Kantser.

The Chairperson welcomed the new members Professors L. Avramov, L. Dubrovinsky, and R. Saladino, and presented a short overview of the PAC report delivered at the session of the JINR Scientific Council in February 2014 about the implementation of the recommendations taken at the previous PAC meeting.

JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 115th session of the JINR Scientific Council and the decisions of the JINR Committee of Plenipotentiaries.

The PAC took note of the report on the results of measurements of the neutron flux density and beam profiles following the modernization of the IBR-2 reactor, and recommended publishing these results and posting them on the FLNP website.

It also noted the information about the status of the REFLEX spectrometer and supported the work to develop the neutron spin echo technique for the pulsed neutron sources.

The PAC heard a report on the activity on the concluding theme "Novel Development and Creation of Equipment for the Spectrometer Complex of the IBR-2 Facility" and a proposal for opening a new theme "Development of Experimental Facilities for Condensed Matter Investigations with Beams of the IBR-2". Noting that all the work previously planned under the concluding theme had been accomplished, the PAC highly appreciated the results obtained. In the same report, a proposal was also presented for opening a new project "Development of PTH sample environment system for the DN-12 diffractometer at the IBR-2 facility" within this new theme. The PAC recommended opening the new theme and project for 2015–2017.

The PAC took note of the report on the concluding theme "Investigations of Nanosystems and Novel Materials by Neutron Scattering Methods" and a proposal for opening a new theme "Investigations of Condensed Matter by Modern Neutron Scattering Methods". The PAC appreciated the quality of the scientific results produced, the significant progress achieved in the development of the IBR-2 instrumental complex and the broad cooperation with research centres of JINR Member States in realization of the theme, and the implementation of the User Programme as a very important activity within the framework of the theme. It recommended opening this new theme for 2015–2017.

Noting the proposal for opening a new project "Isotope-identifying neutron reflectometry at the IBR-2 facility", the PAC considered the activities planned to be useful for developing the experimental capabilities of the REMUR reflectometer and recommended opening this project for period 2015–2017.

The PAC heard a report on the concluding theme "Research on the Biological Effect of Heavy Charged Particles with Different Energies". Noting the high quality of the studies performed under the theme and appreciating the research topics proposed for implementation, it recommended extension of this theme and opening a new project with the same title for 2015–2017.

Regarding the report on the concluding theme "Radiation Effects and Physical Basis of Nanotechnology, Radioanalytical and Radioisotope Investigations at the FLNR Accelerators", the PAC appreciated the quality of the results obtained and noted that the activity within the framework of the theme leads to both important applications and to interesting fundamental findings. The PAC recognized the growing participation of research centres of JINR Member States and associate members in the research work on ion irradiation effects in inorganic materials, modification and nanostructuring of polymers. It appreciated the significant achievements

in the field of new accelerator developments and in the successfully continuing radioanalytical investigations. The PAC welcomed the establishment of the Nanotechnology Centre which will provide new possibilities in the realization of the proposed research programme, and recommended extension of this theme for 2015–2016.

The PAC heard a report on the concluding theme "Multimodal Platform for Raman and Nonlinear Optical Microscopy and Microspectroscopy for Condensed Matter Studies", noted the progress achieved in the development of this theme, and welcomed the research directions proposed for implementation. The PAC recommended extension of this theme and opening a new project with the same title for 2015–2017. With a view to further developing the apparatus infrastructure of the multimodal optical platform and advancing the activities toward single molecule detection spectroscopy, the PAC supported the intention to upgrade the multimodal optical platform by acquiring Atomic Force Microscopy measuring head.

The PAC considered a proposal for opening a new theme and project "Novel Semiconductor Detectors for Fundamental and Applied Research". Realization of this proposal will allow developing an advanced semiconductor detector technology at JINR and preparing for the future accelerator experiments of a new generation. These developments are important for high-energy physics, applied studies in biology, materials science, geophysics, and medicine conducted with synchrotron radiation and X-ray sources. One of the main goals of the proposed project is to create a working scheme for joint interdisciplinary applied studies. The PAC recommended opening these new theme and project for 2015–2017.

As a general remark, the PAC requested the authors of new proposals to present the results already achieved in comparison with results of other research groups competing in the relevant field of studies.

The PAC heard with the great interest the following scientific reports: "Prebiotic chemistry in space conditions: The role of the radiation/meteorite system in the origin of life" by R. Saladino, "The latest advances in the microstructural analysis on the basis of diffraction peak profiles" by M. Leoni, and "Structural studies of detonation nanodiamonds by small-angle neutron scattering" by O. Tomchuk. The PAC welcomed the existing international cooperation.

The PAC considered the poster presentations by LRB young scientists and selected the poster "Meteorites as catalysts of the prebiotic synthesis of biomolecules from formamide under radiation exposure" (M. Kapralov) as the best poster at the session and recommended this poster to be reported at the session of the Scientific Council in September 2014. The PAC also noted two other high-quality posters: "Detection of clustered DNA damage in human fibroblasts after irradiation with boron ions and γ-rays" (L. Ježková) and "The role of the bacterial mismatch repair system in SOS-induced mutagenesis: A theoretical background" (O. Belov).

The 41st meeting of the Programme Advisory Committee for Particle Physics took place on 25–26 June. It was chaired by Professor I. Tserruya.

JINR Vice-Director R. Lednický informed the PAC about the Resolution of the 115th session of the JINR Scientific Council (February 2014) and the decisions of the JINR Committee of Plenipotentiaries (March 2014).

The PAC was informed about the beginning of production of superconducting magnets for the NICA and FAIR projects, the progress with the KRION-6T heavy-ion source and the source of polarized particles. It recognized the ongoing efforts towards finalizing the construction documents for the NICA collider building in order to sign the contract with the general contractor.

The PAC appreciated results of the Nuclotron Runs 49 and 50, and the progress achieved in the beam quality improvement. It supported the plan for implementing the BM@N project and welcomed the intensification of preparation work. The PAC congratulated the VBLHEP Directorate for the establishment of a management team for BM@N and also welcomed the establishment of a Detector Advisory Committee for this project.

The PAC appreciated the progress in upgrading the LHC detectors and supported the proposal for continuation of the CMS and ALICE projects for the next five years.

While considering new projects, the PAC was pleased to see the first steps toward formation of an international collaboration around the "Spin physics experiments at NICA–SPD with polarized proton and deuteron beams". The PAC regards the SPD experiment as an essential part of the NICA research programme. It encouraged the authors of the Letter of Intent to prepare a full proposal and present it at one of the forthcoming meetings of the PAC.

The PAC adopted a proposal for opening the theme "Search for New Physics in Experiments with Fermilab High-Intensity Muon Beams" and confirmed the scientific significance of the proposed $g-2$ and Mu2e experiments. The participation of the JINR group in the project is well justified by the science reach of the experiments and the long-standing and successful JINR–Fermilab cooperation. The PAC recommended approval of this project for 2015–2017. It also endorsed the new proposal "Astrophysical studies in the TAIGA experiment" for implementation in 2015–2017.

Taking into account the results of the JINR groups participating in the NA61 and Daya Bay projects, the PAC supported their proposals for extension for three years (2015–2017). It noted the significant contribution of the JINR group to the preparation of the NA62 experiment and the successful implementation of the projects under the theme "Development of the JINR Basic Facility for Generation of Intense Heavy Ions

and Polarized Nuclear Beams Aimed at Searching for the Mixed Phase of Nuclear Matter and Investigation of Polarization Phenomena at the Collision Energies up to $\sqrt{s_{NN}} = 11$ GeV". The PAC recommended extension of both themes for five years (2015–2019).

The PAC heard the reports on the successful implementation of the projects under the themes "Strangeness in Hadronic Matter and Study of Inelastic Reactions near Kinematic Borders" and "Research on Relativistic Heavy and Light Ion Physics at the Nuclotron, SPS, and SIS18", and recommended their extension for three years (2015–2017).

The PAC highly appreciated the proposal to extend successful Collaboration for the CERN–JINR Teacher Programme and supported the continuation of this educational programme.

The PAC appreciated the reports "Is the directed flow in heavy-ion collisions a puzzle?" presented by V. Toneev and "24 years of efforts: From MELC through MECO to Mu2e" by R. Djilkibaev.

The PAC noted with interest the poster presentations in particle physics by young scientists from DLNP, VBLHEP, and LIT. It selected the poster "The NA48/2 experiment at CERN" by A. Korotkova (VBLHEP) to be reported at the session of the Scientific Council in September 2014.

The 40th meeting of the Programme Advisory Committee for Nuclear Physics was held on 26–27 June. It was chaired by Professor W. Greiner.

The Chairperson of the PAC presented an overview of the implementation of the recommendations taken at the previous meeting. JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 115th session of the Scientific Council (February 2014) and the decisions of the Committee of Plenipotentiaries (March 2014).

The PAC took note of the report on the theme "Synthesis and properties of nuclei at stability limits" presented by M. Itkis, and highly appreciated the results of investigations produced by the FLNR staff under this theme. In order to synchronize the theme with the Seven-Year Plan, the PAC recommended its extension for two more years with first priority. It also commended the initiatives being taken towards attracting young people to this project.

The PAC heard with interest the report "New insight into the ^{6}Be, ^{10}He and ^{17}Ne structure at low excitation energy" presented by V. Chudoba, which was dedicated to studies of light nuclei beyond the driplines using radioactive beams of the U400M cyclotron. It also heard with interest the report "Weak-interaction reactions with hot nuclei under supernova conditions" presented by A. Dzhioev and A.Vdovin.

The PAC was pleased with the presentations of new results and proposals by young scientists in the field of nuclear physics research. The best posters have been selected: "Production of doubly magic nucleus ^{100}Sn in fusion reactions via particle and cluster emission channels" by Sh. Kalandarov and "GEMMA: The results of search for the neutrino magnetic moment" by D. Medvedev. The PAC recommended the report by Sh. Kalandarov for presentation at the session of the Scientific Council in September 2014.

The members of the PAC visited FLNR and thanked the Directorate for the update on new developments at this Laboratory.

PRIZES AND GRANTS

The Presidium of the Russian Academy of Sciences awarded the **P. Cherenkov Prize** to Professor I. Golutvin (Joint Institute for Nuclear Research), for outstanding contribution to successful procedure of the CMS experiment at CERN, in the position of the RDMS CMS spokesperson.

The **N. Bogoliubov Prize** was awarded to Academician V. Rubakov (INR RAS, Moscow) and Professor M. Henneaux (the International Solvay Institutes of Physics and Chemistry, Brussels), for outstanding achievements in theoretical and mathematical physics, and contribution to the development of international scientific cooperation and training of young scientists.

The **V. Dzhelepov Prize** was awarded to the group of authors: Doctor V. Bystritsky, Academician V. Kadyshevsky, and Doctor M. Sapozhnikov (Joint Institute for Nuclear Research), for the cycle of papers "Application of nuclear physics methods for identification of chemical substances".

The **B. Pontecorvo Prize** was awarded to G. Domogatsky (INR RAS, Moscow), for outstanding contributions to high-energy neutrino astrophysics and neutrino astronomy, in particular, pioneering development of a high-energy neutrino detection method by an underwater detector and construction of the detector at Lake Baikal.

JINR PRIZES FOR 2014

I. Theoretical Physics Research

First Prize

"Superconformal Indices and Dualities in Four-Dimensional Supersymmetric Field Theory".
Authors: V. Spiridonov, G. Vartanov.

Second Prize

"Elaboration of Quantum Diffusion Approach for Describing Sub-Barrier Fusion of Nuclei".
Authors: G. Adamian, N. Antonenko, V. Sargsyan, W. Scheid.

II. Experimental Physics Research

First Prizes

1. "Study of CP Violation in Kaon Decays".
Authors: E. Gudzovsky, V. Kekelidze, D. Madigozhin, Yu. Potrebenikov.

2. "Real-Time Measurement of Solar Neutrinos from the *pp* Reaction at Borexino".
Authors: O. Smirnov, D. Korablev, K. Fomenko.

Second Prize

"Investigation of Mechanisms for *pd* and *dd* Reactions in Deuterides of Metals in the Region of Astrophysical Energies".
Authors: V. Bystritsky, G. Dudkin, J. Huran, A. Kobzev, A. Krylov, V. Padalko, F. Penkov, Yu. Teleushev, M. Filipowicz, A. Philippov.

III. Physics Instruments and Methods

First Prize

"Photon Methods for Detection of Radiations".
Author: Yu. Akimov.

Second Prizes

1. "Production of Exotic ^{6}He Ions by Bremsstrahlung of Electron Beam".
Authors: A. Belov, S. Bogomolov, S. Dmitriev, S. Mitrofanov, G. Mishinsky, V. Zagrebaev, V. Zhemenik.

2. "Development of Gas Detectors for Neutron Investigations".
Authors: A. Belushkin, A. Bogzdel, V. Zhuravlev, F. Levchanovski, E. Litvinenko, V. Milkov, Ts. Panteleev, V. Prikhodko, A. Churakov, V. Shvetsov.

IV. Applied Physics Research

First Prize

"Experimental Complex for Radiation Resistance Research of Electronic Components at the Heavy-Ion Beams of FLNR Cyclotrons".

Authors: V. Anashin, B. Gikal, G. Gulbekyan, I. Kalagin, N. Osipov, S. Pashchenko, V. Skuratov, Yu. Teterev, A. Fateev.

Second Prizes

1. "High-Precision Laser Inclinometer".

Authors: Ju. Budagov, M. Lyablin, G. Shirkov.

2. "Neutron Diagnostics of Perspective Reactor Materials".

Authors: A. Balagurov, G. Bokuchava, R. Vasin, I. Papushkin, V. Sumin.

Encouraging Prizes

1. "Structure and Properties of Magnetic Nanoparticles Produced by Bacteria *Klebsiella oxytoca*: Comprehensive Research and Experimental Validation of Biomedical Applications".

Authors: M. Balasoiu, D. Soloviov, A. Rogachev, L. Anghel, O. Orelovich, L. Ishchenko, S. Stolyar, R. Iskhakov, Yu. Raikher.

2. "Heritable γ- and Neutron-Induced DNA Alterations in the Structurally Different *Drosophila melanogaster* Genes and Prospects for the Assessment of Radiation Genetic Risks at the Molecular Level".

Authors: I. Alexandrov, M. Alexandrova, K. Afanasyeva, S. Korablinova.

3. "Superconducting Unclosed Shields for the Electron Cooling System of the NICA collider".

Authors: N. Agapov, G. Dorofeev, V. Drobin, E. Kulikov, H. Malinowski, A. Smirnov, G. Trubnikov.

GRANTS

In 2014, to implement scientific projects, the staff members of the Joint Institute for Nuclear Research received financial support of the Russian Foundation for Basic Research (RFBR), the Russian Scientific Foundation (RSF), the Belarussian Republican Foundation for Basic Research (BRFBR), and the Foundation of the RF Ministry of Education and Science.

The Russian Foundation for Basic Research financed JINR projects in the framework of the following competitions: "Ambitious Scientific Research" — 48 projects; "Scientific Research by Young Scientists" — 4 projects; "Scientific Research by Young Foreign Scientists under the Guidance of Doctors of Science at RF Scientific Centres" — 1 project; "Fundamental Targeted Research in Topical Interdisciplinary Themes" — 10 projects; "Regional Competition 'Central Russia' " — 2 projects.

RFBR financed a number of JINR scientific projects in the framework of international contests: together with the Belarussian Republican Foundation for Basic Research — 1 project; together with the German Research Foundation — 2 projects; together with the State Foundation of Natural Sciences of China — 3 projects; together with the State Foundation for Basic Research of Ukraine — 2 projects; together with the National Centre for Scientific Research of France — 4 projects; together with the European Organization for Nuclear Research (CERN) — 3 projects; together with the National Research Foundation of RSA — 1 project.

RFBR rendered financial support to JINR for organization of 13 scientific conferences in the framework of the competitions "Organization of Russian and International Scientific Events in the Territory of Russia" and "Organization of Scientific Events for Young Researchers in the Territory of Russia".

The Russian Scientific Foundation, in the framework of the competition "Fundamental Scientific Research and Scientific Research in Separate Scientific Groups", financed 3 projects.

The RF Ministry of Education and Science, in the framework of the Federal Target Programme "R&D in Priority Trends of the Development of the Scientific-Technological Complex of Russia for 2014–2020", financed 1 project.

Thirteen projects were financed in 2014 as part of the joint competition of research projects of the Belarussian Republican Foundation for Basic Research and the Joint Institute for Nuclear Research.

Financial support was rendered in the framework of the RFBR programme "Scientific Electronic Library" in the competition to obtain the access to electronic scientific information resources of foreign publishing houses.

In the framework of the state support for young Russian scientists, Candidates of Science in the field "Physics and Astronomy", the grant of RF President was awarded to A. Bednyakov (the Bogoliubov Laboratory of Theoretical Physics).

2014

INTERNATIONAL RELATIONS AND SCIENTIFIC COLLABORATION

COLLABORATION IN SCIENCE AND TECHNOLOGY

The main results of the international cooperation in science and technology of the Joint Institute for Nuclear Research in 2014 reflect the following data:

— joint research was conducted with scientific centres in Member States, as well as with international and national organizations in other countries, on 44 topics of first priority and one topic of second priority;
— to solve cooperation issues and questions of participation in scientific meetings and conferences, the Joint Institute sent 2580 specialists;
— for joint work and consultations, as well as for participation in meetings, conferences, and schools held at JINR, 1613 specialists were received;
— 50 international scientific conferences and schools, 15 workshops, and 15 meetings were organized and held;

The international cooperation of JINR is presented in agreements and treaties. Its development comprises joint experiments at basic facilities of physics centres, the acquisition of research data, preparation of joint publications of the joint research results, the supply of equipment and techniques for the interested sides, etc.

On **30 January**, Head of the RF State Corporation of Atomic Energy "Rosatom" S. Kirienko visited JINR and met with JINR Director Academician V. Matveev, members of the JINR Directorate, and leading scientists and specialists of the Laboratories of Nuclear Reactions and High Energy Physics.

S. Kirienko was acquainted with the accelerator complex of the Flerov Laboratory of Nuclear Reactions and the main basic and applied research trends of the Laboratory. The guest was shown the Nuclotron and informed on the project NICA, as well as on research programmes and application of results of fundamental studies in practice at the Veksler and Baldin Laboratory of High Energy Physics. S. Kirienko was impressed by the status of construction of a complex for assembly and tests of superconducting magnets in the VBLHEP site for the large-scale projects NICA in Russia and FAIR in Germany.

A JINR delegation headed by JINR Acting Vice-Director G. Trubnikov participated in a bilateral meeting with leaders of the Institute of Plasma Physics (ASIPP) of the Chinese Academy of Sciences on **23–25 February** in Hefei (China). On the JINR side, VBLHEP Director V. Kekelidze, VBLHEP Deputy Directors A. Sorin and H. Khodzhibagiyan, and Head of the JINR International Cooperation Department D. Kamanin participated in the meeting. On the Chinese side, the meeting was attended by Vice President of the Chinese Academy of Sciences W. Zhan, ASIPP Director J. Li, and a number of ASIPP leaders and leading experts. The meeting was also attended by the First Secretary of the Russian Embassy in China V. Goza.

The framework agreement on cooperation signed by ASIPP and JINR on 7 August 2013 was aimed primarily at mutually advantageous participation of ASIPP in the NICA project. The participants of the meeting discussed in detail the status of scientific mega-projects NICA and EAST, and formulated particular proposals for exchange of visits and technological cooperation. JINR Acting Vice-Director G. Trubnikov and ASIPP Director J. Li signed a joint proclamation to the Ministry of Science and Technology of China, on the one hand, and the Ministry of Education and Science of the Russian Federation, on the other, with a proposal to establish a relevant joint scientific and technical programme. This programme will provide the basis for China's accession to the mega-project NICA and allow ASIPP to make a significant contribution to construction of its superconducting accelerator complex.

The delegation from JINR was shown around ASIPP laboratories and saw unique production facilities.

On **3–5 March**, a round-table discussion Italy–Russia–Dubna was held at JINR International Conference Hall to exchange views on the topic "What Comes Next?" — theoretical and experimental physics after the discovery of the Higgs boson. The event was organized in the framework of the scientific programme of the Embassy of Italy in RF. Its co-organizers were VBLHEP and BLTP of JINR.

The experimental discovery of the Brout–Englert–Higgs boson that lies at the root of the Standard Model is the result of work of physicists and engineers around the world, including scientists from Italy, Russia, and JINR at CERN.

The following persons took part in the discussion: Deputy Minister of Education and Science of RF L. Ogorodova, Deputy Head of the EU delegation in RF S. Karlson, Advisor on Science and Technology of the EU delegation in RF R. Burger, First Councillor of the Embassy of Italy in RF A. Pinna, Advisor on Science of the Embassy P. Fré, and staff members of the Embassies of Hungary and France in Russia. Reports at the event were made by leading specialists of JINR, CERN, the National Institute of Nuclear Physics (Italy), universities of Italy, Belgium, Great Britain, the Republic of South Africa, and the Russian academic institutes — the Institute for Nuclear Research, the Institute of Mathematics, and the Institute of Theoretical Physics.

Ambassadors of 11 countries of Latin America visited JINR on **4 March**. JINR Director RAS Academician V. Matveev and JINR Chief Scientific Secretary N. Russakovich spoke to the guests about the main components of JINR activities, the most important scientific discoveries and achievements, and international scientific cooperation. JINR Assistant Director A. Ruzaev acquainted the Ambassadors with innovation elaborations of Dubna scientists. The diplomats visited VBLHEP where they were shown the accelerator complex NICA, which is under construction, and FLNR where studies of the new superheavy elements synthesis are conducted.

At the invitation of the Bulgarian Academy of Sciences (BAS), Sofia University "St. Kliment Ohridski", the Regulatory Agency on Nuclear Energy of Bulgaria, and the Institute for Nuclear Research and Nuclear Energy of BAS (INRNE BAS), an official visit of JINR Director Academician V. Matveev to the Republic of Bulgaria was held on **9–11 April**.

At the festive meeting of the Presidium of the Bulgarian Academy of Sciences, Academician V. Matveev was presented a Diploma of his election as a foreign member of the Bulgarian Academy of Sciences. In Sofia University "St. Kliment Ohridski" he was conferred the title "Honorary Doctor". At INRNE BAS, the Bulgarian Academy of Sciences, and Sofia University, V. Matveev gave lectures and reports that raised great interest among BAS members, scientists, and students — a wide range of attendees.

In the course of his visit to Sofia, Academician V. Matveev had meetings and fruitful discussions with BAS leaders, authorities of Sofia University, INRNE BAS, Minister of Education and Science of Bulgaria Professor A. Klisarova, Deputy Prime Minister of the Republic of Bulgaria D. Boeva, Deputy Minister of Economy and Energy of Bulgaria I. Ajolov, Chairman of the Parliamentary Board on issues of education and science V. Dobreva and members of the Board, Chairman of the Regulatory Agency on Nuclear Energy of Bulgaria, Plenipotentiary of the Government of the Republic of Bulgaria to JINR Doctor L. Kostov, and RF Ambassador in the Republic of Bulgaria Yu. Isakov. New landmarks in the mutually beneficial cooperation were scheduled between JINR and scientific-academic and educational centres of Bulgaria.

At the press conference organized in the premises of the government of Bulgaria, V. Matveev talked about the programmes underway at JINR: development of research in fundamental physics, innovations and staff training, development of international scientific cooperation with JINR Member States. He also marked the latest achievements of the international community of JINR and expressed his gratitude to the government of Bulgaria for the support of cooperation of Bulgarian scientists with JINR.

On **22 April**, the 3rd meeting of the Joint Coordinating Committee (JCC) on cooperation of the Republic of Serbia with JINR was held in Belgrade (Serbia) at the "Vinča" Institute for Nuclear Sciences. The delegation from JINR, headed by JINR Vice-Director R. Lednický, included Deputy Chief Scientific Secretary D. Kamanin, Deputy Director of the Frank Laboratory of Neutron Physics E. Lychagin, and staff member of the International Cooperation Department O. Korotchik. Serbia was represented by Assistant Minister of Science and Education of Serbia R. Žikić, Coordinator of JINR–Serbia cooperation S. Petrović (the "Vinča" Institute), and researchers from the Institute of Physics of Belgrade L. Simić and M. Aničić-Urošević.

The participants of the meeting discussed the efficiency criteria in cooperation, issues of long-term planning and financing of joint projects. In particular, it was decided to start the implementation of the project in materials science with neutron beams from IBR-2, and to include young scientists from Serbia in the list of members of summer practice courses at JINR.

The JCC meeting was connected with the 2nd International Meeting on the Serbia–JINR cooperation programme in condensed matter physics, which was held on 22–24 April at the "Vinča" Institute. This trend includes a programme of joint studies with heavy-ion beams at the complex FAMA of the "Vinča" Institute and JINR FLNR.

From **16** to **20 June**, a scientific forum "Frontiers in Elementary Particle, Nuclear and Condensed Matter Physics" was held at the Joint Institute for Nuclear Research, with strong support from the Embassy of India in the Russian Federation and the Embassy of the Russian Federation in India. The aims of the forum were to strengthen the existing cooperation further as well as to explore the possibility of stronger ties between scientific research centres of India and JINR in the fields of fundamental theoretical and experimental physics.

The forum was attended by about 20 reputed experts from leading scientific research institutions of India representing practically all trends of elementary particle physics, physics of atomic nucleus, and condensed matter physics, which are of priority importance for key projects of JINR. The opening ceremony of the forum was attended by representatives from the Indian Embassy in Moscow, RF Ministry of Education and Science, and the RF State Corporation for Atomic Energy.

The agenda of the forum covered a wide range of issues related to the main areas of cooperation and priorities of the scientific programme of JINR and Indian institutions and laboratories.

The reports addressed and discussed the studies related to heavy ion relativistic physics in the context of the NICA project (VBLHEP), the synthesis of superheavy elements and nuclear reactions in the framework of the programmes at FLNR, condensed matter physics at FLNP, and neutrino physics in the framework of experimental projects at DLNP. The forum was also successful in recognizing that all spectra of theoretical and mathematical physics research programmes pursued at BLTP have huge potential for close cooperation.

Moreover, all participants, including the plenary speakers, presented their own research at the special seminars and meetings held at various JINR laboratories on 17 and 19 June.

A very important part of the forum was a series of visits of the Indian scientists and guests to the unique experimental facilities of JINR: the Nuclotron-M at VBLHEP, the accelerator complex at FLNR, and the IBR-2 reactor and the spectrometer complex at FLNP.

A round-table discussion was held at the concluding plenary session. It summed up the results of the forum work and made recommendations on further cooperation.

On **26 June**, representatives of the Italian company ASG Superconductors visited JINR. Their group was headed by Chairman of the company Council of Directors V. Giori and Science Attaché of the Italian Embassy in RF Professor P. Fré.

The company ASG develops and produces superconducting magnets. It manufactured the magnet for CMS at the Large Hadron Collider at CERN. Now the company focuses its attention on the mega-project NICA. The issues of developing the magnet for the MPD detector and taking part in joint project activities are under discussion. The detector must identify effectively the products of the nuclei collisions and measure their parameters to study strong interacting matter. The magnet in this set-up is meant to form a homogeneous magnetic field in its aperture and high tracking accuracy.

The equipment for the collider complex NICA will be produced in Russia and abroad. A group of enterprises in the Urals will manufacture vacuum chambers and elements of superconducting magnets. Polish specialists will produce cryostats and vacuum chambers; Slovak specialists are responsible for the power system. The Chinese Institute of Plasma Physics is ready to manufacture HTS-based superconducting cables. The Italian manufacturers of superconducting magnets will discuss prospects of cooperation with the Joint Institute for Nuclear Research on their return home and opportunities to take part in the NICA project.

On **8 July** the JINR Directorate had a meeting with representatives of the Republic of Armenia. The meeting was attended by JINR Vice-Directors M. Itkis and G. Trubnikov, Academician Yu. Oganessian, Head of the JINR International Cooperation Department D. Kamanin, Plenipotentiary of the Government of Armenia to JINR S. Harutyunyan, his Assistants V. Kirakossian and Kh. Kirakossian, and JINR staff members G. Torossian and Eh. Airian. The sides discussed the issues related to a new mechanism of receiving contributions from participating countries, further scientific cooperation, in particular, organization of expert evaluation of scientific projects of Armenia. The participants also discussed the preparation measures for JINR's 60th anniversary and jubilee events in Armenia as a member country of JINR.

Ambassador Extraordinary and Plenipotentiary of Guatemala to RF Mr. Herbert Estuardo Meneses Coronado with his spouse visited Dubna on **10 July**. At a meeting with the JINR Directorate, represented by JINR Vice-Directors M. Itkis and G. Trubnikov, JINR Scientific Leader V. Kadyshevsky, and Head of the JINR International Cooperation Department Dr. D. Kamanin, the guests discussed possibilities of development of the collaboration of universities and scientific organizations of Guatemala with the Joint Institute for Nuclear Research. The guests had an excursion to the DLNP Medico-Technical Complex of proton therapy and the FLNP Sector of Neutron Activation Analysis and Applied Research.

A delegation of the Belarussian State University visited Dubna on **17–18 July**. It included Dean of the Faculty of Physics V. Anishchik, Director of the State Enterprise "Active BSU" V. Hodassevich, and secretary of the Committee on Cooperation between the Republic of Belarus and JINR Yu. Fedotova.

At the JINR Directorate, the guests were received by JINR Chief Scientific Secretary N. Russakovich, Director of the JINR University Centre S. Pakulyak, Head of the JINR International Cooperation Department Dr. V. Kamanin, and Deputy Chairman of the Association of Young Scientists and Specialists M. Nozdrin. Prospects for enhancement of cooperation between JINR and the BSU on educational issues were discussed at the meeting. In particular, there are new prospects for cooperation in the field of education due to the decision on the establishment of the UC Scientific and Engineer-

ing Department. The guests visited the FLNR accelerator complex and educational laboratories of the UC.

The concluding meeting was attended by Dean of the Faculty of Natural and Engineering Sciences of the University "Dubna" A. Denikin. The participants agreed on a visit of a JINR delegation to the BSU in the second half of September to study opportunities to purchase laboratory equipment for JINR educational projects and enlarge the documentary base, regulating cooperation between JINR and the BSU.

A delegation of 15 young scientists from scientific organizations of Armenia, Azerbaijan, Belarus, Kazakhstan, and Moldova visited Dubna on **17–23 September**. Their visit was organized by JINR on the request of the Federal Agency for CIS affairs, compatriots living abroad and international humanitarian cooperation.

On 18 September, the young scientists were received by JINR Director Academician V. Matveev, who talked to the guests about the history, structure and international cooperation of the Institute, large projects under implementation, and important achievements that are acknowledged worldwide. The guests visited the experimental facilities of FLNP, VBLHEP and the UC of JINR, and discussed with UC Director S. Pakulyak the issues of training courses for scientific and engineering staff for the Institute.

The delegation of young scientists also visited the Special Economic Zone "Dubna", met with the administration of the city, visited the University "Dubna", and took part in VI Dubna School of Innovation Management that had a section meeting at the JINR Library named after D. Blokhintsev.

The 172nd session of the CERN Council, which was held on **18–19 September**, unanimously decided to approve the Resolution on the reciprocal granting of Observer status by CERN and JINR.

The Observer status allows non-member states to attend council meetings and to receive council documents, without taking part in the decision-making procedures of the organization. Observer states and organizations currently involved in CERN programmes include the European Commission, India, Japan, the Russian Federation, Turkey, UNESCO, and the USA.

A delegation from the Vietnamese Academy of Sciences and Technology headed by Vice-President of the Academy Professor Duong Ngoc Hai visited JINR on **9–10 October**. The guests were acquainted with the JINR basic facilities and with research which is carried out at JINR laboratories, and discussed with the JINR Directorate prospects for expanding the cooperation. Neutron research, particle physics, and information technology are the three areas in which this cooperation has been traditionally developed. They learned about the UC and intended to use its potentialities to improve skills of their specialists.

A delegation from France consisting of Counsellor for Science and Technology of the French Embassy in Russia A. Michel, Attaché for Science M. Balazard, Coordinator of scientific cooperation C. Lassailly, Coordinator on innovative issues Q. Debetz, and Assistant Counsellor for Science and Technology O. Itkis visited the Joint Institute for Nuclear Research on **30 October**.

The guests visited the construction site of the accelerator complex NICA, the FLNR cyclotron complex, and the IBR-2 reactor at FLNP. A talk in the JINR Directorate was held, where JINR Vice-Director M. Itkis, JINR Chief Scientific Secretary N. Russakovich, Head of the JINR International Cooperation Department D. Kamanin, and DLNP Director V. Bednyakov spoke about joint scientific projects, educational issues, and prospects for associate membership of France to JINR. The sides expressed hope that the two upcoming jubilees — the 60th anniversary of foundation of JINR and the 50th anniversary of establishment of scientific and technical relations between France and Russia — could be important impetus to the promotion of this issue.

Ambassador Extraordinary and Plenipotentiary of Iraq in Moscow Dr. Ismail Shafiq Muhsin visited the Joint Institute for Nuclear Research on **10 November**. He was acquainted with the accelerator complex at the Flerov Laboratory of Nuclear Reactions and development of research on the synthesis and study of superheavy nuclei, with innovative developments of scientists and specialists of the Flerov Laboratory. At the Veksler and Baldin Laboratory of High Energy Physics, the Ambassador of Iraq visited the detector laboratory and the factory of superconducting magnets, where manufacturing of elements for the NICA collider is deployed.

During the meeting with JINR Director Academician V. Matveev, the sides discussed prospects of cooperation in the fields of fundamental science, development of innovative technologies, and educational activities.

On **13 November**, a meeting of JINR national groups' leaders chaired by W. Chmielowski was held. The participants discussed issues of preparation procedure for the meeting of the JINR Finance Committee and the session of the Committee of Plenipotentiaries. They also considered questions of awarding staff members from the Directorate and improvement of their lodging conditions in Dubna.

W. Chmielowski made a suggestion to resume the tradition of joint celebration of Christmas at JINR and acquaint JINR staff members with national traditions of all national groups. Editor-in-chief of the weekly newspaper "Dubna: Science. Community. Progress" E. Molchanov spoke about the editors' plans in preparation for the 60th anniversary of JINR and invited the meeting participants to take part in this work.

A regular session of the Joint Coordinating Committee on RSA–JINR cooperation was held on **13–14 November** in Cape Town (RSA) in the iThemba LABS. The JINR delegation was headed by JINR Chief Scientific Secretary N. Russakovich; Coordinator of RSA–JINR cooperation D. Kamanin, FLNP Director V. Shvetsov, UC Director S. Pakulyak, and the International Cooperation Department member A. Kotova participated in the work of the session. The delegation of the RSA was headed by Deputy Director-General of the Department of Science and Technology T. Auf der Heyde.

The main priorities of cooperation were discussed at the session: heavy ion physics, applied nuclear technology, accelerator technology, theory and simulation, and education. Coordinators from the RSA side for these trends were appointed. New joint projects are scheduled in these and other fields starting in October 2015, after the three-year cycle of current projects expires. The competition for new projects' applications will be held in March–June 2015.

The Committee focused on the educational programme and stressed the growing interest in participation in the UC international student practice. The sides discussed possibilities of more active involving of peripheral universities in cooperation.

During the session of the Committee a standing video conference with Dubna was organized. The UC Director attended for the whole time the Committee's work on the video screen together with S. Mullins, one of the experts coordinating the cooperation in the field of heavy ion physics, who participated at the time in the spectroscopy experiments at the Flerov Laboratory of Nuclear Reactions of JINR.

The Committee endorsed financing of joint projects for the period of 2014–2015 and, in addition to educational issues, took into account the results of the joint competition of ambitious projects of the Russian Foundation for Basic Research and the National Research Foundation of RSA.

A memorial plaque to Yuri Tumanov, an outstanding Russian press photographer, master of scientific photography, and the author of photos that brought fame to the Joint Institute and Dubna, was unveiled on **14 November** at JINR.

Yu. Tumanov started to work for JINR as a professional photographer in 1967. There are thousands of documents on the activities of the international scientific centre in the photo archive of the Institute, and Yu. Tumanov was the author of them.

He had an active stand in life and was a gifted photographer who created portraits of scientists who had founded the Joint Institute for Nuclear Research: D. Blokhintsev, N. Bogoliubov, B. Pontecorvo, V. Veksler, G. Flerov, I. Frank, M. Meshcheryakov, V. Dzhelepov, and many other great physicists, engineers, constructors, and workers involved in fundamental research of the microworld secrets. He conducted photo sessions with highest proficiency, taking photos of most important scientific, methodical or applied studies, new physics facilities and becoming actually one of the researchers. His photo exhibitions were held in many countries of the world. He made a greatest contribution to the development of visual representation of scientific information.

The unveiling ceremony was held by JINR Press Secretary B. Starchenko at the JINR photolaboratory, established and equipped on the initiative and with active personal effort of Yu. Tumanov. The right to unveil the memorial plaque was given to the scientific leader of JINR's Flerov Laboratory of Nuclear Reactions, RAS Academician Yu. Oganessian.

On behalf of the scientific community and all friends of Yu. Tumanov, Academician Yu. Oganessian thanked the JINR Directorate and the initiative group who had developed and installed the memorial plaque for the excellent work. He noted that this was the first step to eternize the memory of the outstanding master of photography.

JINR Director RAS Academician V. Matveev stated that Yu. Tumanov had an unusual, surprising feature: he could show the face of a scientist, a worker, or a man encouraged to do something significant. This is the inspired face, the face of the person.

Head of a group of JINR Polish staff members W. Chmielowski said that Yu. Tumanov was a man not only of Dubna and the Institute but also of all the JINR Member States.

The plaque in the memory of the remarkable master bears the following inscription: "For over 40 years the world saw scientific Dubna through the camera lens of the bright professional".

Ambassador Extraordinary and Plenipotentiary of Romania to the Russian Federation V. Soare with accompanying persons visited JINR on **30 November** and met with the leaders of the Institute and Romanian staff members of JINR. They discussed issues of joint projects, participation in the NICA project, and opportunities for young Romanian specialists to study engineering and other specialties at the JINR UC. The meeting was finished with a concert of a Romanian folk group dedicated to the Great Union Day of Romania celebrated on 1 December.

"International Mega-Science Projects: Growth Points for Fundamental Science and Innovations. Collaboration and Perspectives of Russian and Chinese Mega-Projects" — a scientific forum under this title was held on **3–4 December** in Dubna. It was attended by representatives of the Ministry of Education and Science of the Russian Federation, the Ministry of Science and Technology of China, and scientific centres of Russia, China, Germany, Poland, Italy, and Egypt.

The forum was organized to discuss possibilities of mutually beneficial and mutually enriching ways

and methods of implementation of large-scale research projects in Russia, China, and the European Union. The plenary part of the forum included reports on plans, course of work, prospects and international experience, collaborative efforts in developing of facilities, as well as in solutions of technical problems, exchange of technology, specialists, and practical knowledge.

The participants were informed in detail about two Russian mega-projects in the profound report by director of the National Research Centre "Kurchatov Institute" of the St. Petersburg Nuclear Physics Institute (Gatchina) V. Aksenov on the high-flux beam research reactor PIK and other reports on the status of the accelerator complex NICA (JINR, Dubna) that included the main concept, the accomplished work, further plans, integration of ideas by theoretical physicists for studies of the baryonic matter, and special features and advantages of new techniques.

The contacts with Chinese scientists which attracted the main attention of the forum participants drew the interest of not only the JINR scientists but also of European leaders. The forum continued its work as a round-table discussion where participants could consider the issues of mega-projects in science in more detail. The forum concluded with signing a Protocol of Intent.

CONFERENCES AND MEETINGS HELD BY JINR

Fourteen conferences were the largest among the scientific conferences and workshops held at JINR in 2014.

On 3–8 February, JINR hosted the 21st international conference ***"Mathematics. Computer. Education"*** (MCE). This interdisciplinary conference is held annually on a regular basis during winter students' holidays alternately in scientific centres nearby Moscow, Dubna, and Pushchino.

The conference was organized by the JINR Laboratory of Information Technologies, the International University of Nature, Society and Man "Dubna", the Lomonosov Moscow State University, the Scientific Centre of RAS in Pushchino, the Keldysh Institute for Applied Mathematics (Moscow, RAS), the MSU Centre of National Intellectual Reserve, the foundation "National Intellectual Development", as well as the interregional public organization "Women in Science and Education".

The conference was opened with a bright report "The history and scientific development programme of the Joint Institute for Nuclear Research" delivered by JINR Vice-Director R. Lednický, a renowned expert in high energy physics. The Chairman of the Organizing Committee of the conference, MSU Professor G. Riznichenko, spoke about the history of the MCE conferences, the journal "Computer Studies and Simulations", and a programme of the current conference. Director of the Institute of System Analysis and Management of the University "Dubna" Professor E. Cheremisina delivered a lecture on the modern state and development prospects of the Institute. The report "General Educational Programmes of the JINR UC" was made by its Director S. Pakulyak. In the evening, Professor R. Pose, a well-known specialist in the field of experimental physics of elementary particles and computer science, JINR veteran and a full member of the European Academy of Sciences, told the conference participants about the history of JINR, the remarkable scientists who founded this unique international scientific institute, and about their outstanding discoveries.

The second day of the conference was unique in its own way. At the plenary session, latest scientific achievements were presented by the directors of four JINR laboratories: V. Shvetsov (Frank Laboratory of Neutron Physics), V. Korenkov (Laboratory of Information Technologies), V. Bednyakov (Dzhelepov Laboratory of Nuclear Problems), and E. Krasavin (Laboratory of Radiation Biology). Great interest of the conference attendees was attracted by the report on the NICA mega-project delivered by JINR Vice-Director G. Trubnikov. Professor V. Nikitin's lecture entitled "Physics of fundamental particles of matter — a bird's eye view" was ingenious and cognitive.

The following days were remembered due to the brightest reports delivered by K. Anokhin (NRC "Kurchatov Institute"), Corresponding Member of RAS and RAMS, about achievements of cognitive science, as well as by B. Chetverushkin, Director of the Keldysh Institute of Applied Mathematics, Academician of the Russian Academy of Sciences, who spoke about high-performance computing.

The conference sections, poster sessions, and master classes were accompanied by lively scientific discussions on the issues of mathematical simulation in different scientific areas. Traditionally for the MCE conferences, presentations and discussions of research projects developed by high-school students within the FOROS project were organized at the International University of Nature, Society and Man "Dubna". The students came from Moscow, the Moscow Region, and the cities of Tver and Izhevsk. A television space bridge was organized.

The 21st international conference "Mathematics. Computer. Education" was closed at the final plenary session which summed up and discussed plans for the subsequent conferences. The participants expressed

their profound gratitude to the organizers for the high scientific level and hospitality.

On 24–28 February the ***18th International Scientific Conference of Young Scientists and Specialists of JINR*** was held at the Bogoliubov Laboratory of Theoretical Physics. It was dedicated to the 105th anniversary of the birth of N. Bogoliubov. It gathered over 150 students, postgraduates, scientists from JINR and Russian and foreign universities and institutes.

The programme of the conference included lectures by leading staff members of the Laboratory in mathematical and theoretical physics that discussed the development of ideas by the great physicist and mathematician, and regarded the modern status of theoretical models and experimental results. The participants watched the video of the presentation delivered by D. Shirkov "N. Bogoliubov. Life Lessons" and a video film about the famous scientist, produced at JINR.

The participants of the conference presented their reports in nine plenary sections, traditionally working during the event. For the first time a poster section was organized where 11 papers were presented.

An extensive sports programme was organized for the participants in the evening: archery, airgun rifle shooting, table tennis, basketball, football, climbing wall, bowling, and billiard. Excursions to the IBR-2 reactor, VBLHEP and FLNR accelerators were organized; the Dubna philarmonic orchestra and a young soloist Masha Andreeva gave a concert for the participants.

A traditional competition for the JINR Prize for young scientists and specialists was organized in the framework of the conference. The laureates of 2013 were: V. Katkov, I. Rakhmonov (First Prize), A. Bezbakh (Second Prize), and E. Koval (Encouraging Prize) in the nomination "Theoretical Scientific Research"; S. Merts (First Prize), R. Eremin (Second Prize), and G. Kozlov (Encouraging Prize) in the nomination "Experimental Scientific Research"; N. Shurkhno (First Prize), I. Zinicovscaya (Second Prize), and A. Baranov (Encouraging Prize) in the nomination "Applied Scientific Research".

The ***22nd International Seminar on Interaction of Neutrons with Nuclei*** (ISINN) took place in Dubna on 27–30 May. Dubna hosted the participants of ISINN after a two-year break during which the seminar was held in Alushta. This time it was attended by more than 120 participants from 18 countries, including Algeria, India, Iran, the Republic of South Africa, and Vietnam. The Russian participants traditionally represented IPPE (Obninsk), PNPI (Gatchina), NRC "Kurchatov Institute" and ITEP (Moscow), State Universities of Tula, Kaliningrad, and Ivanovo. The JINR employees of FLNP, FLNR, DLNP, and VBLHEP also took an active part in the meeting.

The scope of this year's seminar was very diverse, ranging from fundamental problems to applied aspects of neutron physics, such as neutron activation analysis, transmutation of radioactive wastes, and methodological problems of conducting experiments. At the opening of the seminar, FLNP Director V. Shvetsov said, "ISINN is a meeting place for physicists who need not necessarily report their final results, it is a forum for researchers to discuss and exchange ideas, to show their results, preliminary though they may be, to get friendly advice, and sometimes to hear some critical remarks".

A large number of ISINN-22 sessions were concerned with the applied problems of neutron physics. The review reports on the applied research topics were presented by the frequent participants of ISINN Professor E. Steinnes (Norway), O. Duliu (Romania), and M. Frontasyeva (JINR).

A significant amount of time was allocated for nuclear analytical methods in life sciences — ecology, biology, and medicine. The number of the participants concerned with these topics (from India and the Republic of South Africa to the European countries) was no less than that at the traditional ISINN sessions on nuclear and physical problems. The participants of the section visited the REGATA facility on the IBR-2 reactor as well as the chemical laboratory. The guests had an opportunity to acquaint themselves with the working conditions and the neutron activation analysis automation system. In between the sessions, new projects with the Republic of South Africa, the Republic of Korea, and India were discussed.

About 50 oral contributions and approximately the same number of posters were presented during the seminar.

Two sessions were devoted to the already traditional problem of using accelerator-driven systems (ADS) for transmutation of radioactive wastes with simultaneous generation of useful power. The young researchers from JINR, Bulgaria, Ukraine, and Iran reported the latest experimental data and the results of the analysis obtained by the international collaboration "Energy + Transmutation", working on the basis of the JINR VBLHEP Nuclotron. Noteworthy also was the report on a molten salt ADS option made by the employee of the NRC "Kurchatov Institute" V. Nevinnitsa.

Z. Gholamzadeh (Iran) spoke about the results of simulation of "incineration" of minor actinides in specific accelerator-driven systems. She presented the theoretical calculations of transmutation of americium and neptunium — the products which are formed as radioactive wastes in nuclear reactors.

The unusually large number of young participants was a pleasant surprise and a distinctive feature of ISINN-22. The IPPE (Obninsk) alone delegated as many as five physicists who only begin to carve their way in science. Many young specialists arrived from other JINR Member States. On the whole, the ISINN traditions were maintained — a democratic and friendly atmosphere, which is always enjoyable (even despite the rain) with a picnic and new scientific contacts. The

seminar was held with the traditional support of the Russian Foundation for Basic Research.

The cycle of international seminars ***"Quarks"*** dwells with issues of modern field theory, elementary particle physics, astrophysics, and cosmology. Traditionally, the seminars are held every other year and organized by the RAS Institute for Nuclear Research.

The 18th seminar "Quarks-2014" was for the first time organized jointly by INR RAS and JINR. Uniting the efforts of the two centres today made it possible to hold this scientific event on a high level. Academicians V. Matveev and V. Rubakov were Co-Chairmen of the seminar Organizing Committee. It was held on 2–8 June in the Russian ancient city Suzdal. Scientists of the world's leading scientific centres took part in it. A considerable delegation represented Dubna, and its members made reports practically on all the main topics of the seminar agenda: cosmology and astrophysics, and their connection to particle physics; particle physics beyond the Standard Model: particle interactions at colliders, rare processes, phenomenology of the Higgs boson, exotic models; modern quantum field theory, strong-coupling theories' dynamics; modern problems of mathematical physics; neutrino physics, neutrino oscillations; quantum chromodynamics, strong interactions; space rays of superhigh energy; and selected experimental results.

The ***2014 European School of High-Energy Physics*** (formerly the CERN–JINR School of Physics) was held from 18 June to 1 July in the village of Garderen (the Netherlands). The school was jointly organized by CERN, JINR, and Nikhef (the Netherlands).

The lectures covered a broad range of HEP topics at a level suitable for students working for a PhD in experimental particle physics.

The scientific programme of the school included the following trends: particle physics and cosmology; future prospects for LHC physics; theory outlook; flavour physics and CP violation; field theory and the electroweak Standard Model; QCD; neutrino physics; Higgs physics; heavy-ion physics; SUSY; practical statistics for particle physicists; and physics beyond the Standard Model.

There were discussion sessions most afternoons during the school. The discussion leaders were: P. Artoisenet (Nikhef, the Netherlands); A. Bednyakov (JINR); C. Delaunay (LAPTh, France); A. Gladyshev (JINR); C. Pisano (Nikhef, the Netherlands); and K. Schmidt-Hoberg (CERN). All students were encouraged to present and discuss their work at poster sessions and took an active part in the school events.

The international conference ***"Distributed Computing and Grid-Technologies in Science and Education"*** was held at the Laboratory of Information Technologies on 30 June – 5 July. The conference was the sixth one organized by LIT since 2004. It should be noted that the conference has become a unique Russian forum for the discussions of a wide range of questions connected with the use of distributed and grid-technologies in different fields of science, education, industry and business, and results.

Financial support was provided by the Joint Institute for Nuclear Research and the sponsors and partners: Supermicro Computer, NIAGARA, Quantum, Jet infosystems, IBM, and PARALLEL.RU.

The conference was attended by more than 200 participants from the scientific centres of Armenia, Belarus, Bulgaria, the Czech Republic, France, Hungary, Mongolia, Romania, Slovakia, South Africa, the USA, etc. Russia was represented by participants from more than 30 universities and research centres. Within the conference, there were organized eight sections, which included discussions on the current and future role of grid-technologies, cloud technologies, Big Data in the models of computing for mega-projects, such as NICA and FAIR. During the conference, there was also held a meeting "Computing Models, Software and Data Processing for the Future HENP Experiments".

The programme of the conference included plenary reports of well-known specialists in the field of distributed computing.

The opening of the plenary programme was made by the LIT Director V. Korenkov with the report on the current situation and perspectives of the development of the Laboratory. A special emphasis was made on the development of Grid infrastructure including the development of Tier-1 centre, the development of computing for the NICA mega-project, the development of a heterogeneous computing system at the Laboratory and other projects.

Within the conference there was held a tutorial on parallel programming technologies. Participants from Mongolia, Romania, and Russia listened to the lectures on the following technologies: MPI, OpenMP, CUDA, and OpenCL. The practical trainings were held on the basis of the heterogeneous computing cluster HybriLIT (http://hybrilit.jinr.ru/).

During the meetings and discussions within the conference, there were considered many questions, suggested promising projects aimed at the extension of LIT collaboration with organizations and universities of Russia and JINR Member States.

Presentations, a book of abstracts in electronic form and photos are available at the site of the conference: http://grid2014.jinr.ru.

On 11–16 August, for the first time in Dubna, the ***33rd Russian Cosmic Rays Conference*** was held at the Laboratory of Information Technologies. It was organized by JINR, SRINP MSU, the Scientific Council on the comprehensive problem "Cosmic Rays", and the University "Dubna". About 200 scientists from all scientific institutes and universities of Russia involved in

various studies of the problem of cosmic rays took part in it, together with specialists from CIS countries and Europe.

The scientific programme of the conference included a wide range of urgent problems related to cosmic rays research: direct ground measurements and theory (nuclei, electrons, gamma rays); muons and neutrinos; solar cosmic rays; galactic cosmic rays modulations; geophysical effects of cosmic rays and their influence on the climate. The meetings were held in the form of plenary sessions and poster sections. The invited reports from JINR were delivered by O. Rogachevsky (VBLHEP), on the physics programme at the NICA accelerator; G. Ter-Akopyan (FLNR), on the synthesis and search for superheavy elements in nature and cosmic rays; B. Shaibonov (DLNP), on the status of the Baikal neutrino experiment; and by A. Olshevsky (DLNP), on neutrino research at JINR.

On 25–29 August the Joint Institute for Nuclear Research, under the auspices of the National Committee of the Society for Industrial and Applied Mathematics (SIAM), the International Coordinating Committee for Computational Mathematics of the CIS Academies of Sciences hosted the international conference for young scientists ***"Modern Problems of Applied Mathematics and Computer Science" (MPAMCS'2014)***.

The conference was organized by the Keldysh Institute for Applied Mathematics of RAS, JINR's Laboratory of Information Technologies, the Institute of Computational Mathematics of RAS, and the Research Computer Centre of MSU.

The conference was attended by participants from Russia, Belarus, Tajikistan, Armenia, Mongolia, Slovakia, and Ukraine. Russia was presented by participants from JINR, the University of Nature, Society and Man "Dubna", Moscow State University, MSU Research Computer Centre, the Keldysh Institute for Applied Mathematics of RAS, Moscow State University of Wood, the National Research Nuclear University "MEPhI", NRC "Kurchatov Institute", the Dorodnicyn Computer Centre of RAS, Moscow Physico-Technical Institute, the Institute of Computational Mathematics of RAS, St. Petersburg State University, Voronezh State University, the Sobolev Institute of Mathematics of the Siberian Branch of the Russian Academy of Sciences (SB RAS), the Trofimuk Institute of Oil-and-Gas Geology and Geophysics of SB RAS, the People's Friendship University of Russia, the Vernadsky Taurian National University, etc.

The total number of the conference participants was 132, with 108 people being students, postgraduates, and young scientists under 35 years of age (more than 80%). Two Academicians, two Corresponding Members of RAS, 21 Doctors and 12 Candidates of Science took part in the conference.

The reports presented covered a wide range of actively developing areas of applied mathematics, such as application of distributed and high-efficiency calculations for solving applied tasks. This is connected with the development of new methods and algorithms as well as the parallel programming technologies that allow one to perform computations on new computing architectures.

At the opening of the conference the JINR Chief Scientific Secretary Professor N. Russakovich, LIT Director Professor V. Korenkov, and Deputy Director of the Keldysh Institute for Applied Mathematics of RAS Professor A. Afendikov extended their greetings to the participants.

A course of studies "Parallel Programming Techniques" was organized in the framework of the conference. It included lectures and tutorials given by LIT specialists on the parallel programming with heterogeneous computing systems. The tutorials were carried out on the heterogeneous cluster HybriLIT just put into operation (http://hybrilit.jinr.ru/) which is a constituent part of the JINR Central Information Computing Complex. Each student of the course got a temporary access to the cluster.

A total of 18 lectures and plenary reports were presented. The young scientists, students, and postgraduates delivered 55 oral and 12 poster reports.

The conference for young scientists MPAMCS'2014 provided a way for young scientists to get acquainted with present-day methods and approaches to solving problems of science and technology with the help of high-performance computing systems, with methods of developing large program complexes, modern parallel programming techniques as well as with the latest achievements in the field of exaflops computations and Big Data.

The best reports presented by young scientists will be published in the journal "Mathematical Modeling". The conference materials are available at http://mpamcs2014.jinr.ru/.

The international symposium on one of the most important and most actively developing fields of nuclear physics — physics of exotic states of nuclei, **EXON 2014**, was held on 8–13 September in Kaliningrad (Russia). The event was organized by five largest scientific centres where this trend is successfully studied. These are the Joint Institute for Nuclear Research in Dubna, the National Centre GANIL (France), the Research Centre RIKEN (Japan), the Scientific Centre on Heavy Ion Physics GSI (Germany), and the Laboratory of Superconducting Cyclotrons (Michigan, the USA). The leading scientists of these scientific centres — RAS Academician Yu. Oganessian (JINR), Professors F. Staley (GANIL), H. Enio (RIKEN), H. Stoecker (GSI), and K. Gelbke (USA) — were Co-Chairmen of the symposium Organizing Committee.

Scientists from 24 countries took part in EXON 2014. Most representative delegations were from Germany (10 persons), France (12 persons), Japan

(10 persons), and the USA (8 persons). Scientific centres in these countries are interested in cooperation with JINR and scientific centres of Russia, which were represented by 28 participants.

Scientists are successful in obtaining nuclei in extreme conditions — the nuclei that have a big angular momentum ("violently" spinning nuclei), high excitation energy ("hot" nuclei), heavily deformed nuclei (super and hyper deformation, nuclei with unusual form configuration), nuclei with abnormally large number of neutrons or protons (neutron-rich and proton-rich nuclei), and superheavy nuclei with proton number $Z > 110$. Studies of nuclear matter properties in extreme conditions give important information about the properties of the microworld and allow simulation of various processes that occur in the Universe.

The scientific programme of the symposium included invited reports on urgent trends of physics of exotic nuclei and new projects at largest accelerator complexes and experimental facilities. In addition, round-table discussions were organized where leading scientists of various scientific centres of the world exchanged their views on cooperation in fundamental physics and applied research.

The results of the latest experiments on the synthesis and study of nuclei properties of new superheavy elements were discussed at the symposium. The discovery of new superheavy elements shows that international collaborations are very efficient. Interesting results were obtained in joint research by JINR FLNR – GSI (Germany) – the Scherrer Institute (Switzerland) in experiments on chemical identification of elements 112 and 114 at the beams of the U-400 cyclotron of FLNR. A bright example of successful cooperation is also the experiment on the synthesis of element 117, in collaboration with scientists from American laboratories who provided the target stuff ^{249}Bk, held at the JINR FLNR cyclotron by a big group of physicists and chemists under the guidance of RAS Academician Yu. Oganessian.

The symposium was held by the Kant Baltic Federal University which is well known for training staff of the highest qualification and organization of joint scientific research. A separate day in the symposium agenda was devoted to present and future accelerator complexes for heavy ions and radioactive nuclei in leading scientific centres of the world — a new generation of accelerators developed at the laboratories that are co-organizers of the symposium, which will allow further advancement in the synthesis and studies of the properties of new exotic nuclei. These projects are SPIRAL, RIKEN RI Beam Factory, FAIR, DRIBs, NICA, and RIB, which were reported at the symposium by their supervisors.

About 80 oral presentations were delivered and 40 poster reports displayed. They will be published in a regular issue of Proceedings of the international symposium EXON.

The 11th international conference ***"Quark Confinement and the Hadron Spectrum"***, a regular event held every other year in different countries, was held on 8–12 September in Saint-Petersburg. It was organized by Saint-Petersburg State University, the National Research Centre "Kurchatov Institute" (Moscow), the Joint Institute for Nuclear Research (Dubna), the Konstantinov Petersburg Nuclear Physics Institute (PNPI SRC KI, Gatchina), and Munich Technical University (Germany).

For the past 20 years the conference has become one of the most representative world forums on physics of strong interactions and related fields. In 2014 it was held for the first time in Russia. Three hundred Russian and foreign scientists took part in it. JINR staff members worked in the Organizing Committee and were members of the International Programme Committee. They headed the work of two out of seven sections, defined the topics and lists of invited speakers.

About 30 plenary reports were given during five days of the conference, and four round-table discussions on urgent problems in modern science were held. Ninety reports were made at seven parallel sections, and 60 reports were presented at a special poster session of the conference.

The plenary reports were reviews and their topics were scheduled for different days. The first day of the conference was devoted to new results at the Large Hadron Collider (LHC) at CERN and hadron spectroscopy.

The second day of the conference was devoted to more traditional fields of QCD. The round-table discussion of that day was devoted to opportunities of lattice measurements in hadron phenomenology and low energy physics (and unsolved problems).

On the third day of the conference, QCD at non-zero temperature and chemical potential, quark–gluon plasma, heavy-ion collisions, and other issues were discussed.

The reports given on the fourth day of the conference were more specialized and given at seven sections: vacuum structure and quark non-confinement; light quarks; heavy quarks; deconfinement and QCD phase diagram; strongly coupled field theory; nuclear physics and astrophysics; QCD and new physics.

On the whole, the level of the conference was very high, and the participants' set was quite impressive. Both Russian and foreign participants noted the excellent organization of the event and hospitable atmosphere of Saint-Petersburg.

The majority of the reports given at the conference can be accessed at https://indico.cern.ch/event/287920/timetable/#20140908.

The traditional XXII international Baldin seminar on high-energy physics problems ***"Relativistic Nuclear Physics and Quantum Chromodynamics"*** was held

from 15 to 20 September at the Joint Institute for Nuclear Research. Among scientists this seminar is called "the Baldin autumn". It has been held every two years since 1969. It should be stressed that lately the interest in the seminar has grown. For the first time (of the eight conferences on high energy physics held in 2014) the seminar was supported by IUPAP Committee. JINR Director Academician V. Matveev opened the seminar, and Professor V. Kekelidze (JINR), on behalf of section C11 IUPAP, wished the event every success.

The seminar was attended by more than 200 participants from 17 countries, practically from all leading centres of high energy physics in the world. 160 reports were delivered. The audience expressed much interest in those reports that discussed the results obtained at the Large Hadron Collider (LHC) at CERN. More interest was shown in the studies of the cumulative effect that was predicted by A. Baldin and discovered at the Laboratory of High Energies of JINR in the early 1970s. A large number of reports discussed this phenomenon at the seminar. It should be mentioned that experiments on the research of cumulative reaction at high energy are held at ITEP (Protvino) and new experiments are planned for the future to conduct even deeper studies of the properties of fluctuons in nuclei (the FLUKTON project). Traditionally, many reports dwelt with studies of structure functions of hadrons and nuclei, relativistic theory of nucleon–nucleon interactions, search for quark–gluon plasma signatures, modern interpretation of experimental data obtained in recent years at various physics centres.

Relativistic nuclear physics opens up big opportunities in applied research. Many of the results of these studies are widely used in medicine and engineering. But there are a lot of questions that invite further investigation. For example, the studies related to safe nuclear energy issues and disposal of radioactive waste applying accelerator nuclear beams are also of great interest. A special section of the seminar discussed these issues of applied research. For the first time an online session was held at the seminar where the speakers in the USA presented the results of the D0 (FNAL) experiment. Live internet broadcasting of the meetings was organized. Professor A. Malakhov made a report that developed the ideas of A. Baldin. Of special note is the fact that the predictions made by A. Baldin more than 15 years ago on the asymptotic behaviour of nuclear interactions at high energies are well proved now. For example, the experimental data on the ratio of the antiproton–proton output obtained at the LHC at the energy up to 7 TeV excellently matched the curves obtained earlier in the studies of A. Baldin and his colleagues.

Academician Yu. Oganessian made a concluding report on the search for superheavy elements. The reports presented are available at the site of the seminar (http://relnp.jinr.ru/ishepp/index.html).

On 29 September – 3 October the international conference ***"Structure and Functions of Biomembranes"*** was held at the Moscow Institute of Physics and Technology (MIPT). It was devoted to the research in the field of biomembranes and membrane proteins. The conference was organized jointly by MIPT and JINR. Staff members of JINR's Frank Laboratory of Neutron Physics took an active part in its work.

Research on biological membranes occupies a central position in cellular and molecular biology. Biomembranes form very complex, dynamic, and heterogeneous structures critical for cellular function. Membrane proteins are involved in transport of ions and nutrients, signal transduction and energy conversion, and their malfunctions often result in numerous serious diseases, such as Alzheimer's or Parkinson's. That leads to the fact that the main bulk of modern drugs target these proteins, emphasizing their crucial value for pharmacology and medicine. Biological membranes are also a focus of intense investigations in soft matter and theoretical physics, as methods for X-ray analysis, electron microscopy, mass spectrometry, fluorescent microscopy, and others are developed for the studies.

Specialists from all over the world discussed new issues and tasks in the research of biomembranes. The topics of reports were the mechanisms of processes in membrane cells, methods to study these processes, their role in aging of the organism and generation of various diseases, and development of drugs. Among the main speakers were: E. Bamberg of the Max Planck Institute of Biophysics (Germany), R. Stevens of the Skripss Research Institute (USA) and iHuman Institute (China), G. Büldt of MIPT and Jülich Research Centre (Germany), N. Dencher of Darmstadt Technucal University, and others. A separate programme was organized for young scientists.

On 20–24 October, the fifth school on information technologies ***"Grid and Advanced Information Systems"*** was held under the auspices of the Joint Institute for Nuclear Research, the European Organization for Nuclear Research, and the National Research Nuclear University "MEPhI". The organizers were the Laboratory of Information Technologies of JINR, a group of Advanced Information Systems at CERN General Infrastructure Services Department, and the National Research Nuclear University "MEPhI".

The goal of the school was to share the knowledge gained and expanded at JINR and CERN in the field of modern information technologies, attracting and preparing students to work in this field.

The school was devoted to the management of scientific complexes and information systems, using the technologies developed at JINR and CERN as an example. This year the list of participating universities has been extended. In total, students from 12 leading universities were invited. The newcomers were Saint-Petersburg State University, the Lomonosov Moscow State Uni-

versity, the Lobachevsky State University (Nizhni Novgorod), the Peoples' Friendship University of Russia, the Plekhanov Russian University of Economics, and Tver State University. Traditionally, among the participants were students of the National Research Nuclear University "MEPhI", the Bauman Moscow State Technical University, the Moscow Power Engineering Institute, and "Dubna" University, as well as students from Slovakia (Pavol Jozef Šafárik University in Košice) and Georgia (Tbilisi State University). The school was opened by JINR Vice-Director G. Trubnikov, LIT Director V. Korenkov, President of the "MEPhI" University B. Onykiy, and co-chairman and co-founder of the school D. Mathieson. The participants heard lectures on database, cloud computing, digital library, grid technologies, software development, the NICA accelerator complex, Tier-1 in Dubna, etc. The lectures were delivered by the leading specialists from JINR and CERN.

The CERN organizers held a competition among the school attendees. At the beginning of the school a task was presented. The students were supposed to work and accomplish it throughout the week. K. Korepanov (the Bauman Moscow State Technical University) was one of the best who coped with the task. A second place was given to the team of Tver State University, and a third one went to the "Dubna" University team. At the end of the school the winners were awarded with prizes.

The international symposium ***"70th Anniversary of the Discovery of the Phase-Stability Principle"*** was held on 10–15 November in Dubna, at the Veksler and Baldin Laboratory of High Energy Physics. It was organized by JINR and the Lebedev Institute of Physics. Co-Chairmen of the symposium Organizing Committee were RAS Academicians G. Mesyats and V. Matveev — the directors of the institutions where V. Veksler worked at the time of publication of his basic papers and his leadership of the construction and launch of the largest proton accelerator in the world — the 10 GeV synchrophasotron. The phase-stability principle allowed widening the area of application of the resonance method for charged particles acceleration. It solved the problem of retaining the accelerated particle's motion stability at relativistic increase of its mass, led to the development of new classes of accelerators, such as electron, proton, and ion synchrotrons, and resonance linear accelerators of light and heavy charged particles of high energy. The majority of the studies accomplished with the application of beams from accelerators that operate on the basis of the Veksler–McMillan principle bring about new knowledge in the physics of the microworld, discoveries of new particles and laws of their interactions, checking principles and symmetries.

The first symposium was held 20 years ago, when the scientific community celebrated the 50th anniversary of the phase-stability principle. It was also organized by JINR and the Lebedev Institute of Physics of RAS. Much progress has been achieved for the two decades in the development of new scientific complexes on the basis of high-energy accelerators, and important scientific data have been obtained. The brightest achievement in this field is, without doubt, the LHC complex and the experimental proof of the existence of the Higgs boson. Academician V. Matveev spoke about this breakthrough in his introductory report at the opening ceremony. Professor L. Evans (CERN) devoted his report "The Long Road to the LHC" to the history of development of the Large Hadron Collider.

The programme of the symposium included only invited reports, so it was possible to evaluate the progress dynamics at leading scientific centres and priorities in their scientific programmes. In particular, the experimental programmes at the Tevatron (Batavia, USA) and HERA (DESY, Germany) had been completed, having greatly contributed to the development of physics and technology of superconducting synchrotrons/colliders.

FAIR (Darmstadt, Germany) and NICA (JINR, Dubna) are among the most advanced projects of future accelerator complexes of heavy ions and polarized particles (antiprotons, protons, and deuterons).

A number of memorial reports were delivered. B. Bolotovsky, I. Savin, V. Nikitin, and V. Glagolev spoke about their personal reminiscences about V.Veksler and made reviews on research results at PI RAS, JINR, and CERN related to the involvement and the name of Academician V. Veksler.

Important events of the symposium that were in a way the conclusions of its work were the consideration of the proposal to develop a future collider complex at the proton energy 2–50 TeV, the status of the CLIC and ILC projects in the report by D. Schulte (CERN) and signing of the Protocol of Intentions on the participation of JINR in the work-out of the conceptual project FCC (Future Circular Collider).

PARTICIPATION OF JINR IN INTERNATIONAL CONFERENCES

In 2014, scientists and specialists of the Joint Institute for Nuclear Research took part in 373 international conferences and meetings.

The largest delegations representing JINR attended the following events: the 3rd JUNO Meeting (Kaiping, China); the Compact Linear Collider (CLIC) Workshop 2014 (Geneva, Switzerland); seminars and discussion sessions "Halo Physics at the Neutron Drip Line" (EMMI programme) (Darmstadt, Germany); the HADES Collaboration Meeting (Munich, Germany);

the seminar "Giant Dipole Resonance. Results and Perspectives" (Moscow, Russia); the 17th International Moscow School of Physics — the 42nd ITEP Winter School of Physics (Otradnoe, Russia); the 32nd Max Born symposium "Three Days of Phase Transitions in Compact Stars, Heavy-Ion Collisions and Supernovae" (Wroclaw, Poland); the 6th International Conference on Fusion (FUSION14) (New Delhi, India); the 48th PNPI Winter School (Roshchino, Russia); the 48th PNPI School on Condensed Matter Physics (Zelenograd, Russia); the seminar "Topology in Space of Impulses: From Elementary Particle Physics to Superconductivity at Room Temperature" (Moscow, Russia); the Scientific Session of the RAS Branch of Physical Sciences dedicated to the 100th anniversary of the birth of Academician Ya. Zeldovich (Moscow, Russia); the 23rd CBM Collaboration Meeting (Darmstadt, Germany); the 7th International Conference on Polynomial Computer Algebra (PCA 2014) (St. Petersburg, Russia); the all-Russian conference "Information and Telecommunication Technologies and Mathematical Modelling of High-Tech Systems" (Moscow, Russia); the 4th International Conference on Superconductivity and Magnetism (ICSM2014) (Antalia, Turkey); the 4th International Workshop on Numerical Modelling of High Temperature Superconductors (Bratislava, Slovak Republic); the 17th International Radiochemical Conference (Marianske Lazne, Czech Republic); the 11th international spring seminar on nuclear physics "Shell Model and Nuclear Structure: Achievements of the Past Two Decades" (in honour of Aldo Covello) (Ischia, Italy); the 26th Rencontres de Blois on "Particle Physics and Cosmology" (Blois, France); the NEMO3 and SuperNEMO Collaboration Meeting (Orsay, France); the 24th Quark Matter Conference (Darmstadt, Germany); the Russian forum "Siemens PLM Connection" (Moscow, Russia); the 17th International Seminar on Neutron Scattering Investigation in Condensed Matter (Poznan, Poland); the ECT Workshop on Low-Energy Reaction Dynamics of Heavy Ions and Exotic Nuclei (Trento, Italy); the 44th International Tulinov Conference on Charged Particle Interaction with Crystals (Moscow, Russia); the 13th International Conference on Meson Production, Properties and Interaction (MESON 2014) (Cracow, Poland); the International Workshop on Radiation Effects in Insulators and Non-metallic Materials (REINM-2014) (Astana, Kazakhstan); the International Conference on Technology and Instrumentation for Particle Physics (TIPP 2014) (Amsterdam, Netherlands); the 2nd Annual International Conference on Large Hadron Collider Physics (LHCP-2014) (Brookhaven, USA); the 26th International Conference on Neutrino and Astrophysics (Neutrino 2014) (Boston, USA); the 7th International Conference and School on Particle Physics (Pomorie, Bulgaria); the 4th International Workshop on Transverse Polarization Phenomena in Hard Processes (Cagliari, Italy); the 5th International Particle Accelerator Conference (IPAC 14) (Dresden, Germany); the international school on subnuclear physics "Status of Theoretical Understanding and of Experimental Power for LHC Physics and Beyond" (Erice, Italy); the international conference "Hadron Structure and QCD: From Low to High Energies" (HSQCD 2014) (Gatchina, Russia); the 15th Russian Gravitational Conference — the International Conference on Cosmology and Astrophysics (RUSGRAV-15) and the International School on Gravitation and Cosmology (GRACOS-2014) (Kazan, Russia); the 10th International Vacuum Electron Sources Conference (IVESC-2014), the 2nd International Conference on Emission Electronics (ICEE), the International Conference on Computer Technologies in Physical and Engineering Applications (ICCTPEA), and the International Symposium on Beam Dynamics and Optimization (BDO) (St. Petersburg, Russia); the 37th International Conference on High Energy Physics (ICHEP 2014) (Valencia, Spain); the 16th GDRE workshop "Heavy Ions at Relativistic Energies" (Nantes, France); the 25th International Cryogenic Engineering Conference (ICEC 25) and the International Cryogenic Materials Conference (ICMC 2014) (Enschede, Netherlands); the 59th Annual Conference of the South-African Institute of Physics (Johannesburg, South Africa); the Advanced Physics Training Course for Students (Prague, Czech Republic); the 9th international workshop "Strong Microwaves and Terahertz Waves: Sources and Applications" (Nizhni Novgorod, Russia); the international conference "Quantum Field Theory and Gravitation" (QFTG'14) (Tomsk, Russia); the 17th International Conference on Textures of Materials (ICOTOM 17) (Dresden, Germany); the 21st International Workshop on ERC Ion Sources (Nizhni Novgorod, Russia); the 20th Particles and Nuclei International Conference (PANIC2014) (Hamburg, Germany); the Zakopane Conference on Nuclear Physics (Zakopane, Poland); the 27th Linear Accelerator Conference (LINAC14) (Geneva, Switzerland); the 2nd International Symposium on Optics and Its Applications (Yerevan, Ashtarak, Armenia); the 16th International Workshop on Computer Algebra and Scientific Computing (CASC'2014) (Warsaw, Poland); the 24th CBM Collaboration Meeting (Cracow, Poland); the International Workshop on Diffraction in High-Energy Physics (DIFFRACTION 2014) (Primosten, Croatia); the International Conference on Exotic Atoms and Related Topics (EXA2014) (Vienna, Austria); the Scientific Workshop on Nuclear Fission Dynamics and the Emission of Prompt Neutrons and Gamma Rays (Opatija, Croatia); the German Conference for Research with Synchrotron Radiation, Neutrons and Ion Beams at Large Facilities (SNI 2014) (Bonn, Germany); the 10th International Conference on Physics of Advanced Materials (Iasi, Romania); the international workshop "Compact Stars in the QCD Phase Diagram" (Prerow, Germany); the 9th International Conference on Nuclear Physics at Storage Rings (STORI'14) (St. Goar, Germany); the 17th in-

ternational conference and school "Foundations and Advances in Nonlinear Science" and the 2nd international symposium "Advances on Nonlinear Photonics" (FANS&ANPh 2014) (Minsk, Belarus); the 21st Conference of the International Collaboration on Advanced Neutron Sources (ICANS XXI) (Mito, Japan); the 16th Small Triangle Meeting on Theoretical Physics (Pticie, Slovak Republic); the 10th World Conference on Neutron Radiography (Grindelwald, Switzerland); the 24th Russian Particle Accelerators Conference (RuPAC-2014) (Obninsk, Russia); the National Scientific Conference on Physics — Plovdiv 2014 (Plovdiv, Bulgaria); the 4th international conference "Engineering of Scintillation Materials and Radiation Technologies" (ISMART 2014) (Minsk, Belarus); the 21st International Symposium on Spin Physics (Spin 2014) (Beijing, China); the 7th Eurasian Conference on Nuclear Science and Its Applications (Baku, Azerbaijan); the 7th Congress on Radiation Research (Radiobiology, Radioecology, and Radiation Safety) (Moscow, Russia); JUNO Workshop 2014 (Prague, Czech Republic); the workshop "Use of Neutron Scattering and Synchrotron Radiation in Condensed Matter" (Peterhof, Russia); the international conference of young scientists "Experimental and Theoretical Biophysics" (Pushchino, Russia); the Daya Bay Analysis Workshop 2014 (Prague, Czech Republic); the International Symposium on Physics of Unstable Nuclei 2014 (ISPUN14) (Ho Chi Minh City, Vietnam); the forum "EU–Russia Year of Science: A Window on Physics, Biology and Technology" (Trieste, Italy); the International Session-Conference of the Nuclear Physics Section of the RAS Physical Sciences Branch (Moscow, Russia); the 9th International Symposium on Intrinsic Josephson Effects and THz Plasma Oscillations in High-T_c Superconductors (THz-Plasma 2014) (Kyoto, Japan); the 22nd ASRC international workshop "Nuclear Fission and Exotic Nuclei" (Tokai, Japan); the PANDA Collaboration Meeting (Aachen, Germany); the 21st DAE–BRNS High Energy Physics Symposium (Guwahati, India); the Session of the Joint Committee on IN2P3–JINR Cooperation (Paris, France); the international workshop on perspectives of particle physics "Neutrino Physics and Astrophysics" (Valdai, Russia); the Advanced Studies Institute on Symmetries and Spin (NICA-Spin-2014) (Prague, Czech Republic); the International Meeting on the Programme of Cooperation of Serbia and JINR: Condensed Matter Physics with Ion Beams (Belgrade, Serbia); the 7th spring school "JINR Days in Bulgaria" (Borovets, Bulgaria); the 3rd Scientific School-Conference of Young Scientists and Specialists (Alushta, Russia); the international seminar on high energy physics "Quarks-2014" (Suzdal, Russia); the workshop "Relativistic Nuclear Physics: From Hundreds of MeV to TeV" (Stara Lesna, Slovak Republic); the European School on High-Energy Physics (a CERN–JINR school) (Garderen, Netherlands); the 22nd International Conference on Integrable Systems and Quantum Symmetries (ISQS-22) (Prague, Czech Republic); the 8th Joint APCTP – JINR BLTP Workshop (Jeju, Republic of Korea); the 14th Baikal International School on Physics of Elementary Particles and Astrophysics (Bolshiye Koty, Russia); the 7th International Symposium on Exotic Nuclei (EXON-2014) (Kaliningrad, Russia); the 11th conference "Quark Confinement and the Hadron Spectrum" (Peterhof, Russia); the international workshop "NICA Accelerator Complex: Problems and Solutions" (Sozopol, Bulgaria); the COMET Collaboration Workshop (Tbilisi, Georgia); the international workshop "Structure and Functions of Biomembranes" (Dolgoprudnyi, Russia); the Meeting of the JINR Finance Committee Working Group (Prague, Czech Republic); the School for Teachers of Physics from JINR Member States (Geneva, Switzerland).

DEVELOPMENT OF THE JINR INTERNATIONAL COLLABORATION AND RELATIONS OF THE YEAR 2014

1.	Number of short-term visits to JINR by specialists from Member States (not counting Russian specialists)	882
2.	Number of visits of specialists from other countries, including visits of specialists from the associated countries	731 407
3.	Number of visits by JINR specialists to Member States	966
4.	Number of visits by JINR sppecilalists to other countries, including visits to the associated countries	1614 600
5.	Number of conferences, schools, and meetings held by JINR	80
6.	New cooperation agreements (memoranda of understanding), addenda to existing ones	16

LIST OF CONFERENCES, SCHOOLS, AND MEETINGS HELD BY JINR IN 2014*

No.	Name	Place	Date	Number of participants
1.	Session of the Joint Committee on IN2P3–JINR Collaboration	Paris, France	14 January	6
2.	Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	20–21 January	71
3.	International workshop on perspectives of particle physics "Neutrino Physics and Astrophysics"	Valdai, Russia	26 January – 2 February	78
4.	Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	28–29 January	70
5.	Meeting of the Programme Advisory Committee for Particle Physics	Dubna	30–31 January	70
6.	12th Winter School on Theoretical Physics	Dubna	2–8 February	50
7.	21st international conference "Mathematics. Computer. Education"	Dubna	3–8 February	240
8.	Advanced Study Institute on Symmetries and Spin (NICA-Spin-2014)	Prague, Czech Republic	11–16 February	61
9.	115th Session of the JINR Scientific Council	Dubna	21–22 February	84
10.	18th International Scientific Conference of Young Scientists and Specialists of JINR (AYSS-2014), dedicated to the 105th anniversary of N. Bogoliubov's birth	Dubna	24–28 March	188
11.	Round table discussion Italy–Russia "What Comes Next?" — theoretical and experimental physics after the discovery of the Higgs boson	Dubna	3–5 March	85
12.	Meeting of the RAS Council on Heavy Ion Physics	Dubna	14 March	50
13.	Meeting of the JINR Finance Committee	Dubna	21–22 March	70
14.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Dubna	25–26 March	88
15.	18th research workshop "Nucleation Theory and Applications"	Dubna	1–30 April	60
16.	NA61/NA49 Collaboration Meeting	Dubna	7–11 April	70
17.	TAIGA Collaboration Meeting	Dubna	13–16 April	51
18.	International workshop "Resonators for New Generation of e^+e^- Accelerators and Colliders: Status and Perspectives"	Minsk, Belarus	22–25 April	20
19.	7th spring school "JINR Days in Bulgaria"	Borovets, Bulgaria	13–16 May	60
20.	Meeting of the Working Group on New Principles of the Calculation of Member States' Contributions to the JINR Budget	Dubna	15–16 May	15
21.	International Student Practice, the First Stage — practice for ARE students	Dubna	18 May – 8 June	26
22.	OPERA Collaboration Meeting	Dubna	19–21 May	49
23.	17th International Workshop on Computer Algebra	Dubna	21–22 May	50
24.	22nd International Seminar on Interaction of Neutrons with Nuclei (ISINN-22)	Dubna	27–30 May	125
25.	3rd Conference of Young Scientists and Specialists (Alushta-2014)	Alushta, Crimea, Russia	2–8 June	57
26.	International seminar on high energy physics "Quarks-2014"	Suzdal, Russia	2–8 June	137

*A number of conferences were held jointly with other organizations.

No.	Name	Place	Date	Number of participants
27.	Workshop of the Baikal Collaboration	Dubna	3–6 June	54
28.	Meeting of the Scientific-Advisory Committee on Baikal Neutrino Project	Dubna	13 June	25
29.	Meeting of CBM STS Workgroups	Heilig-kroeztail, Germany	16–18 June	34
30.	International conference "Relativistic Nuclear Physics: From Hundreds of MeV to TeV"	Stara Lesna, Slovak Republic	16–20 June	25
31.	India–JINR forum "Frontiers in Nuclear, Elementary Particle and Condensed Matter Physics"	Dubna	16–20 June	32
32.	European School of High-Energy Physics (a CERN–JINR school)	Garderen, Netherlands	18 June – 1 July	130
33.	School for Teachers of Physics from JINR Member States	Dubna	22–28 June	56
34.	Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	23–24 June	70
35.	International conference "Condensed Matter Research at the IBR-2"	Dubna	24–27 June	104
36.	22nd international colloquium "Integrable Systems and Quantum Symmetries"	Prague, Czech Republic	24–28 June	70
37.	Meeting of the Programme Advisory Committee for Particle Physics	Dubna	25–26 June	68
38.	Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	26–27 June	60
39.	8th Joint APCTP – JINR BLTP Workshop	Jeju, Republic of Korea	29 June – 4 July	50
40.	School for Teachers of Physics from Moscow	Dubna	30 June – 4 July	18
41.	6th international conference "Distributed Computing and Grid-Technologies in Science and Education"	Dubna	30 June – 5 July	196
42.	Physics workshop of the educational project "Summer School"	Dubna	3 July – 12 August	30
43.	14th Baikal International Shool on Physics of Elementary Particles and Astrophysics	Bolshiye Koty, Russia	5–12 July	72
44.	International Student Practice, the Second Stage — practice for students from JINR Member States and other countries	Dubna	6–27 July	73
45.	BLTP/JINR–SKLTP/CAS Joint Workshop on Physics of Strong Interacting Systems	Dubna	14–19 July	45
46.	Helmholtz international summer school "Nuclear Theory and Astrophysical Applications"	Dubna	21 July – 1 August	64
47.	International school "Advanced Methods of Modern Theoretical Physics"	Dubna	2–9 August	50
48.	17th Annual RDMS CMS Collaboration Conference	Dubna	7–8 August	120
49.	33rd Russian Cosmic Rays Conference (RCRC-2014)	Dubna	11–16 August	162
50.	International conference for young scientists "Modern Problems of Applied Mathematics and Computer Science"	Dubna	25–29 August	132

No.	Name	Place	Date	Number of participants
51.	Helmholtz international summer school "Lattice QCD, Hadron Structure and Hadronic Matter"	Dubna	25 August – 6 September	66
52.	International Student Practice, the Third Stage — practice for students from South Africa	Dubna	7–28 September	58
53.	A-2 Collaboration Meeting	Dubna	8–10 September	50
54.	11th international conference "Quark Confinement and the Hadron Spectrum"	Saint-Petersburg, Russia	8–12 September	350
55.	7th International Symposium on Exotic Nuclei (EXON 2014)	Kalinin-grad, Russia	8–13 September	124
56.	2nd international workshop "Perspectives of Experimental Research at the Nuclotron Beams"	Dubna	11–12 September	56
57.	International workshop "Supersymmetry in Integrable Systems"	Dubna	11–13 September	60
58.	International workshop "NICA Accelerator Complex: Problems and Solutions"	Sozopol, Bulgaria	14–21 September	35
59.	XXII international Baldin seminar on high-energy physics problems "Relativistic Nuclear Physics and Quantum Chromodynamics"	Dubna	15–20 September	203
60.	International Meeting on COMET Experiment	Tbilisi, Georgia	22–26 September	55
61.	116th Session of the JINR Scientific Council	Dubna	25–26 September	78
62.	2nd international summer school and workshop "Complex and Magnetic Soft Matter Systems: Physico-Mechanical Properties and Structure"	Dubna	29 September – 3 October	64
63.	International workshop "Structure and Functions of Biomembranes"	Dolgo-prudnyi, Russia	29 September – 3 October	200
64.	Meeting of the JINR Finance Committee Working Group	Prague, Czech Republic	10–11 October	16
65.	16th international conference "Methods of Symmetry in Physics"	Dubna	12–18 October	33
66.	16th Russian scientific conference "Digital Libraries: Advanced Methods and Technologies, Digital Collections"	Dubna	13–16 October	92
67.	Seminar dedicated to the 70th anniversary of the birth of A. Sissakian	Dubna	14 October	90
68.	CERN–JINR school on information technologies "Grid and Advanced Information Systems"	Dubna	20–24 October	118
69.	International meeting "Topical Issues in General and Space Radiobiology" (to the memory of Academicians N. Sissakian and A. Sissakian)	Dubna	28–30 October	60
70.	School for Teachers of Physics from JINR Member States	Geneva	2–9 November	43
71.	5th international scientific school "Instruments and Methods of Experimental Physics. Electronics and Automatics of Experimental Facilities"	Dubna	10–15 November	96
72.	International symposium "70th Anniversary of the Discovery of the Phase-Stability Principle"	Dubna	10–15 November	200

No.	Name	Place	Date	Number of participants
73.	Meeting of the JINR Finance Committee	Dubna	18–19 November	90
74.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Dubna	21–22 November	82
75.	16th international conference “Science. Philosophy. Religion”	Dubna	25–26 November	60
76.	6th Dubna youth scientific school “Management of Innovations”	Dubna	29 November	70
77.	Workshop on Precision Physics and Fundamental Physics Constants	Dubna	1–5 December	59
78.	Workshop of the Baikal Collaboration	Dubna	2–5 December	50
79.	International workshop “International Mega-Science Projects: Growth Points for Fundamental Science and Innovations. Collaboration and Perspectives of Russian and Chinese Mega-Projects”	Dubna	3–4 December	49
80.	TAIGA Collaboration Meeting	Dubna	11–13 December	45

The Joint Institute for Nuclear Research is an international intergovernmental scientific research organization, the activities of which are based on principles of openness for participation to all interested states and of their equal, mutually beneficial collaboration.

Dubna, 25–26 March. A regular session of the JINR CP

Dubna, 25–26 September.
The 116th session of the JINR Scientific Council

Dubna, 26 June. The joint meeting of the PACs for Particle Physics and Nuclear Physics. Discussion of the JINR Neutrino Physics Programme

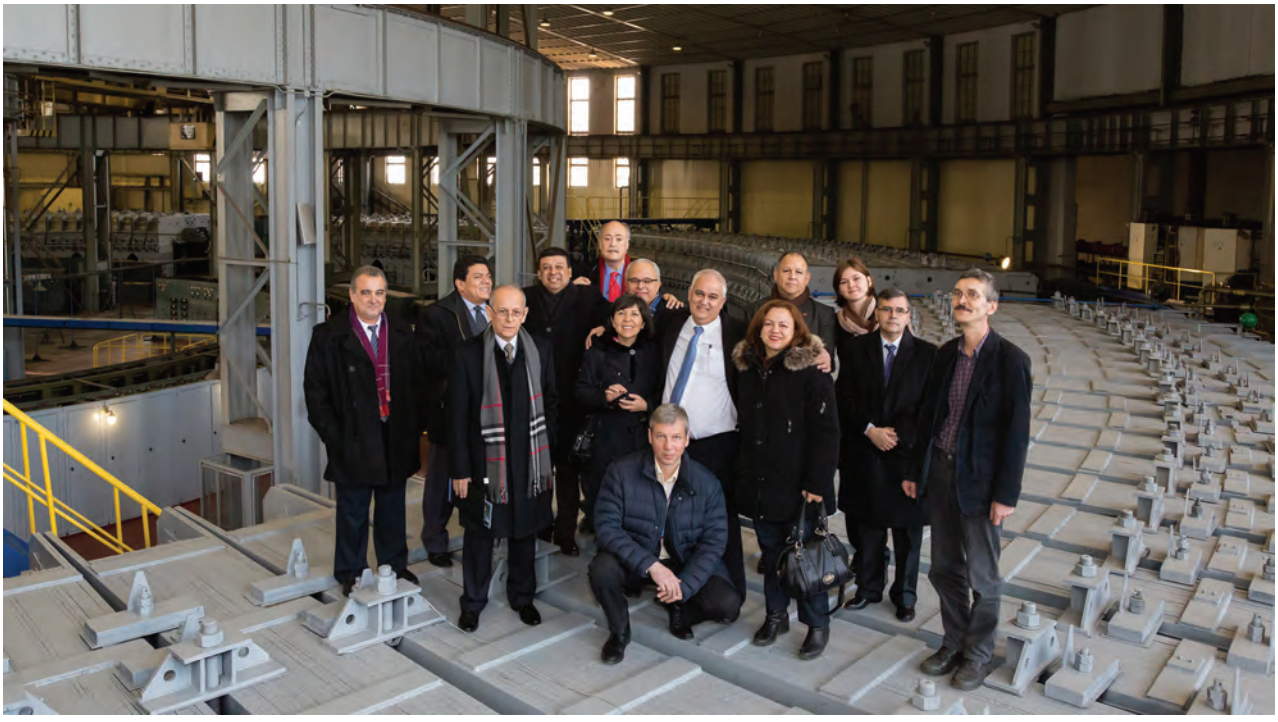
Dubna, 20–21 January. A regular meeting of the Programme Advisory Committee for Condensed Matter Physics

Dubna, 21–22 March. A regular meeting of the JINR Finance Committee

Dubna, 18 April. A regular meeting of the JINR Scientific and Technical Council. FLNR Director S. Dmitriev makes a report

Dubna, 26 March. JINR Director V. Matveev and Director of the National Intellectual Reserve Centre (NIRC) of MSU K. Tikhonova signed a Letter of Intent on cooperation in the sphere of education among NIRC, CERN and JINR, which had been earlier signed by CERN Director-General R.-D. Heuer

Dubna, 4 March. Ambassadors of 11 Latin American countries on an excursion to the Veksler and Baldin Laboratory of High Energy Physics



Dubna, 30 January.
Head of the State Federal Agency “Rosatom” S. Kirienko on a working visit to JINR.
An excursion to the Flerov Laboratory of Nuclear Reactions

Hefei (China),
23–25 February.
A bilateral meeting of JINR’s delegation and the leaders of the Chinese Academy of Sciences’ Institute of Plasma Physics. Signing of a joint address

Belgrade (Serbia), 22 April.
The 3rd meeting of the Joint Coordinating Committee on cooperation of the Republic of Serbia with JINR

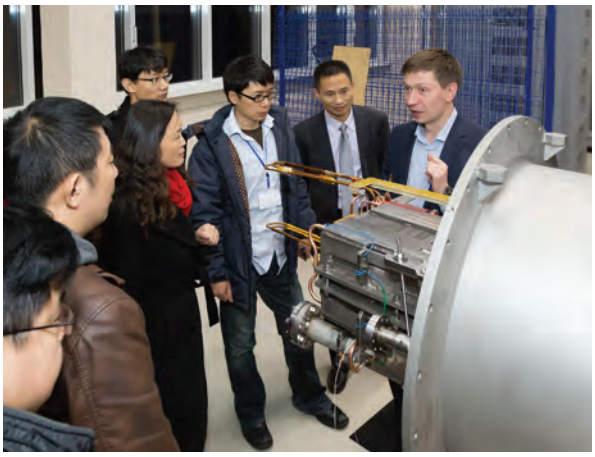
Dubna, 8 July.
JINR leaders meet representatives of the Republic of Armenia

Dubna, 30 October.
A delegation from France on a visit to JINR

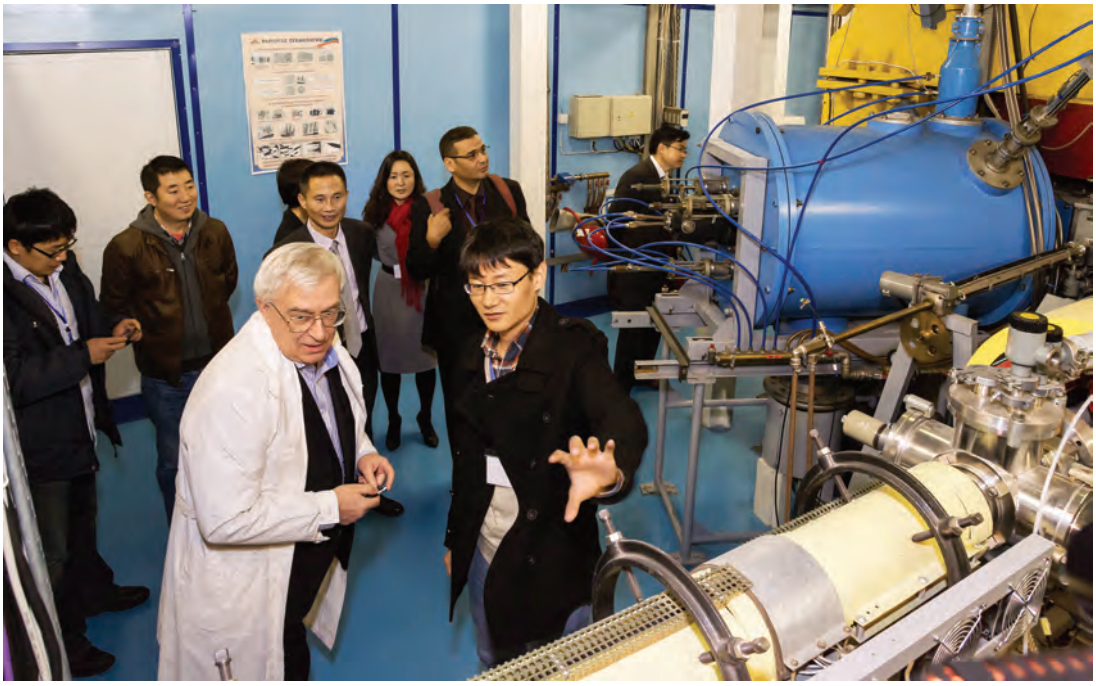
Dubna, 30 November. Ambassador Extraordinary and Plenipotentiary of Romania to RF V. Soare on a visit to JINR

Dubna, 3–5 March. The round-table discussion Italy–Russia–Dubna on the topic
“What Comes Next?” — theoretical and experimental physics after the discovery of the Higgs boson

Dubna, 16–20 June. The India–JINR forum “Frontiers in Elementary Particle, Nuclear and Condensed Matter Physics”



Dubna, 3–4 December. The scientific forum “International Mega-Science Projects: Growth Points for Fundamental Science and Innovations. Collaboration and Perspectives of Russian and Chinese Mega-Projects”



Kaliningrad, 8–13 September. Participants of the International Symposium on Physics of Exotic States of Nuclei (EXON 2014)

The Bogoliubov Laboratory of Theoretical Physics, 15–20 September. XXII international Baldin seminar on high-energy physics problems “Relativistic Nuclear Physics and Quantum Chromodynamics”

Garderen (the Netherlands), 18 June – 1 July. Participants of the European School of High-Energy Physics

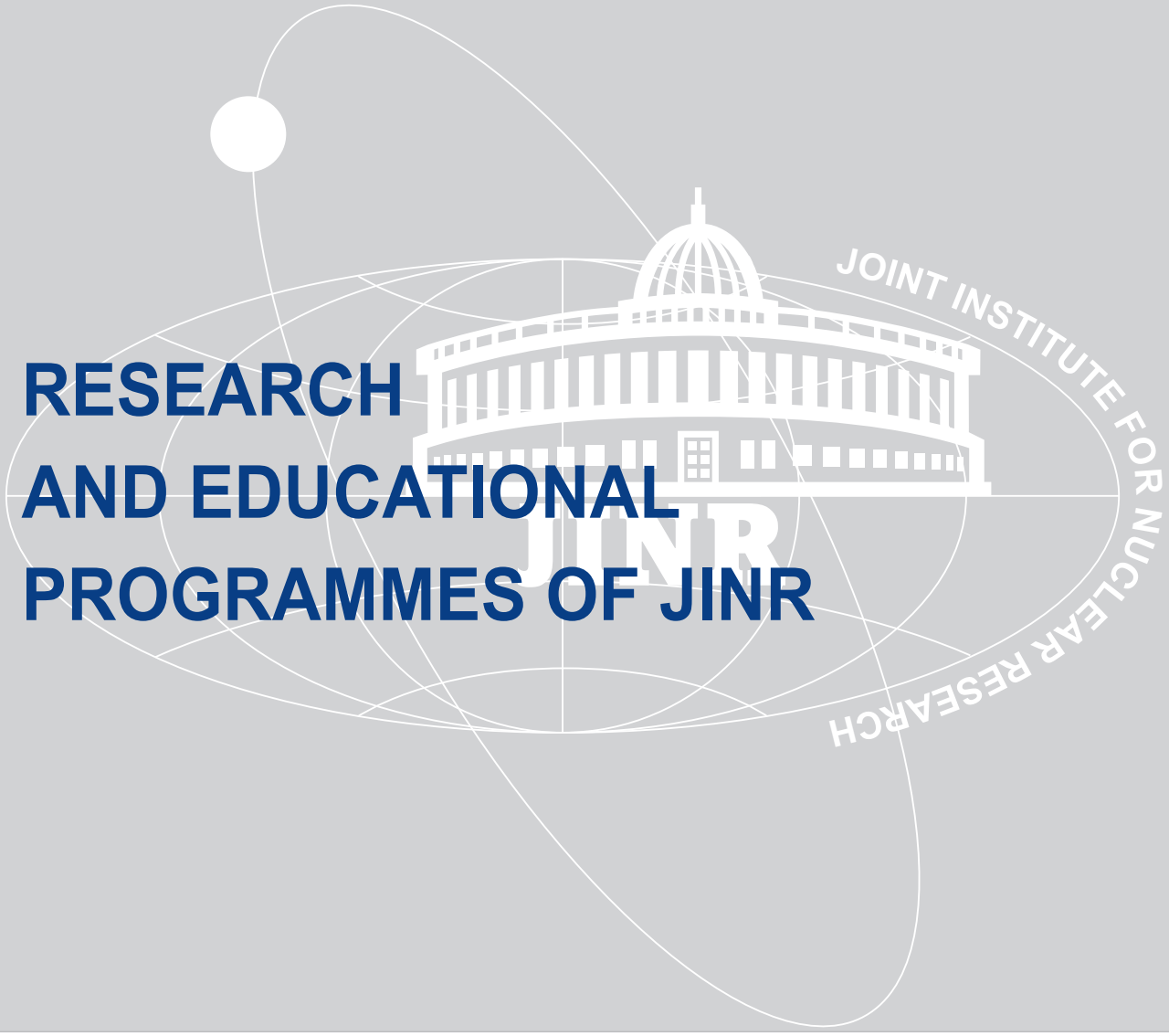
Dubna, 5 September. The Presidium at the first meeting of the Community Council under the JINR Directorate

Dubna, 23 April. The joint seminar “Physics at the LHC”. The Nobel Prize Laureate Professor C. Rubbia (Italy) is speaking

Dubna, 14 November. Ceremonial unveiling of the commemorative plaque in memory of Yu. Tumanov

2014

RESEARCH AND EDUCATIONAL PROGRAMMES OF JINR



BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

At the Bogoliubov Laboratory of Theoretical Physics (BLTP), studies were carried out on the following four themes: Theory of Fundamental Interactions; Theory of Nuclear Structure and Nuclear Reactions; Theory of Condensed Matter; Modern Mathematical Physics: Strings and Gravity, Supersymmetry, Integrability. Two new sectors were organized at BLTP for enhancement of theoretical research in neutrino physics and phenomenology of relativistic heavy-ion physics. An important component of the BLTP activities is theoretical support of experimental research to be carried out within major international projects with the participation of JINR as well as Dubna based experimental programmes of JINR Laboratories. The research resulted in about 500 publications in peer-reviewed journals and proceedings of international conferences. Most of the results were obtained in cooperation with scientists from the JINR Member States, Brazil, China, Egypt, Germany, Italy, France, Serbia, Spain, South Africa, and other countries. The Laboratory has become a site for organization of international conferences, workshops, schools for young scientists in various fields of theoretical physics. In 2014, more than 1000 scientists participated in 16 international conferences, workshops and schools organized at the Laboratory. In 2014, the international collaboration was supported by grants of the Plenipotentiaries of Bulgaria, the Czech Republic, Poland, the Slovak Republic, Hungary, Romania, and the JINR Directorate; the collaboration with German theorists was based on the Heisenberg–Landau Programme; with Armenia, on the Smorodinsky–Ter-Martirosyan Programme; with Polish theorists, on the Bogoliubov–Infeld Programme; with Czech theorists, on the Blokhintsev–Votruba Programme; and with Romanian theorists, on the Titeica–Markov Programme. Collaboration with scientists from Western Europe was carried out in the framework of the JINR–INFN, JINR–IN2P3 agreements and was also supported by RFBR–CNSF, RFBR–DFG, RFBR–CNRS. The agreements for collaboration between the Bogoliubov Laboratory and CERN TH, KEK, APCTP (South Korea), ITP CAN (Beijing) are functioning. Fourteen research projects and five conferences and schools were supported by the RFBR grants. One research group was supported within the RF state programme of scientific schools, and one young scientist was sponsored by the grant of the president of RF. Much attention was paid to recruiting young researchers, students, and postgraduate students to the Laboratory within the research and education project "Dubna International Advanced School of Theoretical Physics" (DIAS-TH), in particular. More than 70 PhD students and young scientists from the JINR Member States participated in the DIAS-TH schools. The Laboratory plays the role of the training center for young scientists and students from many countries. Currently, about one third of the scientific personnel are young scientists and PhD students. Within the JINR fellowship programme for nonmember states, several researchers from Argentina, India, Japan, Mexica, South Korea, Tajikistan, and Turkey have been working at BLTP on the long-term basis.

SCIENTIFIC RESEARCH

Theory of Elementary Particles

Theoretical investigations were continued in the framework of the following projects:

- Standard Model and Its Extensions;
- QCD Parton Distributions for Modern and Future Colliders;
- Physics of Heavy and Exotic Hadrons;
- Mixed Phase in Heavy-Ion Collisions.

The dark matter sector was considered within the constrained minimal supersymmetric SM (CMSSM) and the next-to-minimal supersymmetric SM (NMSSM). In the dark matter sector, the two models are quite orthogonal: in the CMSSM, the WIMP is

largely a bino and requires large masses from the LHC constraints. In the NMSSM, the WIMP has a large singlino component and is, therefore, independent of the LHC SUSY mass limits. The light NMSSM neutralino mass range is of interest for the hints concerning light WIMPs in the Fermi data. Such low mass WIMPs cannot be explained in the CMSSM. Furthermore, prospects for discovery of XENON1T and LHC at 14 TeV are given [1].

A correction proportional to the coupling constant for the conductivity of graphene was calculated. Earlier calculations led to three different values for this correction, only one of which was in agreement with the experimental data on conductivity. Our calculation was carried out in the framework of dimensional regularization as the most standard for calculations in quantum field theory. Properly taking into account the counter-terms of the two-loop diagrams, we confirmed the value of correction, which led to agreement between the calculated conductivity of graphene and experimental data [2].

The whole set of renormalization group functions was calculated for successful analysis in the framework of the Standard Model. The beta functions for all coupling constants and anomalous dimensions, including generalization to the matrix Yukawa couplings, were calculated with three-loop precision. The obtained expressions allow one to evolve SM couplings using the low-energy input at the electroweak scale and to investigate its behaviour at asymptotically high scales even up to the Planck scale with minimal theoretical uncertainty [3].

The QCD analysis of high-precision Jlab data was performed for the polarized Bjorken sum rule at low momentum transfers using four-loop expressions of the ordinary perturbation theory (PT) and the singularity-free analytic perturbation theory (APT). It is shown that the four-loop term of the PT series does not improve the accuracy of theoretical calculation, because the asymptotic nature of the PT series manifests itself at $Q < 1.5$ GeV. Within the APT, the weak sensitivity to higher order contributions, choice of normalization point and the scale parameter $\Lambda_{\rm QCD}$ variations are revealed. This ensures the accuracy of theoretical predictions in APT not worse than 5% already at the two-loop level. It is shown that APT allows one to describe high-precision JLab data up to $Q \sim \Lambda_{\rm QCD} \sim 300$ MeV, and extracted values of higher twists coefficients are not very sensitive to the order of approximation. In PT, these coefficients significantly change from order to order and the twist-4 contribution turns out to be comparable with zero within the experimental error at the four-loop level [4].

The discrepancy found by Hung, Myers, and Smolkin between the holographic calculation of entanglement entropy and the CFT trace anomaly calculation by virtue of the Wald prescription for computation of the entropy in six dimensions was explained by the Jacobson–Myers functional for the holographic minimal surface. For this purpose, we found a simple regularization procedure corresponding to the Wald contribution to the entropy. The discrepancy originates entirely from a total derivative term present in the trace anomaly in six dimensions [5].

Heavy-to-light semileptonic decays of heavy baryons are important physical processes for determining the Cabibbo–Kobayashi–Maskawa matrix elements. In particular, a study of the exclusive Λ_b decay into a baryon and a muon–neutrino pair at the Large Hadron Collider (LHC) gives an opportunity to determine the CKM matrix element $V(ub)$. The discrepancy between the extractions of $V(ub)$ from the exclusive and inclusive semileptonic B-meson decays is the long-standing puzzle in the heavy flavor sector of the Standard Model. A detailed analysis of the heavy-to-light semileptonic decays of λ_b and λ_c baryons in the covariant confined quark model was presented. The invariant and helicity amplitudes were calculated, which then are used for the analysis of the decay characteristics: angular distributions, rates, and asymmetry [6].

Substantial progress was achieved in calculating relativistic and radiative corrections for the Coulomb three-body systems with one electron. In particular, all the contributions to the energy of ro-vibrational states in the fine structure constant expansion up to and including the order $mc^2\alpha^7$, and partially of the order $mc^2\alpha^8$, were calculated. Calculations were performed for the hydrogen molecular ions H^{2+} and HD^+ and the antiprotonic helium atom. The theoretical uncertainty in the value of the fundamental vibrational transition of the hydrogen molecular ion H^{2+}, taking into account the sensitivity of the transition energy to a change of masses, allows determination of one of the fundamental physical constants of modern physics: proton-to-electron mass ratio, $\mu = m_p/m_e$, with a fractional precision of $1.5 \cdot 10^{-11}$. For comparison, it is recalled that uncertainty in the atomic mass of an electron and a proton for the recommended CODATA values is $4.0 \cdot 10^{-10}$ and $8.9 \cdot 10^{-11}$ [7].

It was shown [8] that when a wide resonance cannot decay into a channel, which opens above its pole mass and which is strongly coupled (e.g., the $f_0(500)$ and the kaon–antikaon channel), one should consider this resonance as a multichannel state. For example, studying the f_0 mesons, one ought to consider the 3-channel pion–pion scattering: pion–pion, kaon–antikaon, eta–eta. It was shown that this is a minimal number of coupled channels needed for obtaining correct values of scalar–isoscalar resonance parameters.

The novel effect in the $0\nu\beta\beta$ decay related to generation of an effective in-medium Majorana neutrino mass matrix was proposed. It leads to an enhancement of the $0\nu\beta\beta$ decay rate. A measurement of the rate may lead to the apparent incompatibility of the extracted neutrino mass with the value of neutrino mass determined or restricted by the β decay and cosmological data [9].

A revision was made of the mechanism of the $0\nu\beta\beta$ decay mediated by the exchange with the heavy Majorana neutrino N of arbitrary mass m_N, slightly mixed ($\sim U_{eN}$) with the electron neutrino ν_e. By assuming the dominance of this mechanism, the well-known $0\nu\beta\beta$ decay exclusion plot in the $m_N - U_{eN}$ plane was updated by taking into account recent progress in the calculation of nuclear matrix elements within the quasiparticle random phase approximation and improved experimental bounds on the $0\nu\beta\beta$-decay half-life of ^{76}Ge and ^{136}Xe [10].

The effects were tested for an approximate treatment of two-body contributions to the axial-vector current on the quasiparticle random-phase approximation (QRPA) matrix elements for the $0\nu\beta\beta$ decay in a range of isotopes [11]. The form and strength of the two-body terms come from the chiral effective field theory. The two-body currents typically reduce the matrix elements by about 20%, not as much as in shell-model calculations. The effects for the $0\nu\beta\beta$ decay are significantly less than those for the two-neutrino decay, both in the shell model and the QRPA.

The model for a covariant asymmetric wave packet (AWP) was proposed for description of the asymptotically free in and out states in the field theoretical formalisms of neutrino flavor oscillations. It is proven that the commonly accepted relativistic Gaussian WP is not a special case of AWP. The properties of AWP were studied in detail [12].

It was proposed to perform measurements of asymmetries of the Drell–Yan (DY) pair production in collisions of nonpolarized, longitudinally and transversally polarized protons and deuterons which provide an access to all leading twist quark distributions in nucleons. The measurements of asymmetries in the production of J/ψ and direct photons will be performed as well simultaneously with DY using dedicated triggers. The set of these measurements will supply complete information for tests of the quark–parton model of nucleons at the QCD twist-two level with minimal systematic errors [13].

The quantum dynamics of the Dirac fermion particle in a gauge gravitational field is studied. The anomalous gravitomagnetic and gravitoelectric moments are ruled out on the basis of the covariance arguments. Making use of the Foldy–Wouthuysen Hamiltonian for the Dirac particle coupled to magnetic field in a noninertial reference system, the recent experimental data were analyzed, bounds on the space-time torsion were obtained [14].

It was found that the pion pole effects are essential in the ω-meson production. Without the pion pole contribution it is impossible to explain large unnatural parity effects in the ω case, which is observed experimentally. The results on spin observables are in good agreement with the HERMES data [15].

The analysis of reactions of electron–positron annihilation into the proton–antiproton final state in the energy ranges in the vicinity of the charmed resonance $\psi_c(3770)$ was performed [16]. It was shown that in these energy ranges, a large relative phase between the background electromagnetic mechanism and the mechanism with intermediate charmonium excitation was generated. This leads to the appearance of a characteristic dip in the total cross section in this energy range, which was recently observed at BES III.

In studying color fields created in relativistic heavy-ion collisions, it was observed that the presence of an additional term in the non-Abelian case due to changing color charge leads to a noticeable contribution of "color charge glow" in chromomagnetic and chromoelectric fields. A possible appearance of the "echo" in the scattering of composite color particles like a color dipole was discussed. Arguments were given in favor of the importance of such effects in modeling the initial time evolution of ultrarelativistic heavy-ion collisions, where the initial partonic state is defined by highly nonequilibrium partonic density and strong local color fluctuations [17].

Light-by-light hadronic corrections to the muon anomalous magnetic moments within the chiral quark model were completed [18]. The contributions of light pseudoscalar and scalar mesons and dynamical quark loop were calculated. The gauge invariance of the total set of diagrams and stability of the result with respect to variation of the model parameters were checked explicitly. The main contributions occur due to the pion exchange and the quark loop. It was shown that the total result cannot explain the existing disagreement between experiment and prediction of the Standard Model.

Using the extended Nambu–Jona–Lasinio (NJL) model, a set of predictions was obtained for meson production processes. In particular, processes $e^+e^- \to \eta(\eta')2\pi$, $\tau \to \eta(\eta')2\pi\nu$ and $\tau \to f_1\pi\nu$ were described and, within modified version of the extended NJL model, the axial-vector mesons in the ground and first radial-excited states were described. In the same model, the radiative decay widths of the radial-excited states of the π, η and η' mesons were calculated [19].

Complete lattice calculations of the quark and glue momenta and angular momenta in the proton were performed. These include the quark contributions from both the connected and disconnected insertions. The chirally extrapolated u- and d-quark momentum/angular momentum fraction was found to be $0.64(5)/0.70(5)$, the strange momentum/angular momentum fraction was $0.023(6)/0.022(7)$, and that of the glue was $0.33(6)/0.28(8)$. The quark orbital angular momentum constitutes $0.47(13)$ of the proton spin with almost all of it coming from the disconnected insertions [20].

Modern Mathematical Physics

The topics of the main focus in the theme were:
- Supersymmetry and Superstrings;
- Quantum Groups and Integrable Systems;
- Quantum Gravity and Cosmology.

A new type of $d = 1$ supersymmetric systems was constructed by employing superfields defined on the cosets of the supergroup $SU(2|1)$. As instructive examples, the models associated with the supermultiplets (1, 4, 3) and (2, 4, 2) were considered at the classical and quantum levels. Interesting interrelations with some previous works on nonstandard $d = 1$ supersymmetry were found [21].

The method to construct the on-shell component actions for the theories with $1/2$ partial breaking of global supersymmetry within the nonlinear realization (coset) approach was proposed. The general consideration was illustrated by a detailed example of the component action of $N = 1$ supermembrane in $D = 4$ [22].

The general formulation of $N = 1$ supersymmetric self-dual Abelian gauge theory, involving auxiliary chiral spinor superfields, was constructed. Self-duality in this context is just $U(N)$ invariance of the nonlinear interaction of the auxiliary superfields. A few instructive examples were considered and showed how to generate self-dual $N = 1$ models with higher derivatives in this approach [23].

New finite-energy regular composite solutions in the Einstein–Yang–Mills $SU(2)$ theory, which approach at infinity the anti-de Sitter space-time background, were constructed. Their interpretation in the framework of the holography duality AdS/CFT was investigated [24].

The integrability of the complete symmetric Toda system was investigated. This dynamical system describes the interacting points on a line. A special case was considered in detail when the Lax representation for the system under study was constructed in terms of symmetric matrices possessing coinciding eigenvalues [25].

New models of compact stars with different level equations in the Minimal Dilatonic Gravity (MDG) were developed. For the first time, the densities of energy and pressure for the dark energy and dark matter were introduced, and their role in the construction of compact stars was studied. It was shown that in the framework of MDG it was possible to describe all the effects coming from the dark energy and dark matter in terms of the single scalar field, which is the new scalar component of our gravity theory, and it implies another new notion — the dilatonic sphere of the field around the star [26].

In the framework of the Dirac model of graphene, the localized excitations, surface plasmons, were investigated in detail. Their contribution to the physical properties of the graphene was revealed. The dispersion laws for the surface plasmons with electric and magnetic polarizations were studied numerically. The approach is based on the construction and investigation of the polarization operator within quantum field theory [27].

A rigorous approach to the calculation of the vacuum friction force was developed. The approach relies on the quantum field theory methods applied in condensed matter physics. As a result, the noncontact friction force was expressed in terms of the quantum-statistical 4-point Green function describing the photon in the surrounding medium [28].

Theory of Nuclear Structure and Nuclear Reactions

In 2014, investigations within the area "Theory of Nuclear Structure and Nuclear Reactions" were carried out in accordance with four projects:

• Properties of Nuclei at the Border of Stability;

• Low-Energy Dynamics and Nuclear System Properties;

• Quantum Few-Body Systems;

• Processes with Nuclei at Relativistic Energies and Extreme States of Matter.

The β decay half-lives of neutron-rich even–even Ni isotopes $^{70-80}$Ni and isotones $N = 50$ were calculated in the framework of the self-consistent approach based on the Skyrme interaction, taking into account the separable version for tensor interaction and the coupling with $2p-2h$ configurations. These two effects redistribute the Gamow–Teller strength in the nuclear spectrum. In particular, the lowest 1^+ state strongly shifts down in the open-shell nuclides. As a result, the theoretical values of $T_\beta^{1/2}$ decrease by 2–3 orders of magnitude. The theory successfully reproduces the sharp reduction of half-lives for the $N = 50$ isotones with decreasing proton number, as well as the gradual reduction of half-lives for the Ni isotopes with increasing neutron number [29].

A microscopic proton–neutron symplectic model of collective motions, based on the noncompact symplectic group $Sp(12, R)$, was introduced by considering the symplectic geometry of the two-component many-particle nuclear system. The dynamical group of the whole many-particle system allows the separation of the nuclear variables into kinematic (internal) and dynamic (collective) ones. Then, the number and type of collective degrees of freedom, related to the dynamical variables, were determined properly by the group-theoretical consideration of the coordinate transformation of the microscopic configuration space, spanned by the $m = A - 1$ translationally invariant Jacobi vectors, to the collective and intrinsic submanifolds. As a result, the nuclear wave functions were represented as a product of collective and intrinsic parts. The $Sp(12, R)$ model appears as a hydrodynamic collective model of the proton–neutron nuclear system, which includes 21 collective irrotational flow degrees of freedom and an $U(6)$ intrinsic structure associated with the vortex degrees of freedom. The latter allows one to ensure the full antisymmetry of the total wave function and is responsible for the appearance of the low-lying collective bands [30].

Thermal effects on the rates and cross sections of neutrino inelastic scattering off hot nuclei occuring under supernova II conditions were studied with the sample nuclei ^{56}Fe and ^{82}Ge. By applying the thermal

QRPA, it was shown that de-excitation of thermally excited nuclear states gives the main contribution to the (νA) inelastic scattering at low neutrino energy ($E_\nu < 10$ MeV). Moreover, the same process makes possible neutrino–antineutrino pair emission by hot nuclei. In contrast with the LSSM approach based on the shell model calculations with the strongly reduced single-particle basis, the thermal QRPA does not explore the Brink hypothesis and automatically satisfies the detailed balance principle. As a result, the present calculations predict the value of cross sections and rates of the νA process at $E_\nu < 10$ MeV by an order of magnitude larger than those obtained within the LSSM approach [31].

The production cross sections of neutron-rich isotopes of Ca, Zn, Te, Xe, and Pt were predicted in the diffusive multinucleon transfer reactions with stable and radioactive beams. With these isotopes one can treat the neutron shell evolution beyond $N = 28$, 50, 82, and 126. Due to the small cross sections, the production of nuclei near the neutron drip line requires the optimal choice of reaction partners and bombarding energies. The reactions were suggested for the experimental study [32].

In the standard version of the collective nuclear model, it was assumed that the mass coefficient has the same value for both the rotational and vibrational modes. However, the previous analysis of the experimental data showed that the mass coefficient for the gamma-vibrational motion was 3–4 times larger than that for the rotational motion. Experimental data on the beta-vibrational mode are scarce, nevertheless, they also indicate that the beta-vibrational mass coefficients exceed significantly the rotational mass coefficients. Basing on the cranking model, the ratio of the rotational and gamma-vibrational mass coefficients was calculated for the well-deformed axially symmetric nuclei. The obtained results show that the calculated gamma-vibrational mass coefficient is indeed systematically 2.5–4 times larger than the rotational mass coefficient. This explains qualitatively the experimental data. A very important role in treating the pair correlations of nucleons is played by blocking of the two-quasiparticle components with the largest contribution to the structure of the gamma-vibrational phonon [33].

Bound states and low-lying resonances of the one-neutron halo nucleus ^{11}Be were calculated within the two-body cluster model with core excitation. The lowest ^{10}Be core excited 2^+ state was considered as quadrupole vibration. Shallow potentials were applied for neutron–core interaction, preventing motion in the Pauli forbidden orbits. A good description of available experimental data, including dipole excitations of ^{11}Be, was obtained. For the bound $1/2^-$ excited state the $[p3/2 \otimes 2^+]1/2^-$ wave function component gives the dominant contribution to the structure, which differs from the results obtained in models with deep potentials [34].

The theory of two-dimensional scattering of a slow quantum particle by a central short-range potential was developed. To this end, the variable phase function approach and effective-range approximation were used. For this scattering the explicit low-energy asymptotics of all partial cross sections and radial wave functions were derived. The nonlinear and linear equations adopted for a high-accuracy calculation of the scattering length and effective radius were suggested and analyzed and, in the case of a rectangular potential, the exact solution of these equations was obtained [35].

It was established that the channel components of the eigenvector of the truncated scattering matrix belonging to the zero eigenvalue make sense of breakup amplitudes for the corresponding resonance state of a multichannel system [36].

The new method for the creation of coherent radiation based on using the quantum molecular-nuclear transitions was suggested. The external radiation acts on the two-level system, where the upper level is a molecular state and the lower one is a nuclear resonant state. As a result, unlike the usual laser, there appears a medium with the inverse population and there is no necessity to make preliminary saturation. The process is accompanied by coherent radiation. The method was registered as a patent [37].

The hybrid model of the microscopic optical potential was developed and successfully applied for calculations of cross sections for scattering of π mesons and the light exotic halonuclei on protons and nuclei. Basing on this model and suggesting the two-cluster structure of the ^{11}Be and ^{11}Li nuclei, conclusions were made on the far periphery of these nuclei and on a mechanism of their breakup into clusters. The significant in-medium effect on the parameters of the pion–nucleon amplitude for scattering of pions on nuclei in the region of the 3,3-resonance as compared to those for scattering of pions on free nucleons was ascertained [38].

The detailed analysis of the analytical properties of quark propagators from the Dyson–Schwinger equation was performed within the rainbow approximation. It was shown that the propagators are not analytical functions possessing an infinite number of pole-like singularities, which hamper the solution of the Bethe–Salpeter equation for mesons. Rigorous mathematical methods of finding the exact position of poles and corresponding residues were proposed to be used in solving the Bethe–Salpeter equation for mesons in the presence of singularities [39].

Recent STAR data for the directed flow of protons, antiprotons, and charged pions obtained within the RHIC energy beam scan program show that measured v_1 excitation functions are smooth with a small negative slope at the mid rapidity without irregularities ("wiggles") largely discussed earlier by nuclear community. These intriguing results were analyzed within two complementary approaches: transport hadron-string-

dynamics models (PHSD/HSD) and 3-fluid hydrodynamics (3FD). Both versions of the kinetic approach, HSD and PHSD, are used to clarify the role of quark degrees of freedom. The PHSD results, simulating a partonic phase and its coexistence with a hadronic one, are consistent with the data. Hydrodynamic results were obtained for two equations of states (EoS), pure hadronic and EoS with the crossover type of a phase transition. The latter case is favoured by the experiment under discussion. Special attention is paid to the description of antiprotons based on the balance of the proton–antiproton annihilation channel and inverse process for this pair creation from a multimeson interaction. Generally, a semi-qualitative agreement between the measured data and the model results supports an idea of realization of a crossover type of quark–hadron phase transition, which softens the nuclear EoS [40].

Theory of Condensed Matter

Theoretical investigations within the theme "Theory of Condensed Matter and New Materials" were continued in the framework of the following projects:

• Physical Properties of Complex Materials and Nanostructures;

• Mathematical Problems of Many-Particle Systems.

A concept for a graphene tunnel field-effect transistor was proposed. The main idea was based on the use of two graphene electrodes with zigzag termination divided by a narrow gap under the influence of the common gate. The analysis showed that such a device would have a pronounced switching effect at low gate voltage and high on/off current ratio at room temperature [41].

An analysis of current values averaged by different angular orientations of nucleotide and shifts in the nanogap plane and their peculiar for each nucleotide dispersion showed that in the regime of sequential electron tunneling a specific geometric shape of nucleotide promotes their identification during DNA sequencing [42].

Two parallel stacks of coupled Josephson junctions (JJs) were investigated to clarify the physics of transitions between the rotating and oscillating states and their effect on the IV-characteristics of the system. The coupling between JJs in the stacks leads to the branching of the IV-characteristics and a decrease in the hysteretic region. The crucial role of the diffusion current in the formation of the IV-characteristics of the parallel stacks of coupled JJs was demonstrated. The effect of symmetry in a number of junctions in the stacks and a decrease of the branching in the symmetrical stacks were discussed. The observed effects might be useful for development of superconducting electronic devices based on intrinsic JJs [43].

The $t-J$ model was analyzed in the limit of strong anisotropy, i.e., neglecting the transverse components of the electron spin. The most interesting and important results are the destruction of the antiferromagnetic (AF) order by increasing the charge doping and the formation of the Nagaoka polarons in the limit of strong interactions. The long-range AF order vanishes at hole concentration below 6%, which remains in a perfect agreement with experimental data on high-temperature superconductors. The main mechanism responsible for the destruction of the long-range AF order has its origin in the interplay of the hole mobility and minimization of the spin–spin exchange energy. This strong competition is strictly related to the constraint of no double occupancy. Furthermore, the present approach predicts the segregation of the ferromagnetic hole-rich phase and hole-depleted AF phase in the limit of strong interactions (small J) [44].

The Stuhrmann contrast variation method was generalized for experimental curves from multiphase fractal systems that contain a "knee point" in a double-logarithm scale. The developed analysis allows one to answer the qualitative question of whether one fractal "absorbs" another one or they both are immersed in a surrounding homogeneous medium like a solvent or solid matrix [45].

For the family of iridium oxides, which are strongly correlated $5d$ electron systems, for the first time a method for constructing the lattice quantum spin models together with numerical estimation for the isotropic and anisotropic exchange couplings with strong spin–orbit interaction on iridium ions was suggested and developed. The method is based on a symmetry analysis of the low-energy spectra of electron excitations calculated with the use of the quantum-chemical approach to lattice cluster fragments. In the framework of the spin models derived, phase diagrams were obtained and the ground-state magnetic structures were predicted for layered iridium oxides Na_2IrO_3, Li_2IrO_3 with hexagonal and Ba_2IrO_4 with tetragonal lattices of magnetic ions [46].

Collective dynamics of the Bose–Einstein condensate in optical traps was investigated. The method of calculations of condensate anomalous averages was developed. The method gives an accurate qualitative description of cold boson properties in traps. The ground state of cold Bose atoms in traps was investigated. Thermodynamics of boson atoms in traps close to the phase transition to superfluid state was studied. The strongly nonequilibrium Bose condensate including quantum vortices and granular condensate created under the external strong field modulations was investigated [47].

The microscopic theory of high-temperature superconductivity in cuprates was formulated within the Hubbard model in the limit of strong correlations. It was shown that the kinematic spin-fluctuation interaction plays a major role in the d-wave superconducting pairing, while the intersite Coulomb repulsion and the electron–phonon interaction are small. The spin-excitation spectrum, the staggered magnetization, the dynamic and static susceptibility were calculated for the anisotropic antiferromagnetic $J1-J2$ model for the iron pnictides. The spin wave excitation spectrum, the

magnetization, and the Nèel temperature were calculated for the quasi-two-dimensional spin-$1/2$ antiferromagnetic compass-Heisenberg model proposed for iridates [48].

The Lieb transfer matrix formalism was generalized to address the problem for arrow configurations (or trees) on a cylinder associated with dimer configurations through Temperley's correspondence. The partition functions for the sectors containing a different number of noncontractible loops were computed. A new extended transfer matrix was introduced, which not only keeps the track of the dimer configurations, but also propagates colors along the branches of the associated trees. It was argued that the new transfer matrix contains the Jordan cells [49].

The inverse population transfer of the Bose–Einstein condensate in a double-well trap was investigated. The research is based on the solution of the 3D, time-dependent, nonlinear Gross–Pitaevskii equation for the total order parameter covering both the left and right condensate fractions. The population transfer is driven by the time modulation of the potential barrier sharing the trap. It was demonstrated that, unlike most of other researches for the proposed transport scheme, the interatomic interaction is not a detrimental but a favorable factor. Namely, a repulsive interaction sufficiently supports the transfer, making it possible in a wide velocity interval and three orders of magnitude faster than in an ideal condensate. It was also demonstrated that this transport could be treated as a dc Josephson effect [50].

Stationary states of the totally asymmetric simple exclusion process on an open macroscopic chain with a zero-length shortcut in the bulk were considered. The model describes a directed motion of molecular motors along the twisted filaments. It was shown that the shunted segment could exist not only in low- and high-density phases, but also in a coexistence (shock) phase, provided the network carried the maximum current. The main quantitative parameters of that shock phase were found to obey the domain wall theory with parameters determined by a positive root of a cubic equation with coefficients linearly depending on the probability of choosing the shortcut. The unexpected conclusion was that a shortcut in the bulk of a single lane might create traffic jams [51].

Finite dimensional solutions of the Yang–Baxter equation (YBE) were constructed for symmetry algebras of rank 1 in the form of R-matrices with numerical coefficients and L-operators (matrices with operator coefficients) at the rational, trigonometric, and elliptic levels. In the trigonometric and elliptic cases, some fundamentaly new YBE solutions related to two-index structure of discrete spin values were found [52].

Classification of superconformal indices of known theories related by the Seiberg duality was completed. A relation with the knot theory and two-dimensional vortices was established, the indices were constructed for the theories with spontaneous chiral symmetry breaking [53].

A new Z_N symmetric stochastic model was defined with the use of the periodic Temperley–Lieb algebra. It was shown that in the finite-size scaling limit the spectrum of its Hamiltonian was given by representations of the Virasoro algebra with complex highest weights. This fact leads to the oscillating behavior in the relaxation processes [54].

The regime of formation of giant particle clusters in the generalized totally asymmetric exclusion process was described. The large deviation function of the particle current was obtained, which interpolates between the function obtained by Derrida–Lebowitz for the KPZ universality class and the diffusive Gaussian behavior [55].

DUBNA INTERNATIONAL ADVANCED SCHOOL OF THEORETICAL PHYSICS (DIAS-TH)

In 2014, the research and education project DIAS-TH was successfully continued. There were the following activities in the framework of DIAS-TH:

- XII Winter School on Theoretical Physics (February 2–8);
- XVIII Research Workshop "Nucleation Theory and Applications" (April 1–30);
- Helmholtz International Summer School "Nuclear Theory and Astrophysical Applications" (July 21 – August 1);
- Helmholtz International School "Lattice QCD, Hadron Structure and Hadronic Matter" (August 25 – September 6);
- International School "Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems" (August 2–9);
- Regular seminars for students and postgraduates were organized;
- Computer processing of videorecords of lectures was continued;
- Web-site of DIAS-TH was supported.

Preliminary Plans for 2015

- XVIII Research Workshop "Nucleation Theory and Applications" (April 1–30);
- Helmholtz International Summer School "Dense Matter" (June 29 – July 11);
- Helmholtz International Summer School "Theory Challenges for LHC Physics" (July 20–30).

CONFERENCES AND MEETINGS

• Advanced Study Institute ”Symmetries and Spin”, February 10–16, Prague, Czech Republic;

• XVIII International Conference of Young Scientists and Specialists (AYSS-2014), February 24–28, Dubna;

• EU–Russia–JINR Dubna Round Table “What next? Theoretical and Experimental Physics after Discovery of the Brout–Englert–Higgs Boson”, March 3–5, Dubna;

• The ECT Workshop “Low-Energy Reaction Dynamics of Heavy Ions and Exotic Nuclei”, May 26–30, Trento, Italy;

• India–JINR Forum “Frontiers in Nuclear, Elementary Particle and Condensed Matter Physics”, June 16–20, Dubna;

• XXII International Colloquium “Integrable Systems and Quantum Symmetries”, June 24–28, Prague, Czech Republic;

• SKLTP–BLTP JINR Workshop on “Physics of Strongly Interacting Systems”, July 14–19, Dubna;

• International Workshop “Supersymmetry in Integrable Systems (SIS’ 2014)”, September 11–13, Dubna;

• XXII International Baldin Seminar “Relativistic Nuclear Physics and Quantum Chromodynamics”, September 15–20, Dubna;

• XVI International Conference “Symmetry Methods in Physics”, October 12–18, Dubna;

• Workshop “Precision Physics and Fundamental Physical Constants (FPC-14)”, December 1–5, Dubna.

COMPUTER FACILITIES

In 2014, PC server equipped with top rated Intel processor and Nvidia graphical card has been purchased to support traditional computing and general-purpose calculations with the use of graphical processors (GPGPU). Twenty high-performance desktop PCs were purchased. Most important packages of licensed software like Mathematica, Intel Parallel Studio, and Origin Pro have been updated to the latest versions. Software and hardware have been prepared for regular Internet video broadcasting and recording of events in the Conference Hall of BLTP. The procedures of videorecords processing, archiving, and presentation have been developed.

REFERENCES

1. *Beskidt C., de Boer W., Kazakov D. I.* // Phys. Lett. B. 2014. V. 738. P. 505.
2. *Teber S., Kotikov A. V.* // Europhys. Lett. 2014. V. 107. P. 57001.
3. *Bednyakov A. V., Pikelner A. F., Velizhanin V. N.* // Nucl. Phys. B. 2014. V. 879. P. 256; Phys. Lett. B. 2014. V. 737. P. 129.
4. *Khandramai V. L., Solovtsova O. P., Teryaev O. V.* // Phys. Part. Nucl. 2014. V. 45, No. 1. P. 49; Nonlinear Phenomena in Complex Systems. 2013. V. 16, No. 1. P. 93.
5. *Astaneh A. F., Patrushev A., Solodukhin S. N.* arXiv:1412.0452 [hep-th]; arXiv:1411.0926 [hep-th].
6. *Gutsche T. et al.* arXiv:1410.6043 [hep-ph].
7. *Korobov V. I., Hilico L., Karr J.-Ph.* // Phys. Rev. Lett. 2014. V. 112. P. 103003.
8. *Surovtsev Yu. S. et al.* // J. Phys. G: Nucl. Part. Phys. 2014. V. 41. P. 025006; Phys. Rev. D. 2014. V. 89. P. 036010.
9. *Kovalenko S., Krivoruchenko M. I., Šimkovic F.* // Phys. Rev. Lett. 2014. V. 112. P. 142503.
10. *Faessler A. et al.* // Phys. Rev. D. 2014. V. 90. P. 096010.
11. *Engel J., Šimkovic F., Vogel P.* // Phys. Rev. C. 2014. V. 89. P. 064308.
12. *Naumov V. A., Shkirmanov D. S.* arXiv:1409.4669 [hep-ph]. 2014.
13. *Savin I. A. et al.* arXiv:1408.3959 [hep-ex].
14. *Obukhov Yu. N., Silenko A. J., Teryaev O. V.* // Phys. Rev. D. 2014. V. 90. P. 124068.
15. *Goloskokov S. V., Kroll P.* // Eur. Phys. J. A. 2014. V. 50. P. 146.
16. *Ahmadov A. I. et al.* // Nucl. Phys. B. 2014. V. 888. P. 271.
17. *Voronyuk V. et al.* // Yad. Fiz. 2015. V. 78. P. 1.
18. *Dorokhov A. E., Radzhabov A. E., Zhevlakov A. S.* // JETP Lett. 2014. V. 100. P. 133.
19. *Volkov M. K., Arbuzov A. B., Kostunin D. G.* // Phys. Rev. C. 2014. V. 89. P. 015202;
    Vishneva A. V., Volkov M. K., Kostunin D. G. // Eur. Phys. J. A. 2014. V. 50. P. 137;
    Vishneva A. V., Volkov M. K. // Intern. J. Mod. Phys. A. 2014. V. 29, No. 24. P. 1450125;
    Vishneva A. V., Volkov M. K. // Phys. Part. Nucl. Lett. 2014. V. 11. P. 352.
20. *Deka M. et al.* // Phys. Rev. D. 2015. V. 91. P. 014505.

21. *Ivanov E., Sidorov S.* // Class. Quant. Grav. 2014. V. 31. P. 075013.
22. *Bellucci S., Krivonos S., Sutulin A.* // Phys. Lett. B. 2013. V. 726. P. 497.
23. *Ivanov E., Lechtenfeld O., Zupnik B.* // JHEP. 2013. V. 1305. P. 133.
24. *Kichakova O. et al.* // Phys. Rev. D. 2014. V. 90. P. 124012.
25. *Chernyakov Yu. B., Sharygin G. I., Sorin A. S.* // Commun. Math. Phys. 2014. V. 330. P. 367.
26. *Fiziev P.* arXiv:1402.2813v1 [gr-qc]; arXiv: 1411.0242v1 [gr-qc]; arXiv:1412.3015v1 [gr-qc].
27. *Bordag M., Pirozhenko I.* // Phys. Rev. B. 2014. V. 89. P. 035421.
28. *Nesterenko V. V., Nesterenko A. V.* // JETP Lett. 2014. V. 99. P. 581.
29. *Severyukhin A. P. et al.* // Phys. Rev. C. 2014. V. 90. P. 044320.
30. *Ganev H. G.* // Eur. Phys. J. A. 2014. V. 50. P. 183.
31. *Dzhioev A. A. et al.* // Phys. Rev. C. 2014. V. 89. P. 035805.
32. *Myeong-Hwan Mun et al.* // Ibid. P. 034622.
33. *Jolos R. V., Shirikova N. Yu., Sushkov A. V.* // Intern. J. Mod. Phys. E. 2014. V. 23. P. 1450051.
34. *Ershov S. N., Vaagen J. S., Zhukov M. V.* // Phys. At. Nucl. 2014. V. 77. P. 989.
35. *Pupyshev V. V.* // Phys. At. Nucl. 2014. V. 77. P. 664; Theor. Math. Phys. 2014. V. 180. P. 1051.
36. *Motovilov A. K.* // Phys. At. Nucl. 2014. V. 77. P. 453.
37. *Belyaev V. B., Miller M. B.* Method of Generation of Coherent Radiation. State Register of Russian Federation. July 8, 2014 with patent No. 25227313.
38. *Lukyanov V. K. et al.* // Bull. Rus. Acad. Sci., Phys. 2014. V. 78. P. 1101–1107;
Lukyanov V. K. et al. // Phys. At. Nucl. 2014. V. 77. P. 100;
Lukyanov V. K. et al. // Bull. Rus. Acad. Sci., Phys. 2014. V. 78. P. 421.
39. *Dorkin S. M. et al.* // Phys. Rev. C. 2014. V. 89. P. 034005.
40. *Konchakovsky V. P. et al.* // Ibid. V. 90. P. 014903.
41. *Katkov V. L., Osipov V. A.* // Appl. Phys. Lett. 2014. V. 104. P. 053102.
42. *Isaeva O. G., Katkov V. L., Osipov V. A.* // Eur. Phys. J. B. 2014. V. 87. P. 272.
43. *Shukrinov Yu. M. et al.* // Supercond. Sci. Tech. 2014. V. 27. P. 124007.
44. *Maśkaa M. M., Mierzejewskia M., Kochetov E.* // Philosophical Magazine.
DOI: 10.1080/14786435.2014.977371. 2014.
45. *Cherny A. Yu. et al.* // J. Appl. Cryst. 2014. V. 47. P. 198.
46. *Yushankhai V. et al.* // Inorg. Chem. 2014. V. 53. P. 4833; Phys. Rev. X. 2014. V. 4. P. 021051.
47. *Yukalov V. I., Yukalova E. P.* // Phys. Rev. A. 2014. V. 90. P. 013627; J. Phys. B. 2014. V. 47. P. 095302;
Yukalov V. I., Novikov A. N., Bagnato V. S. // Laser Phys. Lett. 2014. V. 11. P. 095501.
48. *Plakida N. M., Oudovenko V. S.* // Eur. Phys. J. B. 2013. V. 86. P. 115; JETP. 2014. V. 119. P. 554;
Vladimirov A. A., Ihle D., Plakida N. M. // Eur. Phys. J. B. 2014. V. 87. P. 112;
Vladimirov A. A., Ihle D., Plakida N. M. // JETP Lett. 2014. V. 100. P. 885.
49. *Brankov J. G. et al.* // J. Stat. Mech. 2014. P. 09031.
50. *Nesterenko V. O., Novikov A. N., Suraud E.* // Laser Phys. 2014. V. 24. P. 125501.
51. *Bunzarova N., Pesheva N., Brankov J.* // Phys. Rev. E. 2014. V. 89. P. 032125.
52. *Chicherin D., Derkachov S. E., Spiridonov V. P.* arXiv: 1411.7595. 2014; arXiv: 1412.3383. 2014.
53. *Spiridonov V. P., Vartanov G. S.* // Commun. Math. Phys. 2014. V. 325; JHEP. 2014. V. 06. P. 062.
54. *Alcaraz F. C., Pyatov P., Rittenberg V.* // J. Phys. A. 2014. V. 47. P. 462001.
55. *Derbyshev A. E., Povolotsky A. M., Priezzhev V. B.* arXiv:1410.2874. 2014.

VEKSLER AND BALDIN LABORATORY OF HIGH ENERGY PHYSICS

The activity of the V. I. Veksler and A. M. Baldin Laboratory of High Energy Physics in 2014 was focused on the implementation and further development of the NICA project (the Nuclotron-NICA, MPD and BM@N subprojects) and the participation in current researches in various world-class accelerator centers.

THE MOST IMPORTANT RESULTS IN THE DEVELOPMENT OF THE NICA COMPLEX

Development and Running of the Basic Facilities

Development of VBLHEP's accelerator complex in 2014 was aimed at the construction of systems and elements for the newly created accelerator facilities of the NICA complex.

The Nuclotron was operated in 2014 for two runs: Run 49 and Run 50. During these runs, there were carried out the works aimed both to enhance the capabilities of the accelerator complex for the current physics research programme implementation and to test the equipment and operation modes of the newly created facilities of the NICA complex — the Booster and Collider.

Nuclotron-NICA

Among the achievements obtained during the runs, there are the following:

• During the Nuclotron Run 49, the double user operational mode was realized as a routine regime (Fig. 1). Circulation of the coasting (structureless) beam was realized at two consequent flat-tops (plateaus) of the magnetic field. At the first flat-top, the beam was used for

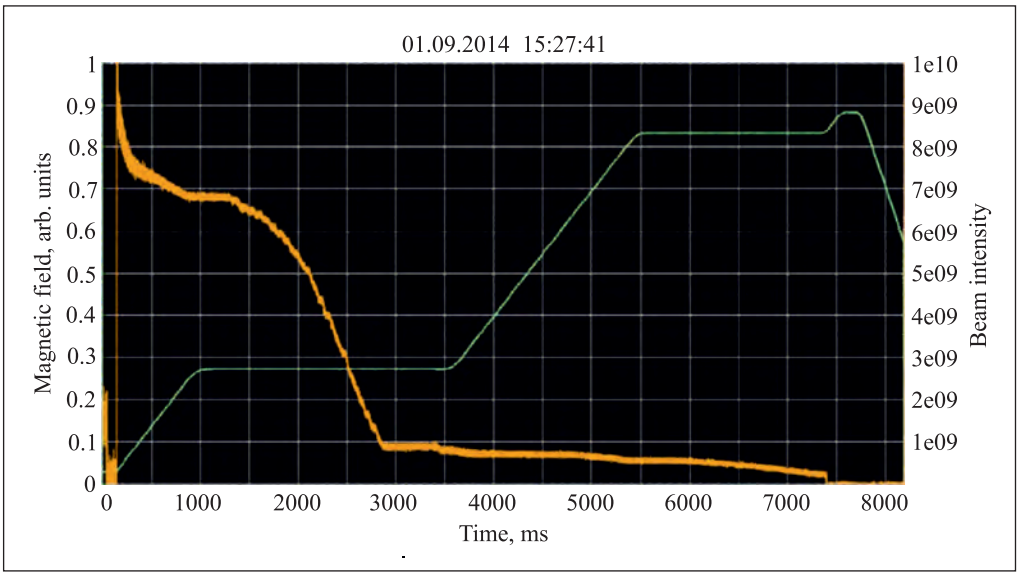


Fig. 1. The magnetic field cycle and beam intensity in the double user mode. At the first flat-top, the beam intensity decreases due to interaction with the internal target, at the second flat-top, the slow extraction is provided. At the both plateaus, RF is off

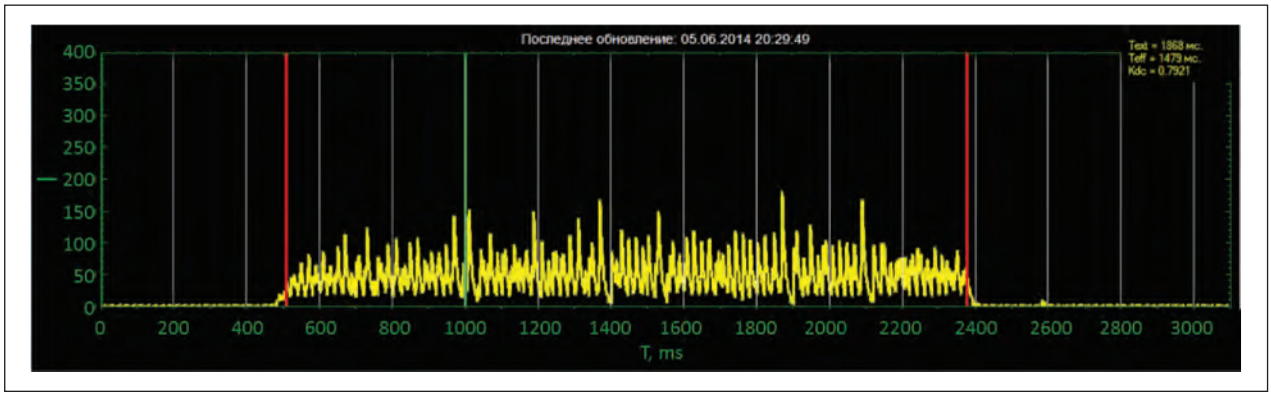


Fig. 2. Intensity time dependence of the extracted $^{40}Ar^{16+}$ beam. Energy is 1.2 GeV/u, total ion number is $1.5 \cdot 10^5$, the spill duration is 2 s

the internal target experiment; at the second flat-top, the slow extraction was realized.

• The first operation of the new stand heavy ion source KRION-6T was performed at the Nuclotron accelerator complex. At the test bench, the magnetic field $B = 5.4$ T was reached in a robust regime; ions of Au^{30+}–Au^{32+} with intensity of $6 \cdot 10^8$ particle per pulse and repetition rate of 50 Hz were produced. At the Nuclotron, the ions Ar^{16+} were accelerated for experiments.

• Optimization of the source and linac LU-20 regimes was provided for generation of a few ion species. The Ar ions were accelerated and delivered for users (Fig. 2). The obtained experimental results will be used for further development of the source.

• The hall for the new heavy ion linac (HILAC) was fully prepared for the equipment installation. The delivering and assembling of the HILAC is going in accordance with the schedule. Start of the commissioning at JINR is planned in June 2015.

• The production of the new RFQ resonator for upgrade of the LU-20 is to be finished in January 2015 (contract with Snezhinsk). Commissioning is expected in September 2015.

NICA

Civil Construction

The year 2014 was an eventful one in the sense of the NICA construction. The preparatory works on the area of 60 000 m^2 were completed. The civil constructions on the NICA complex (Collider ring and experimental halls) have been started.

The schedule of object constructions will be defined in the general contract taking into account Nuclotron operation plans, MPD magnet fabrication schedule and equipment installation plans.

Infrastructure

• A progress was achieved in the preparation of the technological line of NICA and FAIR superconduction (SC) magnets assembly. The first cryo-test bench out of six was put into operation in December 2014. The technological line now has the complete chain for the assembling and tests of SC magnets. It includes the workshop for the cable product ion, the workshop for fabrication of the superconducting coils, the line for the magnet assembly, benches for magnetic field measurements, vacuum and cryogenic tests. The technological line is planned to be completely put into operation according to the staging. The second stage, which is supposed to put another three cryo-test benches into operation, is to be finished in May 2015, and the third one will start up the last two benches in October.

A preserial version of the Booster dipole magnet was assembled and successfully tested.

• The clean room of the workshop for microstrip detector assembly and test was put into operation.

The workshop will start to run in 2015. These works are going in the framework of the MPD–CBM consortium and will produce silicon vertex detectors for BM@N, MPD and CBM experiments. CERN and JINR signed Memorandum of Understanding (MoU) for Collaboration in manufacturing of the carbon fiber space frames for these detectors.

• The work aimed at the construction of the workshop area for Time-Of-Flight (TOF) detectors assembly and tests is going on. The detector assembly procedure started in December. The workshop equipping will be completed in 2015.

• The workshop for Time Projection Chamber (TPC) production and test is under preparation. According to the schedule, it will be ready in 2015.

• Cryogenic complex of the Laboratory is developing according to the schedule. Works aimed at the doubling of the cooling capacity (from 4 to 8 kW at 4.5 K) will be completed in 2018. Two of seven main stages are almost completed — modernization of He Liquefier OG-1000 and extension from 2 to 4 numbers of the helium screw compressors.

NICA Booster

• Two RF accelerating stations of the NICA Booster were constructed at BINP (Novosibirsk). The stations

were assembled and tuned with participation of JINR specialists in May 2014. In October 2014, the stations were delivered to Dubna, consequently assembled and tested. Using the imitator of the magnetic field cycle, the parameters satisfied with technical requirements were demonstrated in the full frequency range.

• The work on the electron cooling system for the Booster is going in accordance with the schedule. Commissioning of both systems at JINR are planned in 2017.

Progress with MPD Detector

The MPD project realization is split into two stages. The first stage (scheduled to 2019) includes creation of TPC, TOF and ECAL for the barrel part of the setup, as well as FFD and ZDC. The second stage is aimed at creation of vertex detector on the base of the silicon strip detectors and endcaps, which includes ECAL and TOF as well as tracker based on the straw tube wills, and possible TPC upgrade. Current status of the MPD subsystems development — R&D and technical design are finished.

MPD Magnet

The superconduction magnet is the basic subsystem of the MPD detector and it has to be produced and installed in a full accordance with time scale of the NICA project. The main effort concerning the MPD magnet in 2014 was aimed at the search for potential manufacturers for various parts production.

Two companies — AGS Superconducting from Italy and Toshiba from Japan — have already experiences in large-scale superconducting solenoid productions (for CMS and ATLAS). Those two were invited to participate in the tender procedure for the production of magnet cold mass (SC solenoid, cryostat and related parts). The corresponding bids were received. Five bids were received as well for the production of another balk part — the magnet yoke. The final choices of the producers and definition of their obligations will be finalized by the mid of 2015.

TPC

Works on TPC are going in accordance with the schedule. In 2014, the production of TPC outer vessels was completed and now all four vessels are produced.

Full-scale Read-Out-Chamber (ROC) prototypes were designed, the preparation of two prototype chambers is in progress. In parallel, a smaller ROC prototype is used for tests with UV laser and cosmic rays.

The Technical Design Report (TDR) of gaseous system for TPC is completed and is under realization in collaboration with PINP, St.-Petersburg, and industry. The main gaseous system equipment components are laying in stock.

The TDR of cooling system is in progress.

Significant progress is achieved in preparing of Front-End-Electronics and DAQ system. The Front-End Cards ‘FEC-64’ were designed and created. The pad-plane printed circuit boards of TPC cathode sector were developed, production started. The FEC’s Read-out Controller architecture design was completed and the FEC’s testing system based on the ‘Cyclone-5 SoC’ development board was created. The FEC’s software for Data ACquisition and Slow Control was developed. The testing of the FE-prototypes ‘FEC64’ was carried out.

TOF & FFD

In order to test properties of the designed detectors and readout electronics, a test facility at the extracted beam of the Nuclotron was constructed.

The studies carried out in 2014 were mainly focused on the optimization of the time-of-flight system, which is planned for the two detectors: MPD and BM@N. The main elements of the time-of-flight systems are multigap resistive plate chamber (MRPC). TOF works together with the fast forward detectors (FFD). The latter are used for the organization of the start signal for the time-of-flight system and zero level trigger. As a result, the TOF time resolution of 65 ps was achieved

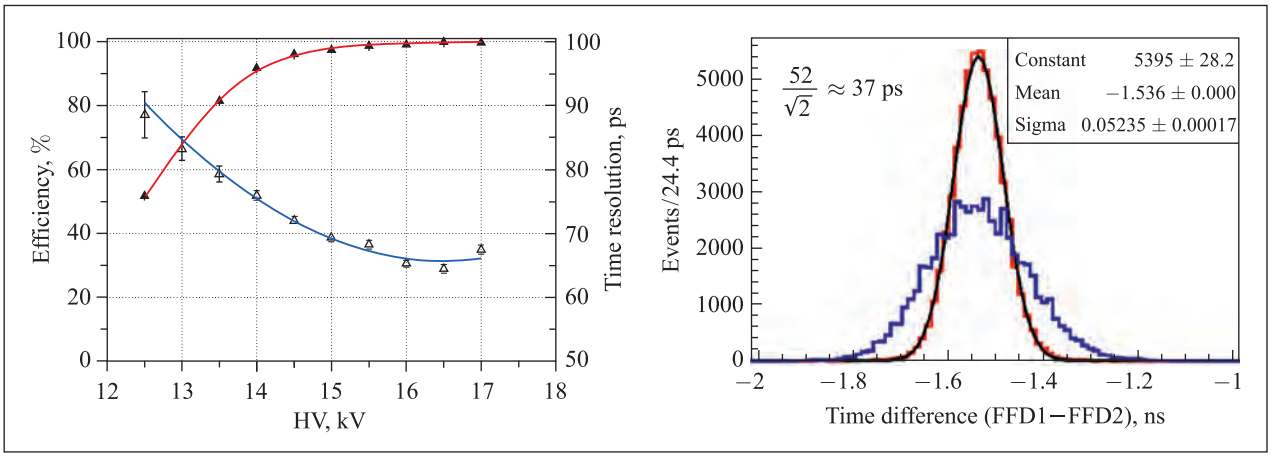


Fig. 3. Time resolution and efficiency of the MRPC strip for the time-of-flight system (left); time distribution between two identical prototypes of FFD (right)

(including the resolution of electronics) with the efficiency of 99.8% (Fig. 3).

A prototype of FFD is a detector of the Cherenkov radiation with a specially created for this system multichannel microchannel photomultiplier PHOTONIS XP85012/A1-Q used as the main sensitive element of FFD. This detector is supposed to generate the "start" signal for the time-of-flight system, therefore it must satisfy special requirements. The time resolution of about 37 ps was obtained (Fig. 3) in the latest experiments for a single detector using a standard VME module TDC32VL, while using DRS4 digitizer gave the time resolution of 21 ps.

BM@N Project

The BM@N project is a fixed target experiment, which was proposed for implementation as the first stage of the NICA program. In that framework, to advance the BM@N project preparation, the following activities were accomplished in 2014:

• The BM@N group was created in the VBLHEP structure to increase the man power in the project.

• The BMNROOT — software for the simulation, reconstruction, event display and physics analysis of the BM@N in framework of the GEANT package, was developed. The Monte-Carlo simulation aimed at the optimization of the detector design, selection of the basic setup and subdetector components for the effective detection and identification of products of nucleus–nucleus interaction was done.

• The BM@N radiation shielding and beam dump were optimized with the help of the FLUKA simulation program.

• The BM@N experimental zone and counting room were prepared for the equipment installation. Concrete shielding against radiation, beam dump and beam shutter were modified. The subdetectors, which have been prepared for the first BM@N test run at the extracted Nuclotron beam in February 2015, were installed.

• The beam line to the BM@N setup was prepared for the test run.

Progress with SPD Project

During 2014, a Letter of Intent (LoI) on the experiment with the Spin Physics Detector (SPD) was prepared. The procedure of the project preparation was started.

PARTICIPATION IN EXTERNAL ACCELERATOR PROJECTS

ILC

The main results achieved by the participating team in 2014 are:

Linac-200 Test Bench. The third accelerating station of the beamline was assembled, vacuum tests were performed. The designed residual gas pressure of $3 \cdot 10^{-8}$ Torr was reached. Klystron and a feeder system of the station were mounted at the nominal position.

Activities concerning an electron beam conducting through the undulator and preparation of the diagnostic equipment for the undulator IR radiation parameters measurement are in progress.

DC Photoinjector Test Bench. Startup of the unique photoinjector laser driver was carried out. The laser has the following parameters: macropulse repetition rate of 10 Hz, laser wavelength of 262 nm, micropulse length of 10 ps, micropulse energy of 1.5 uJ, 8000 micropulses in macropulse. Bulk GaAs "transmissive" photocathodes were produced and investigated. For 15 ns laser ($\lambda = 266$ nm) the measured quantum efficiency was $1 \cdot 10^{-3}$%. The investigations in collaboration with IEE SAS (Bratislava, Slovakia) on the radiation-resistant thin film diamond-like carbon photocathodes fabrication are ongoing [1].

Accelerator LAE-200

The driver of the IREN pulse source of the resonance neutrons successfully worked 5000 h from the startup in 2009.

During the 2014 run, the VBLHEP physicists have used the beams of the LAE-200 to test radiation resistance of different scintillators aimed at the CMS hadron calorimeter upgrade.

THE MOST IMPORTANT EXPERIMENTAL RESULTS

CMS

In 2014, the JINR physicists taking part in the CMS experiment completed processing and analysis of the 2011 and 2012 LHC run data on the Matveev–Muradian–Tavkhelidze–Drell–Yan process with a muon pair production [2]. The predictions of the Standard Model (SM) of elementary particle interactions were proved in a new energy range. The search for signals of new physics beyond the SM was performed as well and the limit of new gauge boson mass was significantly extended (up to $\sim$ 2.7 TeV).

The study of the Higgs boson properties was continued. The boson mass and other parameters were determined more precisely. It allowed making a conclusion about noncontradiction of the discovered boson hypothesis to the SM Higgs boson. The search for rare decays of the Higgs boson was not successful.

During the LHC shutdown, the JINR physicists took part in the Phase 1 Upgrade of the CMS Endcap Muon System and the Hadron Calorimeter.

In particular, the JINR participation in the Endcap Muon System Upgrade in 2014 was to refurbish the SX5 Experimental zone and install the rest 36 cathode strip chambers (CSCs), in addition to 36 CSCs already installed in 2013. All 72 ME1/1 CSCs from both endcaps were commissioned, including the connectivity tests, cosmic-ray tests with HV.

Also, the JINR group took part in R&D for the Phase 2 of the CMS Upgrade for HL-LHC.

ALICE

In the framework of the ALICE experiment, the group of physicists from JINR has continued the investigation of femtoscopical Bose–Einstein correlations for charged kaon pairs ($K^{\rm ch}K^{\rm ch}$) produced in proton–proton (p–p) collisions at energy of 7 TeV [3]. This type of analysis makes it possible to study the space-time sizes of the sources of emission of elementary particles. Previously, similar investigations were carried out in experiments with heavy ion (A–A) collisions, but for p–p interactions they were performed for the first time. The key peculiarity of the obtained results for $K^{\rm ch}K^{\rm ch}$ is the sharp increase of the source size ($R_{\rm inv}$) with the increase of the so-called pair transverse mass (m_T) at the lowest number of created charged particles ($N_{\rm ch}$) and the inverse dependence at a higher $N_{\rm ch}$ (Fig. 4).

The decrease of $R_{\rm inv}$ with the increase of m_T is characteristic of A–A collisions and theoretically explained by the collective effects in pp scattering particle flows, when a big number of nucleons are collided. The same picture for p–p collisions confirms some theoretical suppositions on probability of the manifestation of collective effects on the quark–gluon level in elementary particle interactions with big enough values of $N_{\rm ch}$.

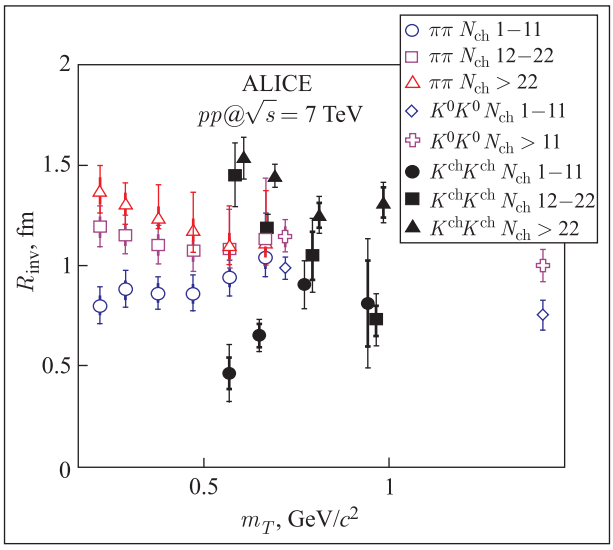


Fig. 4. $R_{\rm inv}$ as a function of m_T

ATLAS

The VBLHEP team participating in the ATLAS Higgs working group continued analysis of the associated production of the Higgs boson with W boson and its decay to a pair of b quarks. Since the last publication in summer 2013, the collected data were re-processed taking into account further improvements in the event selection procedures and the analysis algorithms. The results were improved. The ratio of the measured signal yield to the SM expectation was found to be $\mu = 0.52 \pm 0.32\,(\text{stat.}) \pm 0.24\,(\text{syst.})$ for a Higgs boson mass of 125.36 GeV.

In April 2014, the run at the extracted proton beam of the U-70 accelerator of IHEP aimed at further investigation of liquid argon calorimeter mini-modules parameters was performed. The data collection for measurements of the ionization signals from modules was done, when different values of high voltage were applied to the liquid argon gaps and beam intensities were varied as well. The analysis of the collected data is still continuing.

In the framework of the investigation of the printed boards degradation, the run with high intensity neutron beam at the IBR-2M reactor was hold [4]. During the irradiation, the dose equivalent to that accumulated within the ATLAS detector during 10 years of operation at the luminosity 10 times higher than the nominal one was achieved. The electrical and mechanical parameters of the boards were measured and the conclusions about possibility to use them in the high irradiation environment were drawn. The necessity to test the boards, which are supposed to be used in the high ($\sim 10^{17}$ n/cm^2) dose level, was highlighted.

NA62 and NA48/2 Experiments

The JINR group has continued the work on the analysis of data obtained from the NA48/2 experiment (SPS, CERN).

The rare decay channel $K^{6+} \to \pi^+\pi^0e^+e^-$ was observed for the first time with the essential contribution of the JINR group. This contribution consisted in the development of the criteria for the events selection, the modeling of decay and background source simulation, the test of theoretical models and event generators based on these models, as well as the study of various contributions to the systematic error.

The experimental data accumulated in 2003 were used in this analysis (Fig. 5). 1910 decay candidates were selected from these data with the background estimated to be 60 events (3%). The result was obtained on the relative probability $\text{Br}(K^+ \to \pi^+\pi^0e^+e^-) =$

$(4.06 \pm 0.12_{\text{exp}} \pm 0.13_{\text{ext}}) \cdot 10^{-6}$, which is in agreement with the prediction based on the Chiral Perturbation Theory (CPT) describing strong interactions at low energies [5].

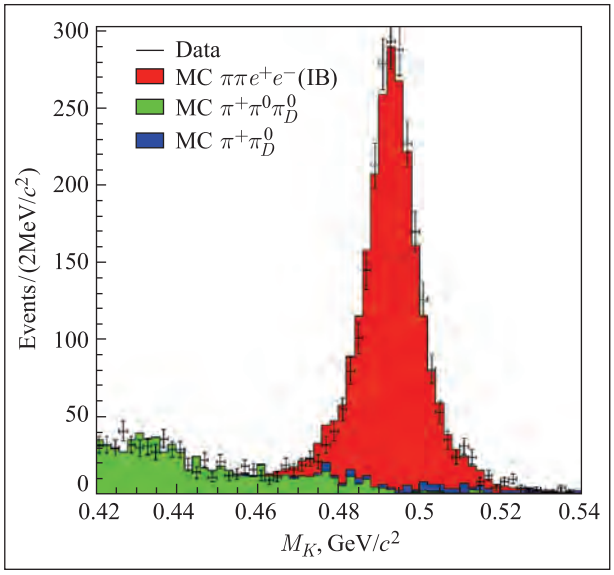


Fig. 5. Reconstructed signal of the decay $K^+ \to \pi^+\pi^0 e^+ e^-$ data and Monte-Carlo

The NA62 experiment is devoted to the study of a very rare charged kaon decay into a charged pion, neutrino and antineutrino. The data taking was started in 2014 with participation of the JINR group. In 2014, the JINR group participating in the experiment fully completed the liabilities on the straw tubes working in vacuum ($\sim 10^{-6}$ Torr) production, creation of the straw tube-based drift chambers and their certification. All the produced drift chamber modules were delivered at CERN and mounted in the experimental hall. During the test run, which was held at CERN SPS in October–December, straw tube chambers were tested in a real beam conditions.

COMPASS Experiment

In 2014, the test run on the Matveev–Muradian–Tavkhelidze–Drell–Yan process measurements with a pion beam of 160 GeV and a hydrogen polarized target was carried out within the framework of the COMPASS experiment. The JINR group was responsible for putting the enhanced Data Acquisition System (DAQ) in operation; preparation of the polarized target; preparation of the engineering facilities of the experimental hall; hadron calorimeter (HCAL1) and tracking detector (MW1).

In February and October of 2014, the tests of the electromagnetic calorimeter (ECAL0) modules at an electron beam of the ELSA accelerator complex (Bonn, Germany) and at beams of the PS accelerator (CERN, Geneva) were held. The obtained results showed that the calorimeter module and the avalanche diode-based read-out system fully satisfy conditions of the future measurements of generalized parton distributions to be carried out in 2016 [6].

STAR

In 2014, the JINR group taking part in the STAR project at the RHIC collider was actively involved in the analysis of new data on measurements of antiquark polarization of the proton. The experiment was conducted at collisions of longitudinally polarized protons at a center-of-mass energy of 0.5 TeV. The W bosons were registered to be produced by the annihilation of a quark and an antiquark, whose types were determined by the charge of W boson. The analysis (Fig. 6) demonstrated the presence of a significant asymmetry indicating the domination of the u antiquark polarization [7].

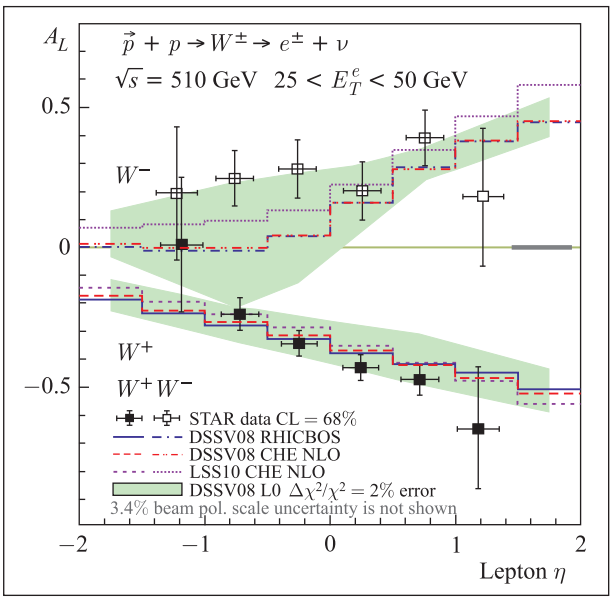


Fig. 6. The asymmetry in the production cross section for $W^\pm$ bosons in proton collisions with a positive (negative) proton beam helicity, $\sigma_+(\sigma_-)$, defined as $A_L = (\sigma_+ - \sigma_-)/(\sigma_+ + \sigma_-)$, is shown as a function of the W boson's decay lepton pseudorapidity. The filled (open) points correspond to the $W^+(W^-)$ asymmetries, in comparison to predictions from different polarized parton distribution functions

NA61 Experiment

The evidence of the existence of the critical point of nuclear matter was received for the first time within the experiments at the NA61 (SPS, CERN) with the active participation of the physicists of the Laboratory of High Energy Physics [8]. These data are highly important for the theory of nuclear matter and for its further application in practice. Matter in the critical point region must have unique properties, which should be studied in detail.

During the 2014 run, the NA61 experiment continued data taking on p–Pb scattering in energy range from 20 until 160 GeV/A.

HADES

During 2014 year, the following results have been obtained:

• The experimental results on the quasi-free $np \to np\pi^+\pi^-$ reaction at 1.25 GeV have been reanalyzed and finalized.

• The preliminary results on the quasi-free $np \to pp\pi^-\pi^0$ reaction at 1.25 GeV with HADES have been obtained and reported.

• The calculation within the modified OPER model for the quasi-free $np \to np\pi^+\pi^-$ and $np \to pp\pi^-\pi^0$ reactions at 1.25 GeV has been performed both for 4π and HADES acceptance cases.

• The theoretical analysis of the proton-spectator distribution in $d{-}p$ dielectron production at HADES setup at $T_{\rm kin} = 2.5$ GeV has been performed [9].

• The final data analysis of the data on dp elastic scattering at $T_d = 2.5$ GeV at HADES has been performed for the new normalization constant. A new draft of the paper is prepared for the hadron working group.

• The JINR participants were involved in the data taking run with π^- beam, as well as in the discussions of the results obtained and published by the HADES collaboration in 2014.

Experiments at the Nuclotron Carried out during the 2014 Runs

About 60% of the beam time of Run 49 and more than 30% of that of Run 50 were used for the current experiments and for the detector beam tests. In particular, the following experiments were used this time:

FAZA-3 Experiment. The main subject of FAZA collaboration is the investigation of the properties of very hot nuclei with excitation energy, which is comparable with total binding energy ($\sim$ 50%). The most important result obtained is measuring the time scale of the multibody disintegration of hot nuclei from reaction $d+$Au: it takes place (100 ± 15) fm/c after the collision moment [10]. This is the expansion time of hot nucleus before the disintegration. This result is very important for the understanding of the dynamic properties of hot nuclei.

DSS Project. In the DSS experiment carried out at the internal target of the Nuclotron, experimental data on the angular dependence of the elastic deuteron–proton scattering cross section at the deuteron beam energies of 1 and 1.8 GeV were obtained. The preliminary results were presented at the international conferences RNP-2014 and IBSHEPP-XXII.

Experimental data for the deuteron break-down with detecting of two protons at the deuteron beam energy of 400 MeV in various kinematic configurations in coplanar geometry were obtained. The preliminary results were presented at the international conferences MESON-2014, RNP-2014 and IBSHEPP-XXII.

Within the relativistic model of multiple scattering, the theoretical calculations were performed for interpretation of the obtained experimental data on deuteron–proton elastic scattering in the deuteron energy range of 880–2000 MeV.

In the framework of the relativistic model of multiple scattering, predictions on the A_y, A_{yy}, A_{xx} and A_{xz} analyzing powers in the $dd \to {}^3\mathrm{H}\,p$ and $dd \to {}^3\mathrm{He}\,n$ reactions at the deuteron energies of 200 and 270 MeV were obtained [11].

STRELA. During Run 49, international team of the STRELA collaboration has finished suspended measurement of the charge-exchange process in the deuteron–proton collision. Data taking was carried out with 3.5 GeV deuteron beam. Two-proton production cross section at small momentum transfers in the $dp \to pp{+}n$ interactions was measured. Data analysis is in progress.

CBM. In 2014, the JINR group taking part in the CBM project carried out the following works in the framework of its liabilities:

• The Technical Design Report (TDR) of superconducting dipole magnet of the CBM setup was prepared [12]. This TDR is fully approved by the FAIR experts and ready for production.

• In the framework of creation of the straw tracker, a prototype detector based on the straw tubes was developed with the consideration of an opportunity of creation of standard modules, which are easy to assemble and able to operate at high gas pressure up to 4 bar without dependence on the environmental parameters, such as humidity and temperature [13]. One layer of the prototype contains 48 straws with the internal diameter of 9.56 mm and 2 m long with the carbon coating of the cathode. The wall thickness is ~ 60 μ and the sensitive area is $2 \cdot 0.5$ m^2.

The possibility of using the Direct Time Method (DTM) to register the signals from the prototype with the straw of 2 m long and with the diameter of 9.53 mm was considered. The measurements carried out with the prototype detector showed the expediency of using the DTM to determine the longitudinal coordinate with the thin-wall drift tubes of 2 m long with the precision better than 2 cm (σ).

A full-scale two-layer prototype containing 1200 tested drift tubes was developed and created. There was less than 0.3% of defective straws.

Besides, the works on the development of methods and algorithms for the global tracking and on the study of multiparticle dynamics in heavy ion collisions were continued.

QUINTA. In framework of the innovative project QUINTA, the following results were obtained in 2014:

• An experimentally measured dependence of secondary neutrons energy specta on the beam energy strongly differs with theoretical calculations [14].

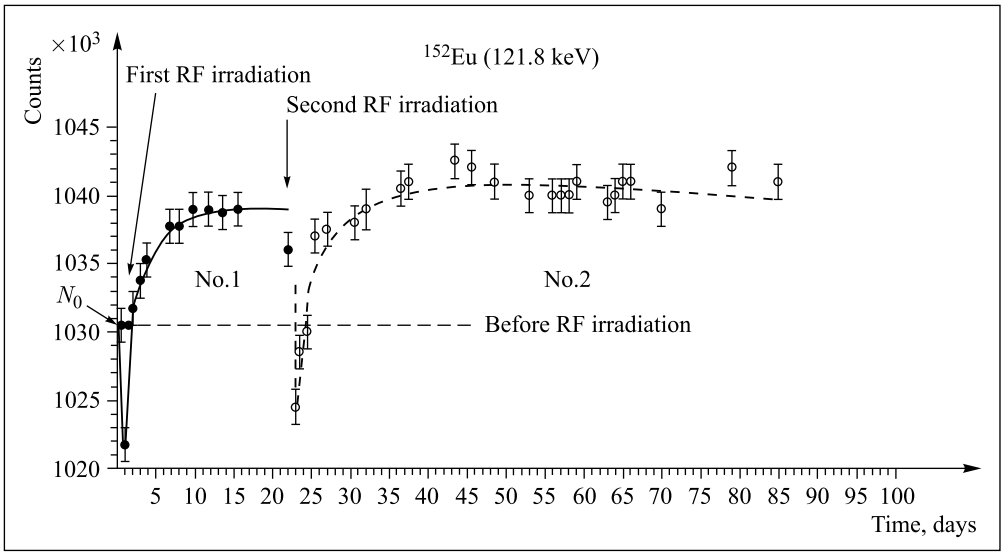


Fig. 7. Evolution of the 121.8 keV line intensity after two RF irradiations

• The neutron jet with $E_n > 20$ MeV transmitted along the beam axes was discovered during irradiation of the uranium assemblage by p, D^2, C^{12}. Jet parameters — intensity and size, depend on the beam type and energy [15].

• Firstly was discovered significant effect in ^{152}Eu radioactive half-life (Fig. 7) caused by the radiation of the pulse laser on the free electrons [16]. Effect cannot be explained by random error.

Events

The second Workshop of the Nuclotron Beam Users "Perspectives of Experimental Research at the Nuclotron Beams" was held on 11–12 September, 2014, at the VBLHEP. The present status and the prospect of the Nuclotron facility, which provides unique possibilities for investigations at relativistic ion beams in the kinetic energy range from hundreds of MeV to several GeV per nucleon, were discussed. Representatives of the JINR Directorate, the Member States, the VBLHEP Directorate, and current experiment group leaders attending the Workshop signed the Protocol, which summarized discussions on the Nuclotron user policy, requests and recommendations aimed at the realization of the scientific programme, as well as at the effective usage of the beam time.

The International Symposium devoted to the 70th anniversary of the discovery of phase stability principle by V. I. Veksler and E. McMillan organized by JINR and the Lebedev Physical Institute (Moscow), was held in Dubna on 10–15 November, 2014, at the Veksler and Baldin Laboratory of High Energy Physics. Academicians G. A. Mesyatz and V. A. Matveev were the co-chairs of the Organizing Committee. The representatives of the leading accelerator centers presented the current status of the accelerator physics and discussed outlooks of its development in 25 invited talks.

REFERENCES

1. *Huran J. et al.* Transmission Photocathodes Based on Stainless Steel Mesh Coated with Deuterated Diamond-Like Carbon Films // Nucl. Instr. Meth. Sec. A.: Accelerators, Spectrometers, Detectors and Associated Equipment. 2014. V. 753. P. 14–18.
2. *CMS Collab.* Measurements of the Differential and Double-Differential Drell–Yan Cross Sections in Proton–Proton Collisions at 8 TeV, CMS-PAS-SMP-14-003 (submitted);
   Konoplyannikov V. F. et al. The Uncertainties of the Sections of the Drell–Yan Processes Birth in Proton Collisions at LHC // Part. Nucl., Lett. 2014. V. 11, No. 6(198). P. 1122–1133.
3. *ALICE Collab.* Charged Kaon Femtoscopic Correlations in pp Collisions at $s_{1/2} = 7$ TeV // Phys. Rev. D. 2013. V. 87. P. 052016.
4. *Bulavin M. et al.* The Irradiation Facility at the IBR-2M Reactor in Dubna // Proc. of the 14th ICATPP Conf. on Astroparticle, Particle, Space Physics and Detectors for Physics Applications (ICATPP 2013): Como, Italy, Sept. 23–27, 2013. P. 583–587; Nucl. Instr. Meth. B. 2015. V. 343. P. 26 (in press).
5. *Misheva M. H.* First Observation of the Very Rare Decay $K^{\pm} \to \pi^{\pm}\pi^0 e^+ e^-$ by the NA48/2 Experiment // Conf. "Recontres de Moriond QCD and High Energy Interactions", La Thuile, March 21–28, 2015.

6. *COMPASS Collab.* CERN-PH-EP/2014-109 hep-ex/1405.6377, CERN-PH-EP/2014-180 hep-ex/1407.6186, CERN-PH-EP/2014-247 hep-ex/1410.1797.
7. *Adamczyk L. et al. (STAR Collab.)* // Phys. Rev. Lett. 2014. V. 113. P. 072301.
8. *Stefanek G. for the NA49 and NA61/SHINE Collabs.* // Nucl. Phys. B. Proc. Suppl. 2014 (in press).
9. *HADES Collab.* Properties of Hot Nuclei Produced in Collisions of Light Relativistic Ions with Heavy Targets // Phys. At. Nucl. 2014. V. 77, No. 12. P. 129 (in press).
10. *Karnaukhov V. A. et al.* Properties of Hot Nuclei in Collisions of Light Relativistic Ions with Heavy Targets // Nucl. Phys. 2014. V. 77, No. 1. P. 120;
Krupka J. et al. Electrical Properties of Deuteron Irradiated High Resistivity Silicon // Nucl. Instr. Meth. B. 2014. V. 325. P. 107.
11. *Ladygina N. B.* Spin Effects in the $dd \to {}^3\mathrm{He}\, n$ Reaction at Intermediate Energies // Phys. Part. Nucl. 2014. V. 45. P. 187–189.
12. The Technical Design Report for the CBM Superconducting Dipole Magnet.
http://www.faircenter.eu/fileadmin/fair/experiments/CBM/TDR/CBM_magnet_TDR_31_10_2013-nc.pdf;
Akishin P. et al. Superconducting Dipole Magnet for the Compressed Baryonic Matter (CBM) Experiment at FAIR // CBM Progress Report. GSI, Darmstadt, 2013. P. 6.
13. *Peshekhonov V. et al.* Straw Based Coordinate Muon Chamber // CBM Progress Report. GSI, Darmstadt, 2014.
14. *Asquith N. L. et al.* Activation of ^{197}Au and ^{209}Bi in Fast Spectrum Subcritical Assembly Composed of 500 kg Natural Uranium Irradiated with 1 and 4 GeV Deuterons // Ann. Nucl. En. 2014. V. 63. P. 742–750.
15. *Asquith N. L. et al.* The Spatial Distribution of Thermal and Epithermal Neutrons in Graphite Moderated Spallation Neutron Source // Rad. Meas. 2014. V. 67. P. 15–23.
16. *Golubykh S. M. et al.* Influence of High-Power Pulse RF Irradiation on Several Types of Beta-Decay // Intern. Workshop “Strong Microwaves and Terahertz Waves: Sources and Applications”, Nizhny Novgorod, July 24–30, 2014. P. 619.

NEUTRINO PHYSICS AND RARE PHENOMENA, ASTROPHYSICS

The most important result within the **Baikal** experiment was deploying in April 2014 the first stage of the demonstration cluster "DUBNA" (the first cluster of GVD), which comprises 112 OMs arranged on five 345-m-long strings, and an instrumentation string with the array calibration and environment monitoring equipment [1]. The long-term *in situ* measurements of the installed system, which were started in 2013 and continued through 2014, demonstrated the possibility of producing equipment on the GVD cluster scale. Primary analysis of the data from the cluster was performed, and showed the expected performance of all parts of the detector. New analysis of the NT200 data for the period 1998–2003 was performed to search for neutrinos from dark matter annihilations in the Sun. Upper limits were obtained for the muon and neutrino fluxes, annihilation rate, and SD/SI cross sections of DM scattering from protons under the assumption of different annihilation channels.

In 2014, a group of scientists from DLNP developed their own software and analysis methods for the **Daya Bay** experiment data. New precision results on the measurement of the neutrino oscillation parameters θ_{13} (mixing angle) and Δm^2_{ee} (mass splitting) were obtained: $\sin^2 2\theta_{13} = 0.084 \pm 0.005$, $\Delta m^2_{ee} = 2.44^{+0.10}_{-0.11}$. The precision of the Δm^2_{ee} measurement is now comparable with the precision of the other flavor average of the mass splitting $\Delta m^2_{\mu\mu}$. The search for sterile neutrinos was done using the previous dataset. As for now, Daya Bay sees no signal of the sterile neutrino and sets limits on its parameters Δm^2_{41} and θ_{14} in the range of Δm^2_{41} between 0.001 and 0.3 eV^2 [2].

For the **JUNO** experiment the DLNP group performed the necessary calculations for the PMT shielding against the Earth's magnetic field. The characterization of the new PMT tubes with MCP, R&D and optimization of the HV system were performed and the HV prototype based on the Cockroft–Walton generator technology for the JUNO PMTs was created.

In 2014, the Dubna group in **Borexino** participated in the data-taking shifts and took an active part in the physical analysis of the accumulated data carried out by the "antineutrino", "rare physics", "cno" and "*pp* neutrino" working groups. The main result of the year was the first real-time measurement of the solar *pp*-neutrino flux [3]. Spectral fit was used to obtain that result, and the *pp*-neutrino signal was there extracted from the spectral analysis. The precision of the measurement of the solar *pp* neutrino is about 10%. The result confirms stability of the Sun at the scale of hundreds of thousands of years. Together with the previous measurements of the solar neutrino fluxes from the ^{7}Be, ^{8}B, and *pep* reactions in the first phase of Borexino, the *pp*-neutrino flux measurement completes the measurement of the neutrino fluxes from the solar *pp* chain of reactions [4].

By September 2014, the **NOvA** experiment completed commissioning and tests of detectors, and in November 2014, the data taking in the full configuration of the Near and Far Detectors started. By the time of the first analysis in January 2015, the integral intensity of about $(1.1{-}1.5) \cdot 10^{20}$ POT (proton on target) was expected. In 2014, the JINR group in NOvA took part in the assembling of the Near Detector, its filling with liquid scintillator, tests of electronics, and detector control during the data taking. With the help of LIT experts the necessary NOvA software was installed at JINR with the purpose of developing reconstruction algorithms and physics analysis [5]. Also, the work on the oscillation analysis started at JINR, with studing the contribution of different theory approximations, MSW effect, and effect of neu-

trino cross sections on systematic uncertainties of the experiment.

In the **OPERA** experiment, the JINR group is responsible for the analysis of the data from the electronic detectors and matching of the information from the electronic detectors and changeable emulsion interfaces. It performs the emulsion data analysis using the automatic scanning stations created in Dubna. In 2014, continuing the data analysis, the OPERA collaboration found the fourth event of the tau neutrino interaction in the target. Considering an expected very low background of 0.23 event, the statistical significance of the evidence for neutrino oscillations in the beam is now 4.2σ. Other results worth mentioning were the new restrictions on the existence of the so-called "exotic" oscillations $\nu_\mu \to \nu_e$ (LSND–MiniBOONe type) and the measurements of the charge ratio of the cosmic muons in the TeV range [6–8].

The **NEMO-3** experiment performed precise measurement of the double-beta decay and searched for the neutrinoless double-beta decay on seven $\beta\beta$ isotopes ^{48}Ca, ^{82}Se, ^{96}Zr, ^{100}Mo, ^{116}Cd, ^{130}Te, and ^{150}Nd, among which ^{100}Mo and ^{82}Se were dominant. The key feature of NEMO-3 was its unique capability to fully reconstruct the kinematics of the events, which allowed reduction of the backgrounds and discrimination among different mechanisms of the neutrinoless double-beta decay. No evidence of $0\nu\beta\beta$ events was found with an exposure of 34.7 kg $\cdot$ y of ^{100}Mo, which proved a limit for the light Majorana neutrino mass mechanism of $T_{1/2}\ (0\nu\beta\beta) > 1.1 \cdot 10^{24}$ y (90% C.L.). It corresponds to an effective neutrino mass of $|m_{\beta\beta}| < 0.3{-}0.8$ eV, depending on the nuclear matrix element considered [9, 10].

The same experimental trecko-calo technique as in NEMO-3 was adopted for the next-generation experiment **SuperNEMO**. The new detector has a modular design with the capability of measuring different isotopes at the same time: ^{82}Se and ^{150}Nd are currently under consideration. With 20 detection modules observing 100 kg of ^{82}Se for five years, the expected sensitivity should reach $T_{1/2}\ (0\nu) > 10^{26}$ y ($|m_{\beta\beta}| < 0.04{-}0.11$ eV), competitive with other experiments [11].

The Dubna team participating in the **EDELWEISS** experiment was mainly involved in the assembly and commissioning of the facility, low background study, development of new low-threshold detectors, detector simulations, and data analysis. In the upgraded EDELWEISS setup, 36 FID800 detectors with cumulative fiducial mass of 22 kg were installed by February 2014. The next goal of the project is exposure of 3000 kg $\cdot$ day to reach the WIMP-nucleon scattering cross-section sensitivity better than $5 \cdot 10^{-45}$ cm^2. By 2018, after 12000 kg $\cdot$ day of data taking, the WIMP discovery potential of EDELWEISS-III will be competitive with other world-leading Dark Matter search experiments. This stage will also be the last R&D stage on the preparation for the EURECA 1-t multitarget Dark Matter search (investigation) experiment. Participation in the EDELWEISS project gives JINR an important access to the low-background infrastructure needed for R&D of the νGeN project: an experiment at the Kalininskaya Nuclear Power Plant for detection of elastic coherent neutrino — Ge nucleus scattering.

The **GERDA** experiment is designed to search for the neutrinoless double-beta $(0\nu\beta\beta)$ decay of ^{76}Ge. In Phase I, the existing enriched detectors (18 kg of ^{76}Ge in total) from the previous Heidelberg–Moscow and IGEX experiments were employed. The total exposure of GERDA Phase I considered for the analysis amounted to 21.6 kg $\cdot$ y of ^{76}Ge detector mass. The analysis of the Phase I data with a very low background of 10^{-2} counts/keV $\cdot$ kg $\cdot$ y [12] did not reveal the neutrinoless double-beta decay of ^{76}Ge and allowed a new limit on the half-life $T_{1/2} > 2.1 \cdot 10^{25}$ y (90% C.L.) corresponding to the limit on the effective neutrino mass $< 0.2{-}0.4$ eV to be established [13]. GERDA is under upgrading to Phase II, which requires a major change of the hardware [14]. Intensive preparation for Phase II of GERDA went on in 2014. Thirty new BEGe detectors of ^{76}Ge were produced and tested (about 20 kg ^{76}Ge) and the optimal system of contacts and signal outputs was designed, built, and tested in the test benches. The muon veto modules based on plastic scintillator were modified for GERDA Phase II, tested, and integrated into the common veto system. Additional methods for further reduction of background were developed. The combined "LAr-scintillation Veto" system for GERDA II was successfully commissioned.

The **TUS** space experiment is aimed to study the energy spectrum and arrival distribution of UHECR at energies above 10^{20} eV. There are two main parts of this detector: a large Fresnel-type mirror-concentrator ~ 2 m^2 in area and a photo-receiver (matrix of 16×16 PM tubes) with the DAQ electronics placed in its focal plane. The mission is planned for implementation on the dedicated "Mikhail Lomonosov" satellite at the end of 2015. The TUS is designed to perform the data taking for 3–5 years. A TUSSIM program package was developed at JINR to simulate the TUS detector performance, including the optical parameters of the Fresnel mirror, the light concentrator of the photo-detector and the FE, and trigger electronics. The expected TUS statistics is evaluated for five years of data collection in the 500-km solar-sinchronized orbit with allowance for the background light intensity change during the space flight. The JINR group plans to design and produce a ground-based system of light sources for the TUS detector calibration in the orbital flight.

Measurements of the CR spectrum, composition, and anisotropy in the energy range of 10^{14}–10^{16} eV are an important part of the **NUCLEON** particle physics experiment aimed at understanding of the CR origin, acceleration, and propagation in our Galaxy. Produc-

tion of the NUCLEON detectors was completed. The complex test of the apparatus entered the final phase. The quality and reliability of the NUCLEON detectors and electronics were confirmed in the high-energy beam tests at the SPS (CERN). The NUCLEON mission started in December 2014 on the RESURS-P 2 satellite with 3–5 years of the data taking.

In 2014, within the **TAIGA** experiment the design documentation was developed and production of a prototype rotary platform of the track detector of the UHECR Cherenkov light was begun. The design documentation was developed and the base for the gamma telescope No. 0 on the platform of the TUNKA-133 experiment in the TUNKA valley was made. The Monte-Carlo simulation of the telescope using the CORSIKA program was performed. In 2015, it is planned to finish the production of gamma telescope No. 0 and to start the production of gamma telescope No. 1.

PHYSICS OF ELEMENTARY PARTICLES

The **ATLAS** group at JINR was searching for high-mass resonances decaying to dielectron or dimuon final states from the analysis of proton–proton (pp) collisions at a center-of-mass energy of 8 TeV corresponding to an integrated luminosity of 20.3 fb^{-1} in the dielectron channel and of 20.5 fb^{-1} in the dimuon channel. A narrow resonance with the Standard Model Z couplings to fermions was excluded at the 95% confidence level for masses less than 2.79 TeV in the dielectron channel, 2.53 TeV in the dimuon channel, and 2.90 TeV in the two channels combined [15].

Search for supersymmetry in final states containing at least one isolated lepton (electron or muon), jets, and large missing transverse momentum was carried out using the ATLAS detector at the Large Hadron Collider. The search was based on the proton–proton collision data collected in 2012 at a centre-of-mass energy $\sqrt{s} = 8$ TeV, corresponding to an integrated luminosity of 20 fb^{-1}. No significant excess above the Standard Model expectation was observed. Limits were set on sparticle masses for various supersymmetric models. Depending on the model, the search excluded gluino masses up to 1.32 TeV and squark masses up to 840 GeV [16].

The JINR team participates in the search for the decay mode $\Lambda_b^0 \to \psi(2S)\Lambda^0$, which has not yet been observed, although measurement of its decay properties can be useful for verification of theoretical predictions. The $\Lambda_b^0 \to \psi(2S)\Lambda^0$ branching fraction should be of the same order of magnitude as that of the decay $\Lambda_b^0 \to J/\psi\Lambda^0$ as suggested by the branching fraction values of the analogous $B^0 \to J/\psi K^0$ and $B^0 \to \psi(2S)K^0$ decays. The theoretical expectation for the ratio of the branching fractions of the $\Lambda_b \to \psi(2S)\Lambda$ and $\Lambda_b \to J/\psi\Lambda$ decays is 0.81 [17].

The **SANC** project includes theoretical predictions for many three- and four-particle Standard Model (SM) processes at the one-loop precision level (QCD and EW NLO). The main results of 2014 were completion of calculations of the J functions for process like $ud \to WA$ and publication of the results [18]; preparation of a new version of the MCSANC integrator containing photon-induced processes and several technical improvements; theoretical support of the ATLAS experiment analysis of the Drell–Yan process by supplying higher order electroweak corrections [19]; inclusion of the QED evolution into the routines for solution of DGLAP equations to take into account the photon-induced processes in the HERAFitter package [20]; release of the first stable version of the HERAFitter framework for QCD analysis of experimental data and corresponding publication.

The main results of the **CDF** project were the precise top-quark mass measurement in $t\bar{t}$ dilepton events using the full CDF Run II data set, obtaining of the "CDF average" mass of the top quark with a total uncertainty of 0.93 GeV/c^2, beam tests of the LYSO crystals matrix with the photon beam at Mainz (Germany) and the electron beam at Frascati (Italy). New mixed BGSO (BGO-BSO) crystals and scintillator strips with different light collection configuration were tested.

Using top–antitop pairs at the Tevatron proton–antiproton collider, the CDF collaboration published results from Run I (1992–1996) with the recent preliminary and published Run II (2001 to now) measurements obtained with the participation of the Dubna group of the full CDF luminosity corresponding to 8.7–9.3 fb^{-1} of data. Considering the properly correlated uncertainties, the resulting preliminary CDF average mass of the top quark is $M_{\rm top} = (173.16 \pm 0.57\,({\rm stat.}) \pm 0.74\,({\rm syst.}))$ GeV/c^2 or, summing the statistical and systematical uncertainties in quadrature, $M_{\rm top} = (173.16 \pm 0.93)$ GeV/c^2, which corresponds to a relative uncertainty of 0.54% [21].

The **BES-III** experiment at the Beijing electron–positron collider BEPC-II continued investigations of charged charmonium-like hadrons $Z_c^{\pm}$ decaying to a charmonium and a charged pion. New $Z_c^{\pm}$ decay modes were observed, and a neutral state $Z_c^0(4020)$ was discovered. The state is presumably an isospin partner of $Z_c^{\pm}(4025)$ [22, 23]. In 2014, the tau lepton mass was measured with a high precision: $M\tau =$

$1776.91^{+0.16}_{-0.18}$ MeV/c^2. The precision is practically as high as the one of the PDG world average [24].

The 2.92 fb^{-1} data sample collected by BES-III at 3.773 GeV was used to measure the branching fraction $B(D^+ \to \mu^+\nu_\mu) = (3.71 \pm 0.19 \pm 0.06) \cdot 10^{-4}$ (the former error is statistical and the latter is systematic). This value combined with the best fit of $|Vcd|$ allowed estimation of the decay constant $f_{D+} = (203.2 \pm 5.3 \pm 1.8)$ MeV. Alternatively, with f_{D+} from the LQCD calculations, the value of $|Vcd| = 0.2210 \pm 0.0058 \pm 0.0047$ was obtained. Currently, both values determined by BES-III are the world's best results [25].

Within the framework of the **DIRAC** experiment 178 ± 49 (3.6σ) characteristic πK pairs from the πK atom breakup in a Ni target were observed and the number of produced πK atoms was estimated at 653 ± 42. Thus, it was possible to measure for the first time the πK atom lifetime $\tau = (2.5^{+3.0}_{-1.8})$ fs and the S-wave isospin-odd πK scattering length $|\bar{a}_0| = \frac{1}{3}|a_{1/2} - a_{3/2} = (0.11^{+0.09}_{+0.04})M_\pi^{-1}$ [26]. The preliminary results of the dedicated experiment on observation of the long-lived (metastable) states of $\pi^+\pi^-$ atoms were obtained. Now, the number of characteristic $\pi\pi$ pairs from the breakup of the long-lived states is found to be 380 ± 53 (7.2σ). The observation of long-lived states opens up the possibility of measuring the energy difference between ns and np states — the Lamb shift.

During the 2008–2010 production runs the **PEN** experiment accumulated some 23M $\pi \to e\nu$ and > 150M $\pi \to \mu \to e$ decays and a significant number of pion and muon radiative decays. A comprehensive blind maximum likelihood analysis is underway to extract a new experimental value of $R^\pi_{e/\mu}$. The analysis of the PEN $\pi \to e\nu$ data is expected to improve the SD$^-$ structure-dependent amplitude, which constrains $F_V - F_A$, and the analysis of the PEN $\mu \to e\nu\nu\gamma$ data is expected to improve the present value of the Michel parameter η.

The international **MEG** collaboration is conducting an experiment to search for the $\mu^+ \to e^+\gamma$ decay on the accelerator muon beam at PSI, Switzerland. The present upper limit on the branching ratio of this decay is $5.7 \cdot 10^{-13}$ (90% C.L.). The processing of the full data set is expected to improve this value by a factor of 1.5. A probability of the polarized muon decay was measured [27]. Comprehensive upgrading of the MEG detector (MEG-II) is now underway [4], which is expected to allow a sensitivity level of $6 \cdot 10^{-14}$ by 2018.

The experiments were carried out with the **ANKE** setup at the COSY accelerator in Jülich in the field of intermediate energy hadron physics using polarized beams and polarized jet targets. The proton analyzing power in small-angle $p\vec{p}$ elastic scattering was measured at COSY-ANKE at 796 MeV, and five other beam energies between 1.6 and 2.4 GeV using a polarized proton beam [28]. Although the analyzing power results agree well with a lot of published data at 796 MeV and also with the most recent partial wave solution at this energy, the ANKE data at the higher energies lie well above the predictions of this solution at small angles. An updated phase shift analysis that uses the ANKE results together with the world data leads to a much better description of these new measurements.

The ^{3}He production was studied in interactions of a polarized deuteron beam with protons. The measurement of the deuteron tensor analyzing power t_{20} of the $d\vec{p} \to {}^3\mathrm{He}\,\eta$ reaction in small steps in excess energy up to 11 MeV showed that the final state interaction causing the energy variation was not influenced by the spin configuration in the entrance channel [29].

In the PAX-related part of **SPRING**, the previous data from the investigation of the beam depolarization were re-analyzed using a more efficient procedure. This allowed the upper limit for the electron–proton spin-flip cross section to be reduced by a factor of three [30], which made the previous conclusion (about impossibility of using the spin-flip method to polarize the beam) even more robust.

In 2014, the experimental equipment of the **TRITON** installation located on the muon channel of the DLNP Phasotron was prepared to study the nuclear fusion reaction from the muonic molecule $pt\mu$ state. In the course of preparation, the programs for the offline analysis of experimental data were developed. The Monte-Carlo simulation of physics processes with the real geometry of the experiment was performed [31].

Within the **NN-GDH** project, the 1K-Cryostat was designed and created at DLNP, JINR, for joint experimental research on the Compton scattering of polarized photons by the polarized proton target carried out by the A2 collaboration at the MAMI C accelerator, which was delivered from Dubna to Mainz in December 2014.

The activity carried out in 2014 within the **MUON** project was aimed at studying the behavior of the polarized muons in condensed matter. Polarized negative muons were used to study the behavior of the boron acceptor centre in diamond produced by the chemical vapour deposition (CVD) method. The temperature dependence of the muon spin relaxation rate and spin precession frequency were measured in the range of 20–330 K in a transverse magnetic field of 14 kOe. For the first time a negative shift of the muon spin precession was observed in diamond. This frequency shift can be explained by the anisotropy of the hyperfine interaction of the acceptor impurity (boron) in diamond [32].

The goal of the **COMET** project is search at J-PARC for neutrinoless muon-to-electron conversion, which can be explained only beyond the Standard Model. In 2014, the technology for production of tubes with wall 20 μm thick was developed, previously only tubes with wall 36 μm thick were manufactured. A test set of 100 tubes was produced and delivered to Japan for manufacturing the prototype detector. A device for measurement of the tube and wire tension was devel-

oped and tested. Characteristics of 50 LYSO crystals, each $2 \times 2 \times 12$ cm in size, were measured at the test bench. A prototype calorimeter based on these crystals, and also on the basis of another crystal candidate, the GSO, was tested with an electron beam at Tohoku (Japan). The analysis of the collected data done in Japan and the independent analysis performed by our group at DLNP led to the same conclusion that LYSO crystals had better characteristics satisfying the experimental requirements. On these grounds, the COMET collaboration decided to build the electromagnetic calorimeter using this type of crystals.

Nuclear fragmentation in the $d(4.4\text{ GeV}) + \text{Au}$ collision was studied with a 4π setup **FASA** on the external beam of the Dubna Nuclotron. The IMF-IMF relative angle correlation function was analyzed using the statistical model of multifragmentation with the main goal of estimating the total time scale of the process. It was found that the fragmentation of the hot nucleus was ≈ 100 fm/c delayed with respect to the collision moment. Kinetic energy of IMFs was analyzed with respect to the radial flow. A radial flow 0.12 c was found in $d(4.4\text{ GeV}) + \text{Au}$ collision [33].

Within the **LESY**, a spectrum of very important and unexpected results on the measurement of the electron screening potential and the energy dependence of the astrophysical S factors for the pd reaction in titanium and zirconium deuterides was obtained for the first time using plasma pulsed accelerators [34, 35]. Information on the energy dependence of the neutron yield from the $d(d,\, n)\,^3\text{He}$ reaction in a textured titanium deuteride target with the predominant $\{100\}$ orientation of the microcrystals was obtained for the first time. It is shown that the energy dependence of the enhancement factor of the dd reaction is described not only by the potential of screening, but also by considering deuteron channeling effects in the crystal lattice [36].

Within the **PANDA** project for the Muon system, the most important achievement of the year 2014 was approval of the Muon TDR by the international committee of experts and the FAIR Council. This required significant effort for demonstrating performance of the prototypes and studying gas flow, ageing and other effects. In 2014, the JINR group further developed the PANDA computing framework by including the Fritiof and DPM model MC generators in PandaRoot and performing their validation. Several new physics subjects were also proposed for the development of the PANDA physics program.

APPLIED RESEARCH AND ACCELERATORS PHYSICS

In the **DLNP Department of multiple hadron processes**, a conceptually new laser detector of ground angular motion with a resolution of $5 \cdot 10^{-9}$ rad was developed. This achievement is of fundamental importance as ushers in a new generation of instrumentation for the high-precision surfaces oscillation studies. The detector can provide fundamentally new approaches to solving numerous scientific and civil engineering problems. The key idea of this detector design is to use the gravity vector as a highly stable reference guaranteeing the horizontality of the laser-ray-reflecting liquid surface taken as a stable reference level [37].

At the **DLNP sector of electron cooling** nine sessions of the PAS experiments were conducted mainly to study thermal oxidation of 304 AISI stainless steel. The material samples were annealed in vacuum in the air, and in the N2 atmosphere at 800 °C for various time. The results showed that multilayered oxides were formed on the surface of the 304 AISI sample. The second research area of the PAS experiments was studying 304 AISI stainless steel samples after multihydrogen implantation. The samples were irradiated by H^+ with different energies and doses. Defect profiles were evaluated. Two areas with a constant concentration of defects and an area with a decreasing defect concentration were observed [38].

The main goals of the research at the **Medicotechnical complex (MTC)** are to carry out medicobiological and clinical investigations on cancer treatment, to upgrade equipment and instrumentation, and to develop new techniques for treatment of malignant tumours and for associated diagnostics with medical hadron beams of the JINR Phasotron. The following main results were obtained in 2014.

In collaboration with the Medical Radiological Research Centre (Obninsk) and the Radiological Department of the Dubna hospital, the regular sessions of proton therapy aimed to investigate its efficiency to treat different kinds of neoplasm were performed. Seven treatment sessions, total duration of 26 weeks, were carried out. Seventy-six new patients were fractionally treated with the medical proton beam. The total number of the single proton irradiations (fields) was more than 5000. Other 28 patients were irradiated using the "Rokus-M" Co-60 gamma-therapy unit.

Development of the software–hardware complex for the for-leaf-pair model prototype of a multileaf proton beam collimator was continued. The full-scale collima-

tor will consist of 33 such pairs of leaves and will be used in the so-called dynamic proton beam treatment technique. Development of a computerized adjustable energy decelerator of a proton beam was continued for this purpose as well.

Together with the Division of Radiation Dosimetry of the Institute of Nuclear Physics (Prague, Czech Republic) and the Proton Therapy Center in Prague (PTC), the secondary-particle background from the scanned proton beam in the patient treatment room was measured using thermoluminescent detectors. In collaboration with the Great Poland Cancer Centre (Poznan, Poland), experiments were continued at the proton beam using radiochromic films and a heterogeneous "Alderson phantom" simulating human anatomy to verify all technological stages of preparation for therapeutic irradiation of patient and the irradiation procedure itself.

The time interval, during which the laser irradiation is capable of reducing radiation damages in mice, was investigated. The results of the investigations showed that the use of laser irradiation to reduce radiation damage in mice is effective 24 h after the exposure to ionizing radiation at dose of 5 Gy that leads to the bone-marrow clinical form of the acute radiation sickness (ARS). When the lethal ionizing radiation dose of 7 Gy (the transitional clinical form of the ARS) is used, the increase in life expectancy of mice is observed with laser radiation used both 2 and 24 h after the exposure to γ radiation, but the effectiveness of the laser 2 h after exposure to the ionizing radiation is much greater [39].

The PCR analysis of 62 γ- and neutron-induced heritable gene/point mutations at the cinnabar locus of Drosophila melanogaster was performed. Two types of the DNA mutation alterations, namely, intragenic deletions (PCR–mutations) and DNA changes not detected by PCR (PCR + mutations), were found. It is important that neutrons are twice as effective as γ rays in induction of deletion mutations. Gene conversion, i.e., substitution of a damaged gene in the irradiated male chromosome by a native gene in the nonirradiated female chromosome after syngamy, was found using the sequence technique [40].

REFERENCES

1. *Avrorin A. V. et al.* Data Acquisition System of the NT1000 Baikal Neutrino Telescope // Instr. Exp. Tech. 2014. V. 57, No. 3. P. 262–273.
2. *An F. P. et al. (Daya Bay Collab.).* Search for a Light Sterile Neutrino at Daya Bay // Phys. Rev. Lett. 2014. V. 113. P. 141802.
3. *Bellini G. et al. (Borexino Collab.).* Neutrinos from the Primary Proton–Proton Fusion Process in the Sun // Nature. 2014. V. 512. P. 383.
4. *Bellini G. et al. (Borexino Collab.).* Final Results of Borexino Phase-I on Low-Energy Solar Neutrino Spectroscopy // Phys. Rev. D. 2014. V. 89. P. 112007.
5. *Anfimov N., Samoylov O., Sotnikov A.* NOvA FEB Crosstalk Measurements. NOvA Internal Note — DocDB #11405.
6. *Agafonova N. et al.* Observation of Tau Neutrino Appearance in the CNGS Beam with the OPERA Experiment // Prog. Theor. Exp. Phys. 2014. P. 101C01.
7. *Agafonova N. et al.* Procedure for Short-Lived Particle Detection in the OPERA Experiment and Its Application to Charm Decays // Eur. Phys. J. C. 2014. V. 74, Iss. 8. P. 2986.
8. *Agafonova N. et al.* Measurement of the TeV Atmospheric Muon Charge Ratio with the Complete OPERA Data Set // Ibid. Iss. 7. P. 2933.
9. *Arnold R. et al.* Search for Neutrinoless Double Beta Decay of ^{100}Mo with the NEMO-3 Detector // Phys. Rev. D. 2014. V. 89. P. 111101 (R).
10. *Arnold R. et al.* Investigation of Double Beta Decay of ^{100}Mo to Excited States of ^{100}Ru // Nucl. Phys. A. 2014. V. 925. P. 25–36.
11. *Remoto A. on behalf of NEMO-3 and SuperNEMO Collabs.* Latest Results from NEMO-3 and Status SuperNEMO // Nucl. Phys. B. Proc. Suppl. 2014.
12. *Agostini M. et al.* The Background of the $0\nu\beta\beta$ Experiment GERDA // Eur. Phys. J. C. 2014. V. 74. P. 2764.
13. *Agostini M. et al.* Results on Neutrinoless Double Beta Decay of ^{76}Ge from Phase I of the GERDA Experiment // Phys. Rev. Lett. 2013. V. 111. P. 122503.
14. *Agostini M. et al.* Upgrade of the GERDA Experiment // Proc. Sci., PoS(TIPP2014)109.
15. *ATLAS Collab.* ATLAS-COM-PHYS-2013-1446 // Phys. Rev. D. 2014. V. 90. P. 052005.
16. *ATLAS Collab.* ATL-COM-PHYS-2014-929, to be submitted to JHEP.
17. *ATLAS Collab.* Observation of the Decay $\Lambda_b^0 \to \psi(2S)\Lambda^0$ with the ATLAS Detector. ATL-COM-PHYS-2014-180.
18. *Bardin D. et al.* J Functions for the Process $ud \to WA$. arXiv:1411.6845.
19. *Aad G. et al. (ATLAS Collab.).* Measurement of the Low-Mass Drell–Yan Differential Cross Section at $\sqrt{s} = 7$ TeV Using the ATLAS Detector // JHEP. 2014. V. 1406. P. 112. arXiv:1404.1212.
20. *Sadykov R.* Impact of QED Radiative Corrections on Parton Distribution Functions. arXiv:1401.1133.
21. *CDF Collab.* Final Combination of the CDF Results on Top-Quark Mass. CDF Note 11080. 2014.
22. *Ablikim M. et al.* // Phys. Rev. Lett. 2014. V. 112. P. 022001.
23. *Ablikim M. et al.* // Ibid. P. 132001.

24. *Ablikim M. et al.* // Phys. Rev. D. 2014. V. 90. P. 012001.
25. *Ablikim M. et al.* // Ibid. V. 89. P. 052001.
26. *DIRAC Collab.* // Phys. Lett. B. 2014. V. 735. P. 288–294.
27. *Adam J. et al.* // Nucl. Phys. Proc. Suppl. 2014. V. 248–250. P. 108–111.
28. *Bagdasarian Z. et al.* Measurement of the Analyzing Power in Proton–Proton Elastic Scattering at Small Angles // Phys. Lett. B. 2014. V. 739. P. 152.
29. *Papenbrock M. et al.* Absence of Spin Dependence in the Final State Interaction of the $d\vec{p} \to {}^3\mathrm{He}\,\eta$ Reaction // Ibid. V. 734. P. 333.
30. *Oellers D. et al.* New Experimental Upper Limit of the Electron–Proton Spin-Flip Cross Section // Nucl. Instr. Meth. A. 2014. V. 759. P. 6.
31. *Bogdanova L. N., Demin D. L., Fil'chenkov V. V.* Izuchenie mekhanizma muonnogo kataliza reaktsii sinteza $t + t$ // Yad. Fiz. 2015. V. 78, No. 1–2 (in Rissian).
32. *Mamedov T. N. et al.* Muonic Atom as an Acceptor Centre in Diamond // J. Phys.: Conf. Ser. 2014. V. 551. P. 012046.
33. *Avdeev S. et al.* Electrical Properties of Deuteron Irradiated High Resistivity Silicon // Nucl. Instr. Meth. B. 2014. V. 325. P. 107–114.
34. *Bystritsky V. M. et al.* First Experimental Evidence of $p(d,\gamma)^3$He Reaction in Deuteride Titanium in Ultralow Collision Energy Region // Nucl. Instr. Meth. A. 2014. V. 753. P. 91–96.
35. *Bystritsky V. M. et al.* Study of the $p(d,\gamma)^3$He Reaction at Ultralow Energies Using a Zirconium Deuteride Target // Ibid. V. 737. P. 248–252.
36. *Bystritsky V. M. et al.* Experimental Verification of Hypothesis of dd Reaction Enhancement by Channeling of Deuterons in Titanium Deuteride at Ultralow Energies // Ibid. V. 764. P. 42–47.
37. *Budagov J., Lyablin M.* Russian Federation Patent No. 2510488. "Device for Measuring the Angle of Inclination".
38. *Horodek P. et al.* Development of Positron Annihilation Spectroscopy at LEPTA Facility // Part. Nucl., Lett. 2014. V. 11, No. 5(189). P. 1092–1098.
39. *Voskanyan K. et al.* Reduction of Radiation Damage in Mice after Acute and Prolonged Irradiation with Gamma Rays by Means of Laser Device // J. Phys. Sci. Appl. 2014. V. 4, No. 8. P. 501–506.
40. *Davkova L. N., Alexandrov I. D., Alexandrova M. V.* // Radiation Biology. Radioecology. 2014. V. 54, No. 1. P. 5–20.

FLEROV LABORATORY OF NUCLEAR REACTIONS

In 2014, the FLNR scientific programme on heavy ion physics included experiments on the synthesis and study of properties of heavy and exotic nuclei using ion beams of stable and radioactive isotopes, studies of nuclear reaction mechanisms, heavy ion interaction with matter, applied research and development of acceleration technology. These research fields were represented in three laboratory topics:

• Synthesis and properties of nuclei at the stability limits (9 subtopics);

• Radiation effects and physical bases of nanotechnology, radioanalytical and radioisotope investigations using the FLNR accelerators (5 subtopics);

• Accelerator complex of ion beams of stable and radioactive nuclides (DRIBs-III) (9 subtopics);

In 2014, the operation time of the U400 and U400M FLNR cyclotrons amounted to 10 630 h.

DRIBs-III. ACCELERATOR COMPLEX OF ION BEAMS OF STABLE AND RADIOACTIVE NUCLIDES

DRIBs-III (Dubna Radioactive Ion Beams) is one of the core JINR projects. The following project tasks approved by JINR's Programme Advisory Committee (PAC) for Nuclear Physics and Scientific Council were fulfilled in 2014:

1. The DC-280 cyclotron:

• The cyclotron magnet construction was manufactured and assembled at the Novokramatorsk Machine-Building Plant (see Fig. 1). Measurements of geometry

Fig. 1. The main magnet of the DC-280 cyclotron at the Novokramatorsk Machine-Building Plant

parameters of the magnet were carried out. Delivery of parts of the magnet was started.

• The bending magnet of the DC-280 cyclotron was delivered in JINR.

2. Experimental hall:

• General construction works on the first floor of the experimental hall, including an accelerator area, an experimental area and laboratory rooms, are practically completed.

3. Laboratory building:

• Laboratory building is put into operation.

• Assembly of the laboratory equipment is completed. The adjustment of the equipment is now underway.

4. In accordance with the contract with the SigmaPhi company on the creation of the ACCULINNA-2 fragment-separator in 2014, all equipment included in the contract was manufactured and delivered in JINR. Assembly of the separator in the experimental area of the U400M cyclotron is underway.

A contract for the design and manufacturing of a zero-degree magnet for the ACCULINNA-2 separator was signed in 2014. The contract implies the delivery of the magnet at the end of 2016.

SYNTHESIS AND PROPERTIES OF NUCLEI AT STABILITY LIMITS

Synthesis of New Elements. In 2014, the experiments on the synthesis and study of the radioactive properties of neutron-deficient isotopes of flerovium (element 114) and their α-decay products synthesized in the ^{239,240}Pu + ^{48}Ca complete fusion reactions were carried out. The experiments were performed in collaboration with the laboratories at Oak Ridge (ORNL), Livermore (LLNL), Knoxville (UT), Nashville (VU), and Dimitrovgrad (RIAR). The FLNR JINR gas-filled recoil separator was employed.

Target	Thickness, mg/cm^2	E_{lab}, MeV	E^*, MeV	Beam dose of ^{48}Ca	No. of ^{284}Fl/^{285}Fl nuclei
^{239}Pu	0.51	245	35.4–40.0	$1.4 \cdot 10^{19}$	1/–
^{240}Pu	0.49	245	36.5–41.1	$4.0 \cdot 10^{18}$	–/3
^{240}Pu	0.49	250	40.9–45.4	$4.7 \cdot 10^{18}$	4/–

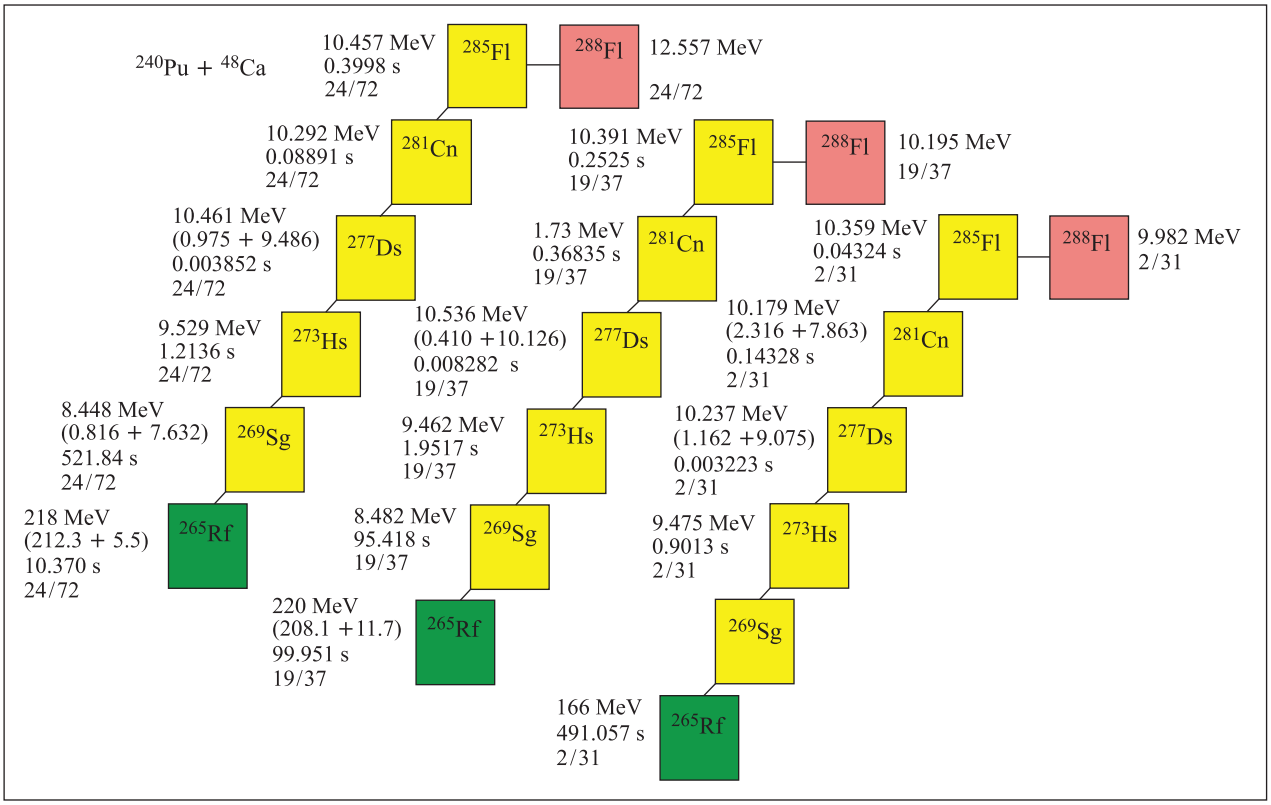


Fig. 2. The decay chains of the ^{285}Fl mother nucleus detected in the ^{240}Pu + ^{48}Ca reaction

The key results are summarized in the Table. A spontaneously fissioning ^{284}Fl isotope was for the first time synthesized in the ^{239}Pu (^{48}Ca, $3n$) and ^{240}Pu (^{48}Ca, $4n$) reactions, but the ^{285}Fl isotope was produced in the ^{240}Pu (^{48}Ca, $3n$) reaction. In earlier experiments, only one decay chain of ^{285}Fl was detected in the ^{242}Pu (^{48}Ca, $5n$) ^{285}Fl reaction at Berkeley (USA). However, the α-particle energy of ^{285}Fl was not measured. The decay chains of this nuclide are shown in Fig. 2.

The cross sections of the $^{239}\mathrm{Pu} + {}^{48}\mathrm{Ca}$ and $^{240}\mathrm{Pu} + {}^{48}\mathrm{Ca}$ reactions turned out to be 50 and 5 times lower, respectively, than those for the production of Fl isotopes in the $^{244}\mathrm{Pu} + {}^{48}\mathrm{Ca}$ reaction. Along with an increased growth of the α-decay energy of ^{285}Fl (compared to heavier Fl isotopes), a decline in the half-life, and dominance of the spontaneous fission over the α decay for ^{284}Fl, a significant decline in the evaporation cross sections of the above reactions is evidence for approaching the edge of stability of superheavy nuclei in the region of neutron-deficient isotopes. Some results obtained earlier were published in 2014 in works [1, 2].

Chemistry of Transactinides. In 2014, the analysis of the experimental data aimed to study the chemical properties of superheavy elements 113, Cn, and Fl produced in the ^{243}Am (^{48}Ca, $2n$) and ^{242,244}Pu (^{48}Ca, xn) nuclear reactions was completed. First studies to chemically characterize element 113 suggested that its behavior resembled species with high volatility. The studies also revealed weak interaction with inert surfaces and an enhanced reactivity towards gold surfaces. In given conditions, the adsorption behaviour of element 113 can be compared to the adsorption properties of mercury and astatine. The obtained results are independent evidence of the synthesis of new elements 113 and 115 through the nuclear fusion reaction $^{48}\mathrm{Ca} + {}^{243}\mathrm{Am}$ [3].

The thermochromatography to study the volatility of Cn and Fl was used. Seven decay chains of ^{287}Cn and ^{289}Cn were detected in the experiment. The deposition temperature range for Cn was found to be from –25 °C to –75 °C. The analysis of empirical correlations between adsorption enthalpies of group 12 elements was carried out. The results revealed that despite the high volatility of Cn, it possesses metallic properties as its chemical properties can be extrapolated within group 12 of the Periodic Table.

A new gas-filled separator-based setup incorporating the features of physical and chemical separation of nuclear reaction products was developed. An experiment aimed to study the chemical properties of element 113 employing the setup is scheduled for 2015.

VASSILISSA Separator. The fine tuning and evaporation residues transmission tests with the ^{22}Ne, ^{40}Ar, ^{48}Ca, and ^{50}Ti beams continued using the recoil separator SHELS (Separator for Heavy Elements Spectroscopy) [4, 5]. A large (10×10 cm) multistripped (128×128 strips) detector was employed in experiments for the first time. It is a real delight to report experimental proof of an at least two-fold increase in the transmission. In the first experiment with the ^{22}Ne beam, the decay properties of the ^{224}U isotope, synthesized in the complete fusion reaction $^{22}\mathrm{Ne} + {}^{206}\mathrm{Pb} \rightarrow {}^{224}\mathrm{U} + 4n$, and its daughters were thoroughly studied. The new results on ^{224}U were published in [6]. Figure 3 shows a spectrum of a new α-decay branch to the $2+$ state in ^{220}Th. In addition, combined electon/gamma-ray spectroscopy was used to study the decay of the $8+$ isomers in ^{210}Ra and a fine structure of the ^{221}Th decay.

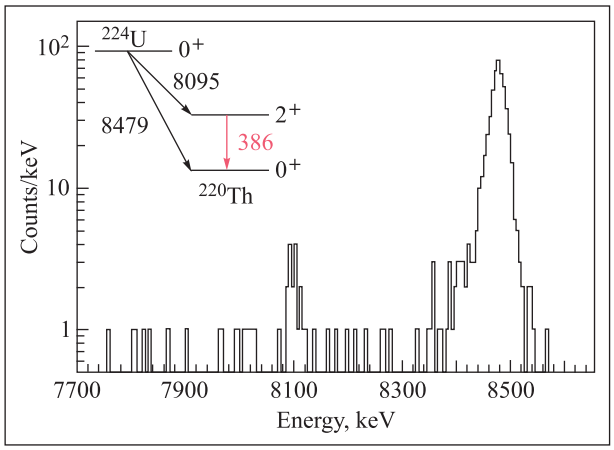


Fig. 3. Spectrum of α decay of ^{220}Th

The neutron detector installed in the focal plane of the SHELS separator was employed to study the properties of the spontaneous fission of the ^{250,252,254}No and ^{256}Rf isotopes in experiments with ^{48}Ca and ^{50}Ti. The complete fusion reactions $^{48}\mathrm{Ca} + {}^{204,206,208}\mathrm{Pb} \rightarrow {}^{250,252,252}\mathrm{No} + 2n$ and $^{50}\mathrm{Ti} + {}^{208}\mathrm{Pb} \rightarrow {}^{256}\mathrm{Rf} + 2n$ were used. Over 1,500 spontaneous fission events of ^{256}Rf were detected.

Mass Spectrometer MASHA. In the course of 2014, the MASHA mass separator working group was engaged in R&D and conducted experiments in accordance with the FLNR scientific plan. Within this period, the following main activities were carried out:

1. The focal-plane detector system for measurement of direct currents generated in 192 strips was upgraded. The modernization made it possible to efficiently tune the ECR–mass spectrometer complex [7].

2. Electronics of the focal-plane well-type silicon detector system was upgraded and converted to digital. Instead of the PCI eXtensions for Instrumentation (PXI) platform, 448 spectrometric channels are currently controlled through Computer Automated Measurement and Control (CAMAC), a standard, which allows the analysis of the signal waveform.

3. A software package was developed to monitor spectra coming from a newly established registration

system during experiments and to quickly sort incoming data.

4. A detector unit for measurement of cross sections of heavy ion complete fusion reactions was designed and assembled. Simulations of experiments were performed to measure the production cross sections of the neutron-deficient isotopes in the $^{40}\mathrm{Ar} + {}^{144}\mathrm{Sm}$ and $^{40}\mathrm{Ar} + {}^{166}\mathrm{Er}$ reactions.

5. Special measures were adopted to ensure safe use of radioactive targets during experiments: continuous monitoring of alpha activity both in the target chamber and the fore-vacuum line, as well as monitoring of the radiation level in the ambient air.

6. The experiment involving $^{48}\mathrm{Ca}$ and $^{242}\mathrm{Pu}$ aimed to measure the mass of $^{283}\mathrm{Cn}$, which is a daughter product of the α decay of $^{287}\mathrm{Fl}$, has begun and is currently in progress.

7. The experimental data for 2013 were processed. Two articles for publication in the EXON-2014 conference materials were prepared.

Dynamics of Heavy Ion Interaction, Fission of Heavy and Superheavy Nuclei. In 2014, the analysis was completed on the mass-energy distributions of binary fission-like fragments produced in the $^{48}\mathrm{Ca} + {}^{232}\mathrm{Th}$, $^{238}\mathrm{U}$, $^{244}\mathrm{Pu}$, and $^{248}\mathrm{Cm}$ reactions at the energies close to the Coulomb barrier. The asymmetric quasifission process was dominant there. Those quasifission fragments peaked around the masses corresponding to the closed neutron and proton shells at $Z = 28,\ 82$ and $N = 50,\ 126$. The fusion probabilities were estimated for the reactions under analysis. Based on the measured capture cross sections and estimated fusion probabilities for the reactions $^{48}\mathrm{Ca} + {}^{244}\mathrm{Pu}$ and $^{48}\mathrm{Ca} + {}^{248}\mathrm{Cm}$, a survival probability lower limit of $\sim 10^{-10}$ was found for the Fl and Lv compound nuclei [8].

The investigation of the role of shell effects in the formation of neutron-rich binary fragments in multinucleon transfer reactions continued in 2014. By employing the U400 accelerator CORSET setup, an experiment aimed to measure mass, energy, and angular distributions of binary fragments formed in the $^{156,160}\mathrm{Gd} + {}^{186}\mathrm{W}$ reactions at the Coulomb barrier energy was carried out. For target-like fragments heavier than 200–215 amu, the yield enhancement for both reactions was observed [9].

This year an experiment aimed to study the fission of $^{220}\mathrm{Th}^{*}$ produced in the $^{34}\mathrm{S} + {}^{186}\mathrm{W}$ reaction at the energy of $^{34}\mathrm{S}$ ions $E_{\mathrm{lab}} = 160$ MeV was also carried out. The experiment was performed at the ALTO facility of IPN (Orsay, France). Fission fragments were detected by the two-arm time-of-flight spectrometer CORSET; γ rays in coincidence with binary reaction fragments were measured using the high-efficiency ORsay GAMma array spectrometer (ORGAM). The Doppler shift correction was applied to the γ spectra by using the measured velocity vectors of both fission fragments. Discrete γ lines of specific isotopes were observed and used to identify fission fragments. As the first step towards data analysis, three fragment pairs, namely, $\mathrm{Mo} + \mathrm{Cd}$, $\mathrm{Sn} + \mathrm{Zr}$, and $\mathrm{Kr} + \mathrm{Xe}$, were studied. Preliminary results of the data analysis were presented at the International Summer School, Romania [10].

Structure of Exotic Nuclei. The data analysis was completed in 2014 for the experiment aimed to study rare decay channels of $^{17}\mathrm{Ne}$ produced in the $^{1}\mathrm{H}\,(^{18}\mathrm{Ne},\, d)\,^{17}\mathrm{Ne}$ transfer reaction at the ACCULINNA separator. The studies were aimed to search for a true $2p$ decay branch to the first excited state of $^{17}\mathrm{Ne}$ ($J^{\pi} = 3/2^{-},\ E^{*} = 1.288$ MeV), which, according to the theory, has a very low probability of occurring compared to the gamma decay that is known to be the main decay mode of this state, i.e., $\Gamma_{2p}/\Gamma_{\gamma} \sim 10^{-5}$. As a result, a new upper limit of a branching ratio $\Gamma_{2p}/\Gamma_{\gamma}$ was set to $\sim 1.5 \cdot 10^{-4}$, which is significantly lower (by a factor of 50) than the value of $\Gamma_{2p}/\Gamma_{\gamma} < 7.7 \cdot 10^{-3}$ known from literature.

The R&D works were carried out on the secondary beam monitoring using silicon and diamond detectors of the ACCULINNA and ACCULINNA-2 fragment separators. Specially designed Si-detectors and several chemical vapor deposition diamond (CVDD) reference detectors were tested in heavy ion beams extracted from U400M. Unique data were for the first time obtained on how Si-detectors, inflicted by 40-MeV/nucleon $^{40}\mathrm{Ar}$ ions within an integral flux of 10^{8}–10^{13} ions/cm^{2}, sustain the radiation damage. Moreover, fast front-end electronics (wide-band preamplifiers and digitizers), which provides extremely good timing ($\sigma_t \sim 20$ ps) when coupled with Si-detectors, was successfully tested.

New equipment for ACCULINNA-2 was delivered and the major bulk of works on its installation was done under the long-term contract between JINR and the SigmaPhi company.

The main results obtained in 2014 were published in [11, 12].

Reactions with Beams of Light Stable and Radioactive Nuclei. In 2014, a series of experiments aimed to study light neutron-rich nuclei (ranging from helium isotopes $^{6,8}\mathrm{He}$ to $^{24}\mathrm{O}$) was conducted at the MC400 cyclotron employing the COMBAS separator. The optimal fusion reactions of these nuclei were selected, and their beams in the focal plane of the separator were extracted. The absolute values of cross sections and effective interaction radii for various targets, depending on the secondary beam energy, were obtained employing the ACCULINNA separator. It was shown that the cross sections of neutron-rich isotopes of O, F, Ne, and Ca were, in some cases, much larger in deep inelastic transfer reactions than in fragmentation reactions.

Experiments aimed to measure neutron emission accompanying the decay of some neutron-rich nuclei

were carried out through a collaborative effort between JINR FLNR (Russia) and the Institute of Nuclear Physics in Orsay (France). Nuclei in the region of the closed neutron shells $N = 50$ and $N = 82$ — ^{80,82,83,84}Ga, ^{82,83}Ge, ^{82,83}As, and ^{123,124,125}Ag, ^{126}Cd, ^{127,128}In, respectively, were studied using laser ionization to increase the selectivity of nuclei. Isomerism was for the first time observed in ^{80}Ga. Lifetimes and partial probabilities of the delayed neutron emission were measured for the two states with the spins $J = 3$ and $J = 6$. Furthermore, isomerism in the ^{83}Ga nucleus was confirmed. Lifetimes of ^{123,124,125}Ag were measured with high accuracy. The neutron emission probability for the ^{126}Cd nucleus was for the first time discovered and measured. Based on the systematics of the delayed neutron emission, an important conclusion was made that the weakening of the $N = 82$ closed shell did not occur in the ^{132}Sn region. This information is of great interest to the fundamental nuclear physics, astrophysics, and nucleosynthesis.

In joint experiments carried out by the Institute of Nuclear Physics (Řež, Czech Republic) and the accelerator laboratory of the University of Jyväskylä Institute of Physics (Finland), the elastic and quasi-elastic scatterings were measured in the reactions ^{9}Be $(^{3}$He, ^{3}He$^{*})$ ^{9}Be and ^{9}Be (α, α) ^{9}Be at the energy of approximately 40 MeV. In addition to these channels, the nucleon transfer reactions ^{9}Be $(^{3}$He, $\alpha)$ ^{8}Be, ^{9}Be $(^{3}$He, ^{5}He$)$ ^{7}Be, and ^{9}Be $(^{3}$He, $t)$ ^{9}B were studied. The analysis of the differential angular distributions for ^{9}Be, using the distorted-wave Born approximation (DWBA) and coupled channel (CC) calculations, enabled spin assignment of $9/2^{-}$ to be made to the excited state at 11.3 MeV. The octu-decapole deformation, which is evidence of the $\alpha + ^{5}$He configuration of ^{9}Be, was required to describe the angular distribution for this level. The analysis revealed that the pairing of neutron and proton results in the formation of the $\alpha + \alpha + d$ deuteron cluster analog, which cannot occur for ^{10}Be being an $A = 10$ isobar-analog triplet.

This work is supported by two grants from RFBR (projects No. 13-02-00533 and 14-02-91053), a grant from the French National Center for Scientific Research (CNRS), and grants from the Plenipotentiaries of the Czech Republic and the Republic of Poland at JINR.

The most important results obtained in 2014 are published in [13–15].

Theoretical and Computational Physics. In 2014, the cross sections were calculated for the formation of light exotic nuclei in low-energy multinucleon transfer reactions for the systems ^{18}O, ^{26}Mg, and ^{36}S + ^{238}U [16]. It was demonstrated that yields of light quite exotic neutron-rich nuclei produced in low-energy multinucleon transfer reactions were about two orders of magnitude higher compared with high-energy fragmentation reactions. Therefore, the former reactions are promising for the production and study of light exotic nuclei.

Comparison with the previous studies suggests that positive Q values are not sufficient for the subbarrier fusion enhancement to occur due to neutron rearrangement [17]. A significant enhancement when colliding nuclei are rather inert to the excitation of collective modes can also be observed. A noticeable subbarrier fusion enhancement of light nuclei can only be observed in reactions involving exotic nuclei.

Based on the conducted analysis of the angular distributions of few-nucleon transfer reaction products, the spectroscopic information on the excited states of the beryllium and boron isotopes in collisions of ^{4}He + ^{9}Be was obtained [13]. Moreover, based on the performed analysis of few-nucleon transfer reactions and the excitation processes of rotational bands in target nuclei, it was found that the cluster structure of the ground and low-lying excited states in ^{9,10}Be and ^{10}B is quite specific.

RADIATION EFFECTS AND PHYSICAL BASES OF NANOTECHNOLOGY, RADIOANALYTICAL AND RADIOISOTOPE INVESTIGATIONS USING FLNR ACCELERATORS

Track Membranes

1. Studies were carried out on the diode-like properties of single asymmetric nanopores fabricated in polymer films bombarded with ions of different atomic numbers. The interdependency between the shape of pore longitudinal profiles and their current-voltage characteristics was showed [18].

2. A method for fabrication of metal-polymer composite membranes, which exhibit conductance asymmetry in electrolyte solutions, was developed. It was found that the conductivity asymmetry is caused by a change in the pore geometry of composite membranes and the existence of an interface between the initial membrane and the aluminum layer.

Nanostructures in Materials

1. The transmission electron microscopy was used to study the radiation damage in Al_2O_3 single crystals irradiated with 1.2-MeV/amu Xe ions [19]. It was found that Xe ions induce discontinuous ion tracks, starting with a specific ionization energy loss level of 9.8–10.5 keV/nm.

2. The methods of the optical, electronic, Raman microscopy, the X-ray diffraction, and the microhardness measurements were used to investigate the in-

fluence of elastic and inelastic energy losses of high-energy 16-MeV Xe ions at a dose of $1 \cdot 10^{12}$ cm^{-2} – $5 \cdot 10^{14}$ cm^{-2} on the development of hydrogen porosity in silicon and dislocation structure in uranium oxide samples. It was established that a change in the energy loss of Xe ions from 0 to 13.5 keV/nm in inelastic interactions inhibits hydrogen blistering of silicon.

3. The studies examined the impact of gamma rays with the threshold energy of 10 MeV on the synthesis and formation of microstructures and chemical elements in a tin sample placed in the dense atmosphere of helium (1.1 kb) and hydrogen (3.5 kb).

Radioanalytical Investigations

The distribution of the isotopes ^{97}Ru, ^{237}U, ^{236}Pu, ^{99}Mo(^{99}Tc), and ^{236}Np was studied, using the nanostructured material and the TEVA resin. The $^{118}\mathrm{Sn}\,(\gamma,\, n)\,^{117m}\mathrm{Sn}$ and $^{196}\mathrm{Pt}\,(\gamma,\, n)\,^{195m}\mathrm{Pt}$ reactions were studied to investigate the possibility of producing radioisotopes for biomedical research.

In 2014, the fulfillment of the scientific programme of the Flerov Laboratory of Nuclear Reactions was supported by 15 grants of the Russian Foundation for Basic Research and also by the grant of the government of the Moscow region.

REFERENCES

1. *Oganessian Yu. Ts. et al.* Study of the Properties of the Superheavy Nuclei $Z = 117$ Produced in the $^{249}\mathrm{Bk} + {}^{48}\mathrm{Ca}$ Reaction // EPJ Web of Conferences. 2014. V. 66. P. 02073-1-4.
2. *Sagaidak R., Andreyev A.* Effects of Beam Energy Distribution on Fusion-Evaporation Excitation Functions // Intern. J. Mod. Phys. E. 2014. V. 23. P. 1450001-1–1450001-15.
3. *Dmitriev S. N. et al.* Pioneering Experiments on the Chemical Properties of Element 113 // Mendeleev Commun. 2014. V. 24. P. 253.
4. *Yeremin A. et al.* First Experimental Tests of the SHELS Separator // Part. Nucl., Lett. 2015. V. 12, No. 1.
5. *Yeremin A. et al.* Experimental Tests of the Acceleration of ^{50}Ti Ions and Study of ^{50}Ti Induced Complete Fusion Reactions with SHELS Separator // Ibid.
6. *Lopez-Martens A. et al.* Fine Structure in the Alpha Decay of ^{224}U // Eur. Phys. J. A. 2014. V. 50. P. 132; DOI: 10.1140/epja/i2014-14132-8.
7. *Rodin A. M. et al.* Separator MASHA at a Beam of Heavy Ions for the Measuring of Masses and Physical Properties of Isotopes of Heavy and Superheavy Elements // Instr. Exp. Techn. 2014. No. 4. P. 14–22.
8. *Kozulin E. M. et al.* Fusion-Fission and Quasifission of Superheavy Systems with $Z = 110-116$ Formed in ^{48}Ca-Induced Reactions // Phys. Rev. C. 2014. V. 90. P. 054608.
9. *Kozulin E. M. et al.* Experimental Study of Heavy Ion Induced Reactions at Energies Close to the Coulomb Barrier // Proc. of the VII Intern. Symp. on Exotic Nuclei EXON-2014, Sept. 8–13, 2014, Kaliningrad, Russia (to be published in World Scientific Publishing, 2015).
10. *Harca I. M. et al.* Investigation of Shell Effects in the Fusion-Fission Process in the Reaction $^{34}\mathrm{S} + {}^{186}\mathrm{W}$ // Carpathian Summer School of Physics. Exotic Nuclei and Nuclear/Particle Astrophysics (V) "From Nuclei to Stars", July 13–26, 2014, Sinaia, Romania (to be published in AIP, 2015).
11. *Sharov P. G. et al.* Anomalous Population of ^{10}He States in Reactions with ^{11}Li // Phys. Rev. C. 2014. V. 90. P. 024610.
12. *Golovkov M. S. et al.* Two-Proton Decay of the First Excited State of ^{17}Ne Nucleus // Proc. of the VII Intern. Symp. on Exotic Nuclei EXON-2014, Sept. 8–13, 2014, Kaliningrad, Russia (in press).
13. *Lukyanov S. M. et al.* Study of Internal Structures of ^{9,10}Be and ^{10}B in Scattering of ^{4}He from ^{9}Be // J. Phys. (London). 2014. V. G41. P. 035102.
14. *Skobelev N. K. et al.* Fusion and Transfer Cross Sections of ^{3}He Induced Reaction on Pt and Au in Energy Range 10–24.5 MeV // Phys. Part. Nucl. Lett. 2014. V. 11. P. 114.
15. *Penionzhkevich Yu. E.* Beams of Radioactive Nuclei — Present and Future // Yad. Fiz. 2014. V. 77, No. 11. (in Russian).
16. *Zagrebaev V. I. et al.* Formation of Light Exotic Nuclei in Low-Energy Multinucleon Transfer Reactions // Phys. Rev. C. 2014. V. 89. P. 054608.
17. *Rachkov V. A. et al.* Examining the Enhancement of Subbarrier Fusion Cross Sections by Neutron Transfer with Positive Q Values // Ibid. V. 90. P. 014614.
18. *Apel P. Yu. et al.* Accurate Characterization of Track-Etched, Conical Nanopores // Phys. Chem. Chem. Phys. 2014. V. 16. P. 15214–15223; DOI: 10.1039/C4CP01686F.
19. *Skuratov V. A. et al.* On the Threshold of Damage Formation in Aluminum Oxide via Electronic Excitations // Nucl. Instr. Meth. B. 2014. V. 326. P. 223–227.

FRANK LABORATORY OF NEUTRON PHYSICS

In 2014, the Frank Laboratory of Neutron Physics' scientific programme was aimed at obtaining new results under four research themes of the JINR Plan for Scientific Research and International Scientific and Technical Cooperation: in condensed matter physics ("Investigations of Nanosystems and Novel Materials by Neutron Scattering Methods", 04-4-1069-2009/2014, headed by V. L. Aksenov, A. M. Balagurov, and D. P. Kozlenko); in neutron nuclear physics ("Investigations in the Field of Nuclear Physics with Neutrons", 03-4-1104-2011/2016, headed by V. N. Shvetsov, Yu. N. Kopatch, E. V. Lychagin, and P. V. Sedyshev); in development of the FLNP basic facilities ("Development of the IBR-2M Reactor with a Complex of Cryogenic Moderators of Neutrons", 04-4-1105-2011/2013, headed by A. V. Belushkin and A. V. Vinogradov); in development of the IBR-2 spectrometers and computation complex ("Novel Development and Creation of Equipment for the IBR-2M Spectrometers Complex", 04-4-1075-2009/2014, headed by V. I. Prikhodko and S. A. Kulikov).

CONDENSED MATTER PHYSICS

The greater part of experimental research was carried out on the spectrometers of the modernized IBR-2 reactor.

In 2014, within the framework of the User Programme, 163 proposals for conducting experiments were received from 17 different countries. The received proposals covered the broad spectrum of neutron research in physics (46%), materials science (26%), chemistry, geosciences, biology and applied sciences (constituting the rest 28%). Of the received proposals, 150 were admitted for realization.

Scientific Results. The atomic and magnetic structures of intermetallic cobalt compounds RCo_2 were studied using neutron diffraction in the range of high pressures of 0–4 GPa and temperatures of 10–300 K [1, 2]. For many years these compounds have been considered as model systems demonstrating a phenomenon of itinerant electron metamagnetism (IEM). This phenomenon involves the appearance of transition metal sublattice magnetization as a response to the action of the magnetic field of the rare-earth metal sublattice in intermetallic compounds. In the course of the experiments it was found that the concept of IEM is valid for compounds with sufficiently high magnetic ordering temperatures $T_C \sim 150-200$ K (R = Tb, Ho), but it cannot describe the magnetic properties of compounds with low values of $T_C \sim 30-40$ K.

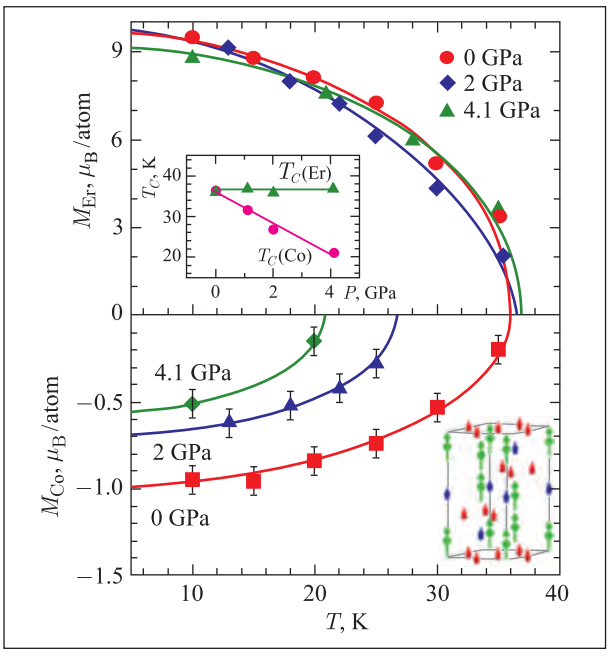


Fig. 1. Temperature dependences of Er and Co sublattice magnetizations in $ErCo_2$ at different pressures, illustrating their independent behavior, which is beyond the IEM concept. The insets show the pressure dependences of the Curie temperatures of Er and Co sublattices and the character of the magnetic ordering in these compounds

Using $ErCo_2$ as an example, the inconsistent behavior of Er and Co sublattice magnetizations and the suppression of Co sublattice magnetism were demonstrated at stable magnetic properties of the Er sublattice under pressure (Fig. 1). The obtained results in combination with the theoretical calculations call for further refinement of the IEM concept taking into account the peculiarities of the electronic structure of RCo_2 compounds.

On the REMUR reflectometer the nonreciprocal transmission of neutrons through a noncoplanar magnetic system (NCMS) was investigated [3]. The new generation of spintronics elements is based on complex noncoplanar magnetic systems (NCMS), in which the spatial dependence of three orthogonal components of the magnetic field induction takes place. Neutrons, like electrons, have spin $s = 1/2$, therefore the investigation of neutron transmission processes is of importance for the identification of common features inherent in both kinds of particles. The approximation of the electron-type behavior by neutrons is justified in ferromagnets, where the exchange field is large and the Lorentz force can be neglected. A noncoplanar magnetic system, in accordance with the solution of the Schrödinger equation, is characterized by the properties, which are not inherent in a coplanar magnetic system (CMS), namely, the dependence of the transmission of unpolarized neutrons (or electrons) on the direction of their propagation. To verify this result, a NCMS was created, in which the interface between regions with different directions of magnetization does not exceed 10 nm, providing

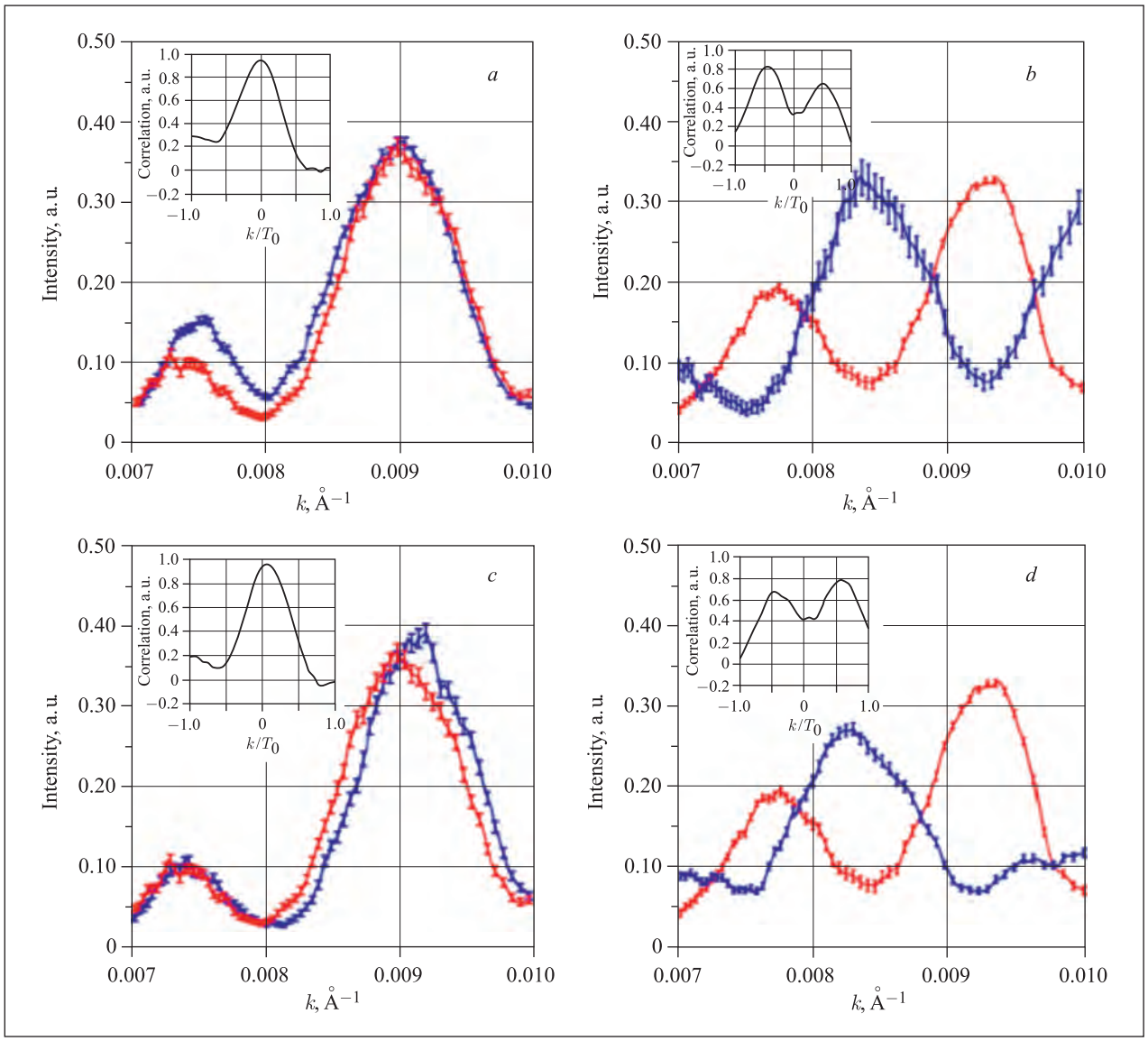


Fig. 2. The transmission for unpolarized neutrons obtained by using the first experimental scheme for CMS (*a*) and NCMS (*b*). The transmission of unpolarized neutrons obtained by using the second experimental scheme for CMS (*c*) and NCMS (*d*)

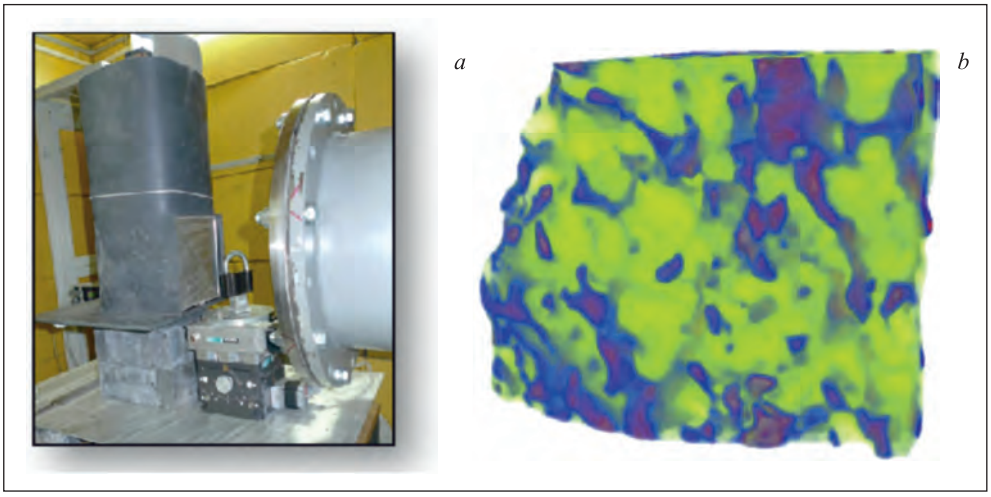


Fig. 3. *a*) Spectrometer for neutron radiography and tomography on IBR-2 beamline 14. *b*) Neutron tomographic image of the meteorite Seymchan showing the distribution of Fe–Ni alloy and fraction of rocks (mainly olivine)

a nonadiabatic regime for the neutron spin transmission through them. The NCMS consisted of two magnetic mirrors with magnetization vectors orthogonal to each other and lying in the mirror planes. It was placed in a magnetic field perpendicular to the mirrors. The neutron beam was directed in such a way that the sequences "first mirror–magnetic field–second mirror" and "second mirror–magnetic field–first mirror" were realized.

Figure 2 shows the neutron intensities for CMS and NCMS, respectively. In the case of NCMS, an antiphase behavior of the transmission curves was observed. Thus, it was shown that the transmission in NCMS depends on the neutron propagation direction, which, in its turn, is a consequence of noncommutativity of the spin algebra for $s = 1/2$.

Instrument Development. The development of a prototype of the spectrometer for neutron radiography and tomography on beamline 14 (Fig. 3) was continued. A HUBER goniometer with translational and rotational degrees of freedom was installed in working position. First tomography experiments with different types of objects were conducted. The procedure of 3D-reconstruction of the internal structure of objects using a variety of software packages was optimized. The obtained results showed a good quality of the acquired data which is comparable to that achieved in other world neutron centers.

NEUTRON NUCLEAR PHYSICS

In 2014, at FLNP the scientific activity in the field of neutron nuclear physics was carried out in the following traditional directions: investigations of time and space parity violation processes in neutron nuclear interactions; studies of the fission process; experimental and theoretical investigations of fundamental properties of the neutron; gamma spectroscopy of neutron nuclear interactions; atomic nuclear structure, obtaining of new data for reactor applications and for nuclear astrophysics; experiments with ultracold neutrons. The greater part of the fundamental investigations was conducted on the modernized IBR-2 reactor, IREN pulsed resonance neutron source and EG-5 electrostatic generator. Of particular note is the wide range of applied research using NAA. A number of investigations in the field of fundamental physics and ultracold neutron physics were performed on the neutron beams of nuclear research centers in Germany, China, the USA, France, and Switzerland.

In 2014, the modernization of the IREN facility was continued. Its purpose is the achievement of design parameters of the neutron source (intensity of the order of 10^{13} n/s) by 2016. The project involves the assembling of the second accelerating section, installation of new modulators and replacement of klystrons. The installation of the second accelerating section, new RF-power sources and a uranium target calls for a thorough modernization of the engineering infrastructure of the IREN facility, which is currently underway. In 2014, an air-conditioning and ventilation system was installed in the accelerator halls; also, work began on upgrading the power supply system of building 43. Along with these activities in 2014, the IREN facility operated for 1,360 h for physics experiments.

The multidetector system "Romashka" consisting of 24 hexagonal NaI(Tl) crystals was tested using γ rays from inelastic scattering of 14-MeV neutrons by carbon, $^{12}\mathrm{C}\,(n,\,n'\gamma)\,^{12}\mathrm{C}$. A neutron generator ING-27 was used as a source of tagged neutrons. Neutrons are produced in the reaction $d + 3\mathrm{H} \rightarrow 4\mathrm{He}\,(3.5\ \mathrm{MeV}) + n\,(14.1\ \mathrm{MeV})$, in which α particles and neutrons fly apart in almost opposite directions, and therefore, with a knowledge of α-particle momentum direction, the neutron momentum direction can be determined with high accuracy.

In 2014, in cooperation with the Czech Technical University in Prague, the measurements of ternary and quaternary spontaneous fission of ^{252}Cf were carried out using TimePix detectors. To identify ternary particles, the $\Delta E{-}E$ method was used to separate light charged particles by charge. A thin (12 μm) silicon detector was used as a ΔE-detector and a pixel detector TimePix with a 300 μm-thick sensor layer — as an E-detector. Seventy-two events were observed, in which two particles were detected simultaneously in one or two telescopes. The events, in which two α particles were emitted at a very small angle to each other, were attributed to the pseudoquaternary fission (decay of unstable short-lived ^{8}Be).

The experimental and theoretical investigations of the (neutron, charged particle) reactions induced by fast neutrons were continued. The experiments are carried out at the Van de Graaff accelerators EG-5 at FLNP JINR (Dubna, Russia) and EG-4.5 of the Institute of Heavy Ion Physics of Peking University (Beijing, China). The measurements of the $^{25}\mathrm{Mg}\,(n,\,\alpha)\,^{22}\mathrm{Ne}$ and $^{54,56,\mathrm{nat}}\mathrm{Fe}\,(n,\,\alpha)$ reactions were conducted. The data analysis for the measurements of the $^{57}\mathrm{Fe}\,(n,\,\alpha)\,^{54}\mathrm{Cr}$ and $^{63}\mathrm{Cu}\,(n,\,\alpha)\,^{60}\mathrm{Co}$ reactions at $E_n \sim 4.0{-}6.5$ MeV was completed.

The experiment to verify the weak equivalence principle for the neutron was continued with the Epigraph gravitational spectrometer built in 2010 and significantly improved in 2011. The operation of the instrument is based on the combined use of the Fabry–Pérot neutron interferometers and a neutron flux modulator-chopper. The change in the energy of the neutron mgH falling in the gravitational field is compared with the energy transferred to the neutron diffracted into the -1 order by a moving diffraction grating.

A specific feature of the instrument is the possibility of using an original time-of-flight technique based on a periodic modulation of the neutron flux and on measurements of the oscillation phase of the detector count rate. The UCN detection is synchronized with the modulator. A high degree of beam monochromatization ($\Delta v/v < 2\%$) makes it possible to work with the times of flight, which manifold exceeds the modulation period, thus ensuring a unique energy resolution of the instrument.

On the IREN facility the effect of neutron and gamma radiation on plastic scintillators used in the CMS experiment at CERN was investigated. Three years of operation experience with the hadron calorimeter have shown an unexpectedly large reduction in light output of plastic detectors. It was concluded that not all the factors of the radiation influence on the scintillators were taken into account. To clarify this issue, plastic scintillators of four types, namely, SCSN-81, UPS-923A (manufactured in Kharkov, Ukraine), BC-408, LHE (manufactured in Dubna, Russia) were studied.

The measurements of light output have shown that there is a significant contribution of the induced radioactivity.

In 2014, the EG-5 accelerator was in operation for various experiments for about 495 h. The main research area is the elemental analysis of surface layers of solids using nuclear analytical techniques: RBS (Rutherford Backscattering Spectrometry) and ERD (Elastic Recoil Detection). The experiments were conducted in cooperation with a number of Russian and foreign research institutes.

During the reporting period in the NAA sector, a software package for complex automation of multielement neutron activation analysis (NAA) at the IBR-2 reactor was developed and three automatic sample changers (SC) were installed to automate mass measurements of spectra of irradiated samples on three detectors.

In 2014, the joint investigations carried out in cooperation with the Institute of Microbiology and Biotechnology of ASM were continued to study the process of removing toxic metals (chromium, nickel) from wastewater using microalgae *Spirulina platensis*. Also, studies were conducted to monitor changes in the content of the main components of *Spirulina* biomass (proteins, carbohydrates, and others) in the process of formation of silver nanoparticles by microalgae.

THE IBR-2 PULSED REACTOR

The IBR-2 research nuclear facility is operated under Rostekhnadzor license No. GN-03-108-2614 of 27 April 2012 and Rostekhnadzor license No. GN-03-108-2871 of 30 April 2014.

Since January 2014, regular IBR-2 cycles of scientific experiments have been carried out at a power of 2 MW with the CM-202 moderator operating either in the water or cryogenic mode, in accordance

Data on the IBR-2 operation for physics experiments

No. cycle	Period	Moderator type	Reactor operation for physics experiments, h
1	January 13–24	Water	267
2	January 30 – February 8	Cryogenic	201
3	May 13–29	Water	390
4	June 3–11	Water	163
5	September 22 – October 6	Water	326
6	October 13–27	Water	327
7	October 31 – November 9	Cryogenic	187
8	November 21 – December 8	Water	398
9	December 15–26	Cryogenic	233
Total:			2492

with the schedule of the physical start-up of the cold moderator.

The Table presents data on the IBR-2 operation for physics experiments in 2014.

NOVEL DEVELOPMENT AND CONSTRUCTION OF EQUIPMENT FOR THE SPECTROMETER COMPLEX OF THE IBR-2 FACILITY

In 2014, studies were conducted on an experimental full-scale stand of cryogenic pelletized CM-201 moderator. The main purpose of the experiments was to test the possibility of loading the chamber of the cryogenic CM-201 moderator with frozen beads made of a mixture of mesitylene and metaxylene by transporting them through a pipeline ascending at the angle of 50°. The experiments have shown that beads without difficulty move up the inclined section of the transport pipeline and reach the simulator chamber located inside the outer vacuum jacket.

The cryogenic moderator CM-202 has been in operation since 2012. In 2014, its control systems and software were upgraded. In 2014, CM-202 operated for physics experiments during three cycles. Also, important studies were conducted aimed at extending the cycle duration of IBR-2 operation in the cryogenic mode up to 11 days.

At present, the maximum duration of CM-202 operation is 410 MW · h (8.5 days of IBR-2 operation). The possibility of increasing the cycle duration depends on the viscosity of the irradiated working mixture (metaxylene and mesitylene) of the moderator.

In order to increase the duration of the reactor cycle in the cryogenic mode up to 11 days, a number of experiments were performed on loading the CM-202 chamber with frozen beads consisting of a solution of naphthalene and metaxylene–mesitylene mixture. The

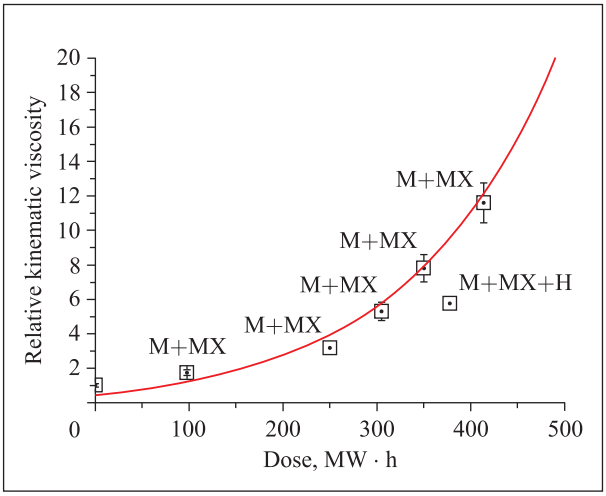


Fig. 4. Dependence of viscosity of the liquid mixture on the radiation dose: M + MX — mesitylene–metaxylene solution (in the ratio of 3:1), M + MX + H — solution of 55 g naphthalene dissolved in 1 liter of mesitylene–metaxylene mixture (in the ratio of 3:1)

investigations have shown that the addition of naphthalene significantly decreases the viscosity of the mixture (Fig. 4). Experiments to extend the duration of the CM-202 operation cycle will be continued in cooperation with Moscow State University in 2015.

CONFERENCES AND MEETINGS

In 2014, the V International Scientific School for Young Scientists and Students "Instruments and Methods of Experimental Nuclear Physics. Electronics and Automatics of Experimental Facilities" (November 10–15, Dubna) was organized at the Frank Laboratory of Neutron Physics. The School brought to-

gether students, postgraduates and young scientists selected with regard to their specialization from 13 cities of Russia, Ukraine, Belarus, Kazakhstan, Armenia, and Mongolia. The purpose of the School was to introduce the participants to the current state of the art in the instrumentation and methods of neutron experiments.

On 27–30 May, the XXII International Seminar on Interaction of Neutrons with Nuclei (ISINN-XXII) was held in Dubna. It is the traditional FLNP annual workshop in the field.

On 24–27 June, FLNP organized a Conference "Condensed Matter Research at IBR-2 Reactor". The aim of the Conference was to bring together the users of the neutron facility for discussion of recent experimental results, prospects of future research and development of IBR-2 instruments.

On September 29 – October 3, the International Summer School and Workshop "Complex and Magnetic Soft Matter Systems: Physico-Mechanical Properties and Structure" was held in Dubna. The Workshop was organized in collaboration with the Institute of Continuous Media Mechanics of the Russian Academy of Sciences, Romanian Society of Physics, West University of Timisoara, and Horia Hulubei National Institute of Physics and Nuclear Engineering.

REFERENCES

1. *Burzo E. et al.* // J. Alloys Comp. 2014. V. 584. P. 393–401.
2. *Kozlenko D. P. et al.* // Sci. Rep. 2014 (in consideration).
3. *Tatarskiy D. A. et al.* // Phys. Rev. Lett. 2014 (submitted).

LABORATORY OF INFORMATION TECHNOLOGIES

The investigations performed at the Laboratory of Information Technologies (LIT) during 2014 in the framework of the JINR research field "Networks, Computing, and Computational Physics" were focused on two first-priority themes, namely, "Information and Computing Infrastructure of JINR" and "Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data". The cooperation with other JINR Laboratories involved the participation of the LIT staff in research work within 25 themes of the JINR Topical Plan for JINR research and international cooperation. The objective of LIT activity is to provide a further development of the JINR network and information infrastructure asked by the research and production activity of JINR and its Member States using the most advanced information technologies. The existing Central Information and Computing Complex of JINR (CICC JINR) is evolving into the Multifunctional Centre for Storing, Processing and Analysis of Data aimed at providing to its users a wide range of possibilities through its main components: a grid infrastructure at Tier-1 and Tier-2 levels devoted to the support of the LHC experiments (ATLAS, ALICE, CMS, LHCb), FAIR (CBM, PANDA), and other large-scale experiments; a general-purpose computing cluster; a cloud computing infrastructure; a heterogeneous computing cluster HybriLIT; an education and research infrastructure for distributed and parallel computating. Each of the mentioned components can possess its own dedicated equipment and shares equipment with other components using modern virtualization tools.

In 2014, 182 scientific papers were published by LIT staff in refereed journals and 36 invited reports were presented at international and Russian conferences.

INFORMATION AND COMPUTING INFRASTRUCTURE OF JINR

During 2014, an important work, directed to the reliable operation and development of the JINR networking and informational infrastructure, was in progress. The key components of this infrastructure are the telecommunication data links, the JINR local area network, the computing complex and the primary software, also on the basis of cloud and grid technologies, integrating the information resources of the Institute into a unified environment available to all users.

JINR Telecommunication Data Links. In 2014, the reliable work of the high-speed computer communication channel Dubna–Moscow was secured. The connection with scientific networks and Internet used the following telecommunication links: LHCOPN/CERN (10 Gbps), RBnet (10 Gbps), E-arena and Russian scientific networks (10 Gbps), RUNet and international scientific networks (10 Gbps). The throughput of the reserve data link was increased up to 10 Gbps and its reliability was improved at the expense of the addition

Table 1

Subdivision	Incoming, TB	Outgoing, TB
VBLHEP	72.71	36.58
DLNP	61.8	56.81
FLNP	50.27	56.84
LIT	46.28	24.01
General Access Servers	42.49	8.91
LRB	25.22	1.25
BLTP	24.61	9.98
JINR Management	19.17	45.58
FLNR	18.07	4.12
Remote Access Node	15.87	4.5
JINR's Hotel & Restaurant Complex	13.56	2.64
Joint-Stock Company "Dedal"	8.19	1.66
Medical-Sanitary Unit-9	5.56	1.11
University "Dubna"	4.85	5.74
Recreation Centre "Ratmino"	4.2	1.29

Table 2

Scientific and educational networks	File exchange (p2p)	Web resources	Social networks	Software	Multimedia
93.04%	4.18%	1.5%	0.65%	0.63%	0.01%

of a supplementary router Cisco7606-S. The possibility of the gradual modernization of the external data link up to 100 Gbps has been studied. Table 1 shows the distribution of the incoming and outgoing traffics (more than 3 TB incoming traffic) in 2014 over the JINR subdivisions.

In 2014, the overall incoming JINR traffic, including the general access servers, Tier-1, Tier-2, and the general-purpose computing cluster, amounted to 3.3 PB (2.6 PB in 2013). The weights of the various incoming traffic categories are shown in Table 2.

The creation of the Tier-1 centre at JINR required a high-speed reliable network infrastructure with a dedicated reserved channel to CERN (LHCOPN). In 2014, the JINR Tier-1 was included in the LHCOPN subsystem. The LHCOPN throughput between Tier-0–Tier-1 and Tier-1–Tier-1 was 10 Gbps.

JINR Local Area Network (LAN). The construction of the 10 GB network inside the laboratories by upgrading the network equipment in the buildings housing the JINR subdivisions to 10 GB optic interfaces was in progress. In frames of the user support, the scheduled work on the enhancement of the mail, proxy and authorization services was done. Work was carried out on the implementation of a unique authorization for the JINR Web services using the protocol OAuth 2.0. In 2014, the number of the connected objects found outside the Institute area was increased. The unique system of the international academic computer network with a transparent roaming of eduroam (education roaming) has been connected. That allowed the JINR users to connect to the network with the password provided by the JINR network service.

In 2014, the JINR LAN included 7802 network elements and 12292 IP addresses, 4057 users were registered within the network; there were more than 1500 users of mail.jinr.ru service, 1416 users of digital libraries and 861 remote VPN users.

Multifunctional Centre for Data Storing, Processing and Analysis. The centre is currently under development as an extension of the CICC and aiming at the expansion of the set of computational services for users.

For the time being, the basic computing cluster comprises 2560 64-bit central processors and a data storage system of the total capacity of 1800 TB. The central router of the cluster network is connected to the main router of the JINR LAN at a rate of 10 GB Ethernet.

A new version of the monitoring of the computing cluster was implemented. In accordance with the proposed objectives and tasks, a new monitoring system allows a real-time follow-up of the computer resources and their proper provision by the system management team.

The management of the computing resources and of the data storage system by means of a new basic software enables sharing and optimization of the resource allocation both for solving international projects involving distributed computing (WLCG, FUSION, BIOMED, HONE, PANDA, CBM, BES, NICA/MPD, etc.) and for sharing tasks of local JINR

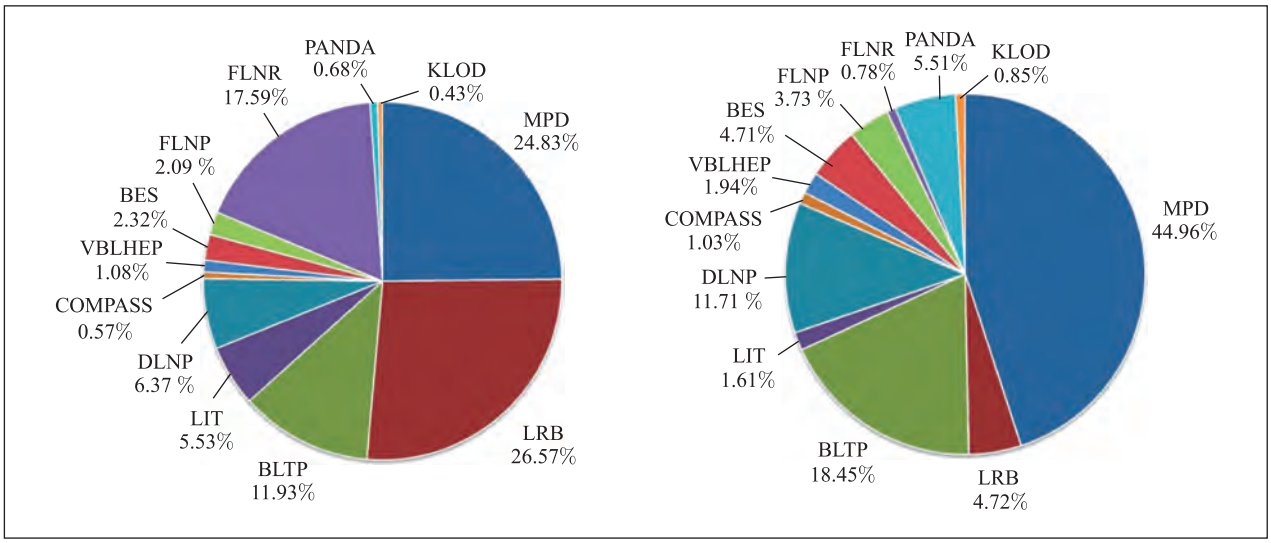


Fig. 1. Sharing of the resources of the computing cluster according to the processing time (left) and to the astronomical time (right) among the divisions of the Institute and user groups

users. To this aim, both the JINR users and the grid users have equal access to all the computer facilities via a unified batch processing system.

The systems of data storage and access dCache and XROOTD ensure data handling both by the local JINR users and by the outer remote users. Two dCache implementations are maintained: dCache-1 for the CMS and ATLAS experiments; dCache-2 for the local users, the user groups and the international projects NICA/MPD, HONE, FUSION, BIOMED, COMPASS. Two implementations of the XROOTD data access system maintain work with data of three international collaborations: ALICE, PANDA, and CBM. All the storage systems are implemented under the hardware data protection mechanism RAID6. Figure 1 shows the distribution of the resources of the computing cluster.

Table 3 provides the 2014 statistics on the CICC use by the JINR subdivisions and user groups, except for the tasks within the grid projects.

Table 3

Laboratory/ group	CPU time, kSi2K · h	Astronomical time, kSi2K · h	Number of jobs
LRB	893701.32	89251.84	1158
MPD	835048.52	850393.16	64120
FLNR	591555.74	14687.34	362
BLTP	401326.39	348956.78	9319
DLNP	214328.90	221485.29	8310
LIT	185922.76	30508.33	468
BES	78183.51	89081.31	32511
FLNP	70211.33	70570.20	392
VBLHEP	36165.57	36715.10	1233
PANDA	22936.75	104304.17	360753
COMPASS	19167.64	19403.42	2582
KLOD	14601.20	16101.93	4368

JINR Grid Environment. In 2014, active work was in progress within the global large-scale grid projects "Worldwide LHC Computing Grid" (WLCG, http://lcg.web.cern.ch/LCG/) and "European Grid Infrastructure" (EGI-InSPIRE — Integrated Sustainable Pan-European Infrastructure for Researchers in Europe, http://www.egi.eu/projects/egi-inspire/). The JINR computing cluster supports, under the grid-site name JINR-LCG2 of the global grid infrastructure, computations of 8 virtual organizations (alice, atlas, biomed, cms, dteam, fusion, hone, lhcb) enabling as well possibilities for using grid resources for the experiments BES and PANDA. The main users of the JINR grid resources are the virtual organizations of all the four large LHC experiments.

The servers of the control system of the cluster operation are used for the task distribution (both for local users and WLCG) at various sites of the WLCG project. The service X509 PX (ProXy) stores and updates the user certificates enabling the protection of resources and tasks of users within grid systems. This is the chief method of access control of the registered users within the WLCG project. The CERN distributed file system CVMFS (CernVM File System) is maintained on the cluster to provide and control the access to the software within the ALICE, ATLAS, CMS, LHCb and BES collaborations. Two VOboxes (Virtual Organization box) are used by the ALICE and CMS collaborations to perform their work at the WLCG sites.

The work of the grid site at JINR is maintained by 22 servers under the EMI2/EMI3 system (WLCG middleware). In addition to the support of the operation of the site JINR-LCG2 itself, a part of the servers provide important services and functions for the support of the Russian segment of the WLCG project. Table 4 and Fig. 2 (left) summarize the VO usage of the JINR grid infrastructure within RDIG/WLCG/EGI in 2014. During 2014, Tier-2 has run almost 5 million jobs, with an overall CPU time exceeding 160 million h (in HEPspec06 units). The JINR grid site is one of the most effective Tier-2 level sites within the WLCG infrastructure.

Table 4

VO	CPU time, HEPspec06 · h	Number of jobs
atlas	41 876 104	2 677 075
cms	46 230 972	1 003 803
alice	45 093 312	786 849
lhcb	21 135 604	141 346
biomed	1 650 056	237 252
bes	300 552	40 456
hone	266 944	20 016
fusion	46 348	16 624
ops	572	80 438
Total	156 600 464	5 003 859

A Tier-1 site for the experiment CMS was created in LIT. At the moment, Tier-1 comprises 1200 64-bit processors, a 660 TB storage system and a 72 TB tape storage. During 2014, almost 1 million tasks were run at the JINR Tier-1 site, with an overall processor time of 65 million h (HEPspec06 units). Figure 2 (right) summarizes data on the usage of the Tier-1 centres of the CMS experiment. The contribution of the JINR's Tier-1 prototype was 4.82%.

By the state of the LHC run, the build-up of the first-level configuration of the fully functional Tier-1 center in JINR should be brought to an end. To this purpose, a 5 PB tape robot (IBM) was already installed, while the works on commissioning the uninterrupted power supply source and the installation of inter-row air-conditioning for new Tier-1 modules have reached the final stage.

In 2014, work continued on building up the parameters of the network connections between the sites of the ATLAS collaboration infrastructure to the targets established within the PanDA (Production and Distributed Analysis System) task processing system. In particular, a service has been created that transfers only necessary data from ATLAS SSB (Site Status Board), which

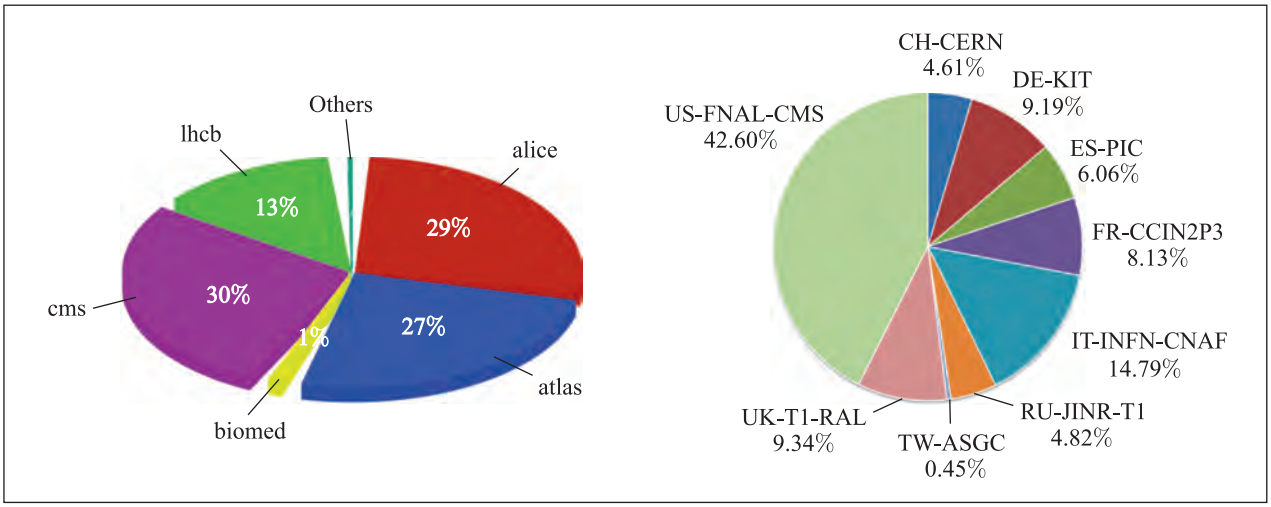


Fig. 2. Summary of the use of the JINR Tier-2 grid infrastructure by virtual organizations that are a part of RDIG/WLCG/EGI (left). Usage of the Tier-1 centers by CMS experiment (right)

stores both the current information and historical data, into AGIS (ATLAS Grid Information System), the unified information system for all systems of the ATLAS collaboration. Also, the service SchedConfig was developed in 2014 to carry out network metrics as well as additional information to the internal information system PanDA. SchedConfig is a database containing configuration parameters required for PanDA operation; partial duplication is made such that to keep the PanDA to serviceability under unviability of inaccessibility of the AGIS information system [1].

Heterogeneous Computing Cluster HybriLIT. In 2014, the computing cluster HybriLIT (http://hybrilit.jinr.ru) was put into operation. It comprises four computing nodes: two nodes containing three graphical accelerators NVIDIA Tesla K40 (Atlas) each, a node containing two co-processors Intel Xeon Phi 7120P, as well as a node containing NVIDIA Tesla K20x and a co-processor Intel Xeon Phi 5110P. Moreover, each computing node includes two processors Intel Xeon E5-2695v2. The HybriLIT cluster also includes a control unit and a data storage unit. Figure 3 shows the structure and the main characteristics. Inclusion of the HybriLIT cluster in the computer infrastructure of the Multipurpose Center of Data Storage, Processing and Analysis provides the specialists from JINR and the JINR Member States with the possibility to create their own software asked by research that needs resource-intensive computations, to use software packages already adapted for hybrid architectures, as well as mathematical libraries. In 2014, on the base of

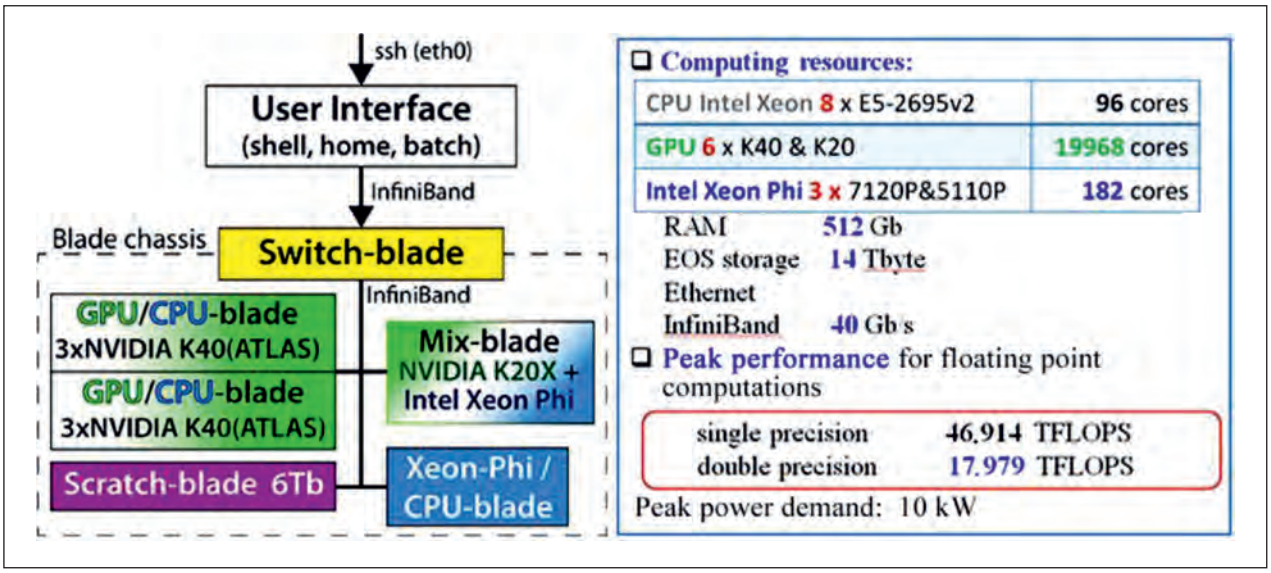


Fig. 3. The structure of the heterogeneous computing cluster HybriLIT (left). The main parameters of the computational elements of the cluster and its efficiency (right)

the HybriLIT cluster, training courses were held on the parallel programming technologies in the framework of the GRID'2014 conference, the International youth conference MPAMCS'2014, as well as within the Helmholtz International Summer School "Lattice QCD, Hadron Structure and Hadronic Matter". The overall number of participants in the training courses exceeded more than 60 people from Germany, Mongolia, Russia, Romania, etc.

For the efficient use of the heterogeneous cluster HybriLIT, an information-software environment that includes services for applications development, debugging and profiling is being developed and implemented by LIT staff together with colleagues from the Institute of Experimental Physics and the Technical University in Košice (Slovakia).

Cloud Environment. During the first half of 2014, a cloud infrastructure was brought into service (http://cloud.jinr.ru). Presently, the cloud resources include 138 cores, 260 GB RAM and 10 TB disk space. At the moment, 67 accounts are registered in the cloud.

The cloud service resources are utilized by users for various activities within the themes of the JINR Topical Plan for JINR research and international cooperation as well as for the fulfillment of LIT and JINR obligations under various projects:

- two test beds for the PanDA Application Software (AS): the first is for development, the second is to estimate its suitability for construction of the computing infrastructure of the NICA project;
- test bed based on the DIRAC AS for experiment BES-III and computing resources for it;
- test beds for the project management (JPMS) services and the document server (JDS).

Figure 4 shows the distribution of the cloud resources over JINR Laboratories and groups in 2014.

Migration of services of education for the research and test grid infrastructure on virtual machines to the JINR cloud service was performed.

A virtual organization NICA has been created on the VOMS-server to perform corresponding investigations under the project with the same name.

Information and Software Support. A new grid- and cloud-service simulation system for the future NICA accelerator complex data storage and processing setup was developed in 2014. Within the new system, the assessment of the quality of the already developed grid- and cloud-service simulation is done together with the design of the further development by combining the simulation code with the monitoring of grid-cloud service through a dedicated database [2].

A comparative analysis of these packages for modeling cloud infrastructures — CloudSim, iCanCloud, and CReST, has been done. These program packages allow the development of models of cloud systems with definite functionality and configuration. The output of the simulation done via the final model consists of statistical information on the most important features of the cloud infrastructures: execution time, virtual machine lifecycle, the use of resources. From the analysis of this information, the developer can reveal bottlenecks in the model and foresee their solution, the validity of the implementation of which being checked at the next iteration of the simulation [3].

Approaches have been developed for ensuring the content integration and interoperability of the information systems assisting the research activities at JINR, namely, the JINR Document Server (JDS), the information-analytical system "Personal Information about JINR employees" (PIN) and the scientific activities management Indico [4].

During 2014, work was in progress on the transition to the unified information platform 1C 8.2 UPP: the 1C 8.2 UPP and ADB2 components regarding operational performance of the JINR budget; a specialized constructor of multiline documents was developed; the module "Budgeting", including the "Application Mechanism", was brought into service. During 2014, courses for users were also organized; for instance, training on the new functional "Mutual Settlement of Accounts with Self-Supporting Divisions". Weekly meetings with users from the Accounting Department were held regularly for revealing and solving urgent tasks and problems arising during the 1C software usage.

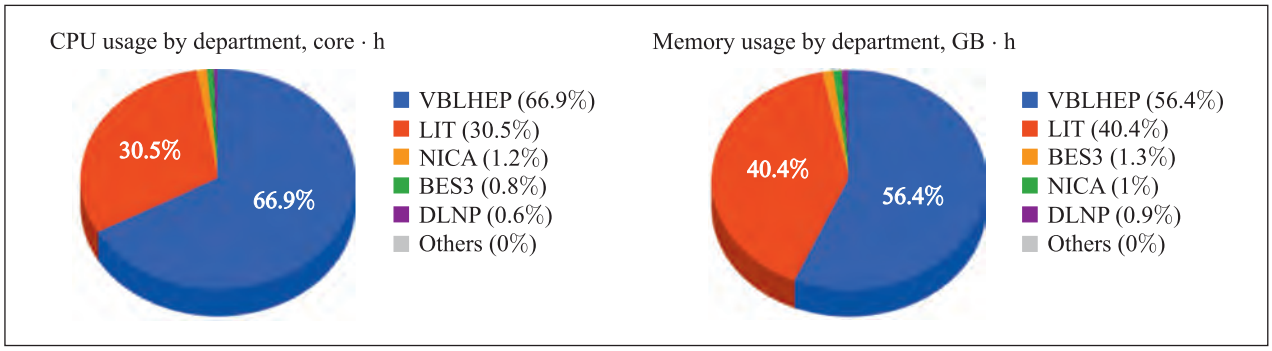


Fig. 4. Distribution of cloud resources among the Laboratories and JINR groups in 2014

In 2014, the system of electronic document circulation (EDC) "1C:DocumentCirculation" EDC was debugged; the document "Turnkey contract" (Contractor's agreement) with corresponding procedures of electronic confirmation was put into commercial operation. Relevant instructions for users were prepared as well, and the users were trained on the creation and confirmation of documents "Turnkey contract" in EDC "1C:DocumentCirculation".

In 2014, work was done on updating the project plans in the information control system of the NICA project (ADB2-EVM), a separate version of the CERN module APT-EVM was prepared, the integration of the APT-EVM functional with the information system (IS) of the NICA project management (ADB2-EVM) was done, APT-EVM was installed on the JINR area, and the functional of integration with the information system of the NICA project management was tested. In the framework of the development of the IS for the NICA project management, the following modules have been elaborated: on the work with baselines; on the input of the parameters of the budgeted cost of the performed work (EV); the notification system; account forms with the ADB2-EVM were tested; the directories of the work breakdown structure (WBS) between IS of the NICA project management (ADB2-EVM) and 1C were synchronized. Further, in 2014, the modernization and development of the module on the verification of actual data on payment of accounts/orders within 1C and ADB2 were carried out together with organization of sessions of leaders of 1-2 WBS ranks for the work with the ADB2-EVM system.

During 2014, work was in progress on the update of the software environment and databases of the LIT/JINR websites http://lit.jinr.ru, http://www.jinr.ru, http://wwwinfo.jinr.ru. Also, an active work was conducted on the creation and storage of electronic documents related to scientific and administrative activity of LIT and the Institute as a whole at the request of the JINR Scientific Organizational Department (information on the operation of the JINR basic facilities, the sessions of the JINR Scientific Council, etc.), and the internet access was ensured to the relevant information concerning the JINR Prizes — a retrieval system (data since 1960) http://wwwinfo.jinr.ru/search_award_dbs.htm; information on conferences and the JINR workshops http://wwwinfo.jinr.ru/confer-e.htm; information on the JINR dissertation councils (http://wwwinfo.jinr.ru/dissertation/JINR_DCs.htm), as well as announcements on defending PhD theses and Doctor's theses at JINR on proposals of the scientific secretaries of the councils. Maintenance and modernization of the web-portal of the journals "Physics of Elementary Particles and Atomic Nuclei" (PEPAN) and "Particles and Nuclei, Letters" (http://pepan.jinr.ru/) were done. Traditional regular work was conducted on the design and support of various information websites, sites of conferences, workshops, symposia organized by JINR Laboratories, as well as organization of a website hosting (upon request). Instances: FLNP (CMR@IBR-2), DLNP (RCRC-2014), FLNP (EXON-2014), LRB (MPGRRE-2015), LIT (RCDL-2014), etc.

METHODS, ALGORITHMS AND SOFTWARE FOR MODELING PHYSICAL SYSTEMS, MATHEMATICAL PROCESSING AND ANALYSIS OF EXPERIMENTAL DATA

One of the main directions of the research activity at LIT is to provide a mathematical, algorithmic and software support of the experimental and theoretical research underway at JINR. Below there is a brief report on some results.

A new algorithm for constructing the segments in endcap cameras of the CMS setup on the LHC has been developed. By means of specially developed programs for finding the parameters of simulated MC objects, there has been carried out the analysis of the results obtained with the use of various algorithms, and the efficiency of the new algorithm over the standard one for particles obtained as a result of collisions and for cosmic rays has been proved.

Within the works on the modeling and optimization of the setup of Baryonic Matter at Nuclotron (BM@N) project, a number of problems have been carried out; in particular, the analysis of the data obtained from the GEM-detector prototype, in the course of which the efficiency and a number of other parameters in the work of the detector have been estimated. The results of the analysis were provided to the specialists for further improvement of the geometry of the prototype. The code for information readout obtained from the GEM-detector has been developed and provided for the implementation into the basic software package of the experiment. The efficiency of the DC-detector at low values of the electric potential has been estimated; and a software for dealing with data obtained from the 8 planes of the detector has been developed.

An algorithm for the real-time charged particles trajectory reconstruction of the CBM experiment (GSI, Darmstadt, Germany) has been developed on the basis of the Kalman filter. The problems related to the reconstruction of charged particle trajectories require high-performance computing resources, so a software implementation of the suggested algorithm was carried out on the basis of various technologies of parallel pro-

gramming adapted to hybrid computing architectures. To solve the considered problem numerically, the hybrid server of LIT JINR with two central processors Intel Xeon X5660 and graphic card NVIDIA GTX 480 was used [5].

The scientists of LIT and VBLHEP involved in the Geant4 Collaboration have performed a research work entitled "The Effect of uu Diquark Suppression in Proton Splitting in Monte-Carlo Event Generators". Most of the Monte-Carlo event generators of multiparticle production assume that nucleons split into diquarks and quarks in strong interactions. In particular, protons split into (ud) diquarks and u quarks with a probability of $2/3$ and into (uu) diquarks and d quarks with a probability of $1/3$. It was demonstrated that using a value of $1/6$ for the last probability allows one to describe at a semi-quantitative level the NA49 Collaboration data for $p + p \to p + X$ reactions at 158 GeV/c. A suppressed weight of (uu) diquarks in protons is expected in the instanton model of the QCD vacuum. According to that model, quark–quark interactions are flavor-dependent. For example, they are nonzero only if quarks are of different flavors. Thus, (uu) diquarks must be suppressed in protons. The Fritiof (FTF) model of Geant4 was used to simulate the $p + p \to p + X$ reactions. Good results were obtained. The suppression of diquarks is included in the last release of Geant4 [6].

The FORTRAN 77 program POTHEA is presented for calculating with a predetermined accuracy of eigenvalues, surface eigenfunctions and their first derivatives with respect to a parameter of the parametric self-adjoined 2D elliptic partial differential equation with the Dirichlet- and/or Neumann-type boundary conditions in a finite two-dimensional region. The program also calculates potential matrix elements that are integrals of the products of the surface eigenfunctions and/or the first derivatives of the surface eigenfunctions with respect to a parameter. Eigenvalues and matrix elements computed by the POTHEA program can be used for solving the bound state and multichannel scattering problems for a system of the coupled second-order ordinary differential equations with the help of the KANTBP program [7].

The analysis of cross sections of inelastic scattering of π mesons by nuclei Si, Ni, Pb at the energy of 291 MeV has been performed on the basis of a microscopic optical potential (OP). These OPs were determined on the basis of a pion–nucleon amplitude and a nucleus density distribution. In doing so, used were parameters of the πN amplitude in nuclear matter obtained earlier from the analysis of data on elastic scattering on the same nuclei. Calculation of cross sections was conducted on the basis of the relativistic wave equation. Parameters of the nuclei deformation were received from a comparison with experiment of cross sections of inelastic scattering [8].

A method and a software complex have been elaborated for numerical simulation of the process of formation of polaron states in condensed matter. Numerical study of this process was carried out for aqueous medium exposed to laser irradiation in a ultraviolet range. It was shown that within the suggested approach one can numerically reproduce the experimental data on formation of hydrated electrons. A scheme was presented of a numerical solution to the system of nonlinear differential equations in partial derivatives describing a dynamic polaron model. Software realization was executed with the use of parallel programming technology MPI [9].

Direct proof of the role of the CuO_2 planes in the occurrence of the high-temperature superconductivity in cuprates was got experimentally from the investigation of the behaviour of the critical temperature T_c under gradual substitution of the in-plane Cu^{2+} ions by divalent metal ions M^{2+}. Functional dependencies $T_c = T_c(y)$ on the y content of M ion are inferred from the existing experimental evidence on $La_{1.85}Sr_{0.15}Cu_{1-y}M_yO_4$ (LSCO) for M^{2+} denoting either Zn^{2+} or Ni^{2+}. Data processing and analysis point, in both cases, to a sharp linear decrease of T_c under the increase of y, with an M ion-dependent slope. The result substantiates the basic hypothesis of the effective two-dimensional two-band Hubbard model (*Plakida N. M. et al.* // Phys. Rev. B. 1995. V. 51. P. 16599; JETP. 2003. V. 97. P. 331; Eur. Phys. J. B. 2013. V. 86. P. 115; *Plakida N. M.* High-Temperature Cuprate Superconductors. Experiment, Theory, and Applications, 2nd Ed. Berlin, Heidelberg: Springer, 2010) of searching the origins of the high-T_c superconductivity in cuprates inside individual CuO_2 planes [10].

For the first time formulas for the polynomial coefficients represented as basic elements (MBE) that depend on the parameters of a three-point grid have been obtained. The use of MBE polynomials of high degrees for piecewise-polynomial approximation (PPA) and smoothing improves the quality of approximation and increases the efficiency of the data processing algorithms [11].

The methods of computation invariant theory together with those of computer algebra have been used to describe the space of separable and entangled states for composite quantum systems. In particular, such quantum systems as a pair of qubits and a three-level quantum system (qudit) have been considered. It has been shown that their state space is uniquely determined by a semi-algebraic set (e.g., set of equations and inequalities) in terms of polynomial invariants of the global unitary group, $SU(4)$ for 2-qubit systems and $SU(3)$ for qutrits [12].

Finite-element-method (FEM) simulations have been performed to determine the current and field distributions and to calculate the AC losses in cables made of MgB_2 superconductors. For current capacities of 2–5 kA (peak), the power cables are assembled from a relatively small number of MgB_2 strands. The performance of such cables strongly depends on the cur-

rent and field distributions, which are, in turn, influenced by the number and the arrangement of the superconducting components and also by the magnetic properties of supporting materials. Numerical simulations can help to test different cable configurations and provide important insights for optimizing the cable's design. The numerical model includes the field dependence of the superconductor's critical current density and the nonlinear properties of magnetic materials [13].

The ground state of a homogeneous Bose gas of hard spheres has been treated in self-consistent mean-field theory. It has been shown that this approach provides an accurate description of the ground state of the Bose–Einstein condensed gas for arbitrarily strong interactions. The results are in good agreement with Monte-Carlo numerical calculations. Since all other mean-field approximations are valid only for very small gas parameters, the present self-consistent theory is a unique mean-field approach allowing for an accurate description of Bose systems at arbitrary values of the gas parameter [14]. It has also been shown that, contrary to all other variants of mean-field theory, which incorrectly describe the condensation phase transition exhibiting instead of the necessary second-order transition a first-order transition, the self-consistent mean-field approach is the sole mean-field theory that provides the correct second-order condensation transition for Bose systems with atomic interactions of arbitrary strength, whether weak or strong [15].

INTERNATIONAL COLLABORATION

In 2014, in cooperation with the Chinese colleagues, a system of distributed computations was designed for experiment BES-III (Beijing Spectrometer III) on the electron–positron collider in Beijing. For the BES-III distributed computations system, the DIRAC infrastructure (Distributed Infrastructure with Remote Agent Control) has been chosen that allows realization of required functionalities. The LIT specialists actively participated in all tasks of the development of grid systems for the BES-III experiment, especially in engineering data and grid-monitoring management systems. Considerable progress was made towards the creation of a data storage infrastructure; also, the first version of the BES-III monitoring system was developed and put into operation.

In collaboration with the University of Plovdiv (Bulgaria) and the University of Cape Town (South Africa), a numerical investigation of complexes of localized states has been performed in two dynamical systems: a directly driven nonlinear Schrödinger equation (NLS) and a double sine-Gordon equation (2SG). Both systems have a wide range of physical applications. In both cases, the numerical approach is based on a numerical continuation with respect to the control parameters of the quiescent (stationary) solutions and stability and bifurcation analysis of the linearized eigenvalue problem. Multisoliton complexes of the NLS equation are studied in the undamped and weak damping regimes. It has been shown that in the weak damping case, the directly driven NLS equation holds stable and unstable

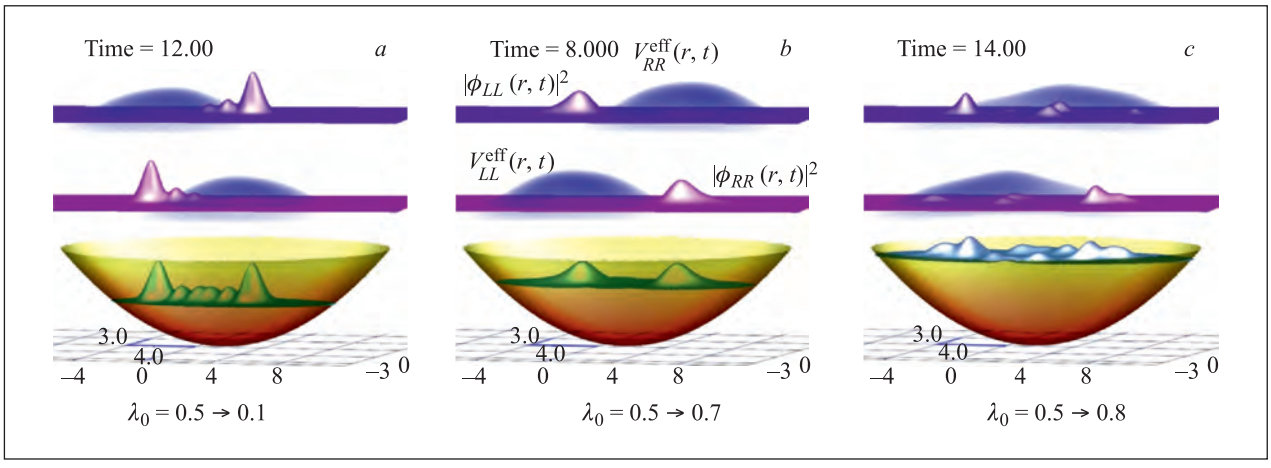


Fig. 5. Visualization of the concept of interaction-induced time-dependent barriers to interpret the two generic dynamical regimes of strongly-interacting trapped bosons; 2D case. Evolutions of a two-fold fragmented initial state induced by a sudden displacement of the harmonic trap $V(x,y) \to V(x-1.5,\, y-0.5)$ with the simultaneous quench of the interparticle repulsion: (*a*) strong decrease $\lambda_0 = 0.5 \to 0.1$, snapshot at $t = 12$; (*b*) moderate increase $\lambda_0 = 0.5 \to 0.7$, snapshot at $t = 8$; (*c*) strong increase $\lambda_0 = 0.5 \to 0.8$, snapshot at $t = 14$

multisoliton complexes. The obtained numerical results have been confirmed by means of direct numerical simulations of the time-dependent NLS equation. The properties of the multifluxon solutions of 2SG equation have been studied depending on the parameter of the second harmonic. It has been shown that the second harmonic changes properties and increases the complexity of coexisting static fluxons of 2SG equation. The results have been discussed in the framework of the long Josephson junction model [16].

In cooperation with the Slovak colleagues, an algorithm of modeling a process of heat conductivity has been developed at the design and optimization of a cryogenic cell, pulse feeding working gases (in a msec range) into an electron-string source of high-charge ions. To speed up the calculations, a parallel algorithm realized in the OpenCL language has been developed. Results of the calculations have shown that the selected characteristics and the configuration of the device meet necessary requirements to the mode of its work [17].

In the framework of ongoing collaboration between Many-Body Theory of Bosons group at the Center for Quantum Dynamics, Heidelberg University (Germany) and the Laboratory of Information Technologies, JINR (Russia), theoretical investigations of the highly-nonequilibrium quantum dynamics realized in trapped systems of ultracold atoms and molecules were in progress. In particular, the development and optimization of the Multiconfigurational Time-Dependent Hartree for Bosons (MCTDHB) package designed to solve the many-body Schrödinger equation for bosons was continued. The program modules designed for the MCTDHB package are intended to perform 1D, 2D and 3D computations on hybrid computing systems including multicore CPU and graphical accelerators. Parallel modules have been realized on the basis of the present-day parallel programming technologies MPI + CUDA (MPI + PGI CUDA). The modules developed will be included into a new version of the package. Examples of the results of the MCTDHB package calculations are shown in Fig. 5. The development, implementation and preliminary computations were performed on the heterogeneous computing cluster HybriLIT (LIT JINR) and on the hybrid K100 cluster (Keldysh Institute of Applied Mathematics) [18].

CONFERENCES AND MEETINGS

On 3–8 February, JINR hosted the 21st International Conference "Mathematics. Computer. Education" (MCE). The Conference was organized by the JINR Laboratory of Information Technologies, "Dubna" University, Lomonosov Moscow State University, Puschino Scientific Center of RAS, Keldysh Institute of Applied Mathematics (Moscow, RAS), MSU Centre of National Intellectual Reserve, Foundation "National Intellectual Development", as well as the Interregional Public Organization "Women in Science and Education". Traditionally for the MCE conferences there were organized presentations and discussions of research projects developed by high-school students within the "FOROS" project, which were held at the International University of Nature, Society and Man "Dubna". The students came from Moscow and Moscow region, the cities of Tver and Izhevsk. For the pupils who were not able to come to Dubna, a television space bridge was organized.

A traditional two-day Workshop on Computer Algebra was held at the Laboratory of Information Technologies on 21–22 May. More than 40 scientists from universities and scientific institutes of Bucharest (Romania), Sofia (Bulgaria), Tbilisi (Georgia), Moscow, St. Petersburg, Ivanovo, Pereslavl-Zalesskiy, Petrozavodsk, Saratov, Tambov, and Dubna took part in this Workshop. Thirty-four reports were presented. This year, a number of new promising results on: analysis and solving of the algebraic, differential and difference equations; increase of computational efficiency of algorithms of computer algebra; study of algebraic properties of the qubits in entangled states in quantum informatics, as well as computer algebra applications to physics and mathematics, were presented.

The 6th International Conference "Distributed Computing and Grid Technologies in Science and Education" was held at the Laboratory of Information Technologies on 30 June – 5 July. This year marked the tenth anniversary of the first conference in 2004. It should be noted that the Conference has become a unique forum for the discussions of a wide range of questions related to the use of distributed and grid technologies in different fields of science, education, industry and business, and of fresh ideas and results. The Conference was attended by more than 200 participants from the following scientific centers: Armenia, Belarus, Bulgaria, Hungary, Mongolia, etc. Russia was presented by participants from more than 30 universities and research centers. Within the Conference, there were organized eight sections, which included discussions on the current and future role of grid technologies, cloud technologies, Big Data in the models of computing for megaprojects such as NICA and FAIR. During the Conference, there was also held a meeting "Computing Models, Software and Data Processing for the Future HENP Experiments". During the work of the Conference, there were made 30 plenary reports, more than 65 sectional reports and 13 poster presentations. Within the Conference, there was held a tutorial on parallel programming technologies. Participants from

Mongolia, Romania and Russia listened to the lectures on the following technologies: MPI, OpenMP, CUDA, and OpenCL. The practical trainings were held on the basis of the heterogeneous computing cluster HybriLIT (http://hybrilit.jinr.ru/).

On 25–29 August, the Joint Institute for Nuclear Research (JINR) under the auspices of the National Committee of the Society for Industrial and Applied Mathematics (SIAM), the International Coordinating Committee for Computational Mathematics of the CIS Academies of Sciences hosted the International conference for young scientists "Modern Problems of Applied Mathematics and Computer Science". The Conference was organized by the KIAM RAS, LIT JINR, INM RAS, and RCC MSU. The Conference was attended by participants from Russia, Belarus, Tajikistan, Armenia, Mongolia, Slovakia, etc. The total number of the Conference participants was 132, 108 persons being students, postgraduates and young scientists under 35 years of age (more 80%). The Conference for young scientists MPAMCS'2014 provided a way for young scientists to get acquainted with the present-day methods and approaches to solving problems of science and technology with the help of high-performance computing systems, with methods of developing large program complexes, modern parallel programming techniques, as well as with the latest achievements in the field of exaflops computations and Big Data. The best reports presented by young scientists will be published in the journal "Mathematical Modeling".

On 13–16 October, the Laboratory of Information Technologies hosted the 16th Conference in a series of annual scientific conferences "Digital Libraries: Advanced Methods and Technologies, Digital Collections" RCDL-2014. Alongside with the Russian employees of scientific research institutes, teachers and postgraduate students, specialists in the field of library affair and industry of information technologies from Moscow, St. Petersburg, Kazan, Yaroslavl, etc., the RCDL-2014 Conference was attended by the representatives of Great Britain, India, Kazakhstan, and France. Fourteen sessions were organized, which, alongside with the invited talks, included 28 reports and 19 communications. By the tradition of the last few years, in the framework of the Conference, a dissertational seminar of young scientists was organized to discuss the directions and results of scientific studies performed by the authors of reports to the seminar.

On 20–24 October, the 5th School on information technologies "Grid and Advanced Information Systems" was held under the auspices of the LIT JINR, CERN and NRNU MEPhI. The 5th School was devoted to the management of scientific complexes and information systems. In total, students from 12 leading universities were invited: Saint-Petersburg State University, MSU, Lobachevsky State University (Nizhni Novgorod), PFUR, Plekhanov Russian University of Economics, Tver State University, NRNU MEPhI, BMSTU, MPEI, and "Dubna" University. Also, students from Slovakia and Georgia took part in work of this School. The participants heard lectures on database, cloud computing, digital library, grid technologies, software development, the NICA accelerator complex, Tier-1 in Dubna, etc. The organizers of the School held a competition among the participants. On the first day of the School the students were given the tasks which they could decide and realize during a week. The best result was shown by Kirill Korepanov from Bauman Moscow State Technical University, the second prize went to a group of students from Tver State University and the third prize went to "Dubna" University. All the winners were presented the prizes.

REFERENCES

1. *Maeno T. (Brookhaven Nat. Lab.) et al. (ATLAS Collab.)* // J. Phys. Conf. Ser. 2014. V. 513. P. 032062; https://inspirehep.net/record/1302031.
2. *Korenkov V. V. et al.* // Comp. Res. Mod. 2014. V. 6, No. 5. P. 635–642.
3. *Korenkov V. V., Muravyev A. N., Nechaevsky A. V.* // Electronic Journal "System Analysis in Science and Education". 2014. No. 2.
4. *Zaikina T. N. et al.* // Proc. of XVI All-Russian Sci. Conf. RCDL-2014. Dubna. 2014. P. 349.
5. *Ablyazimov T. O. et al.* // Part. Nucl., Lett. 2014. V. 11, No. 4. P. 828.
6. *Uzhinsky V., Galoyan A.* arXiv:1410.6612 [hep-ph]. 2014.
7. *Gusev A. A. et al.* // Comp. Phys. Commun. 2014. V. 185. P. 2636–2654.
8. *Lukyanov V. K. et al.* // Bull. of RAS. Physics. 2014. V. 78, Iss. 5. P. 421–426.
9. *Volokhova A. V. et al.* // Comp. Res. Mod. 2014. V. 6, No. 2. P. 253–261.
10. *Oprea A., Adam S., Adam Gh.* // Rom. J. Phys. 2014. No. 5–6. P. 544–549.
11. *Dikusar N. D.* // Mathematical Models and Computer Simulations. 2014. V. 6, No. 5. P. 509–522.
12. *Gerdt V., Khvedelidze A., Palii Yu.* // J. Math. Sci.. 2014. V. 200, No. 6. P. 682–689.
13. *Grilli F. et al.* // Physica C: Superconductivity. 2014. V. 504. P. 167–171.
14. *Yukalov V. I., Yukalova E. P.* // Phys. Rev. A. 2014. V. 90. P. 013627-7.
15. *Yukalov V. I., Yukalova E. P.* // J. Phys. B. 2014. V. 47. P. 095302-6.
16. *Zemlyanaya E. V., Alexeeva N. V., Atamasova P. Kh.* // Bull. of PFUR. Ser. Mathematics. Information Sciences. Physics. 2014. No. 2. P. 363.
17. *Ayriyan A., Pribis J.* // Ibid. P. 67–71.
18. *Streltsova O. I. et al.* // Phys. Rev. A. 2014. V. 89. P. 061602(R).

LABORATORY OF RADIATION BIOLOGY

In 2014, the Laboratory of Radiation Biology (LRB) continued the realization of Theme 04-9-1077-2009/2017 "Research on the Biological Effect of Heavy Charged Particles with Different Energies" in the following fields: fundamental radiobiological and radiation genetics research with heavy charged particles; research on the action of accelerated charged particles on the central nervous system and eye structures; mathematical modeling of radiation-induced effects; and radiation research at JINR's basic facilities and in the environment. Work was continued on Theme 04-9-1112-2013/2015 "Research on Cosmic Matter on the Earth and in Nearby Space; Research on the Biological and Geochemical Specifics of the Early Earth".

RADIATION GENETICS AND RADIOBIOLOGY

A comparative analysis was performed of the induction of clustered DNA double-strand breaks (DSBs) by ^{60}Co γ rays and accelerated heavy ions and their repair. It was shown that for ^{11}B ion irradiation, DNA DSBs are formed along the particle track, while γ ray-induced lesions are uniformly distributed over the cell. The ^{11}B ions induce heavy clustered DNA damage, the repair of which is slower than for γ irradiation (Fig. 1, *a*). The ^{11}B ion irradiation results in a threefold yield of γ-H2AX/53BP1 foci compared with

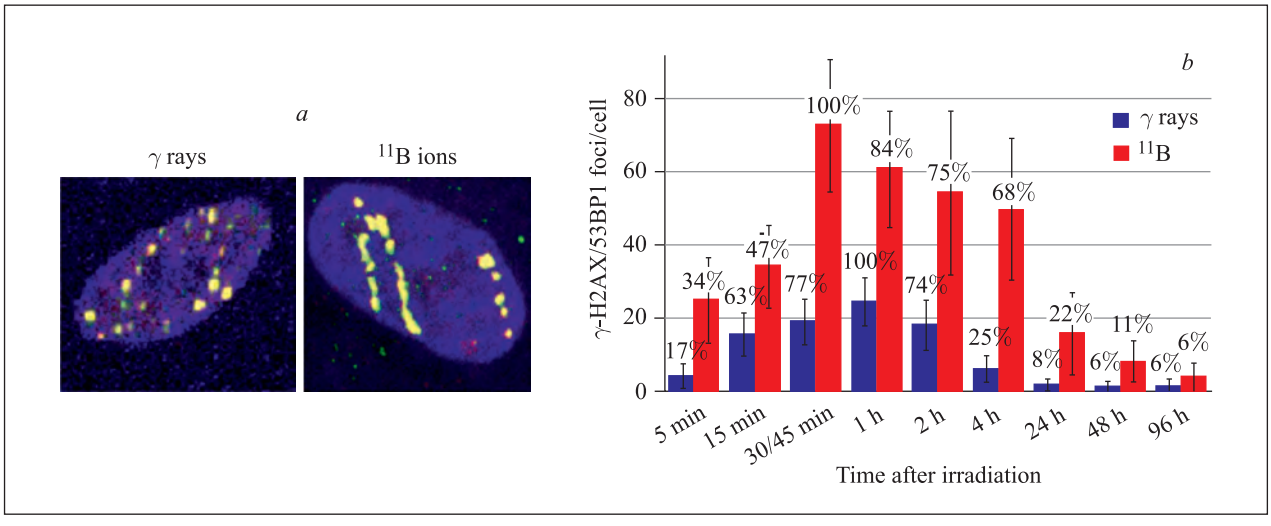


Fig. 1. *a*) Visualization of DNA DSBs in fibroblast nuclei by immunocytochemical staining. *b*) Kinetics of the formation and elimination of the γ-H2AX/53BP1 foci (γ-H2AX histone and 53BP1 repair protein — DNA DSB markers) for ^{60}Co γ ray and accelerated ^{11}B ion exposure

γ irradiation. The highest γ ray-induced foci yield was observed after 1 h of post-irradiation incubation of fibroblasts, and most of the foci ($\sim$ 75%) were eliminated during 4 h (Fig. 1, *b*). The research was performed to study the mechanisms of the action of heavy charged particles of space origin on biological objects — the key problem of space radiobiology [1–7].

Mechanisms were studied that underlie the nonlinearity of the dose — effect dependence for low doses of ionizing radiation — in particular, the role of radiation-induced reactive oxygen species (ROS) in chromosome aberration induction. It had been established earlier that inhibiting the P38 protein kinase suppressed the hypersensitivity of CAL51 breast carcinoma cells to γ rays, which was observed to peak at 5 cGy. It allowed considering NADP oxidase as the main source of ROS that are responsible for an increase in chromosome lesion yield at low doses of γ radiaion. This assumption was confirmed in experiments on studying the yield of aberrant CAL51 cells with the use of the DPI inhibitor of NADP oxidase. Blocking of this oxidase and, as a consequence, blocking of ROS generation causes a significant decrease in aberrant cell yield in a wide dose range (Fig. 2). When it happens, the hypersensitivity peak at 5 cGy is completely removed (the insert in Fig. 2), and the dose dependence approaches a linear one. These data indicate that hypersensitivity at low doses of γ radiation is determined by the cytotoxic effect of the ROS generated by NADP oxidase [8].

The HPRT mutagenesis induced by accelerated ions of different linear energy transfer (LET) (50, 116, 138,

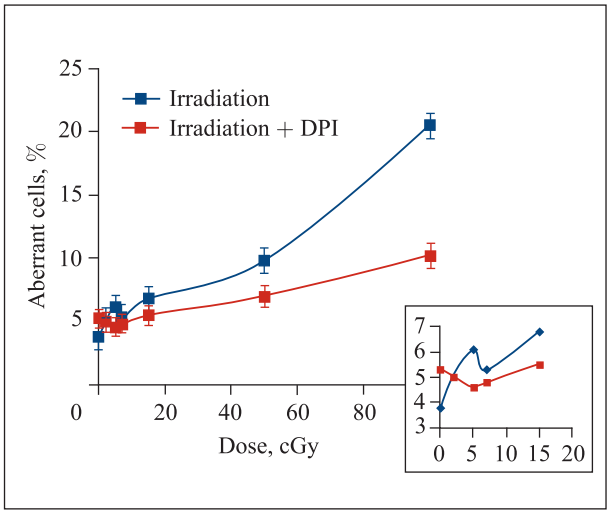


Fig. 2. The effect of the DPI inhibitor of NADP oxidase on aberrant CAL51 cell yield for γ radiation

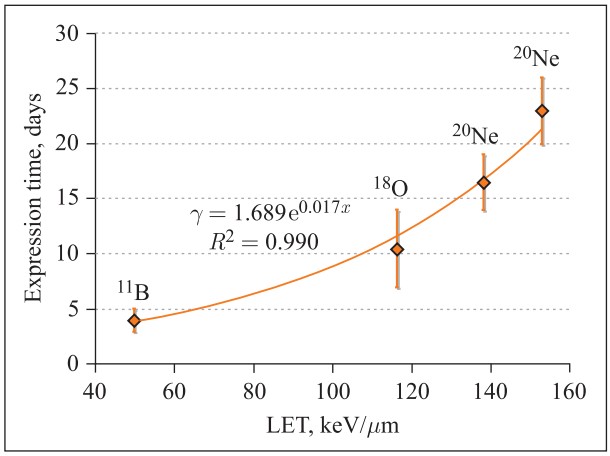


Fig. 3. The maximal level of radiation-induced mutagenesis in Chinese hamster cells depending on expression time and LET accelerated ion

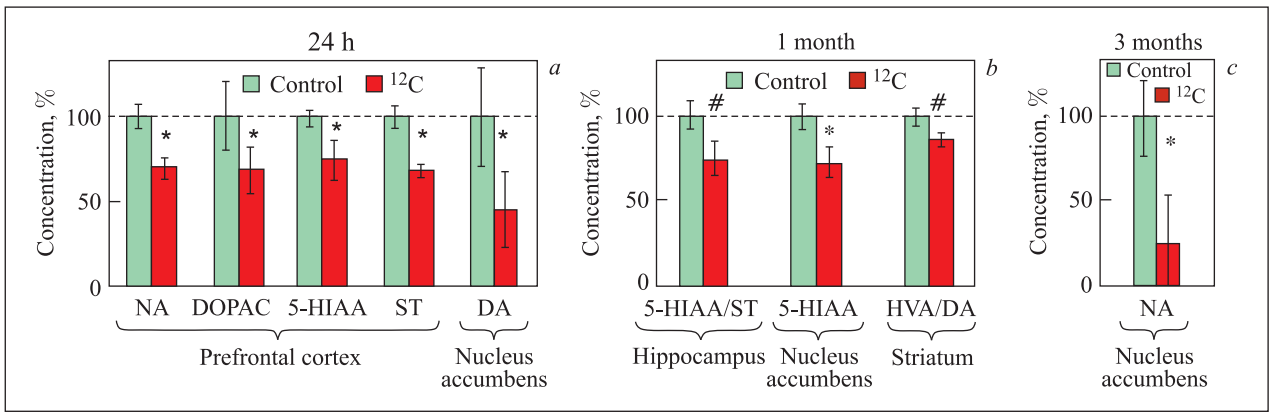


Fig. 4. A change in the level of monoamines and their metabolites in rat brain structures after exposure to ^{12}C ions ($\pm$SD; * $p \leqslant 0.05$; # $p \leqslant 0.1$): NA — noradrenaline, DA — dopamine, ST — serotonin, DOPAC — 3,4-dihydroxyphenylacetic acid, 5-HIAA — 5-hydroxyindoleacetic acid, HVA — homovanilic acid

Time after irradiation	Animal group	Body mass, g	Spleen mass, mg	Thymus mass, mg	BMC, $N \cdot 10^6$/thigh	NL, $N \cdot 10^9$/l	MI, %	NAM, %
43 h	Control	26.4 ± 1.5	126.8 ± 30.5	21.4 ± 9.0	49.4 ± 5.6	9.3 ± 2.0	2.5 ± 0.9	2.2 ± 3.2
	rMnSOD single dosing immediately after exposure	24.8 ± 1.3	29.0 ± 5.1	11.8 ± 1.3	22.9 ± 2.4	0.9 ± 0.3	1.3 ± 0.1	47.6 ± 2.8
	PS single dosing immediately after exposure	24.2 ± 1.5	31.8 ± 1.9	11.5 ± 1.0	24.2 ± 1.7	0.9 ± 0.3	1.3 ± 0.2	45.9 ± 8.1
7th day	rMnSOD single dosing immediately after exposure	24.6 ± 1.1	34.8 ± 3.1	14.8 ± 3.4	63.1 ± 1.0	4.5 ± 0.4	1.6 ± 0.3	26.7 ± 3.3
	PS single dosing immediately after exposure	24.8 ± 0.8	33.2 ± 9.5	11.7 ± 1.5	64.7 ± 4.9	6.1 ± 1.9	1.5 ± 0.2	22.7 ± 2.9
	Daily rMnSOD dosing	25.2 ± 1.9	62.2 ± 16.2	39.0 ± 18.1	79.5 ± 1.7	7.4 ± 0.4	1.5 ± 0.3	29.5 ± 4.8
	Daily PS dosing	24.6 ± 1.3	32.4 ± 3.4	13.0 ± 6.2	67.9 ± 2.6	5.3 ± 1.2	1.3 ± 0.2	29.4 ± 10.5

Note. Abbreviations: PS — physiological solution, BMC — bone marrow cellularity, NL — number of lymphocytes in peripheral blood, MI — mitotic index of bone marrow cells, NAM — number of aberrant mitoses in bone marrow cells.

and 153 keV/μm) was studied in V79 Chinese hamster cells. It was found that its manifestation depends on the duration of irradiated cell seeding (mutation expression time) in a selective nutrient medium with 6-thioguanine and on LET radiation. After four-day expression, the frequency of spontaneous and radiation-induced mutagenesis was about $1.2 \cdot 10^{-5}$. With increasing expression time, the mutagenesis level rose up to a maximum and then decreased to the spontaneous level. The location of this maximum depends on LET accelerated ion (Fig. 3). With increasing LET, the maximum shifts towards longer expression times. For example, the highest level of mutagenesis was observed 11 days after exposure to accelerated ^{18}O ions (LET $\sim$ 116 keV/μm) and 23 days after exposure to accelerated ^{20}Ne ions (LET $\sim$ 153 keV/μm). Based on earlier research, it is possible to assume that an increased level of radiation-induced mutagenesis is determined by higher chromosome instability of the irradiated cell population, and its manifestation at different expression times depends on initial damage severity [9].

Monoamine exchange was studied in different structures of the rat brain after accelerated heavy ion irradiation. For ^{12}C ions (LET $\sim$ 10 keV/μm), the most pronounced effects were observed in the 24-hour acute period after exposure. Induced lesions were repaired during the following three months (Fig. 4). At all times after irradiation, increased sensitivity of the nucleus accumbens was observed, which points to the important role of this brain structure in the radiation-induced disorder of cognitive functions and emotional-motivational states [10–12].

In cooperation with specialists of the National Institute of Cancer in Naples and the University of Udine, Italy, the initial stage of research on the radioprotective properties of a recombinant manganese superoxide dismutase (rMnSOD) was completed. In mice irradiated with protons at a sublethal dose, the bone marrow form of acute radiation sickness was initiated. Daily sixfold rMnSOD introduction after irradiation provided a statistically significant accelerated restoration of thymus and spleen mass and the amount of leukocytes in animals' peripheral blood on the seventh day after exposure (Table). These results indicate that rMnSOD has a therapeutic effect for acute radiation sickness at the level of a sublethal dose of proton irradiation [13, 14].

PHOTORADIOBIOLOGICAL RESEARCH

Total irradiation of mice with accelerated protons and γ rays at a dose of 14 Gy leads to no morphological or functional changes in the retina (Fig. 5).

In response to such an irradiation, DNA single- and double-strand breaks emerge in the retina; they are repaired during 24 h (Fig. 6). At the same

time, in response to retinal irradiation with accelerated protons at 14 Gy, P53 and ATM proteins are expressed, but they do not trigger the apoptosis mechanism. The results of this part of the study show that for ionizing radiation exposure, the *in vivo* retina has a genotoxic stability threshold of about 14 Gy; higher doses cause retinal degeneration and photoreceptor death. For mouse head irradiation with accelerated protons at 25 Gy, an irreversible decrease in retinal functional activity is observed. Nevertheless, the DNA breaks in the retina were fully repaired, which indicates that DNA damage repair is necessary but not sufficient for the recovery processes in the retina.

It was shown earlier that proton irradiation at 1 Gy decreases methylnitrosourea-induced death of photoreceptors and stimulates DNA double-strand break repair in the retina cells. This result was confirmed by a decrease in the apoptotic degradation of double-strand DNA in radiation-preconditioned retinal cells [15–17].

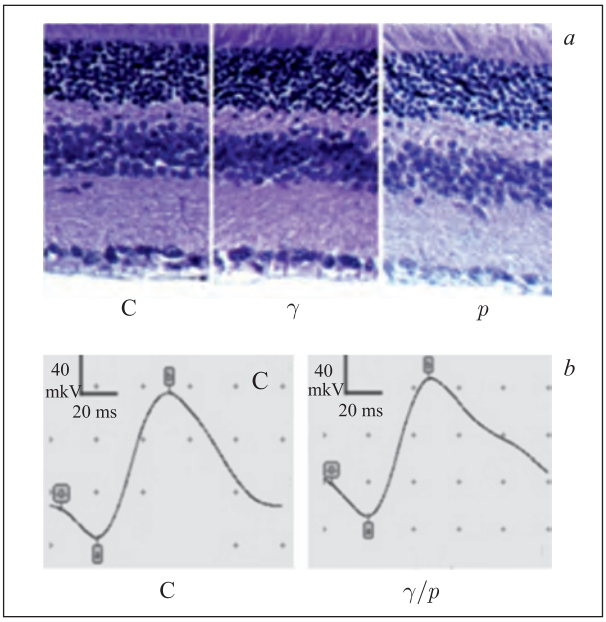


Fig. 5. Photomicrographs of mouse retina sections (*a*) and electroretinograms (*b*) after a total irradiation of mice with accelerated protons and γ rays at a dose of 14 Gy

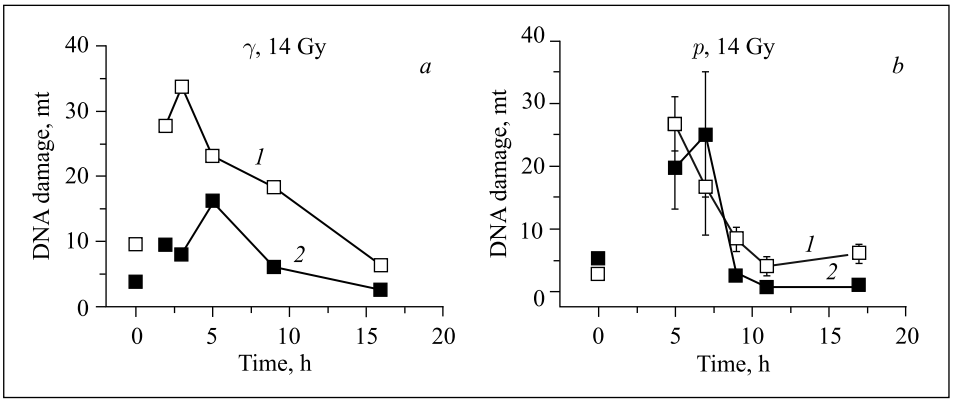


Fig. 6. Dynamics of single-strand (*1*) and double-strand (*2*) DNA break repair in the *in vivo* retina after mouse irradiation with γ rays (*a*) and protons (*b*) at 14 Gy

MATHEMATICAL MODELING OF RADIATION-INDUCED EFFECTS

A detailed mathematical model of the mutation process induced by ultraviolet (UV) radiation in repair-deficient *E. coli* cells was developed. Based on the model, an analysis of the regularities and mechanisms of the influence of defects in different genes on damage repair and the level of mutagenesis is possible (Fig. 7). The proposed theoretical model is the result of the generalization and formalization of a large amount of experimental data on repair systems in bacteria and induced mutagenesis. It can be used for predicting bacterial cell response to exposure to radiations with different physical characteristics [18].

A model was developed that describes the main repair mechanisms of DNA double-strand breaks (DSBs) induced by ionizing radiations of different quality. The proposed calculation approach allows reconstructing the kinetics of the formation and elimination of γ-H2AX

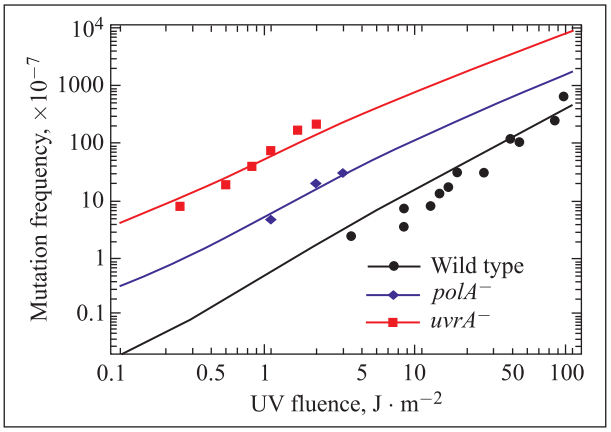


Fig. 7. The UV-induced mutation frequency in *E. coli* cells with defects in the excision repair system in the *uvrA* gene and *polA* genes. The calculation results (solid lines) are compared with experimental data (dots) (*Bates H. et al.* // J. Bacteriol. 1989. V. 171. P. 2480–2484; *Kato T. et al.* // Genetics. 1974. V. 87. P. 1–18)

foci, the level of which correlates with the amount of DNA DSBs in the cell. The model yields the main time characteristics of the repair of DSBs induced by radiations in a wide LET range: from ^{137}Cs γ rays to ^{56}Fe ions (Fig. 8, *a*). It is shown that the model can describe DNA DSB repair in cells with defects in the repair system (Fig. 8, *b*) [19, 20].

A research was conducted on the action of ionizing radiation on the space-time dynamics of a biophysical model of a neural network responsible for short-term capture of information on an object (Fig. 9). It was shown that the change in the properties of the synaptic receptors determined by the action of charged particles results in the loss of the stability of the specific activity patterns for an irradiation dose above a threshold. The proposed mathematical model can be used for a theoretical evaluation of the disorder of the cognitive functions caused by exposure to ionizing radiations of different quality — in particular, for solving problems in space radiobiology [21].

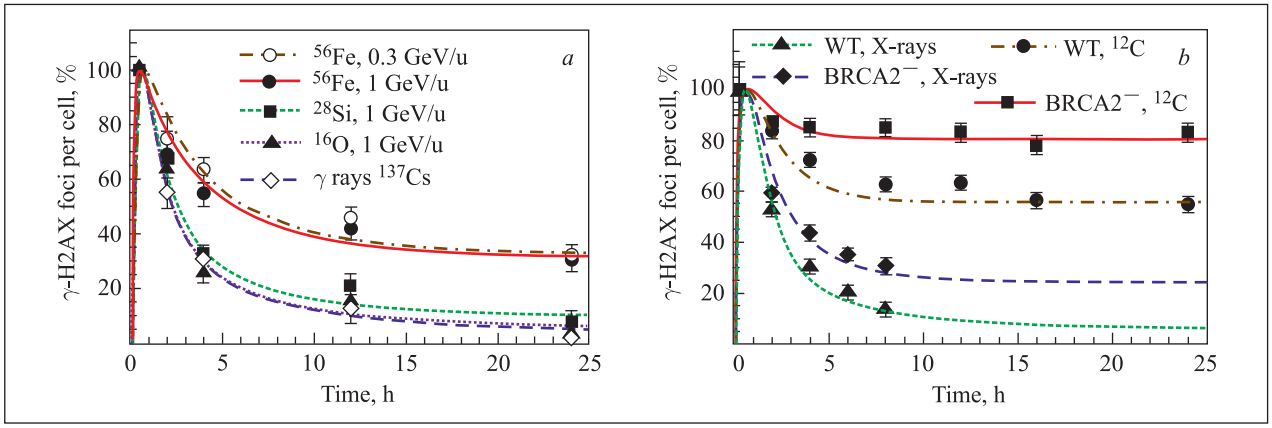


Fig. 8. *a*) The kinetics of the formation and elimination of radiation-induced γ-H2AX foci in human skin fibroblasts. *b*) A comparative estimation of γ-H2AX foci kinetics in wild-type (WT) cells and in cells that have defects in the DNA DSB repair system (BRCA2$^-$). The curves are the calculated results; the dots are experimental data (*Asaithamby A. et al.* // Rad. Res. 2008. V. 169(4). P. 437–446; *Shibata A. et al.* // EMBO J. 2011. V. 30. P. 1079–1092)

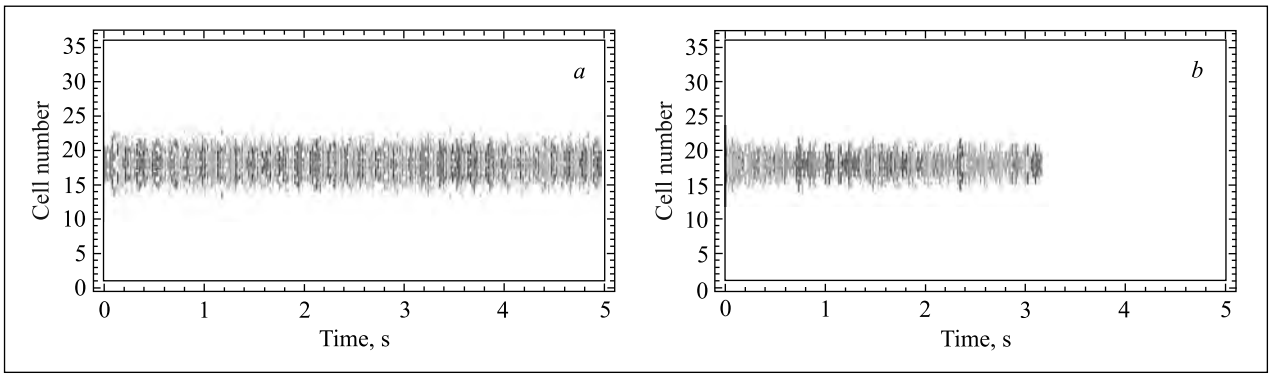


Fig. 9. A calculation of the space-time activity of a neural network part during short-term capture of information on an object in a control sample (*a*) and for an irradiation dose above a threshold (*b*)

In collaboration with specialists of Vinča Institute of Nuclear Sciences, Serbia, a model was developed of the nonlinear dynamics of the microtubules that are part of the nervous cells. A mathematical apparatus was developed for studying such systems. The main types of solutions describing the propagation of linear localized oscillations and structure transitions were obtained numerically and analytically. It was shown that signal attenuation does not obstruct information transfer on a mictrotubule length scale (Fig. 10). The results of the study allow clearing up the pattern of the mechanisms of signal transfer and molecule transport along microtubules during intracellular processes [22].

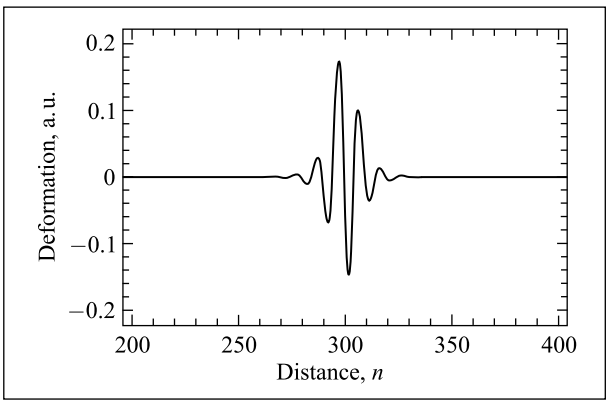


Fig. 10. A typical signal shape in a microtubule. The propagation distance is determined by the number n of structure subunits (tubulin dimers)

RADIATION PROTECTION PHYSICS AND RADIATION RESEARCH

At the Genome-M facility of the MC-400 cyclotron of the Flerov Laboratory of Nuclear Reactions (FLNR), a large number of biological samples were irradiated with 33 MeV/nucleon ^{11}B nuclei. Work is underway to improve the ion beam quality control system at the Genome-M facility — in particular, a two-dimensional $\Delta E/E$ heavy ion spectrometer is being created. Two sessions of biological sample irradiation were performed at the 170 MeV medical proton beam of the Phasotron of the Dzhelepov Laboratory of Nuclear Problems (DLNP).

As part of astrobiological research, two experiments on the irradiation of a formamide – cosmic dust mixture were performed: at a proton beam (LET ~ 0.6 keV/μm) of the Phasotron, DLNP, and at a ^{11}B ion beam (LET ~ 200 keV/μm) of the MC-400 cyclotron, FLNR; the absorbed doses were different. To study the elemental composition of the meteorites, a number of samples were subjected to neutron activation analysis at the REGATA facility of the IBR-2 pulsed reactor of the Frank Laboratory of Neutron Physics (FLNP). The irradiated meteorite samples are undergoing γ spectrometry analysis.

Based on the use of the Monte-Carlo radiation transport code MCNPX, work continued on predicting the radiation environment of the planned booster synchrotron of the NICA complex. The studies were concerned, in particular, with radiation monitoring adequacy with regard to the ambient neutron dose and the regulations on the effective neutron dose in the radiation fields of JINR's nuclear physics facilities [23].

Within the framework of collaboration with the Frank Laboratory of Neutron Physics and the Institute of Space Research of the Russian Academy of Sciences, a stand was constructed for environmental tests and calibration of instruments on planetary soil models. To lower the scattered neutron background, the stand was placed in an hangar at an open site near LRB's Building 72. The stand is designed for work with neutron generators and meets all radiation safety requirements: it has blocking systems, alarms, and an automated system of zonal neutron and γ-radiation monitoring. As the first dry soil model, a float glass pack with a total mass of about 25 t was used. To emulate subsurface ice, polyethylene layers were placed inside the glass pack. Currently tested at the stand are the DAN reference instrument, which is similar to the one on board of the Curiosity rover working on Mars, and the ADRON spectrometer for studying the elemental composition of Moon's surface.

RESEARCH ON COSMIC MATTER ON EARTH AND IN NEARBY SPACE

Research has been continued on the synthesis of chemical compounds from formamide NH_2COH (an HCN hydrolysis product) under exposure to radiations with different linear energy transfer. Synthesis reactions occurred under irradiation with accelerated protons and ^{11}B and ^{12}C ions in the presence of catalysts

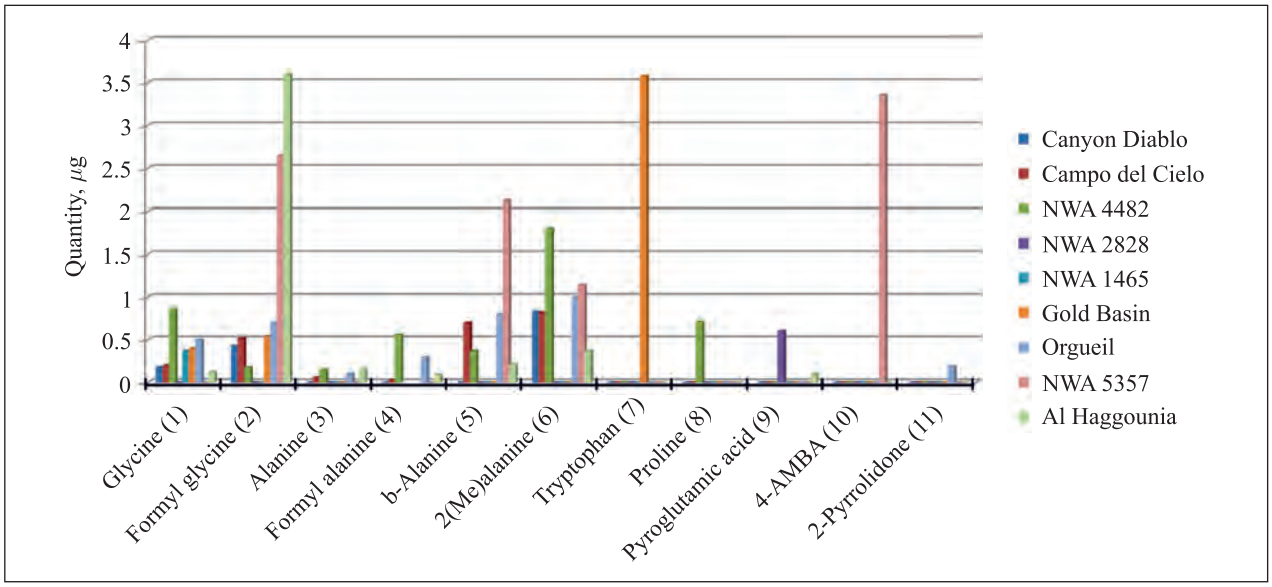


Fig. 11. Data on the production of amino acids

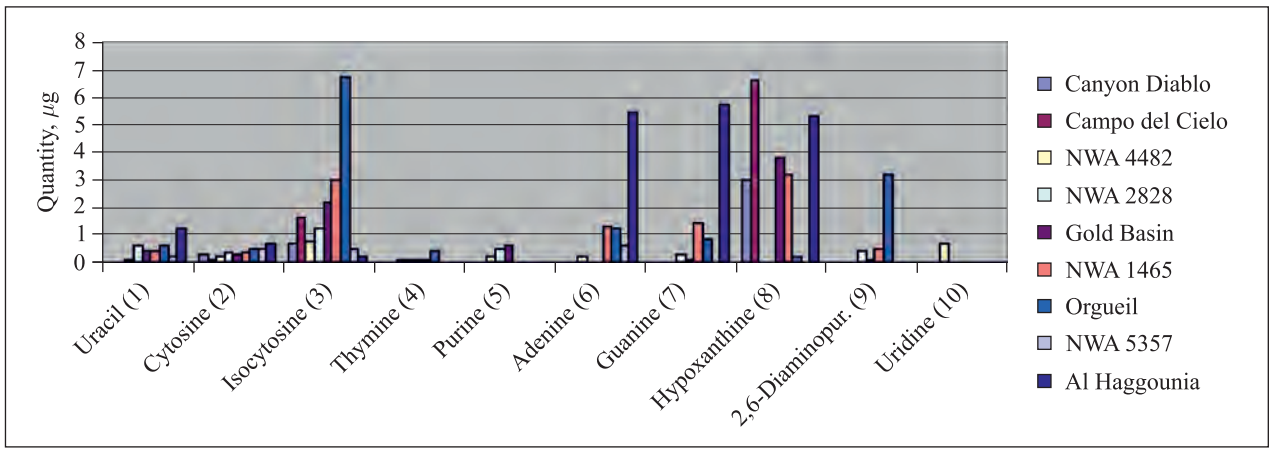


Fig. 12. Data on the production of nucleic bases and nucleosides

obtained from meteorites of different classes. Based on the performed experiments, a conclusion was made that in the system "formamide + meteorite matter + ionizing radiation" prebiotic compounds are produced in noticeable amounts up to nucleosides — the main RNA and DNA building blocks. Examples of all molecule classes necessary for the origination of life on Earth were produced: carboxylic acids, amino acids (Fig. 11), sugars, nucleic bases, nucleosides (Fig. 12), and other complex compounds [24, 25].

CONFERENCES AND EDUCATION

In 2014, LRB staff members participated in eight scientific conferences in Russia and five conferences abroad.

In cooperation with the Scientific Council on Astrobiology with the Presidium of the Russian Academy of Sciences (RAS), RAS Scientific Council on Radiobiology, RAS Scientific Council on Problems of Paleobiology and Organic World Evolution, RAS Institute of Biomedical Problems, RAS Borisyak Paleontological Institute, and Dubna International University of Nature,

Society, and Man, a two-day Conference "Topical Issues of General and Space Radiobiology and Astrobiology" was held in Dubna in memory of Academicians N. M. Sissakian and A. N. Sissakian. The Conference was concerned with the following issues of fundamental radiation biology, space radiobiology, and astrobiology: radiation-induced cytogenetic effects; regularities of DNA damage induction and repair; radiation and radiobiological aspects of long-term manned space flights; radiation safety of long-term manned space flights; high-energy heavy charged particle action on the structures and functions of the central nervous system; modeling the action of heavy charged particles of space origin on biological objects; biogeochemical studies of space dust; research on biofossils in meteorites and ancient terrestrial rocks; and cosmic matter research with nuclear physics methods.

The education process continued at the Department of Biophysics of Dubna University. Total enrollment in the Human and Environmental Radiation Safety specialty is 48 students and six postgraduates attend the Radiobiology specialty programme. In 2014, eight new students were accepted to the Department. Eight students successfully completed their education and received diplomas in engineering physics.

REFERENCES

1. *Ježková L. et al.* Function of Chromatin Structure and Dynamics in DNA Damage, Repair and Misrepair: γ Rays and Protons in Action // Appl. Radiat. Isot. 2014. V. 83. P. 128–136.
2. *Falk M. et al.* Primary and Secondary Clustering of DSB Repair Foci and Repair Kinetics Compared for γ Rays, Protons of Different Energies, and High-LET ^{20}Ne Ions // J. Radiat. Res. 2014. V. 55. P. i79–i80; DOI: 10.1093/jrr/rrt210.
3. *Falk M. et al.* Chromatin Differentiation of White Blood Cells Decreases DSB Damage Induction, Prevents Functional Assembly of Repair Foci, but Has No Influence on Protrusion of Heterochromatic DSBs into the Low-Dense Chromatin // J. Radiat. Res. (Impact Factor: 1.45). 03/2014. V. 55, Suppl. 1. P. i81–i82; DOI:10.1093/jrr/rrt194.
4. *Ježková L. et al.* Induction and Repair of Clustered DNA Double Strand Breaks in Human Fibroblasts after Irradiation with Boron Ions and γ Rays // The 60th Radiation Research Society Meeting. Sept. 21–24, 2014, Las Vegas, USA. Poster. Book of Abstracts. P. 379–380.
5. *Falk M. et al.* Heterochromatinization Associated with Cell Differentiation as a Model to Study DNA Double Strand Break Induction and Repair in the Context of Higher Order Chromatin Structure // Appl. Radiat. Isot. 2014. V. 83. P. 177–185.
6. *Falk M. et al.* Determining Omics Spatiotemporal Dimensions Using Exciting New Nanoscopy Techniques to Assess Complex Cell Responses to DNA Damage: Part A — Radiomics // Crit. Rev. in Eukaryotic Gene Expression. 2014. V. 24(3). P. 205–223.
7. *Falk M. et al.* Determining Omics Spatiotemporal Dimensions Using Exciting New Nanoscopy Techniques to Assess Complex Cell Responses to DNA Damage: Part B — Structuromics // Crit. Rev. in Eukaryotic Gene Expression (IF = 2.065). 2014. V. 24(3). P. 225–247.
8. *Rzyanina A. V. et al.* Radiosensitivity of CAL51 Human Breast Carcinoma Cells at Low Doses of γ Radiation and Its Modifications // Radiat. Biol. Radioecol. (in press) (in Russian).
9. *Blaha P. et al.* HPRT Mutant Induction in V79 Cells at Different Times after Heavy Ion Irradiation // The 60th Radiation Research Society Meeting. Sept. 21–24, 2014, Las Vegas, USA. Book of Abstracts. P. 153.
10. *Stemberg A. S. et al.* High-Energy Bragg Peak Proton Action on Rat Behavior and Monoamine Exchange in Some Brain Structures // Neurochem. J. 2015. V. 32, No. 1. P. 1–8.
11. *Belokopytova K. V. et al.* Distribution of Monoamines and Their Metabolites in Rat Brain Structures at Later Times after ^{12}C Ion Irradiation // Neurochem. J. 2015 (in press) (in Russian).
12. *Belokopytova K. et al.* Early and Long-Term Effects of Low- and High-LET Radiation on Rat Behavior and Monoamine Metabolism in Different Brain Regions // The 40th COSPAR Scientific Assembly. Aug. 2–10, 2014, Moscow. Book of Abstracts. P. F2.1-13-14.
13. *Ambesi-Impiombato F. S. et al.* Effect of Recombinant Manganese Superoxide Dismutase (rMnSOD) on the Hematologic Status in Mice Irradiated by Protons // Med. Radiol. Radiat. Safety. 2014. V. 59(6). P. 5–17.
14. *Ambesi-Impiombato F. S. et al.* // The 40th COSPAR Scientific Assembly. Aug. 2–10, 2014, Moscow. Book of Abstracts. P. F2.2-28-14.
15. *Vinogradova Yu. V. et al.* Damage and Functional Recovery of the Mouse Retina after Ionizing Radiation and Methylnitrosourea Exposure // Radiat. Biol. Radioecol. 2014. V. 54, No. 4. P. 385–392 (in Russian).
16. *Tronov V. A. et al.* Mouse Retinal Adaptive Response to Proton Irradiation: Correlation with DNA Repair and Photoreceptor Cell Death // Phys. Part. Nucl., Lett. 2015. V. 12, No. 1. P. 173–183.
17. *Tronov V. A. et al.* Radiation Preconditioning of the Mouse Retina *in vivo* Increases Its Resistance to a Subsequent Genotoxic Exposure and Stimulates Its Recovery // Cytology. 2015. V. 56, No. 2 (in press) (in Russian).

18. *Bugay A. N. et al.* Modeling Nucleotide Excision Repair and Its Impact on UV-Induced Mutagenesis during SOS-Response in Bacterial Cells // J. Theor. Biol. 2015. V. 364, No. 1. P. 7–20.
19. *Belov O. et al.* A Quantitative Model of the Major Pathways for Radiation-Induced DNA Double-Strand Break Repair // J. Theor. Biol. 2014. DOI: 10.1016/j.jtbi.2014.09.024. P. 1–16.
20. *Belov O. et al.* A Quantitative Model of the Major Pathways for Radiation-Induced DNA Double-Strand Break Repair. JINR Preprint E19-2014-39. Dubna, 2014. 32 p.
21. *Bugay A. N., Parkhomenko A. Yu.* Action of Ionizing Radiations on Signal Transport in the Nervous System // The 7th Congress on Radiation Research (Radiobiology, Radioecology, and Radiation Safety). Oct. 21–24, 2014, Moscow. Theses of Reports. P. 368 (in Russian).
22. *Zdravkovic S. et al.* Localized Modulated Waves in Microtubules // Chaos. 2014. V. 24, No. 2. P. 023139.
23. *Krylov A. et al.* GEANT4, MCNPX, and SHIELD Code Comparison Concerning Relativistic Heavy Ion Interaction with Matter // Phys. Part. Nucl., Lett. 2014. V. 11, No. 4.
24. Problems of Investigations of Cosmic Dust on Earth (for the Investigation Program) / Ed. N. G. Bochkarev; Comp. L. M. Gindilis, M. I. Kapralov. Dubna: JINR, 2014. 87 p.
25. *Saladino R. et al.* Meteorite-Catalyzed Syntheses of Nucleosides and of Other Compounds of Prebiotic Relevance from Formamide under Proton Irradiation // PNAS. 2015 (in press).

UNIVERSITY CENTRE

International Student Practices. Since the first International Student Practice in JINR Fields of Research held in 2004, this event has been attended by 1012 representatives of Belarus, Bulgaria, the Czech Republic, Egypt, France, Poland, Romania, Russia, Serbia, Slovakia, South Africa, Ukraine, and the USA (see Fig. 1).

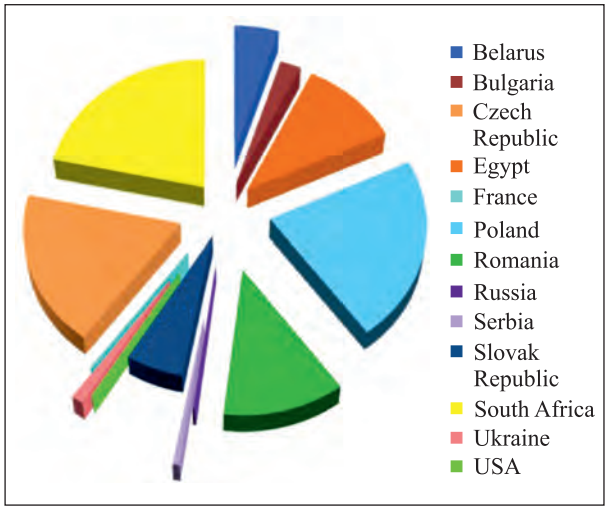


Fig. 1. The number of the International Practice participants by countries (2004–2014)

The annual Student Practice in JINR Fields of Research 2014 was held in three stages.

On 18 May – 8 June, 24 students from Egypt participated in the first stage. The second stage (6–27 July) was attended by 70 students from Bulgaria, the Czech Republic, Poland, Romania, and Slovakia. The participants in the final third stage (7–28 September) were 46 students from Belarus, Serbia, and South Africa.

Apart from introductory lectures and visits to the Institute basic facilities, the Practice participants worked on the education-and-research projects in JINR laboratories (see Fig. 2). All of the students have access to the description of the education-and-research projects on the UC website. Currently, the project database comprises 55 projects, 23 of which have been prepared by FLNR specialists.

The report-presentations of the students on the executed projects are available on the UC website.

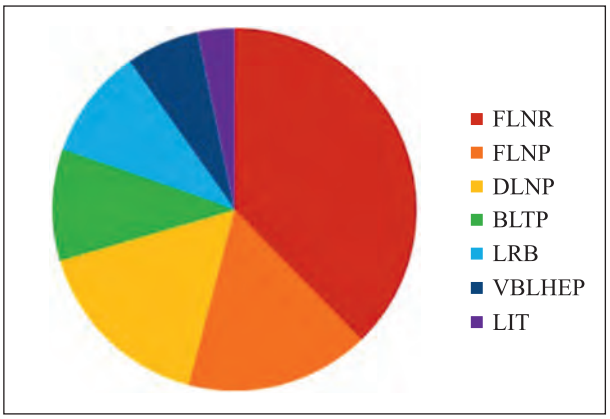


Fig. 2. The database of the education-and-research projects for the participants in the Practice 2014

JINR-Based Educational Process. In 2014, the University Centre trained 422 under- and postgraduate students from the basic departments of MSU, MIPT, MIREA, Dubna University, and JINR Member-State universities.

The summer training courses were attended by 27 students from Belarus National University of Informatics and Radioelectronics, Voronezh State University, Kazan National Research Technological University, Moscow State University, Moscow Power Engineering Institute, Smolensk State University, Tomsk Polytechnic University.

The UC website (http://uc.jinr.ru) training course database has 77 courses in the sections: Particle Physics and Quantum Field Theory, Nuclear Physics, Condensed Matter, Physics of Nanostructures and Neutron Physics, Physics Research Facilities, Information Technologies, Mathematical and Statistical Physics.

JINR Postgraduate Courses. In 2014, JINR PhD courses were attended by 37 students from Armenia, Belarus, Germany, Kazakhstan, Russia. The specialties were distributed as follows: Theoretical Physics — 14 people, Nuclear and Elementary Particle Physics — 9 people, Mathematical Simulation and Numerical

Methods — 6 people. Postgraduate students were supervised by 14 researchers from BLTP, 8 — from VBLHEP, 7 — from LIT, 3 — from FLNR, 3 — from DLNP, and 2 — by researchers from FLNP. Three postgraduate students presented their PhD theses.

New Student Programmes. In 2014, JINR launched a new Summer Student Programme. In developing the Programme, similar experience of running this type of programmes at CERN was taken into account. Participants in the Programme were selected by the Institute researchers on a competitive basis. In 2014, thirty applications for participation were received from nine Member States. Eight undergraduate and postgraduate students from Russia, the Czech Republic, Cuba, Egypt, and Poland were selected. The Programme participants did their research projects in VBLHEP, LIT and DLNP for 6–8 weeks, from June to September. The reports of the students on their work are available on the Programme website at students.jinr.ru.

To enhance cooperation between JINR and the Czech Republic, in the autumn of 2014, a Programme was launched that allows undergraduate and postgraduate students to participate in fundamental and applied research in scientific centres of the Czech Republic.

Organization of Scientific Schools for Teachers of Physics at JINR and CERN. The UC, in collaboration with CERN, continues organizing international scientific schools for teachers of physics from the Member States both at JINR and CERN. The information on organization and running of Schools is available on a dedicated website "Virtual Academy of High Energy Physics" (http://teachers.jinr.ru/).

On 23–27 June, the School at JINR was run for 26 teachers of physics from Russia, Belarus and Bulgaria, and their 12 students. At the initiative of the Moscow Teachers Centre, on 30 June, a dedicated programme for 20 teachers of physics from Moscow was organized.

The School programme traditionally included lectures by the leading JINR specialists on contemporary research, visits to JINR experimental facilities and laboratories. In the School framework, a conference for the teachers was envisaged. At this conference, the teachers could share their teaching experience with the colleagues, while the students attended the UC physical hands-on lab. During a videoconference with CERN, the teachers could ask questions on CERN activities and be introduced to a dedicated programme for teachers run at CERN.

On 2–8 November, 42 teachers of physics from Russia, Armenia, Belarus, Kazakhstan, and Ukraine participated in the School at CERN. The lectures were delivered by the employees of the leading scientific centres from the JINR Member States working at CERN.

Physics Workshop "The 105th Element" of the Independent Educational Project "Summer School". On 21 July – 3 August, 25 students specializing in natural sciences and engineering participated in the Physics Workshop "The 105th Element" of the independent educational project "Summer School" (http://letnyayashkola.org/) held in Dubna and hosted by the JINR recreation centre "Volga". The programme of the Workshop included lectures and visits, as well as hands-on activities. The lectures covered a wide range of problems in nuclear physics, elementary particle physics and relativistic heavy-ion physics, neutrino physics and cosmology, condensed matter, biophysics and radiobiology. The participants visited the JINR basic facilities, performed hands-on activities, and participated in a videoconference with CERN. On the basis of the Workshop results, the participants presented their reports at the general scientific seminar of the School.

International Scientific-and-Practical Conference "Flerov Readings 2014". At the beginning of January 2014, an International Scientific-and-Practical Conference "Flerov Readings 2014" was organized for school and first-year university students. The organizers are JINR, independent educational project "Summer School", Dubna Lyceum No. 6.

"Physics Day" in Dubna. On 25–29 March, Dubna hosted a number of events for children and adults united under the name of "Physics Day". The events were organized by the JINR UC, Museum of the History of Science and Technology of JINR, Library named after D. I. Blokhintsev and Interschool Mathematics and Physics Extracurricular Course. The programme included popular science lectures, guided tours, demonstrations of physics experiments, team contest "Quantum Marathon" and natural science games for school students "Brownian Motion".

Video Conferences. The JINR University Centre continues organizing and providing assistance in the running of video conferences. Live video is provided through a video-conferencing management system of JINR, where using the UC duplex access point one can take part in a meeting, ask questions and speak in a debate.

In 2014, the following video conferences were held:

— video broadcast of the scientific session of RAS LPI Physical Sciences Division "Physics at the Large Hadron Collider. Higgs boson";

— video conference with CERN "Research in the Field of High Energy Physics" for the participants of the Children's Festival of Science in the Moscow Palace of Pioneers on the Sparrow Hills;

— video meetings in the framework of the joint seminar "Physics at the LHC" organized in cooperation of the Russian institutes and JINR Member States in the experiment "Compact Muon Solenoid";

— video session of the Joint Committee on the RSA–JINR Cooperation linking Cape Town and Dubna;

— video conference between JINR and Samara State University. Organizers — JINR Association of Young Scientists and Specialists and SSU.

Organization of Visits. In 2014, tours, video conferences and hands-on activities for students from Dubna (91), Likino-Dulevo (40), Moscow (243), Novgorod (15), Petrozavodsk (18), schools of Stavropol Territory (17), school of Taldom district (30), Tver (15), Yaroslavl (54), as well as for 20 members of the physics group of J. Kennedy school (Berlin, Germany) were organized in the UC physical laboratory.

Traditionally, the UC maintains solid relations with Polish educational institutions. In 2014, training and orientation programmes were organized for 11 students from Lublin, 26 students from Warsaw, and for 18 students and teachers from Torun. For a week, the guests listened to lectures on the research conducted in JINR laboratories. They also visited the Institute basic facilities.

Work with Schoolchildren and Teachers. During the academic year, classes of physics were organized for 25 high-school students from Dubna twice a week. They included lectures, laboratory work and physics demonstrations performed in the UC physical laboratory.

Structural Changes. In 2014, two new departments were established under the JINR University Centre: Engineering Research Team and Department of Development and Implementation of Educational Programmes.

Engineering Research Team was established upon the recommendation given at the spring session of the Committee of Plenipotentiaries held on 25–26 March, 2014. Its main task is implementation of modern educational programmes on training of scientists and engineers for research centres of the Member States and JINR. The Team's activity is aimed at expanding the range of educational programmes of the UC and the universities collaborating with the UC in matters concerning new educational and practical training. Another task of the Team is to provide assistance in preparation of bachelor's, master's and PhD projects in design, development and operation of electrophysical facilities.

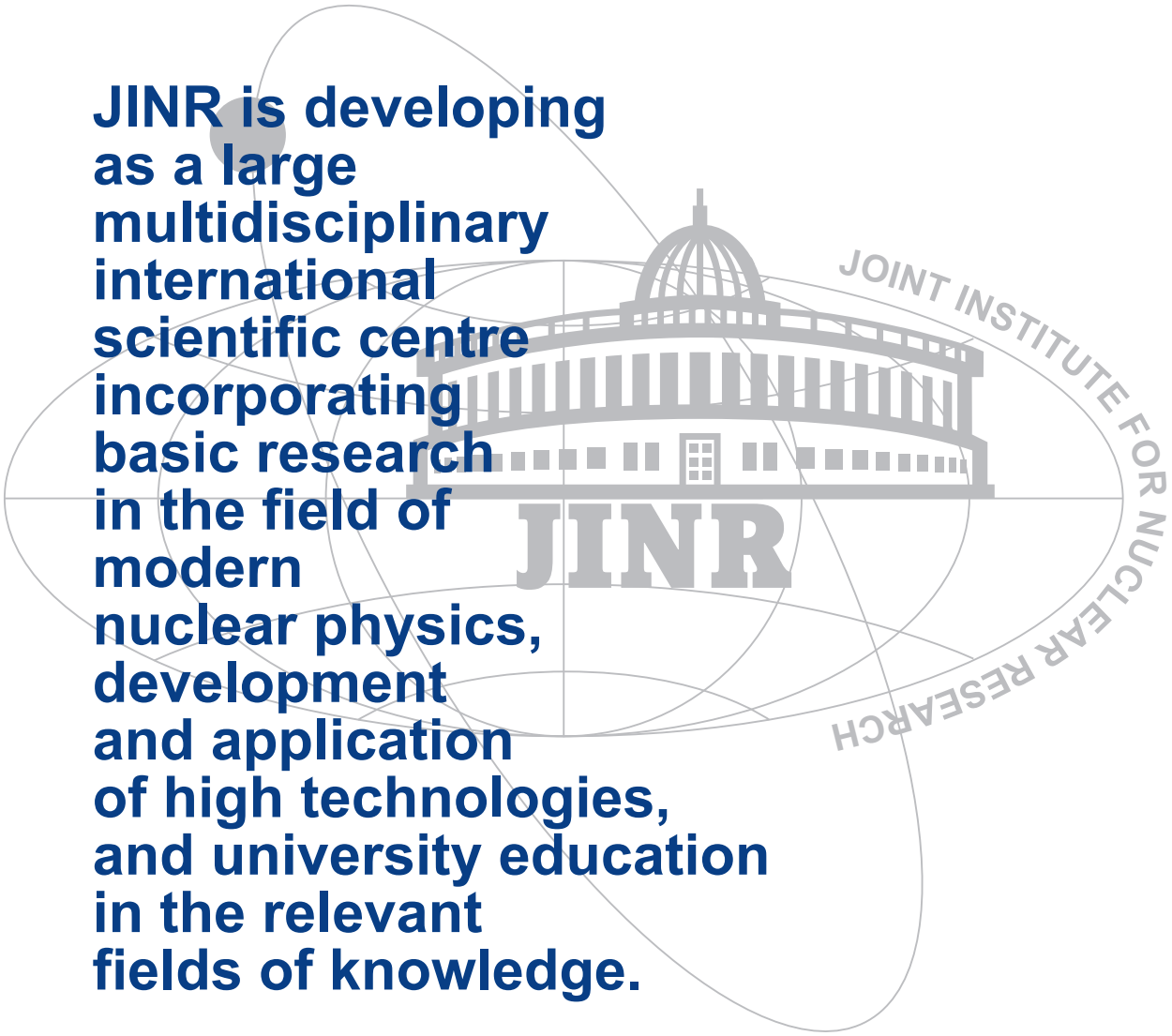
The main task of the Department of Development and Implementation of Educational Programmes is to popularize the achievements of contemporary science and technology, to include modern scientific data in the educational process, to create virtual online laboratory works on the basis of information and communication technologies using contemporary scientific equipment and data from modern physical facilities. The Department provides development and improvement of scientific and information support of JINR, participation in international projects with the JINR Member States, BNL (USA) and CERN on development of scientific educational programmes for school and university students based on modern computer technologies.

On Training and Retraining of Workers, Engineers and Employees. Sixty staff members of the Institute were trained at the training courses for personnel maintaining facilities subordinate to Rostechnadzor.

In 2014, twelve members of the Institute improved their skills at various seminars organized by academic institutions of Moscow; 45 staff members of JINR were trained at the courses organized by JINR and certified by JINR Central Certification Commission. In 2014, certification by the Territory Certification Commission of Rostechnadzor of 12 Institute executives and specialists in the normative legal acts and normative-technical documents stating requirements for industrial safety in various fields of supervision was organized. In 2014, six students from Moscow Region Industrial-Economic and Agrarian-Technological Colleges were trained at JINR.

The UC continues to run English and French language courses for postgraduate students and JINR staff-members, and a Russian language course for foreign specialists.

JINR is developing as a large multidisciplinary international scientific centre incorporating basic research in the field of modern nuclear physics, development and application of high technologies, and university education in the relevant fields of knowledge.



The Bogoliubov Laboratory of Theoretical Physics, 14–19 July. The Workshop on Physics of Strongly Interacting Systems

The Bogoliubov Laboratory of Theoretical Physics, 24–28 February. The 18th International Scientific Conference of Young Scientists and Specialists of JINR, dedicated to the 105th anniversary of N. Bogoliubov's birth

3–8 February. The 12th winter school on theoretical physics
“Few-Body Systems: Theory and Applications”

The Bogoliubov Laboratory of Theoretical Physics, 25 August – 5 September.
The Helmholtz international summer school “Lattice QCD, Hadron Structure and Hadronic Matter”

The Bogoliubov Laboratory of Theoretical Physics, 21 July – 1 August.
Participants of the Helmholtz international summer school “Nuclear Theory and Astrophysical Applications”

The Veksler and Baldin Laboratory of High Energy Physics, January.
The technological site for the construction of the NICA collider

The Veksler and Baldin Laboratory of High Energy Physics, 10–15 November.
Participants of the international symposium “70th Anniversary of the Discovery of the Phase-Stability Principle”

The Veksler and Baldin Laboratory of High Energy Physics, May. A production line of the tube superconducting cable

The Veksler and Baldin Laboratory of High Energy Physics.
Tests for the pre-production booster dipole magnet. Measurement of the magnetic field

The Veksler and Baldin Laboratory of High Energy Physics, December.
The construction site for the NICA complex. The pile pressing machine at work

Dubna, 7–11 April. Participants of the meeting of the NA61/NA49 collaboration

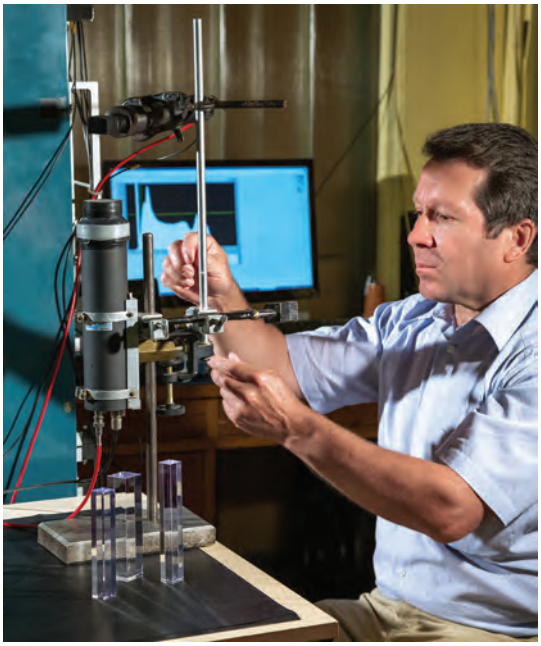
Dubna, 16 September.
A delegation of Indian representatives of science and business on a visit to Dubna

Dubna, 17–23 September.
A delegation of young scientists from scientific institutions of Armenia, Azerbaijan, Belarus, Kazakhstan, and Moldova at the monument to V. Veksler during their visit to JINR

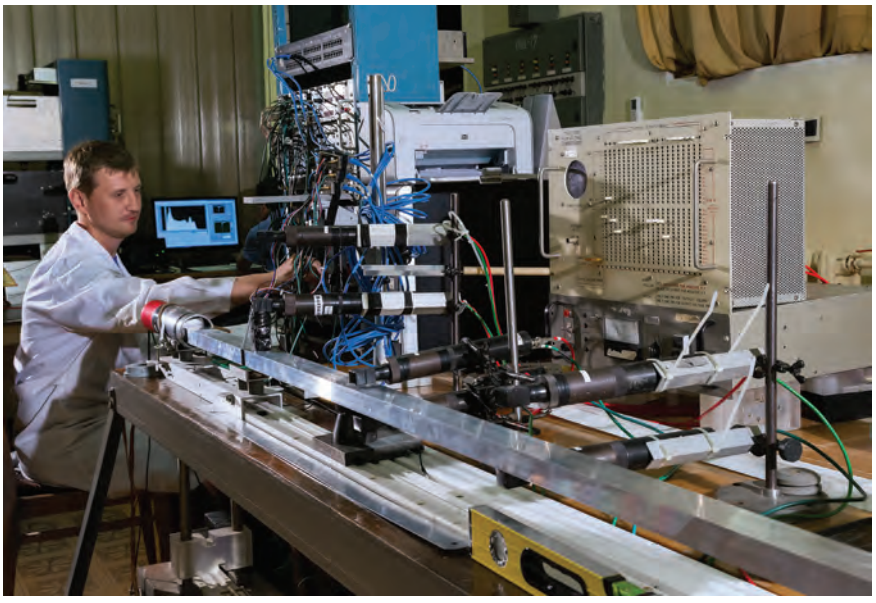
The Dzhelepov Laboratory of Nuclear Problems. From right to left: Laboratory Director V. Bednyakov, work coordinator Professor Yu. Budagov, and the recipients of the ATLAS Prize N. Azaryan and M. Lyablin

Dubna, 19–21 May. Participants of the international meeting of the OPERA collaboration at the monument to B. Pontecorvo and V. Dzhelepov

Dubna, 8–10 September. The 25th meeting of the A2 collaboration



The Dzhelepov Laboratory of Nuclear Problems.
An experimental test stand for studies of the properties
of scintillation crystals

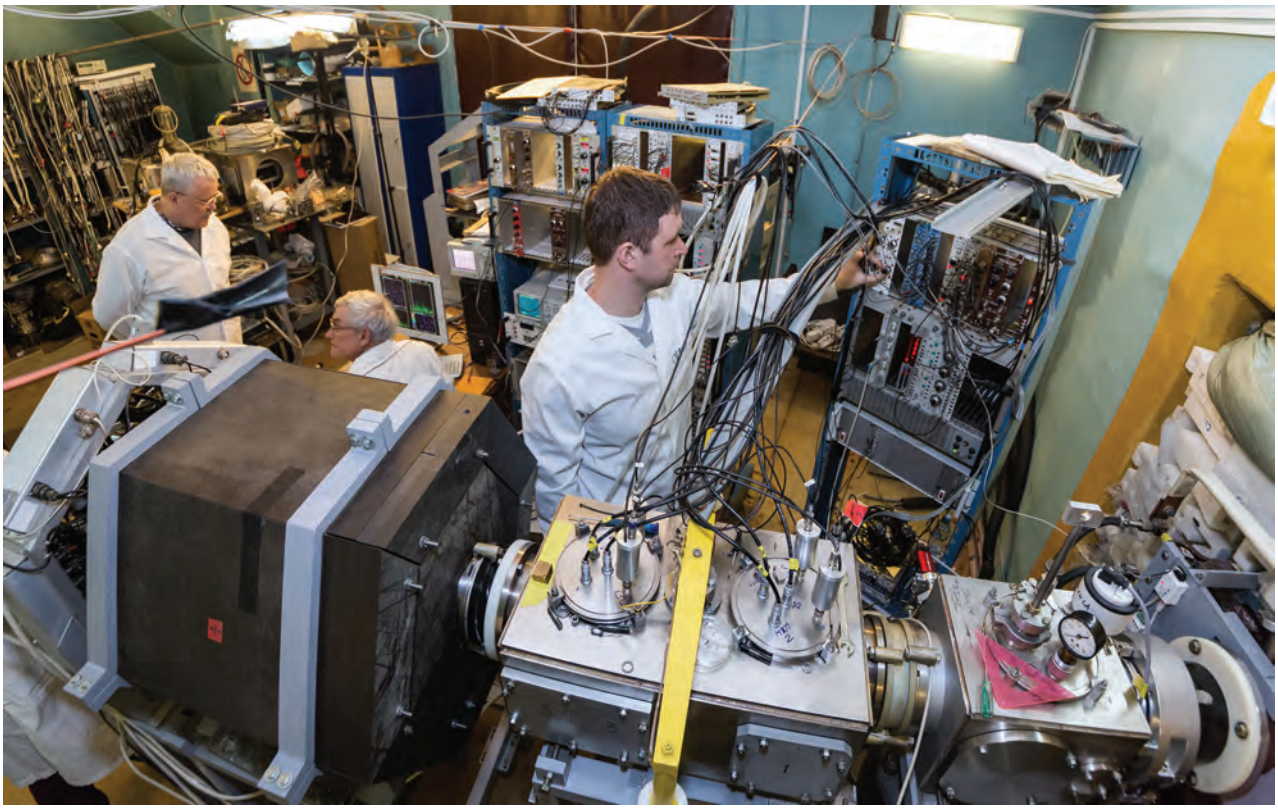


The Dzhelepov Laboratory
of Nuclear Problems.
An experimental test stand for studies
of the properties
of plastic scintillation strips

The building site for the future factory of superheavy elements

The Flerov Laboratory of Nuclear Reactions, December.
Participants of the assembling of the ACCULINNA-2 separator equipment delivered from France

The Flerov Laboratory of Nuclear Reactions, April. The VASSILISSA set-up.
The kinematic separator of heavy-ion reaction products



Dubna, 27 March. Participants of the strategic meeting on the development of RSA–JINR cooperation on an excursion at the Flerov Laboratory of Nuclear Reactions

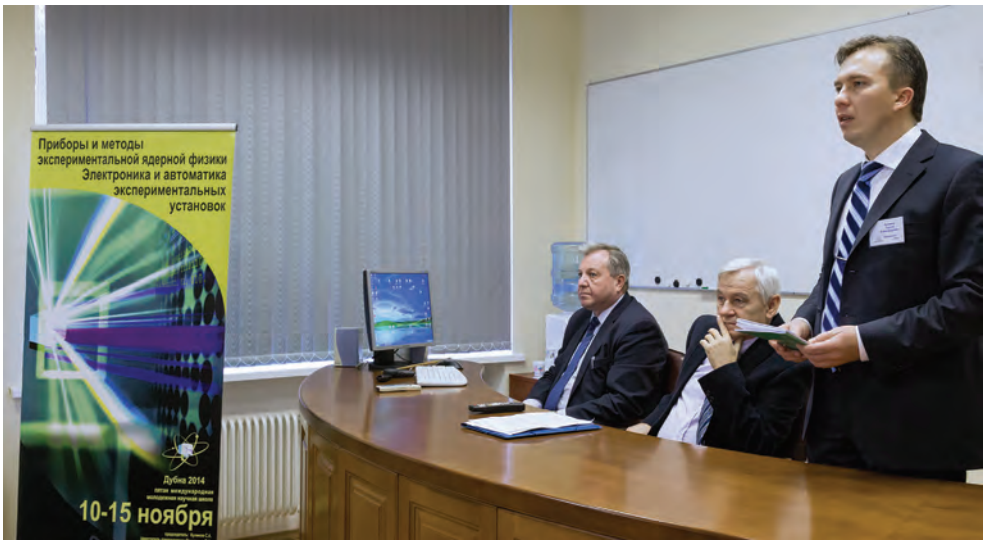
Dubna, 9–10 October. A delegation from the Academy of Sciences and Technology of Vietnam at the Flerov Laboratory of Nuclear Reactions during their visit to JINR

The Frank Laboratory of Neutron Physics.
The test stand of the cryogenic neutron moderator of the IBR-2 reactor

Dubna, 24 June. Participants of the international conference “Condensed Matter Studies at the IBR-2 Reactor”

The Frank Laboratory of Neutron Physics.
Adjustment of the equipment
at the EPSILON experimental set-up

The Frank Laboratory of Neutron Physics, June.
The cryostat of the KOLHIDA set-up.
The assembling of sensors for measuring ultralow temperatures



The Frank Laboratory of Neutron Physics, 10–15 November. The 5th international school
“Instruments and Methods of Experimental Nuclear Physics. Electronics and Automatics of Experimental Facilities”

The Laboratory of Information Technologies.
The JINR Central Information Computing Complex

Dubna, 25 – 29 August.
International conference for young scientists
“Modern Problems of Applied Mathematics
and Computer Science”

The Laboratory of Information Technologies, 30 June – 5 July. Participants of the 6th international conference "Distributed Computing and Grid-Technologies in Science and Education"

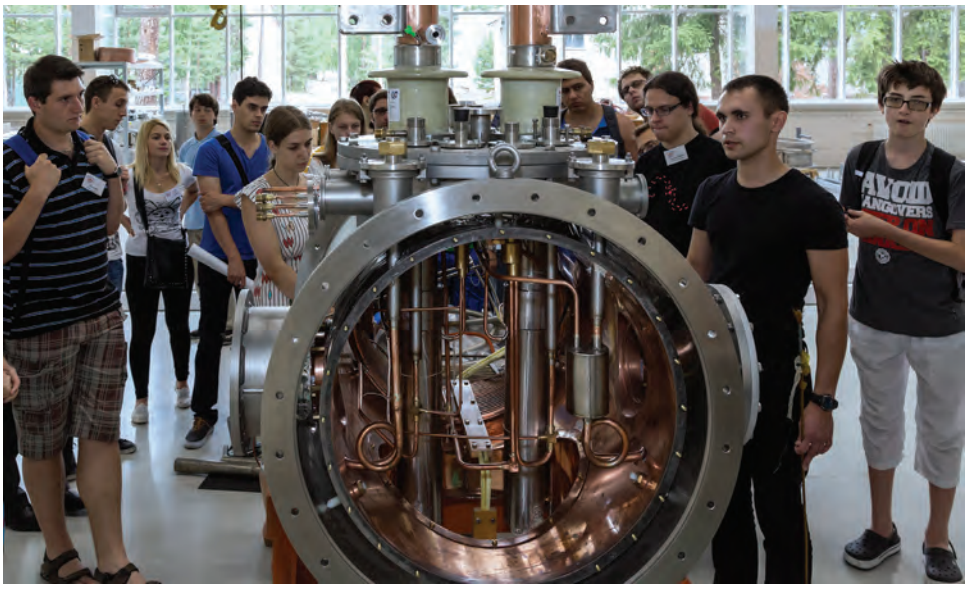
The Laboratory of Information Technologies, 13–16 October. Participants of the all-Russian scientific conference "Digital Libraries: Advanced Methods and Technologies, Digital Collections" (RCDL-2014)

Moscow, 19 February.
Press conference
“Space as the Origin of Life”
at the Embassy of Italy

Dubna, 28–29 October. A round-table meeting “Topical Issues of General and Space Radiobiology and Astrobiology”

Dubna, 18 May – 8 June. The first stage of the international student practice for students from the Arab Republic of Egypt

Dubna, 7–28 September. Participants of the third stage of the student practice of JINR — the students from the Republic of South Africa

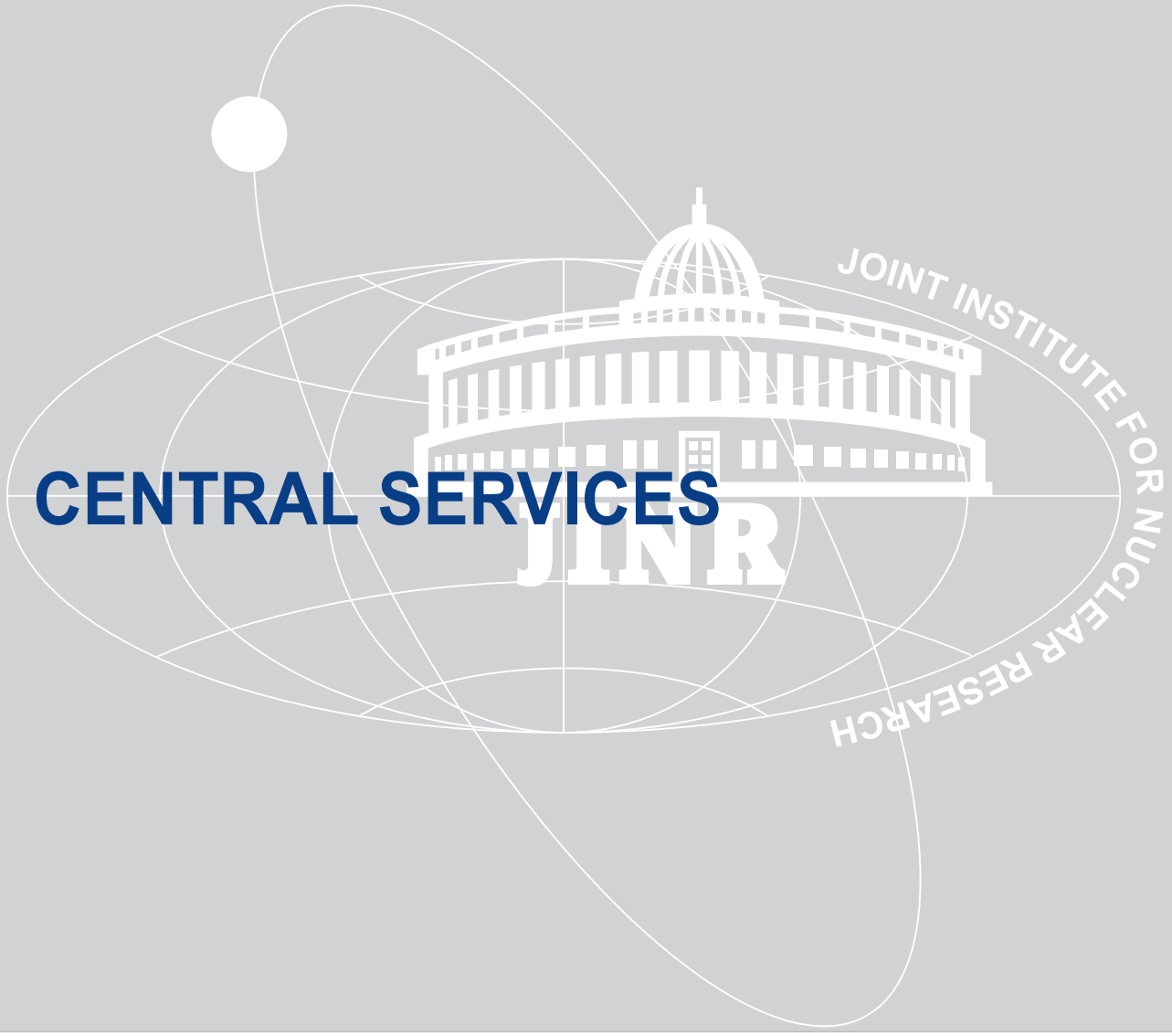


Dubna, 6–27 July. Students from Bulgaria, the Czech Republic, Poland, Romania, and Slovakia — participants of the international student practice — on an excursion to VBLHEP, JINR

Dubna, 24 March. A meeting of the working group on discussion of the development trends for the educational programme of JINR participated by representatives of Armenia, Belarus, Bulgaria, the Czech Republic, Georgia, Kazakhstan, Poland, Romania, Russia, and Slovakia

CERN (Geneva), 2–8 November. The School for Teachers of Physics from JINR Member States (*UC photo*)

2014



CENTRAL SERVICES

PUBLISHING DEPARTMENT

In 2014, the Publishing Department issued 105 publications and 53 official documents.

A total of 29 collections of report theses, proceedings of various conferences, schools, and workshops organized by JINR, monographs, booklets, and other editions were published. Among them are: the collection of abstracts of XXII international Baldin seminar on high-energy physics problems "Relativistic Nuclear Physics and Quantum Chromodynamics" (Dubna, 15–20 September 2014), the Proceedings of XXI International Seminar on Interaction of Neutrons with Nuclei (ISINN-21) (Alushta, Ukraine, 20–25 May 2013), the Proceedings of the international meeting "Relativistic Nuclear Physics: From Hundreds of MeV to TeV" (Stara Lesna, Slovakia, 16–20 June 2014), the Proceedings of XVI all-Russian scientific conference "Digital Libraries: Advanced Methods and Technologies, Digital Collections" (RCDL-2014) (Dubna, 12–18 October), and others.

The JINR Annual Report of 2013 (in Russian and English), the Scientific Report of the Laboratory of Information Technologies of 2012–2013, and the Annual Report of the Frank Laboratory of Neutron Physics of 2013 were issued.

In 2014, a second edition of the book by Yu. Akimov "Photon Methods of Radiation Registration" was issued, revised and enlarged. The book considers properties and applications of scintillation and Cherenkov detectors in fundamental and applied research, as well as the latest achievements in this field.

A book "To the 70th Anniversary of the Birth of A. Sissakian: Memoirs" was published. It is dedicated to Academician Alexei Sissakian, a famous scientist, JINR director in 2005–2010. His colleagues' memoirs are accompanied with photographs and selected poems by A. Sissakian.

The book by G. Kozlov, V. Matveev, and V. Savrin "On the Benefits of Participation in Programmes in Elementary Particle Physics at High Energies" gives the arguments in favour of new opportunities that science, education, industry, technological and informational infrastructure, and economy of Russia will gain from the involvement of Russian physicists in world programmes in elementary particle physics at high energies.

A book "History of the Development of the JINR Synchrocyclotron (in Documents and Reminiscences)" under the general editorship of N. Russakovich was published. The book contains true-to-fact information on the scientific significance of the synchrocyclotron, its design and stages of its development, and first results of operation.

In 2014, six issues of the journal "Physics of Elementary Particles and Atomic Nuclei" ("Particles and Nuclei" for short) that include 33 reviews were published. Issue 1 contains 114 reports made at the 20th International Symposium on Spin Physics (SPIN-2012) (Dubna, 17–22 September 2012).

Seven issues of the journal "Physics of Elementary Particles and Atomic Nuclei, Letters" were published. These include 157 papers. Issue 1 contains the Proceedings of V Cherenkov Readings "New Methods in Experimental Nuclear Physics and Particle Physics" (Moscow, 10 April 2012); issue 5 — the Proceedings of X international seminar in memory of V. Sarantsev "Charged Particle Accelerators: Electron–Positron Colliders" (Alushta, 3–7 September 2013); issue 7 — the Proceedings of the international meeting "Symmetries and Quantum Symmetries" (SQS'2013) (Dubna, 29 July – 3 August 2013).

The bulletin "JINR News" was continued to be published in Russian and English.

Fifty issues of the JINR weekly newspaper "Dubna: Science, Cooperation, Progress" were published in 2014.

In the series of the JINR UC study guides, a book "Techniques of Intellectual Calculations. Soft and Non-integral Calculations in Intellectual Management" by S. Ulianov and G. Reshetnikov was issued.

In the framework of exchange of scientific publications, the following JINR publications were forwarded

to organizations that cooperate with JINR (in over 40 countries of the world): JINR preprints and communications, the information bulletin "JINR News", JINR Annual Reports, and the journals "Particles and Nuclei" and "Particles and Nuclei, Letters".

The Publishing Department forwarded over 110 papers and reports on the results of research conducted by JINR scientists to the editorial boards of journals, to various conferences, symposia, meetings, and schools held both in JINR Member States and in other countries. Papers by JINR staff members were published in the journals "Nuclear Physics", "Theoretical and Mathematical Physics", "Instruments and Experimental Techniques", "Radiation Biology. Radioecology", "Crystallography", "Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques", "Journal of Physics", "Nuclear Instruments and Methods", and other periodicals.

To keep readers of the Science and Technology Library (STL) timely informed about new publications received, express bulletins of STL and the Licensing and Intellectual Property Department are issued by the Publishing Department. "The Bibliographic Index of Papers Published by JINR Staff Members in 2013" was issued.

The Publishing Department fulfilled numerous orders of the laboratories to produce posters, Xerox copies, and book binding. Over 170 thousand various forms were printed.

SCIENCE AND TECHNOLOGY LIBRARY

In 2014, the JINR Science and Technology Library (STL) rendered services to 3680 readers. 11 000 copies of publications were given out. As of 1 January 2015, the Library stock amounted to 435 620 copies, 190 988 of them being in foreign languages. 334 publications ordered by readers were received via the interlibrary loan system. On the whole, the Library received 2977 copies of books, periodicals, preprints, and theses from all compiling sources, including 1334 publications in foreign languages. All the new publications were registered in the central catalogues, branch catalogues, and in the Liber information system.

The weekly express bulletins "Books", "Articles", and "Preprints" (156 issues) were published, including 11 539 titles. Electronic versions of the bulletins are distributed among 100 addresses via e-mail. Subscription is available via the STL website in the section "Services". The exhibitions of new acquisitions of books, preprints, periodicals, and theses were arranged weekly. They displayed 2510 publications. Five topical exhibitions were organized.

The electronic catalogues of books, journals, articles, preprints, and theses are available online at http://lib.jinr.ru/cat.htm. The total number of requests to the electronic catalogues was 11 000. The service of online ordering of literature via OPAC (Online Public Access Catalogue) continues to be available for our users.

"The Bibliographic Index of Papers Published by JINR Staff Members in 2013" (1584 titles) was prepared by the JINR Science and Technology Library and published by the JINR Publishing Department. The Index is available on the STL website, in the section "Services". The database of papers of JINR scientists is Internet accessible.

1143 JINR preprints and communications published in 1985–86 have been scanned and added to the electronic catalogue.

The STL received 150 titles of periodicals. Due to the Library subscription to the foreign journals, JINR scientists have access to full text online versions of these journals.

The Scientific Electronic Library is used by the readers very actively. The total number of requests to the journal online versions through the Scientific Electronic Library and sites of foreign publishing houses was 150 000.

Due to the Library participation in the RFBR and NEICON Consortia, JINR scientists are provided with the electronic access to the full text versions of journals of the publishing houses Elsevier, Springer, and Nature Publishing Group, of the American Physical Society, American Institute of Physics, as well as to the journal "Science" and information retrieval databases "Web of Science" and "MathSciNet".

Within the framework of the project "History of JINR and Dubna in Books, Journals, and Central Newspapers", 60 new bibliographic records have been introduced.

In 2014, in exchange for JINR publications printed by the JINR Publishing Department, the Library received 527 publications from 20 countries. Of them 107 issues were from Russia, 10 from Romania, 18 from Ukraine, 238 from Germany, 4 from Italy, 5 from the USA, 10 from France, 53 from Japan, and 32 from CERN.

In 2014, within the framework of the Liber information system database, the input of documents to electronic catalogue was for: books — 1410 titles, journals — 1486 numbers, preprints — 1264 titles, theses and author's abstracts — 112 titles, book articles — 404 titles, and journal articles — 7932 titles.

In October 2014, the Liber automated library-information system was upgraded to its new version, Absotheque.

As of 01.01.2015, the total number of records in the Absotheque information system was 239 467.

LICENSING AND INTELLECTUAL PROPERTY DEPARTMENT

In 2014, the activities of the Licensing and Intellectual Property Department (LIPD) were conducted in the following areas:

Industrial Intellectual Property Protection. In contact with the Federal Institute of Industrial Property (FIIP) of the RF Federal Service for Intellectual Property (Rospatent), work was done on applications for JINR patents that had undergone the formal FIIP expertise of Rospatent in 2013–2014.

Changes, alterations, and clarifications were agreed upon and included on the application documents according to the comments rendered by FIIP experts. In order to define the technical level of new elaborations made by JINR staff members for the purpose of patentability, a number of elaborations by JINR staff members were inspected: objects of legal protection were defined and classified according to the International Patent Classification; analogues and prototypes were searched. Reports on patent studies were prepared.

For nine elaborations, together with the authors, application packets were prepared and sent to the RF Rospatent to obtain the patents for:

— "A method of axial beam injection into a compact cyclotron with superhigh magnetic field";
— "A device to produce cylinder tubes for gas-filled drift detectors of ionizing radiation";
— "A method to measure the fluence of fast neutrons with a semiconductor detector";
— "A graphene-based tunnel field transistor";
— "A method to accelerate a body";
— "An estimating device of the substance composition";
— "A method to define space distribution of atomic density in a nanolayer";
— "A device to measure the location of wires in gas chambers";
— "A device to measure inclination of a plane".

Nine RF patents were received:

— "A device of balanced stabilized high power supply" by V. Kaplin and V. Karpinsky;
— "A device to measure inclination of a plane" by Yu. Budagov and M. Lyablin;
— "A method of electron inductive acceleration" by G. Dolbilov;
— "A device for radiation protection of biological objects in experiment" by K. Voskanyan, G. Mitsyn, and V. Gaevsky;
— "A method to define inclination of a plane" by A. Volkov;
— "Electron cyclic induction accelerator" by G. Dolbilov;
— "A method to obtain coherent radiation" by V. Belyaev and M. Miller;
— "A drift chamber for work in vacuum" by L. Glonti, Yu. Potrebenikov, and V. Chepurnov;
— "A method to register particles with drift-tube based detectors" by V. Peshekhonov, S. Vasiliev, A. Zinchenko, and V. Myalkovsky.

In 2014, 42 JINR patents were supported.

Patents and Information. In 2014, 146 issues of the Rospatent official gazette "Inventions. Utility Models" were received at JINR. The information published in the bulletins was processed with respect to the JINR topics. The processing results were presented in 12 issues of the LIPD bulletins "Patents" distributed in departments of JINR. The Department stock is 3199 Rospatent bulletins.

The LIPD internet page was regularly updated on the JINR website.

Standardization. The standard library was supplemented with: 38 new intergovernmental and state RF standard documents (GOSTs), 12 GOST directories and standard information directories for 2014, directories of national standards and technical conditions, guidelines, recommendations, and regulations issued in 2014. Over

253 alterations were introduced into relevant documents of the standard library files and subscribers' copies on the basis of these norm documents (ND).

Thirty GOST official copies were distributed in departments for permanent use.

Departments regularly obtained information on new ND and alteration in GOSTs.

Database and automatic search for norm documentation were developed on the basis of the LIPD archives. The access to the database (about 11 700 positions) was organized on the internet page of LIPD.

"The Catalogue of Normative Legal Acts and Norm Documentation Used at the Joint Institute for Nuclear Research" was regularly updated in the database, with urgent references to the legal reference system KONSULTANT PLUS as of the beginning of 2015.

Data on intergovernmental standards (GOST), national standards of the Russian Federation (GOST R) and other normative-technical documentation applied at the Joint Institute for Nuclear Research were updated, as of 2014–2015.

Together with the Department of Labour Protection, the organization standard STO 08626319-009-2014 "General programme of organization and education in labour protection and knowledge check of requirements for staff labour protection" was developed and introduced.

Licensing. In 2014, the validity of licenses issued by RF was checked. As of 01.01.2015, JINR possesses 18 licenses issued by RF Federal bodies that allow activities in the sphere of JINR Charter.

2014

ADMINISTRATIVE ACTIVITIES

FINANCIAL ACTIVITIES

The Committee of Plenipotentiaries of the Governments of the JINR Member States passed the budget for 2014 of US$158 886.5 thousand for scientific research, construction of basic facilities, and other work related to JINR activities.

The budget income in 2014 was shaped at the expense of JINR Member States' contributions, means obtained through agreements on scientific and technical cooperation with the countries that are not JINR members, and other sources. The actual receipt of money during the year was US$154 442.4 thousand.

The actual expenses of the Institute in all trends are demonstrated in the following table:

	Chapter	Actual expenses in 2014 (in thous. US$)	%
I.	Scientific research	87 783.3	62.9
II.	Basic facilities' operation	10 417.8	7.5
III.	Laboratories' infrastructure	19 752.8	14.1
IV.	JINR infrastructure	21 649.5	15.5
	TOTAL	**139 603.4**	**100.0**

STAFF

As of 1 January 2015, the total number of the staff members at the Joint Institute for Nuclear Research was 4698.

Working at JINR are: RAS Academicians V. Kadyshevsky, V. Matveev, Yu. Oganessian, M. Ostrovsky, D. Shirkov; RAS Corresponding Members V. Aksenov, E. Krasavin, I. Meshkov, A. Starobinsky, G. Trubnikov, G. Shirkov; Members of other state Academies of Sciences V. Moskalenko, I. Zvara, R. Mir-Kasimov, A. Hrynkiewicz, B. Yuldashev; 255 Doctors of Science, 564 Candidates of Science, including 79 Professors and 22 Assistant Professors.

In 2014, 398 people were employed and 367 people discharged because of engagement period expiry and for other reasons.

AWARDS

Professor I. Golutvin (Veksler and Baldin Laboratory of High Energy Physics) was awarded the ***A. Raspletin Medal***, for contribution to the strengthening of RF defense capacity.

The title ***"Honorary Doctor of JINR"*** was conferred on L. Kostov (Bulgaria), R. Maier (Germany), S. Enkhbat (Mongolia), G. Stratan (Romania), B. Sharkov (Russia), and Tran Thanh Van (Vietnam/France), for outstanding services to JINR in development of priority trends in science and technology, and training scientific staff.

The title ***"Honorary JINR Staff Member"*** was conferred on six JINR staff members, for the services to JINR and long-standing fruitful work. In 2014, 32 JINR staff members were awarded the departmental badge of Honour in Labour ***"Veteran of Atomic Energy Industry"***. A number of staff members of the Institute were presented other departmental, city and Institute awards.

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Annual Report

2015-14

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