2017

JOINT INSTITUTE FOR NUCLEAR RESEARCH

Joint Institute for Nuclear Research

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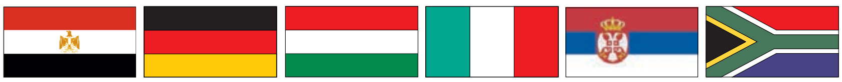
JINR MEMBER STATES

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

CONTENTS

INTRODUCTION

The year 2017 was the starting point of the new seven-year plan of JINR development, and the results achieved by the multinational community of the Joint Institute in 2017, the successful accomplishment of the scientific programme and most important events in international cooperation show that the Institute has entered a “new era” of its development firmly basing on the triunity of its fundamentals. The latter are fundamental studies on the cutting edge of modern physics, international cooperation and multidisciplinary approach in scientific research that, in its turn, includes extensive educational programmes aimed at search for talented scientists and innovation elaborations where nuclear physics methods open new ways to master the accomplishments achieved in related scientific fields.

We also sum up the results of the 25-year period of modern development of the Institute that is connected with the disappearance of the Soviet Union from the political map of the world and political-economic changes in other JINR Member States. This process actually meant the beginning of a new period in the development of the international status of the Joint Institute for Nuclear Research and allowed our centre to strengthen its position in a great number of scientific directions and bring the opportunity of dynamic efficient development to life.

The inauguration of the titles of new elements “moscovium”, “tennessine” and “oganesson” synthesized at the Flerov Laboratory of Nuclear Reactions — famous in the world as a “forge” of superheavy elements and new data in fission physics — became the event of fundamental importance. The inauguration of these elements indicated that the results belong to the brightest achievements of our time. It can be proved by the fact that in December 2017 the UN issued a decision to declare 2019 the International Year of the Periodic Table of Chemical Elements, in honor of the 150th anniversary of the Periodic Law discovered by D. I. Mendeleev.

Summing up the achievements of 2017, it is pleasant to note that we finish the first year of the new seven-year period with positive results. Active work is conducted in the priority sites of the Seven-Year Programme. Within the JINR mega-science project NICA implementation, for the first time the mode of acceleration of polarized protons in the accelerator Nuclotron was executed, that is an essential stride in the accomplishment of the spin physics programme. The main scientific task of this programme is the study of spin quark–parton structure of proton. Prior to this, a high-intensity source of polarized protons and deuterons had been developed by JINR jointly with INP RAS, a new high-frequency section of the pre-accelerator designed in collaboration JINR/MEPhI/ITEP/NRC KI and manufactured in Snezhinsk had been launched. Sophisticated tasks of polarization maintaining of proton beams in fixedly focusing superconducting synchrotron were solved, as well as opportunities to use the Nuclotron at extremely low energy of proton injection — 5 MeV. The measurements showed that the source parameters will provide production of polarized proton and deuteron beams with intensity on the 10^{11} particle level per cycle and polarization degree over 90%. A new pre-injector of the linear accelerator LU-20 was launched; two HF stations and the system of electron cooling of the Booster beam were installed and tested.

More than a third of the effective time of the Nuclotron operation (233 h) was used by the start-up installation of the basic configuration of the NICA — BM@N complex; first results on hyperon production in nucleus–nucleus interactions were obtained with its help.

The construction of the accelerator complex NICA, engineer infrastructure, experimental facilities is conducted according to the schedule. Cooperation is in progress with scientific centres in Member States, Associate Members, China and other partners. Due to target financing of the project by the Government of the Russian Federation it is possible to say that the complex will be constructed in time.

In 2017, the construction of the first stage of the Superheavy Element Factory entered its final phase. The development of the new complex will provide a wide range of research of elements 112–118 which had already been discovered.

It should be stressed that practically all JINR Member States took part in the development of the new accelerator DC-280. All modern technology that our countries possess has been applied in it. Considerable progress has been achieved in the development of experimental facilities, including the target block, separators and detecting systems. In particular, a new gas-filled separator was manufactured and delivered to Dubna — a facility where first experiments will be conducted at the SHE Factory. It was designed at FLNR JINR and manufactured by the famous French company SigmaPhi.

Almost all scientific trends of our Institute are unique; they are much-in-demand in the world community. In view of this, a special mentioning should be made about the inclusion in 2017 of the accelerator complex NICA and the SHE Factory into the long-term plan of NuPECC "Prospects in Nuclear Physics".

The JINR neutrino programme is actively progressing, in particular, the deep-water neutrino telescope in the Baikal — the assembling and launch of the second cluster of the detector were accomplished which consisted of eight deep-water optical modules that were put down on the lake bed. The launched setup possesses efficient capacity for search of 100-TeV neutrino events.

With the stable operation of the IBR-2 pulsed reactor, active user policy was successfully continued, as well as the programme of spectrometer development and new projects. A new ring detector for experiments in neutron small-angle scattering was launched. The design was started of the backward scattering detector with large aperture for the Fourier diffractometer of high resolution. An analytical laboratory equipped with an atomic-force microscope was established in the Raman spectroscopy sector.

The complex of cold moderators worked successfully in three reactor cycles in the experiment. A new stage in the development of the IREN facility has been accomplished — the second accelerator section of the facility was launched. In collaboration with the RAS Institute of Archaeology studies were conducted in one of the new trends in condensed matter physics — nondestructive research of inner structure of objects of historical heritage with methods of neutron radiography and tomography.

Outstanding results were achieved by the community of JINR theoreticians: they worked out a large number of models and innovative efficient numerical methods. These studies are closely connected with the main experimental programmes that are implemented at JINR facilities and abroad, with physics of great interest for SHE Factory and ACCULINNA-2 fragment separator at JINR, as well as for other facilities that operate or are in the start-up period, such as FAIR, SPES, HIE-ISOLDE, SPIRAL2, and ELI-NP.

The general theory of spinning particles with electric and magnetic dipole moments that move in arbitrary electromagnetic, inertial and gravitational fields was developed. Quantum mechanical and classical dynamics were studied. The complete agreement between quantum mechanics and the classical theory was proven in the general case.

The Multifunctional Information and Computing Complex (MICC) is one of the basic facilities of JINR; its development is conducted in all advanced directions. The JINR site Tier-1 is one of the centres for storage and processing of data from the experiment CMS at the LHC (CERN); it is the second in the world — in 2017 over 120 million events were processed at it, which exceeds 14% of the total amount. This grid-component of the Multifunctional Information and Computing Complex of JINR is considered as a prototype of the centre for data storage and processing of the mega-project NICA.

In December 2017, the meeting of the RAS Council on Space Issues was held where the results of experimental studies of specific radiation damage caused by radiation with various physical characteristics that were obtained by JINR radiobiologists were marked as currently important. In particular, those studies concerned damage in the higher integrative functions of CNS that is now a major problem for implementation of manned flights in far space.

With the steadily growing pace of accomplishment of ambitious tasks and projects the role of development of educational activities of the Institute becomes more important. More than 400 students of the basic chairs of MSU, MPTI, MEPhI, "Dubna" University, and universities of Member States took training courses at the UC of JINR. Summer training and work-practice courses were organized for 200 students from higher education institutions. 163 students took part in the annual summer student practice in JINR research trends.

The Institute took an active part in promotional engagements. In 2017, a virtual lesson "NICA — Universe in the Lab" was held for the first time in schools of Russia. It was given by Plenipotentiary of the Government of Russia to JINR Academician G.Trubnikov. In the framework of the 19th World Festival of Youth and Students in Sochi an international group of young JINR staff members presented the flagship project of the Institute — the accelerator complex NICA, and familiarized guests and the festival participants with the JINR educational programme and opportunities for students and post-graduates. Traditionally, the Institute took part in organization of many international meetings, conferences, and schools.

The rate of the scientific, science-organizational, and educational life at the Institute has really increased. In this connection, a number of events should be mentioned, such as the development of the virtual laboratory of fission physics for students from Member States, adoption of the Code of Professional Ethics for JINR staff members by the JINR Science and Technology Council; the resolution of the Government of the Russian Federation came into effect that granted JINR the right to confer scientific titles on its own authority, which shows deep trust to the Institute and becomes our lofty and challenging task.

The second stage of the 10th meeting of the Senior Officials Group of the Global Network of Research Infrastructures was held in Dubna, and it can be regarded as an indisputable proof of keen attention to the Institute and its programmes in the world community. The Senior Officials Group of the Global Network of Research Infrastructures was established in order to look for opportunities of international cooperation and construct a system of efficient joint usage of scientific research infrastructure sites in all fields of knowledge.

Among most important events in strengthening international scientific cooperation that were numerous last year is the signing of a new Agreement on cooperation between JINR and INFN (Italy), in the presence of the President of the Republic of Italy S. Mattarella.

In October an expert meeting of the Russia–China working group on cooperation in the frames of large scientific structures was held in Beijing. The tasks of the meeting were determination and specification of involvement of Chinese scientific centres in the project NICA and participation of JINR in large scientific projects of China.

A delegation of JINR took part in the Russian–German meeting in Berlin on elaboration of the "Road Map of German–Russian Cooperation in Education, Science, Research and Innovations". The projects NICA and FAIR were discussed with great interest.

Progress should be mentioned in the activities to upgrade scientific organizational issues at the Institute, workout of measures to increase the efficiency of application of material and financial resources, enriching the erudition level among staff members, provision of efficiency and high quality of management, openness and transparency in all levels of administration and JINR directorate as a whole.

Today, in the period of this stage of development related to implementation of the strategic programme of JINR on the basis of a new seven-year plan for 2017–2023, the Institute increases its outreach with clear understanding of its responsibility for observance of all scheduled terms, with full hope that the launched projects will be accomplished.

V. Matveev
Director
Joint Institute for Nuclear Research

2017

GOVERNING AND ADVISORY BODIES OF JINR

ACTIVITIES OF JINR GOVERNING AND ADVISORY BODIES

SESSIONS OF THE JINR COMMITTEE OF PLENIPOTENTIARIES

A regular session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held on 27–28 March. It was chaired by the Plenipotentiary of the Government of the Republic of Bulgaria, L. Kostov.

The Committee of Plenipotentiaries (CP) considered the report "Results of JINR activities in 2016. Recommendations of the 121st session of the JINR Scientific Council (February 2017)" presented by JINR Director V. Matveev. The CP recognized the significant progress in implementing the priority projects of the JINR scientific programme, in particular: the progress in the civil construction work of the NICA collider building, the successful commissioning of the linear accelerator of heavy ions HILAC, the official start of the assembly and testing line for superconducting magnets; the active effort towards the preparation of the technical design reports and mass production of the MPD detector elements; the approval by IUPAC of the names of the new superheavy elements moscovium, tennessine and oganesson synthesized at FLNR; the good progress of the installation of the DC-280 cyclotron with its major technological systems in the building under construction of the Factory of Superheavy Elements; the high-quality scientific results obtained at the spectrometers of the IBR-2 research facility and the progress of implementation of the User Programme at the Frank Laboratory of Neutron Physics and its further development; the new results achieved in the field of information technology and the achievements in the development of the JINR educational programme.

The CP expressed concern about the tendency in recent years towards an annual reduction in the level of actual revenues of the JINR budget, which jeopardizes the implementation of the Institute's scientific programme. The Committee proposed that the Plenipotentiaries of the Governments of the JINR Member States take measures for the timely payment of contributions in full as prescribed by the Charter and the Financial Protocol of JINR.

Regarding the report "Implementation of the Seven-Year Plan for the Development of JINR for 2010–2016" presented by N. Russakovich, Chief Scientific Secretary of JINR, the CP recognized that the objectives of the seven-year plan in the area of major facilities had been achieved by JINR. These include the stable operation of the modernized IBR-2 reactor and the increased number of spectrometers now available for experiments at this facility, the ongoing construction of the Factory of Superheavy Elements with an expectation to put it into operation in 2017, the recent signature of important contracts which provide timely realization of the NICA project, the commissioning of the Dubna cluster of the Baikal-GVD facility, and the start-up of the CMS Tier-1 centre.

Based on the report "Execution of the JINR budget in 2016" presented by S. Dotsenko, Chief Accountant of JINR, the CP noted the balanced execution of the budget in 2016 in conditions of incomplete and unstable receipt of budget revenues.

The CP took note of the information on the situation with industrial return to Member States in 2016 and commissioned the JINR Directorate to continue work towards securing the right of industrial return for each Member State in an amount of at least 20% of its contribution on the basis of JINR competitive procedures. The Directorate was also commissioned to continue improving the procurement activities of JINR, which should facilitate efficient work and timely fulfillment of obligations for the implementation of projects, to analyze the application of the Regulation for the Procurement Activities of JINR, and to present the results at the next session of the CP.

Based on the report "Results of the meeting of the JINR Finance Committee held on 24–25 March 2017" presented by A. Khvedelidze, Plenipotentiary of the Government of Georgia to JINR, the CP approved the protocol of this meeting. The Committee appealed to the Plenipotentiaries of the Governments of the JINR Member States which are in arrears with the payment of contributions to the JINR budget to take urgent measures for their repayment and in the future to ensure the timely delivery of contributions.

The CP commissioned the JINR Directorate and the Working Group under the CP Chairman for JINR Financial Issues to submit the draft texts of the "Rules of Procedure of the JINR Finance Committee", the "Rules of Procedure of the Committee of Plenipotentiaries of the Governments of the JINR Member States", and the "Regulation for the JINR Staff" for consideration by the Finance Committee and the CP in November 2017.

The CP supported the position of the JINR Directorate that funds for grants and cooperation programmes should be generally allocated after the Member State has paid its contribution to the budget, in accordance with the Financial Protocol and the Regulation for the Grants of Plenipotentiaries of the Governments of the JINR Member States.

The CP suspended, beginning in 2017, the increase of the arrears of Ukraine in the payment of its contribution to the JINR budget due to force majeure and deferred the consideration of the issue of Ukraine's arrears to the session of the Committee of Plenipotentiaries in March 2018. The Committee authorized the CP Chairman to address the Ministry of Foreign Affairs of Ukraine with a request to ensure the participation of Ukraine's official representative in the meetings of the Finance Committee and in sessions of the CP. The CP set up a working group of representatives or designated delegates of the Republic of Bulgaria, the Czech Republic, the Republic of Poland, the Slovak Republic, and of the JINR Directorate to develop proposals for the redemption of Ukraine's arrears in the payment of its contribution to the JINR budget.

Regarding the "Proposals of the Finance Committee for the selection of a company for auditing the financial activities of JINR for the year 2016" presented by A. Khvedelidze, Plenipotentiary of the Government of Georgia to JINR, the CP approved the LLC AC "Korsakov and Partners" as JINR's auditor for the year 2016 and the plan for auditing the financial activities of JINR for 2016 as presented by the JINR Directorate.

Based on the report "Endorsement of the appointment of the Vice-Directors, the Chief Scientific Secretary, and the Chief Engineer of JINR" presented by V. Matveev, Director of JINR, and based on the results of secret ballot, the CP endorsed the appointment of A. Sorin as Chief Scientific Secretary of JINR and B. Gikal as Chief Engineer of JINR, until the completion of the term of office of the current Director of JINR (1 January 2022).

The CP thanked JINR Chief Scientific Secretary N. Russakovich and JINR Chief Engineer G. Shirkov for many years of their successful work as members of the JINR Directorate, for their contributions to the results obtained by the Institute and to the development of international scientific cooperation.

Based on the results of open vote, the CP deferred the appointment of new candidates for the positions of three Vice-Directors of JINR to the session of the CP in March 2018, allowed Director V. Matveev to extend the term of office of JINR Vice-Director R. Lednický until 31 March 2018 and granted the right to extend the powers or assign temporary duties of JINR Vice-Directors, including to other persons, until their official approval by the CP.

In accordance with Item 2, Article 17 of the Charter of JINR, the CP allowed Director V. Matveev to introduce the position of a fourth Vice-Director at JINR and commissioned him to send the material on this position to the Plenipotentiaries, substantiating the goals, tasks, duties and requirements for the candidates, for the subsequent endorsement of the appointment as Vice-Director of one of the candidates, nominated by the Member States, at the session of the CP in March 2018.

The CP heard with interest the report "New arrivals from the stability island of superheavy elements" presented by Yu. Oganessian, Scientific Leader of FLNR.

A regular session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held in Dubna on 24–25 November. It was chaired by the Plenipotentiary of the Government of the Russian Federation, G. Trubnikov.

The CP heard and discussed the report "Recommendations of the 122nd session of the JINR Scientific Council (September 2017). Brief overview of the results of JINR activities in 2017 and plans for 2018" presented by JINR Director V. Matveev. The CP took note of the information presented, approved the recommendations of the 121st and 122nd sessions of the Scientific Council, and the JINR Topical Plan of Research and International Cooperation for 2018.

The CP noted the important plans for JINR to achieve new scientific and technological results of high significance in 2017–2023, in particular, in the process of realizing and launching the NICA megaproject and the Factory of Superheavy Elements (SHE), and in expanding the spectrometer complex of the IBR-2 reactor and the User Programme at this facility.

The CP also noted the importance for JINR to elaborate a new strategic plan for the long-term development of the JINR Laboratories and requested the JINR Directorate to present regular information on the work in this direction.

The CP supported the efforts by the JINR Directorate towards developing the Institute's research infrastructure and integrating it into the European scientific landscape. In particular, it noted with satisfaction the inclusion, in 2017, of the NICA accelerator complex and of the SHE Factory in the NuPECC long-range plan "Perspectives in Nuclear Physics".

The Committee congratulated JINR on the inauguration of the names of the new superheavy elements moscovium, tennessine and oganesson synthesized at the Flerov Laboratory of Nuclear Reactions, which was held in Moscow on 2 March 2017; took note of the signing of the new Agreement on cooperation between JINR and INFN, which took place in Moscow on 12 April 2017 in the presence of the President of the Italian Republic, S. Mattarella; welcomed the decision taken by the Government of the Russian Federation on 23 August 2017, by which JINR received the right to confer academic degrees. The CP asked the Plenipotentiaries to facilitate the procedure of recognition of JINR's degree diplomas in the Member States.

The CP took note of the initiative of the JINR Directorate and of the Republic of Poland about intentions to jointly establish the Laboratory for Structural Research of Macromolecules and New Materials at the SOLARIS National Synchrotron Radiation Centre of the Jagiellonian University in Kraków (Poland) and commissioned the Directorate to continue this work.

The CP accepted the proposals of the JINR Directorate on the celebration of the 25th anniversary of the accession to the Institute of a group of independent states and on the holding of a festive meeting dedicated to this event on 26 March 2018 to be attended by the heads of relevant ministries and agencies of the Member States, by the ambassadors of these states accredited in the Russian Federation, the Plenipotentiaries of the Governments of the Member States, and by honorary guests.

The CP commissioned the JINR Directorate to organize an open international competition in 2018 for researchers and postgraduates to fill vacancies of positions in JINR's priority scientific projects, as well as to organize a special-purpose grant programme in 2018 to stimulate the participation of scientists of the Member States and other countries in the implementation of the NICA project.

Based on the report "Draft budget of JINR for the year 2018, draft contributions of the Member States for the years 2019, 2020, and 2021" presented by JINR Chief Accountant S. Dotsenko, the Committee approved the JINR budget for the year 2018 with the total expenditure amounting to US$207.24 million. It also approved the scale of contributions, the contributions, and the payment of contribution arrears of the Member States for 2018.

The CP commissioned the JINR Directorate to submit for consideration and approval by the Finance Committee and the CP in March 2018 of the JINR revised budget for 2018, taking into account the payment of arrears of the Russian Federation, in accordance with the approved Order of the Government of the Russian Federation.

The CP determined the provisional volumes of the JINR budget in income and expenditure for the year 2019 amounting to US$205.68 million, for the year 2020 amounting to US$208.57 million, for the year 2021 amounting to US$212.58 million as well as the provisional amounts of the Member States' contributions for the years 2019, 2020, and 2021.

The CP 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 2018, in accordance with the JINR Collective Bargaining Agreement for 2017–2020.

Regarding the report "Progress of implementing the NICA complex project and proposals for spending the special-purpose funds allocated by the Russian Federation in accordance with the Agreement between the Government of the Russian Federation and the international intergovernmental scientific research organization — the Joint Institute for Nuclear Research on the construction and exploitation of the NICA complex of superconducting rings for heavy-ion colliding beams, dated 2 June 2016" presented by VBLHEP Director V. Kekelidze and JINR Vice-Director R. Lednický, the CP noted that high efficiency of the accelerator application for research tasks was achieved during Run 54 of the Nuclotron with the source of polarized particles. The analyzing power of the neutron–proton charge-exchange reaction on a copper target was detected for the first time. Also for the first time, polarized protons were accelerated at the Nuclotron. More than one third of the accelerator's operation time (233 h) was used by the leading facility of the basic configuration of the NICA collider — the BM@N detector, with which first results were obtained on the production of hyperons in nuclear interactions. The CP was pleased to note that a new fore-injector of the linear accelerator LU-20 was commissioned; two RF stations and an electronic cooling system of the Booster beam were installed and tested.

In accordance with the Agreement which provides for the obligations of the Russian Federation to finance the costs of the construction and operation of the basic configuration of the NICA complex in the amount of 8 800.0 million rubles (in 2013 prices), the CP approved, for the year 2018, the JINR budget for the use of the special-purpose funds of the Russian Federation in the amount of 5 400.0 million rubles, adopted the provisional volume of the JINR budget for the use of the special-purpose funds of the Russian Federation, allocated in accordance with the Agreement, for the year 2019 with the total expenditure of 1 500.0 million rubles, and for the year 2020 with the total expenditure of 970.0 million rubles, with a possibility for its adjustment.

The CP commissioned the JINR Director to submit, to the meeting of the Supervisory Board of the NICA complex project, JINR's proposals for financing

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	– R. Plaga
Georgia	– A. Khvedelidze
Republic of Kazakhstan	– E. Kenzhin
Democratic People's Republic of Korea	– Not appointed
Republic of Moldova	– V. Ursachi
Mongolia	– S. Davaa
Republic of Poland	– M. Waligórski
Romania	– F.-D. Buzatu
Russian Federation	– G. Trubnikov
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: A. Sorin

Ts. Baatar	– Mongolia
C. Borcea	– Romania
M. Budzyński	– Poland
L. Cifarelli	– Italy
A. Díaz García	– Cuba
A. Dubničková	– Slovakia
M. Eliashvili	– Georgia
P. Fré	– Italy
S. Galès	– France
B. Grynyov	– Ukraine
A. Harrison	– UK
M. Hnatič	– Slovakia
P. Jenni	– Switzerland
M. Jeźabek	– Poland
Jiangang Li	– China
G. Khuukhenkhuu	– Mongolia
S. Kilin	– Belarus
M. Kovalchuk	– Russia
G. Kulipanov	– Russia
A. Maggiora	– Italy
S. Maksimenko	– Belarus
V. Matveev	– Russia
J. Mnich	– Germany
D. L. Nagy	– Hungary
G. Poghosyan	– Armenia
S. Pospišil	– Czech Republic
I. Povar	– Moldova
E. Rabinovici	– Israel
V. Rubakov	– Russia
K. Rusek	– Poland
B. Sharkov	– Russia
A. Skrinsky	– Russia
M. Spiro	– France
H. Stöcker	– Germany
Ch. Stoyanov	– Bulgaria
Gh. Stratan	– Romania
V. Strazhev	– Belarus
N. Tonchev	– Bulgaria
Tran Duc Thiep	– Vietnam
N. Tyurin	– Russia
M. Waligórski	– Poland
I. Wilhelm	– Czech Republic
A. Zagorodny	– Ukraine
M. Zdorovets	– Kazakhstan
G. Zinovjev	– Ukraine
Not appointed	– Azerbaijan
Not appointed	– Democratic People's Republic of Korea
Not appointed	– Uzbekistan

Programme Advisory Committee for Particle Physics

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

Programme Advisory Committee for Nuclear Physics

Chairperson: M. Lewitowicz (France)
Scientific Secretary: N. Skobelev

Programme Advisory Committee for Condensed Matter Physics

Chairperson: D. L. Nagy (Hungary)
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
Chief Scientific Secretary A. Sorin
Chief Engineer B. Gikal

Bogoliubov Laboratory of Theoretical Physics

Director D. Kazakov

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
– astrobiology
– radiation protection physics
– mathematical simulation of radiation-induced effects

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 work on the construction of the NICA accelerator complex at the expense of the special-purpose funds of the Russian Federation and also at the expense of the funds planned in the JINR budget, and to take control of the use of these funds.

Noting that prior to the signing of the Agreement, in 2013–2015, work was performed on a number of objects of the basic configuration of the NICA complex in the amount of 2 800.0 million rubles using budgetary funds of JINR and those of other countries, the CP agreed with the change in the cost of individual objects of the NICA complex in accordance with the existing design documentation and updated financial estimates while maintaining the total costs for the basic configuration of the NICA complex specified in the Agreement. The CP fully guaranteed implementation of JINR's obligations stipulated by the Agreement.

Based on the report "Results of the meeting of the JINR Finance Committee held on 21–22 November 2017" presented by the Plenipotentiary of the Government of Georgia to JINR A. Khvedelidze, the CP approved the Protocol of this meeting.

The CP commissioned the JINR Directorate to prepare a draft road map for the work on the Regulation for the JINR staff, taking into account the proposals made by the Plenipotentiaries and by the national groups of employees from the Member States, and forward it to the members of the Working Group under the CP Chairman for JINR Financial Issues by 1 February 2018. It also recommended that experts in the field of international law be involved in the work on this Regulation.

Regarding the report "Information from the JINR delegation about the meeting at the Ministry of Education and Science of Ukraine and information from the JINR delegation about the workshop at the Academy of Sciences of the Republic of Uzbekistan" presented by JINR Vice-Director M. Itkis, the CP commissioned the JINR Directorate to continue work on the implementation of a mutually acceptable model of cooperation between JINR and Ukraine. It also took note of the information about the negotiations of the JINR representatives with high officials of the Republic of Uzbekistan on measures to restore the activities of the Republic of Uzbekistan in JINR.

The CP took note of the auditors' report concerning the financial activities of JINR examined for 2016, approved the Accounting report of the Joint Institute for Nuclear Research for the year 2016, endorsed the plan of measures concerning the audit of the financial activities of JINR for 2016, and commissioned the JINR Directorate to prepare for the next session of the CP comments to the auditors' report.

The CP commissioned the Working Group under the CP Chairman for JINR Financial Issues to consider the draft Regulation for the Introduction of Adjustments to the JINR Budget prepared by the Directorate.

Regarding the report "Improvement of the procurement activities of JINR" presented by JINR Vice-Director R. Lednický, the CP noted the importance of conducting effective procurement procedures taking into account the volumes of funding the Institute.

Regarding the report "Amendment proposed to the Rules of procedure of the JINR Scientific Council" presented by JINR Chief Scientific Secretary A. Sorin, the CP allowed the endorsement of appointments of BLTP Deputy Directors to be held at the 123rd session of the Scientific Council (22–23 February 2018).

Regarding the report "JINR's participation in the Russian Federation's targeted research programme within the framework of international cooperation with institutions of the People's Republic of China" presented by VBLHEP Deputy Director H. Khodzhibagiyan, the CP expressed its consent to the participation of JINR in the competition of the Ministry of Education and Science of the Russian Federation on Activity 2.1, Priority 1 "Conducting studies on selected priority areas involving research organizations and universities in China" within the framework of the Federal targeted programme "Research and development in the priority areas of advancement of the Russian scientific and technological complex for 2014–2020" of the following applications: development of linear superconducting accelerators for the NICA and HIAF accelerator complexes; research for the preparation of a technical proposal for a 1 MJ energy storage device made of HTSC material for the NICA project; production of a pilot batch of modules for the electromagnetic calorimeter of the Multipurpose Detector (MPD) at the NICA collider; development of stochastic cooling systems for the NICA and HIAF accelerator complexes.

The CP heard with interest the report "Status of the Factory of Superheavy Elements" presented by FLNR Director S. Dmitriev. It noted that Phase 1 of construction of the Factory of Superheavy Elements (SHE) had entered its final stage and recommended that the JINR Directorate take all necessary measures to ensure the implementation of the scheduled plan for the start-up and commissioning of the SHE Factory (experimental building, DC-280 cyclotron, and new gas-filled recoil separator).

The CP congratulated Academician V. Matveev, Director of JINR, on having been awarded the Order of the Russian Federation "For Merit to the Fatherland", III class and the Order of Merit of the French Republic. The Committee also congratulated Academician Yu. Oganessian, Scientific Leader of FLNR, on having been awarded the Order of the Russian Federation "For Merit to the Fatherland", II class.

The 121st session of the JINR Scientific Council took place on 23–24 February. 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).

V. Matveev made a detailed report which concerned the decisions taken at the session of the JINR Committee of Plenipotentiaries (November 2016), the scientific results produced in 2016, and the major events in the activities of JINR and its international cooperation.

The Scientific Council reviewed the results of implementation of the Seven-Year Plan for the Development of JINR (2010–2016) and the plans of activities for 2017–2023 in the fields of particle physics, high-energy heavy-ion physics, and information technology presented by Vice-Director R. Lednický, and in the fields of low- and intermediate-energy nuclear physics, nuclear physics with neutrons, and condensed matter physics presented by Vice-Director M. Itkis.

JINR Chief Scientific Secretary N. Russakovich presented a proposal for amendments to the "Regulation for the JINR Programme Advisory Committees".

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

The Scientific Council heard the report "Status of the FAIR project at the end of 2016 and prospects for the FAIR–JINR cooperation" presented by JINR Deputy Director B. Sharkov. It also heard the best reports by young scientists as recommended by the PACs.

The award of the diploma "Honorary Doctor of JINR" and of the V. Dzhelepov Prize took place at the session. The recommendations of the juries for the award of the B. Pontecorvo Prize and JINR annual prizes for best papers in the fields of scientific research, instruments and methods, and applied research were approved.

Vacancies of positions in the directorates of JINR Laboratories were announced.

Resolution. General Considerations. Based on the report presented by JINR Director V. Matveev, the Scientific Council appreciated the approval by the Committee of Plenipotentiaries of the Seven-Year Plan for the Development of JINR for 2017–2023 which will determine the strategy of JINR in the coming period and which will be updated on a yearly basis with the actual financial situation taken into account.

The Scientific Council was pleased to note the establishment of a Supervisory Board of the NICA project, which is an important step taken after the recent signing of the Agreement between the Government of the Russian Federation and JINR on the construction and exploitation of the NICA complex of superconducting rings for heavy-ion colliding beams.

The Scientific Council welcomed the successful realization of the idea of an All-Russia Open Lesson on the NICA Project on 8 February 2017 and suggested its wider distribution.

The Scientific Council recognized the significant progress in implementing the priority projects of the JINR scientific programme and the high-quality organizational work being done by the JINR Directorate.

The Scientific Council congratulated the Institute on the approval by IUPAP and IUPAC of the names of the new superheavy elements moscovium, tennessine and oganesson synthesized at the Flerov Laboratory of Nuclear Reactions.

The Scientific Council supported the development of a long-range strategy for JINR beyond the approved Seven-Year Plan at least up to 2030.

Results of the Seven-Year Plan for the Development of JINR (2010–2016) and Plans for 2017–2023. The Scientific Council highly appreciated the results of implementation of the Seven-Year Plan for the Development of JINR (2010–2016) and the plans of activities for 2017–2023 in the fields of particle physics, high-energy heavy-ion physics, and information technology presented by Vice-Director R. Lednický, and in the fields of low- and intermediate-energy nuclear physics, nuclear physics with neutrons, and condensed matter physics presented by Vice-Director M. Itkis. The Scientific Council wished the Directorate and staff of JINR success in realizing these ambitious plans aimed at constructing unique basic facilities (NICA, SHE Factory, Baikal-GVD), upgrading the existing facilities of JINR, integrating them into the European and global research infrastructures, and at accomplishing an extensive programme of fundamental and applied research in the various fields of modern physics based on broad international cooperation.

Recommendations in Connection with the PACs. The Scientific Council took note of the recommendations made by the PACs at their meetings in January 2017 and proposed that the JINR Directorate should take these recommendations into account in preparing the JINR Topical Plan of Research and International Cooperation for 2018.

Particle Physics Issues. The Scientific Council joined the PAC for Particle Physics in appreciating the progress towards realization of the Nuclotron–NICA project, including the successful commissioning of the linear accelerator of heavy ions HILAC, the preparations for the Booster construction, the official start of the assembly and testing line for superconducting magnets, the progress in the civil construction work of the collider building, and the significant achievements in the Nuclotron operation during the 53rd run, with a record duration of stable operation. A beam of polarized deuterium nuclei was accelerated for the first time after a hiatus of 15 years and was delivered to the experiments with a polarization up to 60% and an intensity up to $7 \cdot 10^8$ ions.

The Scientific Council noted the ongoing efforts of the MPD team on the preparation of the technical design reports and mass production of detector elements. It congratulated the MPD management for the progress in attracting new outside collaborators. It also congratulated the BM@N team on the first successful run with a set-up that included all subsystems. The Scientific Council noted the PAC's concern by the six-month delay in the project realization which resulted also from the low availability of beam test. The Scientific Council appreciated the work accomplished by the Detector Advisory Committees of the MPD and BM@N experiments in assisting the realization of the detectors.

The Scientific Council appreciated the progress towards the development of the COMET experiment, which is under preparation at the J-PARC accelerator and is aimed at searching for muon-to-electron conversion. The participants from JINR have made important technical contributions by constructing a straw-tube detector and by supplying and testing scintillating crystals for the COMET calorimeter. The Scientific Council recommended continuation of this project until the end of 2019, encouraging the team to take active roles in physics analysis.

The Scientific Council took note of the new project on JINR's participation in the fixed target NA64 experiment at the CERN SPS. The proposed contribution of JINR to NA64, an interesting project with high scientific potential, is the delivery and operation of a straw-tube tracking detector, with modest resources requested for the next three years. The Scientific Council recommended approval of this project until the end of 2019.

Nuclear Physics Issues. The Scientific Council supported the recommendations of the PAC for Nuclear Physics concerning the theme "Physics of Light Mesons", in which significant results had been obtained in the SPRING project, and in the TRITON and MEG experiments, in particular: to extend this theme until the end of 2017 in order to complete all the studies and activities, and to hear final reports on the results obtained in the MEG-PEN, PAINUC and TRITON experiments. The Scientific Council took note of the recommendations of the PAC to continue the $\mu \to e\gamma$ search in the MEG-II project and to provide funding for the GDH&SPASCHARM project until the end of 2019.

The Scientific Council appreciated the progress of construction of the Factory of Superheavy Elements (SHE) and of the installation of the DC-280 cyclotron with its major technological systems. In accordance with the schedule, the accelerator commissioning will start in December 2017. Implementation of such a tight schedule will require maximum concentration of financial and human resources of the Flerov Laboratory. The Scientific Council recommended that the FLNR Directorate take all necessary measures to ensure the launch of the SHE Factory as scheduled. Monitoring of the construction phase of the facility through a more detailed evaluation of the key components of the SHE Factory, namely, the DC-280 cyclotron including the ion source, the high-power target and detection systems, was also recommended.

Condensed Matter Physics Issues. The Scientific Council appreciated the scientific results achieved at IBR-2 instruments in 2016 and noted their interdisciplinary character. It also welcomed the recent instrumentation developments at the reactor which will increase the quality and level of forthcoming studies, extend the research areas and provide more attractive conditions for the IBR-2 user community. The Scientific Council was pleased with the progress of implementation of the FLNP User Programme at the IBR-2 spectrometers and supported its further development.

The Scientific Council welcomed initiated discussions on the development of a concept for a new neutron source of JINR to be used beyond 2032, noting it as timely, and agreed with the PAC's recommendation that a proposal for the development of a new neutron facility be submitted to the Committee for Long-Term Strategy Planning being currently established at JINR. The Scientific Council shared the opinion of the PAC for Condensed Matter Physics on the urgency of addressing a number of issues such as mobilizing a large scientific community, considering complementarity and competitiveness with other neutron sources to be available after 2032 both in Russia and elsewhere in Europe, clarifying ideas on the instruments and novel technologies to be used at the new source, and identifying the relevant user community both at JINR and outside.

Recognizing the new scientific results in the field of information technology and the recent achievements in the development of the JINR educational programme, the Scientific Council supported the PAC's recommendations on continuation of these activities within the considered themes and projects, as outlined in the PAC report.

Common Issues. One of the reports at the meeting of the PAC for Nuclear Physics concerned the support of young scientists at JINR. The Scientific Council noted with interest the recommendations of this PAC that the JINR Directorate should extend the training PhD programme for all the Member States and Associate Member States and that a postdoctoral fellowship programme should be implemented at JINR in order to address the growth of early-career researchers. The Scientific Council highly appreciated the efforts of the

JINR Directorate to support young scientists and expressed its wish to hear a report on this subject at a future session.

The Scientific Council appreciated the participation of the PACs in updating the governing regulations of the PACs and the evaluation procedures of projects submitted to the PACs. As a general comment, the Scientific Council was pleased with the increased interaction and coordination between the three PACs and the Directorate.

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: "Multimedia educational resources", "Charmonium-like states at COMPASS", "Fusion reactions with light neutron-rich nuclei: a pathway to synthesize new heavy nuclei", "Simulation of radiation damage to different neuronal structures with Geant4-DNA toolkit", — and thanked the respective speakers: N. Sidorov (VBLHEP), A. Gridin (DLNP), V. Rachkov (FLNR), and L. Bayarchimeg (LRB). The Scientific Council welcomed similar reports in the future.

Memberships of the PACs. As proposed by the JINR Directorate, the Scientific Council appointed M. Lewitowicz (GANIL, Caen, France) as Chairperson of the PAC for Nuclear Physics and R. Hall-Wilton (ESS, Lund, Sweden) as a new member of the PAC for Condensed Matter Physics, each for a term of three years. The Scientific Council thanked the outgoing member A. Ceccucci (CERN, Geneva, Switzerland) for his successful work as a member of the PAC for Particle Physics.

Regulation for the JINR PACs. The Scientific Council took note of the amendments to the "Regulation for the JINR Programme Advisory Committees" presented in detail by Chief Scientific Secretary N. Russakovich. An updated version of the Regulation provides an extended description of the PAC functions, enabling the PACs to establish their operating procedures and develop specific methods of the evaluation of projects. The revised Regulation also encourages the PACs to appoint one or two of its members to perform continuous monitoring of a specific project, allows the PAC members to carry out the evaluation of projects by electronic means of communication, and includes a number of minor corrections suggested by the JINR Directorate and PACs. The Scientific Council approved the amended text of this document.

Scientific Report. The Scientific Council highly appreciated the report "Status of the FAIR project at the end of 2016 and prospects for the FAIR–JINR cooperation" and thanked JINR Deputy Director B. Sharkov for his informative presentation. Based on the reported FAIR time schedule, the Scientific Council emphasized the need for a timely and successful completion of the NICA project with broad international cooperation. This will enable complementarity among the projects.

Awards and Prizes. The Scientific Council congratulated Professor F. Dydak (Austria) on the award of the diploma "Honorary Doctor of JINR", in recognition of his outstanding contributions to the advancement of science and the education of young scientists.

The Scientific Council congratulated Professor Ju. Budagov (JINR) on the award of the V. Dzhelepov Prize for the development and construction of a unique laser metrology system for measuring the angular oscillation of the Earth's surface.

The Scientific Council approved the Jury's recommendations on the award of the B. Pontecorvo Prize to a group of authors including: Professor Yifang Wang (IHEP, Beijing, China), Professor Soo-Bong Kim (Seoul National University, South Korea), and Professor Koichiro Nishikawa (KEK, Tsukuba, Japan), for their outstanding contributions to the study of the neutrino oscillation phenomenon and to the measurement of the θ_{13} mixing angle in the Daya Bay, RENO, and T2K experiments.

The Scientific Council approved the Jury's recommendations on the award of JINR annual prizes for best papers in the fields of scientific research, instruments and methods, and applied research.

Election of the Co-Chairman of the Scientific Council. The Scientific Council re-elected M. Waligórski as Co-Chairman of the Scientific Council until the completion of the current membership of the Scientific Council (March 2018).

Elections and Announcement of Vacancies in the Directorates of JINR Laboratories. The election of the Director of the Bogoliubov Laboratory of Theoretical Physics took place at the session. Since none of the candidates had obtained the required majority of votes, the Scientific Council announced new elections for this position to be held at the next session of the Scientific Council in September 2017.

The Scientific Council announced the vacancies of positions of the Director of the Frank Laboratory of Neutron Physics and of the Director of the Laboratory of Information Technologies. The elections for these positions will take place at the 123rd session of the Scientific Council in February 2018.

The 122nd session of the JINR Scientific Council took place on 18–19 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).

V. Matveev delivered a comprehensive report, presenting an in-depth analysis of the role and place of JINR in the world's fundamental nuclear physics science and covering the decisions of the latest session of the JINR Committee of Plenipotentiaries (March 2017), the progress in implementing the JINR scientific programme in the first, starting year of the new seven-year plan, and major events in the activities of JINR and its international cooperation.

The Scientific Council heard the report “Status of the Factory of Superheavy Elements and its future prospects” by FLNR Director S. Dmitriev and the report “Progress of the NICA project” by VBLHEP Director V. Kekelidze.

The recommendations of the Programme Advisory Committees were reported by I. Tserruya (PAC for Particle Physics), M. Lewitowicz (PAC for Nuclear Physics), and D. L. Nagy (PAC for Condensed Matter Physics).

The Scientific Council heard two invited scientific reports: “The quest for phase transitions in strongly interacting matter” by Professor A. Rustamov and “Probing dense matter at NICA energies with dileptons: prospects and challenges” by Professor I. Tserruya. The Scientific Council also heard the best reports by young scientists as recommended by the PACs.

The award of the B. Pontecorvo Prize took place at the session, and diplomas to the winners of JINR prizes for the year 2016 were presented.

The election of the Director of BLTP was held, and vacancies of positions in the directorates of JINR Laboratories were announced.

General Considerations of the Resolution. The Scientific Council was pleased to note the important strategic plans for JINR to achieve new scientific and technological results of high significance in 2017–2023, in particular, in the process of realizing and launching the NICA megaproject and the Factory of Superheavy Elements (SHE), and in expanding the spectrometer complex of the IBR-2 reactor and the User Programme at this facility.

The Scientific Council highly appreciated the efforts undertaken by the JINR Directorate towards developing the Institute’s research infrastructure and integrating it into the European scientific landscape. It noted, in particular, the inclusion, in 2017, of the NICA accelerator complex and the SHE Factory in the NuPECC long-range plan “Perspectives in Nuclear Physics”.

The Scientific Council congratulated JINR on the inauguration of the names of the new superheavy elements moscovium, tennessine and oganesson synthesized at the Flerov Laboratory of Nuclear Reactions, which was held in Moscow on 2 March 2017.

The Scientific Council welcomed the signing of the new Agreement on cooperation between JINR and INFN, which took place in Moscow on 12 April 2017 in the presence of the President of the Italian Republic, S. Mattarella.

The Scientific Council emphasized the importance of the elaboration of JINR’s new strategic plan based on long-term future of the JINR Laboratories and wished to be informed about the strategic planning process and timeline.

The Scientific Council took note of the appointment of A. Sorin as Chief Scientific Secretary and B. Gikal as Chief Engineer of JINR. The Scientific Council thanked their predecessors, N. Russakovich and G. Shirkov, for their long-term successful work.

The Scientific Council was pleased to learn of the appointment of G. Trubnikov, Deputy Minister of Education and Science of the Russian Federation, as Plenipotentiary of the Government of the Russian Federation to JINR and wished him successful work in these two responsible positions.

Progress of the SHE Factory. The Scientific Council took note of the report by FLNR Director S. Dmitriev “Status of the Factory of Superheavy Elements and its future prospects”, noting with satisfaction that Phase 1 of construction of the SHE Factory had entered its final stage. Civil construction is planned to be completed at the end of 2017; a complete range of installation work for the DC-280 cyclotron, the new ECR ion source, and for the engineering systems is planned to be finished in December 2017; the installation and adjustment of the new gas-filled recoil separator GFS-2 is to be completed during November 2017 – June 2018; and first experiments are planned for the second half of 2018.

Given the high priority of the research work on the synthesis of superheavy elements and study of their properties, the Scientific Council recommended that the JINR and FLNR Directorates ensure the implementation of programmes on the further development of the SHE Factory (construction of new and upgrade of the existing physics instruments for the studies of chemical and nuclear properties of superheavy elements).

Progress of the NICA Project. The Scientific Council took note of the report by VBLHEP Director V. Kekelidze “Progress of the NICA project”, noting with satisfaction the very good progress in implementing this flagship project of JINR which has been recognized as an important element of the European research infrastructure.

The Scientific Council was pleased to note the successful development of the Nuclotron–NICA accelerator complex, including the recent production of polarized proton beams with the new source of polarized particles; was satisfied with the ongoing construction of the Booster, for which the electron cooling system was manufactured by the Budker INP (Novosibirsk) and delivered to JINR; and was also satisfied with the progress of civil construction for the collider. A large amount of work is being done by the BM@N and MPD collaborations to develop the detectors and their subsystems; efforts have been undertaken to enhance these collaborations by new participants. The Scientific Council looks forward to new results expected to be obtained with BM@N during the next, 55th run of the Nuclotron at the end of 2017.

On the whole, the Scientific Council commended the dynamic progress of the NICA project, encouraged further expansion of the international collaborations around the planned experiments, and expressed hope that the challenging work for the NICA complex would be successfully continued.

Scientific Reports. The Scientific Council highly appreciated the scientific reports “The quest for phase transitions in strongly interacting matter” and “Probing dense matter at NICA energies with dileptons: prospects and challenges” and thanked Professors A. Rustamov and I. Tserruya for their presentations inspiring new ideas and suggestions for the NICA physics programme.

Recommendations in Connection with the PACs. The Scientific Council took note of the recommendations made by the PACs at their meetings in June 2017 as reported at this session by I. Tserruya, Chairman of the PAC for Particle Physics, M. Lewitowicz, Chairman of the PAC for Nuclear Physics, and D. L. Nagy, member of the PAC for Condensed Matter Physics. The Scientific Council proposed that the JINR Directorate should take these recommendations into account in preparing the JINR Topical Plan of Research and International Cooperation for 2018.

Particle Physics Issues. The Scientific Council appreciated the significant progress achieved in the Nuclotron operation during Run 54, when a beam of polarized protons was accelerated for the first time, and the beginning of the commissioning of the Booster electron cooling. Sharing the PAC’s concern about the availability of sufficient manpower for the efficient Booster construction, the Scientific Council urged the JINR management to take corrective actions.

The Scientific Council welcomed the significant advance in the yoke construction for the MPD magnet and the ongoing efforts for the detector development, appreciating the progress and efforts toward defining the participation and commitments of groups from China and Mexico in the MPD experiment.

The Scientific Council was very pleased with the progress towards realization of the BM@N experiment and with the achievements in the recent runs with deuteron and carbon beams. Due to lack of manpower to analyze the data collected in these runs, the Scientific Council urged the project and laboratory management to undertake the necessary steps to attract external groups to the BM@N experiment. The Scientific Council was pleased with the proposal to extend the BM@N physics programme to “Probing Short-Range Correlations”, involving groups from Tel Aviv University, MIT, GSI, and CEA together with the BM@N collaboration. This is the first outside proposal to use the BM@N facility. It is a pioneering measurement that can only be performed at the Nuclotron and aims at studying short-range correlations in the carbon nucleus using inverse kinematics of a carbon beam incident on a hydrogen target.

The Scientific Council appreciated the work accomplished by the Machine Advisory Committee and Detector Advisory Committees for the MPD and BM@N experiments in assisting the realization of the Nuclotron–NICA project.

The Scientific Council supported the PAC’s recommendations on the approval of new projects and the continuation of ongoing projects in particle physics within the suggested time scales, as outlined in the PAC recommendations. It welcomed, in particular, the revised proposal for JINR’s participation in the COMPASS-II project but also supported the PAC’s request to take the necessary measures to significantly reduce the group size and the travel budget. A similar concern was expressed regarding JINR’s participation in the Daya Bay/JUNO project: it was recommended that the team and laboratory management reconsider whether the large manpower and corresponding large travel budget are justified.

Nuclear Physics Issues. The Scientific Council was impressed with the progress of work for the DC-280 cyclotron (Dubna cyclotron, K-factor 280), which is the central device of the Factory of Superheavy Elements (SHE). The cyclotron and all its subsystems are in the installation phase. The main cyclotron magnet has been mounted and magnetic measurements are completed. The ECR-type ion source (DECRIS-PM) is ready to be installed at the SHE Factory.

The manufacturing of the new gas-filled separator GFS-2 is under completion. Documentation for the new target unit designed for GFS-2 has been prepared, and a detection system for recording rare events of formation of superheavy elements with a high position and energy resolution is under development.

The Scientific Council looks forward to the completion of all installation work on schedule (December 2017) and to the commissioning of the cyclotron in the period from January to April 2018.

In order to meet the deadlines of the start-up and putting into operation of the SHE Factory, the PAC recommended that the JINR and FLNR Directorates ensure coordinated implementation of the schedule of civil construction, installation and commissioning work for the accelerator, separator, target and detector systems. The FLNR Directorate should focus on the preparation of day-one experiment, with special attention to be given to the timely provision of the SHE Factory complex with engineering and technical personnel. The Scientific Council also recommended that a careful quality control be ensured during the installation and commissioning of all SHE Factory components in order to guarantee the reliable operation of the facility at its optimal performance.

The Scientific Council was pleased with the start-up of the new fragment separator ACCULINNA-2 and welcomed the programme of first experiments to investigate ^{7}H, ^{13}Li, ^{17}Ne and ^{26}S decaying via $3n$, $4n$ and $2p$ emissions.

The Scientific Council supported the recommendations of the PAC for Nuclear Physics on extension of the TANGRA project "Design and development of the tagged neutron method for determination of the elemental structure of materials and nuclear reaction studies" and of the E&T&RM project "Study of deeply subcritical electronuclear systems and possibilities of their application for energy production, transmutation of radioactive waste and research in the field of radiation material science" until the end of 2019.

The Scientific Council noted the endorsement by the PAC of the final reports on the results obtained in the MEG-PEN, TRITON, and PAINUC experiments on the theme "Physics of Light Mesons" and supported the PAC's recommendation on the continuation of the participation in the upgraded MEG-II frontier experiment in the search for lepton flavour violation.

Condensed Matter Physics Issues. The Scientific Council took note of the results of the discussion, held at the meeting of the PAC for Condensed Matter Physics, of plans for the preparation of a concept for JINR's new neutron source replacing IBR-2 after the decommissioning of the reactor. The Scientific Council agreed that starting the strategic planning of a possible project for a new source is an important task and welcomed further follow-up of this activity by the PAC. The first step in the planning process should be a comprehensive paper containing a clear science case and identifying the specific added value of the future JINR neutron source within the global and the European neutron source landscapes as well as the realistic user needs. The Scientific Council appreciated the intention of the PAC to be involved in preparing this document, noting that, regarding the principal parameters of the new facility, already in the preliminary design phase attention should be paid to the needs of the scientific community.

The Scientific Council acknowledged the high quality of the implementation of the IBR-2 User Programme which made this basic JINR facility one of the world's leading open-access neutron sources. The successful operation of the IBR-2 User Programme and the enhancement of its performance through instrumentation upgrades is a prerequisite to a new JINR neutron source.

The Scientific Council supported the PAC's recommendations on the continuation of ongoing activities and the opening of new themes and projects in condensed matter physics and related fields, appreciating the scientific and technical results obtained. In particular, the Scientific Council welcomed the progress in upgrading the IBR-2 spectrometers and in developing the PTH sample environment system for the DN-12 diffractometer as well as recent achievements in the fields of Raman microscopy, development of novel semiconductor detectors for fundamental and applied research, positron annihilation spectroscopy, and radiobiology. Among new proposals considered by the PAC, the Scientific Council noted the development of a wide-aperture backscattering detector for the HRFD diffractometer and the designing of an additional sample environment system.

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: "Investigation of exotic states in light nuclei" and "Neurochemical alterations in central nervous system of rodents after exposure to different radiation modalities", and thanked the speakers: D. Janseitov (BLTP) and K. Belokopytova (LRB). The Scientific Council welcomed similar reports in the future.

Memberships of the PACs. As proposed by the JINR Directorate, the Scientific Council appointed D. L. Nagy (Wigner RCP, Budapest, Hungary) as Chairman of the PAC for Condensed Matter Physics and P. Mikula (INP, Řež, Czech Republic) as a new member of this PAC, each for a term of three years. The Scientific Council also appointed L. Musa (CERN, Geneva, Switzerland) as a new member of the PAC for Particle Physics for a term of three years.

Awards and Prizes. The Scientific Council congratulated Professors Yifang Wang (IHEP, Beijing, China), Soo-Bong Kim (Seoul National University, Korea), and Koichiro Nishikawa (KEK, Tsukuba, Japan) on the award of the B. Pontecorvo Prize, for their outstanding contributions to the study of the neutrino oscillation phenomenon and to the measurement of the θ_{13} mixing angle in the Daya Bay, RENO and T2K experiments. The Scientific Council thanked them for their excellent presentations.

The Scientific Council congratulated the winners of JINR annual prizes for best papers in the fields of scientific research, instruments and methods, and applied research.

Elections and Announcement of Vacancies in the Directorates of JINR Laboratories. The Scientific Council elected D. Kazakov as Director of the Bogoliubov Laboratory of Theoretical Physics for a term of five years. The Scientific Council thanked V. Voronov for his successful tenure as Director of this Laboratory.

The Scientific Council announced the vacancies of positions of Deputy Directors of BLTP and asked the Committee of Plenipotentiaries to allow the endorsement of appointments for these positions to be held at the 123rd session of the Scientific Council (February 2018).

The Scientific Council announced the vacancies of positions of the Director of the Dzhelepov Laboratory of Nuclear Problems and of the Director of the Flerov Laboratory of Nuclear Reactions. The elections will take place at the 124th session of the Scientific Council (September 2018).

MEETINGS OF THE JINR FINANCE COMMITTEE

A meeting of the JINR Finance Committee was held on 24–25 March. It was chaired by A. Zarubin, a representative of the Russian Federation.

The Finance Committee considered the report "Results of JINR activities in 2016. Plans for scientific activities for 2017" presented by JINR Director V. Matveev. The Committee took note of the scientific results achieved by the JINR international staff in 2016: the progress towards realization of the Nuclotron–NICA project, including the successful commissioning of the linear accelerator of heavy ions HILAC, the start of the assembly and testing line for superconducting magnets, as well as the record duration of the operation of the Nuclotron during its latest run; the progress in construction of the Factory of Superheavy Elements and in the installation of the DC-280 cyclotron with its major technological systems; the progress in implementation of the FLNP User Programme at the spectrometers of the IBR-2 research facility and the scientific results obtained with them.

The Finance Committee congratulated the Institute on the approval by IUPAC of the names of the new superheavy elements moscovium, tennessine and oganesson synthesized at FLNR.

Regarding the report "Implementation of the Seven-Year Plan for the Development of JINR for 2010–2016" presented by N. Russakovich, Chief Scientific Secretary of JINR, the Finance Committee took note of the information about the main scientific results obtained in implementing the seven-year plan and about its financial support.

Based on the report "Execution of the JINR budget in 2016" presented by S. Dotsenko, Chief Accountant of JINR, the Finance Committee recommended that the CP appeal to the Plenipotentiaries of the Governments of the JINR Member States which are in arrears with the payment of contributions to the JINR budget to take urgent measures for their repayment and in the future to ensure the timely delivery of contributions.

Regarding the report "Results of the meeting of the Working Group (WG) for JINR Financial Issues under the CP Chairman held on 23 March 2017" presented by S. Harizanova, Chairperson of the WG, the Finance Committee recommended that the CP take note of the report by the JINR Directorate concerning the draft texts of the "Rules of Procedure of the JINR Finance Committee", the "Rules of Procedure of the Committee of Plenipotentiaries of the Governments of the JINR Member States", and the "Regulation for the JINR Staff". It was also recommended that the JINR Directorate receive comments and suggestions from the Plenipotentiaries concerning the draft "Regulation for the JINR Staff" by 1 June 2017 so that all these drafts would be submitted for consideration by the Finance Committee and the CP in November 2017.

The Finance Committee recommended that the CP support the position of the JINR Directorate that funds for grants and cooperation programmes should only be allocated after the Member State has paid its contribution to the budget and that the CP consider the issue of rotation of members of the WG for JINR Financial Issues under the CP Chairman.

Based on the report "Results of the meeting of the Working Group to develop proposals towards the redemption of Ukraine's arrears in the payment of its contributions to the JINR budget" presented by WG Chairperson S. Harizanova, the Finance Committee recommended that the CP suspend, beginning in 2017, the increase of the arrears of Ukraine in the payment of its contribution to the JINR budget due to force majeure, defer the consideration of the issue of Ukraine's arrears to the CP session in March 2018, appeal to the Ministry of Foreign Affairs of Ukraine to ensure the participation of Ukraine's official representative in the meetings of the Finance Committee and in sessions of the CP, and commission the WG and the JINR Directorate to study the possibility of holding a visiting meeting in Ukraine.

Regarding the report "Selection of a company for auditing the financial activities of JINR for the year 2016" presented by JINR Vice-Director R. Lednický, the Finance Committee approved the plan for auditing the financial activities of JINR for 2016. It recommended that the CP approve the LLC AC "Korsakov and Partners" as JINR's auditor for the year 2016 and authorize it to conduct an audit of the Institute's financial activities for the specified period.

The Finance Committee heard with interest the report "Activity of the JINR Science and Technology Council (STC)" presented by R. Jolos, Chairman of the STC, endorsing the efforts being taken by this Council to involve JINR research teams in discussing the implementation of plans and measures to improve the efficiency of the Institute.

A meeting of the JINR Finance Committee was held in Dubna on 21–22 November. It was chaired by S. Harizanova, a representative of the Republic of Bulgaria.

The Finance Committee heard the report "Plans of research activities for 2018" presented by JINR Director V. Matveev, took note of the information on the implementation of the plan of research and international cooperation in the starting year of the Seven-Year Plan for the Development of JINR (2017–2023) as well as of the priorities of JINR activities proposed for 2018. Noting the importance for JINR to elaborate a new strategic plan for the long-term development of the JINR Laboratories, the Finance Committee requested the JINR Directorate to present regular information on the work in this direction.

The Finance Committee took note of the signing of the new Agreement on cooperation between JINR and INFN, which took place in Moscow on 12 April 2017 in the presence of the President of the Italian Republic, S. Mattarella; welcomed the decision taken by the Government of the Russian Federation on 23 August 2017, by which JINR received the right to confer academic degrees.

Based on the report "Draft budget of JINR for the year 2018, draft contributions of the Member States for the years 2019, 2020, and 2021" presented by JINR Chief Accountant S. Dotsenko, the Finance Committee recommended that the CP approve the JINR budget for the year 2018 with the total expenditure amounting to US$207.24 million as well as the scale of contributions, the contributions, and the payment of contribution arrears of the Member States for 2018.

The Finance Committee recommended that the CP determine the provisional volumes of the JINR budget in income and expenditure for the year 2019 amounting to US$205.68 million, for the year 2020 amounting to US$208.57 million, for the year 2021 amounting to US$212.58 million as well as the provisional amounts of the Member States' contributions for the years 2019, 2020, and 2021.

The Finance Committee recommended indexing the salary and tariff parts of the compensation package of the staff members, taking into account the possibilities afforded by the JINR budget in 2018, in accordance with the JINR Collective Bargaining Agreement for 2017–2020.

Regarding the report "Progress of implementing the NICA complex project and proposals for spending the special-purpose funds allocated by the Russian Federation in accordance with the Agreement between the Government of the Russian Federation and the international intergovernmental scientific research organization — the Joint Institute for Nuclear Research on the construction and exploitation of the NICA complex of superconducting rings for heavy-ion colliding beams, dated 2 June 2016" presented by VBLHEP Director V. Kekelidze and JINR Vice-Director R. Lednický, the Finance Committee recommended that the CP take note of the ongoing implementation of the NICA complex project in accordance with the Seven-Year Plan for the Development of JINR (2017–2023) and the Agreement; agree with the proposal of the NICA project management on the use for the year 2018 of the special-purpose funds of the Russian Federation in the total amount of 5 600.0 million rubles, allocated in accordance with the Agreement; also agree with the provisional volumes of expenditures for the year 2019 — 1 500.0 million rubles and for the year 2020 — 970.0 million rubles, with a possibility for its adjustment.

The Finance Committee recommended that the CP commission the JINR Director to submit, to the meeting of the Supervisory Board of the NICA complex project, JINR's proposals for financing the work on the construction of the NICA accelerator complex at the expense of the special-purpose funds of the Russian Federation and also at the expense of the funds planned in the JINR budget, and to take control of the use of these funds.

Noting that prior to the signing of the Agreement, in 2013–2015, work was performed on a number of objects of the basic configuration of the NICA complex in the amount of 2 800.0 million rubles using budgetary funds of JINR, the Finance Committee agreed with the change in the cost of individual objects of the NICA while maintaining the total costs for the basic configuration of the NICA complex specified in the Agreement, and confirmed that the funds for implementation of JINR's obligations by the Agreement are envisaged in JINR's long-term financial plans.

Regarding the report "Results of the meeting of the JINR Finance Committee held on 21–22 November 2017" presented by A. Khvedelidze, Chairman of the Working Group under the CP Chairman for JINR Financial Issues, the Finance Committee recommended that the CP take note of the information by the JINR Directorate on the current work on the Regulation for the JINR staff, commission the Directorate to involve experts in the field of international law in the work on this Regulation, to prepare a draft road map for the work on the Regulation, taking into account the proposals made by the Plenipotentiaries and by the national groups of employees from the Member States, and to forward it to the members of the Working Group by 1 February 2018.

Regarding the report "Results of the audit of the JINR financial activities for the year 2016" presented by D. Korsakov, Director of the audit company "Korsakov and Partners", the Finance Committee recommended that the CP approve the Accounting report of JINR and the auditors' report, take note of the plan of measures in connection with the audit concerning the JINR financial activities for 2016, and commission the Directorate to prepare comments to the auditors' report by the next CP session (March 2018).

Regarding the report "Analysis of application of the Regulation for the Procurement Activities of JINR" presented by N. Kalinin, Head of the Internal Audit Service, the Finance Committee recommended that the CP take note of the information presented.

The Finance Committee heard with interest the report "Synchrotron radiation in modern scientific research" presented by N. Kučerka (FLNP).

The Finance Committee recommended that the CP take note of the initiative of the JINR Directorate and of the Republic of Poland about intentions to jointly establish a Laboratory for Structural Research of Macromolecules and New Materials at the SOLARIS National Synchrotron Radiation Centre of the Jagiellonian University in Kraków (Poland).

The 46th meeting of the Programme Advisory Committee for Particle Physics took place on 16–17 January. It was chaired by Professor I. Tserruya.

JINR Vice-Director R. Lednický informed the PAC about the Resolution of the 120th session of the Scientific Council (September 2016) and the decisions of the Committee of Plenipotentiaries (November 2016).

The PAC was very pleased with the progress towards realization of the Nuclotron–NICA project: the successful commissioning of the linear accelerator of heavy ions HILAC, the preparations for the Booster construction, the official start of the assembly and testing line for superconducting magnets, and the progress in the civil construction work of the collider building. The PAC was also pleased to note that a beam of polarized deuterons had been accelerated during the 53rd Nuclotron run for the first time after a hiatus of 15 years and delivered to the experiments with a polarization up to 60% and an intensity up to $7 \cdot 10^8$ ions. The PAC also noted that this run had a record duration of 1412 h of stable operation.

The PAC highly appreciated the ongoing efforts for the preparation of the technical design reports for the different subsystems foreseen in Stage 1 of the MPD detector as well as the progress in the preparations for mass production of detector elements. The Committee congratulated the MPD management on the progress in attracting new outside collaborators and encouraged further efforts. The PAC was satisfied with the commissioning of the internal GEM-tracker of the BM@N detector and congratulated the team on the first successful run with a set-up that included all subsystems in which significant statistics was collected to address various methodological and detector issues. The PAC was concerned about the half-a-year delay in the project realization that resulted also from the low availability of beam test.

The PAC was satisfied with the progress towards development of the COMET experiment at J-PARC. The participants from JINR had made important technical contributions to the straw-tube detector and to the COMET calorimeter. The PAC recommended approval of the continuation of this project for three years, encouraging the team to take active roles in physics analyses. Also, the Committee considered written reports on the projects approved earlier until the end of the previous seven-year plan and recommended the continuation of the projects ALPOM-2, HADES, STAR, NA62 and "New accelerators" for the periods requested in their initial proposals.

The PAC took note of the new project on JINR's participation in the fixed target NA64 experiment at the CERN SPS aimed at searches for physics beyond the Standard Model, and recommended its approval until the end of 2019.

Two proposals were presented at the PAC meeting for JINR's participation in the COMPASS experiment. The PAC realized the important role of the JINR group in data taking, detector maintenance, physics analysis, as well as the potential synergy with future involvement in the NICA/SPD experiment. However, the PAC considered it unjustified to have two different JINR groups participating in the same experiment and recommended that they resubmit one single proposal, outlining the JINR strategy and goals for the next three years of the COMPASS-II experiment. This proposal should include the following specific information: number of participants, COMPASS authors, PhD students, engineers, and a list of all the physics analyses they propose to carry out. In addition, as far as the travel expenses are concerned, the group should provide justification for the large amount of about 200 k$ requested per year. Last, the R&D activities in view of the detector upgrade should be better described, keeping in mind that the PAC has not yet discussed any future COMPASS-III project and any possible impact on the SPD experiment.

The PAC took note of the reports from the JINR groups participating in the LHC experiments. The Committee appreciated the results from the module testing of the electromagnetic calorimeter PHOS ALICE, the search for pentaquarks in Λ_b decays in the ATLAS experiment, and the study of muon pair production in the CMS experiment.

The PAC heard the following scientific reports "JINR neutrino programme. Daya Bay and JUNO: precision measurements with reactor neutrinos" and "Electromagnetic and gravitational effects for spin dynamics in accelerators" presented by M. Gonchar and A. Silenko, respectively.

The PAC reviewed 26 poster presentations in particle physics by young scientists from DLNP, VBLHEP, and LIT. It was very pleased with the large number of posters presented and with their overall very good quality. The PAC selected the poster "Multimedia exhibition 'Main facilities at JINR'" presented by N. Sidorov and the poster "Charmonium-like states at COMPASS" presented by A. Gridin to be reported at the session of the Scientific Council in February 2017.

The 45th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 19–20 January. It was chaired by Professor V. Kantser.

The Chairperson of the PAC presented an overview of his report delivered at the session of the JINR Scientific Council in September 2016 concerning the implementation of the recommendations of the previous PAC meeting.

JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 120th session of the JINR Scientific Council (September 2016) and the decisions of the JINR Committee of Plenipotentiaries (November 2016).

The PAC heard with much interest a report by V. Aksenov "A 15-year forward look at neutron facilities at JINR" with the scientific rationale for an idea to develop a new neutron source for JINR. Since the construction of a neutron source takes significant time, the PAC found it timely to consider a proposal for a new facility at the moment. At the same time, the PAC noted the urgency of addressing a number of issues such as mobilizing a large scientific community for the development of a new source, considering complementarity and competitiveness with other neutron sources to be available after 2032 both in Russia and elsewhere in Europe, clarifying ideas on the instruments and novel technologies to be used at the new source, and identifying the relevant user community both at JINR and outside. Considering the idea of constructing a new neutron source at JINR to be an important and urgent task, the PAC recommended that the FLNP Directorate start preparing a proposal for considering the development of a new neutron facility to be presented at the next meeting of this PAC. The PAC also suggested that a proposal for the development of a new neutron facility be submitted to the Committee for Long-Term Strategy Planning being currently established at JINR. As additional matter to be discussed at the next meeting, the PAC requested information on the new SOLARIS synchrotron source in Kraków (Poland) and on possible cooperation with JINR in this direction.

The PAC appreciated highly the scientific results achieved at IBR-2 instruments in 2016 and reported by D. Kozlenko. It also welcomed the recent instrumentation developments at the reactor, which will increase the quality and level of forthcoming studies, will extend the research areas and will provide more attractive conditions for the IBR-2 user community. The PAC was pleased with the progress of implementation of the FLNP User Programme at the IBR-2 spectrometers and supported its further development.

The PAC heard a series of reports on themes and projects. Recognizing the new scientific results in the field of information technology, the PAC recommended extension of these activities in the next three years within the theme "Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data" as reported by Gh. Adam. Noting the recent achievements of the JINR University Centre in the development of the JINR educational programme, the PAC proposed continuation of this work within the theme "Organization, Support and Development of the JINR Educational Programme" as reported by S. Pakuliak. Based on the report by Yu. Panebrattsev on the concluding project "Development of modern education programmes", the PAC noted its successful implementation and recommended opening a new one — "Development of an open educational environment to support research priorities in materials science and structure of matter" for the next three years.

The PAC was informed on a number of scientific meetings, schools and training courses which took place at JINR. In particular, the PAC noted the report by O. Belov on plans for the development of applied research at the NICA complex discussed at the International Workshop on Biophysics and Materials (12–13 December 2016, Dubna). It was pleased with the information about the III International Conference on Small-Angle Scattering Dedicated to the 80th Anniversary of Yu. Ostanevich (6–9 June 2016, Dubna) and the 7th International Scientific School for Young Scientists and Students "Instruments and Methods of Experimental Nuclear Physics. Electronics and Automatics of Experimental Facilities" (7–11 November 2016, Dubna) presented by A. Kuklin and E. Litvinenko, respectively. The PAC also heard a report by M. Balasoiu on the student training course "Advanced Material Studies by Neutron Scattering Methods" (27 August – 4 September 2016, Dubna) and noted the great interest shown in it by Romanian universities (West University of Timişoara and Ovidius University of Constanţa).

The PAC thanked the speakers of the following scientific reports in condensed matter physics and related fields: "Numerical investigation of vesicular systems and pion–nucleus scattering within the asynchronous differential evolution method" (E. Zemlyanaya), "Spin dynamics in compounds with intermediate valence: comparison of inelastic scattering results to ab initio theory" (E. Goremychkin), and "Forecasting the NICA complex radiation environment" (G. Timoshenko).

The PAC selected the poster "Simulation of radiation damage to different neuronal structures with Geant4-DNA toolkit" by L. Bayarchimeg as the best poster at the session. It also noted two other high-quality posters: "Asymmetric track-etched single nanopores for use in the sensor technology" by K. Olejniczak and "Approach on developing a heterogeneous computing cluster in terms of the HybriLIT cluster" by M. Matveev. The authors of these papers will receive diplomas at the next meeting.

In the general discussion, the PAC discussed the possibility of including one or two of its members in the Committee for Long-Term Strategy Planning being currently established at the Institute. The PAC also endorsed the final draft of the Regulation for the JINR Programme Advisory Committees for approval by the Scientific Council and the guidelines for the preparation of projects and their evaluation by the PACs. It was noted that the general items of these guidelines had also been accepted by the other PACs — for Particle Physics and Nuclear Physics.

The 45th meeting of Programme Advisory Committee for Nuclear Physics was held on 25–26 January. It was chaired by Professor F. Piquemal.

F. Piquemal 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 120th session of the Scientific Council (September 2016) and the decisions of the Committee of Plenipotentiaries (November 2016).

The PAC heard a report on the support of young scientists at JINR presented by V. Chudoba. Noting the importance of work for attracting and training young scientists at the Institute, the PAC strongly supported the policy of the JINR Directorate in this direction. The PAC recommended that the Directorate extend the training PhD programme for all the Member States and Associate Member States. It also recommended that a postdoctoral fellowship programme be implemented at JINR in order to address the growth of early-career researchers.

The PAC heard a report on the theme "Physics of Light Mesons" presented by A. Kulikov and recommended its approval, noting particularly the significant results obtained in the terminated project SPRING. The accomplished studies of polarized proton and deuteron interactions with the jet polarized targets have produced numerous new data about hadron interaction dynamics through the measurement of spin observables. The PAC also noted the success in the TRITON and MEG experiments. In the TRITON experiment at the DLNP Phasotron, the studies of muon catalysis in a fusion reaction in the $pt\mu$ system were concluded in 2016. Two successful runs were carried out and all three known reaction channels were detected (from which the channel e^+e^- had not been observed before), and a new channel with emission of two gammas was discovered. Measurements were performed with different concentrations of tritium and in two different detector geometries. In the MEG experiment, a new upper limit of the neutrinoless decay $\mu \rightarrow e\gamma$ was established at $4.2 \cdot 10^{-13}$ and published in 2016. MEG is now continued as MEG-II aiming at a 10 times reduced upper limit of the decay.

The PAC recommended extension of the theme "Physics of Light Mesons" until the end of 2017 in order to complete all the studies and activities within this theme. The PAC recommended that the DLNP Directorate provide funding for the GDH&SPASCHARM project until the end of 2019 and present information about this at the next meeting of the PAC. The PAC recommended continuation of the $\mu \rightarrow e\gamma$ search in the MEG-II project. The PAC looks forward to hearing final reports on the results obtained in the MEG-PEN, PAINUC and TRITON experiments.

The PAC heard a report presented by S. Dmitriev on the status of construction of the Factory of Superheavy Elements (SHE). The PAC appreciated the progress in the installation of the DC-280 cyclotron and its major technological systems. In accordance with the schedule, the accelerator commissioning will start in December 2017. The PAC recommended that the FLNR Directorate take all necessary measures to ensure the launch of the SHE Factory as scheduled. A more detailed presentation of the cyclotron, ion source, high-power target and detection system developments for the SHE Factory should be presented at the next PAC meeting.

The PAC took note of the report presented by N. Russakovich on the main directions of research planned at JINR for 2017–2023. The PAC wished the JINR Directorate and staff success in implementing this ambitious plan.

The PAC heard the following scientific reports: "JINR neutrino programme. Baikal neutrino experiment: towards high-energy neutrino astronomy" and "Cluster approach to the structure of heavy nuclei" presented by B. Shaibonov and T. Shneidman, respectively.

The PAC appreciated the high quality of presentations of new results and proposals by young scientists in the field of nuclear physics research. The best posters selected were "Fusion reactions with light neutron-rich nuclei: a pathway to synthesize new heavy nuclei" presented by V. Rachkov, "Chemical investigation of the superheavy elements Cn and Fl: kinetic studies on the Hg–Se interaction using inverse thermochromatography" presented by A. Madumarov, and "SHELS (Separator for Heavy ELement Spectroscopy)" presented by A. Kuznetsova. The PAC recommended the poster "Fusion reactions with light neutron-rich nuclei: a pathway to synthesize new heavy nuclei" for presentation at the session of the Scientific Council in February 2017.

The members of the PAC visited VBLHEP to get acquainted with the implementation of the NICA project.

The 46th meeting of Programme Advisory Committee for Nuclear Physics was held on 14–15 June. It was chaired by Professor M. Lewitowicz.

The Chairman 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 121st session of the Scientific Council (February 2017) and the decisions of the Committee of Plenipotentiaries (March 2017).

The PAC heard reports on the status of the Factory of Superheavy Elements (SHE Factory) presented by I. Kalagin, S. Bogomolov, and A. Popeko, and appreciated the high pace of the installation and commissioning work of their subsystems. In order to meet the deadlines of the start-up and putting into operation of the SHE Factory, the PAC recommended that the JINR and FLNR Directorates ensure coordinated implementation of the schedule of civil construction, installation and commissioning work for the accelerator, separator, target and detector system, as well as ensure a careful quality control during the installation and commissioning of all mentioned SHE Factory components in order to guarantee the reliable operation of the facility at its optimal performance. The PAC also recommended that the FLNR Directorate focus on the preparation of first-day experiment. Special attention should be given to the timely provision of the SHE Factory complex with engineering and technical personnel.

The PAC heard a report on the progress in commissioning and preparing first-day experiments at the new fragment separator ACCULINNA-2 presented by A. Fomichev. The start-up of this fragment separator was carried out in March 2017. The design parameters of the setup were experimentally confirmed. The collaboration proposed that the first experiments would investigate ^{7}H, ^{13}Li, ^{17}Ne, and ^{26}S decaying via the $3n$, $4n$ and $2p$ emission. The PAC endorsed the presented programme of the first experiments at the ACCULINNA-2 fragment separator, awaiting a report on their results at future meetings of the PAC.

The PAC heard a proposal for the extension of the project "Design and development of the tagged neutron method for determination of the elemental structure of materials and nuclear reaction studies (project TANGRA)" presented by Yu. Kopatch. The PAC noted the successful realization of the first stage of the project during 2014–2016, the expansion of the list of its participants, as well as the balanced research programme for 2017–2019. The PAC recommended extension of the TANGRA project until the end of 2019.

The PAC heard a report on the project "Study of deeply subcritical electronuclear systems and possibilities of their application for energy production, transmutation of radioactive waste and research in the field of radiation material science. Quasi-infinite target (project E&T&RM)" presented by V. Wagner. The PAC noted the large amount of work carried out by the authors of the project to develop methods for studying the main nuclear physics parameters of the uranium assembly "Quinta" (neutron field, plutonium production time, energy yield of the assembly, transmutation rates of minor actinides). The PAC recommended extending the work on this project until the end of 2019. More detailed recommendations on this topic will be formulated at the next PAC meeting.

The PAC heard reports on the results obtained in the PEN-MEG, TRITON, and PAINUC experiments within the theme "Physics of Light Mesons". The PAC endorsed the final reports on the results obtained in these projects, suggesting that the participation in the upgraded MEG-II frontier experiment in the search for lepton flavour violation should be continued.

The PAC heard the following scientific reports: "Dipole toroidal resonance: vortical properties, anomalous deformation splitting, relation to pygmy mode" and "Search for spatial parity violation effects in reactions of cold polarized neutrons with lightest nuclei" presented by V. Nesterenko and P. Sedyshev, respectively.

The PAC appreciated the high quality of presentations of new results and proposals by young scientists in the field of nuclear physics research. The best posters selected were "Investigation of exotic states in light nuclei" presented by D. Janseitov and "Impact of tensor interaction on β-delayed neutron emission in neutron-rich Ni isotopes" presented by E. Sushenok. The PAC recommended the poster "Investigation of exotic states in light nuclei" for presentation at the session of the Scientific Council in September 2017.

The members of the PAC visited FLNR to get acquainted with the progress in construction of the Factory of Superheavy Elements.

The 46th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 19–20 June. It was chaired by Professor D. L. Nagy.

The members of the PAC commemorated Academician V. Kantser who had made outstanding contributions to the development of JINR, its international cooperation, and to the successful activity of the PAC for Condensed Matter Physics which he chaired during 2008–2017.

The Chairman of the meeting D. L. Nagy presented an overview of the implementation of the recommendations of the previous PAC meeting. JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 121st session of the JINR Scientific Council (February 2017) and the decisions of the JINR Committee of Plenipotentiaries (March 2017).

The PAC heard with interest a report on the plan for the preparation of a concept for JINR's new neutron source presented by A. Vinogradov. In parallel to the growing need for neutrons in modern sciences, the PAC noted that the number of neutron sources decreases worldwide. In this regard, the PAC considered starting the strategic planning of a possible project for JINR's new neutron source replacing IBR-2 after reactor shut-down to be an important task and took note of the presented plan for its implementation. The PAC also heard a report on user demands to the parameters of a future neutron source at JINR presented by N. Kučerka. The PAC appreciated the attention being given to the needs of the scientific community regarding the principal parameters of the new source already in the preliminary design phase.

The PAC recommended that the JINR Directorate start the strategic planning process of a potential new neutron source at JINR after the IBR-2 reactor shutdown, starting with the preparation of a comprehensive paper containing a clear science case and identifying the specific added value of the future JINR neutron source within the global and the European neutron source landscape as well as the realistic user needs. The PAC offered its involved contribution to preparing this document, noting that a prerequisite to a new neutron source is the continued successful operation of the

IBR-2 User Programme and enhancement of its performance through instrumentation upgrades.

The PAC heard a number of reports on concluding themes and projects. Recognizing the significant progress achieved in the development of the IBR-2 spectrometer complex, the broad cooperation with Member States, and the special importance of implementation of the User Programme, the PAC recommended extension of these activities within the theme "Investigations of Condensed Matter by Modern Neutron Scattering Methods" reported by D. Kozlenko. Endorsing the implementation of additional sample environment facilities at the IBR-2 reactor, the PAC supported the opening of a new project "A system for neutron *operando* monitoring and diagnostics of materials and interfaces for electrochemical energy storage devices at the IBR-2 reactor" reported by M. Avdeev. Appreciating the results obtained within the concluding theme "Development of Experimental Facilities for Condensed Matter Investigations with Beams of the IBR-2 Facility" as reported by S. Kulikov, the PAC recommended extension of the theme. The PAC considered it reasonable to extend the project "Development of PTH sample environment system for the DN-12 diffractometer at the IBR-2 facility" being performed within this theme in order to resolve the situation with the supplier of the high-temperature superconducting tape, which characteristics proved to be different from those specified in the Manufacturer's Certificate. Within the same theme, the PAC recommended opening a new project "Development of a wide-aperture backscattering detector (BSD) for the HRFD diffractometer", recognizing that its implementation would significantly increase the HRFD detector solid angle coverage, improve gamma/neutron discrimination, and enhance diffractometer's capabilities. Noting the progress in the development of the concluding theme "Multimodal Platform for Raman and Nonlinear Optical Microscopy and Microspectroscopy for Condensed Matter Studies", the PAC recommended opening a new theme "Modern Trends and Developments in Raman Microspectroscopy and Photoluminescence for Condensed Matter Studies" and project "Ultrasensitive SECARS microspectroscopy and luminescent core-shell nanostuctures" as reported by G. Arzumanyan. Considering the report on the concluding theme and project "Research on the Biological Effect of Heavy Charged Particles with Different Energies" presented by E. Krasavin, the PAC recommended its extension. Reviewing the proposal for extending the theme and project "Novel Semiconductor Detectors for Fundamental and Applied Research" presented by S. Kotov, the PAC found it to be aimed at the applied use of products of fundamental research and endorsed it. Noting the progress in the development of the PAS method at the LEPTA facility including construction of a specialized channel of slow monochromatic positrons, the PAC recommended further extension of the project "Experiment technology development and applied research with slow monochromatic positron beams (project PAS)" as reported by P. Horodek.

As a common issue, the PAC acknowledged the high level of the implementation of the IBR-2 User Programme which has made this basic facility of JINR one of the world's leading open-access research infrastructures.

The PAC heard with interest the following scientific reports in condensed matter physics and related fields: "Fermi surface reconstruction in underdoped cuprates", "Magnetic phenomena in intermetallic compounds RCo_2: studies of the limits of the itinerant electron metamagnetism concept" and "Simulation of damage threshold and structure in swift heavy-ion tracks in Al_2O_3", and thanked the speakers E. Kochetov, S. Kichanov, and R. Rymzhanov, respectively.

The PAC reviewed poster presentations by young scientists in the field of radiation biology and took note of the summarizing report by O. Belov. The PAC selected the poster "Neurochemical alterations in central nervous system of rodents after exposure to different radiation modalities" by K. Belokopytova as the best poster at the session. It also noted two other high-quality posters: "Structure induction and repair of DNA double-strand breaks in hippocampal neurons of mice of different age after exposure to ^{60}Co γ rays *in vivo* and *in vitro*" by R. Kozhina and "Microfossils in carbonaceous meteorites" by A. Ryumin.

The 47th meeting of the Programme Advisory Committee for Particle Physics took place on 26–27 June. It was chaired by Professor I. Tserruya.

JINR Vice-Director R. Lednický informed the PAC about the Resolution of the 121st session of the JINR Scientific Council and the decisions of the JINR Committee of Plenipotentiaries.

The PAC was very pleased with the progress towards realization of the Nuclotron–NICA project — the beginning of the commissioning of the Booster electron cooling and preparations for the Booster construction. The PAC expressed concern about the availability of sufficient manpower for the efficient Booster construction and urged the JINR management to take corrective actions. The Committee appreciated the significant progress in the Nuclotron operation achieved during Run 54: a beam of polarized protons was accelerated for the first time in the Nuclotron, all requests from the beam users were satisfied including a beam of carbon nuclei for the BM@N experiment and a beam of polarized deuterons for the ALPOM-2 experiment. The PAC was pleased to learn that the closed circulating water system for the VBLHEP cryogenic complex is now operational, making possible the non-stop testing of the superconducting magnets.

The PAC welcomed the advance in the yoke construction for the MPD detector's magnet. It also appreciated the progress and efforts towards defining the participation and commitments of groups from China and Mexico in the MPD experiment.

The PAC noted progress towards realization of the BM@N project and acknowledged the results of the experiment in recent runs with deuteron and carbon beams. The PAC recommended approval of the proposal "Probing Short-Range Correlations" which extends the BM@N physics programme and involves groups from Tel Aviv University, MIT, GSI, and CEA. This is the first outside project proposal to use the BM@N facility. It is a pioneering measurement that can be performed only at the Nuclotron and aims at studying short-range correlations in the carbon nucleus using inverse kinematics of a carbon beam incident on a hydrogen target.

The PAC took note of the JINR participation in the NA61 experiment, which is expected to complete the data-taking phase in 2018, and recommended its continuation until the end of 2018. Continuation of the JINR team activities within NA61 on data analysis or R&D beyond 2018 would require submitting a new proposal.

At the previous meeting, the PAC recommended resubmitting revised proposal for the COMPASS-II experiment and requested detailed information about the project organization, manpower involved, and corresponding expenses. The Committee was pleased to note that the two groups from VBLHEP and DLNP laboratories had merged and presented a common proposal with a well-defined management structure, strategy and objectives. The PAC requested the team and laboratory management to take the necessary measures to significantly reduce the group size and the travel budget. In order to avoid any further delays in the approval process, the PAC recommended continuation of the participation of the JINR group in the COMPASS-II experiment until the end of 2020.

The PAC appreciated the efforts and scientific achievements of the JINR team in the Daya Bay and JUNO experiments, recognizing that work on the JUNO PMT system must have first priority as the flagship hardware contribution from JINR. The PAC recommended continuation of JINR's participation in the Daya Bay/JUNO project until the end of 2020. The PAC also recommended the team and laboratory management to reconsider whether the large manpower and corresponding large travel budget are justified.

The PAC noted the important and visible contributions from the JINR group in the NOνA project since the start of the experiment in 2014. The relatively young group was able to substantially contribute to the data taking via a virtual control room organized in Dubna. Taking into account the high potential of the NOνA experiment and the broad scope of the JINR involvement, the PAC recommended continuation of this activity until the end of 2020.

The PAC recommended continuation of the JINR participation in the Mu2e and Muon g–2 experiments at Fermilab until the end of 2020. The JINR group has made significant contributions to the muon beam facility and the detectors and is playing a visible and important role in both experiments.

The PAC noted the importance of the JINR obligations in the TAIGA collaboration, which can make a significant contribution to the understanding of the origin of cosmic rays, and recommended extension of the project until the end of 2020.

The PAC took note of the reports "Search for muon-to-electron conversion: the Mu2e experiment at Fermilab" presented by J. Miller and "Weak decays of B mesons in the light of the search for new physics" presented by M. Ivanov and thanked the speakers.

The PAC reviewed 12 poster presentations in particle physics by young scientists from DLNP and VBLHEP. The Committee selected the poster "The TUS space experiment" presented by M. Lavrova to be reported at the session of the Scientific Council in September 2017. The PAC recommended the management of laboratories to consider the possibility of presenting the young scientists' work using multimedia presentation of a maximal three-minute duration in addition to static posters.

PRIZES AND GRANTS

The ***B. Pontecorvo Prize*** was awarded to Professors G. Fogli (University and INFN, Bari, Italy) and E. Lisi (INFN, Bari, Italy) for their pioneering contribution to the development of global analysis of neutrino oscillation data from different experiments.

JINR PRIZES FOR 2017

I. Theoretical Physics Research

First Prizes

1. "Pseudotoric Structures: Lagrangian Tori and Lagrangian Fibrations".
Author: N. Tyurin.

2. "Spin Dynamics in Arbitrary Gravitational and Electromagnetic Fields".
Authors: Yu. Obukhov, A. Silenko, O. Teryaev.

3. "Strong Electron Correlations in Underdoped High-Temperature Superconductors".
Authors: A. Ferraz, I. Ivantsov, E. Kochetov, M. Maśka, M. Mierzejewski.

II. Experimental Physics Research

First Prize

"Delayed Neutron Emission of Exotic Nuclei".
Authors: D. Testov, Yu. Penionzhkevich, E. Sokol, E. Kuznetsova, V. Smirnov, M. Ivanov, A. Severyukhin, D. Verney, F. Ibrahim.

Second Prize

"Search for $2p$ Decay of the First Excited State of ^{17}Ne(3/2$^-$)".
Authors: A. Bezbakh, R. Wolski, M. Golovkov, S. Krupko, Yu. Parfenova, S. Sidorchuk, R. Slepnev, G. Ter-Akopian, A. Fomichev, P. Sharov.

III. Physics Instruments and Methods

First Prize

"Development and Construction of Gas-Filled Detectors Based on a New Type of Straw Tubes for Operation in Vacuum into a Track Spectrometer of the NA62 Experimental Setup".
Authors: L. Glonti, H. Danielsson, T. Enik, V. Kekelidze, A. Kolesnikov, D. Madigozhin, S. Movchan, Yu. Potrebenikov, V. Samsonov, S. Shkarovskiy.

Second Prize

"Structure of Deterministic Mass, Surface and Multiphase Fractals: Theory and Methods of Analysing the Intensity of Small-Angle Scattering".
Authors: A. Cherny, E. Anitas, V. Osipov, A. Kuklin, M. Balasoiu.

IV. Applied Physics Research

First Prizes

1. "Development and Construction of the Permanent Magnet ECR Ion Source, DECRIS-PM, for the DC-280 Cyclotron".
Authors: V. Bekhterev, S. Bogomolov, A. Bondarchenko, A. Efremov, K. Kuzmenkov, A. Lebedev, V. Loginov, V. Mironov, N. Yazvitsky, N. Konev.

2. "Construction of a Facility for Assembling and Testing Superconducting Magnets, Investigation of the Characteristics of Magnets".

Authors: N. Agapov, V. Borisov, A. Galimov, A. Donyagin, V. Karpinskiy, V. Kekelidze, S. Kostromin, D. Nikiforov, G. Trubnikov, H. Khodzhibagiyan.

Encouraging Prizes

1. "Study of Ultracold Neutron Diffraction by a Moving Grating".

Authors: G. Kulin, A. Frank, S. Goryunov, D. Kustov, A. Bushuyev, P. Geltenbort, M. Jentschel, A. Panzarella.

2. "Determination of the Decay Time of Scintillators and Investigation of Space Correlation of Nuclear Radiation by the Autocorrelation Method".

Authors: V. Morozov, N. Morozova, V. Zlokazov.

3. "Investigation of the Nonlinear Dynamics of Waves in the Terahertz Frequency Range in Condensed Media and Living Systems".

Author: A. Bugay.

4. "Monte-Carlo Simulation of Neutron Spectrometers and Neutron Scattering Experiments".

Authors: A. Belushkin, S. Manoshin, V. Bodnarchuk, A. Joffe.

GRANTS

In 2017, 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 Belarusian Republican Foundation for Basic Research (BRFBR), and the Foundations of the RF Ministry of Education and Science.

RFBR financed JINR projects in the framework of the following competitions: "Competition of Projects of Fundamental Scientific Research" (25 projects); "Competition of Projects Accomplished by Young Scientists (My First Grant)" (1 project); "Competition of Projects Accomplished by Young Scientists under the Guidance of Candidates and Doctors of Science in RF Scientific Institutions" (5 projects); "Competition of Fundamental Oriented Research in Urgent Interdisciplinary Topics" (3 projects).

RFBR financed a number of JINR scientific projects in the framework of international contests: together with the State Foundation of Natural Sciences of China (1 project); together with the Department of Science and Technology of the Government of India (4 projects); together with the German Scientific-Research Community (5 projects); together with the National Centre of Scientific Research of France (2 projects); together with the National Scientific Foundation of Bulgaria (1 project).

RFBR rendered financial support to JINR for organization of 5 scientific conferences in the framework of the competitions "Organization of Conferences and Scientific Events in the Territory of Russia" and "Organization of Russian and International Scientific Events for Young Researchers".

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.

RSF, in the framework of the competition "Fundamental Scientific Research and Scientific Research in Separate Scientific Groups", financed 6 projects.

The RF Ministry of Education and Science, under 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.

Twenty projects were financed in 2017 in the framework of the joint competition of research projects of BRFBR and JINR.

2017

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 2017 reflect the following data:

— joint research was conducted with scientific centres in the Member States, as well as international and national organizations in other countries, on 41 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 3085 specialists;

— for joint work and consultations, as well as for participation in meetings, conferences, and schools held at JINR, 2104 specialists were received;

— 56 international scientific conferences and schools, 13 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, the preparation of joint publications of the joint research results, the supply of equipment and techniques for the interested sides, etc.

On 12 January, a representative delegation of the National Institute for Nuclear Physics and Particle Physics of France (IN2P3) visited JINR to participate in the regular 27th meeting of the Joint Committee on the Collaboration IN2P3–JINR. On the French side the meeting was attended by IN2P3 Director R. Pain, IN2P3 Deputy Directors for Research U. Bassler, F. Farget, P. Verdier and Head of the IN2P3 Department of International Relations M. Moguen-Toursel.

JINR was represented by JINR Director V. Matveev, JINR Vice-Directors G.Trubnikov and R. Lednický, JINR Chief Scientific Secretary N. Russakovich, Head of the JINR International Cooperation Department D. Kamanin, Director of the Dzhelepov Laboratory of Nuclear Problems V. Bednyakov, Director of the Bogoliubov Laboratory of Theoretical Physics V. Voronov, and Director of the Flerov Laboratory of Nuclear Reactions S. Dmitriev.

The meeting was finished with the adoption of the final document that contained information on the number of scientific visits in the framework of cooperation on 21 joint projects.

After the meeting of the Coordination Committee at the JINR Directorate the delegation members visited JINR Laboratories. They were acquainted with current projects of the Dzhelepov Laboratory of Nuclear Problems — the Baikal project and the results of the EDELWEISS joint project. At the Flerov Laboratory of Nuclear Reactions the guests visited the cyclotron complex and the Factory of Superheavy Elements which is being developed. The guests visited the Veksler and Baldin Laboratory of High Energy Physics, where they saw the construction site of the NICA project and noted the achievements at the factory of superconducting magnets; they also were acquainted with the BM@N project.

On 20 January, JINR was visited by delegations of Bolivia and representatives of the JSC "Rusatom Overseas" (the state corporation Rosatom). The Bolivian delegation included Ambassador Extraordinary and Plenipotentiary of the Plurinational State of Bolivia to the Russian Federation A. Diaz Mamani, Vice-Minister for Energy and Alternative Sources of Energy J. Rodríguez and officials of the Ministry. The delegation of "Rusatom Overseas" was headed by President of the company E. Pakermanov. At the JINR Directorate the guests were welcomed by JINR leaders and discussed possible joint programmes of cooperation.

The guests visited JINR Laboratories and met with their leaders and specialists who told them about the research in heavy ion physics, condensed matter physics, the proton therapy centre for treatment of oncological diseases, and development of the NICA complex. In conclusion of the visit, a press conference with the participants of the delegations was organized for local mass media.

A festive ceremony of the inauguration of element 117, tennessine, was held at the Oak Ridge National Laboratory (Tennessee, USA) **on 27 January**. It was attended by Governor of Tennessee W. Haslam and a delegation from JINR headed by JINR Director RAS Academician V. Matveev. The Scientific Leader of the JINR Flerov Laboratory of Nuclear Reactions Yu. Oganessian delivered a lecture on the synthesis of superheavy elements, and the American mass media called this lecture an outstanding one.

"This cooperation shows what can be done when scientific research institutes work together solving complex scientific tasks", — stressed Director of the Oak Ridge National Laboratory (ORNL) T. Mason.

Yu. Oganessian presented a special gift to Governor of Tennessee — a gingerbread cake baked by young Dubna confectioners with a dressing in the form of the pattern of element 117 in the Mendeleev Table.

A visit of a JINR delegation headed by JINR Vice-Director R. Lednický to Montenegro was held **on 30–31 January**. The delegation also included LIT Director V. Korenkov, UC Director S. Pakuliak and Head of the JINR International Cooperation Department D. Kamanin.

At the Ministry of Science of Montenegro in Podgorica, the delegation was received by Minister of Science S. Damjanović. The parties discussed possibilities of effective participation of Montenegro in the CMS experiment at CERN through collaboration with Dubna. They also discussed JINR educational programmes, in particular, opportunities for Montenegrin students studying in Russian universities. The participants of the meeting paid special attention to planning of JINR conferences in Montenegro.

A representative delegation of the Helmholtz Association of German Research Centres headed by its President Professor O. Wiestler visited JINR **on 7 February**.

The delegation met with members of the JINR Directorate, leading scientists and specialists of JINR Laboratories at JINR Club of Scientists.

The sides exchanged information on the activities of the Joint Institute for Nuclear Research and the largest Association in Germany, paying special attention to prospects of development of mutually beneficial cooperation between Helmholtz institutes and JINR in science, technology and education.

The German delegation visited the Flerov Laboratory of Nuclear Reactions and the Veksler and Baldin Laboratory of High Energy Physics.

Speaking on the results of the visit the head of the German delegation marked outstanding results obtained at JINR and the atmosphere of international cooperation of scientists who work in Dubna.

Ambassador Extraordinary and Plenipotentiary of the Plurinational State of Bolivia to the Russian Federation A. Diaz Mamani visited JINR **on 7 February**.

The Ambassador was acquainted with the multimedia presentation of JINR in the Visit Centre; he visited the complex of the superconducting collider NICA and met with JINR Director RAS Academician V. Matveev.

The meeting was attended by Head of the JINR International Cooperation Department D. Kamanin, the UC Director S. Pakuliak, and FLNP Deputy Director O. Culicov. The parties exchanged opinions on establishing of scientific and technical cooperation. The Bolivian side affirmed its interest in cooperation with JINR on personnel training to develop nuclear physics and nuclear energy. Scenarios for professional training of Bolivian specialists in Dubna and plans to prepare documents governing the participation of Bolivian scientists in JINR research were considered.

The 4th session of the Joint Coordination Committee on cooperation between JINR and the Republic of Serbia was held as a videoconference **on 9 February**. The main objective of the session was to approve a roadmap for the development of the JINR–Serbia cooperation for the period until 2020.

On the JINR side the session was attended by a delegation headed by JINR Vice-Director R. Lednický; the delegation of the Serbian side was headed by Coordinator of JINR–Serbia cooperation S. Petrović from the Vinča Institute of Nuclear Sciences. The Committee approved funding of joint projects from the membership's fee of Serbia received by JINR in December 2016. In particular, the Committee has launched two new projects in the fields of experimental nuclear physics, one of which will enhance the relations of JINR with the University of Novi Sad. The Committee also traditionally focused attention on educational issues.

On 10 February, this year's first meeting of the Science and Technology Council of JINR was held at the International Conference Hall, under the chairmanship of R. Jolos. The meeting opened with the report by JINR Director Academician V. Matveev about the first month of the new seven-year period at JINR.

Head of the JINR Human Resources and Innovation Development Office A. Ruzaev talked about the work on the new variant of the Staff Regulations. V. Furman, Yu. Potrebenikov, I. Meshkov, R. Jolos, M. Itkis, S. Nedelko, and V. Matveev took part in the discussion. The speakers expressed their remarks and recommended that the work on this important document should be continued. V. Matveev suggested that the draft of the Regulations should be improved within a short time with an account of STC recommendations and that the Plenipotentiaries of the governments of JINR Member States should be informed about it.

The participants of the meeting supported the nomination of the scientific leader of the RAS Institute of Mathematical Problems in Biology Doctor of Physics and Mathematics Professor V. Lakhno for the title "Honoured Worker of RF Science". V. Korenkov, E. Krasavin, and Gh. Adam praised his considerable contribution to science.

JINR Chief Scientific Secretary N. Russakovich made a review report of scientific results of 2016 obtained at JINR Laboratories. These results are to be included into the report of Director for the March session of the Committee of Plenipotentiaries. N. Russakovich also noted most important scientific achievements of JINR that are annually forwarded to the Office of RF President for the final report.

JINR Chief Engineer G. Shirkov spoke about the status of the preparation of the technical project of the medical cyclotron according to the agreement with China and plans to install it at the Laboratory of Nuclear Problems instead of the Phasotron. As G. Shirkov said, the replacement of the Phasotron with a new modern compact superconducting cyclotron will allow maintaining methods and beams that were developed in Dubna and, what is the most important, continuation of the irradiation of oncological patients. V. Gerdt, M. Itkis, D. Peshekhonov, E. Krasavin, I. Meshkov, and V. Bednyakov took part in the discussion.

Director General of the International Centre for Scientific and Technical Information (ICSTI) E. Ugrinovich, accompanied by Head of the Department of Information Resources D. Moon, visited JINR **on 14 February**.

At the JINR Directorate the guests were welcomed by JINR Chief Scientific Secretary N. Russakovich. The participants of the meeting discussed the experiences and possibilities of cooperation between JINR and ICSTI, in particular, prospects for mutual use of the sites of the organizations for holding of events, discussed some aspects of international cooperation and handling of scientific and technical information. The guests spoke about the main tasks of ICSTI at present and made presentation of the renewed journal “Information and Innovations”.

The representatives of ICSTI were acquainted with works on synthesis of superheavy elements at FLNR, with the progress towards construction of the megaproject NICA and met with VBLHEP Director V. Kekelidze.

A governmental delegation from the Republic of Zambia arrived at JINR with a reconnaissance visit **on 17 February**. The delegation was headed by Secretary to Cabinet of the Office of the President R. Msiska.

The delegation also included Permanent Deputy Secretary to Cabinet of the Office of the President S. Miti, Permanent Deputy Minister of Higher Education O. Mugemezulu and other officials. The delegation was accompanied by representatives of the SC “Rosatom”.

In the JINR Visit Centre the guests were welcomed by members of the JINR Directorate, leaders of the JINR International Cooperation Department, representatives of JINR Laboratories and JINR University Centre.

The guests were acquainted with the basic facts about JINR, the Medico-Technical Complex of the Dzhelepov Laboratory of Nuclear Problems, and synthesis of superheavy elements at the Flerov Laboratory of Nuclear Reactions. Further, the delegation visited the spectrometers complex of the IBR-2 reactor and the factory of superconducting magnets of the NICA megaproject.

Summing up the results of the visit, the head of the delegation R. Msiska expressed interest in continuing contacts with JINR and especially emphasized the interest in activities of the Sector of Neutron Activation Analysis of the Frank Laboratory of Neutron Physics.

From 14 to 19 March, events dedicated to the 10th anniversary of participation of the Republic of Serbia in the Joint Institute for Nuclear Research as an associate member and the past 60th anniversary of JINR were held in Serbia. The JINR delegation was headed by JINR Vice-Director R. Lednický and included members of the Serbia–JINR Joint Coordination Committee (JCC) and leaders of joint projects. The festive events were also associated with the 4th International Russian-Serbian Industrial Exhibition “EXPO-Russia Serbia 2017”, where JINR was represented by a stand.

On 15 March, State Secretary of the Ministry of Education, Science and Technological Development V. Popović met with the full JCC. During the meeting, the participants discussed the main challenges and prospects of cooperation between JINR and Serbia, as well as the adoption of the Cooperation Roadmap 2017–2020.

On 16 March, a meeting of leaders of the JINR delegation with the Serbian Academy of Sciences and Arts (SASA) Vice-President Z. Popović was held. JINR Vice-Director R. Lednický made a presentation at SASA about the present-day JINR and the results of the 10-year cooperation between JINR and scientific organizations of Serbia. The lecture brought together more than two hundred listeners. V. Nedović made a welcoming speech on behalf of the Ministry.

On the same day, the JINR delegation visited the University of Novi Sad, where the guests were received by University Rector D. Nikolić, Dean of the Faculty of Natural and Mathematical Sciences M. Pavkov-Hrvojević and Professor of the Physics Department M. Krmar. The meeting participants discussed possible steps on enhancement of cooperation, primarily, participation of students of the University in JINR educational programmes. An excursion to the nuclear physics laboratories of the University was organized for the guests from Dubna.

On 17 March, the JINR delegation visited the Laboratory of Physics of the Vinča Institute of Nuclear Sciences which has a long-term successful cooperation with Dubna. The focus of the meeting was the development of cooperation in accelerating issues.

The JINR delegation took part in a round-table discussion jointly with the Ministry of Education, Science and Technological Development of Serbia “Extending Cooperation between Russia and Serbia in Higher and Secondary Education". UC Deputy Director A. Zhemchugov made a report on the educational programmes of JINR.

On 11 April, President of National Institute for Nuclear Physics (INFN, Italy) F. Ferroni, Spokesperson of the ALICE collaboration (CERN) F. Antinori, accompanied by colleagues, visited JINR. The guests met with the Institute leaders, visited the Laboratories of High Energy Physics, Nuclear Reactions, Neutron Physics, as well as the Memorial Room of Bruno Pontecorvo.

JINR Director V. Matveev called the visit of the Italian delegation a great event in the light of implementation of such big projects as NICA and the Factory of Superheavy Elements at JINR.

On 12 April, the ceremonial signing of the new Agreement on cooperation between the Joint Institute for Nuclear Research and the National Institute for Nuclear Physics (INFN, Italy) was held at the Embassy of Italy in RF in Moscow. The previous Agreement between JINR and INFN was signed in 2011 and expires in June 2017.

JINR Director V. Matveev and INFN President F. Ferroni signed the new Agreement on INFN–JINR cooperation in the presence of President of the Italian Republic Signor S. Mattarella. The signing ceremony was also attended by Deputy Minister of Education and Science of Russia and Plenipotentiary of the Government of the Russian Federation to JINR G. Trubnikov, Ambassador Extraordinary and Plenipotentiary of the Italian Republic to the Russian Federation C. M. Ragaglini, Scientific Counsellor of the Italian Embassy in the Russian Federation P. Fré, INFN Vice President A. Masiero, INFN Vice President A. Zoccoli, JINR Chief Scientific Secretary A. Sorin, Director of the JINR Veksler and Baldin Laboratory of High Energy Physics V. Kekelidze, and Director of the INFN International Affairs Service R. Pellegrini.

The Agreement is concluded for the term of 6 years and encompasses collaboration in the field of theoretical, experimental, astroparticle, nuclear and elementary particle physics, and related technologies.

On 17–21 April, a visit to JINR of the Arab Atomic Energy Agency (AAEA) delegation headed by AAEA General Director S. Hamdi was held. The delegation got acquainted with the activities of JINR Laboratories and the JINR University Centre, JINR social infrastructure and activities of AYSS JINR. At the Directorate the sides discussed prospects for development of mutual relations, deepening of cooperation and its future opportunities.

On 20 April the signing of the protocol No. 1 was held to the Memorandum of understanding of 21 December 2016 on mutual understanding between JINR and the Arab Atomic Energy Agency that includes 15 states of Asia and Africa.

The regular meeting of the JINR Science and Technology Council was held **on 19 April** at the International Conference Hall under the chairmanship of R. Jolos. It was opened by information of JINR Director, Academician V. Matveev, who commented on the milestones of the JINR Finance Committee and the JINR Committee of Plenipotentiaries, which were held in March.

Plans for modernization of the JINR engineering infrastructure were the objective of the report of JINR Chief Engineer B. Gikal. He gave a review of tasks and prospects of the development of the Institute engineering infrastructure and spoke about current and scheduled work in Institute services, i.e., the technical communication service (to complete the assembling of the equipment for the central ATS-6), the Department of Radioactive and Fissible Substances, the Department of Radiation Safety, the Headquarters of Civil Defence. V. Matveev, I. Meshkov, E. Krasavin, A. Brun, G. Shirkov, A. Kovalenko asked questions and commented on the report.

JINR Deputy Director B. Sharkov reported on the working group on the JINR development strategy elaboration, its status, forming and scope of work for the group in the development strategy for JINR to 2030. This topic provoked an animated discussion, which was attended by V. Shvetsov, V. Kekelidze, D. Peshekhonov, M. Itkis, S. Dmitriev, I. Savin, V. Korenkov, Yu. Oganessian, S. Nedelko, I. Meshkov, A. Sorin, and V. Matveev. The participants of the discussion noted the need to focus primarily on defining perspective areas of research and formation of the concept of development of JINR as an international intergovernmental organization.

On 27 April, JINR was visited by the Minister of Economy of the Slovak Republic P. Žiga, Minister of Education, Science, Research and Sport P. Plavćan and their accompanying persons. They arrived in Moscow a day earlier to take part in the work of the Intergovernmental Board on Economic Cooperation. The Slovak delegation was acquainted with work on establishment of the NICA complex at the Laboratory of High Energy Physics, research in the fields of heavy-ion physics and the Factory of Superheavy Elements construction project at the Flerov Laboratory of Nuclear Reactions, and they met with representatives of the Slovak national group of JINR staff members.

The reception was attended by JINR Vice-Directors M. Itkis, R. Lednický, FLNR Director S. Dmitriev, VBLHEP Deputy Director R. Tsenov, BLTP Deputy Director M. Hnatič, and UC staff member E. Karpova. The representatives of the Slovak delegation shared their impressions about their stay in Dubna with local reporters.

On 27 April, JINR welcomed a delegation from the Republic of Paraguay accompanied by representatives of the state corporation "Rosatom". It included Ambassador Extraordinary and Plenipotentiary of the Republic of Paraguay to the Russian Federation R. Diaz Pereira, Minister and Executive Secretary of the National Radiological and Nuclear Regulatory Authority of Paraguay C. J. Cardozo Roman, and member of the Management Board of the Authority R. R. Amaria Martinez.

The guests visited the Frank Laboratory of Neutron Physics where they met with FLNP Deputy Director O. Culicov. Acquaintance with the Joint Institute was continued at the JINR Visit Centre, where the Paraguayan delegation was welcomed by JINR Vice-Director R. Lednický and JINR Deputy Director B. Sharkov, who presented the major activities of the Institute. The meeting was also attended by Head of the Scientific and Engineering Group of the JINR University Centre M. Nozdrin.

Members of the Paraguayan delegation noted that they are especially interested in cooperation that gives opportunities for education of Paraguayan students at JINR and applied research and for-profit application of JINR elaborations in business.

A visit to JINR of a Czech delegation headed by Director of the NUVIA company M. Pazur and Director of the Institute of Experimental and Applied Physics of the Czech Technical University I. Štekl was held **on 10–11 May**. A meeting with JINR Director V. Matveev, JINR Vice-Director R. Lednický, JINR Chief Scientific Secretary A. Sorin and JINR Chief Engineer B. Gikal was held. The participants of the meeting discussed opportunities of future NUVIA–JINR cooperation.

The guests visited JINR Laboratories. The delegation was acquainted with the cyclotron complex of the Flerov Laboratory of Nuclear Reactions; the Czech colleagues visited the Medico-Technical Complex at the Dzhelepov Laboratory of Nuclear Problems and the Scientific and Engineering Group of the JINR University Centre. At the Veksler and Baldin Laboratory of High Energy Physics the delegation visited the Factory of Superconducting Magnets and was acquainted with the megascience project NICA. The guests visited the JINR Multifunctional Information and Computing Complex of the Laboratory of Information Technologies.

On 15–16 May, the first meeting of the BRICS Working Group on Research Infrastructure and Mega-Science Projects started at JINR. The event was organized by the governments of Russia, China, Brazil, India, and the Republic of South Africa. Representatives of ministries and departments, embassies, scientific centres and agencies of all five countries took part in it, forming a quorum for decisions.

The meeting was held in different sessions: "National Policy of BRICS States in Global Research Infrastructure and Development of the Project of the Global Network of Modern Research Infrastructure", "Tasks for the Working Group of BRICS States in Research Infrastructure", "Procedure Availability of Global Research Infrastructure". Presentations were given on the list of infrastructures available in Russia, and excursions to JINR sites were made.

On 25 May, a delegation of JINR staff members took part in the reception held at the Embassy of Bulgaria in Moscow on the occasion of the Day of Slavic Writing and Culture. Young musicians, vocal-instrumental and dance ensembles from Bulgaria presented their congratulations. Guests were served dishes of Bulgarian cuisine; besides, details how to cook such dishes as sarmi, kashkaval, banitsa, pita were explained to them. Trying delicacies, guests discussed customs and life in Bulgaria.

On 26 May, JINR was visited by an Italian delegation headed by H. E. Ambassador Extraordinary and Plenipotentiary of the Italian Republic to the Russian Federation Cesare Maria Ragaglini. He was accompanied by First Counsellor W. Ferrara and Science Attaché, Professor P. Fré. This is the first visit of H. E. Cesare Maria Ragaglini to Dubna.

The guests visited VBLHEP and the project NICA, FLNP, FLNR, and DLNP. In the latter they saw the memorial study of B. Pontecorvo. In front of the International Conference Hall they were shown the monument to B. Pontecorvo and V. Dzhelepov.

On 16 June, a regular meeting of the JINR STC was held, chaired by R. Jolos. It was devoted to programmes of training staff for JINR at the University "Dubna" and the University Centre of JINR.

Rector of Dubna University D. Fursaev made a report where he stressed, in particular, that 237 graduates of the University had been employed at JINR. He underlined that in future it would be necessary to synchronize development of educational programmes of the University (and introduction of new programmes) with plans of JINR development with an account of elaboration of new large projects.

Pro-Rector of University "Dubna" A. Denikin informed the participants of the meeting about the University programme of training staff in the interests of JINR in the period of 2017–2024, whose implementation implies the accomplishment of the following tasks: development of educational laboratory infrastructure of the basic JINR chairs; availability of state-financed openings in JINR required trends of education; review of educational trends and contents of curricula, syllabus and practice courses, etc., due to proposals from JINR Laboratories; joint work with schools; elaboration of new forms of education to attract senior students from leading higher education institutions of RF and abroad, including technology of open education. The speaker talked about directions and specialization of training of Bachelors and Masters at seven basic chairs of the University that are headed by leading scientists and specialists of JINR and University, trends of post-graduate courses and opportunities of meeting the demands of JINR in staff due to new trends in training specialists of scientific technological type.

Head of the UC S. Pakuliak spoke in his report about the development of a specialized engineer-training centre organized in 2014 to implement programmes of training for engineers-physicists and technicians for JINR Laboratories and Member States, and gave a detailed review of UC practice courses and their plans and prospects.

In the discussion of the reports the participants of the STC meeting supported the idea of elaboration at the University "Dubna" joint training programmes for JINR staff.

On 26–27 June, a delegation of the MGIMO University (the Moscow State Institute of International Relations of the Ministry of Foreign Affairs (MFA) of Russia) and representatives of the RF MFA visited JINR. It was headed by MGIMO Vice-Rector for Human Resources V. Morozov.

The guests were acquainted with the main trends of JINR activities, visited the research sites of the Institute infrastructure, and were informed about the synthesis of superheavy elements at the Flerov Laboratory of Nuclear Reactions and the construction of the megascience project NICA at the Veksler and Baldin Laboratory of High Energy Physics.

A round-table discussion was held on the topic "Diplomacy and Science: Opportunities and Directions of JINR–MGIMO Cooperation" where JINR Directorate, Laboratories and the JINR University Centre took part. The programme of the discussion was organized in three sections: experience of JINR, issues of diplomacy in science, and tasks for practical interactions. During the exchange of opinions the participants defined fields of discussion that are for mutual interest of JINR and MGIMO, in particular, organization of traineeship for MGIMO students at JINR, participation of JINR in scientific research and educational activities of MGIMO, joint publications and organization of joint events. The round-table discussion was concluded with ceremonial signing of the agreement of cooperation in organization of traineeship for MGIMO students at JINR.

On 30 June – 1 July, a delegation of JINR participated in festive events dedicated to celebration of the 60th anniversary of the Bulgarian Nuclear Regulatory Agency, which is headed by Plenipotentiary of the Government of Bulgaria to JINR L. Kostov. JINR Director Academician V. Matveev, VBLHEP Director Professor V. Kekelidze, and Head of the JINR International Cooperation Department D. Kamanin arrived in Sofia to convey congratulations from Dubna. The Russian Federation was represented by a delegation of Rostekhnadzor headed by State Secretary Deputy Head of Rostekhnadzor A. Rybas.

The programme of the festive meeting included two lectures by international organizations — Director of Department of Technical Cooperation M. Krause made a presentation of IAEA, and JINR Director V. Matveev spoke about JINR nowadays and its cooperation with Bulgarian scientific centres.

The JINR delegation met with Deputy Minister of Education and Science of Bulgaria Professor I. Dimov. They established contacts with the Bulgarian Nuclear Society and proposed new initiatives in the sphere of educational projects.

Within a month **from 24 July** the 10th training course for young scientists and specialists from CIS countries was held in Dubna on the basis of JINR. It was organized by the International Innovation Centre of NanoTechnology of CIS under the support of the Intergovernmental Foundation for Educational, Scientific and Cultural Cooperation of CIS member states and JINR. 180 young scientists from over 50 scientific institutions from CIS have completed the course.

Excursions to JINR Laboratories, lectures of leading scientists, and visits to facilities were organized for the trainees, along with their acquaintance with innovation companies in Dubna, meetings with SEZ "Dubna" representatives, a visit to the University "Dubna" and a trip to the innovation centre "Skolkovo". The training was based on JINR Laboratories, at the University "Dubna", and at scientific and innovation enterprises of the city.

On 28 July, Dubna was visited by Minister of Health of the Russian Federation V. Skvortsova, accompanied by State Duma Deputy, Vice-Chairman of the State Duma Health Protection Committee N. Sanina, and Deputy Chairman of the Moscow Region Government O. Zabralova.

The Minister was welcomed by City Mayor V. Mukhin and JINR representatives: Director of the Joint Institute for Nuclear Research V. Matveev, Assistant Director G. Shirkov, Chief Scientific Secretary of the Veksler and Baldin Laboratory of High Energy Physics D. Peshekhonov, and Head of the JINR Social Infrastructure Management Office A. Tamonov.

The guests visited the Veksler and Baldin Laboratory of High Energy Physics, where they were acquainted with the construction of the accelerator complex NICA. The guests paid special attention to JINR expertise in the fields of proton therapy of cancer diseases, as well as to the Medico-Technical Complex of JINR.

On 9 August, the Joint Institute for Nuclear Research was visited by a delegation from the Embassy of the Republic of Armenia, headed by Ambassador Extraordinary and Plenipotentiary V. Toganyan who came to Dubna for the first time. The delegation also included Trade Representative of the Republic of Armenia in RF K. Asoyan and representative of the Embassy Press Office A. Voskanyan.

JINR Director RAS Academician V. Matveev, Vice-Director M. Itkis, Director of the Flerov Laboratory of Nuclear Reactions S. Dmitriev, FLNR Scientific Advisor Yu. Oganessian, Deputy Head of the JINR International Cooperation Department A. Kotova, leader of the Armenian national group Eh. Airian, and senior researcher of the Dzhelepov Laboratory of Nuclear Problems G. Torosyan welcomed the guests at the JINR Directorate.

A talk was held after the guests were informed about the main trends of activities, basic facilities and flagship projects of the Institute. In the discussion, the Ambassador expressed his intention to employ potentials of the Embassy to promote JINR elaborations in the framework of JINR–Armenia relations. Bright examples of successful cooperation were given. Besides, special attention was paid to the importance of attracting young talents to science and promotion of development of national science and education.

The visit resulted in the conclusion to organize Days of Armenia at JINR that will allow Dubna citizens to learn more about the culture of Armenia. The guests continued their visit in excursions around JINR Laboratories.

On 10 August, a delegation of the Federal Service for Environmental, Technological, and Nuclear Oversight (Rostekhnadzor) headed by State Secretary Deputy Head of Rostekhnadzor A. Rybas arrived at JINR with a reconnaissance visit.

At the JINR Directorate, the guests were welcomed by JINR Director V. Matveev, JINR Vice-Director M. Itkis, JINR Chief Engineer B. Gikal, Advisors to Director A. Mikhan and G. Shirkov, Deputy Chief Engineer A. Dudarev, and FLNP Chief Engineer A. Vinogradov. During the meeting, the guests were acquainted with general information about JINR, its history and achievements, scientific infrastructure, research programme and the flagship projects.

After the meeting at the JINR Directorate, excursions to the Flerov Laboratory of Nuclear Reactions, the Frank Laboratory of Neutron Physics, and the Veksler and Baldin Laboratory of High Energy Physics were organized for the delegation.

On 22 August, a JINR delegation participated in the 2nd Meeting of Russia–Cuba Working Group on Cooperation in Science, Technology and Environment in Moscow. Deputy Minister of Education and Science of RF, Plenipotentiary of the Government of the Russian Federation to JINR, Academician G. Trubnikov was the Co-Chairman from the Russian side. The Institute was represented by Deputy Director of the JINR University Centre A. Zhemchugov and Head of the JINR International Cooperation Department D. Kamanin. From the Cuban side, Director of the Centre for Applied Technology and Nuclear Development (CEADEN) A. Díaz García, member of the JINR Scientific Council, participated in the meeting.

The parties discussed measures to ensure mobility for young Cuban scientists and students, as well as how to make modern research infrastructure available to them. The JINR representatives took part in a discussion of the organization of experts and scientists exchange programmes in the framework of scientific and technical cooperation between the two countries.

On 23 August, RF Prime-Minister D. Medvedev signed a directive according to which 19 higher education institutions and four scientific organizations were granted the right to independently confer academic degrees, starting from 1 September. The corresponding document was published on the website of the RF Government.

Among those four scientific organizations is the Joint Institute for Nuclear Research. In this connection, JINR is to reorganize the activities of dissertation councils. During the coming year norm documents must be elaborated that determine the procedure of defense of candidate and doctoral theses and principles of organization of new councils. These documents must be adopted at the nearest sessions of the Committee of Plenipotentiaries, and it will allow the acknowledgement of JINR diplomas in the JINR Member States.

On 12–15 September, a representative delegation of leaders of JINR arrived in Almaty for participation in the international scientific forum "Nuclear Science and Technologies" dedicated to the 60th anniversary of the Institute of Nuclear Physics of the Ministry of Energy of the Republic of Kazakhstan, as well as in the 11th international conference "Nuclear and Radiation Physics", the international conference "Nucleus-2017", and the 8th Eurasian conference "Nuclear Science and Its Application".

On 14 September, JINR Vice-Director M. Itkis made a congratulatory speech at the festive meeting dedicated to the 60th anniversary of INP and noted that INP made an outstanding contribution to the development of nuclear physics in Kazakhstan and in the Soviet Union in general. He also marked the active role of INP in the development of cooperation with JINR.

The programme of the Dubna delegation visit to INP was devoted to another important date — the 25th anniversary of the participation of the Republic of Kazakhstan in JINR as an independent state. The guests were acquainted with the recently opened Nuclear Security Training Center; they visited the experimental hall of the WWR-K reactor, as well as the new infrastructure — the hall of the Cyclone-30 accelerator and the facility for radiation sterilization on the basis of the ILU-10 electron accelerator. INP Director General, Plenipotentiary of the Government of the Republic of Kazakhstan to JINR E. Kenzhin, leaders of nuclear science of Kazakhstan and Kazakh young scientists met with the JINR delegation at the round-table meeting devoted to strategic planning of collaboration between INP and JINR. A meeting of the INP and JINR leaders with the President of the Nuclear Society of Kazakhstan, appointed Advisor to the President of the Republic of Kazakhstan V. Shkolnik concluded the business programme of the Dubna delegation.

The 2nd Forum on Development of Cooperation between JINR and Czech Academic and Scientific Institutions was held **on 19–21 September** in Dubna. Representatives of Universities of Prague, Brno, Plzeň, Ostrava, Opava, and Řež took part in it. The Forum was aimed at engagement of new scientific institutions of the Republic in the joint research projects carried out in Dubna and at initiating new programmes focused on innovation of technology, advanced systems, development of nuclear electronics, semiconductor detectors and special measurement tools, design and construction of accelerators, automation, programming and information technology.

JINR Vice-Director R. Lednický opened the Forum. He informed the participants about the history of JINR establishment and modern research at the Institute. LRB staff member P. Bláha made a review on the cooperation of the Czech Republic with JINR. Director of the Institute of Applied Experimental Physics of the Polytechnic University (Prague) I. Štekl spoke about support and coordination of scientific cooperation in the Czech Republic. The Czech guests had excursions to VBLHEP, FLNR, FLNP, DLNP and were acquainted with research at BLTP, LIT and LRB.

On 21–22 September, Director of the Institute of Accelerator Technologies of Ankara University (Turkey) A. Aksoy came to JINR on a working visit. He had a meeting with JINR Vice-Director R. Lednický where they discussed scientific tasks of mutual interest. The guest also visited the site of the complex NICA under construction, the Factory of Superheavy Elements, a training linear accelerator and the engineering physics practice course of the UC. A. Aksoy also had a talk with JINR Chief Engineer B. Gikal and, as a result, the sides agreed to work out a plan of cooperation development, with the application of JINR educational opportunities as a priority.

On 4 October a delegation of representatives of the National Romanian TV channels TVR and TVR International visited JINR with an aim to make a news item about the Joint Institute.

The acquaintance of the Romanian journalists with the Institute started with a meeting with JINR Director Academician V. Matveev. On the JINR side, the meeting was also attended by Deputy Director of the Laboratory of Information Technologies, Head of the Romanian national group in JINR Gh. Adam. During the meeting at the Directorate the Romanian journalists were informed in detail about the cooperation of JINR with Romania: about the involvement of Romanian specialists in scientific research at the Institute and applied studies at JINR and their use in practice.

Accompanied by Gh. Adam, they visited JINR Laboratories. At LIT the guests saw the operation of the Multifunctional Information and Computing Centre of JINR; at DLNP the journalists performed video shooting in the Medical-Technical Complex of JINR. At FLNR, Deputy Director of the Laboratory A. Popeko presented the world's first Factory of Superheavy Elements centered about the new accelerator DC-280 and spoke about the achievements and discoveries of JINR in the synthesis of superheavy elements. At FLNP, Director V. Shvetsov showed the guests the IBR-2 reactor and experimental facilities where Romanian scientists actively participate in scientific research. Head of the FLNP Department of Neutron Investigations of Condensed Matter D. Kozlenko gave an overview of the cooperation with Romanian scientists.

The journalists were acquainted with the accelerator complex NICA, being under construction, and with the factory of superconducting magnets. At the end of the visit, the Romanian journalists met with the Romanian national group, where they further learned about the scientific research of the Romanian scientists at JINR and about their life in Dubna.

On 10–11 October, the second stage of the 10th Meeting of Group of Senior Officials (GSO) on Global Research Infrastructures, which was held in the Russian Federation for the first time and consisted of three parts, was held at the International Conference Hall in Dubna. The meeting was organized by the Ministry of Education and Science of the Russian Federation with the support of the Joint Institute for Nuclear Research, the NRC "Kurchatov Institute", the Petersburg Nuclear Physics Institute, and the International Centre for Innovations in Science, Technology and Education.

GSO works to tackle issues of priority scientific research all over the world, compiling strategic plans of research infrastructure development. It was organized in 2008 to identify opportunities for international collaboration and develop a system of joint efficient use of items of scientific research infrastructure in all spheres of knowledge.

According to the GSO regulations, the chairmanship in GSO is taken by its members one after another. At the meeting in Dubna, the authorities of chairmanship were taken by Russia; the meetings were chaired by RF Deputy Minister of Education and Science G. Trubnikov.

The meeting was attended by representatives of Austria, Belgium, Great Britain, Germany, India, Italy, Spain, China, the Netherlands, the USA, France, Switzerland, RSA, Japan, as well as of RF federal ministries and departments, leading Russian and international scientific research centres, educational organizations and foundations, the European Commission and delegates of Embassies, and leaders of mega-science projects and international research societies.

From 10 to 13 October a workshop on development of scientific and educational contacts between the Republic of Moldova and the Joint Institute for Nuclear Research was held in Chisinau. The visit of the JINR delegation and the workshop were organized on the occasion of the 25th anniversary of participation of Moldova in JINR as an independent state. On the Moldovan side the workshop programme was coordinated by Plenipotentiary of the Government of the Republic of Moldova to JINR V. Ursachi. Executive officer of the JINR contacts with the Republic of Moldova V. Voronov, Director of the JINR University Centre S. Pakuliak, Head of the JINR International Cooperation Department D. Kamanin represented the JINR side. Participants of the Workshop analyzed the current state of cooperation and outlined steps to improve its coordination.

During the Workshop, a meeting with the leaders of the University of the Academy of Sciences of the Republic of Moldova and a round table with its students were held. Opportunities in education at JINR were discussed at the round table that was organized by the Ministry of Education of the Republic of Moldova.

On 25–26 October, Deputy Director General of the International Atomic Energy Agency (IAEA) D. Yang who heads the IAEA Department of Technical Cooperation visited JINR. Mr. D. Yang arrived in Dubna accompanied by A. Chupov, Programme Management Officer of the IAEA Department of Technical Cooperation.

Mr. Yang visited the JINR laboratories — FLNP, FLNR, DLNP, LRB, and VBLHEP. During the meetings and negotiations with members of the JINR Directorate and Directors of JINR Laboratories, the honored guest was informed about practical experience of cooperation between JINR and IAEA, as well as about readiness of JINR to expand and diversify its participation in the IAEA projects.

The visit of Mr. D. Yang was preceded by a visit to JINR of Mr. M. Krause, Director of the Division for Europe of the Department of Technical Cooperation, IAEA, on 12 October. On the results of the visit of Mr. Krause, Notes for file containing ideas for further development of cooperation between IAEA and JINR were compiled.

On 25–27 October, a delegation of the Joint Institute for Nuclear Research paid a working visit to Mongolia to participate in several meetings including the one of the Organizing Committee of an educational conference which will be held in Ulaanbaatar in August 2018.

The meeting of the Organizing Committee of the conference, preliminarily entitled "Modern Trends in Science and Advanced Technology in Natural Sciences Education", was held at the Institute of Physics and Technology of the Academy of Sciences of Mongolia (ASM). The discussion was attended by prominent scientists, Mongolian academicians, and young researchers — members of the Local Organizing Committee.

Working meetings during the visit of the JINR delegation were devoted to enhancement of cooperation with JINR, increasing the involvement of young Mongolian scientists in joint projects. The JINR delegation was received by Secretary and Head of the Nuclear Energy Commission of Mongolia G. Manlaijav, President of ASM Academician D. Regdel, Director of the Department for Science of the Ministry of Education and Sciences of Mongolia Academician T. Gan-Erdene. The guests from Dubna were welcomed by leaders of the Mongolian University of Science and Technology, the New Mongol Institute of Technology, the Institute of Astronomy and Geophysics of ASM. In conclusion of the visit programme, a meeting of the JINR delegation with members of the Committee on Science and Education of the State Great Hural was held. Parliamentarians emphasized the importance of the participation of Mongolia in JINR and promised full support to initiatives for its development.

On 28 October, an expert meeting of a Working Group on cooperation between Russia and China in the framework of the large (mega-science) research infrastructures was held in Beijing. The purpose of the Working Group meeting was the participation of Chinese scientific centres in the NICA/MPD project at JINR and the JINR's participation in major Chinese scientific projects. On the Chinese side the meeting was attended by representatives of the Institute of Modern Physics (Lanzhou), the Institute of Plasma Physics (Hefei), and Tsinghua University (Beijing). The NICA project on the Russian side was represented by the JINR delegation chaired by Leader of the project V. Kekelidze.

The parties defined expected financial parameters of the cooperation and areas of interaction within the Electromagnetic Calorimeter project for the NICA/MPD, establishment of an energy storage based on high-temperature superconducting magnets, as well as conditions of participation in other projects. The sides considered ways for technology transfer, in particular, in the framework of implementation of the joint project on the SC-200 superconducting compact proton cyclotron for medical applications.

On 31 October, at the Embassy of France in Moscow, a festive presentation of national awards to representatives of Russian science who contributed to the development of cooperation between scientists of the two countries was held. Academician A. Makarov, Director of the Engelhardt Institute of Molecular Biology (EIMB RAS), the world-acknowledged expert in the fields of biomedicine, bioengineering and biotechnology, was awarded the National Order of the Legion of Honour, Knight Degree. Academician V. Matveev, Director of the Joint Institute for Nuclear Research, the world-acknowledged expert in the fields of high energy physics, particle physics and quantum field theory, was awarded the National Order of Merit, Officer Degree.

The festive ceremony was opened by Ambassador of France in Moscow, Mrs. S. Bermann, who attracted the audience's attention to the portrait of Peter the Great — a copy of the painting by Jean-Marc Nattier where the moment of the reception of the distinguished guest — the Emperor of Russia Peter the Great in the Royal Academy of Sciences in Paris on 19 June 1717 is shown. Since that time for 300 years the French–Russian scientific cooperation has never been interrupted.

The awards were presented by Permanent Secretary of the French Academy of Sciences, President of the National Centre of Scientific Research (CNRS), Professor Catherine Brechignac, the daughter of the outstanding French scientist and science organizer Jean Teillac. On 25 May 2007 Catherine Brechignac took part in the opening ceremony of the memorial alley named after Jean Teillac near the Flerov Laboratory of Nuclear Reactions.

In his acceptance speech, Academician V. Matveev expressed his deep gratitude for the high appreciation of his efforts by the French government and noted: "I would like to stress that I accept this prestigious award as a symbol of the fact that international cooperation of scientists contributes greatly to understanding between people and friendship of nations. For a good reason our slogan *Science Bringing Nations Together* has become global. We see that scientific cooperation is a most precious treasure for the whole world and modern civilization... Cooperation with scientists from France is one of the most important parts of our activities. There are so many colleagues, friends of ours in France, so many contacts with French scientists, and with one of such organizations we have been keeping close contacts for already 42 years — it is CNRS. I am especially glad to be awarded with this Order by you. One of the main streets of our small beautiful town is named after the outstanding French scientist Frederique Joliot-Curie. It is the main street in our Institute."

Viktor Anatolievich expressed his hope that time would come when the relations between the international centre in Dubna and France would gradually reach an official status and invited the French colleagues to "visit our town and see that it is a real capital of modern physics today, a capital of international cooperation."

On 1–3 November, a delegation of JINR visited Uzbekistan to participate in the workshop "Science and Education in the Joint Institute for Nuclear Research and the State Atomic Energy Corporation 'Rosatom'". The workshop was organized by the Academy of Sciences of the Republic of Uzbekistan. The workshop took place at the Academy of Sciences of the Republic of Uzbekistan in Tashkent and at the Institute of Nuclear Physics of AS RUz in Ulugbek.

The Workshop was intended to enhance Uzbekistan's scientific cooperation with JINR and the State Corporation "Rosatom" in the fields of scientific personnel training, to attract young people to scientific research, and to acquaint students with educational opportunities of JINR and the State Universty "Dubna". Two hundred Uzbek scientists took part in the Workshop, over 100 postgraduate and doctoral students of higher education institutes of Tashkent, Samarkand, Namangan, Ferghona, Andijon, and Dzhizak.

The Joint Institute for Nuclear Research was represented by JINR Vice-Directors M. Itkis and R. Lednický, Directors of the JINR laboratories D. Kazakov (BLTP), V. Korenkov (LIT), V. Shvetsov (FLNP), FLNR Deputy Director S. Sidorchuk, Director of the JINR University Centre S. Pakuliak, Head of the JINR International Cooperation Department D. Kamanin, and DLNP department head A. Artikov. The Dubna delegates made reports on a wide range of the JINR research activities, prospects for development of the JINR research infrastructure, educational programmes of JINR, and aspects of international cooperation.

During the visit, the JINR delegation visited the Centre of Genomics and Bioinformatics where delegates could learn about research in the field of gene engineering of cotton and other agricultural crops. The delegates had also an opportunity to visit laboratories of the Institute of Nuclear Physics of the AS RUz, in particular, the research reactor and the Institute of Material Sciences that is a part of the Scientific Association "Physics-Sun" of the Physical-Technical Institute of the Uzbek Academy of Sciences.

A delegation from JINR headed by Director of the Institute Academician V. Matveev visited Berlin **on 9–10 November** to take part in the Russian–German meeting on the work-out of "The Roadmap of German–Russian cooperation in education, science, research and innovation". On the side of Germany the event was attended by leaders and representatives of departments of the Federal Ministry of Education and Research of Germany (Bundesministerium für Bildung und Forschung, BMBF), the Helmholtz Association, the German Agency of Academic Exchange (Deutscher Akademischer Austauschdienst, DAAD), the German Academy of Sciences Leopoldina (Deutsche Akademie der Naturforscher Leopoldina), the M. Planck Society of Scientific Research, and the Humboldt Foundation. Among Russian participants were Assistant to RF President A. Fursenko, RF Ambassador in Germany V. Grinin, Deputy RF Minister of Education and Science G. Trubnikov, RAS President A. Sergeev, President of NRC KI M. Kovalchuk, Chairman of the RFBR Council V. Panchenko and other representatives of Russian scientific centres.

Joint recommendations were discussed on the contents of the German–Russian Roadmap. Much attention in the discussions was paid to the projects NICA and FAIR.

On 15 November, a meeting of the JINR Science and Technology Council was held at the International Conference Hall. Opening the Meeting Professor R. Jolos, Chairman of the JINR Science and Technology Council, greeted on behalf of all present V. Matveev who had been awarded the RF Order "For

Merit to the Fatherland", III class, and National Order of Merit of France, Officer degree, and Academician Yu. Oganessian who had been awarded the RF Order "For Merit to the Fatherland", II class.

V. Matveev presented information on the latest significant events at JINR, in particular about the results of Scientific Council September session, meetings in Uzbekistan and prospects of cooperation with France and Germany.

JINR Press Secretary B. Starchenko made a report "Distribution of information about JINR activities", where he presented a review of JINR activities in several years, including the year of the JINR 60th anniversary celebration. The report evoked remarks, suggestions and questions. In the debates the following participants took part: Yu. Panebrattsev, M. Itkis, I. Meshkov, B. Sharkov, E. Krasavin, R. Tsenov, O. Culicov, D. Kamanin, and S. Nedelko.

Members of JINR Science and Technology Council chose the final version of JINR Code of Professional Ethics by a majority vote.

The report presented by G. Shirkov, Corresponding Member of RAS, was devoted to the Medical Compact Superconducting Accelerator being constructed jointly by specialists from JINR and the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP). In particular, G. Shirkov noted that at present the main elements of the facility are in the stage of adjusting. The SC202 accelerator is to be manufactured and delivered to Dubna next year when it will replace the Phasotron. E. Krasavin, R. Tsenov, I. Meshkov and others made remarks and suggestions on the report.

On 1 December, an extended meeting of the RAS Council on Heavy-Ion Physics was held in Dubna. It was attended by the Council members, and specialists from leading institutes of Russia, France and Germany were invited. The programme of the meeting included discussion of research programme on radioactive nuclei beams at the U400M/ACCULINNA-2 Accelerator Complex in the present and coming Seven-Year Plans, as well as prospects for the development of this theme up to 2030. The meeting was joined by more than 60 participants, which is explained by a deep interest in the discussed issue.

Chairman of the Council Yu. Oganessian opened the Meeting with the report "Investigations of nuclei far away from the β-stability line as one of three FLNR fields of research". Reports by M. Lewitowicz (GANIL, France), Ch. Scheidenberger, H. Simon and Yu. Litvinov (GSI, Germany) were devoted to advanced technologies for conducting experiments with beams of radioactive nuclei in leading institutes of the world. G. Ter-Akopian, S. Krupko, and A. Fomichev in their reports spoke on the status of the ACCULINNA-2 separator development and experiments programme for the nearest and midterm perspectives. L. Grigorenko made a report "Scientific programme for electron–ion collider". G. Trubnikov, G. Gulbekyan, and S. Polozov (MEPhI) made reports that were met with considerable interest. I. Meshkov made a report "Electron–ion collider using crystalline ion beams". During a round table chaired by B. Sharkov, a lively discussion was held.

In conclusion, the meeting affirmed the scientific programme of research at the U400M/ ACCULINNA-2 up to 2023 and also showed great interest in the plans for the future. The DERICA (Dubna Electron–Radioactive Ion Collider fAcility) project brought up for discussion was considered promising and ambitious for potential discoveries. This project is able to advance JINR to the world level in this field just like NICA.

On 7 December, an interdepartmental delegation from Vietnam visited JINR. The delegation consisted of representatives of the Vietnam Atomic Energy Institute VINATOM headed by its President Tran Chi Thanh, Expert of the Department of Education and Training of the Government of Vietnam Nguyen Trieu Nhien, and representatives of the Vietnamese Ministry of Industry and Trade, the Ministry of Finance, and the Ministry of Science and Technology. The delegation was accompanied by Chief Specialist of the International Cooperation Department of the State Atomic Energy Corporation "Rosatom" V. Pestov and Professor Nguyen Manh Shat, a Member of the JINR Scientific Council and Head of the national group of Vietnam in JINR.

At the meeting with JINR representatives headed by JINR Vice-Director M. Itkis, a lecture on JINR activities and JINR educational programmes was delivered by Head of the JINR International Cooperation Department D. Kamanin and Director of the JINR University Centre S. Pakuliak. The sides discussed issues of attracting young scientists and engineers from Vietnam who are studying at Russian universities at the moment. Initiation and development of unique JINR infrastructure objects and possibility of technology transfer were marked as the most advantageous directions of cooperation.

The delegation had excursions to the Flerov Laboratory of Nuclear Reactions and the Factory of Superheavy Elements, and got acquainted with the spectrometer complex of the IBR-2 reactor at the Frank Laboratory of Neutron Physics.

On 17–19 December, Head of the Division of Science Policy and Capacity Building of the Natural Sciences Division of UNESCO M. Zebaze Kana and Leading Specialist of the Sector for Natural Sciences J.-P. Ngome Abiaga visited JINR.

The UNESCO representatives discussed with the leaders of the Institute possibilities of strengthening and expanding JINR–UNESCO cooperation in the framework of the Agreement on cooperation renewed in 2017 and new issues of contacts concerning educational initiatives of JINR and preparation of the programme for UNESCO grant-aided students at JINR. Due to the

UNESCO's decision to proclaim 2019 as the International Year of the Periodic Table of Chemical Elements, some aspects of JINR's participation in corresponding festive UNESCO events were discussed, as far as JINR made an invaluable contribution to the discovery of new superheavy elements.

The guests visited JINR Laboratories, learnt about the research infrastructure of the Institute and activities of the University Centre.

On 27 December, the meeting of the JINR Science and Technology Council chaired by R. Jolos was held; reports on two JINR basic projects were considered: the Factory of Superheavy Elements, by FLNR Director S. Dmitriev, and the NICA complex, by VBLHEP Director V. Kekelidze.

At the beginning of the meeting, JINR Director V. Matveev awarded E. Kolganova, Scientific Secretary of JINR STC, Senior Scientific Researcher of BLTP, with the JINR commemorative honorary medal "For Services to Science and the Joint Institute for Nuclear Research" for her great contribution to organization and successful work of the JINR Science and Technology Council.

In his report S. Dmitriev demonstrated major stages of the Factory of Superheavy Elements development: construction of a new experimental building, the DC-280 cyclotron assembly, preparation of the area and technological systems for the new accelerator complex. Preparation and performance of the first experiments are planned for September–November 2018. R. Jolos, V. Matveev and Yu. Oganessian took part in the discussion of the report. In their comments they underlined the importance of contacts with external organizations and, as a whole, praised the work of the laboratory community aimed at the solution of major tasks.

V. Kekelidze named the main objects of basic configuration of the NICA complex: the accelerator complex, the operating modernized Nuclotron, the Booster, the Injection Complex, the experimental zone, and two storage rings with two cross points of the collider. Under development are the MPD, BM@N detectors and the NICA Centre — the infrastructure item that will include a computing centre. The speaker demonstrated a sketch of a new centre and then touched upon development stages of each of the mentioned objects; he reported on attracting specialists and organizations from Russia, CERN, Germany, China, the Czech Republic and other countries to participate in the project. In conclusion, V. Kekelidze noted that establishment of the accelerator complex, engineering infrastructure, and experimental facilities is under way due to the plan. Cooperation with China and other countries is developing. M. Itkis, V. Matveev, Yu. Oganessian, and I. Meshkov posed questions and made comments.

JINR Director informed STC members about the activities of the Directorate and spoke about the main results of the year and tasks for the JINR staff to solve in 2018.

CONFERENCES AND MEETINGS HELD BY JINR

Eleven conferences were the largest among the scientific conferences and workshops held at JINR in 2017.

The ***festive ceremony on the occasion of the discovery and naming of new chemical elements*** of the Mendeleev Periodic Table of Elements with atomic numbers 115, 117 and 118 was held on 2 March at the Central Club of Scientists of the Russian Academy of Sciences in Moscow.

The ceremony was attended by RF Minister of Education and Science O. Vasilyeva, Deputy Minister G. Trubnikov, Presidents of the International Union of Pure and Applied Chemistry (IUPAC) and the International Union of Pure and Applied Physics (IUPAP), leaders and official representatives of leading world laboratories in the field of the synthesis of superheavy elements from the USA, Germany, France, Japan, scientists and specialists from JINR Laboratories, partners from Russian scientific centres and other JINR Member States. The inauguration ceremony of the new elements was held by IUPAC President Professor N. Tarasova.

According to RF Minister of Education and Science O. Vasilyeva, the discovery of the new superheavy elements as well as the fact that two of them have names associated with Russia and the Russian scientists — moscovium, element 115 in honour of the Moscow land, and oganesson, element 118 in honour of Yuri Oganessian — of course, can be attributed to the most brilliant achievements of our time.

The inauguration ceremony included a scientific colloquium. Academician Yu. Oganessian made a report on the synthesis of new elements at the Flerov Laboratory of Nuclear Reactions. Professor W. Nazarewicz from Michigan State University (the USA) dedicated his report to element 118, oganesson. Vice-President of the Royal Society of London for Improving Natural Knowledge M. Poliakoff (Great Britain) presented films about each of 118 elements of the Mendeleev Table produced by the team of Nottingham University. On 3 March, the scientific colloquium continued its work in Dubna, at the Flerov Laboratory of Nuclear Reactions.

The 25th jubilee ***International Seminar on Interaction of Neutrons with Nuclei (ISINN-25)*** dedicated to the 60th anniversary of the Frank Laboratory of Neutron Physics took place in Dubna at the JINR International Conference Hall on 23–26 May.

The seminar is held by FLNP annually and attracts both experienced and young scientists from JINR Laboratories, Member States of the Institute, as well as from other countries. This year it was attended by about 130 physicists from leading neutron centers and Russia including ITP (Chernogolovka), ITEP (Moscow), INR RAS (Troitsk), IHEP (Protvino), SINP MSU (Moscow), PNPI (Gatchina), NRC KI (Moscow), IPPE (Obninsk), as well as from universities of Moscow, Voronezh, Samara, Tula and other cities.

The scientific program of ISINN-25 included reports on new results obtained in the fields of fundamental interactions and UCN physics, physics of nuclear fission, nuclear analytical techniques in biology and ecology, nuclear reactions with fast neutrons, nuclear structure, methodological aspects of experiments with neutrons, accelerator-driven subcritical systems, as well as a number of review reports related to the 60th anniversary of FLNP JINR and the 25th jubilee of the seminar. During the four working days the participants presented a total of 50 oral and more than 40 poster reports (for more details, see the seminar webpage http://isinn.jinr.ru/past-isinns/isinn-25/program.html).

At the poster session, studies of young scientists from Russia, Azerbaijan, Bulgaria and other countries on medicinal plants, biomonitoring of territories with a strong anthropogenic load (Absheron Peninsula in the Caspian Sea), as well as joint investigations with FLNP into new materials conducted in cooperation with the Scientific and Practical Center of the National Academy of Sciences of Belarus for Materials Science, were presented.

The program of the seminar was continued by a round table devoted to the construction of a pulsed neutron source of the next generation in JINR and its research program. In their introductory reports Ye. Shabalin and Yu. Kopatch from FLNP JINR outlined the desirable parameters and design solutions for the new source, which could provide JINR and Russian physicists with a world-class highly competitive facility upon the expiration of the IBR-2 reactor service life. In the ensuing lively discussion, specialists from the JINR Member States and Russian neutron centers expressed their interest in the creation of such a source and implementation of a promising research program on it.

The success of ISINN-25 has confirmed the usefulness and attractiveness of the format chosen a quarter of a century ago of annual meetings on a wide range of issues in neutron physics. The feasibility and effectiveness of neutron methods for solving fundamental and applied problems of science have been proved as well.

On 6–10 June, the 25th international conference ***"Integrable Systems and Quantum Symmetries"*** was held in Prague, the Czech Republic. The conference was organized by the Faculty of Nuclear Sciences and Physical Engineering, the Czech Technical University in Prague, and the Bogoliubov Laboratory of Theoretical Physics of JINR.

The conference was marked by special broadness and representativeness. During five working days about 210 talks were given by the scientists from 26 countries — Australia, Azerbaijan, Bulgaria, Brazil, Canada, China, the Czech Republic, Denmark, France, Germany, Greece, Israel, Ireland, Italy, Japan, the Netherlands, Poland, Romania, Russia, Serbia, Slovakia, Sweden, Taiwan, Turkey, Ukraine, and the USA. The presented studies covered a very wide spectrum of topics: quantum groups, noncommutative geometry, quantum space-time and their quantum symmetries, discrete integrable systems and Painlevé equations, supersymmetry and integrability, spectral asymptotics of quantum integarable systems, higher spin field theory, modern mathematical methods, quantum integrable systems.

The participants had wide possibility to communicate discussing the subjects presented in the talks, in warm informal atmosphere at the breaks and during free time. No doubt, next year the majority of the scientists who participated in the 25th Conference will accept with enthusiasm the invitation to take part in this conference again.

The materials of the conference can be found at www.intsystems.cz.

On 3–7 July, LIT hosted the ninth international conference ***"Mathematical Modeling and Computational Physics" (MMCP'2017)***. The conference was devoted to the 60th anniversary of the foundation of JINR. Co-organizers of the conference were LIT JINR, IFIN-HH (Bucharest, Romania), Technical University (Košice, Slovakia), Institute of Experimental Physics of the Slovak Academy of Sciences (Košice, Slovakia), P. J. Safarik University in Košice (Slovakia). The conference was sponsored by the Intel Company. The Chairman of the Conference was LIT Director V. Korenkov, and co-chairmen of the Organizing Committee were G. Adam (LIT JINR, IFIN-HH) and M. Hnatič (JINR Laboratory of Theoretical Physics, Institute of Experimental Physics SAS and P. J. Safarik University).

Scientific topics of the Conference covered a wide range of issues: distributed and parallel computing and tools for scientific computing; mathematical methods and software application for modeling of complex physical and technological systems; bioinformatics and computational biophysics; physical processes simulations and related computational methods; computer algebra and quantum computing with applications.

The conference was attended by over 250 scientists and specialists from various scientific centers of Romania, Bulgaria, Germany, Lithuania, Finland, France, Slovakia, the USA, Mongolia, Canada, and a large number of Russian research centers and universities, such as NRC "Kurchatov Institute", IMPB RAS, ITAM SB RAS, St. Petersburg University, NSU, PFUR and others.

A series of plenary repots was devoted to various aspects of bioinformatics and applications of mathematical methods in biophysics. A number of plenary talks were dedicated to computational mathematics and simulations of complex systems. Particular attention within the MMCP'2017 conference was given to the problem of processing and analysis of experimental data and Big Data technologies. One of the traditional fields of computational mathematics presented at the MMCP conferences is related to the development of methods of symbolic computations and computer algebra as well as to the development of the methods of quantum computing and their applications.

A total of 212 reports (31 plenary, 158 oral and 23 poster ones) were presented at the conference.

A conference-school "Mathematical Modeling for the NICA Project" was organized in framework of the MMCP conference under the support of the JINR Directorate. The school program included lectures and practical classes as well as master classes.

The conference-school was attended by 54 young scientists and specialists of JINR, students of the University "Dubna", the Moscow Engineering Physics Institute, Moscow State University, St. Petersburg State University, Tver State University, PFUR, KazNU al-Farabi (Kazakhstan) and others. Materials of the conference and school are available on the official conference website at http://mmcp2017.jinr.ru.

The regular workshop ***"Classical and Quantum Integrable Systems"*** took place at the Bogoliubov Laboratory of Theoretical Physics from 24 to 29 July. A series of these conferences began even in the Soviet Union at the Institute of High Energy Physics (Protvino). Nowadays these workshops traditionally take place in Protvino, Dubna, Chernogolovka, and St. Petersburg. This year, the event was dedicated to L. Faddeev — the outstanding scientist, one of the founders of modern mathematical physics.

The number of participants of the workshop was more than one hundred people who came from more than 40 organizations situated in 11 countries, including Australia, the USA, Great Britain, Germany, France and Japan. The majority of the participants traditionally came from JINR, the Landau Institute of Theoretical Physics of RAS (Chernogolovka), the Steklov Mathematical Institute (Moscow and Saint Petersburg), IHEP (Protvino), ITEP (Moscow), the Department of Mathematics of the Higher School of Economics (Moscow), and the Lebedev Institute of Physics (Moscow). In particular, there were many our compatriots working abroad.

The main themes of this workshop were the following: recent results in the theory of classical and quantum integrable systems; quantum field theory, conformal field theory, AGT correspondence; quantum groups, cluster algebras and other sections of mathematics related to integrable systems; integrable models in the probability theory and the asymptotic representation theory.

In this series of workshops it has already become traditional to organize introductory mini-courses for students, where the leading world experts read lectures on the currently important directions of mathematical physics. In 2017, such lectures were given by M. Bershtein, S. Derkachov, O. Zaboronsky, and O. Ogievetsky. Most of the listeners were the students and young scientists from BLTP JINR, NRU HSE and St. Petersburg University.

As a whole, the conference was held at a very high scientific level. Its successful work became possible due to the financial support of BLTP JINR, RFBR, Heisenberg–Landau program, and, especially, the Laboratory of Mathematical Physics, Department of Mathematics of the Higher School of Economics. The Organizing Committee is grateful to JINR and all other sponsors for the help in organizing this workshop. A short video report on the conference can be watched on the webpage http://science-tv.jinr.ru/?p=4517.

The international workshop ***"Supersymmetries and Quantum Symmetries" (SQS'2017)*** was held at the Bogoliubov Laboratory of Theoretical Physics from 31 July to 5 August. These biennial meetings were initiated in 1989 by Professor V. Ogievetsky (1928–1996) and are regularly organized at BLTP. For many years the Organizing Committee of the SQS workshops has been headed by Professor E. Ivanov, a disciple of V. Ogievetsky.

This time, the main topics of the conference were: string theory, quantum and geometric aspects of supersymmetric theories, higher-spin theories, supersymmetric integrable models, quantum groups and noncommutative geometry, Standard Model and its supersymmetric extensions.

The workshop was attended by 121 scientists. They represented Australia, England, Armenia, Belgium, Bulgaria, Brazil, Germany, Spain, Italy, the Netherlands, Taiwan, Poland, the Republic of Korea, Russia, Serbia, the USA, Ukraine, France, Sweden and the Czech Republic. Among the participants there were leading experts in the theory of elementary particles, quantum field theory, gravitation and string theory, noncommutative geometry and integrable systems.

The SQS'2017 workshop became possible due to the finance support from BLTP JINR, the Russian Foundation for Basic Research, Heisenberg–Landau, Blokhintsev–Votruba and Bogoliubov–Infeld Programs.

The results of SQS'2017 have once more highlighted the fundamental role of the theory of strings, supersymmetry and quantum symmetries in modern theoretical and mathematical physics, importance of further studies in these directions, and the fruitfulness and effectiveness of the international scientific cooperation with the participation of JINR. More information on the workshop and files of the talks are available on the website http://theor.jinr.ru/sqs17/.

The 12th International Scientific Workshop on Problems of Charged Particle Accelerators in memory of Professor V. Sarantsev was held on 3–8 September in the holiday hotel "Dubna" (Alushta). It was organized by the Joint Institute for Nuclear Research, the Budker Institute of Nuclear Physics (Novosibirsk), and the Scientific Council of the Russian Academy of Sciences on issues of charged particle accelerators.

The workshop was aimed at exchange of information and discussions of issues of accelerator science and technology, physics of charged particle beams, working out of new projects of lepton and hadron colliders, upgrading of current facilities, use of accelerators for scientific and applied tasks, and attraction of young scientists to the solution of problems in accelerator technology. In particular, much attention was paid to the discussion of these questions in the light of implementation of the mega-project NICA.

Representatives of largest accelerator centres of Russia traditionally took part in the workshop. Lecturers came to Alushta from such scientific centres as INP SB RAS, JINR, ITEP, the Lebedev Institute of Physics, St. Petersburg State University, NRNU MEPhI, LLC "Impulsnye Tekhnologii" (Ryazan), INR RAS, ICKC SB RAS, NRC "Kurchtov Institute" (Moscow), the Efremov SRI of Electrophysical Apparatus, the Frumkin Institute of Physical Chemistry and Electrochemistry of RAS (Moscow), MRTI RAS, PTC PI RAS (Protvino), MSU Physics Faculty, and IHEP (China). The workshop has been held in Alushta since 2005. According to organizers, this year a record number of participants arrived at the event, about 130 persons. Fifty-six oral and 83 poster presentations were submitted.

The European School of High Energy Physics (ESHEP-2017) organized jointly by CERN and JINR was held on 6–19 September in the town of Evora (Portugal). This school was a jubilee one — the 25th event. It not only once again confirmed serious scientific concern of scientists but also demonstrated the growing interest of the public in science issues.

The European schools on high energy physics have been held since 1993. They continue the traditions of earlier CERN–JINR schools aimed at educating young experimentalists in theoretical aspects of elementary particle physics. Schools are held in turns in CERN and JINR member states and always attract great interest among the young by their significant scientific program and careful selection of lecturers and discussion leaders. For example, a hundred attendants of the school in Evora represented 33 nationalities and were chosen from over 230 candidates, on the basis of their scientific potential and involvement in advanced research.

The scientific program of the school included basic lectures on quantum field theory and the Standard Model, quantum chromodynamics, physics beyond the Standard Model and many other aspects of special interest in the main JINR trends — heavy ion physics and neutrino physics.

Among the lecturers were Professors E. Gross (Israel), K. Melnikov (Germany), S. Davidson (France), (JINR) and P. Silva (CERN). The rector of the University "Dubna" Professor D. Fursaev gave the students a lecture on gravitational waves. Discussion sessions under the guidance of experienced mentors were organized each evening of the school to help young specialists master the topics of the lectures. Among these discussion leaders were JINR employees from BLTP A. Gladyshev and A. Bednyakov; discussions for students were also led by I. Ivanov (CFTP/IST), M. Nardecchia (CERN), E. Re (CERN), and R. Santos (ISEL).

Among the lecturers from JINR were A. Arbuzov, D. Kazakov, D. Fursaev. The reviews on scientific programmes at international scientific centres were presented by CERN Director F. Gianotti and JINR Director V. Matveev.

The attendants expressed interest in the course of application of statistical methods in elementary particle physics which was illustrated with examples of the recent discovery of the Higgs boson and search for new particles at the Large Hadron Collider. Some attendants of the school presented their research at a special poster session.

Forty lectures, each 90 minutes long, were delivered during two weeks of the school. At the end of each day, a discussion session was held where attendants, organized in six groups, could ask questions to the discussion leaders and lecturers. This format, that was established at the very beginning of the event, made the atmosphere more open and comfortable for attendants and facilitated more profound understanding of the discussion topics.

Since 2014, the agenda of the European School of High Energy Physics has included a practice course of delivering scientific results to the public that is given by BBC science journalists. This course enjoys steady popularity among the participants. The program of the current school had practical classes — interviews of participants and the competition of student projects on a certain scientific topic. The jury chose a team of students who made a report about the discovery of the Higgs boson the best group of the competition.

The issues of science popularization are an inseparable part today of the activities of scientific groups, especially in implementation of large scientific projects. JINR and CERN acknowledge and bring to life this important role of science. It is because of this aspect that public lectures, round table discussions, and meetings of scientists with the public have always been included into the programs of European schools. The school in Evora was by no means an exception.

On 15 September, a meeting with the public was organized at Evora University attended by CERN Director F. Gianotti, JINR Director V. Matveev, and Minister of Science, Technology and Higher Education of Portugal M. Heitor. F. Gianotti delivered a lecture "Higgs Particle and Our Life", while V. Matveev and Director of the Institute of Experimental Particle Physics (LIP) of Portugal G. Barreira took part in the discussion and answered questions from the audience of 300 people, including not only University students but also school children who arrived at the meeting from different places, like Lisbon and Spain.

The whole cycle of the European schools of high energy physics continues its scientific and cultural mission on a high level, constantly improving its program and modes of communication with attendants and the public. The jubilee 25th school in Evora was a significant event of high standard with prospects for the future.

The 17th Workshop on High-Energy Spin Physics (DSPIN-17) was held at BLTP, JINR on 11–15 September. The first conference in this series took place in 1981 at the initiative of the outstanding theoretical physicist L. Lapidus. Since then, each odd year similar meetings have been organized in Protvino and Dubna.

A specific feature of this conference is a large number of participants from different countries: Russia, the USA, Belarus, Ukraine, Poland, Germany, the Czech Republic, Italy, Slovakia, China, Belgium, Bulgaria, and India.

As usual, many physicists from JINR participated in the conference. The reason for the increased popularity of the conference is apparently in the fact that last years have brought many new experimental (RHIC, COMPASS, LHC) and theoretical results. Many of them are related to spin (or/and internal transverse momentum) dependent parton distributions.

The success of the conference was due to the support of the Russian Foundation for Basic Research, the International Committee for Spin Physics, the European Physical Society, the National Research Nuclear University (Moscow Engineering Physics Institute), and the JINR programs for international collaboration: Heisenberg–Landau, Bogoliubov–Infeld and Blokhintsev–Votruba.

On 25–29 September, the town of Budva, Montenegro, hosted the ***XXVI International Symposium on Nuclear Electronics and Computing (NEC'2017)***. The symposium has been traditionally held by JINR since 1963, and for the ninth time JINR and CERN became its organizers. Co-chairmen of the symposium were LIT Director V. Korenkov (JINR) and Dr. I. Bird (CERN).

The symposium was attended by more than 120 leading specialists in the field of modern computer and network technologies, distributed computing and nuclear electronics from 14 countries: Belarus, Moldova, Bulgaria, Great Britain, Germany, Russia, the USA, France, the Czech Republic, Slovakia, Italy, China, the Netherlands, and Switzerland. The scientific program of the symposium covered a wide range of issues and included the following sections: detector and nuclear electronics; triggering, data acquisition and control systems; machine learning and Big Data analytics; grid-technologies and cloud computing; computing for large-scale accelerator facilities (LHC, FAIR, NICA, SKA, PIC, XFEL, ELI, etc.); nonrelational databases and heterogeneous repositories; research data infrastructure, computations with hybrid systems (CPU, GPU, coprocessors), as well as a traditional topic of the symposium related to innovative IT education. Within the symposium, a workshop "BigPanDA Technical Interchange Meeting" was held. The symposium was organized under the sponsorship of the companies Niagara Computers, JET Infosystems, Dell-EMC and IBS Platformix.

The plenary sessions included 36 reports. At the sections, reports were presented which caused great interest of the symposium participants and were devoted to the topical issues of the technical development of detectors, data acquisition systems and automation, as well as to computing for large-scale experimental facilities, the development of research data infrastructures, use of present-day IT technologies such as grid, cloud computing and hybrid computing to solve modern scientific problems.

Special attention was paid to the implementation of the NICA project. Within the symposium program, presented were 2 plenary and 11 sectional reports. Two reports were dedicated to the training of specialists for the NICA project.

For the fourth time the International School on Modern Information Technology for students and postgraduates was organized within the symposium. This school was devoted to heterogeneous distributed computing infrastructures. The JINR Laboratory of Information Technologies (http://www.jinr.ru), Laboratory of Big Data for Mega-Science Experiments of NRC "Kurchatov Institute" (http://bigdatalab.nrcki.ru/) and the TPU Institute of Cybernetics (http://portal.tpu.ru/ic) provided a full financial and organizational support to the participants of the youth school. The school was attended by leading scientists from Russia, the UK, the USA, Italy as well as staff members from JINR, NRC KI, CERN and DESY.

The school-conference was attended by 32 senior students as well as masters and postgraduates majoring in information technology from the leading Russian universities (National Research Nuclear University MEPhI, Saint Petersburg State University, University "Dubna", Ryazan State Radio-Engineering University, Magnitogorsk State Technical University, Russian University of Peoples' Friendship, and Tomsk Polytechnic University).

The 21st International Scientific Conference of Young Scientists and Specialists of JINR (AYSS-2017) was held on 2–6 October in Dubna. This annual event attended by students, post-graduates, young scientists and specialists from JINR and other Russian and foreign scientific centres is devoted to fundamental and applied trends of research at JINR.

JINR Director Advisor G. Shirkov greeted the participants at the opening ceremony. Co-Chairman of the Organizing Committee V. Chudoba announced the full agenda of the conference. At the plenary session, leading specialists of the Institute gave lectures in modern research in theoretical physics, mathematical simulation and computer physics, high energy physics, charged particle accelerators and nuclear reactors, experimental nuclear physics, applied research, information technologies, condensed matter physics and life sciences. About 220 people took part in the conference. They were staff members of JINR and guests from 18 countries. At the section meetings, participants presented 140 oral reports in 9 sections and 60 poster reports. On the last day of the conference, authors of best presentations were announced.

For the first time a competition "Falling Walls Lab" was held in Dubna as a part of the conference — a project to commemorate the 20th anniversary of the fall of the Berlin Wall. The participants of the competition — young scientists, specialists and entrepreneurs — have an opportunity to show the world community their ideas, projects, methods of solving the tasks that the mankind confront. The main requirement for any competitor is to explain his or her idea in a comprehensible way in three minutes with three slides. Competitors are selected worldwide; three best finalists out of 100 will go to Berlin in November where their presentations will be considered by the jury of politicians, economists, scientists and journalists.

Eight young staff members of JINR took part in the Dubna stage of Falling Walls Lab, together with students of the University "Dubna" and Wroclaw University. The winner was BLTP staff member A. Slyamov (scientific leader E. Anitsash).

PARTICIPATION OF JINR IN INTERNATIONAL CONFERENCES

In 2017, scientists and specialists of the Joint Institute for Nuclear Research took part in 462 international conferences and meetings.

The largest delegations representing JINR attended the following events: 24th international conference "Mathematics. Computing. Education" (Pushchino, Russia); 9th JUNO Collaboration Meeting (Zhuhai, China); 30th ICP Vegetation Task Force Meeting (Poznan, Poland); CREMLIN WP2 Workshop on Big Data Management (Moscow, Russia); international conference "Instrumentation for Colliding Beam Physics" (INSTR17) (Novosibirsk, Russia); 51st Annual Winter School of St. Petersburg Nuclear Physics Institute NRC KI (St. Petersburg, Russia); 51st PNPI School on Condensed Matter Physics (St. Petersburg, Russia); international scientific and practical conference "Radiation Oncology-2017" (Moscow, Russia); 29th CBM Collaboration Meeting (Darmstadt, Germany); ISF Workshop on the Study of High-Density Nuclear Matter with Hadron Beams (Rehovot, Israel); 23rd All-Russian Scientific Conference of Physics Students and Young Scientists (Yekaterinburg, Russia); 14th International Workshop on Hadron Structure and Spectroscopy (IWHSS17) (Cortona, Italy); CMS Week (Geneva, Switzerland); 24th International Scientific Conference of Students, Postgraduates and Young Scientists "Lomonosov" (Moscow, Russia); 7th All-Russian conference "Information and Telecommunication Technologies and Mathematical Modeling of High-Tech Systems" (Moscow, Russia); 1st international symposium "Integration of Belarussian Scientists in the Research Programs of the World's Leading Nuclear Physics Centers" (Minsk, Belarus); JUNO European Collaboration Meeting (Catania, Italy); workshop "The Future of Biology and Soft Matter Research on Reactor PIK" (BioSoft@PIK) (Peterhof, Russia); international conference "Isospin, Structure, Reactions and Energy of Symmetry" (ISTROS2017) (Casta Papiernička, Slovakia); 1st All-Russian scientific conference "Toxicology and Radiobiology of the XXI Century" (St. Petersburg, Russia); Ginzburg Centennial Conference on Physics (Moscow, Russia); workshop "Matrix Elements for the Double Beta Decay Experiments" (MEDEX 17) (Prague, the Czech Republic); 10th International Conference on Chaotic Modeling and Simulation (CHAOS 2017) (Barcelona, Spain); 47th International Tulinov Conference on Physics of Charged Particles Interactions with Crystals (Moscow, Russia); International Session-Conference of the Section of Nuclear Physics of the Physical Sciences Department of the Russian Academy of Sciences "Physics of Fundamental Interactions" (Nalchik, Russia); TAIGA Collaboration Meeting (Moscow, Russia); NOνA Meeting (Wichita, USA); 5th International Conference on Radiation and Applications in Various Fields of Research (RAD 2017) (Budva, Montenegro); BESIII Collaboration 2017 Summer Meeting (Anshan, China); workshop "Neutron Diffraction-2017" (Gatchina, Russia);

International Symposium on Cosmic Rays and Astrophysics (ISCRA-2017) (Moscow, Russia); 36th International Workshop on Nuclear Theory (IWNT36-2017) (Rila, Bulgaria); 62nd Annual Conference of the SA Institute of Physics (SAIP 2017) (Stellenbosch, RSA); EPS Conference on High Energy Physics (Venice, Italy); International Conference on Neutron Optics (NOP-2017) (Nara, Japan); 20th International Conference on Surface Modification of Materials by Ion Beams (SMMIB-2017) (Lisbon, Portugal); 17th International Conference on Strangeness in Quark Matter (SQM 2017) (Utrecht, Netherlands); 35th International Cosmic Ray Conference (ICRC 2017) (Busan, South Korea); Workshop on Condensed Matter Research by means of Neutron Scattering Methods (Constanta, Romania); 6th International Conference on New Frontiers in Physics (ICNFP 2017) (Crete, Greece); 23rd international conference "Ion-Surface Interactions" (ISI 2017) (Moscow, Russia); Euroschool on Exotic Beams 2017 (Cabourg, France); PANDA-Meeting 2017 III at BINP Novosibirsk (Novosibirsk, Russia); international workshop "Anvanced Many-Body and Statistical Methods in Mesoscopic Physics" (Busteni, Romania); symposium "Molecular Simulation Studies in Material and Biological Sciences" (MSSMBS'17) (Peterhof, Russia); 22nd International School on Nuclear Physics and Applications (Varna, Bulgaria); 4th international conference "Multiscale Modeling of Structures, the Structure of Substance, Nanomaterials and Nanotechnologies" (Tula, Russia); 23rd Congress of I. P. Pavlov Physiology Society (Voronezh, Russia); International Workshop on Hadron Polarimetry in the GeV Region (Orsay, France); 40th European Cyclotron Progress Meeting (Legnaro, Italy); CBM School and 30th CBM Collaboration Meeting (Wuhan, China); International Symposium on Physics of Unstable Nuclei 2017 (ISPUN17) (Halong City, Vietnam); 3rd International Conference on Particle Physics and Astrophysics (ICPPA 2017) (Moscow, Russia); international school and workshop "Critical Stability of Quantum Few-Body Systems" (Dresden, Germany); 34th HADES Collaboration Meeting (Santiago de Compostela, Spain); 19th World Festival of Youth and Students (scientific and educational thematic areas) (Sochi, Russia); Small Triangle Meeting 2017 (Medzilaborce, Slovakia); 9th International Conference on Nanomaterials — Research and Application (NANOCON) (Brno, the Czech Republic); Latin-American Symposium on Nuclear Physics and Applications (LANSPA-WONP-NURT) (Havana, Cuba); RO-LCG 2017 conference "Grid, Cloud and High-Perfomance Computing in Science" (Sinaia, Romania); international scientific conference "Youth in Science 2.0'17" (Minsk, Belarus); GERDA General Meeting (Assergi, Italy); 7th international conference "Deformation and Destruction of Materials and Nanomaterials" (Moscow, Russia); Symposium in Memory of Laszlo Czer (Budapest, Hungary); international scientific and practical conference "Nuclear Medicine and Radiation Therapy: Status and the Nearest Perspectives" (Moscow, Russia); Meeting of the Steering Committee on the Heisenberg–Landau Programme (Hamburg, Germany); International Colloquium Dedicated to the Naming of the New Elements of the Mendeleev Periodic Table with Atomic Numbers 115, 117 and 118 (Moscow, Russia); Jubillee Events Dedicated to the 10th Anniversary of the Associate Membership of Serbia in JINR (Belgrade, Serbia); Conference Dedicated to the 25th Anniversary of JINR Participation in the ATLAS Experiment (Budva (Becici), Montenegro); International School of Nuclear Physics "JINR Days in Bulgaria" (Sofia (Borovets), Bulgaria); 25th International Conference on Integrable Systems and Quantum Symmetries (ISQS-25) (Prague, the Czech Republic); 6th Annual Conference of Young Scientists and Specialists "Alushta-2017" (Alushta, Russia); 17th International Conference on Symmetry Methods in Physics (Yerevan, Armenia); 17th International Baikal Summer School on Physics of Elementary Particles and Astrophysics (Bolshie Koty, Russia); 5th international school "Symmetry in Integrable Systems and Nuclear Physics" (Tsakhkadzor, Armenia); 11th workshop "Modern Problems in Nuclear and Elementary Particle Physics" (Peterhof, Russia); 8th International Student Summer School "Nuclear Physics — Science and Applications" (Brasov, Romania); 7th Pontecorvo Neutrino Physics School (Prague, the Czech Republic); 18th Lomonosov Conference on Elementary Particle Physics (Moscow, Russia); 2nd CMS workshop "Perspectives of Physics and CMS at HL–LHC" (Varna, Bulgaria); 12th International Workshop in Memory of Professor V. P. Sarantsev "Problems of Colliders and Charged Particle Accelerators" (Alushta, Russia); 2017 European School of High-Energy Physics (Evora, Portugal); 3rd International Symposium on Super-Heavy Elements "Challenges in the Studies of Super-Heavy Nuclei and Atoms" (SHE 2017) (Kazimierz Dolny, Poland); international scientific forum "Nuclear Science and Technologies" (to the 60th Anniversary of the Institute of Nuclear Physics in Almaty) (Almaty, Kazakhstan); 26th International Symposium on Nuclear Electronics and Computing (NEC'17) (Budva (Becici), Montenegro); CERN School for Teachers of Physics from JINR Member States (Geneva, Switzerland); NICA Days 2017 in Warsaw (Warsaw, Poland); International Coordination Meeting on Swift and Highly Charged Ions in Material Science (Port Elizabeth, RSA); 2017 KLFTP/CAS–BLTP/JINR Joint Workshop on Physics of Strong Interaction (Shenzhen, China).

DEVELOPMENT OF THE JINR INTERNATIONAL COLLABORATION AND RELATIONS OF THE YEAR 2017

1.	Number of short-term visits to JINR by specialists from the Member States (not counting Russian specialists)	1192
2.	Number of visits of specialists from other countries, including visits from the Associate Members	922 450
3.	Number of visits by JINR specialists to the Member States (not counting Russian visits in Russia)	1261
4.	Number of visits by JINR specialists to other countries, including visits of specialists to the Associate Members	1824 549
5.	Number of conferences, schools, and meetings held by JINR	84
6.	New cooperation agreements (memoranda of understanding), addenda to existing ones	24

CONFERENCES, SCHOOLS, AND MEETINGS HELD BY JINR IN 2017*

No.	Name	Place	Date	Number of participants
1.	27th meeting of the Joint Committee on the IN2P3–JINR Collaboration	Dubna	12 January	13
2.	Meeting of the Programme Advisory Committee for Particle Physics	Dubna	16–17 January	46
3.	Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	19–20 January	63
4.	Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	25–26 January	70
5.	Winter school “Heavy Ion Physics: From LHC to NICA”	Dubna	30 January – 4 February	38
6.	121st Session of the JINR Scientific Council	Dubna	23–24 February	94
7.	International Colloquium Dedicated to the Naming of the New Elements of the Mendeleev Periodic Table with Atomic Numbers 115, 117 and 118	Moscow, Dubna	2–4 March	150
8.	Jubillee Events Dedicated to the 10th Anniversary of the Associate Membership of Serbia in JINR	Belgrade, Serbia	14–19 March	40
9.	Meeting of the Working Group on Financial Issues under the CP Chairman	Dubna	23 March	25
10.	Meeting of the JINR Finance Committee	Dubna	24–25 March	79
11.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Dubna	27–28 March	96
12.	Physics Days in Dubna	Dubna	31 March – 2 April	200
13.	International workshop “Simulations of HIC for NICA Energies”	Dubna	10–12 April	24
14.	International seminar “The 60th Anniversary of Synchrophasotron Launching and the 110th Birth Anniversary of Academician V. I. Veksler”	Dubna	21 April	128

*A number of conferences were held jointly with other organizations. There were also held meetings of the JINR Science and Technology Council, session of the Joint Coordination Committee of the Ministry of Education, Science and Technology of the Republic of Serbia and JINR (via videoconference), training programme “JINR Expertise for Specialists from Member States and Other Countries”. Besides, JINR assisted in organization of the 24th international conference “Mathematics. Computing. Education”, the 4th international conference “Multiscale Modeling of Structures, the Structure of Substance, Nanomaterials and Nanotechnologies”, symposium “Molecular Simulation Studies in Material and Biological Sciences”, and some other events held in 2017.

No.	Name	Place	Date	Number of participants
15.	Conference “25 Years of JINR’s Involvement in the ATLAS Collaboration”	Budva (Becici), Montenegro	24–29 April	49
16.	Meeting of the BRICS Working Group on Research Infrastructure	Dubna	15–16 May	53
17.	International school of nuclear physics “JINR Days in Bulgaria”	Sofia, (Borovets), Bulgaria	16–19 May	51
18.	Celebration of the 60th anniversary of the Flerov Laboratory of Nuclear Reactions	Dubna	17–19 May	136
19.	NICA International Machine Advisory Committee Meeting	Dubna	22–23 May	35
20.	25th International Seminar on Interaction of Neutrons with Nuclei (ISINN-25)	Dubna	23–26 May	100
21.	First Stage of the International Student Practice (for students from RSA)	Dubna	28 May – 17 June	15
22.	“Baikal” Collaboration Workshop	Dubna	30 May – 2 June	51
23.	Summer Student Program at JINR	Dubna	1 June – 30 September	45
24.	25th international conference “Integrable Systems and Quantum Symmetries” (ISQS-25)	Prague, Czech Republic	6–10 June	100
25.	6th School-Conference of Young Scientists and Specialists in Alushta (“Alushta 2017”)	Alushta, Russia	12–19 June	63
26.	Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	14–15 June	71
27.	Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	19–20 June	61
28.	Meeting of the Technical Advisory Board of Baikal-GVD Project	Dubna	20–22 June	25
29.	JINR School for Teachers of Physics from JINR Member States	Dubna	25 June – 1 July	28
30.	Meeting of the Programme Advisory Committee for Particle Physics	Dubna	26–27 June	40
31.	3rd International Summer School and Workshop on “Complex and Magnetic Soft Matter Systems: Physico-Mechanical Properties and Structure”	Dubna	27 June – 1 July	89
32.	Second Stage of the International Student Practice (for students from the JINR Member States)	Dubna	2–22 July	85
33.	International conference “Mathematical Modeling and Computational Physics”	Dubna	3–7 July	168
34.	3rd Summer School on “Sociocultural Morphology of a Small Town: Authors, Practices, Institutions (Dubna)”	Dubna	4–14 July	40
35.	17th international conference “Methods of Symmetries in Physics”	Yerevan, Armenia	9–15 July	90
36.	International workshop “Lattice and Functional Techniques for Exploration of Phase Structure and Transport Properties in Quantum Chromodynamics”	Dubna	10–14 July	25
37.	Helmholtz international summer school “Nuclear Theory and Astrophysical Applications”	Dubna	10–22 July	70
38.	17th International Baikal Summer School on Elementary Particles Physics and Astrophysics	Bolshie Koty, Russia	13–20 July	79

No.	Name	Place	Date	Number of participants
39.	School of Young Scientists and Specialists in Dubna	Dubna (Lipnya)	14–16 July	60
40.	International school “Symmetry in Integrable Systems and Nuclear Physics”	Tsaghkadzor, Armenia	16–23 July	65
41.	11th workshop “Modern Problems of Nuclear and Elementary Particle Physics”	Peterhof, Russia	23–28 July	62
42.	11th international workshop “Classical and Quantum Integrable Systems” (CQIS-2017)”	Dubna	24–29 July	100
43.	8th International Student Summer School “Nuclear Physics — Science and Applications”	Brasov, Romania	26 July – 4 August	70
44.	International workshop “Supersymmetries and Quantum Symmetries”	Dubna	31 July – 5 August	101
45.	29th Summer International Computer School	Dubna	2–20 August	90
46.	International school “Advanced Methods of Modern Theoretical Physics”	Dubna	6–12 August	49
47.	7th Pontecorvo Neutrino Physics School	Prague, Czech Republic	20 August – 1 September	102
48.	Helmholtz International Summer School “Lattice QCD, Hadron Structure and Hadron Matter”	Dubna	20 August – 2 September	63
49.	18th Lomonosov Conference on Elementary Particle Physics	Moscow, Russia	24–30 August	195
50.	2nd CMS workshop “Perspectives on Physics and CMS at HL-LHC”	Varna, Bulgaria	29 August – 1 September	64
51.	12th International Scientific Workshop in Memory of Professor V. P. Sarantsev “Problems of Colliders and Charged Particle Accelerators”	Alushta, Russia	3–8 September	120
52.	4th Russian–Spanish Congress “Particle, Nuclear, Astroparticle Physics and Cosmology”	Dubna	4–8 September	61
53.	European School of High-Energy Physics (a CERN–JINR School)	Evora, Portugal	6–19 Sep-tember	130
54.	Third Stage of the International Student Practice (for students from Cuba, Egypt, Serbia and RSA)	Dubna	10–30 Sep-tember	53
55.	3rd International Symposium on Superheavy Elements “Challenges in the Studies of Superheavy Nuclei and Atoms”	Kazimierz Dolny, Poland	10–14 Sep-tember	90
56.	17th Workshop on High Energy Spin Physics (DSPIN-17)	Dubna	11–15 Sep-tember	100
57.	International scientific forum “Nuclear Science and Technologies” (to the 60th Anniversary of the Institute of Nuclear Physics in Almaty)	Almaty, Kazakhstan	12–15 Sep-tember	320
58.	122nd Session of the JINR Scientific Council	Dubna	18–19 Sep-tember	103
59.	2nd Forum on Development of Cooperation between JINR and Czech Academic and Scientific Institutions	Dubna	19–21 Sep-tember	45
60.	7th Report Seminar of the National Group of Ukraine at JINR	Dubna	19 September	21
61.	International Scientific Workshop Dedicated to the 75th Birth Anniversary of Professor N. M. Shumeyko (in frame of all-Institute seminar “Physics at LHC”)	Dubna	20 September	28
62.	Dubna Scientific Youth School “Management of Innovations”	Dubna	20–26 Sep-tember	50

No.	Name	Place	Date	Number of participants
63.	Workshop on Cooperation in the framework of the JINR–BMBF Agreement	Dubna	21 September	6
64.	International seminar “Development of Neutron Nuclear Methods” dedicated to the 80th birth anniversary of A. Strelkov	Dubna	22 September	80
65.	26th International Symposium on Nuclear Electronics and Computing (NEC’17)	Budva (Becici), Montenegro	25–29 September	142
66.	International meeting “Compact Stars in the QCD Phase Diagram VI”	Dubna	26–29 September	35
67.	21st International Scientific Conference of Young Scientists and Specialists of JINR (AYSS-2017)	Dubna	2–6 October	205
68.	5th International workshop “Perspectives of Experimental Research at the Nuclotron Beams”	Dubna	5–6 October	67
69.	International conference “Condensed Matter Research at the IBR-2”	Dubna	9–12 October	143
70.	10th Meeting of the Group of Senior Officials on Global Research Infrastructures	Dubna	10–11 October	68
71.	International conference “Modern Problems in General and Space Radiobiology”	Dubna	12–13 October	85
72.	Meeting on Straw Tubes Production for the Straw Tracker of the SHiP Experiment at CERN	Dubna	19–20 October	16
73.	7th JINR–CERN School on Information Technology “GRID and Advanced Information Systems”	Dubna	24–28 October	94
74.	School at CERN for Physics Teachers from the JINR Member States	Geneva, Switzerland	5–12 November	23
75.	NICA Days in Warsaw	Warsaw, Poland	6–10 November	100
76.	International School for Young Scientists and Students “Instruments and Methods of Experimental Nuclear Physics”	Dubna	7–11 November	57
77.	International Coordination Meeting on Swift and Highly Charged Ions in Material Science	Port Elizabeth, South Africa	8–10 November	20
78.	Meeting of the Working Group on Financial Issues under the CP Chairman	Dubna	20 November	25
79.	Meeting of the JINR Finance Committee	Dubna	21–22 November	76
80.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Dubna	24–25 November	95
81.	KLFTP/CAS–BLTP/JINR Joint Workshop on Physics of Strong Interaction	Shenzhen, China	26 November – 1 December	84
82.	“Baikal” Collaboration Workshop	Dubna	28 November – 1 December	50
83.	Ceremonial Meeting Devoted to the 60th Anniversary of the Frank Laboratory of Neutron Physics	Dubna	29 November	420
84.	Extended Meeting of the RAS Council on Heavy Ion Physics	Dubna	1 December	60

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, 26 March. The ceremonial meeting on the JINR Establishment Day

Dubna, 21–22 November. Presidium of the JINR Finance Committee

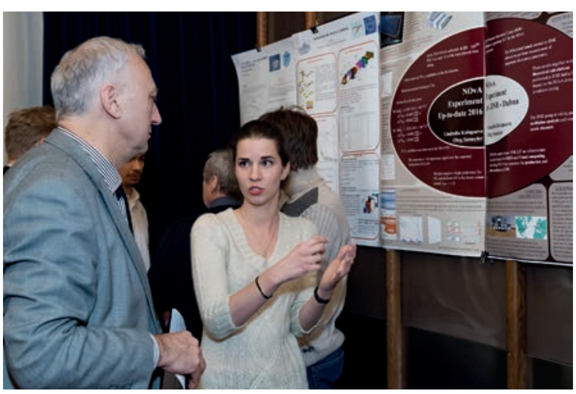
Dubna, 27–28 March. The JINR CP session.
Ambassador of the European Union to the Russian Federation V. Ušackas takes the floor with a greeting address

Dubna, 18–19 September.
The 122nd session of the
JINR Scientific Council

Dubna, 25–26 January. The participants of the 45th meeting of the Programme Advisory Committee for Nuclear Physics on an excursion at the Veksler and Baldin Laboratory of High Energy Physics

Dubna, 19–20 January. The 45th meeting of the Programme Advisory Committee for Condensed Matter Physics. The author of the best poster report chosen at the previous PAC meeting E. Zhabitskaya receives the Award

Dubna, 16–17 January. The 46th meeting of the Programme Advisory Committee for Particle Physics



Dubna, 12 January. Participants of the 27th meeting of the Joint Committee on the IN2P3–JINR Collaboration

Dubna, 7 February. A delegation of the Helmholtz Association of the German Research Centres on a visit to JINR

Dubna, 28 March. The signing of the Agreement on establishment of the Chair of Nuclear Physics Materials Science at Kazan Federal University

Dubna, 20 March. A delegation of the Vietnamese Academy of Sciences and Technology headed by VAST Vice-President Nguyen Dinh Cong on a visit to JINR

Moscow, 12 April. The signing of the Agreement on JINR–INFN cooperation

Dubna, 27 April. Minister of Economy of the Slovak Republic P. Žiga,
Minister of Education, Science, Research and Sport P. Plavčan and their accompanying persons on a visit to JINR

Belgrade (Serbia), 14–19 March. Participants of the Serbia–JINR Joint Coordination Committee

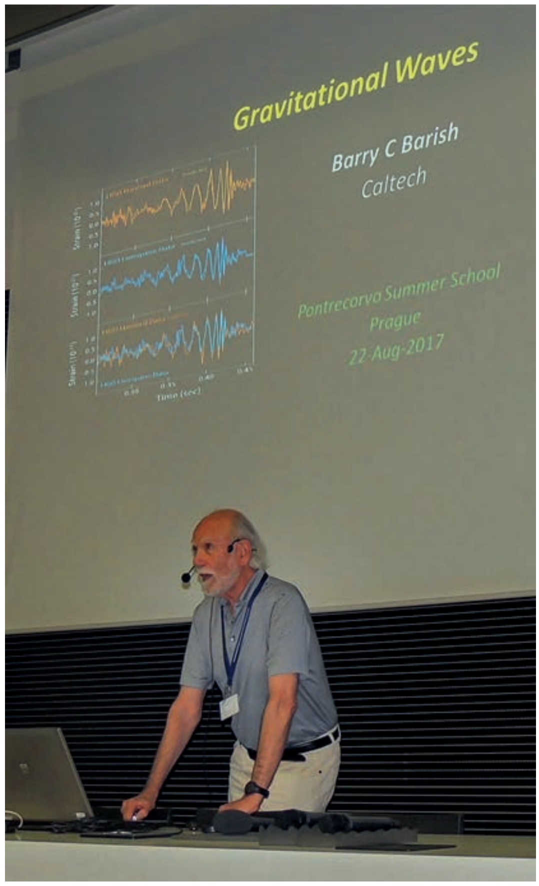
The “Borovets” complex (Bulgaria), 16–19 May.
Participants of the 10th international school on nuclear physics “JINR Days in Bulgaria”

Dubna, 20 September. Signing of the Agreement on cooperation in scientific research and staff training between JINR and Tomsk State University, following the visit to JINR of a delegation headed by TSU Rector Eh. Galazhinsky

Dubna, 28 July. RF Health Minister V. Skvortsova and accompanying persons on a visit to JINR. At the Veksler and Baldin Laboratory of High Energy Physics

Dubna, 9 August. A delegation from the Embassy of the Republic of Armenia in RF headed by Ambassador Extraordinary and Plenipotentiary V. Toganyan on a visit to JINR

Moscow, 31 October. Ceremonial presentation of national awards at the Embassy of France in RF. Left to right: JINR Director Academician V. Matveev, awarded the National Order of Merit, Ambassador of France in Moscow Mrs. S. Bermann and Permanent Secretary of the French Academy of Sciences Professor C. Brechignac



Prague (Czech Republic), 20 August – 1 September.
Participants of VII International Pontecorvo Neutrino Physics School at the Czech National Library of Technology. Right: B. Barish (USA) is delivering a lecture on the discovery of gravitational waves

Evora (Portugal), 6–19 September. Participants of the European School of High-Energy Physics (ESHEP-2017) organized by CERN and JINR

The Veksler and Baldin Laboratory of High Energy Physics, 19–21 September. Participants of the Forum on Development of Cooperation between JINR and Czech Academic and Scientific Institutions on an excursion to the laboratory

Dubna, 10–11 October. Participants of the second stage of the 10th Meeting of Group of Senior Officials on Global Research Infrastructures

2017

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. 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 600 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, France, Germany, India, Italy, 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 2017, more than 900 scientists participated in 18 international conferences, workshops and schools organized at the Laboratory. The international collaboration was supported by grants of the Plenipotentiaries of the Governments of Bulgaria, the Czech Republic, Hungary, Poland, the Slovak Republic, 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 and JINR–IN2P3 agreements. The agreements for collaboration between the Bogoliubov Laboratory and APCTP (South Korea), ITP CAN (Beijing) are functioning, as well as the active cooperation with theorists from CERN. Seventeen research projects and 5 conferences were supported by the RFBR grants, and 2 research projects by the RSF. 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). More than 150 PhD students and young scientists from the JINR Member States participated in the DIAS-TH schools. The Laboratory plays the role of a training centre 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 non-member states, several researchers from India, Japan, Mexico, Tajikistan, and Vietnam have been working at BLTP on a long-term basis.

SCIENTIFIC RESEARCH

Theory of Fundamental Interactions

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;
- Hadron Matter under Extreme Conditions.

Leading four-loop electroweak corrections to the beta function of the strong coupling in the Standard Model (SM) were obtained. The ambiguity due to gamma 5 treatment in dimensional regularization was fixed by the requirement of transversality of the background gauge field self-energy. Preliminary results for an analogous contribution to the beta functions of the top-Yukawa coupling and self-coupling of the Higgs field were found. The well-known approach for calculation of "threshold" corrections to the running strong coupling and b-quark mass in QCD was extended to include electroweak corrections. It was demonstrated how the behavior of perturbative series could be improved by utilizing the above-mentioned approach. The analysis of the SM vacuum stability was carried out, in which recent results on beta functions were taken into account [1, 2].

The method that enables one to properly account for the effects due to continuation of the spacelike perturbative QCD results into the timelike domain at an arbitrary loop level is developed. By making use of this method the proper expression for the R-ratio of electron-positron annihilation into hadrons was calculated up to the five-loop level and its properties were studied. In particular, it was shown that the loop convergence of the obtained expression for the R-ratio was better than that of its commonly employed approximation and that the higher-order π^2 terms omitted in the latter could produce a considerable effect [3].

A description of form factors of local and Wilson line operators (reggeon amplitudes) in the framework of four-dimensional ambitwistor string theory was considered. Explicit expressions for the corresponding string vertex operators were obtained. It was shown that the corresponding tree-level string correlation functions correctly reproduced existing results. A new effective gluing operation for the calculation of different form factors was introduced based on known expressions for on-shell amplitudes [4].

The longitudinal, transverse, and normal polarization components of the tau lepton in the decays $\bar{B}^0 \to D^{(0)}\tau^-\bar{\nu}_\tau$ were studied, and their role in searching for new physics (NP) beyond the Standard Model (SM) was discussed. It was shown that the normal polarization, which was predicted to be negligibly small in the SM, could be very sizable assuming NP complex Wilson coefficients [5].

The new double charm baryon state found by the LHCb collaboration was interpreted as being at the origin of the decay chain

$$\Xi_{cc}^{++} \to \Sigma_c^{++} \left(\to \Lambda_c^+ \pi^+\right) + \bar{K}^{*0}(\to K^- \pi^+).$$

The previously developed covariant confined quark model was used to calculate the four helicity amplitudes that described the dynamics of the transition $\Xi_{cc}^{++} \to \Sigma_c^{++}$ induced by the effective $c \to u$ current. A branching rate of Br $(\Xi_{cc}^{++} \to \Sigma_c^{++} \bar{K}^{*0}) = 10.5\%$ was found [6].

Refined values of the fundamental transition frequencies in the hydrogen molecular ions were calculated, which allowed one to determine such fundamental constants as the Rydberg constant, proton charge radius, and proton to electron mass ratio with significant accuracy [7].

The so-called λ mechanism ($W_L - W_R$ exchange) of the neutrinoless double beta decay ($0\nu\beta\beta$) was reconsidered; the mechanism has its origin in the left-right symmetric model with right-handed gauge boson at a TeV scale. A possibility was manifested to distinguish between the conventional (light) neutrino mass and the λ mechanisms by observation of the $0\nu\beta\beta$ decay of several nuclei. By making viable assumption about the see-saw type mixing of the light and heavy neutrinos with the Dirac mass, m_D, within the range of 1 MeV to 1 GeV, it was concluded that there was a dominance of the conventional light neutrino mass mechanism in the $0\nu\beta\beta$ decay rate [8].

A hypothesis based on a field-theoretical treatment of the neutrino flavor transition problem was suggested that the so-called "reactor antineutrino anomaly" can be a consequence of the inverse-square law violation at short but macroscopic distances between the reactor and detector. The current experimental data (including recent data from the experiments NEUTRINO-4 and DANSS) do not contradict this possibility, but their accuracy is still insufficient to surely approve or disapprove it [9].

A new phenomenological method for calculation of the differential CCQE neutrino–nucleus interaction cross sections is suggested. The method is based on the notion of so-called "running" (energy-dependent) axial mass of the nucleon within the framework of the standard nuclear relativistic Fermi-gas model. The C++ realization of the method is included in the MC neutrino event generator GENIE (release 2.11.0 and higher). The results are claimed in the current neutrino oscillation experiments with accelerator and atmospheric neutrinos [10].

A superfluid pairing gap and equation of state for neutron matter were obtained in the framework of the quark compound bag model with nucleon–nucleon interactions generated by s-channel exchange of the Jaffe–Low primitives (6-quark states) [11].

In connection with new COMPASS results, the new single spin asymmetries were proposed to be measured by COMPASS which directly probed gluon poles of higher twist terms together with chiral-odd and time-odd functions. The fundamental duality between different factorization regimes was shown [12].

The QCD predictions for the azimuthal $\cos 2\varphi$ asymmetry in charm leptoproduction for the kinematics of the COMPASS experiment at CERN were presented. The asymmetry was predicted to be large, about 15%. The nonperturbative contributions to the $\cos 2\varphi$ distribution due to the gluon transverse motion in the target and the c-quark fragmentation was analyzed [13].

The general theory of spinning particles with electric and magnetic dipole moments moving in arbitrary electromagnetic, inertial and gravitational fields was developed. The results obtained were compared to the general classical description of the spinning particle interacting with electromagnetic, inertial and gravitational fields. The complete agreement between the quantum mechanics and the classical theory was proven in the general case. The case of a spin-1/2 particle in a constant magnetic field perturbed by a circularly polarized gravitational wave was considered. Unlike the previous investigation, it was proposed to analyze the spin components orthogonal to initial spin polarization and apply the magnetic field orthogonal to the wave propagation [14].

By using appropriate classes of truncated momentum models (TMM), the generalized Bjorken sum rule was constructed. The derived sum rules allowed one to determine the Bjorken sum rule (BSR) value from the experimental data in a restricted kinematic range of x. The proposed analysis was applied to COMPASS data on the spin structure function g_1 [15].

The structure of vorticity and hydrodynamic helicity fields in peripheral heavy-ion collisions was explored using the kinetic quark–gluon string model. The formation of specific toroidal structures of the vorticity field (relativistic vortex sheets) was observed. Their existence, combined with spin-orbital coupling due to axial anomaly, was mirrored in the polarization of hyperons of the percent order. Its properties (decrease with energy and charge independence), recently studied experimentally, are in accordance with the predictions. In terms of mesonic degrees of freedom, polarization may be related to the cores of quantized vortices in pionic superfluid [16, 17].

In the framework of the quasipotential method in quantum electrodynamics, the contribution of pseudoscalar mesons to the interaction operator of a muon and a proton in a muonic hydrogen atom was calculated. The parametrization of the transition form factor of two photons into π and axial-vector mesons, based on the experimental data on the transition form factors and QCD asymptotics, was used. Numerical estimates of the contributions to the hyperfine structure of the spectrum of the S and P levels are presented. The found contributions are relevant for the resolution of the problem with the proton radius determination [18, 19].

The space of parameters fulfilling the existing constraints of QCD effective chiral theories that support the high-mass twin neutron stars was explored. The four-polytrope scheme was implemented. In addition, due to the recent detection of gravitational waves from the merging of neutron stars, it was found that such events, together with mass and radius measurements, would be able to clarify the nature of the hadron to quark matter transition and its existence in compact star interiors [20].

The meaningful specific anisotropy in the angle distribution of leptons with respect to the three-momentum of pairs was predicted as a feasibility signature of synchrotron-like mechanism resulting from the quarks interacting with a collective confining color field in the heavy ion collisions. The lepton pair production rate and the spectrum of pair invariant mass was presented for this new di-lepton source that was apparently not taken into consideration in the available phenomenological estimates [21].

A study of the confinement/deconfinement transition in the lattice $SU(2)$ QCD at finite quark density and zero temperature was performed on a lattice with rooted staggered fermions at a lattice spacing $a = 0.044$ fm. This small lattice spacing allowed one to reach very large baryon density (up to quark chemical potential 2000 MeV) avoiding strong lattice artifacts. In the region of chemical potential about 1000 MeV the confinement/deconfinement transition was observed for the first time. After the deconfinement was achieved, a monotonous decrease of the spatial string tension was seen which ended up with vanishing value at the chemical potential of about 2000 MeV. These observations led to the conclusion that the confinement/deconfinement transition at finite density and zero temperature was quite different from that at finite temperature and zero density. The results indicated that in very dense matter the quark–gluon plasma was in essence a weakly interacting gas of quarks and gluons without a magnetic screening mass in the system, sharply different from a quark–gluon plasma at large temperature [22].

Relativistic magnetohydrodynamics (RMHD) simulations were carried out to study the effects of this magnetic field on the evolution of the plasma and on resulting flow fluctuations in the ideal RMHD limit. The results showed that the magnetic field led to enhancement in an elliptic flow for small impact parameters while it suppressed it for large impact parameters. It was demonstrated that the magnetic field in localized regions could temporarily increase in time as evolving plasma energy density fluctuations led to reorganization of the magnetic flux. The situation of nontrivial magnetic field configurations arising from collision of deformed nuclei was considered and was shown to lead to an anomalous elliptic flow [23].

Theory of Nuclear Structure and Nuclear Reactions

In 2017, investigations were carried out in accordance with four projects:

• Nuclear Properties 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.

Starting from an effective Skyrme interaction SLy5, the effect of phonon–phonon coupling on the $E1$-strength of the pigmy resonance in even–even nuclei $^{40-58}$Ca was studied. It was shown that the inclusion of two-phonon configurations brought a sizeable contribution to the low-lying ($<$ 10 MeV) $E1$-strength in $^{40-48}$Ca. A strong increase (by a factor of 9) in the total $E1$-strength below 10 MeV was predicted with an increasing neutron number from ^{48}Ca until ^{50}Ca. This effect is due to the interference between proton and neutron two-quasiparticle states. It was found that the dipole polarizability for the $^{40-58}$Ca isotopes increased with increasing both neutron excess and the neutron skin thickness, while the phonon–phonon coupling had small influence on the dipole polarizability [24, 25].

The electron neutrino and antineutrino absorption cross sections on hot nuclei ^{56}Fe and ^{82}Ge were studied. These reactions play a fundamental role in the core-collapse supernova mechanism. The strength functions for charge-exchange Gamow–Teller (GT) transitions, which dominate in low-energy neutrino–nucleus reactions, were obtained by applying the thermal quasiparticle RPA with different Skyrme force. It was shown that rise in temperature shifted the GT resonance peak to lower energies and unblocked negative-energy GT transitions. The temperature-driven changes in the GT strength lead to a significant thermal enhancement of the cross sections. The important point is that different Skyrme forces predict cross sections, which do not differ significantly. The obtained cross sections are larger than those from shell-model calculations. The reason for this discrepancy is that shell-model calculations underestimate the contribution of low- and negative-energy GT transitions from thermally excited states [26].

Effects of nuclear deformation and particle–particle pp interaction on nuclear excitations were investigated within the self-consistent Quasiparticle Random Phase Approximation (QRPA) method based on the Skyrme force SLy6. The particle–particle interaction was accounted for both the monopole pairing and the residual interaction. Using ^{152,154,156}Sm as an example, it was demonstrated that the effect of the pp-channel in $K^{\pi} \neq 0^{+}$ excitations was negligible. However, there was a noticeable difference between the QRPA results obtained with volume pairing and with surface pairing when studying the collective low-energy peak of the toroidal dipole resonance. It was found that for excitation energy $E > 10$ MeV the $K = 0$ structure lay lower than the $K = 1$ one for all dipole resonances, whereas at lower excitation energies the $K = 1$ branch dominated in the pigmy and toroidal dipole resonances. This remarkable feature can be used as a fingerprint of the toroidal dipole resonances in future experiments [27].

The structure of the kinetic energy term of the nuclear collective Hamiltonian was investigated. It was shown that the higher order terms in collective momentum produced a sizable effect on the excitation energies and the $E2$ matrix elements [28].

The excitation functions of the production of new heaviest isotopes of superheavy nuclei with charge numbers 111–117 in the pxn and αxn evaporation channels of the ^{48}Ca-induced hot fusion reactions were predicted for the first time for future experiments [29].

The production cross sections of several isotopes of Hs and their properties are considered. The optimal reactions were predicted for producing $^{268-271}$Hs. The possible alpha-decay chains including these isotopes were analyzed and compared with the available experimental data. A number of new isomeric states were predicted in the nuclei of these alpha-decay chains. The role of alpha decay in the identification of these isomeric states was discussed [30].

A general approach to describe spreading widths of monopole, dipole and quadrupole giant resonances in heavy and superheavy spherical nuclei was proposed. The approach is based on the ideas of the random matrix distribution of the coupling between one-phonon and two-phonon states generated in the random phase approximation. The Skyrme interaction SLy4 was used as a model Hamiltonian to create a single-particle spectrum and analyze excited states of the doubly magic nuclei ^{132}Sn, ^{208}Pb and ^{310}126. The approach enables one to describe a gross structure of the spreading widths of the considered giant resonances [31].

Tunneling rates of two interacting ultracold atoms confined in an anharmonic trap were calculated. The ground and excited states with respect to relative and centre-of-mass motions were considered, and a monotonic and nonmonotonic behavior of the tunneling rates as a function of the interatomic coupling strength was observed. It was also found that the only possible tunneling scenario in the considered cases was a sequential particle tunneling. Another interesting feature of the tunneling from the excited state is a two-stage decay in which the population of the atoms of different quantum states during the tunneling process occurs [32].

A manifestation of the Efimov effect in heteronuclear cold atomic systems formed of the ^{4}He and ^{6}Li or ^{7}Li atoms was studied. The binding energies of ^{6}Li He$_2$ and ^{7}Li He$_2$ systems and the scattering length for the collision of a ^{4}He atom with a ^{4}He^{7}Li dimer were calculated for the first time. It was shown that the excited states in both systems were of the Efimov nature. The results were obtained by using the hard-core version of the Faddeev differential equations and realistic interactions [33].

Anisotropic characteristics of a "two-dimensional" (2D) hydrogen atom induced by a magnetic field were studied. The ground state energy (GSE) of the "2D" hydrogen atom and the corresponding wave function were numerically calculated in the Born–Oppenheimer approximation and taking into account the finite proton mass. The nonlinear dependence of the GSE on angle α between the magnetic field vector and the normal to the electron motion plane was found in a wide range of the magnetic field values. The effect of a significant reduction of the GSE (up to 1.9-fold) was observed with increasing the angle α up to 90°. The agreement with experimental data was demonstrated. The dependences of the GSE of a "2D" exciton in GaAs/Al$_{0.33}$Ga$_{0.67}$As on the values of tilt angles and magnetic fields were determined [34].

The bound state of three nucleons was investigated using the Faddeev equations within the Bethe–Salpeter approach. The relativistic and nonrelativistic nucleon–

nucleon interaction was chosen in a multirank separable form. The extension for partial states with $L > 0$ was made. Three partial-wave states — $1S0$, $3S1$ and $3D1$ — were taken into account. The Gauss quadrature method was used to calculate the integrals and find the triton binding energy by iterations [35].

The energy dependence of the Tsallis statistics parameters was presented for charged pions produced at beam energies ranging between 6.3 GeV and 7 TeV. It was found that deviations from the Boltzmann statistics were monotonically growing with beam energy. The energy dependence of the parameters T and q of the negatively charged pions in the energy range $6.3 < \sqrt{s} < 7000$ GeV revealed that the deviation of the transverse momentum distribution from the exponential became more and more pronounced as the beam energy was increased. The parameter q increased with beam energy while the temperature T slowly decreased [36].

The production mechanisms of open strangeness (K^*) and open charm (D^*) vector mesons in p–p scattering were investigated within the modified quark–gluon string model. It was found that the decay distributions and density matrix elements were sensitive to the production mechanisms and could be used to disentangle the vector trajectory and pseudoscalar trajectory exchange models. The proposed predictions can be tested at the present or planned experimental facilities [37].

The semi-inclusive deep inelastic electron scattering off transversely polarized ^{3}He, i.e., the process $e +^3\overrightarrow{\mathrm{He}} \rightarrow e' + h + X$ with h being a detected fast hadron, was studied beyond the plane wave impulse approximation. To this end, a distorted spin-dependent spectral function of a nucleon inside an $A = 3$ nucleus was actually evaluated through a generalized eikonal approximation in order to take into account the final-state interactions between the hadronizing system and the $(A - 1)$ nucleon spectator one. To illustrate how and to what extent the model dependence due to the treatment of the nuclear effects was under control, the approach was applied to the extraction procedure of the neutron single spin asymmetries from those measured for ^{3}He for values of the kinematical variables relevant for both forthcoming experiments at the Jefferson Lab and, with an exploratory purpose, the future Electron Ion Collider [38].

Theory of Condensed Matter

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

• Complex Materials and Nanostructures;

• Contemporary Problems of Statistical Physics.

It was shown that any surface fractal could be composed of mass-fractal iterations of the same fractal dimension. It was demonstrated that small-angle scattering (SAS) from a surface fractal could be explained in terms of a power-law distribution of sizes of objects composing the fractal (internal polydispersity), provided the distance between the objects was much larger than their size for each iteration of composing mass fractals. The analysis allowed one to extract additional information from SAS intensity for dilute aggregates of single-scaled surface fractals, such as the fractal iteration number and the scaling factor [39].

New general properties of fractals were predicted. It follows from the decomposition of surface fractal into a sum of mass fractals that the scattering amplitude of a surface fractal can be calculated as a sum of the mass fractal amplitudes. An effective method was developed for calculating the correlations between the amplitudes [40].

The theory of spin excitations in the antiferromagnetic Heisenberg model on the honeycomb lattice was developed. The microscopic theory of spin excitations and the high-temperature superconductivity in cuprates were formulated within the extended Hubbard model in the limit of strong correlations. The spin-wave excitation spectrum, magnetization, susceptibility and the Néel temperature were calculated for the quasi-two-dimensional compass-Heisenberg model proposed for iridates, for the Kitaev–Heisenberg model on the honeycomb lattice [41].

The peculiarities of defining the phase transition critical temperature of Bose–Einstein condensation for different systems were considered, including homogeneous Bose gas, trapped Bose atoms, and bosons in optical lattices. A method of self-similar approximants for calculating the critical temperatures was suggested. The method provides the results that are in perfect agreement with numerical Monte Carlo simulations [42].

A one-dimensional stochastic model of vehicular traffic on open segments of a single-lane road of finite size L was studied based on the stochastic discrete-time dynamics which is a particular case $\hat{\tilde{p}} = p$ of the generalized TASEP with two hopping probabilities, p and $\hat{\tilde{p}}$ [43, 44].

A rotor-router version of the internal diffusion-limited aggregation (DLA) introduced by J. Propp was investigated. The existing estimations of boundary fluctuations of the aggregation cluster showed that they grow not faster than $O(\log r)$ with the cluster radius r. The rotor-router internal DLA on the semi-infinite cylinder was considered, and it was proved that the constant width of the boundary fluctuations did not exceed 1 independent of the radius of the cylinder [45].

A new method of computing $6j$-symbols or Racah coefficients for tensor products of infinite-dimensional unitary principal series representations of the group $SL(2, C)$ was suggested, which is based on the Feynman diagrams techniques. These symbols were found earlier by Ismagilov; however, his answer differs from the derived one by the signs of representation parameters and is less general since it assumes that discrete representation parameters are even. The derived $6j$-symbols are expressed either as triple integrals over complex plane, or as bilateral infinite sum of Mellin–Barnes type integrals [46].

A new heuristic method of computing the Casimir energy was proposed, which determines leading asymptotics of the partition functions at low temperatures for four-dimensional supersymmetric field theories on the Hopf manifold. It is based on the $SL(3, Z)$ modular transformation laws for superconformal indices of the corresponding theories expressed in terms of the elliptic hypergeometric integrals. This recipe was checked in several cases for which the answers were obtained earlier by an alternative method [47].

The pure $SU(2)$ Yang–Mills theory on de Sitter dS_4 and anti-de Sitter AdS_4 spaces was considered and various solutions to the Yang–Mills equations were constructed. Both Abelian and non-Abelian solutions were found, all having finite energy and finite action. A possible lower bound for the action on both backgrounds was suggested. After Euclidean continuation of dS_4 and AdS_4, the self-dual (instanton-type) Yang–Mills solutions on these backgrounds were determined [48, 49].

For the first time, the experimental data on the charge ordering in doped cuprates were reproduced within a microscopic model. A number of recent experiments on the high-temperature superconductors highlighted a transformation of a large cuprate Fermi surface into small pockets in the underdoped region. It was shown that this unexpected behavior of the Fermi surface of the high-temperature superconducting cuprates could be explained in the framework of the $t{-}J$ model due to strong electron correlations resulting in charge density wave instability [50].

The magnetization reversal in a Josephson junction with direct coupling between magnetic moment and superconducting current was studied. The simulations of the magnetic moment dynamics showed that, by applying an electric current pulse, one could realize the full magnetization reversal. Different protocols of full magnetization reversal are proposed based on the variation of the Josephson junction and pulse parameters [51].

Modern Mathematical Physics: Strings and Gravity, Supersymmetry, Integrability

The topics of main focus in the theme were:

- Quantum Groups and Integrable Systems;
- Supersymmetry;
- Quantum Gravity, Cosmology and Strings.

During the study of the $N = 4$ supersymmetric n-dimensional mechanics, the generalization of the Witten–Dijkgraaf–Verlinde–Verlinde (WDVV) equation to curved spaces was found. A series of solutions of this equation on isotropic spaces, which modified the solutions of the usual WDVV, were constructed. Some potentials for the mechanics on isotropic spaces were found. It was shown that generalization of Calogero and conformal mechanics potentials to the n-dimensional spheres induces an additional Higgs oscillator potential [52].

A method for studying physical effects in cosmology caused by massless cosmic strings was suggested and realized. Perturbations of velocities of test bodies and anisotropy of cosmic microwave background generated by massless cosmic strings were analyzed. These phenomena are analogous to the string wake effect and the Kaiser–Stebbins effect for standard (massive) cosmic strings. Massless string and massive string effects are quite different at ultrahigh energies [53].

Using the $N = 4$, 1D harmonic superspace approach, a new type of $N = 4$ supersymmetric mechanics involving $4n$-dimensional Quaternion-Kähler (QK) 1D sigma models as a bosonic core was constructed. The basic ingredients of the construction were local $N = 4$, 1D supersymmetry realized by the appropriate transformations in 1D harmonic superspace, the general $N = 4$, 1D superfield vielbein and a set of $2(n{+}1)$ analytic "matter" superfields representing $(n + 1)$ off-shell supermultiplets $(4, 4, 0)$. Both superfield and component actions were given for the simplest QK models with the manifolds $H^n = \mathrm{Sp}\,(1, n)/[\mathrm{Sp}\,(1) \times \mathrm{Sp}\,(n)]$ and $P^n = \mathrm{Sp}\,(1 + n)/[\mathrm{Sp}\,(1) \times \mathrm{Sp}\,(n)]$ as bosonic targets. For the general case, the relevant superfield action and constraints on the $(4, 4, 0)$ "matter" superfields were presented. Further generalizations were briefly discussed [54].

The one-loop effective action was studied for the 6D, $N = (1, 0)$ supersymmetric Yang–Mills (SYM) theory with hypermultiplets and 6D, $N = (1, 1)$ SYM theory as a subclass of the former, using the off-shell formulation of these theories in 6D, $N = (1, 0)$ harmonic superspace. The corresponding supergraph technique was developed and applied to compute the one-loop divergences in the background field method ensuring the manifest gauge invariance. The two-point Green functions of the gauge superfield and the hypermultiplet, as well as the three-point gauge-hypermultipet Green function, were calculated. Using these Green functions and exploiting gauge invariance of the theory, the full set of the off-shell one-loop divergent contributions, including the logarithmic and power ones, was found. The results precisely match those obtained earlier within the proper time superfield method [55].

New solutions were constructed of the Faddeev–Skyrme model with a symmetry breaking potential admitting vacuum on a circle. It includes, as a limiting case, the usual $SO(3)$ symmetry breaking mass term, another limit corresponds to the Heisenberg potential, which gives a mass to the corresponding component of the scalar field. It was found that the spatial distribution of the energy density of these solutions had a more complicated structure than in the case of the usual Hopfions; typically it represented two separate linked tubes with different thicknesses and positions. In order to classify these configurations, a counterpart of the usual position curve was defined. In this model, in the sectors of degrees $Q = 5, 6, 7$, solutions of a new type were found, for which one or both of these tubes represented trefoil knots [56].

There was proposed a generalization of the Witten–Dijkgraaf–Verlinde–Verlinde (WDVV) equation from the n-dimensional Euclidian space to an arbitrary Riemannian manifold. Its form was obtained by extending the relation of the WDVV equation with the $N = 4$ supersymmetric n-dimensional mechanics from flat to curved space. It was found that the resulting "curved WDVV equation" was written in terms of the third-rank Codazzi tensor. For every flat-space WDVV solution subject to a simple constraint, a curved-space solution was provided on any isotropic space, in terms of the rotationally invariant conformal factor of the metric [57].

In the harmonic superspace approach, the six-dimensional $N = (1, 0)$ supersymmetric Yang–Mills gauge multiplet minimally coupled to a hypermultiplet was considered in an arbitrary representation of the gauge group. Using the superfield proper-time and background-field techniques, the divergent part of the one-loop effective action depending on both the gauge multiplet and the hypermultiplet was computed. It was demonstrated that in a particular case of $N = (1, 1)$ SYM theory, which corresponds to the hypermultiplet in the adjoint representation, all one-loop divergencies vanished, so that the $N = (1, 1)$ SYM theory was one-loop finite off shell [58].

Cosmologic and spherically symmetric solutions were compared to metric and Palatini versions of the vector Horndeski theory. It appeared that Palatini formulation of the theory admitted more degrees of freedom. Specifically, homogeneous isotropic configuration was effectively bimetric, and static spherically symmetric configuration contained nonmetric connection. In general, the exact solution in the metric case coincided with the approximative solution in the Palatini case. The Palatini version of the theory appeared to be more complicated, but the resulting nonlinearity could be useful: it was demonstrated that it allowed the specific cosmological solution to pass through singularity, which was not possible in the metric approach [59].

The phase space of a Friedmann–Robertson–Walker Universe filled with various cosmological fluids which could or could not interact was studied in detail. Various expressions for the equation of state were used, and the physical significance of the resulting fixed points was analyzed. In addition, the effects of the stability or instability of some fixed points were discussed and an interesting phenomenological scenario for which there was an oscillating interaction between the dark energy and dark matter fluid was studied. It was demonstrated that, in the context of the model used, at early times the interaction was negligible and it started to grow as the cosmic time approached the late-time era. Also, the cosmological dynamical system was split into two distinct dynamical systems which had two distinct de Sitter fixed points, with the early-time de Sitter point being unstable. This framework gives an explicit example of the unification of the early-time with late-time acceleration [60].

Polarizable sheets were considered which recently received some attention, especially in the context of the dispersion interaction of thin sheets like graphene. These sheets are modeled by a collection of delta function potentials and resemble zero range potentials, known in quantum mechanics. A theoretical description was developed and the so-called *TGTG*-formula was applied to calculate the interaction of two such lattices. Use was made of the formulation of the scattering of waves off such sheets provided earlier. All limiting cases, providing a link to earlier results, were considered. The relation to the pairwise summation method was also discussed [61].

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

In 2017, the research and educational project DIAS-TH was successfully continued. There were the following activities in the framework of DIAS-TH:

• XIII Winter School on Theoretical Physics "Heavy Ion Physics: From LHC to NICA", 30 January – 4 February, Dubna;

• Helmholtz International Summer School "Nuclear Theory and Astrophysical Applications", 10–22 July, Dubna;

• International School "Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems", 6–12 August, Dubna;

• Helmholtz International Summer School "Hadron Structure, Hadronic Matter and Lattice QCD", 20 August – 2 September, Dubna;

• Regular seminars for students and postgraduates were organized;

• Computer processing of video records of lectures was continued;

• Website of DIAS-TH was supported.

CONFERENCES AND MEETINGS

Eighteen conferences, workshops and schools were organized in 2017:

- XIII Winter School on Theoretical Physics "Heavy Ion Physics: From LHC to NICA", 30 January – 4 February, Dubna;
- International Workshop "Simulations of HIC for NICA Energies", 10–12 April, Dubna;
- International Session-Conference of SNP PSD RAS "Physics of Fundamental Interactions", 6–8 June, Nalchik, Russia;
- XXV International Conference "Integrable Systems and Quantum Symmetries", 6–10 June, Prague, Czech Republic;
- Mini-Workshop on Lattice and Functional Techniques for Exploration of Phase Structure and Transport Properties in Quantum Chromodynamics, 10–14 July, Dubna;
- Helmholtz International Summer School "Nuclear Theory and Astrophysical Applications", 10–22 July, Dubna;
- XVII International Conference "Symmetry Methods in Physics", 10–15 July, Yerevan, Armenia;
- International School "Symmetry in Integrable Systems and Nuclear Physics", 16–23 July, Tsakhkadzor, Armenia;
- International Conference "Classical and Quantum Integrable Systems", 24–29 July, Dubna;
- 11th APCTP–BLTP JINR–PINP NRC KI–SbSU Joint Workshop "Modern Problems in Nuclear and Elementary Particle Physics", 25–31 July, St. Petersburg, Russia;
- International Workshop "Supersymmetries and Quantum Symmetries", 31 July – 5 August, Dubna;
- International School "Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems", 6–12 August, Dubna;
- VII International Pontecorvo Neutrino Physics School, 20 August – 1 September, Prague, Czech Republic;
- Helmholtz International Summer School "Hadron Structure, Hadronic Matter and Lattice QCD", 20 August – 2 September, Dubna;
- IV Russian–Spanish Congress "Particle, Nuclear, Astroparticle Physics and Cosmology", 4–8 September, Dubna;
- XVII International Workshop on High Energy Spin Physics, 11–15 September, Dubna;
- International Conference "Compact Stars in the QCD Phase Diagram VI", 26–29 September, Dubna;
- BLTP/JINR–SKLTP/CAS Joint Workshop "Physics of Strong Interacting Systems", 26 November – 1 December, Shenzhen, China.

COMPUTER FACILITIES

In 2017, a gradual expansion of the BLTP's computer network began to provide at least two Ethernet cable connections per workplace. Diagnostic and additional switching network equipment was purchased. Several outdated switches were replaced. The introduction of high-speed 802.11ac access points in BLTP WiFi network was started. A shared large-format (A3) color laser printer was brought into operation. Five personal computers were purchased for workplaces upgrades. The technical support was extended, and updated versions were installed for Mathematica, Maple, Origin Pro, Intel Parallel Studio.

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VEKSLER AND BALDIN LABORATORY OF HIGH ENERGY PHYSICS

The activity of the Veksler and Baldin Laboratory of High Energy Physics in 2017 was focused on the implementation and further development of the NICA project (the Nuclotron–NICA, MPD, SPD and BM@N subprojects), and participation in current research at the Nuclotron and in various experiments jointly realized at world-class accelerator centres.

MOST IMPORTANT RESULTS IN THE DEVELOPMENT OF THE NICA COMPLEX

The base configuration of the NICA complex includes the following elements:

- superconducting (SC) accelerator Nuclotron;
- injection complex (ion and polarized particle sources, linear accelerators);
- SC synchrotron — Booster;
- SC heavy ion collider;
- Multi-Purpose Detector (MPD) to provide the investigation of the hot and dense baryonic matter at the collider;
- Baryonic Matter at Nuclotron (BM@N), the setup aimed at the investigations of the hot and dense baryonic matter at the Nuclotron extracted beams;
- Spin Physics Detector (SPD) aimed at the nucleon spin structure and polarized phenomena investigation;
- a new experimental zone for applied research;
- a new innovation centre — “NICA Centre”;
- IT infrastructure that includes computer centre, data storage resources and the net infrastructure.

The works carried out in 2017 were aimed at the further development of the NICA complex systems and elements as well as at the Nuclotron operation.

Nuclotron Run

The 54th Nuclotron run was performed from 10 February to 24 March with the duration of 1008 h. The main task of the run was the exploitation of the new source of polarized proton and deuteron beams (SPI) in operation mode. During the run the stable operation of the SPI was demonstrated, a high-polarized deuteron beam was successfully achieved in the intensity range from $1 \cdot 10^8$ up to $2 \cdot 10^9$ particles per cycle. The maximum extracted beam energy reached 5.2 GeV/u. A beam of polarized protons was obtained, accelerated and successfully extracted at the accelerator complex for the first time in the history of the Laboratory of High Energy Physics. Thus, an important step was taken to ensure the Laboratory base for carrying out investigations according to the spin programme of the NICA complex, which is the main task of the SPD facility.

Also, some important results in accelerator physics were achieved during the Nuclotron run, in particular:

- The mode of adiabatic capture was implemented and the repeatability of the magnetic field at the injection at the level of $3 \cdot 10^{-5}$ was achieved, which is one of the best results in the world.
- New power supply and digital control systems were put into operation at the extracted beam line to the BM@N setup.
- To increase a coefficient of particle capture from the ion source, the Medium Energy Beam Transfer system (including two triplets of quadruple lenses and a buncher) was installed in front of LU-20, which allows increasing the intensity for heavy ions several times.

Collider

The construction of the NICA collider is proceeding according to schedule. The earth, drainage and pile works have been almost finished. The concrete works on ditches of the MPD and SPD buildings and the collider ring were completed. The eastern collider semi-ring and a building for the collider electron cooling system are under construction now. By the end of

2017, 17 540 m^3 of concrete were filled in, 1006 t of fitting were used for reinforcing. For equipping the MPD and SPD halls, 156 base plates with an overall weight of 140 t were ordered and received to strengthen the floor in the transporting rail zone. Two cranes with a loading capacity of 80 and 20 t were manufactured at Uralkran.

The collider electron cooling system (electron accelerator at an energy of 2.5 MeV) is under design in collaboration with the Budker INP.

The contract on the design, manufacturing and putting into operation of the beam transporting channels from the Nuclotron to the collider was signed with Sigma-Phi Company (France).

The RF1 system was designed and now is under manufacturing at the Budker INP. The RF2 and RF3 systems are under design. The CDR for the collider stochastic cooling system is now being developed.

Booster

In 2017, the first element of the NICA Booster — the electron cooling system — was assembled inside the Synchrophasotron yoke and successfully tested, demonstrating design parameters (see Fig. 1).

The Booster vacuum system designed at 10^{-11} Torr is under preparation for the assembly.

The prototypes of the Booster power supply system elements were manufactured and tested. The power supply sources have been ordered from the LMInvertor Company (Russia). The RF system was successfully tested. The injection system for the beam transporting channel from the Booster to the Nuclotron is under construction. The design of the injection channel from the heavy ion linear accelerator HILac to the Booster synchrotron is at the final stage.

Superconducting Magnets Fabrication and Test Workshop

In 2017, serial production and tests of the NICA Booster superconducting (SC) magnets were continued at the VBLHEP facility. Status of the production and readiness is due to the time schedule (see the table). Measured values of the magnets main parameters are in good agreement with the project requirements.

In order to fulfill JINR responsibilities towards the FAIR project in Darmstadt, full cryogenic tests of two First-of-Serial (FoS) units of quadrupole magnets for the SIS-100 synchrotron have been performed at the test facility. The delivery of these magnets units to Darmstadt is currently under preparation.

One of the FoS dipole magnets of the NICA collider has also passed successfully the full cryogenic test programme. Measured values of the magnet main parameters are in the specified range. Serial assembly of the NICA collider magnets is foreseen for the second half of 2018.

Cryogenic Complex

As part of the NICA project implementation, the most powerful cryogenic system in the Russian Federation capable of operating at liquid helium temperature (4.5 K) is under development. Russia's biggest helium liquefier with an efficiency of 1000 l/h and the water reverse cooling system of the compressor station were put into operation.

The contract on the design of three satellite helium refrigerators for the Booster and collider was signed. The freezing capacity of each of them is 2000 W at a temperature of 4.5 K.

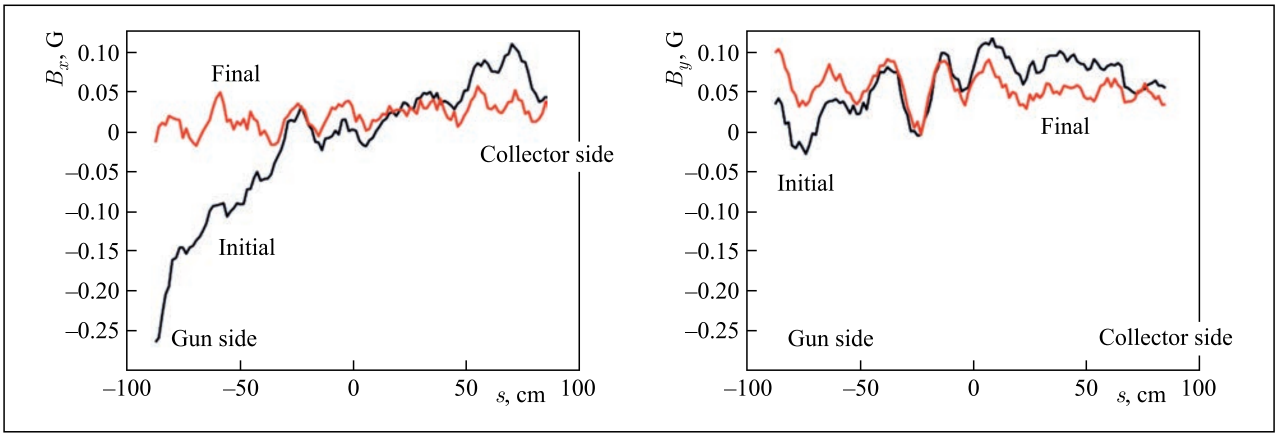

Fig. 1. Test of the Booster electron cooling system: tuning of the magnetic field. RMS of both components B_x and B_y are about 10^{-5} G

Status of the Booster SC magnets production (December 2017)

Magnet type	Number	Produced yokes	Produced coils	Tested
Dipoles	40	40	40 + 1	33
Quadrupole dublets	24	24 + 4	22 + 2	4
Correctors	32	32	—	—

The full configuration of the cryogenic complex is planned to be completed in the middle of 2020.

MPD Setup

Status of the MPD Magnet Construction

MPD SC solenoidal magnet is under construction at the ASG Superconductors Company (Italy). The magnet has to provide 0.5 T magnetic field with the 10^{-4} homogeneity in the MPD central region. In 2017, construction of the magnet elements was proceeding as planned. More than half of the work on the so-called cold part of the magnet has already been done. In particular:

— two of three support cylinder modules of the MPD magnet were produced;

— 70% of the superconducting cable (total length of the MPD solenoid cable is about 28 km) has been successfully tested by the end of 2017;

— 26 out of 28 bulks for the MPD magnet yoke were assembled and tested;

— manufacturing of correction coils was on schedule;

— production of a vacuum casing was started.

TPC Status

Time projection chamber (TPC) is the main detector for the particle identification of the MPD setup. In 2017, the following results were achieved in the TPC manufacturing:

— the clean room for the TPC assembly was prepared and equipped;

— one out of 24 read-out chambers was tested, 20 are ready to be assembled;

— the TPC gas system was installed and the laser calibration was finished;

— the first prototype of the new FEC64S boards based on the SAMPA chip for read-out chambers was designed and tested.

ECAL Status

One of the unique high-tech projects within the framework of the MPD experiment is the large-scale electromagnetic calorimeter of the shashlyk type with the projection geometry. This is a joint project with Tsinghua University (Beijing, China). It is required to produce more than 40 thousand modules and assemble them into a single cylindrical system, calibrate and put into operation.

The production and testing zone has been constructed at Tsinghua University and is now under construction at VBLHEP. The preparation for the mass production of ECAL modules (see Fig. 2) is at the final stage:

— technical part of the ECAL TDR is ready, feasibility studies have to be completed by the end of 2018;

— the production of main elements of the ECAL module is debugged, mass production of the scintillator plates (10^7 units) was started.

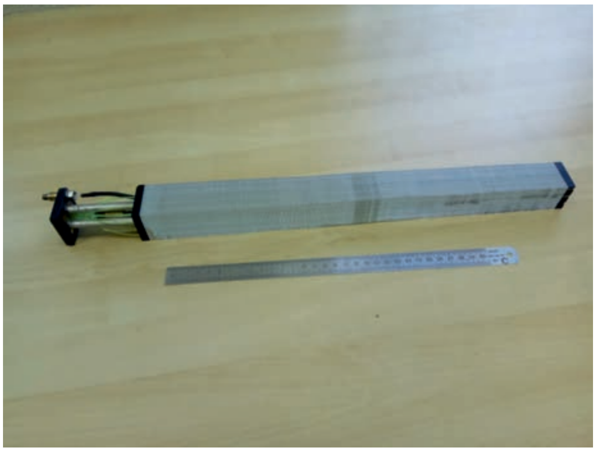

Fig. 2. First prototypes of the electromagnetic calorimeter modules, created in collaboration with Tsinghua University

Status of FHCAL

The Forward Hadron Calorimeter (FHCAL) is under the INP RAS full responsibility. By the end of 2017, 60 out of 90 calorimeter modules were produced. The production will be finished by the end of 2018. A real full-scale prototype of the FHCAL electronics was tested. Mass production was started; by the end of 2018, 20% of the electronics are expected to be ready.

Progress with STS

The MPD vertex detector — silicon tracker system (STS) — is based on the Monolithic Active Pixel Sensor (MAPS) technology developed for ALICE. Structural elements and ladders were produced in close cooperation with the ALICE group. The workshop for micro strip detector assembly and test is in operation now at JINR. It will be used for assembly of stations for BM@N and MPD/NICA, as well as for CBM/FAIR. The plan of common activity on these issues with ALICE is under preparation now.

In 2017 the following results were achieved:

— the clean room for assembling and testing was commissioned;

— the ALICIA-8 chip "pick&place robot" was shipped from the Netherlands, installed and commissioned;

— the development of MAPS sensors of the ALICE type for about $6 \cdot 10^9$ pixel cells was started.

BM@N Setup

BM@N setup is the 1st stage of the NICA project. Its base configuration is now under preparation for data taking in 2019.

BM@N technical runs were performed with a deuteron beam at a kinetic energy of $4A$ GeV and with a carbon beam at a kinetic energy of 3.5, 4 and $4.5A$ GeV at fixed C, Al and Cu targets.

The setup was equipped with the TOF system and electromagnetic calorimeters. The tracking system consisting of six two-coordinate planes of GEM detectors was placed inside the analyzing magnet. An additional two-coordinate silicon strip detector was in operation during the run with the carbon beam to improve the primary vertex reconstruction.

The obtained experimental data allow calculating the momentum resolution of the setup for the carbon beam at different magnetic fields and reconstruct the decay signals of Λ hyperon and K_s^0 meson in the invariant mass spectra of $p\pi^-$ and $\pi^+\pi^-$, respectively (see Fig. 3).

In 2017, the BM@N physics programme was extended by the project "Probing Short-Range Correlations". New participants from the USA, Israel, France and Germany joined the collaboration.

The current setup includes the following major subsystems of the base configuration: trigger system, DAQ, Slow Control, online monitoring, ToF, ZDC, outer tracker, calorimeters, two forward silicon detectors and seven half-planes of the GEM detectors.

During the next Nuclotron run it is planned to operate with Ar, Kr and C beams obtained from the heavy-ion source KRION-6T and with the liquid hydrogen target.

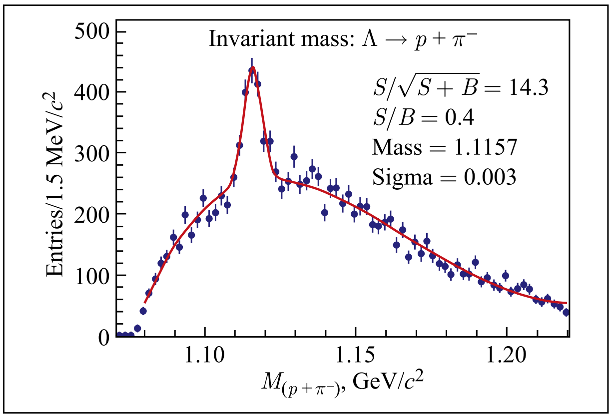

Fig. 3. Invariant mass signal for Λ hyperon

SPD Setup

The next stage of the SPD project aimed at the Conceptual Design Report preparation and at forming an international collaboration was started in 2017. Agreements have been prepared or are currently under negotiation with the groups from Tomsk State University, Tomsk Polytechnic University, Charles University (Prague) and a group from INFN (Turin, Italy). Interim Steering and Technical Committees of the project have been formed.

EXPERIMENTS CARRIED OUT AT THE NUCLOTRON

FASA

The relative angle correlations of intermediate mass fragments (IMF) have been studied for ^{4}He + Au collisions at 4 GeV [1]. Strong suppression at small angles was observed, which is caused by the Coulomb repulsion between the coincident fragments. Figure 4 shows the comparison of the experimental correlation function and the theoretical one obtained by the multibody Coulomb trajectory calculations with decay time as a parameter. The combined model including the intranuclear cascade followed by the statistical multifragmentation model was used to generate starting conditions for these calculations. The mean decay time of the fragmenting system is found to be (47 ± 12) fm/c, which corresponds to the simultaneous multiple decay of a hot and expanded nuclear system.

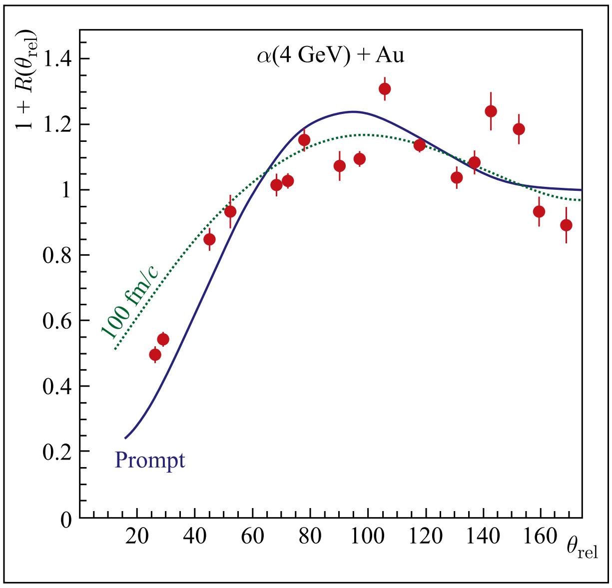

Fig. 4. Relative angle correlation functions for IMF produced in ^{4}He + Au collisions at 4 GeV. Points — experimental data. Solid line — INC + SMM calculations with prompt secondary disintegration. Dotted line corresponds to INC + SMM calculations with mean time of secondary disintegration equal to 100 fm/c

DSS

The fully upgraded version of the polarimeter at the internal beam, which is based on the measuring of the asymmetry in deuteron–proton elastic scattering, was put into operation during the 54th Nuclotron run (February–March 2017).

New data on the analyzing powers A_y, A_{yy} and A_{xx} in deuteron–proton elastic scattering at 1400 and 1700 MeV were obtained during the 54th run in addition to the data obtained in the 53rd run [2].

The tuning of the new source of polarized ions for six different spin modes has been performed.

The measurements of the proton beam polarization, accelerated at JINR for the first time, have been performed at 500 MeV, the value of polarization was -0.35 ± 0.02 [3].

ALPOM2

The ALPOM2 setup was designed to measure analyzing powers from different targets.

In 2017, on the extracted Nuclotron beam the analyzing power for the charge-exchange $n \uparrow + CH_2 \to p + X$ reactions was measured for the first time, for C, CH (scintillator) and Cu analyzers. Based on the existing data on charge-exchange analyzing power for $np \to pn$, the expectation was that the same reaction channel for more complex targets (C, CH, CH_2 and Cu) would be significantly larger than for the forward process, $np \to np$. The new data fully support this expectation.

PARTICIPATION IN EXPERIMENTS AT EXTERNAL ACCELERATORS

Experiments at the Large Hadron Collider

ALICE

In 2017, new results of the 1D and 3D femtoscopic correlation analysis for $K^{\pm}K^{\pm}$ pair production in Pb–Pb collisions were obtained and compared with the model and with the previous results. A good agreement has been observed (Fig. 5).

New results were obtained for the comparison of the ALIICE femtoscopic data with the EPOS-3 model ones (including hadronic rescattering) for Pb–Pb collisions at 2.76 TeV [4]. Figure 6 shows that the data and model femtoscopic radii are congruous at the same centralities.

With the JINR team participation, new results were obtained for the ρ^0 production in ultraperipheral Pb–Pb collisions at 5.02 TeV. The differential cross section is given in Fig. 7 with the theoretical predictions for comparison.

The photodetectors and the prototype of the readout electronics for the upgrade of the PHOS ALICE electromagnetic calorimeters were tested at the T9 test electron beam at CERN. The main goals of these studies were to check the PHOS operation at the temperature above the dew point (from -28 to $+18$°C) and to improve the time resolution in order to decrease the background from antineutrons and the pileup of neighboring bunches.

The TQDC-16E module developed at VBLHEP was used for the measurements of the energy and time of flight. Avalanche photodiodes (APD) of 10×10 mm and matrix of silicon photomultipliers of 6×6 mm

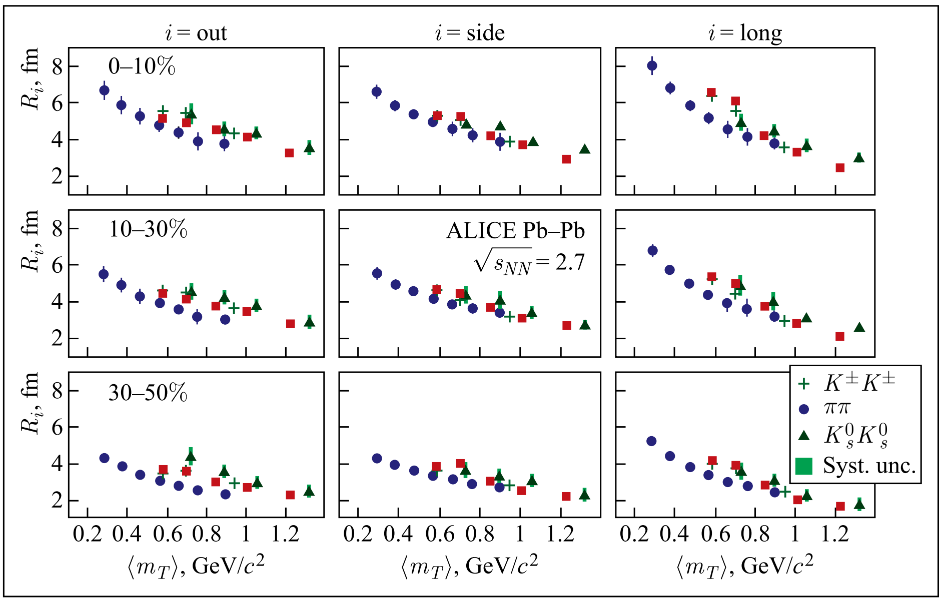

Fig. 5. The 3D source radii versus transverse mass (m_T) for $K^{\pm}K^{\pm}$ and $\pi\pi$ pairs

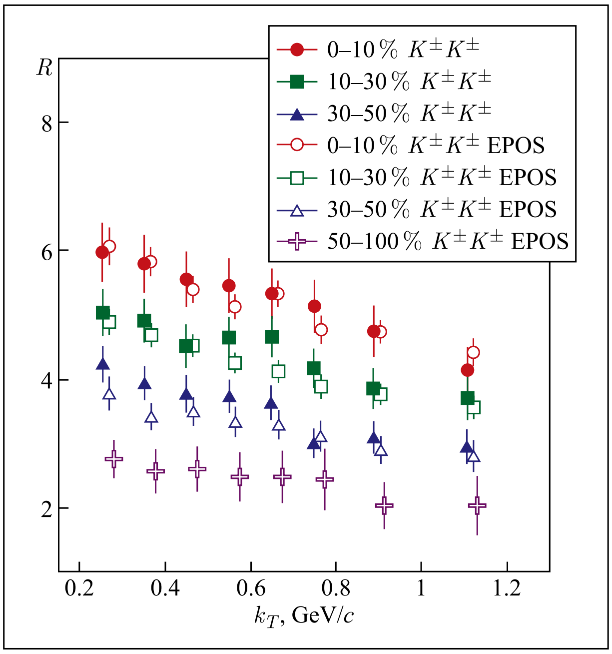

Fig. 6. 1D source radii of $K^{\mathrm{ch}}K^{\mathrm{ch}}$ versus pair transverse momentum

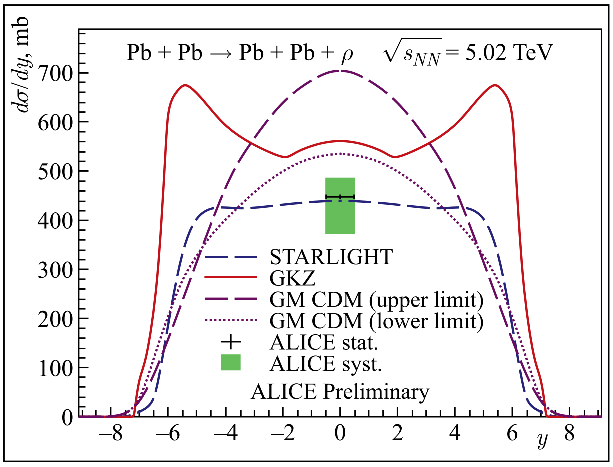

Fig. 7. Differential cross section of ρ^0 production in ultra-peripheral Pb–Pb collisions

(SiPM) were used. In both cases the obtained energy resolution was much better than for the current configuration of PHOS at −28°C. The time resolution was obtained in the range of 0.4–0.8 ns for APD and 0.2 ns for SiPM.

ATLAS

Analysis of the ATLAS experimental data was ongoing aimed at the search for the Standard Model Higgs boson that decays into the pair of b quarks produced in association with the W boson. The MVA method for the Higgs boson mass of 125 GeV revealed the excess of the observed events over the expected background from the Standard Model (see Fig. 8). The observed (expected) excess of 3.6σ (4.0σ) and signal strength were obtained in the combined analysis of the Run-1 (7 and 8 TeV) and Run-2 (13 TeV) data. Reliability of the results was confirmed with a similar analysis of the $(W/Z)Z$ (with $Z \to bb$) process which found the value of $\mu = 1.11^{+0.25}_{-0.22}$ and the observed (expected in SM) excess of $(W/Z)Z$ signal of 5.8σ (5.3σ).

CMS

In 2017, the JINR group took part in the data taking, processing and physics analysis of the data collected during the LHC Run-2 with the proton beams at an energy of 13 TeV and a luminosity of up to $1.8 \cdot 10^{34}$ cm$^{-2} \cdot$ s^{-1}. The mass limits for new heavy neutral gauge bosons Z' were improved by the combination of both electron and muon channels. New mass limits (95% C.L.) are 3.5 and 4.0 TeV/c^2 for Sequential Standard Model and GUT model E$_6$, respectively.

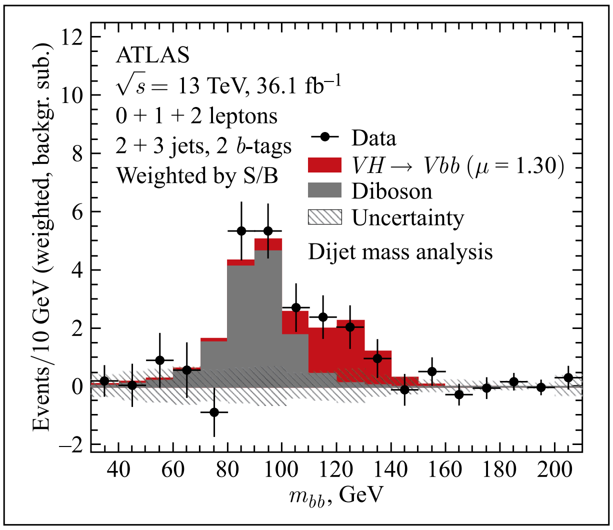

Fig. 8. The distribution of m_{bb} in data after subtraction of all backgrounds except for the WZ and ZZ diboson processes. Observed (expected) excess is 3.5σ (2.8σ)

The first study of forward–backward asymmetry A_{FB} was performed with the LHC Run-2 data [5]. To improve consistency of the data and SM predictions (Fig. 9, *a*) the step-by-step corrections were applied for the data including the acceptance efficiency and muon momentum resolution corrections, pile-up, etc. The preliminary results for the measured asymmetry A_{FB} are shown in Fig. 9, *b*.

Experiments at the CERN Super Proton Synchrotron

COMPASS

In 2017, the COMPASS collaboration with the active participation of JINR physicists performed the

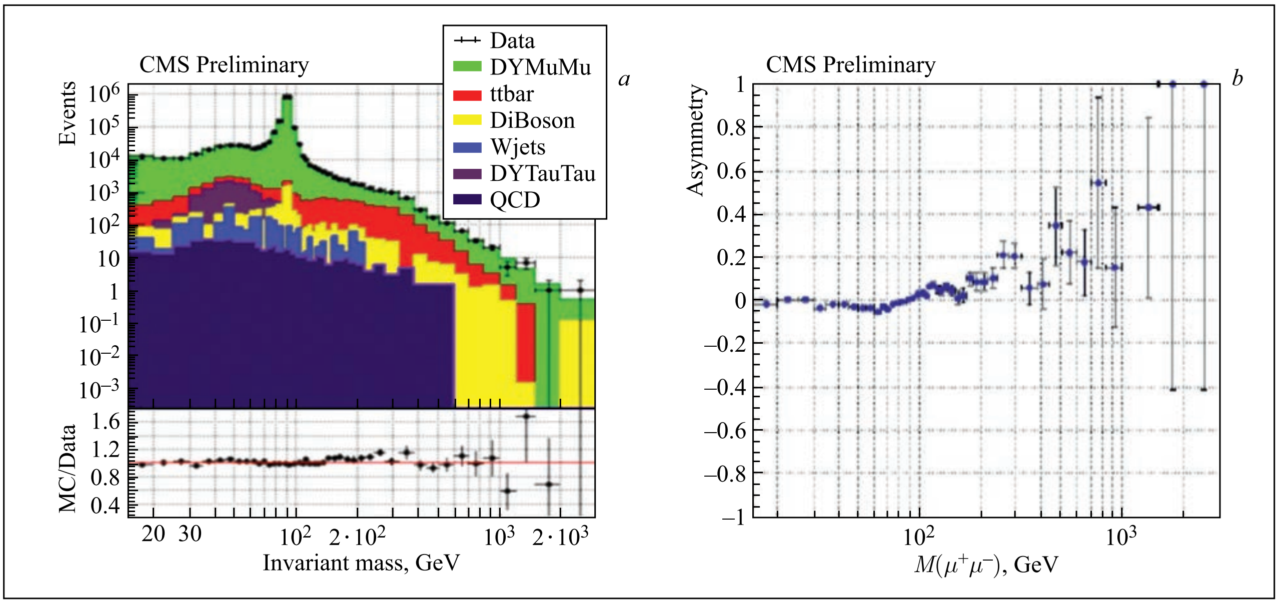

Fig. 9. *a*) Muon invariant mass spectra. The first LHC data at 13 TeV of 2017 was used. *b*) The measured value of $A_{\rm FB}$ in the different $\mu\mu$ mass bins [6]

first measurement of transverse-spin-dependent azimuthal asymmetries in the pion-induced Drell–Yan (DY) process with the use of the CERN SPS 190 GeV/c π-beam and a transversely polarized ammonia target.

The azimuthal asymmetries, which give the access to different transverse-momentum-dependent (TMD) parton distribution functions (PDFs), have been extracted using dimuon events with the invariant mass between 4.3 and 8.5 (GeV/c)^2. The observed sign of the Sivers asymmetry is found to be consistent with the fundamental prediction of QCD that the Sivers TMD PDFs extracted from DY have a sign opposite to the one extracted from semi-inclusive deep-inelastic scattering (SIDIS) data. Two other asymmetries originating from the pion Boer–Mulders TMD PDFs convoluted with either the nucleon transversity or pretzelosity TMD PDFs are also extracted from the data [6]. These DY results obtained at the hard scale are comparable to those of the recent COMPASS SIDIS measurement and hence allow conducting unique tests of the fundamental QCD universality predictions.

NA61/SHINE

In 2017, the following results were obtained at the CERN Super Proton Synchrotron using the large acceptance NA61/SHINE hadron spectrometer.

The measurements of inclusive spectra and mean multiplicities of $\pi^{\pm}$, $K^{\pm}$, p and anti-p produced in inelastic $p+p$ interactions at incident projectile momenta of 20, 31, 40, 80 and 158 GeV/c ($\sqrt{s} = 6.3$, 7.7, 8.8, 12.3 and 17.3 GeV, respectively) were performed [7]. The spectra are presented as a function of rapidity and transverse momentum and compared to predictions of current models. An example of such spectra for antiprotons at momenta of 80 and 158 GeV/c is given in Fig. 10.

Results on two-particle $\Delta\eta\Delta\varphi$ correlations in inelastic $p+p$ interactions were obtained. The data show structures which can be attributed mainly to the effects of resonance decays, momentum conservation, and quantum statistics. The results are compared with the EPOS and UrQMD models. Two-particle correlation function $C\ (\Delta\eta, \Delta\varphi)$ for all charge pairs in $p+p$ interactions at 20–158 GeV/c is presented in Fig. 11 [8].

NA62

In the framework of the NA62 experiment, JINR and CERN groups are jointly responsible for the NA62 magnetic spectrometer calibration and operative support, as well as for the software development for simulation and reconstruction of the recorded events.

A new gas monitor system has been developed and produced by the JINR group. It will be used for the spectrometer response stability control.

JINR group continued the analysis of the NA48/2 and NA62 experimental data during 2017:

— NA48/2 data on the decay $K^{\pm} \to \pi\mu\mu$ were used for the search for the lepton number violation. A new upper limit for the rate of the lepton number violating decay $K^{\pm} \to \pi\mu^{\pm}\mu^{\pm}$ is reported: Br $< 8.6 \cdot 10^{-11}$ at 90% C.L. Upper limits for the possible short-living $\pi\mu$ and $\mu\mu$ resonances are below 10^{-9}.

— The measurement of the π^0 electromagnetic transition form factor slope has been performed on the basis of the NA62 data (stage R_K) [9]. The measured value $a = (3.68 \pm 0.57) \cdot 10^{-2}$ is in good agreement with the theoretical expectations and previous measurements, and represents the most precise result in the time-like momentum transfer region.

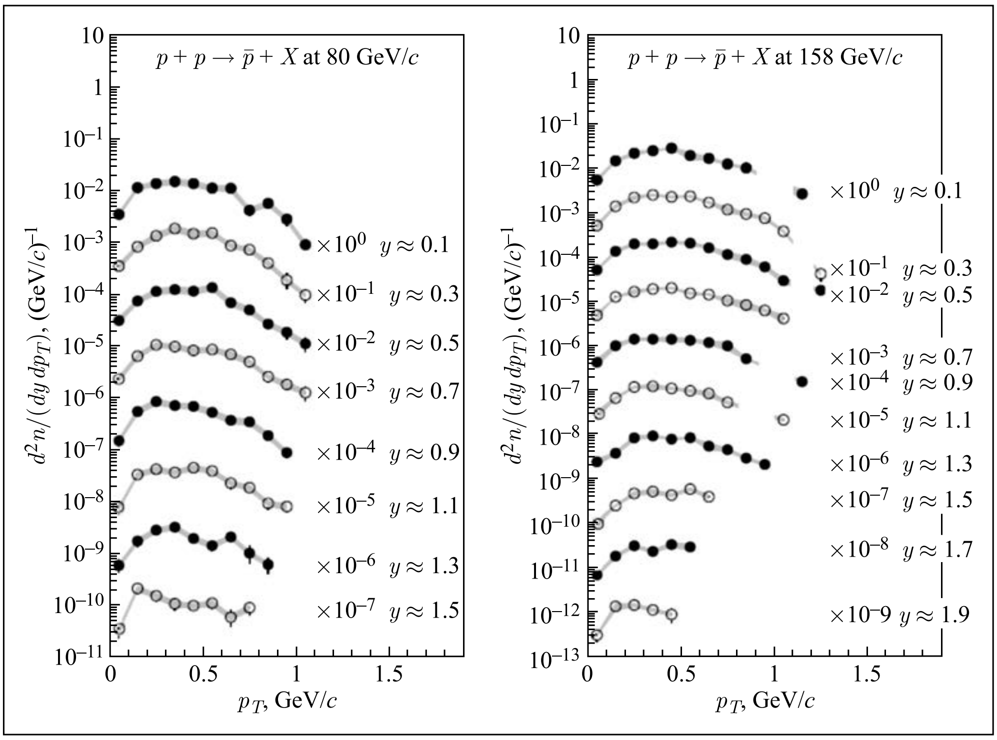

Fig. 10. Transverse momentum anti-p spectra in rapidity slices produced in inelastic $p + p$ interactions at 80 and 158 GeV/c

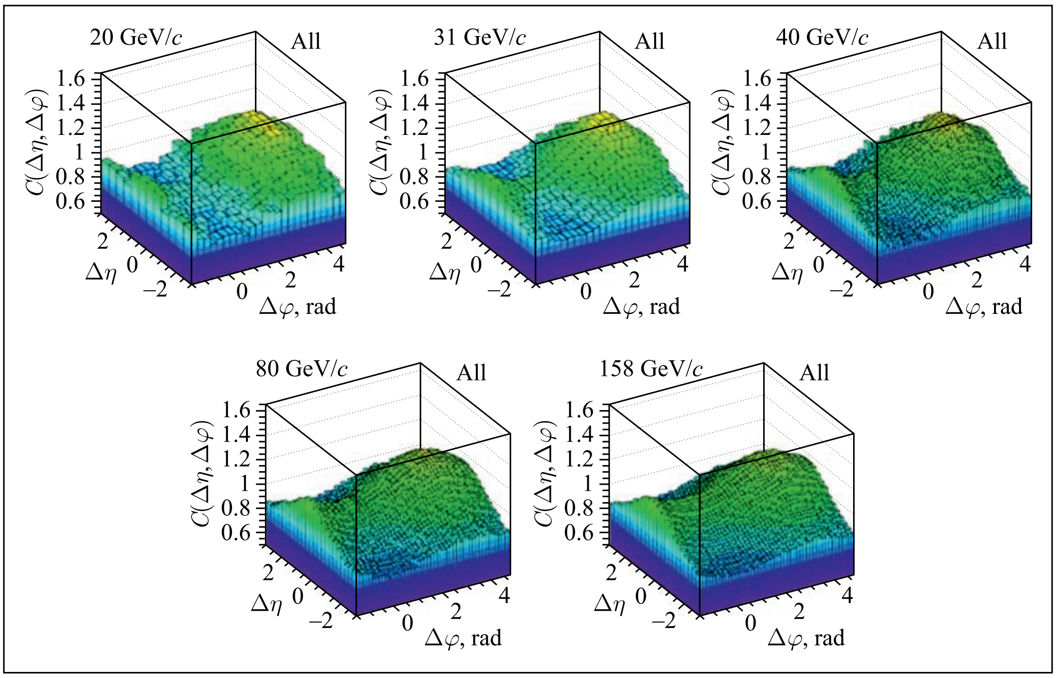

Fig. 11. Two-particle correlation function $C\ (\Delta\eta, \Delta\varphi)$ for all charge pairs in $p + p$ interactions at 20–158 GeV/c

— The search for heavy neutrinos in $K^+ \to \mu^+\nu_\mu$ decays has been performed on the basis of the NA62 data (stage R_K) [10]. Upper limits in the range $2 \cdot 10^{-6}$ to 10^{-5} have been set on the squared mixing matrix element $|U_{m4}|^2$ for heavy neutrino masses in the range 300–375 MeV/c^2.

A series of NA62 publications devoted to the spectrometer design and production was nominated for the JINR prize in 2017.

Experiments at the Relativistic Heavy Ion Collider, BNL

STAR

The STAR collaboration with strong support of JINR team has recently reported the first observation of the global polarization of Λ hyperons in heavy ion collisions [11].

It was discovered that the polarization direction of the Λ's was correlated at the level of several percent with the direction of the system angular momentum in non-central collisions at $\sqrt{s_{NN}} = 7.7{-}32$ GeV.

It has been well established that the hot system created at mid-rapidity in the system may be considered as a fluid, and hydrodynamic calculations directly relate the polarization of emitted particles to the vorticity — the curl of a flow field — of a fluid. Using this relation, the curl of the fluid created at RHIC has been estimated to be about $9\cdot10^{21}$ s^{-1}, which is 14 orders of magnitude higher than that of any fluid ever observed. Previous results have proved the system at RHIC to be the hottest and the least viscous (relative to entropy density) fluid ever created. The new result adds another record — collisions at RHIC produce the most vortical fluid.

EVENTS

International Workshop "Perspectives of Experimental Research at the Nuclotron Beams"

The 5th International Workshop of the Nuclotron Beam Users "Perspectives of Experimental Research at the Nuclotron Beams" was held on 6–7 October at VBLHEP.

The present status and prospects 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. Proposals on the research programme at the Nuclotron beams and runs schedule 2017–2018 were presented. The advanced work schedule (up to 2020) for the operation and development of the accelerator complex and the beams infrastructure was considered.

International Seminar "The 60th Anniversary of the Synchrophasotron and 110th Anniversary of V. I. Veksler's Birth"

An international seminar devoted to the 60th anniversary of the Synchrophasotron startup and 110th anniversary of V. I. Veksler's birth was held on 21 April at the Laboratory. During the seminar, the memorial square named after Academician V. I. Veksler was inaugurated.

China–Russia Working Group Meeting

On 28 October, an expert meeting of a Working Group on cooperation between Russia and China in the framework of the large (mega-science) research infrastructures was held in Beijing. On the Chinese side the meeting was attended by representatives of the Institute of Modern Physics (Lanzhou), the Institute of Plasma Physics (Hefei) and Tsinghua University (Beijing). The NICA project on the Russian side was represented by the JINR delegation chaired by the leader of the project V. D. Kekelidze.

CERN–JINR Meeting

A CERN–JINR meeting devoted to the possible collaboration between the two centres in the framework of the MPD, BM@N and SPD projects, as well as to preparation to obtain for these projects the status of the CERN recognized experiments, was held in Geneva in April.

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DZHELEPOV LABORATORY OF NUCLEAR PROBLEMS

NEUTRINO PHYSICS AND RARE PHENOMENA, ASTROPHYSICS

The most important achievement of the **Baikal** collaboration in 2017 is the construction and operation of the two-cluster deep underwater detector on Lake Baikal as the next step to the full-scale Baikal-GVD detector [1]. The detector consists of 576 optical modules (OMs) assembled on 16 vertical strings (eight strings in each cluster) and distributed over a depth range of 750 to 1250 m. The deep underwater detector GVD-2017 has the effective volume of 0.1 km^3 for cascade registration which provides the ability to look into the astrophysical neutrino flux of ultra-high energy detected in the IceCube experiment. During 2017 the detector ran in regular data-acquision mode and in special test regimes. More than 600 OMs for the next-stage clusters (3 and 4) of the Baikal-GVD telescope were assembled and tested in Dubna (JINR) and Moscow (INR). The analysis of the experimental data from the first cluster (detector-2016) also proceeded during this year. The cascade analysis of 686 million events from 182 days of data acquisition revealed five events with the energy higher than 100 TeV that satisfied all trigger conditions. One of these events has multiplicity of 38 fired OMs.

Within the **Daya Bay** project, the most precise values of the neutrino oscillation parameters $\sin^2 2\theta_{13} = 0.0841 \pm 0.0027(\text{stat.}) \pm 0.0019(\text{syst.})$ and $\Delta m^2_{32} = (2.45 \pm 0.06(\text{stat.}) \pm 0.06(\text{syst.})) \cdot 10^{-3}$ eV^2 [2] and the first experimental limits on the neutrino decoherence parameters [3] were obtained with a major contribution of the DLNP group. By studying the evolution and spectrum of the reactor antineutrino flux, it was shown that the reactor neutrino anomaly is mainly due to the discrepancy between the observed and predicted ^{235}U neutrino fluxes [4].

Within the **JUNO** project, the support structure for the Top Tracker (TT) was developed. Several prototypes were built and tested. The TT modules are stored near the JUNO site. In order to monitor the TT stability, the modules now operate as a cosmic muon detection system. The PMT scanning station for 50-cm PMTs was produced [5] and the software for the station control, DAQ, and data storage was developed. The station was shipped from JINR to China and put into operation. The design of the high-voltage system for the JUNO PMTs was finalized. The preparation for the mass (25k units) production of the HV cells is in progress.

In 2017, within the **Borexino** project, the results of the time variation studies of the beryllium neutrino flux was published. The best fit value for the period of the signal variation $T = (367 \pm 10)$ d could be considered as the first measurement of the astronomic year duration using solar neutrinos [6]. A new model-independent limit on the effective moment of the solar neutrino $\mu_\nu^{\text{eff}} < 2.8 \cdot 10^{-11}$ μ_B (90% C.L.) was obtained [7]. Within the framework of the modern multimessenger approach to the astrophysical events, neutrinos and antineutrinos were searched for in coincidence with gravitational wave events (events GW150914, GW151226, and GW170104) [8] and with 2350 gamma-ray bursts (GRB) observed for eight years of the Borexino data-taking [9].

During 2017, within the **NOνA** experiment, new oscillation results were obtained (using an exposure equivalent to $6.05 \cdot 10^{20}$ POT) in the measurement of $\nu_\mu \to \nu_e$, $\nu_\mu \to \nu_\mu$ transitions and in the first search for sterile neutrino mixing with active neutrinos through the neutral-current interactions [10–12]. The JINR group has contributed significantly to the study of the matter effect on neutrino oscillations in long-baseline experiments [13]. Within the framework of the international cooperation, the JINR remote operation centre and the LIT computing infrastructure for NOνA are operating routinely. In 2017, according to the agreement with Fermilab, the NOνA scintillator was delivered to JINR in order to measure its characteristics required for the detector simulation.

The assembly of the **SuperNEMO** Demonstrator (first module) in the Modane Underground Laboratory was finished (Fig. 1), the official inauguration was on 7 November 2017. The first data will be collected in early 2018. The goal of the Demonstrator is to validate the technique and reach the $0\nu\beta\beta$-decay half-life sensitivity $T(0\nu)_{1/2} > 5.9 \cdot 10^{24}$ y with the zero background in the region of interest [14]. The world's first-ever limit $T(0\nu)_{1/2} > 1{-}3 \cdot 10^{21}$ y on quadruple double beta decay $0\nu4\beta$ in ^{150}Nd was obtained [15]. The final NEMO-3 result for ^{116}Cd was also published [16].

Direct search for WIMPs is the fundamental scientific problem addressed by the **EDELWEISS** experiment. It searches for WIMPs scattering from Ge nuclei within Ge crystals. The main objective of the experiment is now shifted to the low-mass WIMP region (10 GeV and below). An increase in interest in the search for low-mass WIMPs is caused, on the one hand, by the absence of evidence for SUSY at the LHC and, on the other hand, by new theoretical approaches favoring lighter candidates. In 2017, EDELWEISS-III obtained low-mass WIMP results, and the positive results reported by some other experiments were directly verified (Fig. 2). At the same time, EDELWEISS continues the R&D widening the investigation of the low-mass region via the Neganov–Luke effect of internal amplification of the heat signal [17–19]. It must be emphasized that participation in the EDELWEISS project allows JINR to get an important access to the low-background infrastructure for development and tests of low-radioactivity low-energy-threshold setups for neutrino experiments at the Kalinin NPP.

In 2017, **GERDA** Phase II continued data taking. The new unblinding of the data collected in 2016–2017 was performed in June 2017. The total exposure used for the last analysis is 23.5 kg · y and 23.2 kg · y for Phase I and Phase II, respectively. No event close to $Q\beta\beta$ is found and a 90% C.L. lower limit of $T^{0\nu}_{1/2} > 8.0 \cdot 10^{25}$ y is set for the frequentist analysis, with a median sensitivity of $5.8 \cdot 10^{25}$ y. This is the best half-life sensitivity amongst all existing $0\nu\beta\beta$ experiments [20]. GERDA data taking will continue until the designed exposure of 100 kg · y is achieved, which is planned for 2019. Then the half-life sensitivity will be well above $1.0 \cdot 10^{26}$ y. The sensitivity of GERDA can be additionally improved by reducing the background of the experiment and adding novel enriched Ge detectors. This upgrade of GERDA is supposed to be performed in 2018. It should include not only an increase in the enriched isotope mass by adding new enriched detectors but also replacement of the existing active liquid argon veto by its improved version.

The **TUS** experiment is the first space detector for measuring fluorescence and Cherenkov radiation of extensive air showers (EAS) produced by Ultra High Energy Cosmic Rays (UHECRs) at $E \sim 10^{20}$ eV. TUS was launched on 28 April 2016 in a solar-synchronous orbit from the Vostochny cosmodrome on board the "Lomonosov" satellite. The regular data are received since 16 August 2016. In the search for UHECRs a large number of background events of various ori-

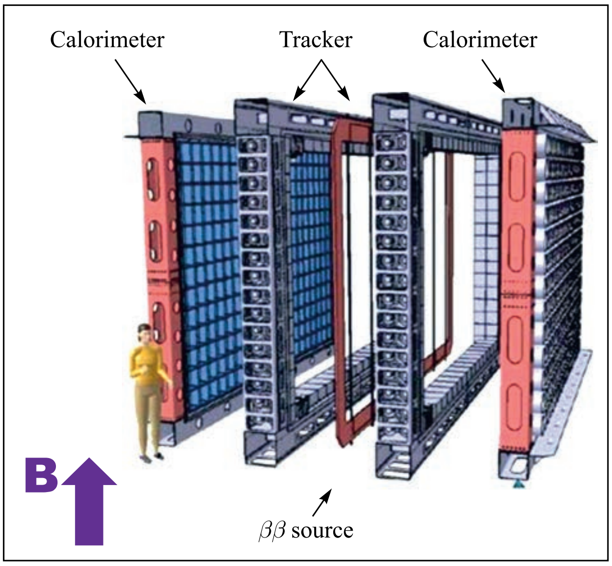

Fig. 1. The first module of the SuperNEMO experiment (Demonstrator)

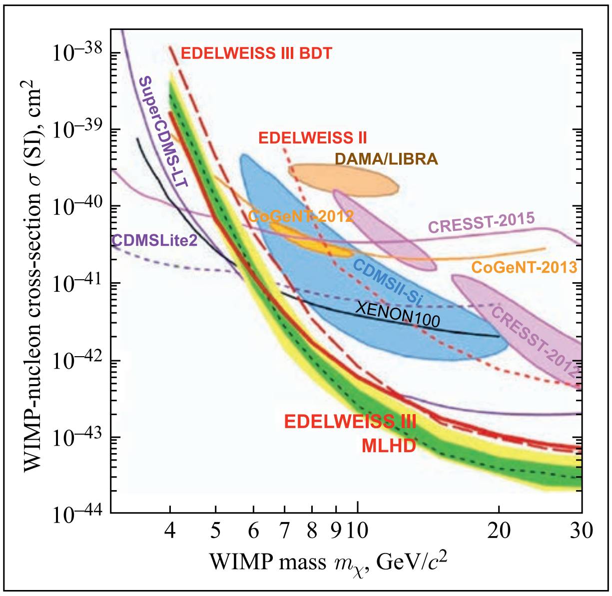

Fig. 2. EDELWEISS-III WIMP search results. EDELWEISS III BDT is the Boosted Decision Tree analysis, EDELWEISS-III MLHD is the likelihood approach. Shown for comparison are possible positive results (contours) and exclusion limits (lines) from other Dark Matter search experiments

gin were found in the Earth's atmosphere. A multilevel algorithm for the search for EAS-like events was developed and applied to the TUS data set analysis. A few EAS candidates with $E \sim 100$ TeV were found.

The **NUCLEON** satellite experiment is aimed at measuring energy spectra and charge composition of cosmic rays (CRs) in the energy range of 1 to 1000 TeV directly adjoint to the kink in the GCR spectrum. The energy distribution of the intensity of the cosmic radiation particles and their charge and mass distribution (chemical composition) contain significant information on sources and mechanisms for acceleration and propagation of CRs in the Galaxy. The NUCLEON-2 space experiment is intended for studying the isotopic composition of superheavy cosmic rays. The spectrometer is capable of measuring the isotopic composition of cosmic ray nuclei with energies from tens of MeV/nucleon to ~ 1 GeV/nucleon in the charge range from nitrogen ($Z = 7$) to dysprosium ($Z = 66$). The main NUCLEON-2 detector is a total-absorption microstrip silicon calorimeter. JINR participates in this experiment, being involved, among other things, in beam tests of prototypes at accelerators, including the Nuclotron [21, 22].

Within the **TAIGA** project, JINR is responsible for the mechanical platform of the IACT. In addition, JINR participates in the data taking in the Tunka area, MC simulation, and physical analysis [23]. In December 2016, the first TAIGA–IACT was put into operation. A number of EAS events were detected both by the IACT and by TAIGA–HiSCORE. Fabrication of the IACT-2 started at JINR in 2017.

In 2017, within the **OPERA** experiment, the data analysis was continued. A new advanced approach was applied to the data selection, which allowed increasing the number of τ-neutrino events to 10 (with two expected background events) and increasing the statistical significance of the discovery to 6σ. New restrictions on the contribution of non-standard oscillations (like LSND) were obtained in the $\nu_\mu \to \nu_e$ channel. The seasonal variation results for the cosmic muon flux in LNGS were obtained. The OPERA data are prepared for publication within the framework of the CERN Open Data project with the leading participation of JINR group.

ELEMENTARY PARTICLE PHYSICS

Within the **ATLAS** project, a search for the decay of the Standard Model Higgs boson into a $b\bar{b}$ pair when it is produced in association with a W or Z boson was performed. The analyzed data, corresponding to an integrated luminosity of 36.1 fb^{-1}, were collected in pp collisions in Run 2 of the LHC at a centre-of-mass energy of 13 TeV. Final states containing zero, one and two charged leptons (electrons or muons) were considered to search for the decays $Z \to \nu\nu$, $W \to l\nu$, and $Z \to ll$. For a Higgs boson mass of 125 GeV,

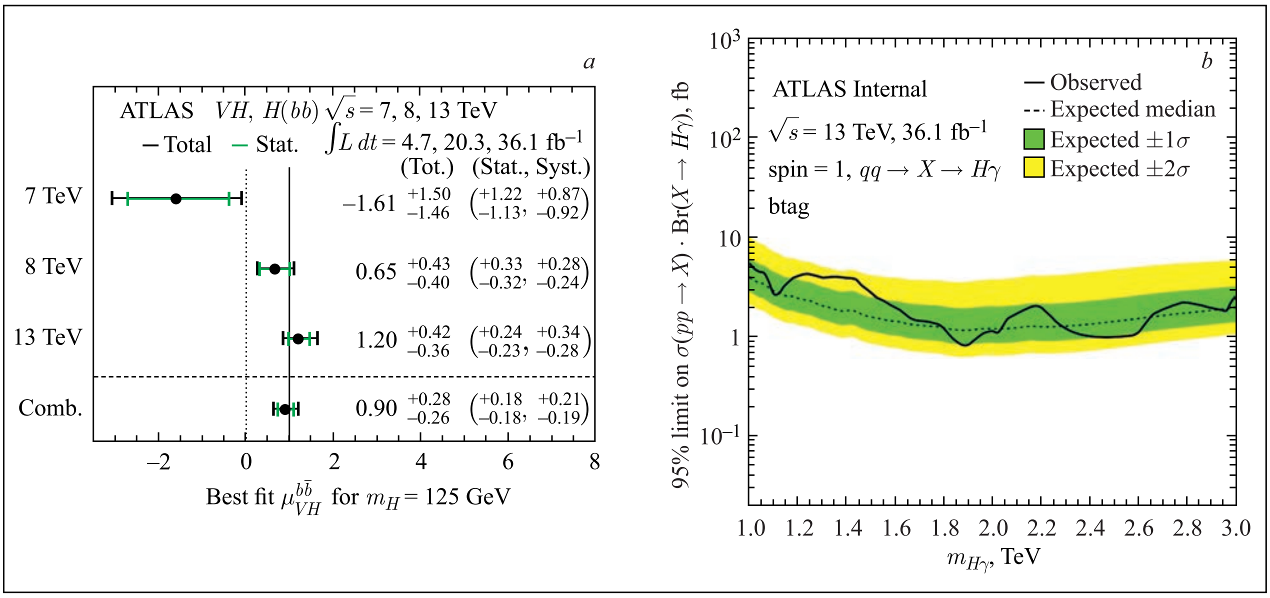

Fig. 3. *a*) The fitted values of the Higgs boson signal strength parameter μ for $m_H = 125$ GeV separately for the 7, 8 and 13 TeV datasets and their combination. *b*) The production cross section limits for the $H\gamma$ resonance as a function of its mass

an excess of events over the expected background from other Standard Model processes was found with an observed significance of 3.5σ, compared to an expectation of 3.0σ. This excess provides evidence for the Higgs boson decay into b quarks and for its production in association with a vector boson. The combination of this result with that of the Run 1 analysis yields $\mu = 0.90 \pm 0.18(\text{stat.})^{+0.21}_{-0.19}(\text{syst.})$ (Fig. 3, a) [24].

A search was performed for new resonances with mass larger than 1 TeV decaying to a W, Z, or Higgs boson and a photon. The dataset consisted of an integrated luminosity of 36.1 fb^{-1} of pp collisions collected at $\sqrt{s} = 13$ TeV with the ATLAS detector at the LHC. The $W/Z/H$ bosons were identified through their decays to hadrons. The data were found to be consistent with the expected background in the entire investigated mass range (Fig.3, b), and upper limits were set on the production cross section times decay branching ratio to $W/Z/H + \gamma$ of a narrow scalar boson with a mass between 1 and 6.8 TeV.

The main objectives of the **SANC** group in 2017 were the Drell–Yan process analysis in the ATLAS experiment, participation in the DYTURBO Working Group created to fit the effective weak mixing angle, and development and maintenance of the xFitter project [25]. For the ATLAS experiment, theoretical predictions and fast calculation of the differential cross section using dedicated simulation tools were performed. Higher-order corrections were introduced into the DYTURBO package. Within the xFitter activity for extension of functionality, debugging was performed, new experimental data and their analysis were added and photon PDFs were extracted from the high-mass Drell–Yan data at the LHC.

In 2017, within the **Mu2e** project, the possibility of obtaining a low-intensity (1–3 electrons) beam of electrons at the linear accelerator LINAC-200 was investigated. The low-intensity electron beam with 1–3 electrons per spill will allow one to study characteristics of CsI crystals. A 16-channel fiber profilometer based on Kuraray SCSF 81J of 2 mm scintillating fibers with a 16-channel PMT for readout is under development for the LINAC-200 trigger system. The R&D of the UV photodetector for selecting the rapid radiation scintillation component of BaF_2 crystals was performed [26]. To get the photodetector that can be used in the Mu2e electromagnetic calorimeter, a photomultiplier based on microchannel plates (MCPs) was developed. For the cosmic ray veto system, studies of light yield and radiation hardness of scintillation strips with optical fillers were continued. A set of 1×1 m cathode strip chambers was built to test modules of the cosmic ray veto system for the Mu2e experiment [27].

In 2017, within the **COMET** project, a combined test with an electron beam (1.3 GeV) was conducted at Tohoku University (Japan). Prototypes of an electromagnetic calorimeter and a straw tracker were tested using a 105 MeV beam. A prototype calorimeter was composed of 16 modules of LYSO crystals. Each module consisted of four crystals, giving a total of 64 crystals in the prototype. The efficiency and position resolution of the straw-tracker prototype was measured for different types and combinations of gases. The measurements showed that the best efficiency of $> 90\%$ and position resolution of < 150 μm were obtained for Ar [28].

The **MEG-II** experiment is a continuation of the MEG experiment (in which a new value of the upper limit on the branching ratio of the decay $\mathrm{Br}\,(\mu^+ \to e^+\gamma) < 4.2 \cdot 10^{-13}$ (90% C.L.) was obtained). The collaboration proposes to upgrade the experiment for increasing the sensitivity by an order of magnitude compared to the final MEG result. The JINR group takes part in the following improvements of MEG-II: a new positron tracker with a reduced radiation length, better granularity, and position resolution and a new DAQ system.

Within the **GDH&SPASCHARM** project, the first-ever measurements of the beam asymmetry for Compton scattering below the pion photoproduction threshold have been performed [29]. The results confirm the existing predictions of the perturbation theory and dispersion relation models and deviate notably from the Born term in which the contributions of the proton polarizabilities are not included. The results show that the extraction of the scalar polarizabilities from the beam asymmetry below the threshold is an alternative to the extraction from the unpolarized Compton scattering cross section.

The reactions $\gamma p \to \eta p$ and $\gamma p \to \eta' p$ were measured from their thresholds up to the center-of-mass energy $W = 1.96$ GeV using the tagged-photon facility at the Mainz microtron MAMI. Differential cross sections were obtained with an unprecedented accuracy, providing fine energy binning and full production-angle coverage. A strong cusp is observed in the total η photoproduction cross section at the energies in the vicinity of the η' threshold, $W = 1896$ MeV ($E\gamma = 1447$ MeV). This behavior in combination with the steep rise of the total η'-photoproduction cross section is explained in a revised ηMAID2017 isobar model by a contribution of the $N(1895)1/2^-$ nucleon resonance. The new precision data allowed properties of this resonance to be determined [30].

The double-polarization observable E and the helicity-dependent cross sections $\sigma_{1/2}$ and $\sigma_{3/2}$ have been measured for the first time for π^0 photoproduction from protons and neutrons bound in the deuteron. The experiment used a polarized photon beam of the MAMI accelerator and a longitudinally polarized deuterated butanol target. The reaction products (recoil nucleons and decay photons from the π^0 meson decay) were detected with the Crystal Ball and TAPS electromagnetic calorimeters. A comparison to the data measured with a free proton target showed that the absolute scale of the cross sections was significantly modified by nuclear final-state interaction (FSI) effects. However, there is no significant effect on the asymmetry of E [31].

APPLIED RESEARCH AND ACCELERATORS PHYSICS

The DLNP has created a high-precision new-generation instrument — the **Precision Laser Inclinometer** (PLI) [32], which allowed monitoring angular oscillations of the Earth surface in two orthogonal directions in the frequency band of 10^{-6}–4 Hz with a maximal sensitivity of $2.4 \cdot 10^{-11}$ rad/Hz$^{1/2}$. This new instrument steadily registers Earth surface inclinations caused by the Moon, Sun, far located (above 104 km) earthquakes, microseismic peaks and sources of industrial origin. The use of the inclinometer for stabilizing the spatial location of the LHC beams in the first-priority CERN programme "High-Luminosity LHC" is under consideration.

In 2017, the first two units of a fundamentally new instrument, the Professional Precision Laser Inclinometer (PPLI), were created. Completely assembled and tested at JINR, they were sent to CERN (Switzerland) and the Garni Seismic Observatory (Armenia) for the adjustment and overall testing. Technical documentation about the commissioning of the first PPLI in the TT1 was included in the official CERN database as authorship of DLNP scientists [33]. The creation of the new instrument was noted at the CERN–Russia Meeting in October 2017.

Within the **SC202** project, two cyclotrons are planned to be manufactured in China according to the Collaboration Agreement between JINR and ASIPP. The first cyclotron will be used for proton therapy in Hefei, and the second one will replace the Phasotron in the research and treatment programme on proton therapy in Dubna. At present, the engineering design of the SC202 project is completed, each subsystem of the Hefei cyclotron is under production or experimental verification. The project of the SC202 cyclotron (Dubna) is not finished. Its extraction system will substantially differ from the one used in the cyclotron for the Hefei medical centre. Particles will be extracted from the SC202 (Dubna) cyclotron with one ESD electrostatic deflector and two magnetic channels. The SC202 cyclotron (Dubna) extraction system will have compensation channels to avoid the first harmonic of the magnetic field which can induce resonances $2Q_z = 1$ and $Q_r - Q_z = 1$. The proposed extraction system allows efficient extraction of the beam from an isochronous superconducting cyclotron with a minimal increase in the transverse beam envelopes. Beam losses will depend mainly on the thickness of the septum electrode of the deflector and will be below 15% for the 0.1 mm septum. This extraction system is also suitable for a cyclotron with an energy of 230–250 MeV, standard for proton therapy.

The main goals of the research at the **Medico-Technical Complex (MTC)** are to carry out medico-biological and clinical investigations into tumour treatment, upgrade equipment and instrumentation, and 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 2017.

Regular sessions aimed to investigate proton therapy efficiency to treat different kinds of neoplasm were performed in collaboration with the Russian Medical Academy for Postgraduated Education (Moscow) and the Radiological Department of the Dubna hospital. During the year, seven treatment sessions for a total duration of 28 weeks were carried out. Forty-six new patients were fractionally treated with the medical proton beam. The total number of the single proton irradiations (fields) was about 4000. Another 27 patients were irradiated with the Co-60 gamma-therapy unit "Rokus-M" (1600 fields) [34, 35].

Together with the staff of the Department of Radiation Dosimetry of the Institute of Nuclear Physics (Prague, Czech Republic), dosimetry calibration of the ^{60}Co gamma source was carried out in a water phantom on the basis of the IAEA recommendation, and dose distributions outside the target volume in the JINR Phasotron proton therapy treatment room were measured using thermoluminescent detectors and radiochromic films. Together with the staff of the JINR LRB, measurements of background neutrons in the treatment room were performed. These studies are important for estimation of the risk to healthy tissues during the proton treatment.

Together with the staff of the University of Bucharest (Magurele, Romania), the Department of Radiation Dosimetry of the Institute of Nuclear Physics (Prague, Czech Republic) and the Proton Therapy Centre (PTC) in Prague, the influence of dental implants on spatial dose distributions in anthropomorphic phantom was measured using the JINR and PTC proton beams. A similar experiment was carried out at the Proton Therapy Centre in Chicago (USA). Together with the staff of the Institute of Biomedical Problems and JINR LRB, the influence of protons with different LET on biological objects was studied.

Within the **Radiogene** project, the results of the comparative analysis of the genetic and cytogenetic nature of γ-ray- and neutron-induced mutations in five different genes located in the haploid Drosophila sperms were summed up. All mutations of each gene can be classified as point mutations (with mutation lesions inside the gene) and genomic mutations (with additional damages outside the gene). The rate of the point mutations is almost equal for the genes studied and for both γ-rays and neutrons varying within the limits of $0.9{-}1.3 \cdot 10^{-6}$ /gene/Gy. At the same time, the rate of the genomic mutations is substantially higher than that for the point mutations varying for different genes in the range of $1.5{-}4.0$ and $4.5{-}7.1 \cdot 10^{-6}$ /gene/Gy for γ rays and neutrons, respectively [36, 37].

In 2017, within the **R&D of new semiconductor detectors**, a workshop for manufacturing microcell chambers of the small muon wheel for the ATLAS muon detector was fully equipped and put into operation. The workshop includes five areas, among them a cleanroom (72 m^2, ISO class 7) for manufacturing readout panels and testing their geometric characteristics, a hall (~ 150 m^2) housing the test bench for cosmic-ray tests of chambers, a room (~ 25 m^2) for gas leak tests of panels, a cleanroom (~ 50 m^2, ISO class 6) for assembling and testing quadruplets, and an area (~ 25 m^2) for washing panels.

In the assembly area, the following test benches and systems are mounted, tested, and put into operation: a test bench for semiautomatic measurement of geometric characteristics, a test bench for gas leak testing of panels, an assembly stand for assembling quadruplets, a test bed for cosmic-muon testing of quadruplets, a semiautomatic gluing system, a system of two support tables with removable supports for fast and precise deployment of the gluing system.

According to the ATLAS schedule approved in 2015, ten Timepix-based pixel detectors with a GaAs:Cr sensor were manufactured and thoroughly tested. In 2016–2017, these detectors were mounted in various places of the ATLAS facility. A GaAsPix system was developed and put into operation for taking, storing, and processing ATLAS data. During the 2017 ATLAS runs, readings of all detectors were continuously recorded. Now a software for identification of detected events by types of radiation (gammas, electrons, relativistic charged particles, neutrons) is under development.

The main objective of the electronic cooling sector of the JINR DLNP for 2017 was development of the **positron annihilation spectroscopy (PAS)** method for measuring the Doppler line broadening of the radiation spectrum arising from annihilation of positrons on electrons of the material atoms (Doppler PAS). The method allows investigating distribution of defects in various materials. Eleven spectroscopy sessions were conducted with monochromatic positron beam. Evolution of defects in copper, stainless steel and bronze subjected to sandblasting of different strength and also concentration of defects in copper, silver, and titanium irradiated with Xe^{26+} ions were investigated. Designing of an RF resonator and the positron acceleration part of ordered positron flow formation system for the PAS complex channel equipment was started to build a PAS spectrometer for measuring positron lifetime in matter (Positron Annihilation Lifetime Spectroscopy, PALS).

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FLEROV LABORATORY OF NUCLEAR REACTIONS

In 2017, a wide variety of scientific and applied investigations in heavy-ion physics was conducted at the Flerov Laboratory of Nuclear Reactions using the existing U400, U400M, and IC100 cyclotrons. The total operation time of the cyclotrons in 2017 was 15 700 h. The U400 cyclotron was mainly used to implement a research programme focused on the ^{48}Ca (DGFRS and SHELS setups) and ^{50}Ti beams (SHELS setup). Most of the U400M cyclotron operation time was spent on the implementation of the research programme focused on the ^{15}N (ACCULINNA-1,2 setups), ^{22}Ne (COMBAS setup), and ^{48}Ca beams (MASHA setup). The upgraded IC100 cyclic implanter was used for the implementation of the applied research programme. The MT25 microtron was employed in applied research for 670 h. The investigations were carried out in collaboration with the JINR laboratories, MSU, the Republic of South Africa, Poland, Serbia, Belarus, Kazakhstan, and the Czech Republic.

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

Construction of the Accelerator Complex "Factory of Superheavy Elements" Based on the DC280 Cyclotron [1]. In 2016, the cyclotron main magnet was assembled in the DC280 hall, and the magnet structure was adjusted for optimal performance. In January–February 2017, a switching magnet of the accelerated beam transport system was installed. Furthermore, the assembly of the beam transport channels began. A base platform of the injection system and a high-voltage platform were installed during the April–May period. From May through June, the main magnet was connected to the power supply. The water cooling system was also launched. In June–September, magnetic field measurements were performed, magnetic structure shimming was carried out, and the contribution to the magnetic field of the radial trimming coils was measured. The distribution of the average magnetic field along the radius measured at several levels was in fairly good agreement with the calculated data. The ion optics elements were installed in the injection channel in July–September. High-frequency generators were assembled, and the DC280 feeder lines were mounted in July–October. Azimuthal trimming coils were set in magnet sectors from September to October. The internal probe guides were also installed at that time. The DC280 vacuum chamber was installed in November. A vacuum pumping test to $3 \cdot 10^{-3}$ Torr was conducted. The bench tests of the DECRIS-PM ECR source that began at the end of 2016 were completed in October. The ECR-source parameters correspond precisely to the designed ones [2]. The adjustments to axial injection elements were made. Vacuum equipment was installed. In December the ECR ion source was mounted onto a high-voltage platform of the DC280 cyclotron. Furthermore, the acceleration system — the resonators and the dees — was installed and adjusted. Most of the DC280 cyclotron installation work is complete. The adjustments and testing of the systems, commissioning and the start-up of DC280 are planned for the first half of 2018.

Development of Currently Operating FLNR Accelerator Complex. As part of the project for the reconstruction of the U400R cyclotron, the design data were prepared for the construction of a new experimental hall. A call for tenders for the purchase of the necessary equipment was issued.

Within the U400M cyclotron modernization programme, which involves an increase in the energy of light ions up to 50–70 MeV/nucleon, the following was done [3]:

• influence of a new winding on the magnetic field of the cyclotron was evaluated;

• a possibility of increasing the energy of light ions used in the existing systems of the U400M cyclotron (the axial injection system, magnetic structure and output) was analyzed;

• magnet shimming calculations were performed for the purpose of increasing the beam output radius;

• axial injection system parameters were evaluated at an ion extraction voltage increased up to 40 keV in the ECR ion source;

• spiral inflector and central region parameters were evaluated; capture efficiency in acceleration at an increased injection energy was measured;

• beam extraction system parameters were determined.

Construction of Experimental Setups of the Factory of Superheavy Elements. A new gas-filled recoil separator (DGFRS-II) was manufactured and delivered to Dubna. The separator assembly is planned for the beginning of 2018.

A contract with SigmaPhi for the manufacture of a pre-separator for the studies of the chemical properties of SHE was signed in 2017. Under the contract, the pre-separator assembly and installation are planned for 2019.

ACCULINNA-2 Fragment Separator. The fragment separator ACCULINNA-2 was commissioned. Owing to the production of first radioactive beams in March 2017, the implementation of the scientific programme became possible. The basic ion-optical characteristics of some radioactive beams (^{14}B, ^{12}Be, ^{9,11}Li, ^{6,8}He and others) were experimentally verified. The obtained yields of the isotopes on average exceeded those produced in ACCULINNA-1 — a separator functioning at FLNR since 1996 — by a factor of 25.

Construction of a Separator Based on Resonance Laser Ionization (GaLS Setup). The laser equipment for the first laser subsystem (CW TiSa and dye lasers, beam diagnostics, doubling optics, etc.) was delivered to FLNR and installed in the laser lab. Test experiments on selective resonance laser ionization with the use of reference cells whose preparation is underway will be performed in 2018.

Front-end subsystems (an extraction system, an Einzel lens, correction dipoles, etc.) were fabricated and delivered to the laboratory. A separator magnet was manufactured. The yoke and coils of the separator were jointly assembled, and the elements were tested at the manufacturer's construction site. The joint assembly of the separator vacuum chamber is scheduled for 2018. A gas cell for first-day experiments was manufactured. An improved tape station was designed, and its prototype was fabricated at iThemba LABS. The testing of the new tape station is planned for 2018.

Simulations of the ion extraction system were carried out using the SIMION 8.0 software. They showed that the system developed at FLNR had better parameters in terms of beam losses and ion energy divergence than those of a similar LISOL setup constructed in Leuven, Belgium [4]. The basic spectroscopic data for osmium atoms were studied, and an appropriate multi-step transition to laser ionization was found [4].

MASHA Mass Spectrometer. A new WAGO-I/O-SYSTEM based control system for the MASHA facility was developed and implemented. The system was successfully tested in two experiments carried out this year.

An experiment was conducted to test a new design of the hot catcher. In the hot catcher, graphite nanotube thin films and graphene foil were used for synthesizing nuclei in experiments with high-intensity primary beams. Short-lived mercury and radon isotopes were produced in the Ar + ^{144}Sm and ^{40}Ar + ^{166}Er fusion reactions. These materials at the ^{40}Ar beam intensity up to 0.5 pμA proved to be promising.

Efforts were continued to fabricate and test new versions of the ECR source and the hot catcher created to the new design. The new design incorporates the features that enable the entire complex to withstand temperatures up to 300°C. The inner surfaces of vacuum pipelines and the chamber will be coated with chemically nonreactive glass enamel.

The current situation on the development of the MASHA separator is described in [5].

SYNTHESIS AND PROPERTIES OF NUCLEI AT STABILITY LIMITS

Synthesis of New Elements. The experiments for the synthesis of neutron-deficient isotopes of flerovium (element 114) and the study of their radioactive properties and the products of their α decay in the complete fusion reactions ^{240}Pu + ^{48}Ca at the ^{48}Ca energy of 250 MeV commenced at FLNR at the end of 2016 and continued into 2017. A total beam dose of ^{48}Ca ions was $1.4 \cdot 10^{19}$. The experiments were conducted using the Dubna gas-filled recoil separator (DGFRS) in collaboration with the research centres at Oak Ridge (ORNL), Knoxville (UT), Warsaw (UW), Nashville (VU), Olomouc (PU), Livermore (LLNL), and Lanzhou (IMP).

Three decay chains of the ^{285}Fl isotope and its five daughter nuclei ranging from ^{281}Cn to ^{265}Rf were detected (Fig. 1). The radioactive properties of most nuclei in the chains were in good agreement with the data obtained in a single chain detected with the BGS separator (Berkeley, USA) in the ^{242}Pu (^{48}Ca, $5n$)^{285}Fl reaction and in three chains produced earlier with DGFRS

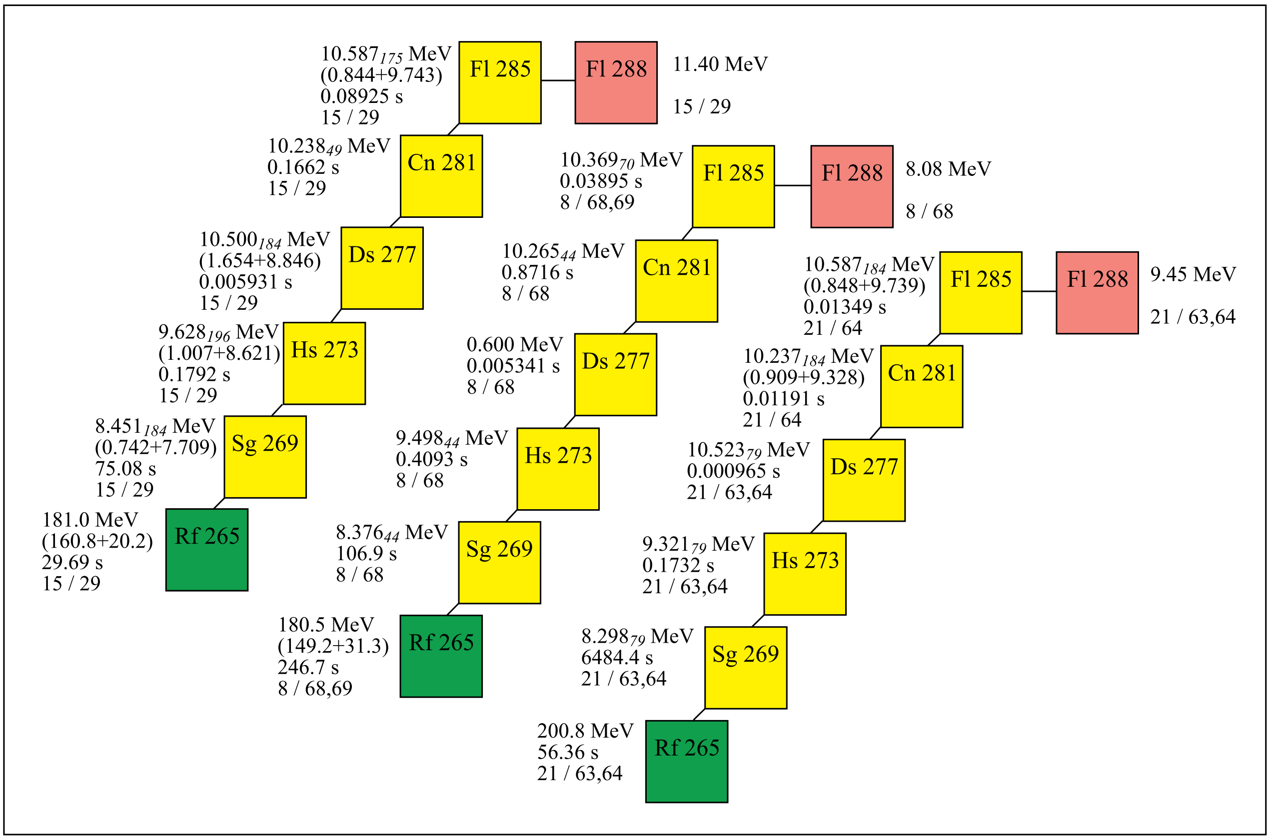

Fig. 1. The decay chains of the ^{285}Fl mother nucleus detected in the ^{240}Pu + ^{48}Ca reaction in 2016–2017

in the ^{240}Pu (^{48}Ca, $3n$)^{285}Fl reaction. However, the decay time of ^{269}Sg in the last chain shown in Fig. 1 exceeded the average lifetime of the isotope measured in other chains by a factor of 33. In addition, the decay times of the daughter nuclei ^{285}Fl, ^{281}Cn, ^{277}Ds, and ^{273}Hs proved to be shorter, while the energies of α particles of ^{273}Hs and ^{269}Sg were lower than the values measured in other cases. The decays observed through various excited levels accounted for such a difference in the nuclei properties. The cross section of the ^{240}Pu(^{48}Ca, $3n$)^{285}Fl reaction at 250 MeV was $0.58^{+0.60}_{-0.33}$ pb, which was 3–4 times lower than that measured at 245 MeV but nevertheless corresponded to the expected value of the cross section of the $3n$ channel reaction. Furthermore, 25 decays of spontaneously fissioning nuclei were registered. Some of these may be accounted for by ^{284}Fl and the ^{240,242mf}Am isomers.

Chemistry of Transactinides. Key results in 2017 were obtained in experiments aimed at studying the formation conditions of volatile chemical compounds of Nh in inert gases. Their production was also studied via examining the results of previous experiments at U400 aimed to explore the influence of relativistic effects on the chemical properties of the Nh [6], Cn, and Fl [7] superheavy elements.

The experimental data obtained with the cryodetector was evaluated. The preliminary separation of Nh isotopes from a beam of accelerated ^{48}Ca ions and incomplete fusion reaction products with ^{243}Am target atoms was carried out at DGFRS [6]. A lower limit of the interaction of elemental Nh with the Teflon surface — $\Delta H^{\mathrm{Teflon}}_{\mathrm{ads}}(\mathrm{Nh}) > 45$ kJ/mol — was consequently set (Fig. 2). It follows from the above that the transport of Nh isotopes through the Teflon capillary is impossible at room temperature. Neither was it possible in previous thermochromatographic experiments.

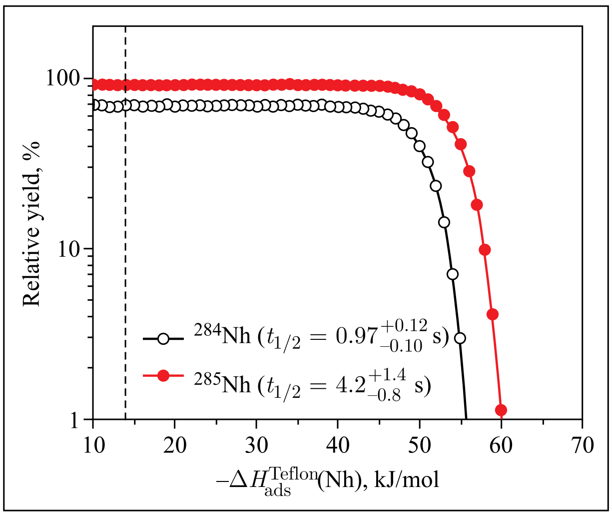

Fig. 2. Monte Carlo simulations of the expected relative yields of Nh isotopes during adsorption on the surface of Teflon (as an adsorption enthalpy function)

Moreover, the volatility of Nh was observed in the form of chemical compounds NhO_xH_y rather than in the atomic state.

Experiments aimed at studying the formation and volatility of chemical compounds like NhO_xH_y were conducted at the SHELS separator. For this purpose, a new setup comprising a recoil transfer chamber, a gas transport system and an isothermal chromatography column was fabricated and installed in the focal plane of the separator. A key feature of the recoil transfer chamber coupled to SHELS is that it can be heated up to 800°C. The kinetics of the formation and the yield of chemical reaction products was studied at the level of single atoms as a function of temperature, water, vapour content, and a composition of a mixture of inert gases. An experiment for the production and isolation of radioactive isotopes of Tl — a light homologue of Nh — in the ^{46}Ti (^{141}Pr, xn)$^{187-x}$Tl reactions was carried out successfully. The experiments will continue in 2018.

A first series of joint experiments was carried out through a collaborative effort between scientists from JINR FLNR and PSI (Switzerland) at the COLD facility in 2016. The experiments were aimed at studying the adsorption of Cn and Fl on selenium and gold surfaces using a chemical withdrawal of the U400 accelerator [7]. The analysis of the experimental data showed that PIN diodes coated with red amorphous and trigonal selenium can be used as a stationary phase in further thermochromatographic experiments with Cn and Fl. In 2018, the fusion reaction of ^{48}Ca with ^{242}Pu will be used to synthesize Cn and Fl isotopes. This will allow concurrent investigations of their adsorption.

Spectroscopy of Heavy and Superheavy Nuclei. The spontaneous fission properties of the ^{254}Rf isotope formed in the ^{50}Ti + ^{206}Pb reaction were studied. The neutron detector with 54 ^{3}He counters allowed measurements of neutron multiplicity for spontaneous fission of three activities: an activity with a half-life of about 20 μs (a ground state) and two activities (presumably the isomeric states of ^{254}Rf) with half-lives of about 5 and 200 μs.

The decay properties of the ^{255}Rf isotope synthesized in the ^{50}Ti + ^{207}Pb reaction were studied using the GABRIELA detector system. A new isomer with a half-life of about 50 μs was found to decay by emitting high-energy gamma rays.

The spontaneous fission of the ^{255}Rf isotope was registered. The half-life was 1.69(4) s for ^{255}Rf and 7.3(4) ms for ^{256}Rf (corresponding to $1n$ evaporation channel). On the whole, about 1600 ^{255}Rf and 430 ^{256}Rf spontaneous fission events were registered. The number of observed alpha decays and fission events allowed the measurement of the partial spontaneous fission probability that reached 44%. Figure 3 depicts the recoil–alpha–alpha type correlations formed in the ^{50}Ti + ^{207}Pb experiment. In addition, seven recoil (^{255}Rf)–alpha–fission type correlations were observed, which corresponded to the partial spontaneous fission probability of about 0.7%.

Figure 3 shows an example of registered low-energy signal in the focal detector generated by the decaying isomeric state in ^{255}Rf followed by the ^{255}Rf alpha decay. The half-life of the isomeric state in ^{255}Rf was 59(6) μs. The detection of high-energy γ quanta indicates that the ^{255}Rf and ^{257}Rf isomer excitation energies each are rather high.

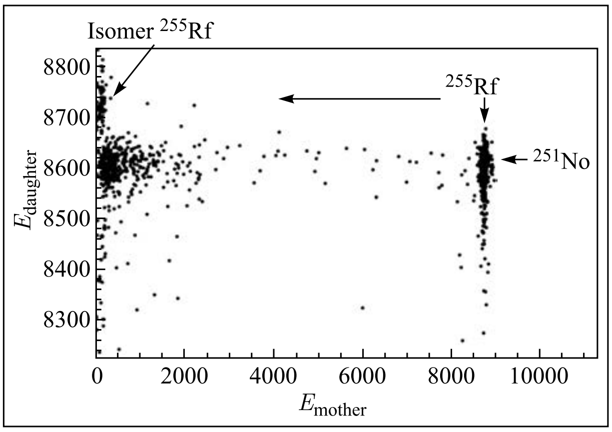

Fig. 3. Recoil–alpha–alpha correlations

The information on the current status of SHELS and some experiment results are presented in [8, 9].

Dynamics of Heavy-Ion Interaction, Fission of Heavy and Superheavy Nuclei. The investigation of the role of shell and orientation effects in the formation of neutron-rich nuclei in multinucleon transfer reactions continued into 2017. The analysis of mass, energy, and angular distributions of binary fragments formed in the ^{156,160}Gd + ^{186}W reactions at energies close to the Coulomb barrier was completed. An enhanced yield of fragments with masses 200–215 amu was observed in both reactions. To study the influence of mutual orientation in collisions of well-deformed nuclei on the production cross sections of neutron-rich fragments in deep inelastic reactions during inverse quasifission, the mass, energy and angular distributions of binary fragments formed in the ^{160}Gd + ^{186}W reaction were measured. The experiments were conducted at the energy above the Coulomb barrier at the U400 accelerator of FLNR by employing the CORSET setup. The formation cross section of lead-like fragments with a mass of $\sim$208 amu at an energy of 935 MeV (when all the orientations of interacting nuclei are feasible) was found to be higher by a factor of 50 compared to that at the energy close to the Coulomb barrier, whereas the reaction cross section was only 2.6 times higher. Thus, orientation effects caused by the strong deformation of colliding nuclei play an important role in the formation of reaction fragments and can give a gain in the yield of fragments with mass $\sim$208 amu. [10].

Shell effects in the modal fission of actinide nuclei were studied in 2017. In the studies, mass-energy distributions of fission fragments of the compound nuclei ^{248}Cf* and ^{254,256}Fm* produced in the ^{16}O, ^{22}Ne + ^{232}Th, ^{16,18}O + ^{238}U reactions at an excitation energy of 40–45 MeV were measured [11]. Special attention was given to the superasymmetric fission mode caused by the magic shells $Z = 20$, 28, 82 and $N = 28$, 50, 126. The experiments were conducted using a beam from the FLNR U400 cyclotron. The energies of ^{16}O ions were 84, 89, 96, and 101 MeV, while those of ^{18}O and ^{22}Ne were 85 and 108 MeV, respectively. The double-arm time-of-flight CORSET spectrometer was used in the experiments. Enhanced fragment yields in the mass region ~ 70 amu were observed in all the reactions under consideration, which is due to the influence of proton and neutron shells with $Z = 28$ and $N = 50$.

In June 2017, a joint experiment aimed at studying binary and ternary decays in reactions at energies close to the Coulomb barrier was conducted through a collaborative effort between JINR (Dubna) and the University of Jyväskylä (Finland) at the K130 cyclotron. The velocities, energies and angles of fragments formed in the reactions ^{37}Cl, ^{40}Ar + ^{205}Tl, ^{208}Pb at the energies of incident ^{37}Cl and ^{40}Ar ions of 195 and 230 MeV, respectively, were measured with the four arms of the CORSET-TOF spectrometer coupled to six E-ΔE telescopes. The obtained experimental data are being analyzed.

The measurements of correlation mass distributions for the spontaneous fission of ^{252}Cf carried out with the FOBOS spectrometer allowed the detection of peculiar structures in the region of the large missing mass. One of the most prominent structures is attributed to the formation of magic Ni isotopes [12] and is distinguished by low values of the total kinetic energy (about 90 MeV). Such events can be explained by the scenario of sequential ternary scission.

Experiments aimed at measuring absolute cross sections and excitation functions in the ^{40}Ar + ^{144}Sm, ^{36}Ar + ^{148}Sm, ^{40}Ca + ^{144}Nd, ^{48}Ca + ^{142}Nd, and ^{40}Ar + ^{166}Er fusion reactions were conducted at the MASHA separator. A moving absorber technique was employed in the experiments. The absorber is made of ultra thin aluminum foil where the reaction products were stopped. The silicon detectors registered the alpha decay of synthesized nuclei. The energy resolution of alpha radioactive isotopes was ~ 100 keV. The absorber velocity between the two extreme positions was 0.3 s. The beam interruption technique allowed measurements of the half-lives of synthesized nuclei. Thus, the reaction products were identified unambiguously. The experimental data are under analysis.

Structure of Exotic Nuclei. A new method was developed for determining a spectrum of ^{17}Ne excited states undergoing $2p$ decay [13]. The method was used for the analysis of the $3/2^-$ state of the ^{17}Ne nucleus formed in the ^{1}H (^{18}Ne, d) ^{17}Ne reaction. Thus, a new width ratio limit $\Gamma_{2p}/\Gamma_\gamma$ was set to $< 1.6\cdot 10^{-4}$, which is lower in magnitude by a factor of 50 compared to that defined in the work by M. J. Chromik et al. (Phys. Rev. C. 2002. V. 66. P. 024313). The new results are of great interest for making calculations that describe the origin of the elements in the Universe. They are key to determining a possibility of the radiation capture of a proton pair by the ^{15}O nucleus, which is a so-called "waiting point" in the astrophysical rp-nucleosynthesis. A simplified model of di-proton decay used previously for the estimation of the width ratio of $2p$ and gamma decays can be neglected.

The collaboration of scientists from the University of Strasbourg (France), the Institute of Nuclear Physics (Orsay, France), the University of Manchester (England), and CERN performed experiments in which they determined neutron decay probabilities (β_{1n}) of a number of nuclei in the neutron shell region $N = 50$ (^{82,83,84}Ga, $N = 51, 52, 53$) with high precision [14]. The experiments were conducted with a unique neutron detector based on ^{3}He-filled counters designed and developed at FLNR. The pioneering discovery of so-called Pygmy Gamow–Teller resonances in the ^{82,83,84}Ga nuclei provided positive evidence for β-delayed neutron emission occurring in the nuclei. Pygmy resonances were shown to be located in the region of excitation energies below the giant Gamow–Teller resonance.

The theoretical analysis confirmed that Pygmy resonances are collective charge-exchange excitations that can be sufficiently described within both the self-consistent microscopic approach and the quasi-classic approximation. The obtained results are of great importance for describing the structure of nuclei at neutron stability boundaries and are essential for astrophysics in describing nucleosynthesis in the Universe.

Reactions with Beams of Light Stable and Radioactive Nuclei. The production cross sections of the ^{46}Sc and ^{65}Zn isotopes in the ^{6}He + ^{45}Sc and ^{6}He + ^{64}Zn reactions were measured at the ACCULINNA separator. The analysis of the data obtained with the time-dependent Schrödinger equation showed that calculated and experimentally estimated values were in good agreement. The conclusion to be drawn from these measurements is that external neutrons of ^{6}He affect the reaction probability.

The excitation function of the reaction between ^{9}Li and Si nuclei in a wide energy range (5–40A MeV) was measured using the transmission method based on the recordings of energy losses in the material (dE) of the Si target detector. In this case, n- and γ-radiation was detected by a 4π-scintillation spectrometer. A local increase in the total cross section was observed in the ^{9}Li + Si reaction within the energy range 10–30A MeV. A similar increase was observed in the ^{6}He + Si reaction in the energy range of 10 to 20A MeV. A theoretical analysis on the basis of a numerical solution of the time-dependent Schrödinger equation for external neu-

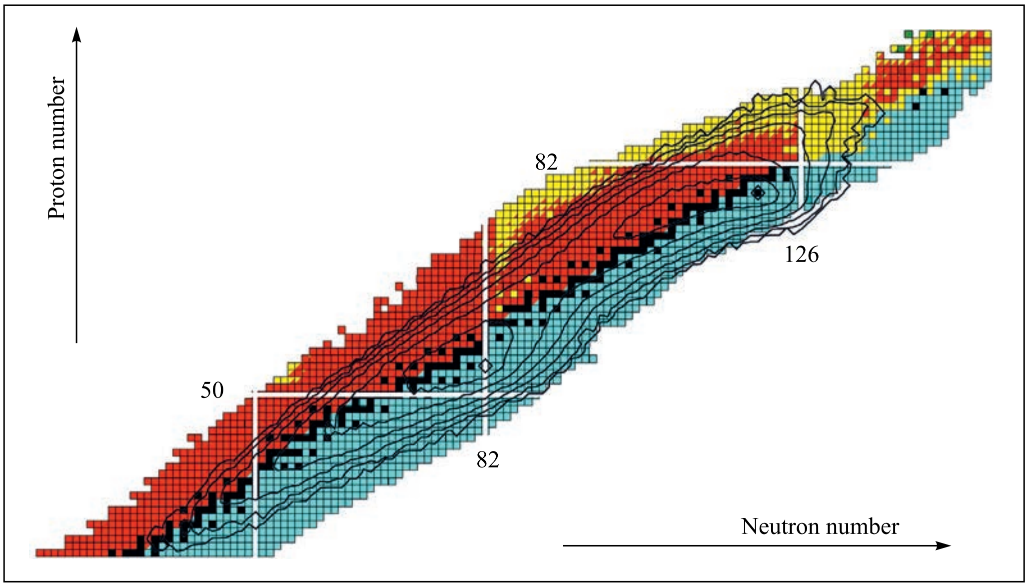

Fig. 4. The upper part of the nuclear chart of the known nuclides. The contour lines show the yields of products for the $^{136}Xe + ^{198}Pt$ reaction at $E_{\rm cm} = 643$ MeV. The contour lines are drawn over each order of magnitude of the cross section down to 100 nb

trons of projectile nuclei was conducted. The analysis showed that during collision the redistribution of external weakly bound neutrons of the ^6He and ^9Li nuclei changes the real and imaginary parts of the interaction potential, which may cause a local increase in the total cross section of the reaction. This increase is most noticeable in the energy range at which the relative velocity of nuclei is close in magnitude to the average velocity of external neutrons in weakly bound nuclei under investigation.

The results of the performed studies were published in [15, 16].

Theoretical and Computational Physics. A dynamical model of nucleus–nucleus heavy-ion collisions was developed. The model allows the description of all the main regularities observed in multinucleon transfer reactions at low energies [17]. A possibility of synthesizing new neutron-rich isotopes of heavy elements in deep inelastic transfer reactions was investigated. The analysis of near-barrier collisions of heavy spherical nuclei showed that this type of reactions is promising for synthesizing new nuclei. In particular, the predicted cross sections for the production of new neutron-rich isotopes ^{201}Re and ^{200}W (having $N = 126$) in the $Xe + ^{198}Pt/^{208}Pb$ reactions exceed 100 nb (Fig. 4).

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

The morphology and overlapping processes in bismuth and xenon induced latent tracks in Al_2O_3 single crystalline were studied using numerical modelling methods and high-resolution transmission electron microscopy. Ion track overlapping was found to result both in damage recovery and in the formation of a damaged region, depending on the distance between the tracks. The flux density, fluence, and mass-energy distributions of uranium and plutonium fission fragments on the interior surface of nuclear fuel cladding were quantitatively estimated. The fraction of swift fission fragments was estimated to be $\sim 25\%$ of the total number of fission products crossing the nuclear fuel cladding surface. The total flux density reached 10^{16}–10^{17} cm^{-2} during one year of the reactor operation.

The osmotic effects occurring during etching of heavy-ion tracks in polyester films are currently under investigation. A model for the convective diffusion transport of electrolytes in channels 30 to 50 nm in diameter was proposed [19]. Porous composite membranes with hydrophilic and hydrophobic sides were synthesized by vacuum magnetron sputtering of polytetrafluoroethylene (PTFE) thin films. Their surface, structure and morphology properties were studied [20]. A technique for the immobilization of silver nanoparticles on a track membrane surface [21] was developed and optimized. Nanoparticles were produced using the electric spark method with a view to developing flow-type SERS-active sensors.

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FRANK LABORATORY OF NEUTRON PHYSICS

In 2017, the Frank Laboratory of Neutron Physics' scientific programme was aimed at obtaining new results under five research themes of the JINR Plan for Scientific Research and International Scientific and Technical Cooperation: in condensed matter physics ("Investigations of Condensed Matter by Modern Neutron Scattering Methods", 04-4-1121-2015/2017, headed by D. P. Kozlenko, V. L. Aksenov and A. M. Balagurov; "Multimodal Platform for Raman and Nonlinear Optical Microscopy and Microspectroscopy for Condensed Matter Studies", 04-4-1111-2013/2017, headed by G. M. Arzumanyan); in neutron nuclear physics ("Investigations in the Field of Nuclear Physics with Neutrons", 03-4-1128-2017/2019, 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-2 Facility with a Complex of Cryogenic Neutron Moderators", 04-4-1105-2011/2019, headed by A. V. Belushkin and A. V. Vinogradov); in development of the IBR-2 spectrometers and computation complex ("Development of Experimental Facilities for Condensed Matter Investigations with Beams of the IBR-2 Facility", 04-4-1122-2015/2017, headed by S. A. Kulikov and V. I. Prikhodko).

CONDENSED MATTER PHYSICS

In 2017, within the framework of the User Programme 221 proposals for conducting experiments were received from 20 different countries. The received proposals covered a broad spectrum of neutron research in physics (32%), materials science (36%), chemistry, geosciences, biology and applied sciences (constituting the rest 32%). 203 received proposals were admitted for realization.

Structure Investigations of Novel Oxide, Intermetallic and Nanostructured Materials. Binary copper oxide CuO is one of the most structurally simple improper multiferroics in which spontaneous ferroelectric polarization arises as a result of symmetry inversion violation by the modulated antiferromagnetic (AFM) ordering formed in the intermediate phase in the temperature range T_{N1}–T_N of 213–230 K. Theoretical calculations predicted the existence of such a phase at room temperature at high pressures of 20–40 GPa and the extension of its temperature range up to 0 K. To verify this assumption, the atomic and magnetic structures of CuO were studied by neutron and X-ray diffraction (Fig. 1) [1]. It was revealed that the crystal lattice compressibility of the monoclinic CuO structure exibits an anomalous behavior; it is accompanied first by an increase in the lattice parameter a in the pressure range of up to 13 GPa, and then by its decrease (with a subsequent growth in pressure up to 40 GPa) down to the value approximately equal to the value at normal pressure. No anomalies in the behavior of other lattice parameters were observed. The Néel temperature in the pressure range of up to 11 GPa increases up to 250 K. The region of existence of the incommensurate AFM phase with ferroelectric polarization at high pressures was determined using temperature dependences of the monoclinic angle of the crystal lattice for which the anomalies at the points of magnetic transitions, T_N and T_{N1}, are observed (Fig. 1). The temperature range of its stability extends under pressure. The estimates based on the experimental data showed that in a pressure range of up to 40 GPa the Néel temperature increases up to about 265 K, which is much below room temperature. To explain the observed anomalies in the structural behavior of CuO under pressure, theoretical first-principles calculations were carried out and the pressure dependences for the structural parameters were successfully reproduced.

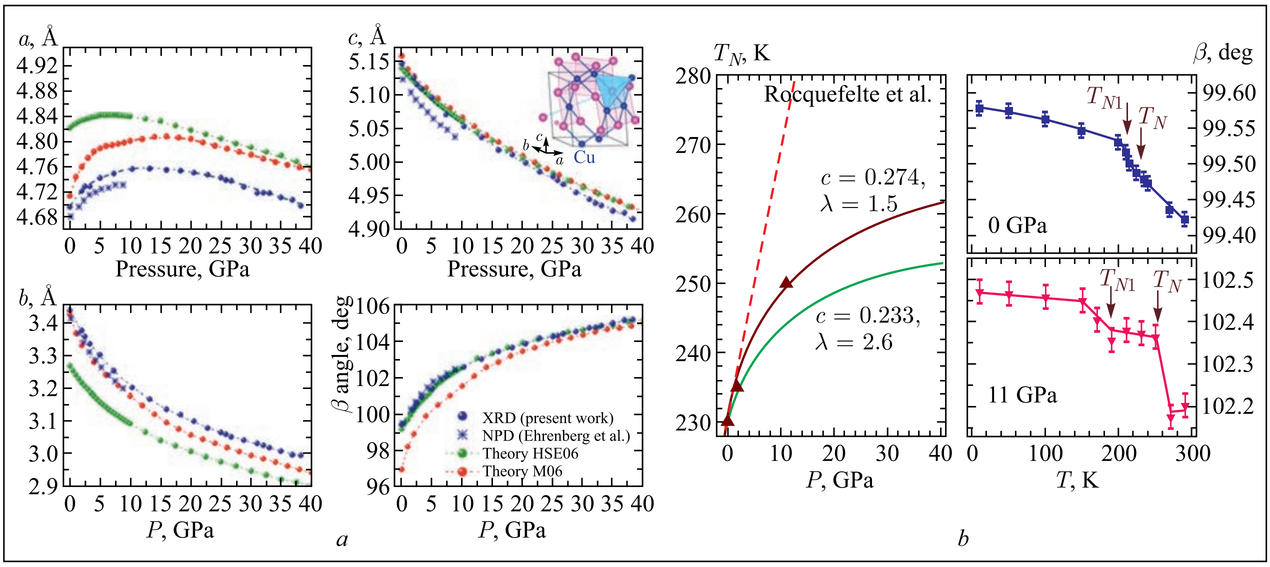

Fig. 1. *a*) Pressure dependences of unit cell parameters of CuO. Experimental points, results of theoretical DFT calculations using hybrid functionals HSE06, M06 and results of previous neutron studies are shown. *b*) Experimental and calculated pressure dependences of Néel temperature and temperature dependences of monoclinic angle of CuO crystal lattice at a pressure of 0 and 11 GPa

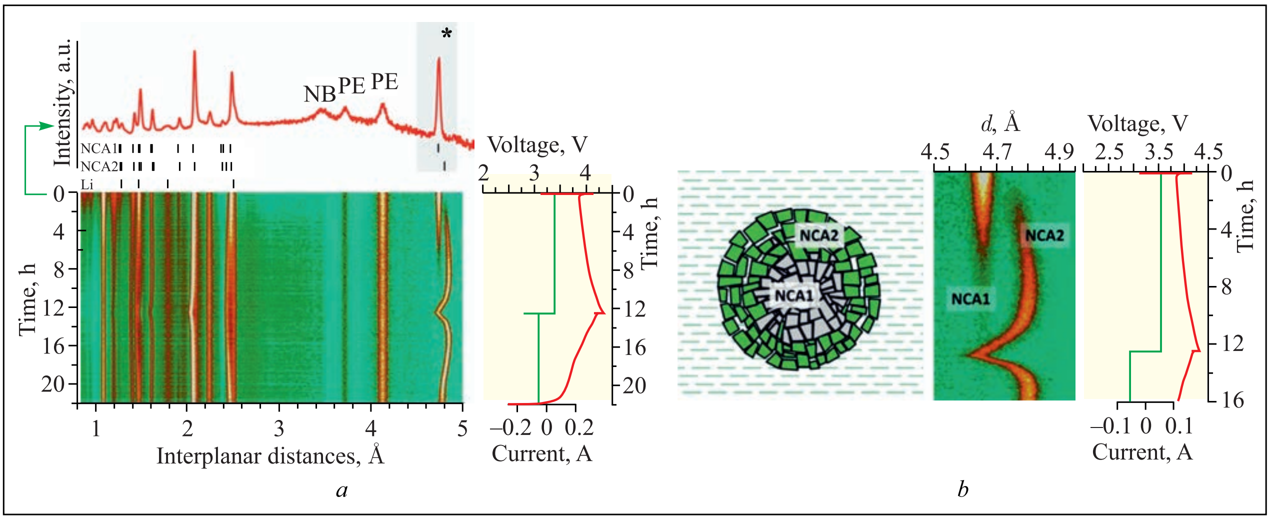

Fig. 2. *a*) Evolution of diffraction peaks from NCA electrode material during electrochemical cycling. Measurements were made with a specialized electrochemical cell. At the top, diffraction spectrum for the initial state of NCA is given. In addition to the peaks from anode and cathode, peaks from boron nitride (NB) and a separator (PE) can be seen. The asterisk denotes the area of peak (003) from NCA, which was used in the analysis of the phase separation, manifesting itself as a splitting at a certain level of charge. *b*) Evolution of peak 003 from NCA material during first charging. Model representation of the process shows a spherical conglomerate of primary NCA particles during electrochemical cycling. The gray area corresponds to the NCA1 phase which does not satisfactorily contact with electrolyte. The green-colored particles correspond to the NCA2 phase already in contact with electrolyte (at the left)

An anomalous structural phase separation observed in layered electrode materials of lithium-ion batteries at first charging and disappearing during their subsequent operation was investigated. The study was carried out for $Li_xNi_{0.8}Co_{0.15}Al_{0.05}O_2$ (NCA) prepared at different calendering levels (high-temperature rolling to reduce electrode bulk density). A specialized electrochemical cell with a new design was used in the neutron experiment. The in operando/in situ studies were performed at the HRFD diffractometer. The presented illustrations (Fig. 2) clearly show a splitting of the diffraction peak (003) because of the formation of a two-phase state in the cathode material. The analysis of the obtained results revealed that the phase-separation state in NCA in the first electrochemical cycle observed by diffraction is not caused by the properties of atomic and electronic

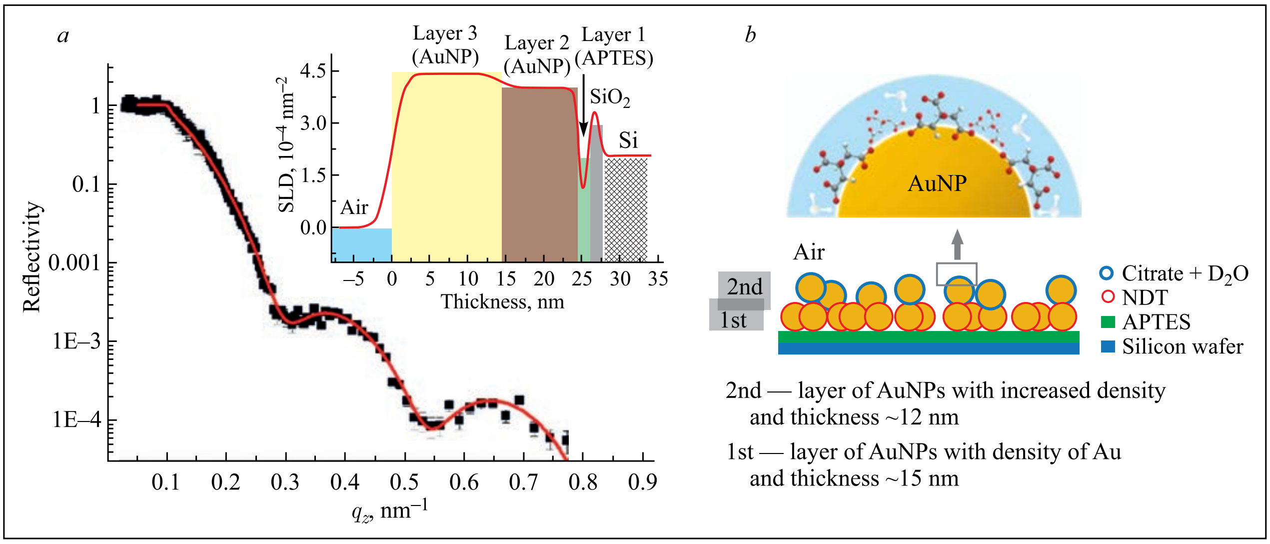

Fig. 3. Layers of functionalized gold nanoparticles on silicon substrate: neutron reflectometry data with the corresponding SLD profile (*a*) and a model suggested for structural organization of gold particles on the surface (*b*)

structures of NCA, but determined by the peculiarities of the microstructure of material in use. The results of these investigations were submitted for publication [2].

Investigation of Magnetic Fluids and Nanoparticles. The structural organization of layers of gold nanoparticles deposited from aqueous solutions on silicon substrate and functionalized with a molecular layer of 1.9-nonanedithiol (promising systems for nanoelectronic devices due to their specific optical properties) was studied. For a full description of the system, data of neutron reflectometry, atomic force microscopy, X-ray reflectometry and diffraction were used. On the basis of neutron reflectometry data (GRAINS reflectometer), the structure profile of gold nanoparticle layers was determined and used to estimate the layer thickness and particle packing density (Fig. 3). The presence of water molecules in the adsorbed layers of gold nanoparticles was established. The obtained results were used in the complex approach, which allowed one to reliably and unambiguously describe the surface packing of nanoparticles [3]. The study was performed in cooperation with the Chuiko Institute of Surface Chemistry of NASU, Institute of Physics of NASU, Faculty of Physics of Taras Shevchenko National University of Kyiv (Kiev, Ukraine).

Investigation of Carbon Nanomaterials. In the framework of research of biological activity of fullerenes, the effects of inhibition and depolymerization of amyloid fibrils (lysozyme, insulin) in aqueous solutions of C60 and C70 fullerenes (synthesized by various methods) were considered [4, 5]. The approach combining the analysis of small-angle neutron scattering (YuMO spectrometer), atomic force microscopy and Thioflavin T fluorescence was applied. Thus, out of the two types of solutions under study (solutions prepared by solvent replacement and dilute solutions based on N-methylpyrrolidone (NMP)), C60 and C70 solutions prepared using NMP exhibited a noticeable inhibitory and depolymerizing activity. In order to exclude the effect of a moderately toxic NMP solvent on amyloids, additional experiments were performed with a pure solvent containing the same fullerene amount as in the mixtures. The results of these experiments revealed no effect of the solvent on amyloids. Thus, the residual concentration of the primary NMP solvent in aqueous solutions of fullerenes is not the cause of the effects of depolymerization/inhibition of amyloid fibrilization. The analysis of the small-angle scattering data revealed several stages of amyloid depolymerization. The study was performed in cooperation with the Institute of Experimental Physics of the Slovak Academy of Sciences (Košice, Slovakia) and the Faculty of Physics of the Taras Shevchenko National University of Kyiv (Kiev, Ukraine).

Applied Research. At the spectrometer of neutron radiography and tomography, studies of objects of cultural heritage were continued. Thus, a Viking fibula was studied, for which a 3D model of the internal structure based on tomographic data was reconstructed (Fig. 4). The obtained results will allow one to analyze the features of ancient technologies for manufacturing similar objects in Scandinavia.

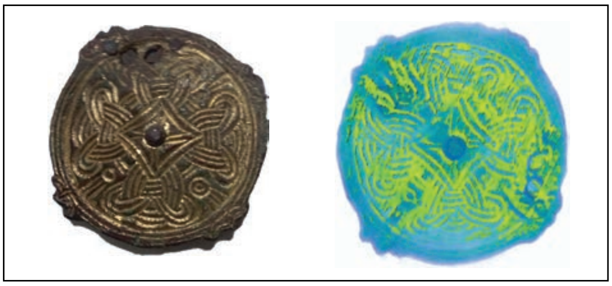

Fig. 4. Photo (*a*) and tomographic 3D model of Viking fibula (*b*)

MULTIMODAL PLATFORM FOR RAMAN AND NONLINEAR OPTICAL MICROSCOPY AND MICROSPECTROSCOPY FOR CONDENSED MATTER STUDIES

The studies in 2017 were focused on achieving the following major results:

• obtaining first preliminary results on surface-enhanced micro-CARS from gold nanoparticle-immobilized organic molecules;

• assessment of the concentration detection limit of phospholipid molecules by SERS;

• investigation of SERS-signal intensity dependence on the shape of silver nanostructures grown in the porous SiO_2 template;

• a complex study of structural and spectral properties, including upconversion luminescence, of oxyfluoride glasses and glass-ceramics doped with rare earth elements (REE);

• verification of tumor and stem cells by Raman microspectroscopy.

Surface-Enhanced Micro-CARS. Surface-enhanced Raman scattering (SERS) was investigated in 2017 for a new active substrate where gold nanoparticles were spread over a cerium dioxide (CeO_2) faceted dielectric film deposited on the aluminum layer. Molecules of thionitrobenzoic acid (TNB) were used as a reporter molecule since they are of interest for biochemical and immunological analysis.

Au nanoparticles with an average diameter of 56 nm and covered with a monolayer of reporter molecules were spread over a faceted CeO_2 film after a monolayer of polycation (PDDA) had been deposited on the surface. The fraction of the CeO_2 surface occupied by islands of Au nanoparticles is evaluated to be $\sim 5\%$. Epi-SECARS images at the Raman shifts of 1344 cm^{-1} (TNB) and 1571 cm^{-1} (MPBA) of CeO_2 film surface, with the dimensions of $\sim 25 \times 25$ μm, supported by optical and scanning electron microscope images, were obtained.

The excellent chemical imaging contrast obtained is an indication of high detectability of reporter molecules by SECARS in the metamaterial under study. Further research will be focused on the study of the imaging contrast dependence on the CeO_2 film thickness, estimation of SECARS signal sensitivity to the probed reporter molecules, and the comparison of their detectability by using SECARS and SERS at the surface of the metamaterial under investigation.

Detection Limit of DPPC Phospholipid by SERS. The detection limit is the smallest amount of analyte concentration in the sample that can be reliably distinguished from zero. Following this rule, the lowest concentration of analytes at which they are detectible was estimated when their least intensive Raman peak becomes unresolved at the background level.

Silver particles, predominantly with the size of 40–80 nm, were deposited onto porous silicon by immersion plating to form substrates appropriate for the detection of organic molecules by surface-enhanced Raman scattering technique. These substrates have demonstrated for the first time the possibility of detecting phospholipid molecules represented by dipalmitoylphosphatidylcholine (DPPC) at concentrations as low as 10^{-12} M.

The detection of phospholipids at their concentration in a solution of about 10^{-12} M has been experimentally demonstrated for the first time using DPPC as an example. It is believed that the detection limit demonstrated in this study for silvered porous silicon SERS substrates can be further improved by optimizing the technological process.

NEUTRON NUCLEAR PHYSICS

Development of the IREN Facility. In 2017, the second stage of the LUE-200 accelerator operated for experiments for 1049 h a repetition rate of 20–25 Hz.

Main Scientific Results. *Measurement of ROT Effect for Gamma-Rays in ^{235}U Fission on a Hot Source of Polarized Neutrons.* In the framework of the JINR FLNP–ITEP–PNPI–FRM-II collaboration, a series of experiments was continued to measure the ROT effect in the emission of prompt γ rays and neutrons in binary fission of ^{235}U and ^{233}U induced by polarized cold neutrons. The experiments were carried out at the POLI instrument at the FRM-2 reactor (Garching, Germany). T-odd effects in the fission of heavy nuclei have been known for more than ten years. The magnitude of the effect turned out to be surprisingly high, and the current explanation does not imply the existence of such a violation, but is based on the interaction of the reaction products in the final state. In other words, the effect is not related to the violation of the invariance with respect to time reversal, but is connected with the mechanism of the fission process. Nevertheless, in the literature the effect is still called TRI effect.

In addition, it was noted that when the direction of the neutron beam polarization is changed, the angular distribution of α particles is shifted by a small angle relative to the fragment emission axis, and the direction of the shift is determined by the direction of the neutron beam polarization. The authors called this effect the ROT effect. Both TRI and ROT effects are formally T-odd, but have no direct connection with the violation of time reversal invariance. An analogous effect was observed in the emission of instant gamma rays and neutrons in the fission of ^{235}U and ^{233}U, though its magnitude was an order of magnitude smaller than for the emission of α particles in triple fission.

At present, there are several theoretical models that can describe both effects. According to the model proposed in 2016, both effects depend on the quantum numbers J and K which characterize the fission channels. In fission induced by thermal (or cold) neutrons (for which all previous data were obtained), there is a mixture of several spin states whose contributions are unknown. The only way to obtain "clean" data is to perform measurements on isolated resonances. Such an experiment was carried out at the POLI facility at the FRM-II reactor in Garching, which provides a required polarized neutron beam of hot neutrons with an energy of 0.27 eV corresponding to the lowest resonance of ^{235}U.

A monochromator made of a mosaic of Cu crystals was used to select a narrow neutron beam with an average energy of 270 meV (λ = 0.55 Å). This energy exactly coincides with the position of the lowest resonance of ^{235}U. The monochromator also makes it possible to simultaneously focus the neutron beam at a given position, providing maximum intensity of unpolarized neutrons of about $4 \cdot 10^6$ $cm^{-2} \cdot s^{-1}$.

Neutrons were polarized using specially constructed ^{3}He cells. The same cell type was used as an analyzer for measuring beam polarization. Since polarized ^{3}He nuclei have a very high spin-dependent neutron absorption efficiency over a wide energy range, a ^{3}He cell can be used as a broadband neutron polarizer or analyzer with the possibility of optimizing its efficiency for almost all neutron wavelengths. In our experiment, the cell size of $\varnothing\, 60 \times 130$ mm and a pressure of 2.5 bar ensured maximum neutron polarization of about 70%. To change the polarization direction from vertical to horizontal, a specially developed spin control system consisting of several magnetic coils with a μ-metal screen was used, which also made it possible to rotate the spin in a given position by 180° every 1.3 s.

The uranium target containing about 82 mg of ^{235}U (99.99%) oxide deposited on both sides of a thick aluminum substrate with dimensions of 40×100 mm was positioned on the chamber axis. Thin low-pressure multiwire proportional counters (MWPC) placed on both sides of the target were used as detectors for fission fragments. Eight cylindrical plastic scintillators and four NaI-based scintillators were inserted into the rotating holder at a distance of about 30 cm from the target centre, which provided subsequent measurements of the coincidences of instant gamma rays and neutrons with fission fragments at angles of $\pm$22.5°, $\pm$45°, $\pm$67.5°, $\pm$112.5°, $\pm$135° and $\pm$157.5° relative to the average fragment detection axis. Each event matching coincidence of signals from neutron and fragment detectors is digitized by multichannel TDC CAEN V775N and stored together with the information about the direction of polarization of the neutron beam.

A new model of the ROT effect (proposed recently) predicts a decrease of the effect in the 0.3 eV resonance of ^{235}U. The preliminary analysis of the data shows that the effect actually diminishes, but a more detailed analysis is required to obtain its exact value or determine its upper limit.

Investigation of Prompt Neutron Emission in Neutron-Induced Nuclear Fission. In 2016–2017, a complex spectrometer consisting of a double ionization chamber with Frisch grids (DIC) and a scintillation (BC501) fast neutron detector was developed and designed at the Department of Nuclear Physics. The spectrometer is intended for experimental studies of fission processes in the late stages of the evolution of the fissioning system (after passing through the "saddle point") using the IBR and IREN neutron sources.

The experimental study of the PFN emission process in the $^{235}\mathrm{U}(n_{\mathrm{th}}, f)$ reaction was necessary, since the available data were obtained more than 50 years ago and are somewhat ambiguous. New measurements were made on IBR-2 beamline 11B equipped with a curved mirror neutron guide effectively suppressing gamma radiation from the neutron source. The obtained results [6] made it possible to correct the available data and for the first time obtain FF mass distribution, which is in good agreement with the data obtained at a spectrometer with a resolution of about 0.5 amu. The dependence of the number of PFN on FF mass carries very important information on the impact of quantum effects (nuclear shells of forming FF) on the FF formation processes.

Investigations of Neutron–Charged Particle Reactions. Experimental and theoretical investigations of neutron-charged particle reactions induced by fast neutrons were carried out. The experiments were conducted at the Van de Graaff accelerators EG-5 at FLNP and EG-4.5 of the Institute of Heavy Ion Physics of Peking University. Data on the neutron reactions with the emission of charged particles induced by fast neutrons are of much interest for studying the mechanisms of nuclear reactions and atomic nuclear structure as well as in choosing engineering materials and in performing calculations in the development of new facilities for nuclear power engineering.

The cross sections for the $^{10}\mathrm{B}(n, t2\alpha)$ three-body reaction and $^{10}\mathrm{B}(n, \alpha)^7\mathrm{Li}$ reaction at E_n = 4.0, 4.5 and 5.0 MeV were measured. An ionization chamber manufactured at FLNP was used as a detector.

Activities within the Framework of TANGRA Project. In 2017, the detector system of the TANGRA facility was upgraded, which involved the replacement of gamma-ray detectors based on NaI crystals with more efficient BGO crystal detectors. Each detector is a scintillation assembly consisting of a BGO crystal (76 mm in diameter and 65 mm thick) and Hamamatsu R1307 photomultiplier. In total, there are 24 detectors which can be arranged in different geometric configurations relative to the target depending on the problem being solved.

The physical characteristics of the system, such as resolution, efficiency, optimum operating voltage for the new detectors, were tested. To determine the optimal geometric configuration of detector arrangement, various configuration variants were tested. Figure 5 show different configuration variants with 10 detectors with and without a collimator.

Application of the Neutron Resonance Analysis Method to Investigate the Elemental Composition of Archaeological Finds. In 2017, at the IREN facility, experiments were carried out to determine the elemental composition of a number of archaeological artefacts provided by the Institute of Archeology, RAS. The studies were done using the neutron resonance capture analysis (NRCA).

The applied analytical research method is quite new for FLNP. However, it could find application in the study of unique objects of archeology and cultural heritage, since it is absolutely non-destructive, requires no special sample preparation procedures (for example, cleaning from patina), and leaves practically no induced radioactivity in objects under study.

Analysis of Human Remains from the Necropolises of the Moscow Kremlin. A neutron activation analysis (NAA) of three samples of human remains of the 16th and 17th centuries from the necropolises of the Moscow Kremlin has been carried out at FLNP (Fig. 6). The samples were irradiated at two facilities: the IREN source of resonance neutrons and the IBR-2 reactor.

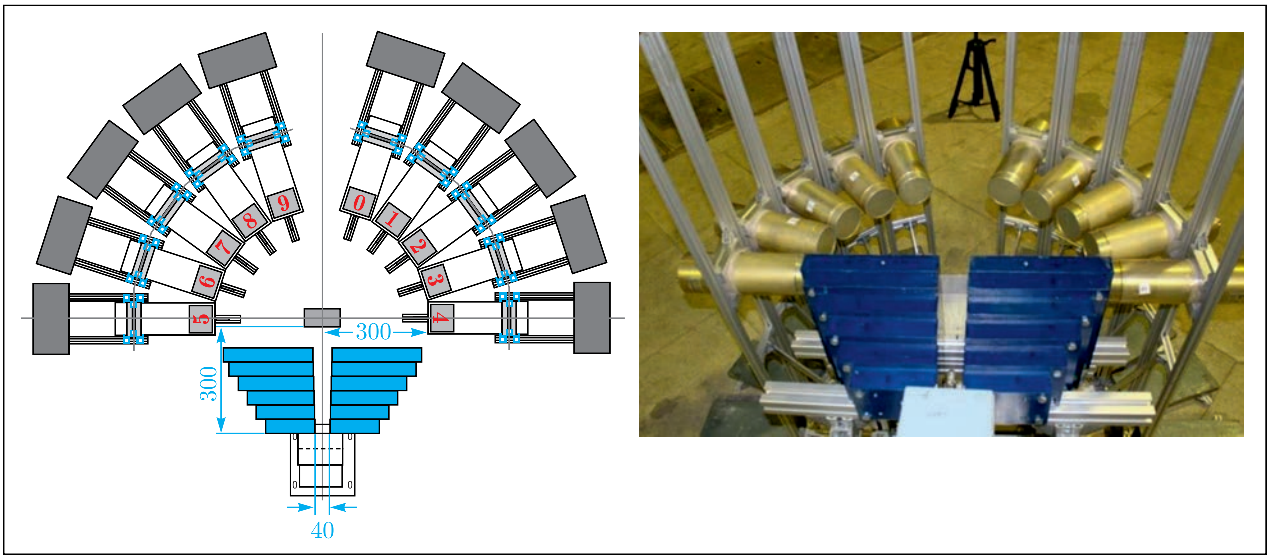

Fig. 5. Schematic of TANGRA experimental facility with 10 detectors; configuration variant "A" — compact geometry with a collimator

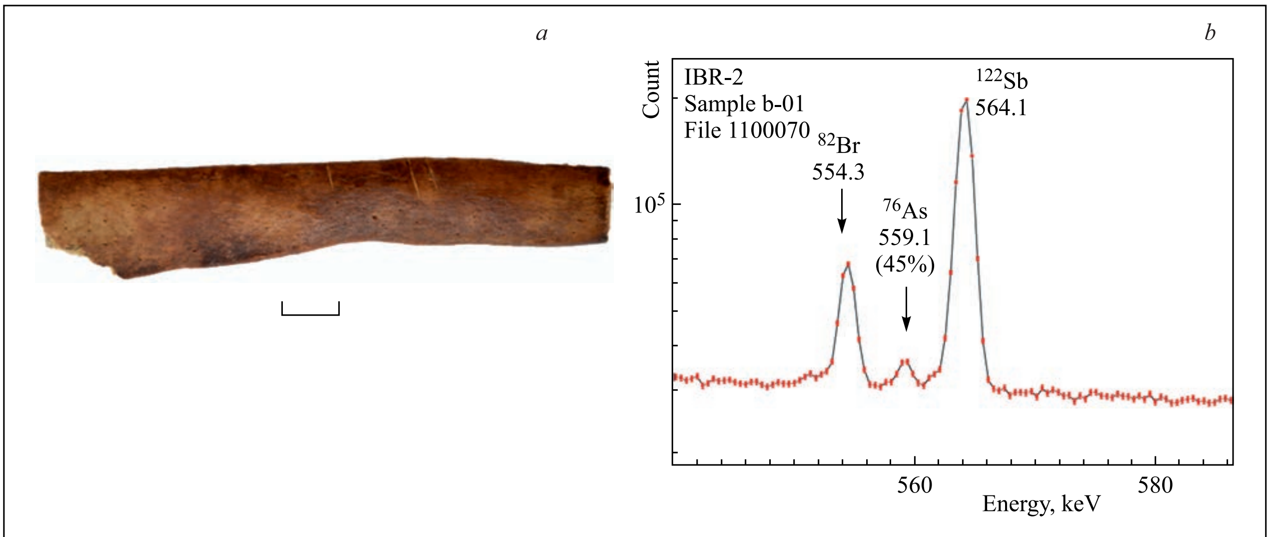

Fig. 6. *a*) Cleaned rib fragment from the burial of the son of Tsar Ivan the Terrible, Tsarevich Ivan Ivanovich; *b*) fragment of gamma-ray spectrum of the sample after irradiation with neutrons at the IBR-2 reactor

Mass fractions of arsenic, mercury, and some other elements were calculated using two NAA methods– relative and absolute. The obtained values confirm the fact of acute mercury poisoning of Anastasia Romanovna, the first wife of Tsar Ivan the Terrible. High levels of mercury were detected in the bone remains of Tsarevich Ivan Ivanovich, the son of Tsar Ivan the Terrible, and Prince Mikhail Vasil'evich Skopin-Shuiskii.

Analytical Investigations at the IBR-2 Reactor. In 2017, the REGATA facility was used for multi-element instrumental neutron activation analysis of about 1900 environmental samples (vegetation, soil, air filters), a number of technological, biological and archaeological samples, as well as of samples of extraterrestrial origin in the framework of programmes and grants of the JINR Member States and Protocols on scientific and technical cooperation with the JINR Non-Member States. Investigations of test samples were conducted for an interlaboratory comparison of the results under the IAEA programme. The elemental analysis of ~ 500 samples was performed using a Thermo Scientific iCE 3500 Atomic Absorption Spectrometer.

THE IBR-2 PULSED REACTOR AND COMPLEX OF CRYOGENIC NEUTRON MODERATORS

In 2017, the IBR-2 research nuclear facility was operated in a nominal on-power mode under Rostekhnadzor license valid until 30 September 2022. Statistical data on the IBR-2 operation are presented in table.

No. of cycle	Period	Moderator type	Reactor operation for physics experiments, h
1	16.01–28.01	Water	264
2	08.02–18.02	Cryogenic	230
3	13.03–28.03	Water	336
4	04.04–14.04	Water	238
5	15.05–26.05	Cryogenic	264
6	26.09	Water	4
7	09.10–27.10	Water	432
8	14.11–25.11	Cryogenic	247
9	04.12–23.12	Water	456
		Total:	2471

In the 8th cycle, the cold moderator CM-202 operated with a new cryogenic system, which made it possible to reduce the temperature in the moderator chamber by 8 K (down to 23 K) at a reactor power of 2 MW as compared to the previous cryogenic system. This allowed a significant increase in the yield of cold neutrons from the surface of the cold moderator. In addition, the new cryogenic system was tested under simultaneous cooling of the CM-202 cold moderator chamber and CM-201 test stand at a zero reactor power. The results showed that the use of the new cryogenic system allowed a three-fold reduction in temperature (down to 20 K) in both chambers as compared to the previous cryogenic system.

NOVEL DEVELOPMENT AND CONSTRUCTION OF EQUIPMENT FOR THE SPECTROMETER COMPLEX OF THE IBR-2 FACILITY

In 2017, the development and support was continued for the modules of the program for simulating neutron spectrometers and experiments for VITESS [7] (Virtual Instrument Tool for European Spallation Source). Almost half of all VITESS modules have been developed at FLNP; in particular, the tasks of simulating neutron instruments for polarized neutrons have been almost completely carried out. The simulation of spin-echo spectrometers with time-dependent magnetic fields and model systems has been successfully performed.

Cryogenics and Vacuum Systems. Major activities in this area were carried out in accordance with the project "Development of PTH sample environment system for the DN-12 diffractometer at the IBR-2 facility" aimed at developing a cryostat for temperature and magnetic investigations of condensed matter under pressures of up to 10 GPa at the DN-12 spectrometer. A significant extension of the range of scientific problems solved by means of this diffractometer has required the construction of a cryostat with a variable temperature (in the range of 300–4 K) and magnetic field (0–4 T), which will allow one to distinguish between the effects from various types of interactions when studying complex magnetic structures, build detailed magnetic phase diagrams of magnets under study and thoroughly investigate mechanisms of magnetic phase transitions.

Detectors and Electronics. In 2017, a new ring gas detector for small-angle thermal neutron scattering was assembled and tested with a neutron source on the RTD diffractometer (IBR-2 beamline 6a). The detector is designed for studies of biological (organic) and nanodispersed polymer objects containing functionally significant inhomogeneities of various structural complexity. A distinguishing feature of the detector is the simultaneous determination of angular and radial coordinates of detected neutrons.

CONFERENCES AND MEETINGS

1. The 24th International Seminar on Interaction of Neutrons with Nuclei: Fundamental Interactions & Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics (ISINN-25), 23–26 May, Dubna (hppt://isinn.jinr.ru).
2. The 4th International Conference of the Serbian Society for Ceramic Materials, 14–16 June, Belgrade, Serbia. With the financial support of the JINR FLNP (http://ceramic-society.rs/).
3. The Third International Summer School and Workshop on Complex and Magnetic Soft Matter Systems: Physico-Mechanical Properties and Structure (CMSMS'17), 28–30 June, Dubna.
4. The International Conference on Neutron Scattering 2017 (ICNS2017), 9–13 July, Daejeon, Republic of Korea. With the financial support of the JINR FLNP (http://www.icns2017.org/).
5. The international seminar "Development of Neutron Nuclear Methods" dedicated to the 80th anniversary of the birth of Aleksandr Strelkov, 22 September, Dubna.
6. The international conference "Condenced Matter Research at the IBR-2", 9–12 October, Dubna (http://indico.jinr.ru/conferenceDisplay.py?confId=192).
7. The VIII international school for young scientists and students "Instruments and Methods of Experimental Nuclear Physics. Electronics and Automatics of Experimental Facilities", 7–11 November, Dubna (http://d-instruments.ru/).

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LABORATORY OF INFORMATION TECHNOLOGIES

The investigations performed at the Laboratory of Information Technologies in 2017 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 26 themes of the JINR Topical Plan for JINR research and international cooperation. The LIT activity is aimed to provide a further development of the JINR network and information infrastructure, mathematical and software provision for research and production activity under way at JINR and its Member States on the basis of advanced information and computer technologies.

The implementation of the project on the development of the Multifunctional Information and Computing Complex (MICC) of JINR has been started. It currently comprises the following basic components:

- Central Information and Computing Complex (CICC) of JINR with home built up computing elements (CE) and mass storage elements (SE),
- grid site of Tier-2 level for experiments at the Large Hadron Collider (LHC) and other large-scale experiments and projects within the grid environment,
- grid site of Tier-1 level for CMS experiment,
- heterogeneous cluster HibryLIT for parallel computing,
- cloud infrastructure.

The JINR MICC provides resources needed for different tasks, implied by many projects the JINR researchers take part in, namely: MPD, BM@N, CMS, ALICE, ATLAS, NOνA, BESIII, OPERA, PANDA, STAR, COMPASS, etc. The JINR grid sites of Tier-1 and Tier-2 levels are elements of the Russian Grid Segment of the global Grid infrastructure used within the WLCG project for data processing of ALICE, ATLAS, LHCb and CMS on LHC and other grid applications.

In 2017, construction of a specialized engineering infrastructure for high-performance computing (HPC) was started. It is based on the technology of contact liquid cooling and intended for the development of the heterogeneous cluster HibryLIT with the aim of multiple increase in the computing power needed for a drastic speed-up of complex theoretical research underway at JINR.

In 2017, 213 scientific papers were published by LIT researchers in referred journals, and 61 reports were presented at international and Russian conferences.

INFORMATION AND COMPUTING INFRASTRUCTURE OF JINR

During 2017, the work related to the reliable operation and development of the JINR networking and information infrastructure was in progress. The key components of this infrastructure are telecommunication data links, JINR local area network (LAN), Multifunctional Information and Computer Complex as well as the primary software, including on the basis of cloud, grid and hybrid technologies, integrating information resources of the Institute into a unified environment accessible to all users.

JINR Telecommunication Data Links. In 2017, the reliable work of the high-speed computer communication channel Dubna–Moscow was secured. The external JINR computer channel is based on the DWDM technology (Dense Wave Division Multiplexing means spectral multiplexing on the wavelength) and uses one lambda of 100 Gbps and two lambdas (two frequencies) of 10 Gbps each. The external distributed network of JINR includes external overlay network LHCOPN (JINR–CERN) passing through MGTS-9 in Moscow, Budapest and Amsterdam to link the centres of Tier-0 (CERN) and Tier-1 (JINR) and external overlay network LHCONE of the same route which is intended for Tier-2 centre at JINR; direct communication links based on EN-VRF technology with the collaboration of research centres RUHEP (Gatchina, NRC "Kurchatov Institute", Protvino and with networks Runnet, RASnet). IPv6 routing for Tier-1 and Tier-2 sites was realized. The throughput of the backup communication channel is 20 Gbps.

Table 1 shows the distribution of the incoming (more than 4 TB) and outgoing traffics in 2017 over JINR subdivisions.

Table 1

Subdivision	Incoming, TB	Outgoing, TB
DLNP	158.23	82.88
VBLHEP	115.36	89.71
LIT	58.15	18.89
FLNP	54.38	37.56
FLNR	41.18	21.1
JINR Management	39.65	74.95
Remote access node	35.96	4.95
JINR's Hotel & Restaurant Complex	30.54	4.05
BLTP	22.75	8.68
Resort Hotel "Ratmino"	15.46	2.41
LRB	7.73	4.39
Procurement and Logistics Service	7.18	2.05
Chief Power Engineer's Department	5.02	0.48
Social Infrastructure Management Office	4.79	0.58
Technical Communication Service	4.12	1.04

In 2017 the overall incoming JINR traffic, including the general access servers, Tier-1, Tier-2, and the computer complex, amounted to 23.5 PB (14.2 PB in 2016). The weights of the various incoming traffic categories are shown in Table 2.

Table 2

Scientific and educational networks, %	File exchange (p2p), %	Web resources, %	Social networks, %	Software, %
97.54	1.34	0.9	0.17	0.05

JINR Local Area Network. In 2017, work was in progress on the further development and improvement of the JINR network IT elements intended to increase the working efficiency of the JINR staff. The JINR local area network (LAN) has been transferred to DHCP (Dynamic Host Configuration Protocol). A project was developed of a new link using 4×100 Gbps between the territories of DLNP and VBLHEP with a double redundancy to improve the reliability of the optical transport highway.

Currently, the main optical highway of the JINR local area network operates at a speed of 10 Gbps. Its transition to 100 Gbps is planned in 2018.

There is a system of network services: DNS, DHCP, SMTP, SNMP, user registration, authorization devices, user authentication, switching, routing, security, videoconferencing communications, VoIP, IPDB (Internet Protocol Data Base), WebMail, etc.

The JINR LAN currently comprises 8008 network elements and 14 129 IP addresses, 4559 users registered at present within the network, 2584 users of mail.jinr.ru service as well as 1597 users of digital libraries and 396 remote VPN users.

JINR Grid Environment. The JINR grid infrastructure is presented by a Tier-1 centre for CMS experiment at LHC and a Tier-2 centre which supports a large number of virtual organizations (VOs) such as ALICE, ATLAS, BES, BIOMED, COMPASS, CMS, LHCB, MPD, NOνA, STAR, etc. The Tier-1 CMS centre at JINR comprises the following basic elements:

1. The data processing system supports 248 64-bit 12- and 20-core worker nodes (WNs) which in total give 4160 cores. Tasks are serviced in a batch mode. To support the batching system, there is a special server with a system for resource distribution of cluster's resources and a scheduler. Software Torque/Maui is used as a resource manager of the task scheduler.

2. The mass storage system is served by dCache and Enstore software as a buffer for work with the tape robot. One of the installations of dCache works only with storage servers and is used for online data storage with fast access to them. The second installation serves special dCache disk servers and tape robot. The disk servers are a buffer zone for the exchange with tapes, while the tape robot is designed for a long, practically eternal storage of CMS data. Totally, two installations have now 6.4 PB of effective disk space, and the tape robot IBM TS3500 has 9 PB of data storage capacity. To support the storage and access to data, 8 physical and 14 virtual machines have been installed.

3. The system for service support ensures the operation of the computing service, storage service, grid service, service of data transmission (File Transfer System (FTS)), distributed computing management system (Portable Batch System (PBS)), information service (monitoring of services, storage servers, data transfer, information sites). Grid-VOBOX service is designed for transferring data between CMS grid sites by means of FTS; the proxy server SQUID is also configured and used, which is necessary when working with specialized CMS databases (conditions DB). The FTS service is used to reliably transfer files between large data stores, primarily between the centres of Tier-0 and Tier-1 levels. Additionally, the services FTS provides control and monitoring of transmission, distribution of site resources between different organizations, and managing user requests. For

calculation a default software stack of the WLCG project is used: $2 \times$ CREAM, $4 \times$ ARGUS, BDII top, BDII site, APEL parsers, APEL publisher, EMI-UI, $220 \times$ EMI-WN + gLExec-wn, $4 \times$ FTS3, LFC, WMS, L&B, glite-proxyrenewal.

The JINR CMS Tier-1 has shown its stable state for the whole period after putting it into a full-operation mode [1]. During 2017, this centre performed 6 778 864 tasks, using a normalized CPU time of 227 802 717 h in HEPSpec06 units. Figure 1 gives the contribution of the Tier-1 global centres to the CMS experimental data processing (in MEvents) in 2017. The JINR site takes a second place in the world as to its productivity.

Figure 2 shows the number of events processed at the JINR CMS Tier-1 in 2017 for the CMS activities (production, reprocessing, analysis, etc.).

One of the main functions of the Tier-1 centres is the archival storage of raw experimental and simulated data. Figure 3 shows the load of the tape robot during 2017.

Figure 4 illustrates a data transfer rate and amount of data transferred for recording and processing (Fig. 4, *a*, *b*) from the Tier-1 and Tier-2 centres to JINR

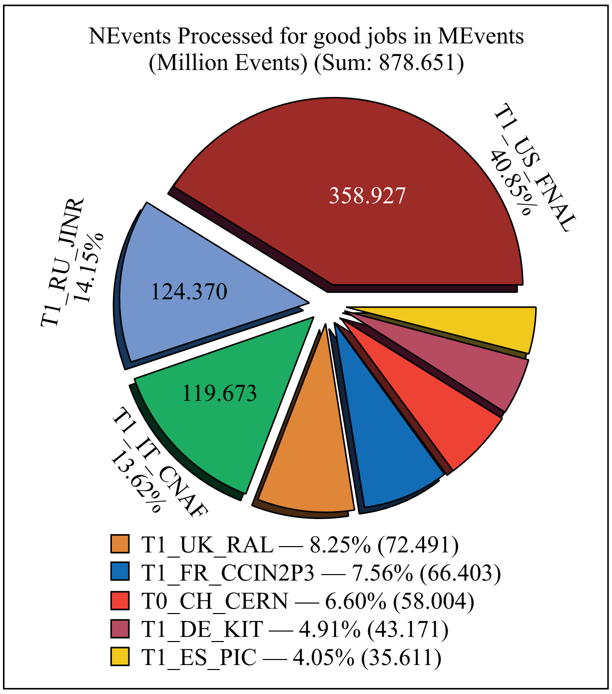

Fig. 1. Number of events processed for all CMS Tier-1 in Million Events in 2017 (Sum: 878.651)

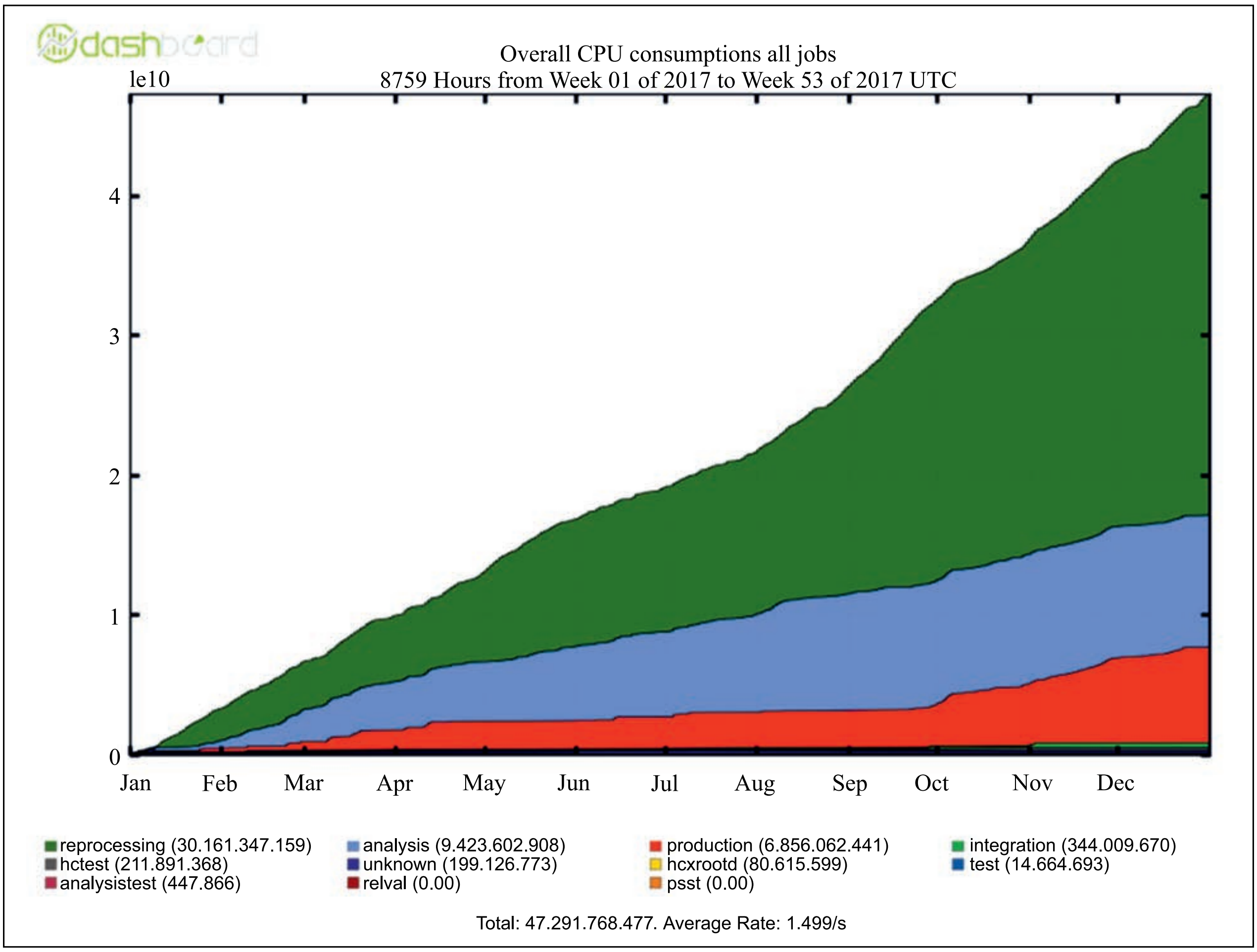

Fig. 2. Number of events processed at the JINR CMS Tier-1 in 2017 for CMS activities (reconstruction, simulation, reprocessing, analysis, etc.)

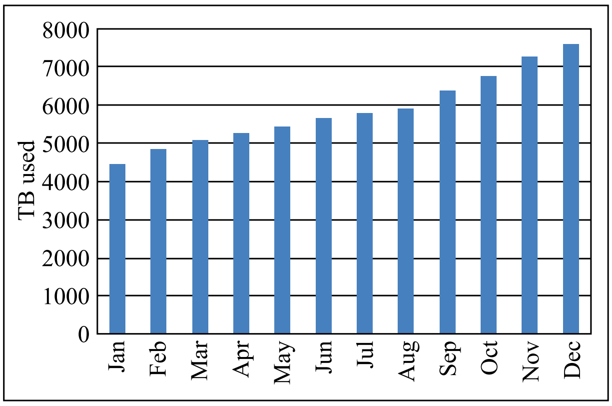

Fig. 3. JINR CMS Tier-1 tape robot load in 2017

CMS Tier-1 as well as a data transfer rate and amount of data transferred from JINR CMS Tier-1 for recording and processing to centres Tier-1 and Tier-2 (Fig. 4, *c*, *d*) during 2017. The average speed of raw data transfer to JINR CMS Tier-1 is 280–380 Mbps.

The Tier2 level centre at JINR [1] allows the data processing for all the four LHC experiments (ALICE, ATLAS, CMS, and LHCb) and, in addition, supports a number of VOs that are not included in the LHC (BES, BIOMED, COMPASS, FUSION, MPD, NOνA, STAR, etc.). The computational resources of the Tier-2 centre consist of 3640 cores. The data storage system is installed in two versions of software: two dCache installations and two XROOTD installations. One of the dCache installations is used by CMS and ATLAS. The other dCache is used by the JINR users and user groups as well as for the NICA experiment (MPD). Besides, this installation is used to store data of several third-party experiments (BIOMED, BES, FUSION). One XROOTD installation is used by ALICE, and the other within the FAIR project of the PANDA collaboration. The size of the storage system is 1909.8 TB. The storage systems support 19 servers that organize data distribution, authorization of access to data and protocols to work with the data.

For VO to work, special servers have been installed that support the WLCG grid environment. Part of the WLCG services was installed on physical machines, some of them on virtual ones. The WLCG services use software UMD for compatibility with the grid software environment in WLCG. Currently, 23 WLCG services are installed. These services provide the entire infrastructure for remote work with grid: user and VO authorization, job run from remote VO services, WLCG information system, and various algorithms for remote testing and checking the service environment on the local resources. There are five settings of user interface (UI) for job run into a distributed grid environment.

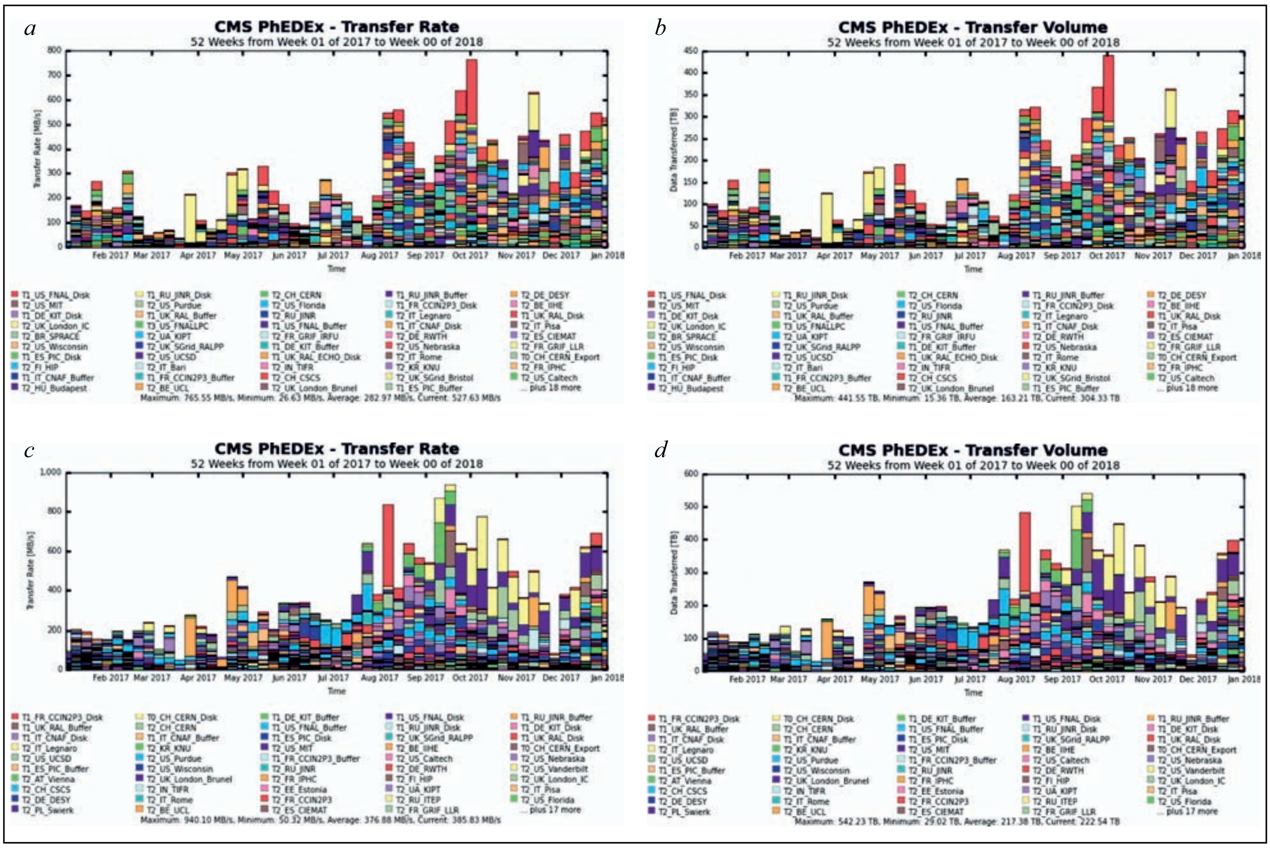

Fig. 4. The data transfer rate and amount of data transferred for recording and processing (a, b) from Tier-1 and Tier-2 centres to CMS Tier-1 at JINR and the transfer rate and amount of data transferred from JINR CMS Tier-1 for recording and processing to centres Tier-1 and Tier-2 (c, d) in 2017

The computing element OSG HT-CONDOR has been integrated in the Tier-2 centre infrastructure. This provides a way for VO STAR to process data using JINR Tier-2.

The main users of the JINR grid resources are virtual organizations of all LHC experiments. During 2017, the Tier-2 site performed 6 682 112 tasks, CPU time was 236 405 186 h in HEPSpec06 units. Figure 5 gives data on using the Tier-2 site (JINR-LCG2) at JINR by the virtual organizations within projects RDIG/WLCG/EGI in 2017.

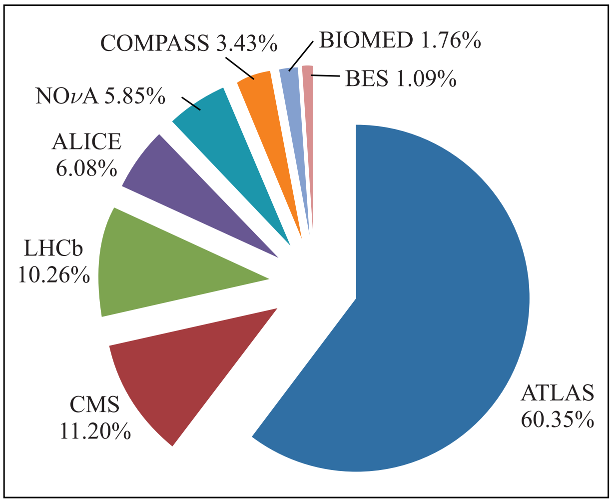

Fig. 5. The use of the JINR-LCG2 grid site by virtual organizations within RDIG/WLCG/EGI

The development of a new service monitoring system for CMS Tier-1 at JINR was begun. The system has a modular structure. The following modules have been developed: Job Status — number of completed and emergency-ended jobs; SSB Status — results of the monitoring performed by Dashboard; PhedexQuality — quality of transfers between other sites and T1_RU_JINR; PhedexErrors — errors associated with T1_RU_JINR. The test version of the service monitoring system was lunched at lcgsens01o.jinr.ru. Now it aggregates and displays on the web page the data related to Phedex, dCache and WLCG monitoring. The system is developed as a general-purpose tool which could lately be adapted for other Tier-1 centres and experiments.

A new data processing system of the COMPASS experiment in a grid environment (Grid COMPASS Production System) has been developed and commissioned [2]. The management infrastructure is located in the cloud of JINR. Data processing is performed with the help of PanDA, which allows one to send a job to any available computational resource: Condor, LSF, PBS, etc. Most of the processing is executed on the grid resources of CERN and JINR.

High-Performance Computer System. The MICC at LIT provides carrying out computations, including the parallel ones, outside the grid environment. They are asked both by the experiments NOνA, PANDA, BES, NICA/MPD, etc., and by the local users of the JINR Laboratories. The JINR users and the grid users have access to all the computer facilities via a unified batch processing system. Figure 6 gives the time distribution of the tasks executed on the computing cluster by the JINR subdivisions and the user groups.

The systems of storage and access to dCache and XROOTD data ensure work with data both for local JINR users and for the WLCG users and collaborations. Two dCache installations are supported: dCache-1 for the experiments CMS and ATLAS; dCache-2 for local users, groups of users and the international projects NICA/MPD, HONE, FUSION, BIOMED, COMPASS. Two installations of the XROOTD data access arrangement maintain work with data of three international collaborations: ALICE, PANDA and CBM. All the storage systems are constructed under a hardware data protection mechanism RAID6 and a software mechanism

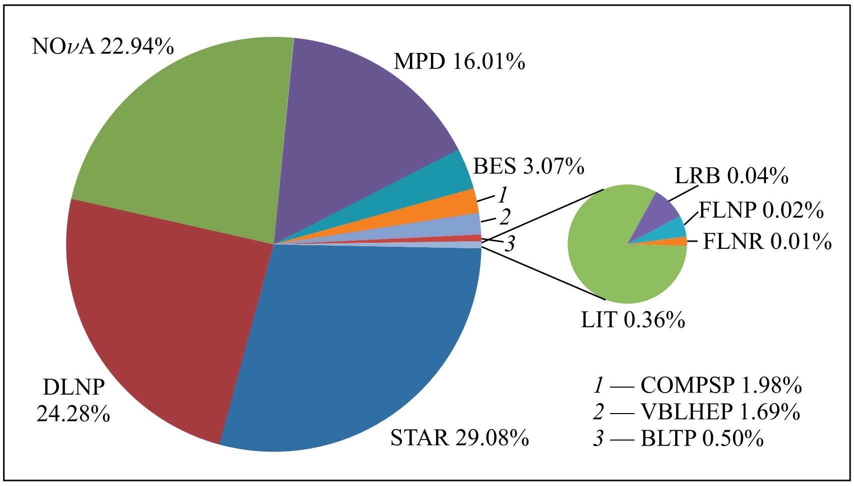

Fig. 6. Statistics of using the computing cluster by the subdivisions and experiments underway at JINR in 2017 without grid users

RAIDZ2, which is not inferior to the reliability of the RAID6 hardware.

Cloud Environment. In 2017, the cloud infrastructure of JINR was equipped with 14 servers Dell PowerEdge R630 with the total number of CPU cores 336 and total RAM size of 1792 GB, 6 servers Dell PowerEdge R730xd with 16 8TB disks in each for a cloud storage based on ceph, 2 Dell PowerEdge R630 servers for head machines of the cloud. In order to support the computing infrastructure of the NOνA experiment, five Dell PowerEdge R430 servers with 120 CPU cores and total RAM size of 640 GB were commissioned as well as one Dell PowerEdge R730xd server with 16 8TB disks to expand the cloud storage for the needs of the NOνA experiment.

In 2017, a new fault-tolerant cloud architecture of JINR was designed on the basis of the Raft-algorithm implemented on a new version of cloud platform OpenNebula. The work was done with a purpose to optimize the architecture of the cloud storage based on ceph [3].

In cooperation with SRI NP BSU (Minsk, Belarus), work was in progress on the integration of the cloud infrastructure with the JINR cloud. Similar work [4] is underway with the following organizations:

• Nazarbayev University and the Institute of Nuclear Physics (Astana, Kazakhstan);

• Georgian Technical University (Tbilisi, Georgia);

• Yerevan Physics Institute (Yerevan, Armenia);

• Institute for Nuclear Research and Nuclear Energy and Sofia University (Sofia, Bulgaria);

• University "St. Kliment Ohridski" in Bitola (Bitola, Macedonia).

The geography of organizations of the JINR Member States which provide part of their resources to integrate with the JINR Cloud is presented in Fig. 7.

In 2017, work was complete on refactoring the driver of JINR LIT Cloud on the platform OpenNebula to deploy an OpenVZ container. For the task to be solved, a test polygon has been deployed and configured which consists of two virtual machines, one of which is equipped with a host system OpenNebula, and the other has its work node. For a correct operation of the test polygon, synchronization is required for the driver data between the host system and its work node. During the execution of the work, a unified class OneDriver was created which includes all the container management methods required for the correct operation of the driver as well as some auxiliary methods and functions that are involved in the work of the container. In OpenNebula, the rules for third-party driver developers provide calls of the container management functions from the same-name scripts. For example, the command to create and deploy the container "deploy" needs to be called from the same-name file. So, all necessary scripts were set up to create an object of class OneDriver and then to call a container management method. The driver is based on the Ruby programming language.

In 2017, a smart scheduler for the cloud was developed that proposes using an overcommitment mechanism (assigning more virtual resources than physically available) with the automated virtual machine migration to de-allocated resources. A necessary part of this project is to collect current and historical information on the load distribution in the cloud. The default monitor-

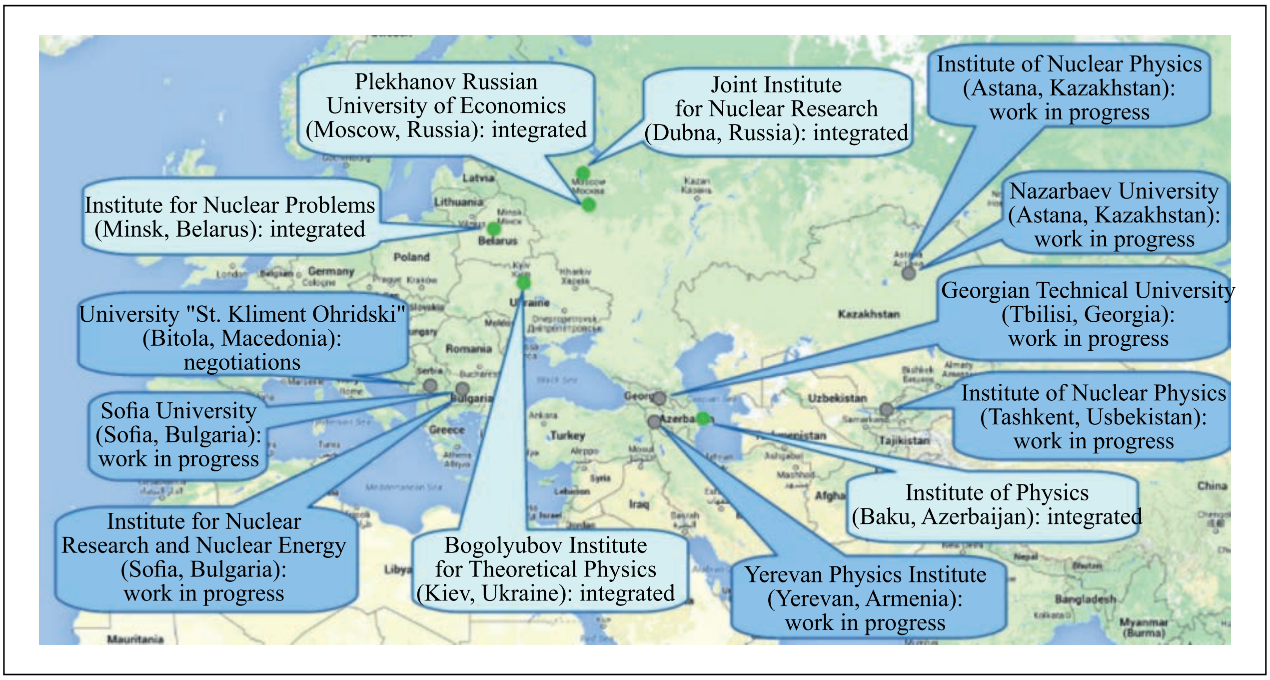

Fig. 7. Geographical location of cloud infrastructures of the JINR-participating organizations which provide part of their resources for integration with JINR Cloud

ing system embedded into the OpenNebula cloud platform possesses limited possibilities as to data collection and data processing options. Therefore, the problem of choosing the most suitable external monitoring system gets urgent. Another important aspect to be considered is its performance and scalability as in large clouds it can be a critical limiting factor for the scheduler. Based on the test results and the experience gained with the systems Ganglia, Icinga2, NetXMS, NMIS and Zabbix, Icinga2 has been chosen as a load information collection system for the smart cloud scheduler project [5].

Heterogeneous Computation Cluster HibryLIT. The development of the information and software environment of the heterogeneous computing cluster HibryLIT [1] that is a component of MICC of LIT [2] was in progress in 2017. The cluster is intended for carrying out massive parallel computations using modern computing architectures such as GPUs (Nvidia Tesla K40, K80) and Intel Xeon Phi coprocessors/processors. At the moment, the computing component of the cluster contains 10 nodes with NVIDIA Tesla K80 graphical processors, NVIDIA Tesla K40 accelerators, Intel Xeon Phi7120P coprocessors and two types of computing accelerators NVIDIA Tesla K20x and Intel Xeon Phi 5110P. All the nodes have two multi-core processors Intel Xeon. Overall, the cluster contains 252 CPU cores, 77 184 GPU cores, 182 PHI-cores; it has 2.5 TB RAM and 57.6 TB HDD, and its total capacity is 140 Tflops for operations with single precision and 50 TFlops for double precision. HibryLIT infrastructure allows developing modern software along with providing JINR Member States with possibilities for carrying out resource-demanding computations. SLURM is being used in the structure of the cluster as a workload manager. SLURM settings allow distributing computation nodes by partitions formed according to computation architectures used in the process of carrying out computations. In order to get information about available resources in different SLURM partitions, characteristics of the nodes and a status of running tasks — in other words, information for more efficient organization of computing on the cluster, a MobiLIT mobile application has been developed. It provides the following possibilities:

- user's jobs monitoring;
- quick view of user's files (*.out, *.dat, *.in or *.sh);
- possibility to kill jobs directly via the app;
- monitoring of the expected computation time;
- monitoring of available resources on different nodes and partitions of the cluster which are meant for using different computing architectures;
- full information on jobs launched on the cluster, the resources they require, etc.

The MobiLIT application is developed using NativeScript framework. It is available in Google Play Store [5] for users of smartphones and tablets under Android; for iOS users the application is available in App Store in test mode. To sign in, users need authorization data for the HibryLIT cluster. The developed mobile application MobiLIT for users of HibryLIT enriches its information-software environment with a convenient and modern IT service, which makes it simpler to carry out parallel computations and provides additional optimization while using computation resources of the cluster.

A new service HLIT-VDI has been developed for shared use of applied software packages on the HibryLIT cluster using GUI (graphical user interface). By means of this service, it is now possible to work with applied software packages such as Wolfram Mathematica, Maple, Matlab, COMSOL, GEANT4, etc., via remote access to the virtual machines (VMs) in the framework of the HibryLIT cluster. The developed service allows carrying out computations in frames of VMs and massive computations using the resources of the cluster (Fig. 8).

The cluster's resources are widely used not only for massive-parallel computations to solve the problems underway at JINR, but also to train how to work with high-performance computing systems (HPC). On the basis of the cluster HibryLIT that is a dynamic,

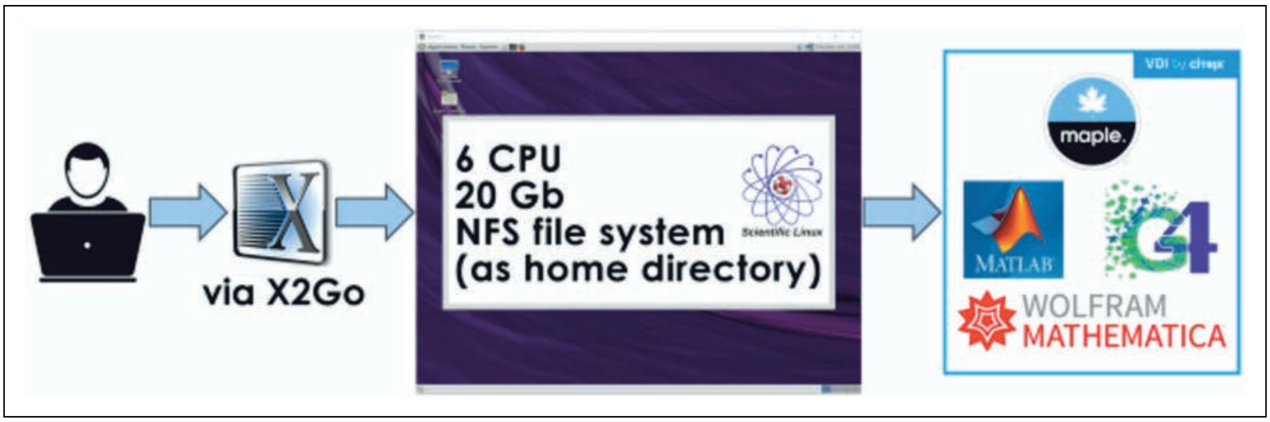

Fig. 8. A scheme of work with HLIT-VDI service

actively developing structure which includes state-of-the-art HPC computing architectures and possesses an advanced software and information environment, educational programs of advanced level are being developed. These programs allow students, postgraduates and young scientists to learn how to work on the present-day computing platforms and to study advanced IT technologies [6].

Information and Software Support. A specialized platform was designed at the Laboratory of Information Technologies. It is a set of interconnected cloud services and resources providing useful tools for management and processing of bio-monitoring data and allowing one to simplify and automate the stages of the monitoring beginning from the selection of places for sample collection and ending with the generation of the contaminant distribution maps and prediction of changes in the environment. The need to develop such a platform is caused by the need of automation of the control over the environment pollution, which is of great importance for the countries of Europe and Asia and overseen by a special Commission of the UN. The platform, using modern analytical, statistical, programs and organizational methods, allows one to improve the quality and speed of data processing, to expand the possibilities of interaction between the participants, to provide a framework for retrospective analysis as well as to arrange access to all available information which could give opportunity to strengthen forecasting of distributing the transboundary pollutions. Currently, the system contains information on more than 6000 sampling points in 40 regions across Europe and Asia. The program participants can go online to analyze data, to make comparisons with other regions, mapping contaminants and more. The platform can be used for other areas with a similar research process [7].

In 2017, the computer program SyMSim (Synthesis of Monitoring and SIMulation), developed for simulation of grid and cloud storage systems and data processing, was first used for modeling interprocessor communication when running HPC applications in the cloud on the basis of MPI implementation of the program calculation of the volt-ampere characteristics of long Josephson junctions. Comparison of the results obtained empirically and the results of simulations has shown that the simulation model correctly simulates the parallel computations performed with the help of the MPI technology and proved that for fast computing of this class tasks one should increase the network throughput simultaneously with increasing the number of processors. The results have demonstrated that the simulation software SyMSim can be successfully used to estimate the execution time of MPI algorithms in the cloud environment taking into account interprocessor connections [8]. For solving this problem, a service with a web user interface has been developed for modeling long Josephson junctions, the computations being performed on virtual machines dynamically created in the cloud and connected as work nodes of the batch system HTCondor. Also in 2017, software SyMSim was used to simulate a distributed data processing for the BM@N experiment as well as for an infrastructure optimization of the data centre in a joint project with IHEP (China).

During 2017, a traditional direction of LIT activity was the development and the support of the program library JINRLIB. The library was replenished with educational materials related to parallel programming technology and with two programs: PSD2SAS — a computer program to convert data of a position-sensitive detector of the small-angle neutron scattering spectrometer in case of isotropic scattering sample, authors A. G. Solovyov, S. A. Kutuzov, O. I. Ivankov, A. I. Kuklin, and IntroOMP — selection of training programs-examples on parallel programming technology OpenMP, authors M. V. Bashashin, T. F. Sapozhnikova, E. V. Zemlyanaya.

In 2017, the development of the unified system 1C 8.2 UPP was progressing as well as provision of the regular end-user support in the system. Also, regular work was continued on the creation and storage of electronic documents related to scientific and administrative activities of the Institute; in particular, the software of the JINR Document Server (JDS) was improved. It was developed as a repository of open access articles, pre-prints, collections of video lectures for young scientists and other materials that reflect the research activity underway at the Institute.

METHODS, ALGORITHMS AND SOFTWARE FOR MODELING PHYSICAL SYSTEMS, MATHEMATICAL PROCESSING AND ANALYSIS OF EXPERIMENTAL DATA

One of the main research activities at LIT is a mathematical, algorithmic and software support of the experimental and theoretical research underway at JINR. Below there is a brief report on some results.

New calculation schemes and algorithms have been suggested for solving a parametric self-adjoint elliptic boundary-value problem with the Dirichlet and/or Neumann type boundary conditions in a 2D finite domain using a high-accuracy finite element method (FEM) with rectangular and triangular elements. The programs complexes implementing the algorithms calculate eigenvalues, surface eigenfunctions and their first derivatives with respect to the parameter and the potential matrix elements — the integrals of the products of surface eigenfunctions and/or their first derivatives with respect to the parameter which appear when reducing the multidimensional boundary-value problem to a one-dimensional one by means of the Kantorovich method. The efficiency of the proposed calculation schemes and algorithms is demonstrated in benchmark calculations of the 2D elliptic boundary-value problems describing quadrupole vibrations in a collective nuclear model [9].

The influence of the iterative parameter in the continuous analog of Newton's method (CANM) on the area and speed of convergence is under study. The proposed approach to the optimization of the process of convergence of the CANM is based on the use of a quadratic interpolation polynomial. Based on this approach, a mechanism was developed for control over the CANM convergence rate using as a control parameter the coefficient of changing a step of difference scheme for a numerical solving of the CANM differential equation. On the basis of the developed mechanism, a modification of the continuous analog of Newton's method has been proposed [10].

In order to obtain a more effective algorithm for calculation of characteristics for SDEs, it is proposed to use a representation of the probability density function (PDF) for solution of SDE by means of a functional integral and methods for approximate evaluation of the arising functional integrals. To represent PDF by means of functional integral, the Onsager–Machlup functionals technique is proposed to be used. In order to evaluate the arising functional integrals, a method is used which is based on distinguishing among all trajectories a classical trajectory for which the action takes an extreme value, and decomposition of the action with respect to the classical trajectory [11].

A model of quantum evolution has been constructed on the basis of combining methods of computational group theory and Monte Carlo simulation. The model is inspired by the quantum Zeno effect — the most convincing illustration of the role of observation in the dynamics of quantum systems. In the model under consideration, the trajectory of a quantum system is represented as a sequence of observations with unitary transitions between them. Time is assumed to be fundamentally discrete. From a mathematical viewpoint, the *observation* (*measurement*) is an orthogonal projection onto the subspace of a Hilbert space that is defined by the "measuring device". Statistics of the results of observations is described by the Gleason theorem (a special case of which is the Born rule). Standard quantum mechanics assumes a single deterministic unitary evolution of a quantum system in the time interval between observations. However, in accordance with the principle of least action, this single evolution appears as the dominant element in some set of "virtual" evolutions. A unitary transition between observations is interpreted as a kind of gauge connection, that is, a way of identifying indistinguishable entities at different instants of time (in discrete time it is impossible in principle to trace the individuality of indistinguishable objects in the process of their evolution), and it is assumed that all possible unitary transformations are involved in transitions between observations with weights corresponding to transition probabilities. This assumption is confirmed by the Monte Carlo simulation that demonstrates a sharp dominance of some of the evolutions over the others. This dominance grows rapidly with increasing size of the symmetry group of states and the dimension of the Hilbert space. The probability of a trajectory of a quantum system is calculated as a product of the probabilities of transitions between adjacent observations. The continuum limit of the (negative) logarithm of this product is an *action*. Thus, the principle of selection of the most probable trajectory turns into the principle of least action in the continuum limit [12].

In order to improve the quality of the muon track reconstruction in the CSC (Cathode Strip Chamber) of the muon system of the CMS experiment, a new algorithm has been developed [13]. A detailed comparative analysis was conducted to confirm the necessity of using the new algorithm as a basic algorithm of reconstruction in the CSC using the Monte Carlo [14] and experimental data. As compared to a standard algorithm, the multiplicity of track segments significantly reduces (Fig. 9, *a*). This increases the accuracy and reduces the execution time of reconstruction at the subsequent stages which require sorting all the built track segments. The efficiency of the standard algorithm decreases with increasing pseudorapidity, while for the new algorithm the efficiency remains at high ($\sim 95\%$) level for the entire range of pseudorapidity overlapped by CSC (Fig. 9, *b*). The accuracy of the reconstruction of azimuthal coordinate that provides a precision of the muon transverse momentum reconstruction has been significantly improved (Fig. 9, *c*, *d*), as clearly demonstrated by the example of high-energy muons (Fig. 9, *c*), where a standard deviation of the displayed distribution is more than three times smaller for the new algorithm as compared to the old one. The new algorithm for the track-segment reconstruction was implemented in the official software package CMS in July 2016, and since 2017 it has been used by default in the reconstruction of simulated and experimental data.

A fast and efficient algorithm has been designed for the reconstruction of muon tracks in decay $J/\psi \to \mu^+ + \mu^-$ registered by the MUCH detector of the CBM experiment. One of the key tasks of this experiment is to study the processes of birth of charmonium in high-energy nucleus–nucleus collisions. The registration of such decays as $J/\psi \to \mu^+ + \mu^-$ will be done in real time. The muon track recognition algorithm is based on the model of cellular automaton (CA) which is used successfully in a number of experiments in high energy physics. The CA model is good because it allows one to reduce the number of recursive operations on the in-

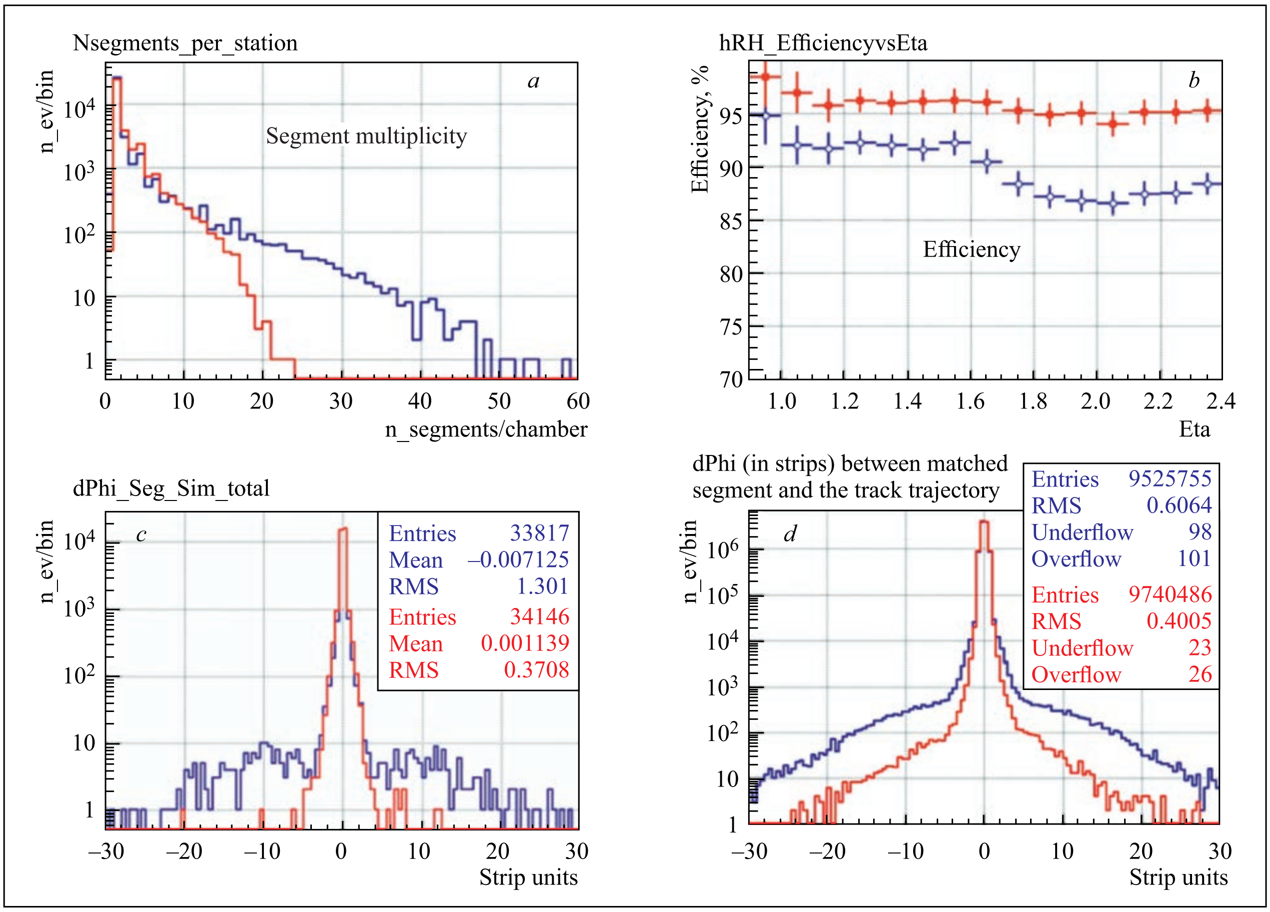

Fig. 9. Comparison of standard ST (blue) and new RU (red) algorithms for track-segment reconstruction: *a*) number of reconstructed track segments in the chamber for simulated muons with $P_t = 1$ TeV; *b*) dependence of the efficiency of the reconstruction upon pseudorapidity for simulated muons with $P_t = 1$ TeV; *c*) difference of azimuthal coordinates (in units of the strip width) of the track segment associated with the reconstructed muon, and the simulated muon with $P_t = 1$ TeV; *d*) difference of the azimuthal coordinates of a track segment associated with the muon and the reconstructed muon on experimental data of 2016

put data array and to perform most of the calculations locally. In this case, the CA elements ("cells") are segments of the broken line from which the approximation of the straight track is built. The track recognition algorithm includes three consecutive stages: calculation of average points; forming segments — the elements of the reconstructed tracks; connection of the segments and track reconstruction. The developed algorithm was included into the package CBMROOT as a dynamic link library under the name of Lx. This same library is also supplied with algorithms that implement a trigger to select decays $J/\psi \to \mu^+ + \mu^-$ and a set of methods for tuning the parameters of the algorithm on model data. In the future we plan to investigate a possibility of applying a similar approach for the selection of light vector mesons decaying in the muon channel [15].

The variation of the multiply differential cross section of the $(e, 2e)$ simple ionization of H_3^+, with the incident and ejection energy values, as well as the directions of the ejected and scattered electrons, is studied. The calculations have been performed in the framework of the perturbative first Born procedure, which has required the development of equilateral triangular three-centre bound and continuum state wave functions. The results explore the optimal conditions and the particularities of the triangular targets, such as the appearance of interference patterns in the variation of the fourfold differential cross section (FDCS) with the scattering angle for a fixed orientation of the molecule. The comparison between the results obtained by two H_3^+ ground wave functions, with and without a correlation term r_{12}, shows that the effect of correlation on the magnitude of the triple differential cross section is not large, but it produces some modification in the structure of the FDCS [16].

As examples of algorithmic construction of difference schemes for partial differential equations receiving their basic algebraic properties on a discrete level, new difference schemes have been constructed for Navier–Stokes equations and Korteweg–de Vries equation. These new schemes demonstrate a good numerical behavior [17].

The methods of obtaining functional equations for Feynman integrals on the basis of the algebraic relationships for propagators have been improved. The computations of the QCD contributions to the constant of renormalization of the mixed propagator of fermions are performed taking calibration into account [18].

A geometric description of the Maxwell equations in terms of stratified spaces has been obtained. Proposed were different variants of a permeability tensor and, correspondingly, different versions of geometrization of the Maxwell equations. In particular, the version of geometrization based on a quadratic metric leading to the Yang–Mills type equations should be noted. The developed formalism was applied to the problems of transformation optics and designing optical instruments and devices of a sub-wave range [19].

APPLIED RESEARCH

A fundamental possibility of predicting the daily energy consumption for the Moscow Region using artificial neural networks (ANN) has been demonstrated. Such factors as an optimally matched ANN architecture, an adequate structure of the sample at the input of the network, as well as originally built procedures for training and predicting the network, play an important role in the solution of this problem. The first three variables at the input of the ANN are responsible for the seasonal and periodic fluctuations in the energy consumption. Particularly noteworthy is the fourth variable which plays a role of a "tip" for the ANN which is taken either from filtered data (during the training phase of the network) or from predicted values calculated with the help of the "Caterpillar"-SSA package (at the network's testing phase). The fifth variable is the value taken from the original series (during the network training) or the value predicted for the day by the trained ANN (at the training stage). It is shown that thus formed input sample has allowed one to achieve a fast and effective training of the neural network and to provide an acceptable medium-term forecasting of the daily energy consumption for the Moscow Region [20].

In cooperation with the Plekhanov Russian University of Economics, an automated system for monitoring and predict matching of a compliance of higher vocational education with the needs of labor market has been developed. To create the system, a significant arsenal of methods and tools of Big Data Analytics and the experience gained in the projects on computing for the ATLAS and CMS experiments at CERN were used. The task, which lies in the mainstream of the so-called "digital economy", looks quite complicated so its solution requires new approaches and methods of data science, including methods of semantic analysis and machine learning. The constantly updated information database is generated using open sources. The developed system provides additional opportunities to reveal qualitative and quantitative interrelationships between education and labor market. It is aimed at a broad circle of users, including authorities and management of regions and municipalities; the management of universities, companies, and recruitment agencies, as well as graduates and university enrollees [21].

Simulations of structural changes on the nickel surface exposed to 100–700 MeV uranium ions have been performed. The dimensions of specific injuries have been obtained in dependence on the energy of irradiation at different points of time. It should be noted that when irradiating the metal sample by high-energy ions, the most energy is lost in the electron gas and then passed to the crystal lattice, but a certain amount of the energy is accumulated in the electron gas. Therefore, if choosing the initial conditions for the molecular dynamics simulation, this fact must be taken into account. The initial conditions (temperature profiles) can be varied in this case. In addition, the experimental data can be used to refine the initial conditions. In the framework of the conducted research, one can make the following two conclusions: the technique proposed is well suited to describe the structural changes in the surface layers of the material under irradiation and to obtain more accurate predictions on the structural changes; the use of experimental data is recommended as well as a better use of nonlinear dependence on the temperature of parameters of a thermal spike model [22].

INTERNATIONAL COOPERATION

The LIT specialists, in cooperation with their colleagues from the international CBM collaboration, develop the readout and data acquisition systems of the ring imaging Cherenkov detector (RICH), an integral component of the future Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany. A detailed analysis of the readout and DAQ prototype has been conducted using the data gathered during the tests of the CBM RICH prototype in the beam conditions at CERN and using the results of the laboratory measurements performed by means of a specifically developed test stand. The readout and DAQ module prototype consists of a Hamamatsu H12700 MAPMT, PADIWA preamplifier-discriminator boards and a TDC-HUB board TRBv3. Calibration techniques were developed and implemented along with the DAQ and analysis code in the CbmRoot framework. Optimization of the readout module components has been performed which allows achievement of best timing characteristics in the high beam rate conditions, expected at CBM. The obtained sub-nanosecond time precision also allows one to directly measure the time profile of the additional wavelength-shifting films on top of the MAPMT windows and investigate their effect on timing of the full CBM RICH readout chain [23].

In cooperation with Bulgarian colleagues, LIT researchers developed a continuously atomic model (CAM) to simulate the interactions of high-energy heavy ions with condensed matter. The CAM is described by two different classes of equations, namely, continuous heat conduction equations of the thermal spike model and by equations of motion of material points of the molecular dynamics method. The use of high-performance systems for the continuous–atomistic modeling requires the development of new computational schemes and parallel algorithms. To study the CAM, a computational scheme and algorithms with the ability of their using in multiprocessor systems have been developed. The efficiency of the numerical scheme and the parallel algorithms is investigated [24].

In cooperation with colleagues from South Africa and USA, a recipe for the stable PT-symmetric extension of the Dirac equation has been proposed. The P- and T-breaking terms account for the gain and loss of energy in the system. The recipe has been used to formulate three PT-symmetric spinor models with cubic nonlinearity. Of these, the PT-symmetric extensions of the Thirring and Gross–Neveu models were shown to possess infinitely and finitely many conserved quantities, respectively. The PT-symmetric extension of the third, novel, spinor system has no conservation laws at all. Despite this dramatic difference in the integrability and conservation properties, all the three PT-symmetric models were shown to have exact soliton solutions. Numerical analysis indicates that all these solitons are stable — regardless of the soliton's frequency and the value of the PT-extension parameter. The persistence under the P- and T-breaking perturbations, as well as the all-inclusive stability, highlights a remarkable sturdiness of spinor solitons in two dimensions. The structural stability of spinor solitons with respect to the perturbations that violate P- and T-symmetry, as well as stability to perturbations of initial data, points to a fundamental nature of the particle like objects in the theories described by a nonlinear Dirac equation [25].

CONFERENCES, MEETINGS

On 3–7 July, LIT hosted the ninth international conference "Mathematical Modeling and Computational Physics" (MMCP'2017). The conference was devoted to the 60th anniversary of the foundation of the Joint Institute for Nuclear Research. Co-organizers of the conference were LIT, IFIN-HH (Bucharest, Romania), Technical University (Košice, Slovakia), Institute of Experimental Physics of the Slovak Academy of Sciences (Košice, Slovakia), and Pavol Jozef Šafárik University in Košice (Slovakia). The conference was sponsored by the Intel Company. The chairman of the conference was LIT Director V. V. Korenkov, and co-chairmen of the Organizing Committee were G. Adam (LIT JINR, IFIN-HH) and M. Hnatič (JINR Laboratory of Theoretical Physics, Institute of Experimental Physics of SAS and P. J. Šafárik University).

Scientific topics of the conference covered a wide range of issues, including distributed and parallel computing and tools for scientific computing; mathematical methods and application software for modeling complex physical and engineering systems; bioinformatics and computational biophysics; physical processes simulations and related computational methods; computer algebra and quantum computing with applications.

The conference was attended by over 250 scientists and specialists from various scientific centres of Romania, Bulgaria, Germany, Lithuania, Finland, France, Slovakia, USA, Mongolia, Canada and a large number of Russian research centres and universities such as NRC "Kurchatov Institute", IMPB RAS, ITAM SB RAS, St. Petersburg State University, Novosibirsk State University, PFUR and others.

In total, 212 reports (31 plenary, 158 oral and 23 poster ones) were presented at the conference.

A conference-school "Mathematical Modeling for the NICA Project" was organized in the framework of the MMCP conference under the support of the JINR Directorate. The school programme included lectures and practical classes as well as master classes.

The tutorials were conducted on the basis of the heterogeneous cluster HibryLIT under the support of the Heterogeneous Computing Team at LIT.

The conference-school was attended by 54 young scientists and specialists of JINR, students of the University “Dubna”, Moscow Engineering Physics Institute, MSU, St. Petersburg State University, Tver State University, PFUR, KazNU al-Farabi (Kazakhstan) and others.

On 25–29 September, the town of Budva, Montenegro, hosted the XXVI International Symposium on Nuclear Electronics and Computing (NEC’2017). The symposium has been traditionally held by JINR since 1963, and for the ninth time JINR and CERN became its organizers. Co-chairmen of the symposium were LIT Director V. V. Korenkov (from JINR) and Dr. Ian Bird (from CERN). The symposium was attended by more than 120 leading specialists in the field of modern computer and network technologies, distributed computing and nuclear electronics from 14 countries: Belarus, Moldova, Bulgaria, Great Britain, Germany, Russia, USA, France, Czech Republic, Slovakia, Italy, China, Netherlands, and Switzerland. The scientific programme of the symposium covered a wide range of issues and included the following sections: detector and nuclear electronics; triggering, data acquisition and control systems; machine learning and big data analytics; grid technologies and cloud computing; computing for large-scale accelerator facilities (LHC, FAIR, NICA, SKA, PIC, XFEL, ELI, etc.); non-relational databases and heterogeneous repositories; research data infrastructure, computations with hybrid systems (CPU, GPU, coprocessors) as well as a traditional topic of the symposium related to innovative IT education. Within the symposium, a BigPanDA Technical Interchange Meeting was held. The symposium was organized under the sponsorship of the companies Niagara Computers, JET Infosystems, Dell-EMC and IBS Platformix.

In total, 89 reports (36 plenary and 53 sectional ones) were heard. At the educational section, 10 reports were delivered.

For the fourth time the International School on Modern Information Technology for Students and Postgraduates was organized within the symposium. This school was devoted to heterogeneous distributed computing infrastructures.

The school was attended by leading scientists from Russia, UK, USA, Italy, as well as by employees from JINR, NRC KI, CERN and DESY.

The school-conference was attended by 32 senior students, as well as by masters and postgraduates majoring in information technology from the leading Russian universities (National Research Nuclear University MEPhI, St. Petersburg State University, University “Dubna”, Ryazan State Radio-Engineering University, Magnitogorsk State Technical University, Peoples’ Friendship University of Russia, and Tomsk Polytechnic University.

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LABORATORY OF RADIATION BIOLOGY

In 2017, the Laboratory continued research within the framework of Theme 04-9-1077-2009/2020 “Research on the Biological Effect of Heavy Charged Particles with Different Energies” in the following fields: fundamental radiobiological and radiation genetics research; research on the action of accelerated charged particles on the central nervous system; mathematical modeling of radiation-induced effects; and radiation research at JINR’s basic facilities and in the environment. Work was continued on Theme 04-9-1112-2013/2019 “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

In 2017, research was continued on the regularities in the induction and repair of DNA double-strand breaks (DSBs) in mammalian and human cells after exposure to ionizing radiations with different physical characteristics [1–5]. The biological samples were irradiated at the MC-400 cyclotron at JINR’s Flerov Laboratory of Nuclear Reactions, Phasotron’s proton beam at JINR’s Dzhelepov Laboratory of Nuclear Problems (DLNP), and the γ-ray facility *Rocus-M* of the DLNP Medical Technical Complex.

To clear up the influence of the track parameters of accelerated ^{11}B, ^{20}Ne, and ^{15}N ions in the energy range of 13 to 47 MeV/nucleon and the linear energy transfer (LET) range of 44 to 183 keV/μm on the efficiency of complex DNA DSB repair, the kinetics of the formation and elimination of γH2AX/53BP1 foci in the nuclei of irradiated fibroblasts was studied. With increasing charged particles’ LET, a decrease in DNA DSB repair efficiency was observed (Fig. 1).

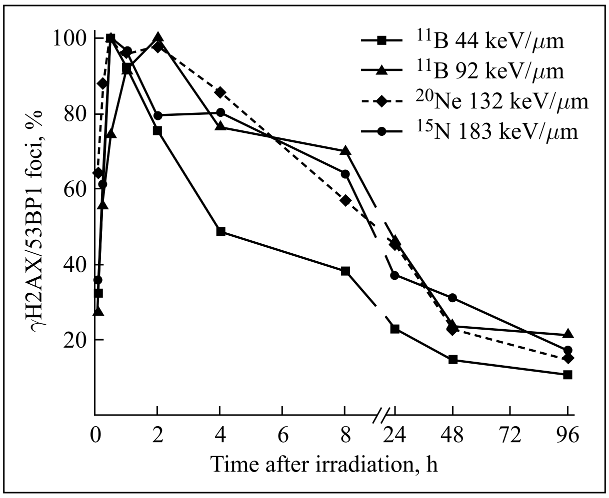

Fig. 1. Kinetics of γH2AX/53BP1 foci formation after exposure to accelerated ions with different physical characteristics

Irradiation with accelerated ^{20}Ne and ^{11}B ions at small angles with respect to the beam axis allowed studying the influence of charged particle track parameters on the complexity of the induced DNA DSBs (Fig. 2). It was found that ^{20}Ne ions with a high density of δ electrons in the track $(Z^{*2}/\beta^2 = 1454)$ induce larger and more complex clustered γH2AX/53BP1 foci (Fig. 3).

Comparative analysis was performed of the induction and elimination of colocalized γH2AX/53BP1 foci in neurons of the rat cerebellar cortex after exposure to ^{60}Co γ rays at a dose of 3 Gy, 170 MeV protons at 1 Gy, and 150 MeV protons at 3 Gy. It was shown that the foci are effectively eliminated during 24 h (Fig. 4, *b*). An estimation of the size of the radiation-induced foci showed that their area increases with time in the Purkinje cells after proton exposure (Fig. 4, *a*) [6, 7].

Using the DNA comet assay technique, regularities were studied of DNA DSB formation in human peripheral blood lymphocytes in the presence of DNA repair

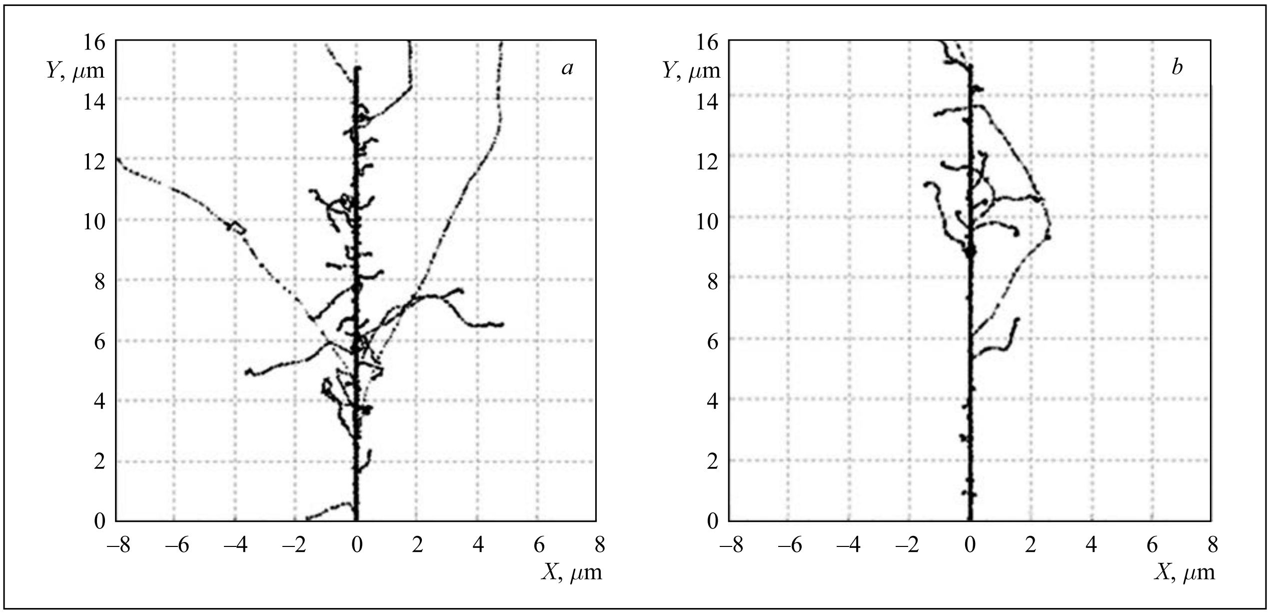

Fig. 2. Visualization of the ion track structure: *a*) ^{20}Ne (34 MeV/nucleon energy; LET 171 keV/μm); *b*) ^{11}B (25 MeV/nucleon energy; LET 55 keV/μm); RITRACKS v.3.1

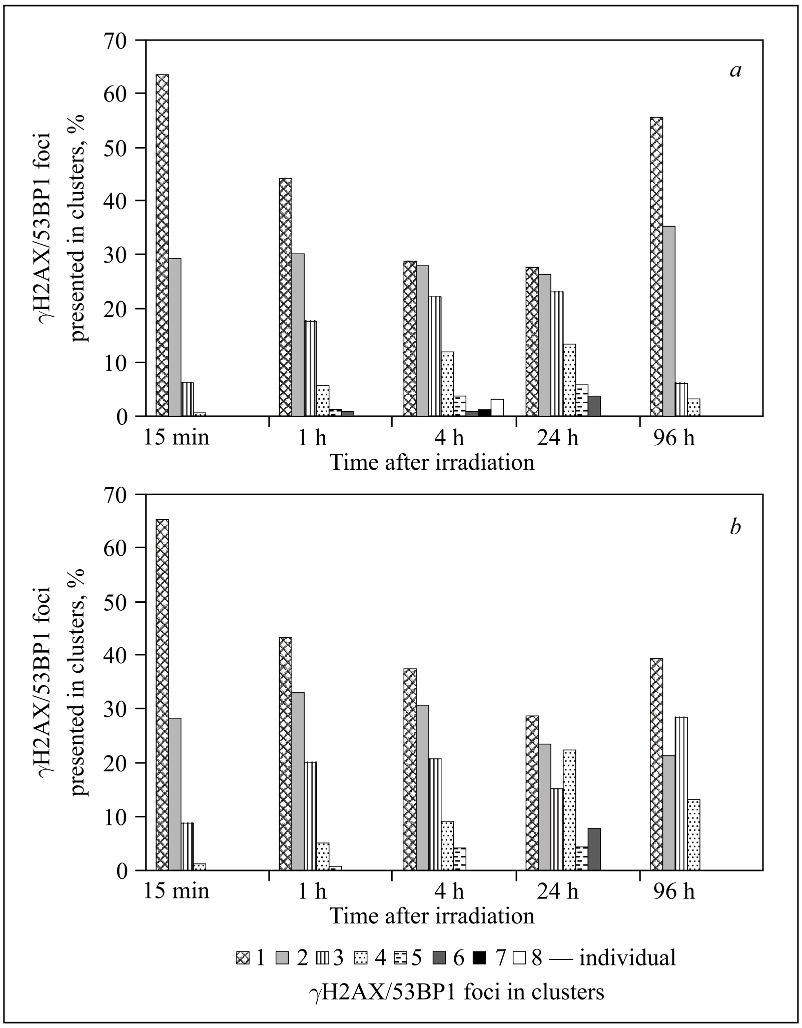

Fig. 3. Distribution of individual foci in complex γH2AX/53BP1 clusters after exposure to accelerated ions: *a*) ^{20}Ne (34 MeV/nucleon energy; LET 171 keV/μm); *b*) ^{11}B (25 MeV/nucleon energy; LET 55 keV/μm)

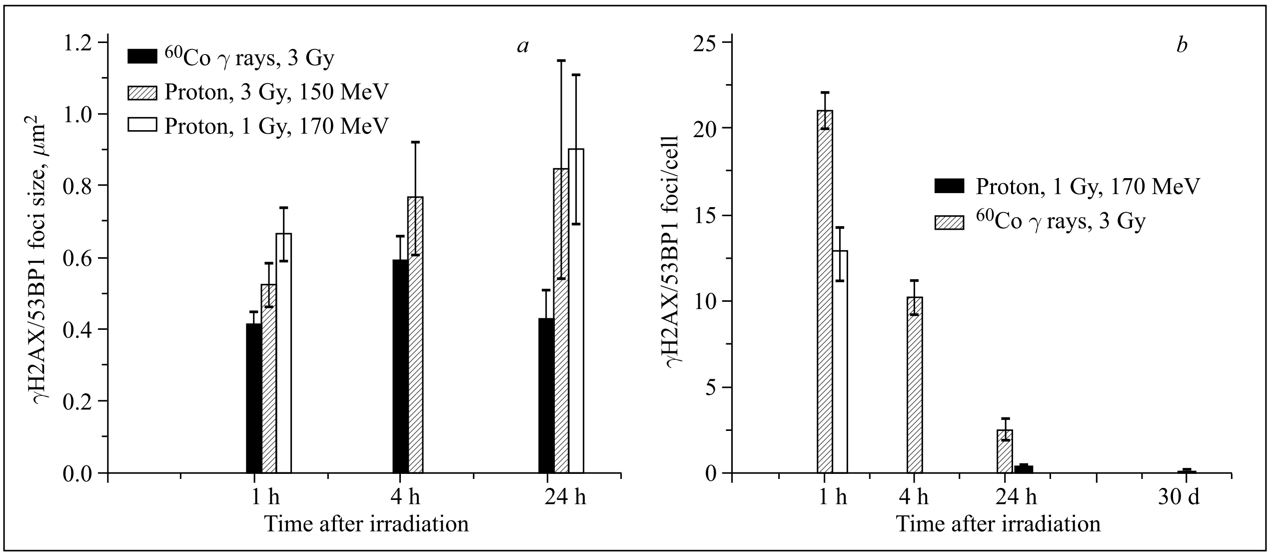

Fig. 4. *a*) The area of γH2AX/53BP1 foci induced by ^{60}Co γ rays at a dose of 3 Gy, 150 MeV protons at 3 Gy, and 170 MeV protons at 1 Gy. *b*) γH2AX/53BP1 foci yield after 170 MeV proton exposure at a dose of 1 Gy and ^{60}Co γ-ray exposure at 3 Gy

inhibitors cytosine arabinoside (AraC) and hydroxyurea (HU) after irradiation with γ rays and accelerated ^{11}B ions with different LET (44, 89, and 127 keV/μm) (Fig. 5). With increasing ^{11}B ions' LET, attenuation of the modifying effect of the repair inhibitors on DNA DSB yield is observed, which points to a change of the spectrum of the lesions induced by ionizing radiations with different characteristics.

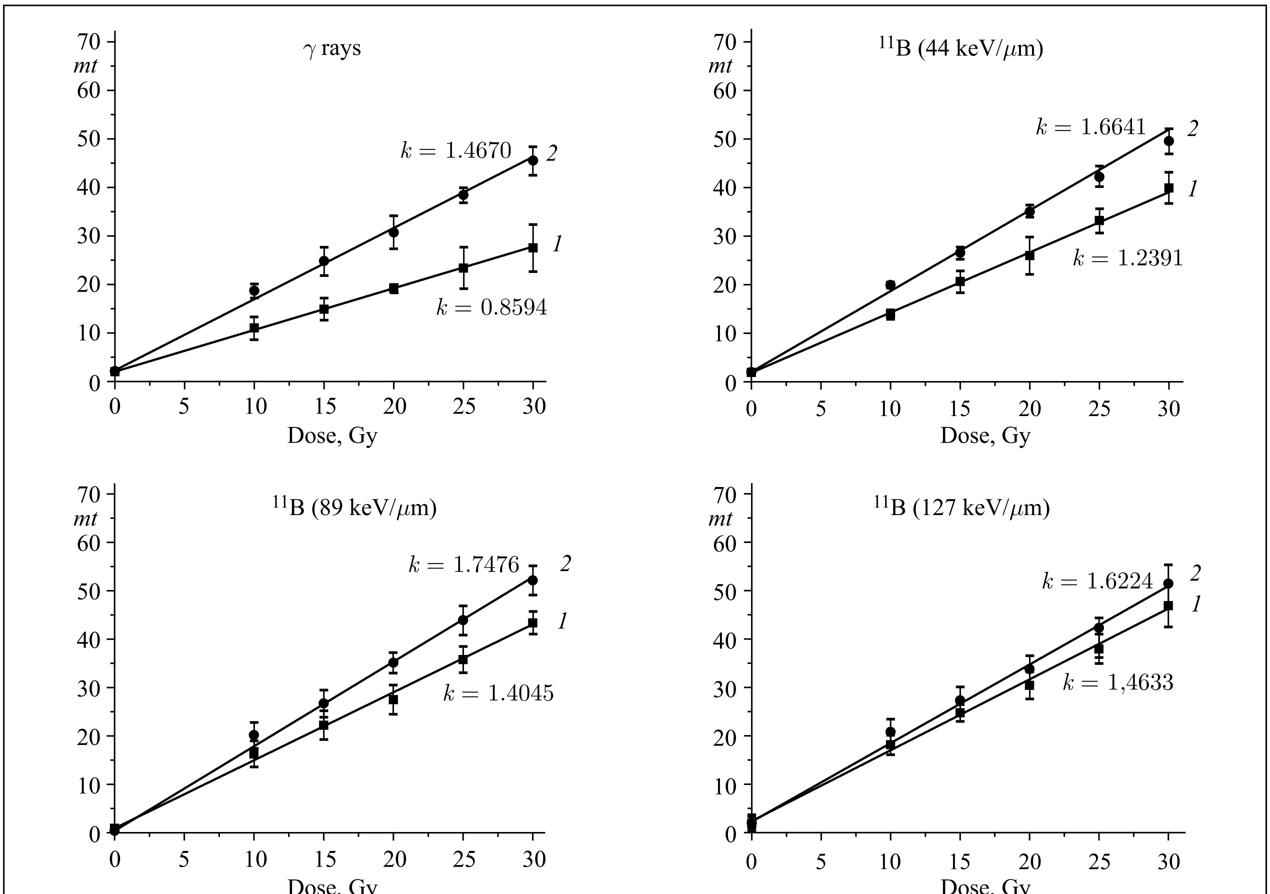

Fig. 5. A dose dependence of the parameter mt for irradiation with γ rays and accelerated ^{11}B ions with different LET: (*1*) under normal conditions; (*2*) in the presence of the inhibitors AraC and HU

Research was continued on the regularities in the formation and repair of molecular damage in mouse hippocampal cells. It is known that hippocampal neurogenesis continues throughout the organism's life; however, the ratio of the quantities of the stem and highly differentiated neurons changes with age, which should reflect on hippocampal radiosensitivity. Regularities were studied of DNA DSB induction and repair in hippocampal neurons of mice of different ages *in vivo* and *in vitro* after exposure to ^{60}Co γ rays. Age-related differences were detected in the yield of DNA DSBs induced by γ rays. It was shown that for irradiation *in vivo* repair kinetics is complicated and is fundamentally different from exponential kinetics observed for irradiation *in vitro* (Fig. 6) [8].

The first experiments were conducted on the irradiation of human blood lymphocytes with neutrons from a ^{252}Cf source in 4π geometry at the Frank Laboratory of Neutron Physics, JINR. The neutron dose rate was 131.5 μGy/s. The 30-minute exposure dose was 0.23 Gy; 60-minute, 0.47 Gy. To analyze the obtained data, metaphases of the first post-irradiation cell cycle were studied. The percentage of aberrant cells and the frequency and spectrum of chromosomal aberrations are presented in Table 1; the dose dependence of the aberration frequency, in Fig. 7. The relative biological effectiveness (RBE) coefficients calculated as the ratios of isoeffective doses of ^{60}Co γ rays and neutrons for 30- and 60-minute exposures were $\sim$10.0 and $\sim$5.6, respectively. As expected, the RBE values depend on the dose and fixation time: they were higher for the lower dose and longer research time, when heavily damaged cells reached mitosis.

With the use of the chemically induced premature chromatin condensation technique, the induction and repair were studied of chromosomal damage in human peripheral blood lymphocytes after exposure to ionizing radiations of different quality. This method allows calculation of the number of chromatin breaks immediately after exposure, observation of repair kinetics, and measurement of the residual level of chromatin breaks in G_2-phase cells. The initial and final levels of the dam-

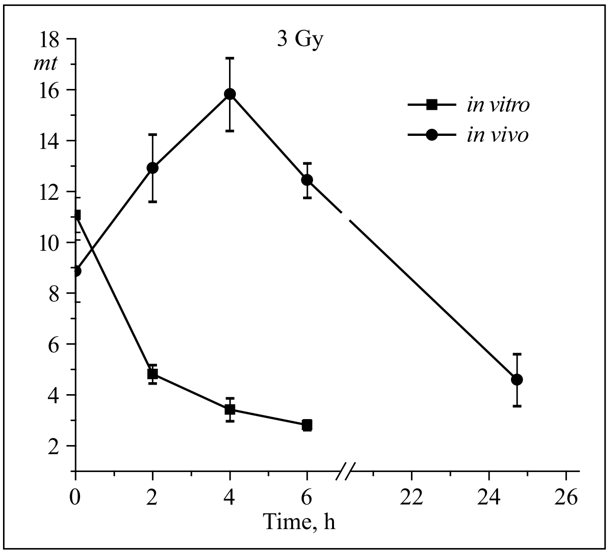

Fig. 6. DNA DSB repair kinetics in hippocampal cells for γ-ray exposure *in vivo* and *in vitro*

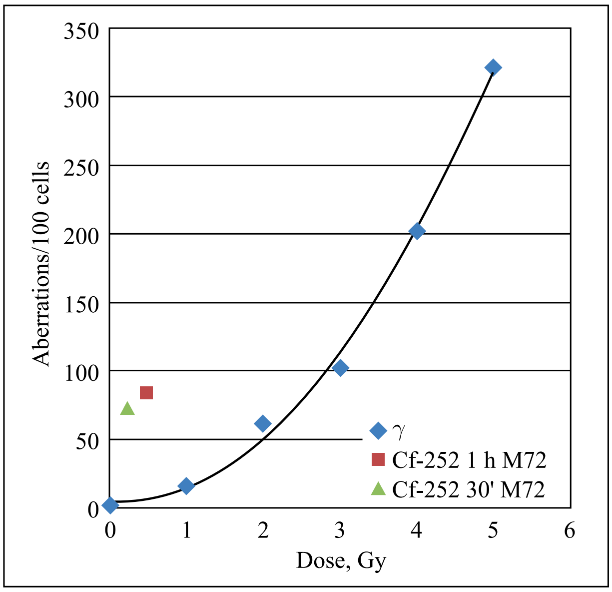

Fig. 7. The dose dependence of the chromosomal aberrations

Table 1. The frequency of neutron-induced chromosomal aberrations in peripheral human blood lymphocytes

Time	Dose, Gy	Cells scored	Aberrant, cells %	Aberrations per 100 cells							Aberrations per 100 cells	Aberrations/ aberrant cell
				Ctb	Csb	Race	Dic	Rings	Trans	Cte		
M48	0	100	1	1							1	1.0
	0.23	100	31	1	13	4	20	2	1	0	41	1.3
	0.47	100	36	1	11	9	27	3	0	2	53	1.5
M72	0	100	2	1	1						2	1.0
	0.23	100	41	2	16	5	40	6	3	0	72	1.8
	0.47	100	47	1	26	10	41	2	3	1	84	1.8

Note. Ctb — chromatide fragments; Csb — chromosome fragments; Dic — dicentrics; Race — acentric rings; Rings — centric rings; Trans — translocations observed without karyotyping; Cte — chromatide exchanges.

age induced by 22 MeV/nucleon ^{11}B ions and ^{60}Co γ rays in human lymphocytes in the G_2 phase of the cell cycle are shown in Fig. 8. The RBE coefficient of the boron ion is 2 for the initial and more than 10 for the final level of damage; the latter ultimately determines the biological effectiveness of radiation.

The damaging and mutagenic action was studied of 150 MeV protons and ^{60}Co γ rays on haploid eukaryotic organisms: the yeast *Saccharomyces cerevisiae* and the alga *Euglena*. It was shown that their survival rate was not different for proton and γ-ray exposure (Fig. 9, *a*). No differences were observed in the mutagenic effect, too. In particular, for yeast cells, the frequencies of frameshift mutations (Fig. 9, *b*), direct gene mutations, and recombination were the same after exposure to γ rays and protons at doses up to 35 Gy [9, 10].

Mutagenesis induced in yeast cells by accelerated 12–34 MeV/nucleon ^{11}B ions with different LET (44 and 60 keV/μm) was studied. It was shown that cells' sensitivity to the lethal action of radiation increases with increasing LET (Fig. 10, *a*). For LET of 44 and 60 keV/μm, the relative biological effectiveness (RBE) coefficients were 1.8 ± 0.5 and 2.8 ± 0.5, respectively. But for the induction of base pair substitutions, RBE did not depend on LET; for the frameshift and direct mutations in the *CAN1* gene, decreased. Along with this, the RBE of inducing chromosomal restructurings increased (Fig. 10, *b*) and was 5.4 and 6.6 for LET of 44 and 60 keV/μm, respectively [11].

For yeast cell exposure to ^{60}Co γ rays and 46 MeV/nucleon ^{15}N ions with different LET (67 and 177 keV/μm), the biological effectiveness of the lethal action of nitrogen ions was the same for both LET values and higher than that of γ rays (Fig. 11, *a*). Nitrogen ion exposure induced twice as many lethal lesions (RBE 2.4–2.9) as γ rays. However, for different mutation types, for example, frameshifts (Fig. 11, *b*), base pair substitutions, direct gene mutations Can^R, and chromosomal recombination, nitrogen ions' was ~ 1 (RBE 1.0–1.5).

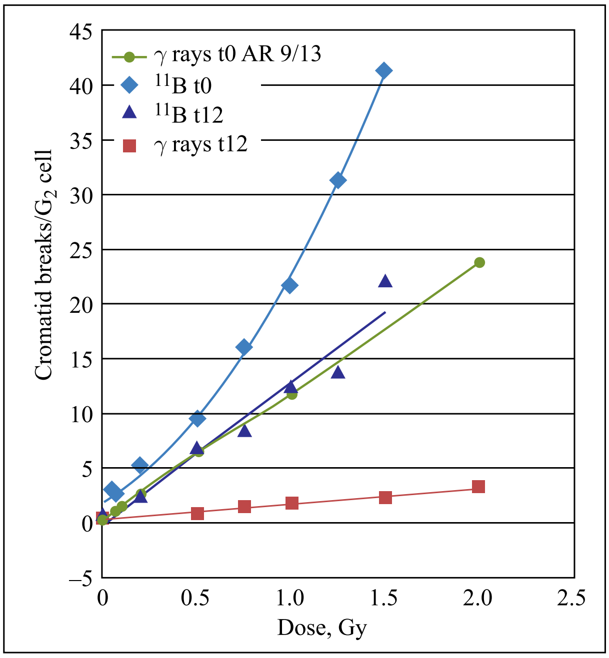

Fig. 8. The initial (t0) and final (t12) yield of chromatid breaks induced by 22 MeV/nucleon ^{11}B ions and ^{60}Co γ rays in human peripheral blood lymphocytes in the G_2 phase of the cell cycle

The identified regularities in the development of mutagenesis, including the one induced by UV light and γ rays, were analyzed and summed up in a series of reviews of the molecular mechanisms of cell response to damaging exposure, in particular, repair, mutagenesis, and checkpoint control, which arrests the cell cycle and provides time for DNA repair [12–15].

Radiation-induced mutagenesis was studied in V79 Chinese hamster cells after exposure to accelerated heavy charged particles with different LET (50, 116,

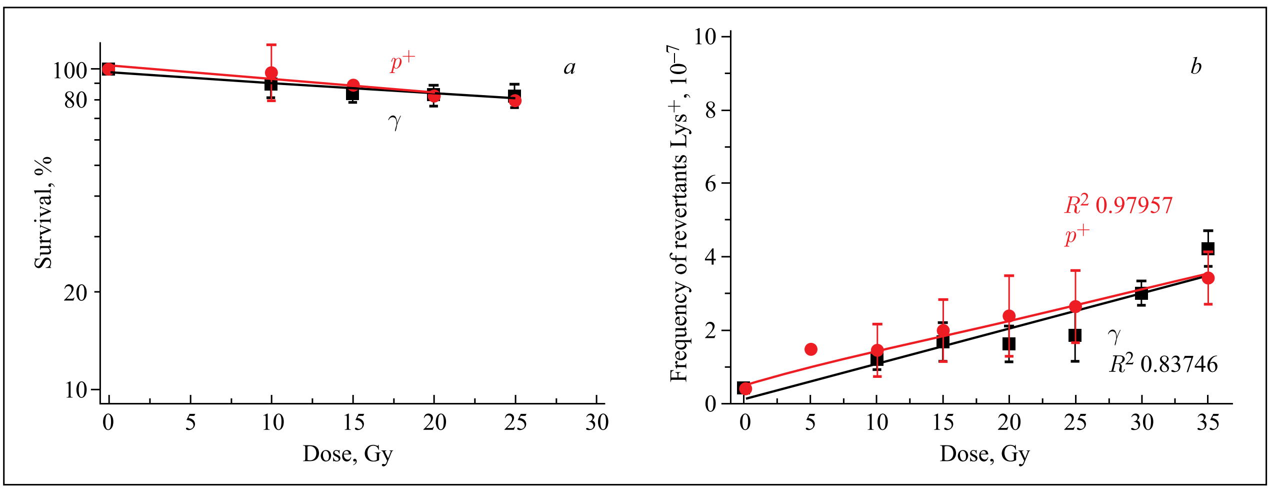

Fig. 9. The dose dependence of the survival rate (*a*) and frameshift mutation frequency in the LYS2 gene (*b*) for proton and ^{60}Co γ-ray irradiation of *Saccharomyces cerevisiae* yeast cells

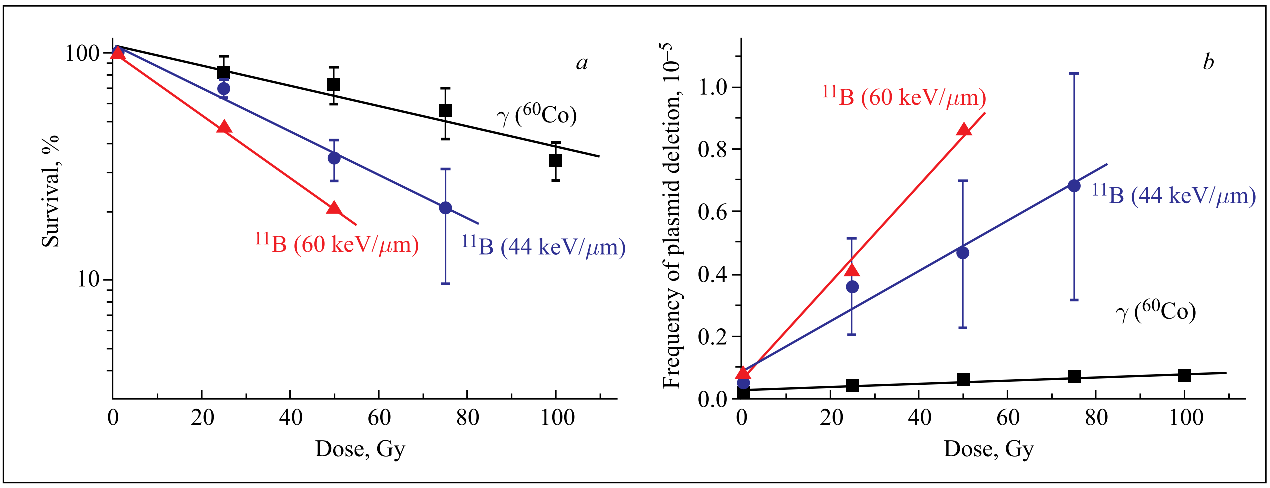

Fig. 10. Dose dependences of the survival rate (*a*) and deletion formation (*b*) for yeast cell irradiation with ^{60}Co γ rays and accelerated ^{11}B ions with LET of 44 and 60 keV/μm

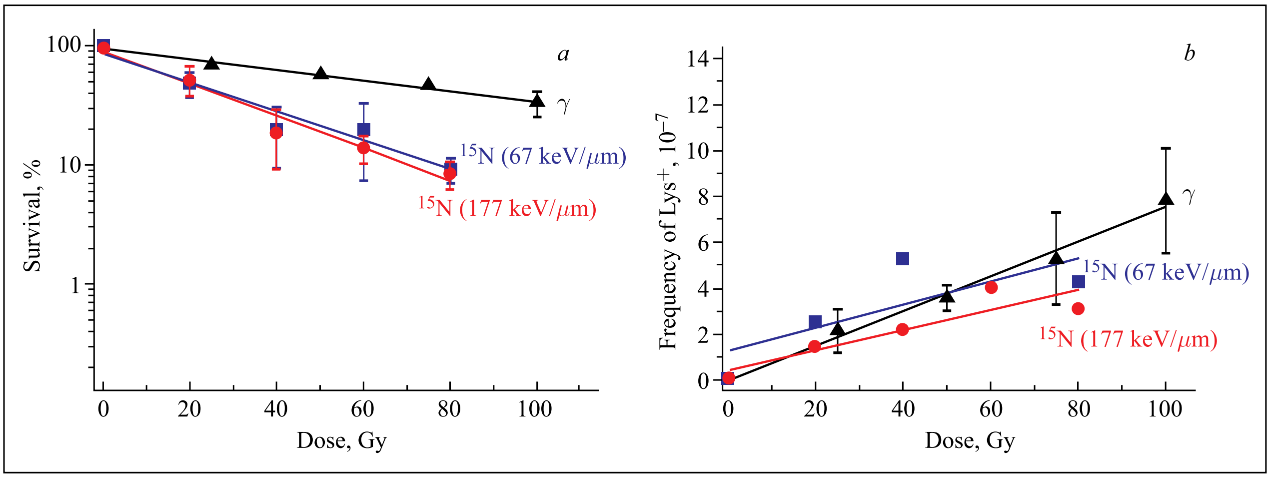

Fig. 11. Dose dependences of the survival rate (*a*) and frameshift mutation frequency (*b*) for yeast cell irradiation with ^{60}Co γ rays and accelerated ^{15}N ions with LET of 67 and 177 keV/μm

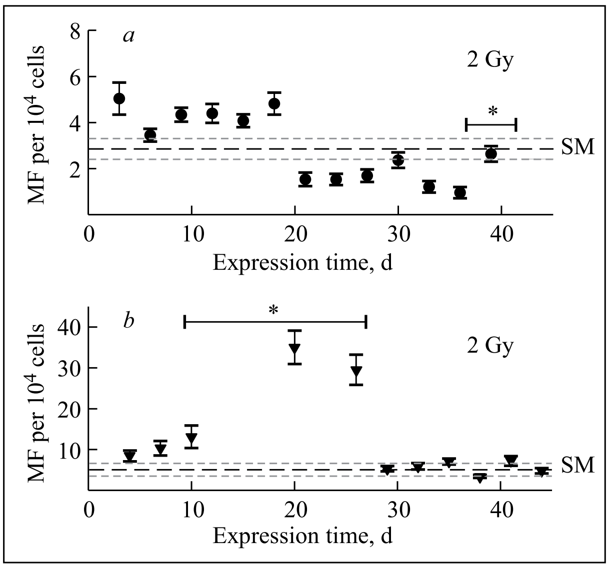

Fig. 12. The mutant fraction (MF) induced by γ rays (*a*) and ^{20}Ne ions (*b*) at a dose of 2 Gy as a function of expression time. SM is the mean MF value of spontaneous mutants. Asterisk denotes a significant difference ($p < 0.05$) between the radiation-induced and spontaneous MF

138, and 153 keV/μm) and γ rays [16]. A correlation was found between radiation-induced mutagenesis in the HPRT gene and expression time after heavy ion exposure. A monotonic decrease with time in mutant cell formation was observed after ^{60}Co γ-ray exposure (Fig. 12, *a*); however, for high-LET radiations the dependence is not monotonic and has a pronounced maximum (Fig. 12, *b*). With increasing heavy ions' LET, the mutant fraction maximum is reached at longer expression times. The dependence of the location of the mutant fraction yield maximum on LET can be fitted well with an exponential function. These effects are probably connected with the differences in the spatial distribution of energy in accelerated ion tracks.

RADIATION PHYSIOLOGY

In an experiment conducted at the Nuclotron, JINR's Laboratory of High Energy Physics, cytological effects were studied in the rat cerebellum after exposure to 500 MeV/nucleon ^{12}C ions at a dose of 1 Gy. An increase was observed in the proportion of destructively changed neurons in the cerebellar cortex (Table 2). For heavy ion exposure, the dynamics of the formation of morphological changes indicates more clearly pronounced radiation-induced effects in the central nervous system [17]. Along with cytological effects, the animals' behavioral reactions were studied. Laboratory rats were tested at an open field apparatus. Behavioral

Table 2. The number of Purkinje cells in the rat cerebellar cortex on the 30th and 90th days after exposure in different experimental groups

Time after exposure, d	Animal group	Number of animals	Proportion of neurons, %		
			1st group	2nd group	3rd group
30	Control	4	67.7 ± 2.6	28.1 ± 2.7[1]	4.2 ± 1.4
	γ	5	54.3 ± 6.3	35.8 ± 6.1[1]	9.9 ± 0.4*[1]
	^{12}C	5	49.2 ± 3.1	34.6 ± 2.8*	16.2 ± 2.3**[1]
90	Control	4	75.5 ± 1.0	20 ± 2.0	4.5 ± 1.6
	γ	4	71.0 ± 3.2	24.1 ± 3.2	4.9 ± 0.8
	^{12}C	5	61.8 ± 2.3	30.3 ± 1.5**	7.9 ± 1.0**

* Reliably different from the control.

** Reliably different from the control and γ-irradiated groups.

[1] Reliably different from the 90th day's indicators; $p < 0.05$.

Note. 1st neuron group — normochromic neurocytes; 2nd — cells with morphofunctional and compensatory adaptive changes; 3rd — neurons with dystrophic changes.

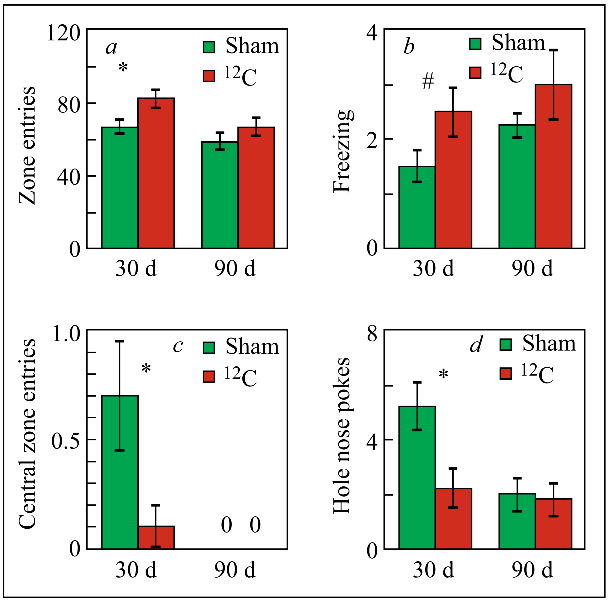

Fig. 13. Changes in behavior indicators in an open field test after exposure to carbon ions at a dose of 1 Gy: *a*) number of zone entries; *b*) freezing; *c*) central zone entries; *d*) hole nose pokes. The sham-irradiated rats were subjected to transportation and the stress of being kept in restrainers

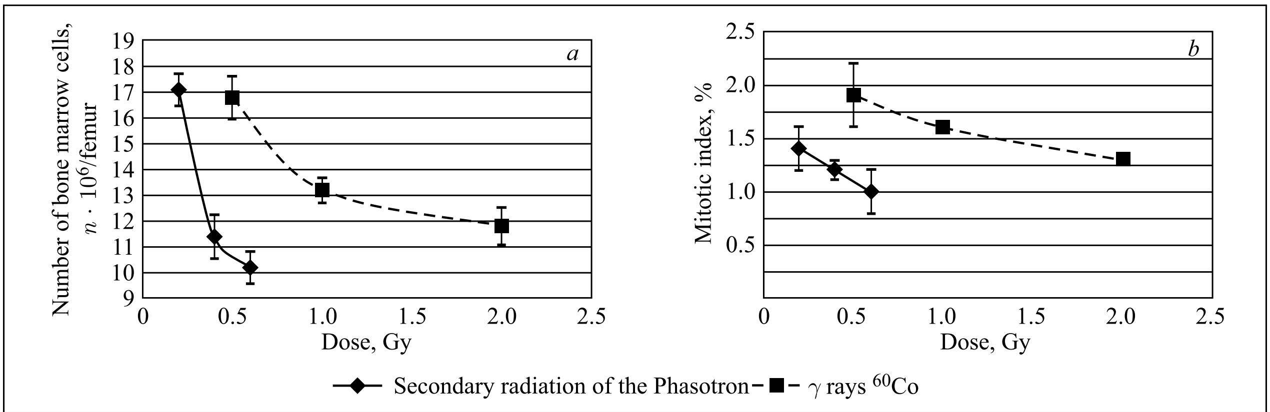

Fig. 14. The effect of mouse exposure to neutrons and ^{60}Co γ rays in the Phasotron's field on the number (*a*) and mitotic index (*b*) of marrow cells

reactions were recorded on the 30th and 90th days after exposure. An analysis of the behavior elements at these times showed an increase in the level of anxiety and changes in locomotor and exploratory activities in the irradiated animal group (Fig. 13).

In an experiment at the Phasotron (JINR's DLNP), a mixed neutron, proton, and photon radiation field was generated that approximated to the radiation field inside a spacecraft during a solar proton event. It was found that the biological effectiveness of this type of secondary radiation, estimated by the number and mitotic activity index of marrow cells and the mass of thymus and spleen, is 1.89–7.7 times as strong as standard γ radiation (Fig. 14) [18, 19].

MATHEMATICAL MODELING OF RADIATION-INDUCED EFFECTS

To overcome the computational difficulties of modeling radiation-induced effects in neural networks of the hippocampus, simplified models of neurons were developed matching the real neural morphology in geometry and electrophysiological properties [20–23]. With the use of the Monte Carlo software toolkit Geant4-DNA, it was shown that the distributions of energy deposition events and radiolysis products are the same for irradiation with 170 MeV protons, 290 MeV/nucleon carbon ions, and 600 MeV/nucleon iron ions — in both simplified and realistic models of the granular and pyramidal neurons of the hippocampus (Fig. 15).

Energy deposition events and radiolysis product formation were calculated in structures of the main types of synaptic receptors (NMDA, AMPA, and GABA(A)) and membrane ion channels (K^+, Na^+, and Ca^{2+}). With the use of the GEANT4 software toolkit, calculations were performed for protons and iron ions of different energies near the Bragg peak. In each model of ion channels and receptors, estimated were the frequency distribution of energy deposition events (the number of ionizations) inducing direct damage and the concentration of free radicals causing indirect damage. It was shown that the membrane protein complexes of the K^+ ion channel have the lowest level of direct and indirect damage; the synaptic GABA(A) receptors, the highest (Figs. 16 and 17) [24]. The modeling results confirm the experimental data showing that the synaptic recep-

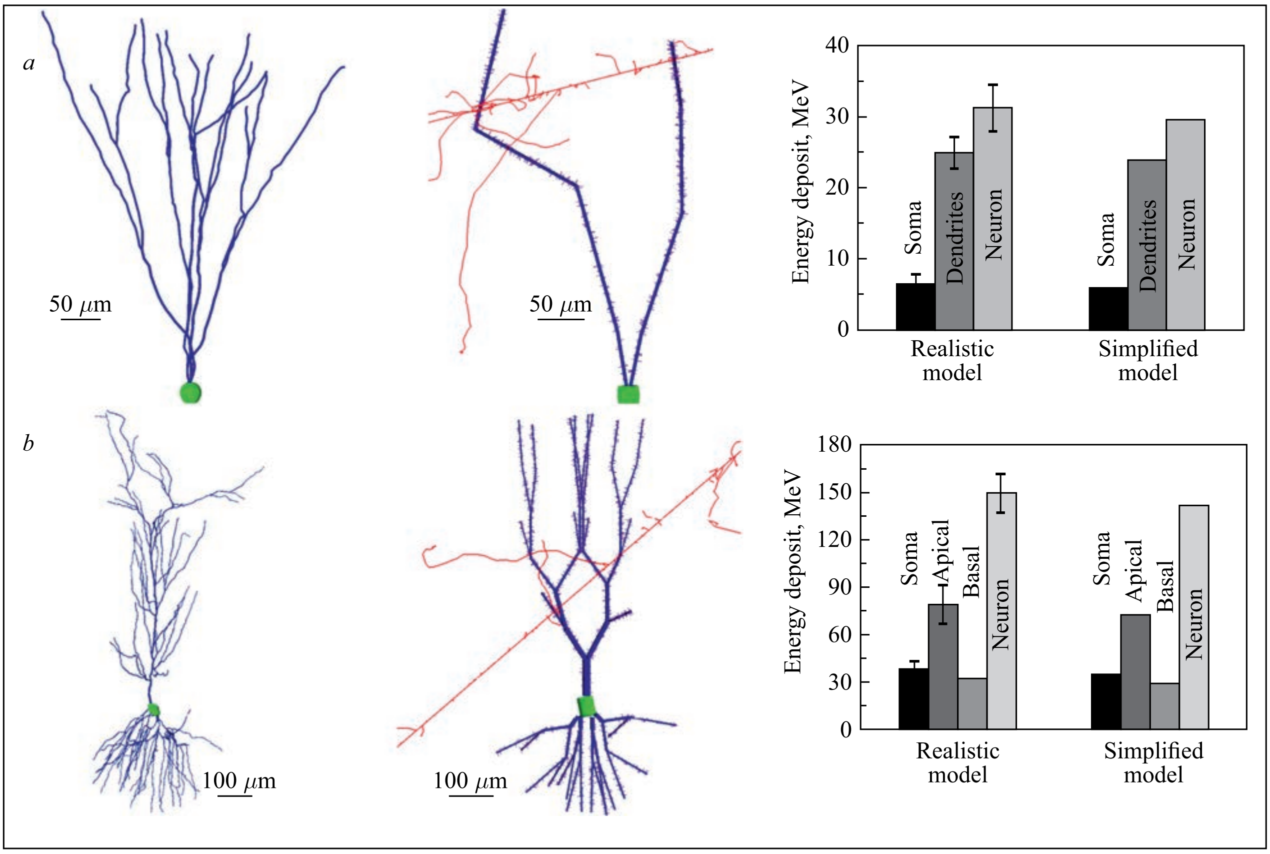

Fig. 15. Total energy deposition in a realistic (left) and simplified (right) models of a granular cell (*a*) and a pyramidal cell (*b*) of the hippocampus for irradiation with 290 MeV/nucleon carbon ions at a dose of 10 cGy. The particle track is red

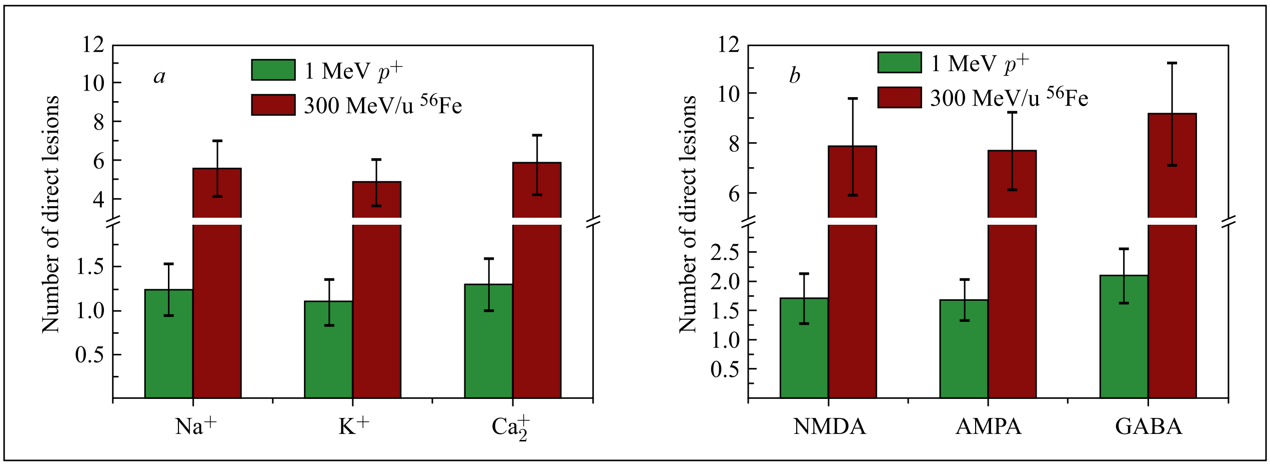

Fig. 16. The mean number of ionization-induced direct lesions calculated using a membrane ion channel model (*a*) and a synaptic receptor model (*b*) for irradiation with 1 MeV protons and 300 MeV/nucleon iron ions

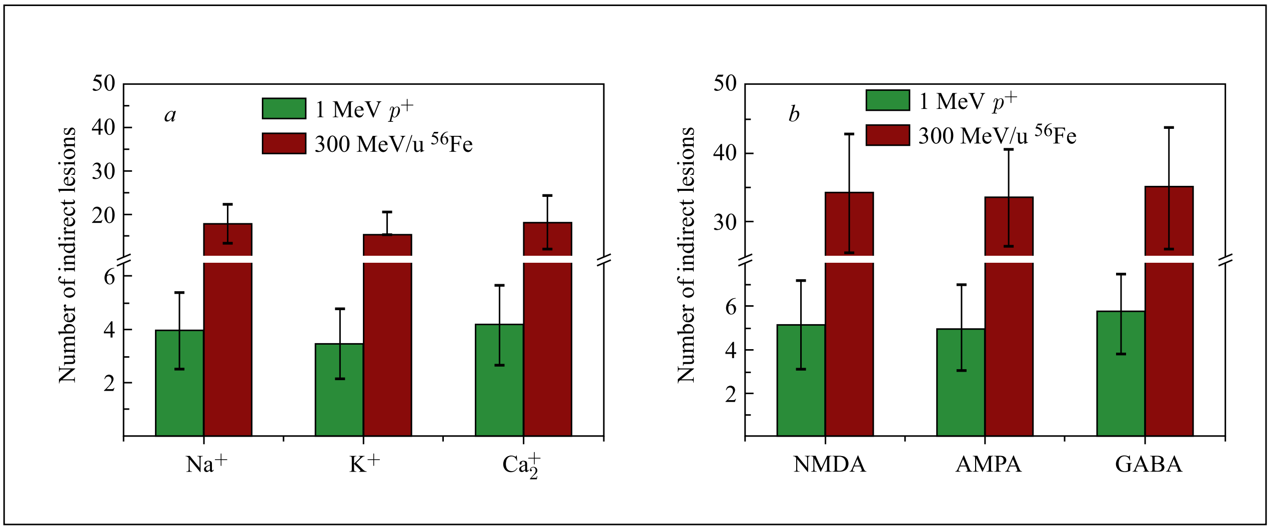

Fig. 17. The mean number of indirect lesions induced by hydroxyl free radicals (OH) calculated using a membrane ion channel model (*a*) and a synaptic receptor model (*b*) for irradiation with 1 MeV protons and 300 MeV/nucleon iron ions

tors NMDA and GABA(A) are the most probable functional objects in neural cells where heavy ion exposure can induce damage.

An approach was proposed to the mathematical modeling of the induction of different types of primary DNA damage (single- and double-strand breaks and clustered damage) by accelerated heavy ions [25–27]. With the use of the Geant4-DNA code, the spatial structure of heavy charged particle tracks was modeled. Spatial energy deposition distributions were calculated for exposure to different heavy ions in a wide LET range on the cell nucleus scale. A quantitative evaluation of the induction of primary DNA damage depending of particles' LET was done using the DUBSCAN algorithm (Fig. 18). A spatial visualization of the distribution of different DNA damage types was performed in accordance with particle track structure. The degree of DNA damage clustering was evaluated depending on particle LET.

A quantitative connection was studied between gene mutations and the synaptic receptors' functional properties, which is important for the analysis of neurodegenerative disorders caused by different diseases and radiation exposure. For the first time, computer molecular dynamics modeling allowed tracing the influence of specific gene mutation types on the dynamics of the opening of the NMDA receptor's ion channel (Fig. 19) when it is activated by neurotransmitter (glutamate) molecules. Quantitative analysis of the channel's geometry (Fig. 20) in the native and the examined mutant forms of the receptor (the double mutation 540Arg → His, 615Asn → Leu) displayed an about twofold decrease in ion conductance, which determines the formation of the postsynaptic action potential. A receptor synthesized from mutant forms of the NR2 subunits would thus have a decreased ability for the transmission of the action potential, which might cause an effect like synaptic depression.

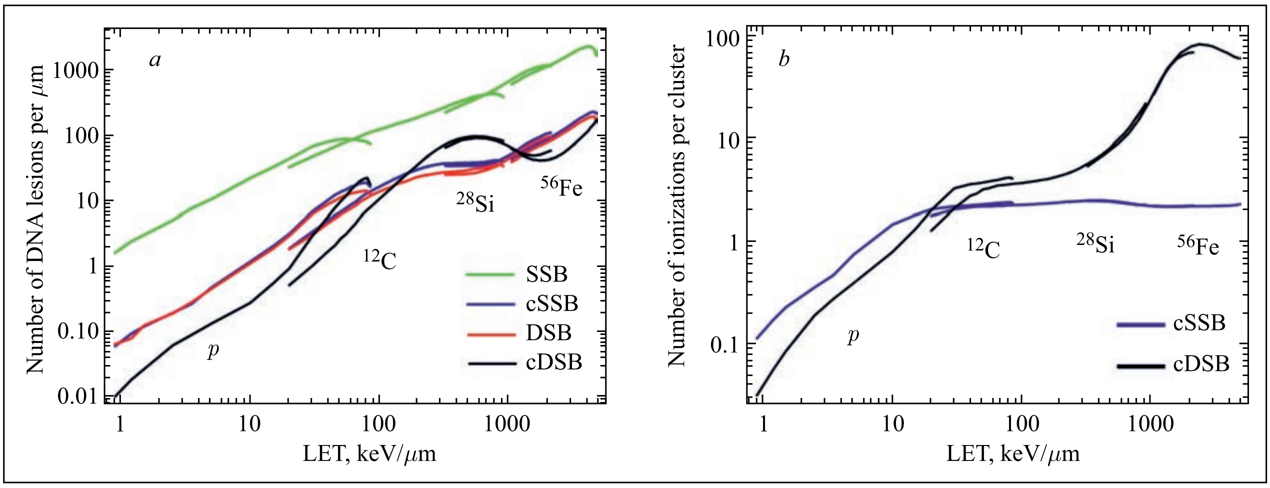

Fig. 18. *a*) Induction of primary DNA damage per particle track length μm: single-strand breaks (SSB), clustered SSB (cSSB), double-strand breaks (DSB), and clustered DSB (cDSB). *b*) Clustered damage structure

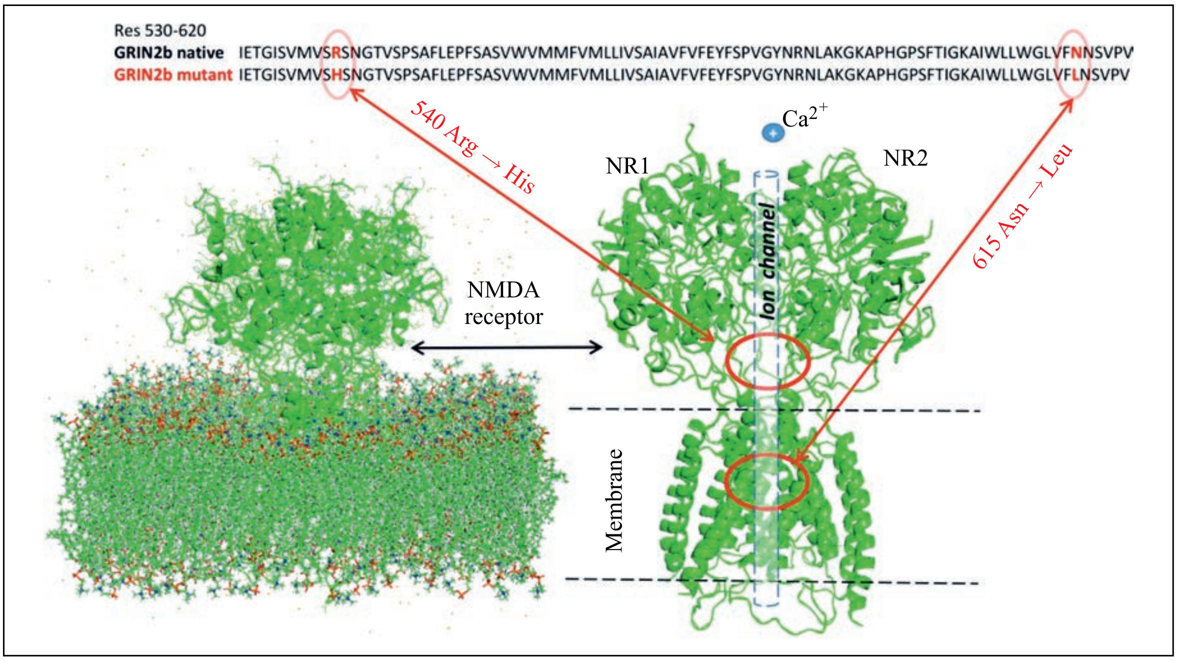

Fig. 19. The molecular structure of the NMDA receptor embedded into the cell membrane (left). The action of the mutations of the considered types on ion channel's parts (right, red) consists in a replacement of the specified amino acids in the sequence encoded by the *GRIN2b* gene

Molecular dynamics techniques were also used to study the specifics of a lipid bilayer's interaction with potential radioprotective molecules, in particular, the ones that attenuate the negative consequences of oxidative stress. The influence of molecules of two sulfoxide types — DMSO and DESO — on a lipid bilayer was compared; the latter was found to be more advantageous [28].

Research was continued on the intracellular signal transport in the nervous cell cytoskeleton [29, 30]. The model of cellular microtubes' nonlinear dynamics was improved. It was shown that the correct account of spatial dispersion and anharmonicity of the interaction of two neighboring subunits of a polymer allows the existence of two different types of travelling wave-like signals: bipolar pulses and kinks. It was found that a change in the interaction potential in the key types of chemical bonds in this polymer system can lead to a selective disorder of intracellular signaling.

Mathematical models of pyramidal neurons of the CA1 and CA3 regions of the hippocampus were developed [31], describing the membrane and biochemical processes underlying the generation of the action potential. The models of the spatial structure of these neurons were adapted for microdosimetry calculations of energy deposition in charged particle tracks (see above). Examples were studied of the generation of action potential bursts with synaptic transmission being blocked.

The dynamics was studied of neural activity in the prefrontal cortex during working memory functioning [32]. A biophysical model was developed, which is a neural network made up of pyramidal neurons and interneurons connected by glutamatergic (AMPA, NMDA) and GABAergic (GABA(A)) synapses. For each neuron, considered also were the ion channels of the main types (Na, K, Ca) on its membrane. During a short capture of information on some object, space-ordered structures with high cell activity emerge in the prefrontal cortex. To evaluate the radiation-induced disorders of working memory, experimental data on changes in the concentrations of the synaptic receptor proteins, neuromediator level, and membrane ion channels' conductance were included in the model. An absorbed dose threshold was identified above which the stability of the neural network-specific space-time structures is lost.

RADIATION PROTECTION PHYSICS AND RADIATION RESEARCH

Two radiobiological sessions were conducted at 46 MeV/nucleon ^{15}N nuclear beams at the MC-400 cyclotron, JINR's Laboratory of Nuclear Reactions. In one of the experiments, grape snail brain neurons were irradiated; their electrophysiological activity was measured immediately during exposure to ^{15}N nuclei with a mean LET value of 87 keV/μm.

Work was continued on the prediction of the radiation environment of the NICA complex during its operation. In particular, for the sanitary protection zone border, the radiation component was estimated that would be produced by the BM&N experiment facility with a fixed target in Building 205. A report on the radiation conditions at the complex under design was presented at a session of the NICA Machine Advisory Committee.

With the use of Monte Carlo software toolkits MCNPX and GEANT4 for the analysis of radiation transport in matter, calculations were performed of hadron fields inside a spacecraft's habitable module with aluminum skin thickness of 15 g/cm^2 exposed to light particles (p, d, ^{3}He, ^{4}He) of galactic cosmic radiation (GCR) beyond Earth's magnetosphere during solar minimums and maximums. Spectral distributions of the fluences of internal protons, neutrons, charged π and K mesons, deuterons, ^{3}He and ^{4}He nuclei, and γ quanta were obtained, averaged over the module's volume. Realistic values were calculated of the fluence–effective dose conversion coefficients based on the relative biological effectiveness dependences on linear energy transfer and using tissue weighting coefficients for the cohort of adult men, which is close to the cosmonaut cohort. By the convolution of internal particle spectra and energy dependences of the fluence–effective dose conversion coefficients, partial doses were calculated for cosmonauts inside the habitable module from different components of the radiation field at solar minimum and maximum.

On the basis of the performed calculations, a methodology has been proposed of generating a mixed field of protons, neutrons, and π mesons at the Nuclotron's 10 GeV proton beam in order to model a radiation field (averaged over solar activity) generated by GCR's light particles inside a spacecraft's habitable module [33]. This reference field can be produced in a fixed space volume by a linear combination of the fields of secondary particles emitted from three different polyethylene and beryllium targets at different angles. The advantage of the proposed technique is that it allows a relatively simple generation of an energy-continuous mixed hadron field under terrestrial conditions which would adequately model a real radiation field where crew would be working.

With the participation of specialists from the Institute of Space Research of the Russian Academy of Sciences, space equipment tests were continued at the DAN (Dynamic Albedo of Neutrons) experimental stand.

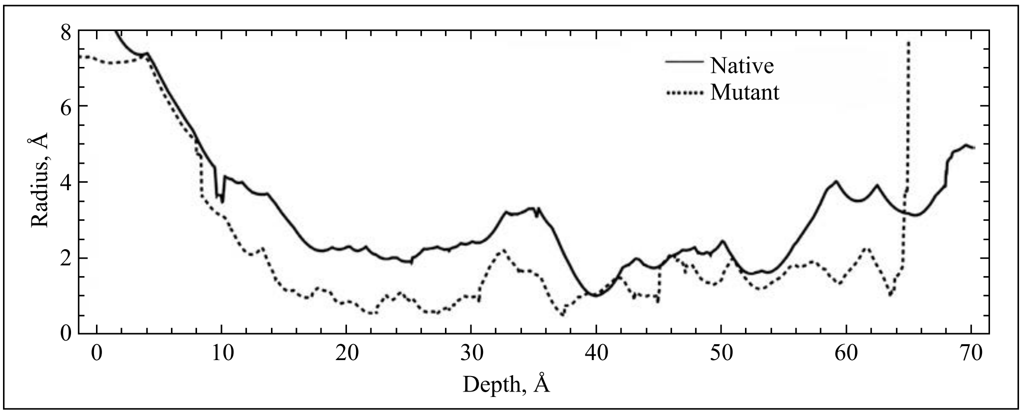

Fig. 20. The dependence of the radius of the activated (open) ion channel of the NMDA receptor on its depth for the native and mutant forms of the NR2B subunits of the protein complex

Production of nucleosides under abiotic conditions is necessary for the formation of living systems. In collaboration with the LRB's colleagues of Tuscia University (Viterbo, Italy), experiments were conducted on the synthesis of RNA and DNA component nucleosides in the system formamide (FA) + meteorite matter exposed to ionizing radiation (accelerated protons). Matter of chondrite meteorite NWA1465 was used as a synthesis catalyst. The pathway was determined of the general reaction that leads to the synthesis of ribo- and 2′-deoxyribonucleasides from sugars and purine nucleotides under exposure to 170 MeV protons in the presence of NWA1465 matter — these factors simulate the supposed conditions in space or on early Earth. The reaction requires neither pre-activated precursor molecules nor any intermediate stages. The synthesis is based on a certain radical mechanism and is characterized by stereoselectivity, regioselectivity, and (poly)glycolysis. The yield of the reaction products is much higher in the presence of formamide and meteorite matter than in the control (Table 3). The results were published in [34].

A scanning electron microscope (SEM) Tescan Vega 3 was put into service at the Astrobiology Sector in 2017. This new instrument is used to search for fossilized remains of microorganisms in meteorites (Orgueil and Murchison). They were found to contain a wide variety of well-preserved remains of cyanobacteria, ray fungis, diatoms, prasinophytes, and other microorganisms. In particular, frustules of pennate diatoms (Fig. 21) were found in fresh cleavages of interior surfaces of the Orgueil meteorite, which represents the first detection of diatoms in the Orgueil meteorite. Also found in the Orgueil meteorite were ancient microfossils (cyanobacterial threads, ray fungi threads, and prasinophytes), pyrite framboids, and magnetite slices. The energy dispersive X-ray microanalysis of the samples shows that the diatoms in the Orgueil meteorite are ancient microfossils and not a modern biological contamination. This research was reported in [35].

With a view to SEM data interpretation, extremely high-quality 2D and 3D images of meteorite matter samples and modern terrestrial epiphyte diatoms were obtained and compared. To verify the quality of energy dispersive microanalysis, modern cyanobacteria were studied. Samples of Low Cambrian rocks of Eastern Siberia (Sinyaya formation) were investigated. Hyphae — a modern contamination — were found.

In a collective monograph "Life and the Universe", results were presented of a micropaleontological study of Low Proterozoic pillow lavas of Karelia and South Africa. Various pseudomorphoses of biogenic objects were found there. It was concluded that the colonization of Earth by organisms might have begun after Earth's crust had cooled down to 113°C (other data suggest 120–130°C); colonization progressed along rifts; and water was a barrier against hard UV radiation [36].

An analysis was performed of the past two decades of astrobiological research. On the basis of this study: 1) it was suggested that remains of eukaryotic algae are present in the Low Archean rocks of the Isua formation; 2) the oxygen-free character of the Archean and early Proterozoic atmosphere was called into doubt; 3) it was concluded that water did not appear on Earth in significant amounts earlier than 4 billion years ago; 4) the time of the probable emergence of the RNA world was extended to 7 billion years ago [37].

Table 3. **The Reaction of adenine and ribose**

Conditions	Adenine [a], %	Reaction product yield, % [c]		
		α-pA	β-fA	α-fA (10) + β-pA
Dry [b]	75	7.3	2.9	14.8
FA	63	10.4	5.6	21.2
FA/NWA1465	52	6.1	20.1	16.9

Note. In the course of the reaction, furanosides (f) and pyranosides (p) are produced; they have the α- and β-isomer structure, respectively. α-fA = α-D-ribofuranosyl adenine; β-fA = β-D ribofuranosyl adenine; α-pA = α-D-ribopyranosyl adenine; β-pA = β-D-ribopyranosyl adenine.

[a] Unreacted adenine.

[b] Obtained by ribose dissolution in distilled water followed by drying.

[c] Calculated as the proportion (%) of nucleoside (mmol) to original adenine. The data are the mean results of three experiments with standard deviation not greater than 0.1%.

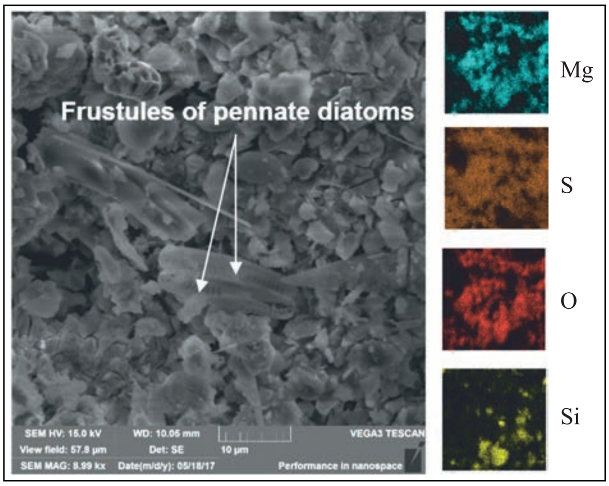

Fig. 21. Pennate diatoms in the Orgueil meteorite and energy dispersive spectra-based images of the element distribution

CONFERENCES AND EDUCATION

In 2017, the Laboratory's researchers participated in nine scientific conferences in Russia and five conferences worldwide. Jointly with the Scientific Council on Radiobiology of the Russian Academy of Sciences, a two-day conference "Modern Problems of General and Space Radiobiology" was held. It was attended by about 70 scientists from institutes and research organizations of the Czech Republic, Mongolia, Russia, and the USA. The conference programme included discussions on topical issues in space radiobiology and molecular and cell radiobiology. The main fields and tasks of further research in space radiobiology were defined.

The education process continued at the Department of Biophysics of Dubna University. The Department's current total enrolment includes 34 students and seven postgraduates. Bachelor's education is given in the field of Nuclear Physics and Technology represented by the programme *Human and Environmental Radiation Safety*; Master's education is given in the field of Physics represented by the programme *Radiation Biophysics and Astrobiology*; and postgraduate education is given in the specialty of Radiobiology. In 2017, eight students were enrolled in the Bachelor's programme; five students continued their Master's programme. Six students successfully completed education and received their Master's diplomas in the field of Physics (the programme *Radiation Biophysics and Astrobiology*).

A patent was obtained in 2017 for an invention, "An experimental method of the prophylaxis of acute radiation sickness-related psychoneurological status disorders" (A. A. Ivanov, E. A. Krasavin, K. N. Lyakhova, Yu. S. Severyukhin, A. G. Molokanov). The invention pertains to experimental medicine; it can be used in cosmonautics to keep the high level of crew's operational activity under the conditions of unforecasted radiation exposure; it can also be used for the rehabilitation of patients after the proton therapy of brain tumors.

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UNIVERSITY CENTRE

International Student Practice. International Student Practices (ISP) in JINR Fields of Research have been organized since 2004 and continue arousing steadily heightened interest among young people from the JINR Member States. About 1500 representatives of Azerbaijan, Belarus, Bulgaria, Cuba, Czech Republic, Egypt, Poland, Romania, Serbia, Slovakia, South Africa, and Ukraine have already taken part in this annual event (Fig. 1).

In total, 161 students took part in ISP 2017. They represented Azerbaijan, Belarus, Cuba, Czech Republic, Egypt, Poland, Romania, Serbia, Slovakia, and South Africa (Fig. 2).

This year, Stage 1 of the International Student Practice was opened on 29 May by 15 students from 8 universities of South Africa. The first visit of African students to JINR took place in 2007, and up to date more than 300 representatives of the African continent have taken part in the event.

Stage 2 of ISP 2017, which began on 2 July, as always, was marked by a large number of participants. In 2017, 85 students from Azerbaijan, Czech Republic, Poland, Romania, and Slovakia were selected in their countries to become participants in the event.

Sixty-one representatives of Belarus, Cuba, Egypt, Serbia, and South Africa took part in Stage 3 that was held in September. The participants went through a serious competition in their countries. For example, for Egyptian participants the competition rate was 8 people per vacancy, which is twice as high as last year.

Traditionally, the ISP programme includes lectures that introduce participants to the scientific research conducted in the laboratories of the Institute, visits to the basic facilities, and work on research projects. The social programme featured excursions to Dubna, Moscow, Tver, a trip to Lipnia island, and the "International Morning" — favourite event of the ISP participants, where they get a chance to introduce their country to students of other nationalities.

JINR-Based Education. In 2017, more than 400 students from Armenia, Belarus, Kazakhstan, and Russia studied at the University Centre of JINR. 219 students of the universities of Armenia, Belarus,

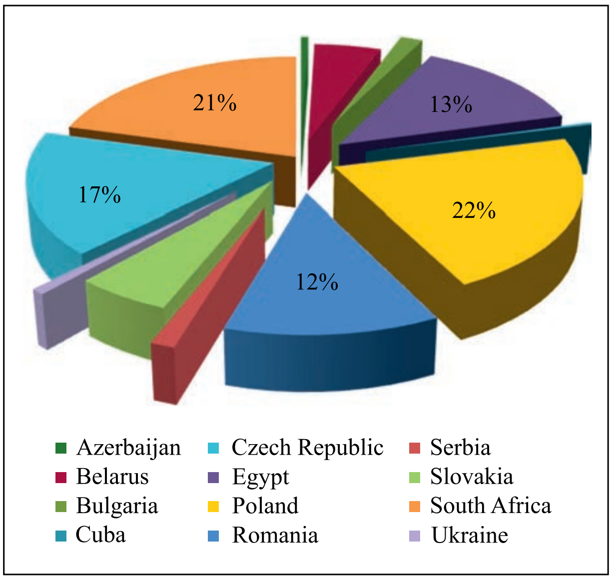


Fig. 1. Number of participants by countries over 2004–2017

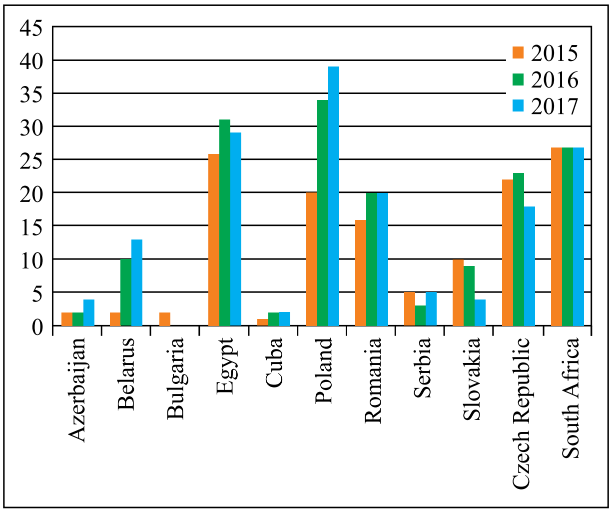


Fig. 2. Number of participants over 2015–2017

and Russia were trained at the JINR laboratories in the framework of their summer practice.

In 2017, 21 degree-seekers from Georgia, Mongolia, Kazakhstan, and Russia were attached to JINR to prepare their PhD theses without mastering postgraduate academic programmes. More than half of the applicants chose the specialty "Nuclear Physics and Elementary Particle Physics".

For 2017/2018, 88 lecture courses are available at the UC website (uc.jinr.ru) for students of the JINR-based departments of MIPT, MSU, and University "Dubna".

JINR Summer Student Programme. For 4–8 weeks, 49 students and post-graduates from Belarus, Bulgaria, Cuba, Egypt, Kazakhstan, Mexico, Poland, Romania, Russia, Serbia, Spain, and Ukraine participating in the Summer Student Programme 2017 carried out research projects in the framework of the Topical Plan for JINR Research and International Co-operation.

VIII International Summer Student School "Nuclear Physics — Science and Applications" (NUCPHYS-SC&APPL). In the summer of 2017, the Romanian city of Brasov hosted the VIII International Summer Student School "Nuclear Physics — Science and Applications" (NUCPHYS-SC&APPL). The school was organized by JINR, Transylvania University of Brasov (UTBv), Faculty of Medicine, with the support of the National Institute ICPE-CA. The school programme traditionally included lectures by the leading researchers and student reports. More than 70 students and postgraduates from Armenia, Cuba, Czech Republic, Macedonia, Poland, Russia, Romania, Serbia, and Ukraine participated in the event.

Scientific Schools for Physics Teachers at JINR and CERN. On 25 June – 1 July, JINR hosted the annual School for Physics Teachers from the JINR Member States. Eighteen teachers and 10 high-school students from Azerbaijan, Belarus, Bulgaria, Kazakhstan, Russia, and Ukraine were welcomed to participate in the school. The event programme included popular science lectures by the leading JINR specialists, visits to the JINR laboratories and the basic facilities of the Institute. The school students were involved in hands-on activities at the JINR UC Physics Lab and made reports at a scientific seminar.

On 5–12 November, the X Scientific School for Physics Teachers from the JINR Member States was held at the European Organization for Nuclear Research (CERN). The school programme, worked out for 23 teachers from Azerbaijan, Belarus, Kazakhstan, Moldova, Russia, and Ukraine, included lectures, formal and informal meetings with scientists, visits, a lab hands-on, and introduction to the local culture and history.

VII All-Russia Science Festival NAUKA 0+. At the VII All-Russia Festival NAUKA 0+ in Moscow, JINR presented its expositions at two exhibition sites. The EXPOCENTRE hosted a programme organized for visitors of all ages. It included experiments in physics and chemistry, master classes in robotics, and brain games. In the Fundamental Library of the Moscow State University, visitors were introduced to the fields of research conducted at JINR, saw the mock-ups of the Multi-Purpose Detector of the NICA accelerator complex, the IBR-2 reactor, the deep-water neutrino telescope for the Baikal experiment, and the calorimeter used in the COMPASS experiment. At both sites, popular science lectures were given by the young scientists of JINR.

JINR at the XIX World Festival of Youth and Students. Within the XIX World Festival of Youth and Students held in Sochi, the RF Ministry of Education and Science organized exhibition and discussion sites, including a site "Megascience: Russia in the World — Russia for the World". An international group of young JINR staff members presented the flagship project of the Institute — the NICA accelerator complex, and introduced the guests and participants of the festival to the educational programme and opportunities for students and postgraduates at JINR.

Open School Lessons "NICA — Universe in the Lab". The UC Department of development of Educational Programmes developed multimedia materials for the open lesson "NICA — Universe in the Lab". The lesson is available on the NICA project website. These video materials were used for open lessons in Russian schools.

Work with School Students. Physics classes including hands-on activities in the UC Physics Lab and lectures training for the Unified State Examination were held twice a week for 38 senior school students from Dubna.

Supplementary Education Centre PRIMER. In the Supplementary Education Centre PRIMER, LEGO-based robotics classes (for primary school students), classes on C programming (Arduino-based robotics), as well as trainings in mathematics, initial and project programming were organized.

Physics Days. In the spring of 2017, Dubna hosted the IV Physics Days organized by the JINR UC and the Inter-School Optional Physics and Maths Course staff. For the amateurs of physics, lectures on the scientific research at JINR, master classes, physics and maths brain games, and demonstrations of scientific experiments were organized. Within the framework of the Physics Days, the VI Robotics Tournament of the Upper-Volga Educational Cybernetics Network was held. The event was attended by school students from Bryansk, Dubna, Moscow, and St. Petersburg.

HACATHON "Racing along the Line". On 1 November, the JINR Library hosted the 1st selection round of the regional robotics competitions "Technical HACATHON — Racing along the Line" organized by the Interregional Computer School (ICS) together with JINR. Participants of the competition were school students from Dubna and Moscow. The main goal of the event was to spot and support children inclined to technical creativity.

Videoconferences. The JINR University Centre organizes and assists in running videoconferences, as well as in the broadcasting through the JINR videoconference management system. In 2017, as a videoconference, the lecture course "Introduction to the Theory of Accelerators" was read by A. Sidorin for students of the JINR-based departments and Kazan University. In addition, sessions of the joint seminar "Physics at the LHC" were broadcast.

Visits to JINR. JINR UC organizes introductory visits for school and university students and science teachers. When planning the visit programmes, UC staff members take into account the level of training and the field of interest of the guests. In 2017, about 500 science teachers and university and school students specialising in physics, mathematics, engineering, and IT visited JINR. The guests were introduced to the history and research fields of the Institute Laboratories at the JINR Science and Technology Museum. They also visited the basic facilities of JINR.

Skill Improvement Courses for JINR Staff Members. 120 JINR staff members and 5 employees of Dubna organizations were trained at the courses intended for the personnel maintaining the facilities subordinate to Rostechnadzor. 154 JINR staff members, including top executives, engineers, technicians, and specialists, were trained in the normative legal acts and normative-technical documents stating requirements for industrial safety in various industries of supervision, and certified by the Central Attestation Commission of the Institute. Ten students of MRICC and MRATT were trained at JINR.

The UC language courses were attended by 138 JINR staff members: English — 98 people, French — 12 people, German — 14 people, and Russian — 14 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, 12 May. The memorial seminar on the 80th anniversary of the birth of Academician V. Kadyshevsky

The Bogoliubov Laboratory of Theoretical Physics, 30 January – 4 February.
Participants of the Winter School on Theoretical Physics

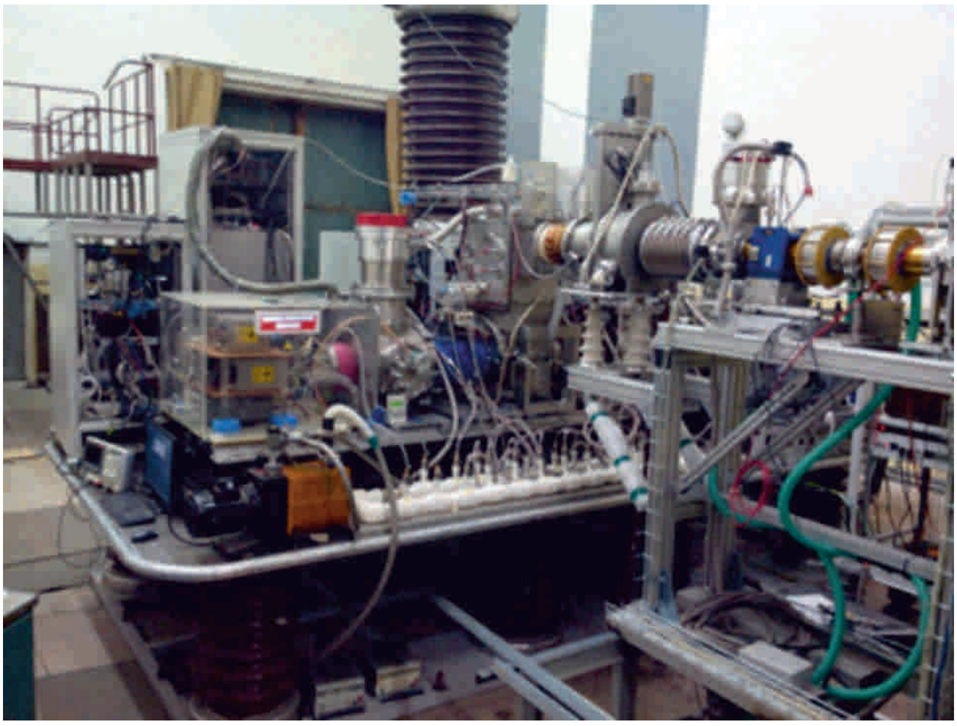
The Bogoliubov Laboratory of Theoretical Physics, 31 July – 5 August.
Participants of the workshop “Supersymmetries and Quantum Symmetries” (SQS’2017)

The Veksler and Baldin Laboratory of High Energy Physics, 21 April. The international seminar dedicated to the 60th anniversary of the synchrophasotron launching and the 110th anniversary of the birth of V. Veksler. The opening ceremony of Veksler square

Construction of the NICA collider

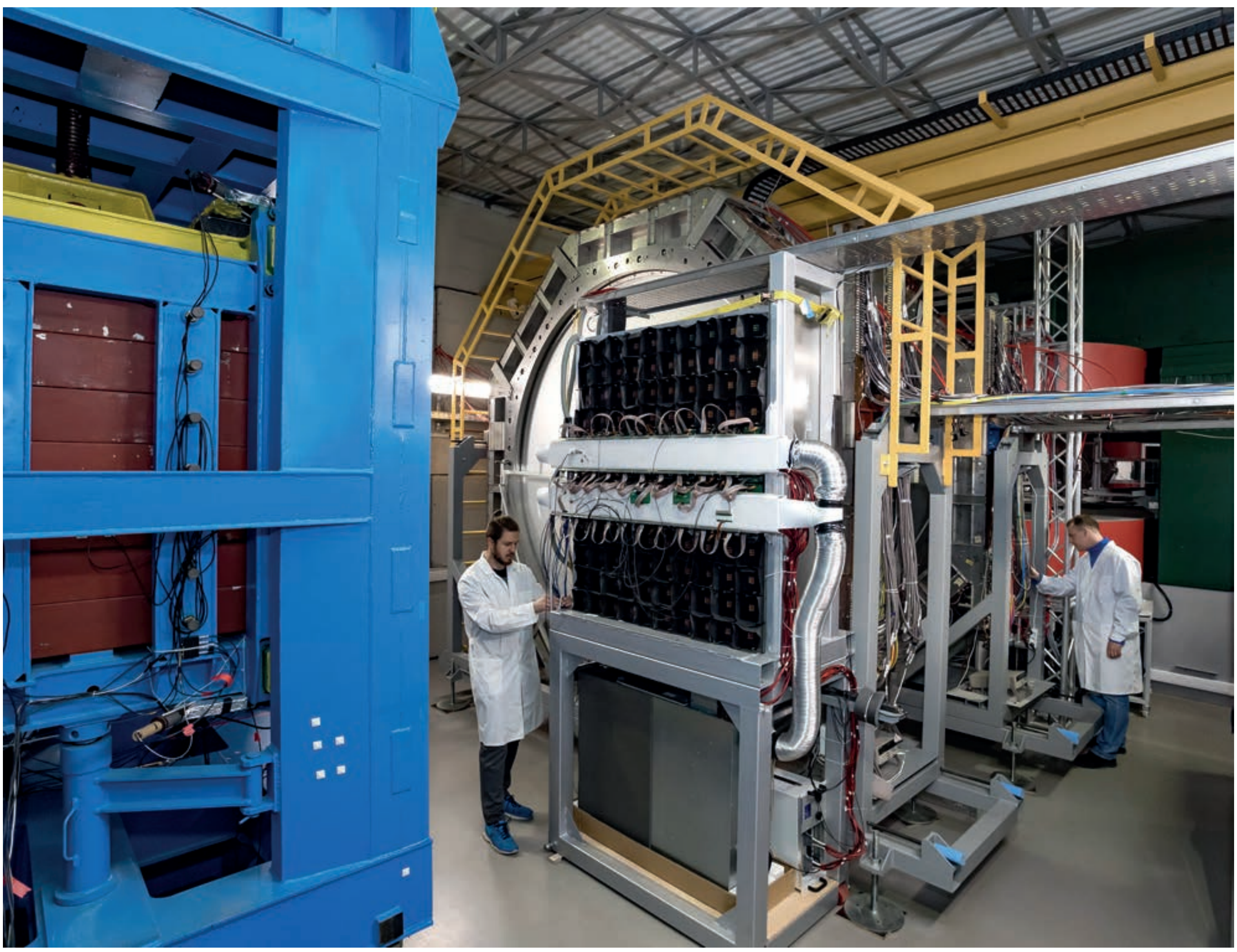
The Veksler and Baldin Laboratory of High Energy Physics. HILAC team for commissioning

The Veksler and Baldin Laboratory
of High Energy Physics. The high-intensity pulsed source of polarized ions (SPI)



Warsaw (Poland), 6–10 November. Participants of the conference “NICA Days in Warsaw”

The Veksler and Baldin Laboratory of High Energy Physics. The BM@N experimental facility



Montenegro, 24–29 April. Participants of the conference “25 Years of JINR’s Involvement in the ATLAS Collaboration”

The Dzhelepov Laboratory of Nuclear Problems.
Checking of the reading circuit plates of the Micromegas chambers for the ATLAS facility

Bolshie Koty (Irkutsk Region), 13–20 July. Participants of the Baikal Summer School
on Elementary Particle Physics and Astrophysics

The Dzhelepov Laboratory of Nuclear Problems.
Assembling optical modules for the Baikal-GVD project

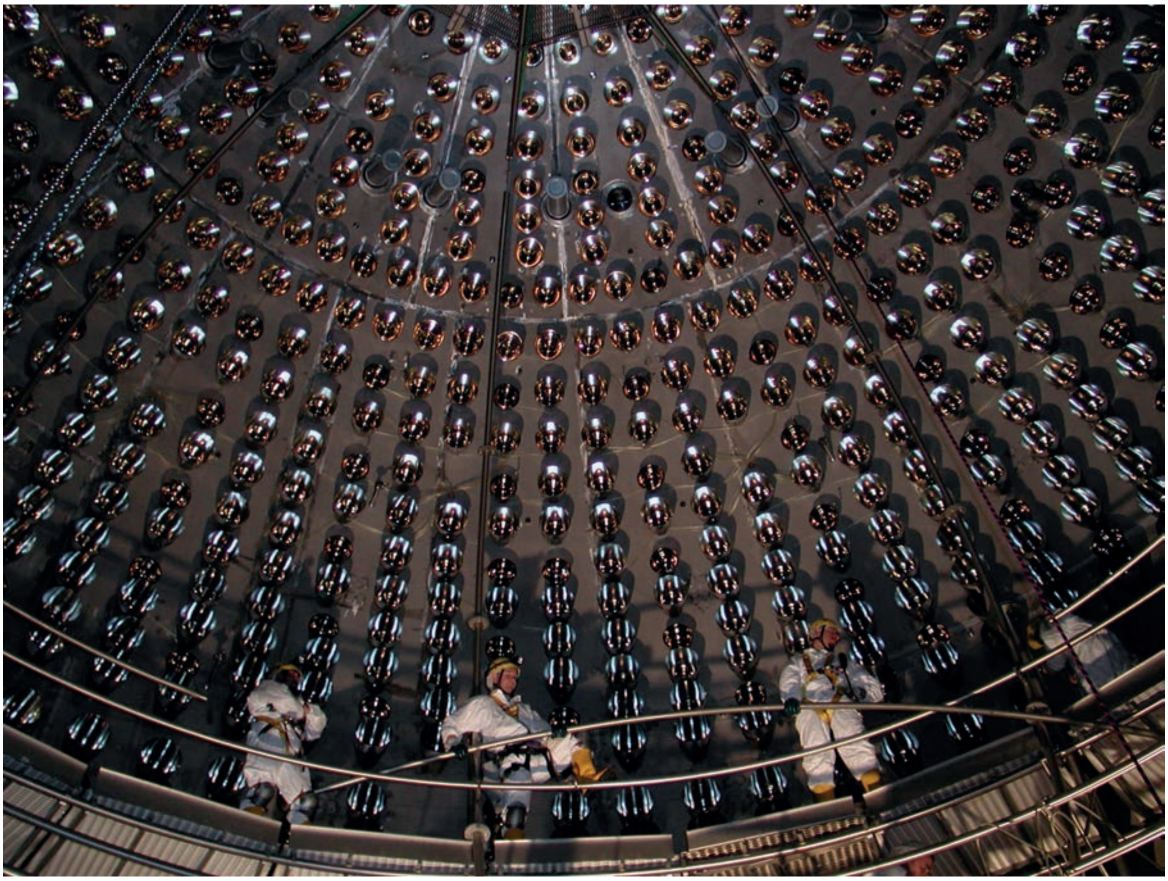
The Underground Laboratory LNGS (Italy). The experimental facility GERDA

The Kalinin Atomic Power Station (Russia). The facility GEMMA (νGeN)

The Kalinin Atomic Power Station (Russia). Assembling the facility DANSS

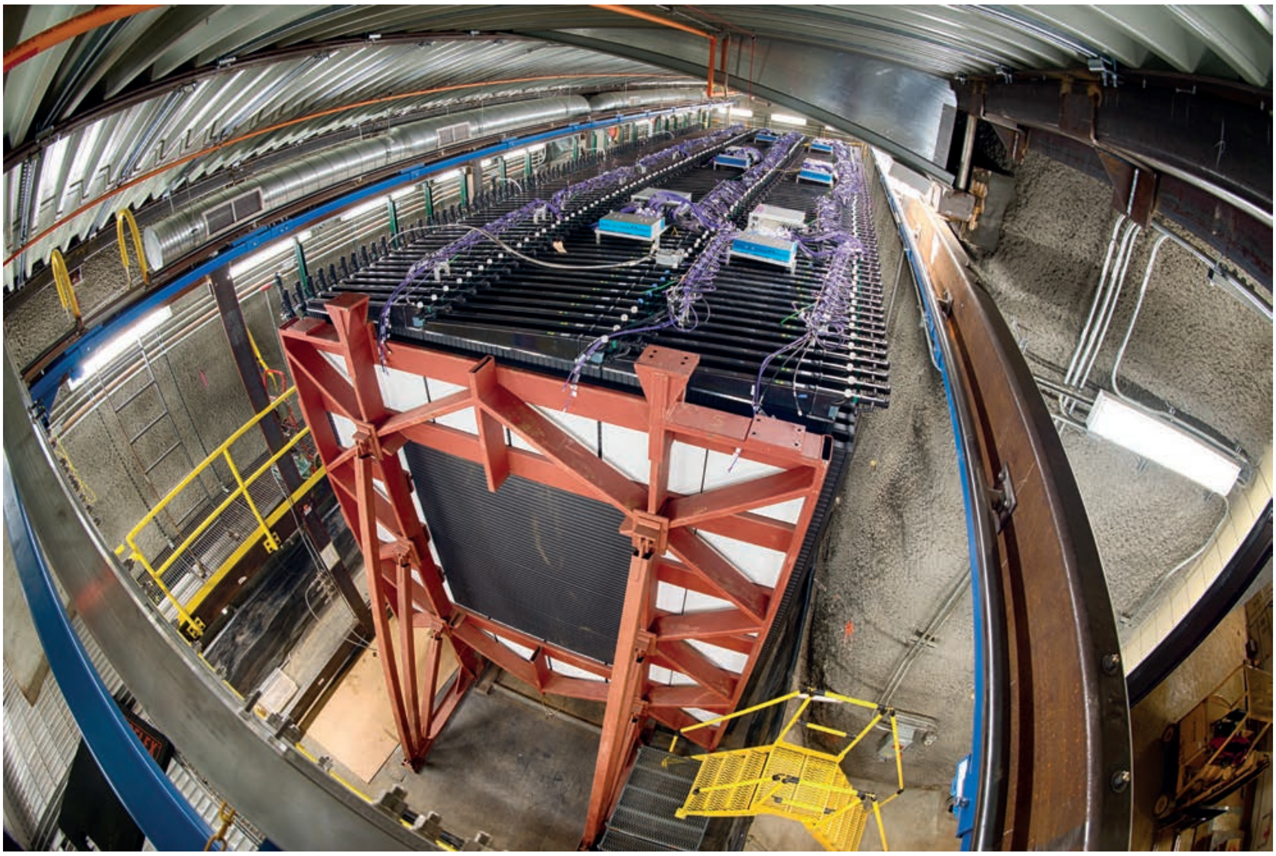
The Dzhelepov Laboratory of Nuclear Problems.
HPGe-detectors for the TGV-2 experiment

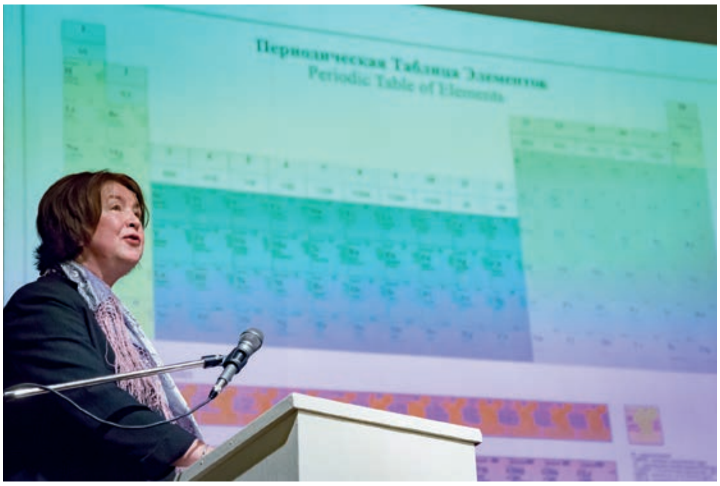
The Modane Underground Laboratory (LSM, France). Assembling the detector EDELWEISS-III

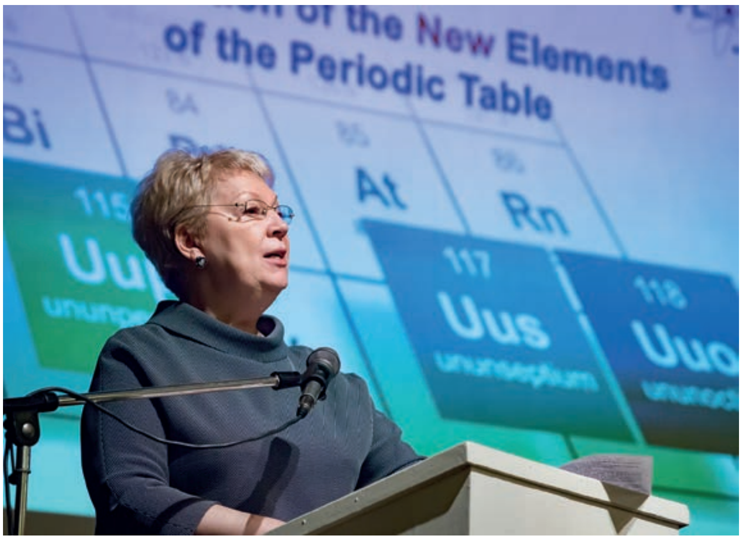


Gran Sasso (Italy). The detector of the Borexino experiment

The Modane Underground Laboratory (LSM, France). The SuperNEMO demonstrator







Moscow, 2 March.
The festive ceremony on the discovery and naming of new chemical elements of the Mendeleev Periodic Table of Elements with atomic numbers 115, 117 and 118

Moscow, 2 March. At the festive ceremony on the discovery and naming of chemical elements of the Mendeleev Periodic Table of Elements with atomic numbers 115, 117 and 118

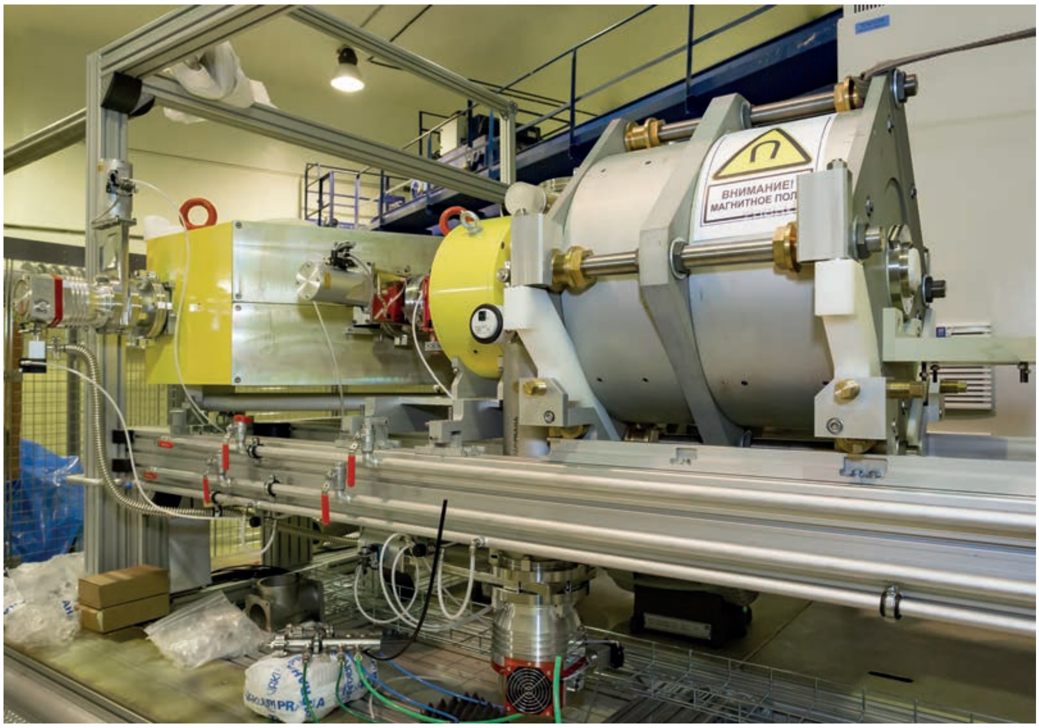
Dubna, 1 December. An extended meeting of the RAS Council on Heavy Ion Physics

Dubna, 17 May. The gala meeting on the occasion of the 60th anniversary of the Flerov Laboratory of Nuclear Reactions

The Flerov Laboratory of Nuclear Reactions. The ACCULINNA-2 setup

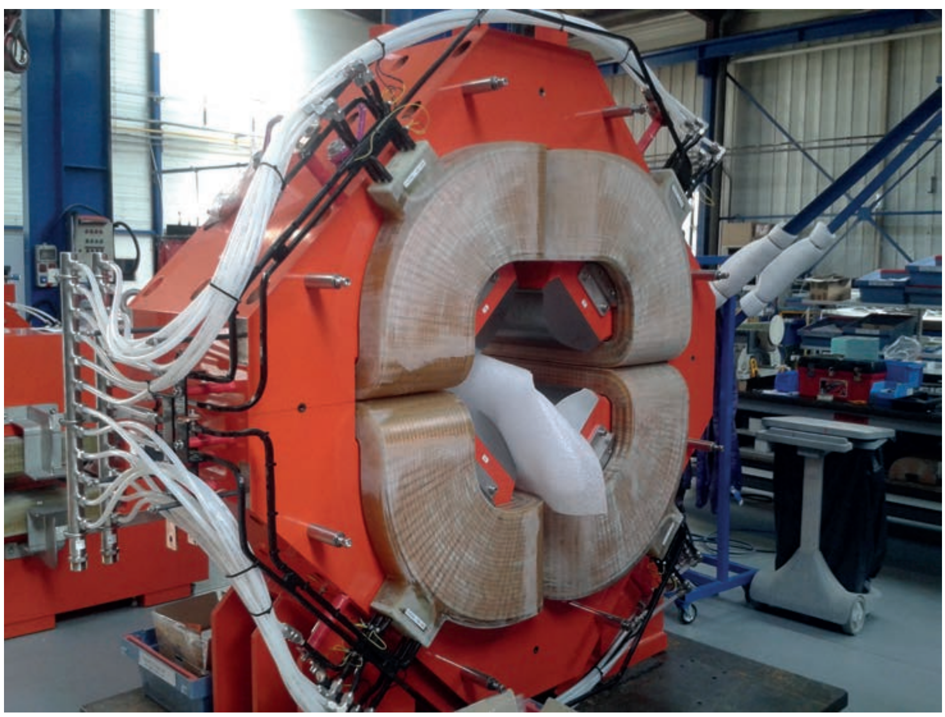
The Flerov Laboratory of Nuclear Reactions. The building of the Factory of Superheavy Elements

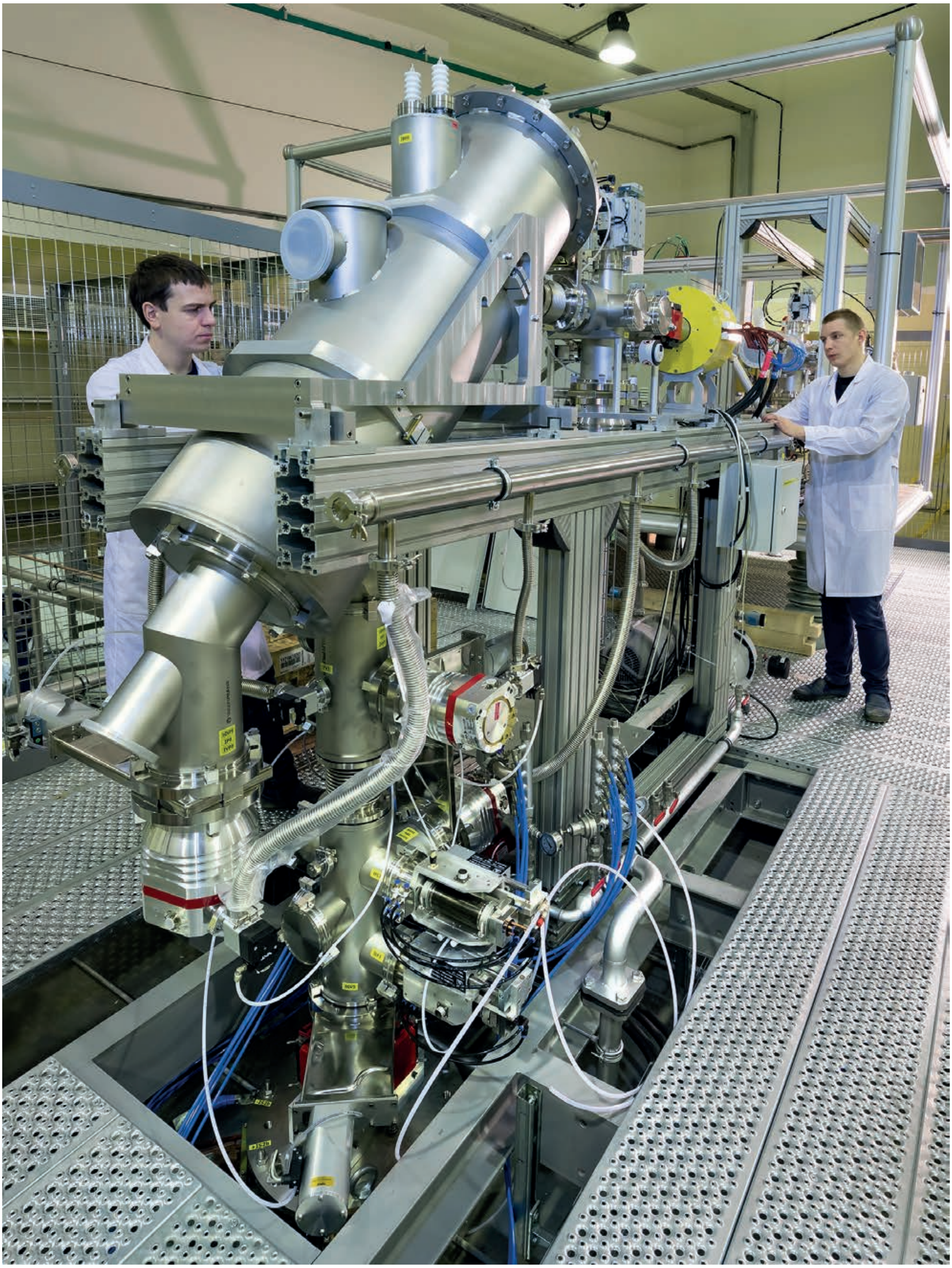
Dubna, 3 March. Participants of the scientific colloquium at the Flerov Laboratory of Nuclear Reactions



The Flerov Laboratory of Nuclear Reactions. The ECR source of ions

The Flerov Laboratory of Nuclear Reactions. The magnet of the new gas-filled separator





The Flerov Laboratory of Nuclear Reactions. Equipment of the axial injection system
of the DC-280 cyclotron of the Superheavy Elements Factory

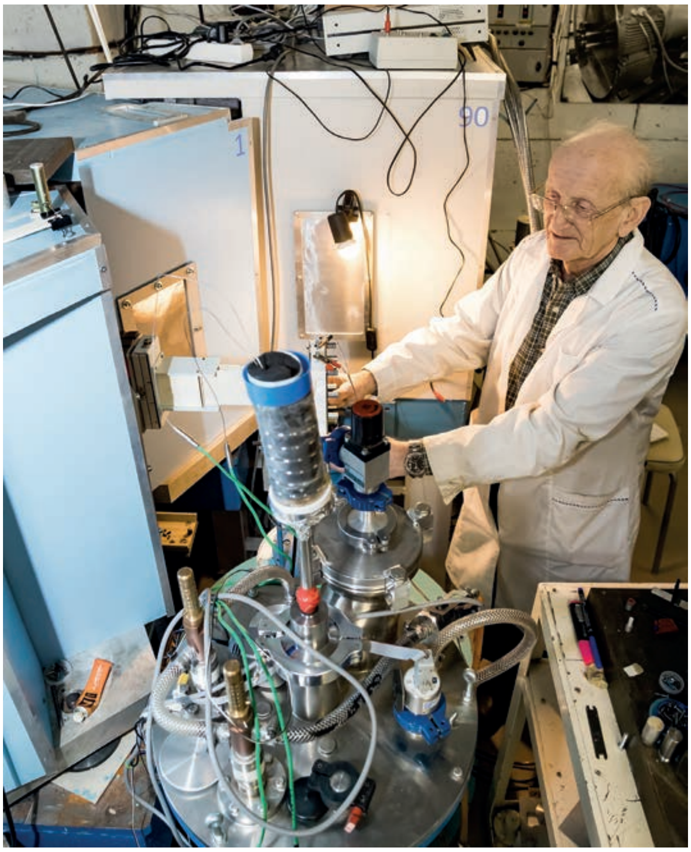
Dubna, 29 November.
The ceremonial meeting
on the occasion
of the 60th anniversary
of the Frank Laboratory
of Neutron Physics

The Frank Laboratory of Neutron Physics, 25–26 October. Deputy Director General of the International Atomic Energy Agency (IAEA) D.Yang on an excursion to the laboratory

The Frank Laboratory of Neutron Physics, 7–11 November. The 8th international school for young scientists and students “Instruments and Methods of Experimental Nuclear Physics. Electronics and Automatics of Experimental Facilities”

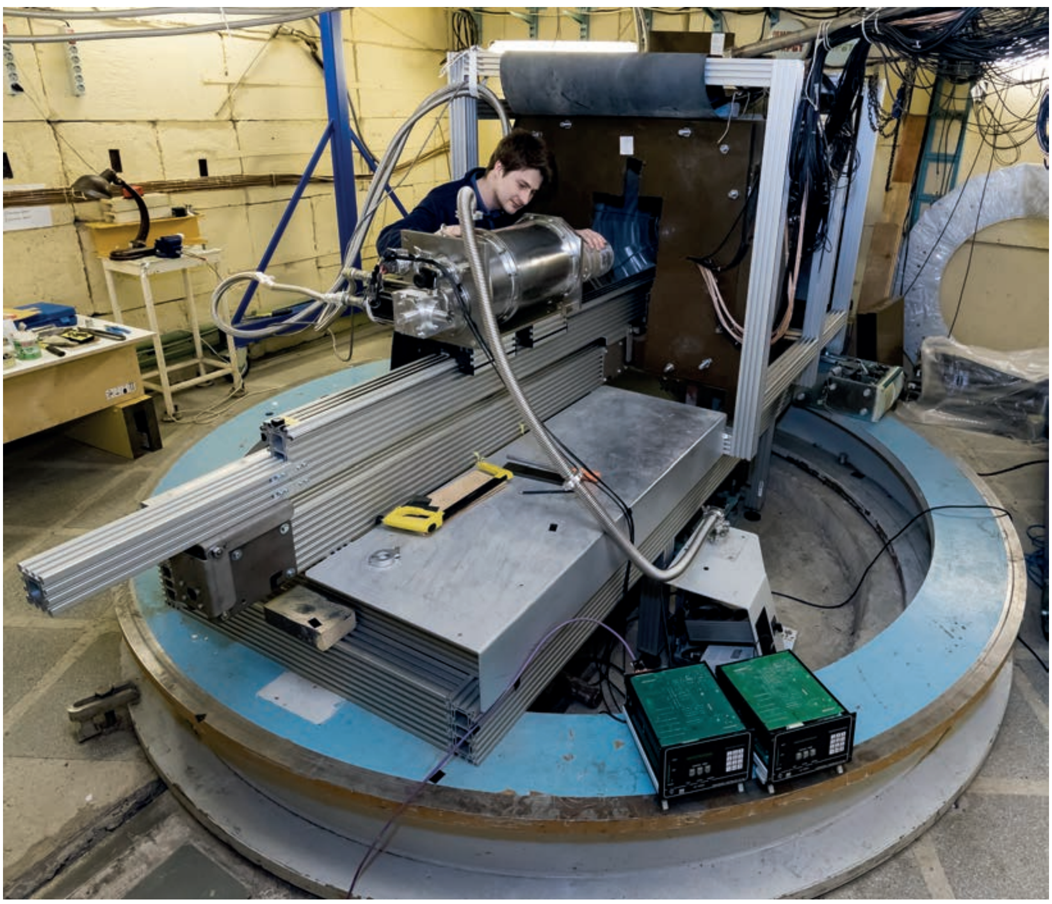
Dubna, 23–26 May. The 25th International Seminar on Interaction of Neutrons with Nuclei (ISINN-25)

A team of FLNP and LIT staff members involved in work to develop a system for management of biological monitoring data



The Frank Laboratory of Neutron Physics.
Preparation of neutron diffraction experiment at the HRFD station

The Frank Laboratory of Neutron Physics.
The detection system and the helium refrigerator of the neutron diffractometer DN-6



The Laboratory of Information Technologies, 3–7 July. Participants of the conference “Mathematical Modeling and Computational Physics” (MMCP’2017)

Budva (Montenegro), 25–29 September. The International Symposium of JINR on Nuclear Electronics and Computing (NEC’2017). CERN Advisor on Eastern Europe T. Kurtyka is speaking

Moscow, 5 December. LRB (JINR) Director E. Krasavin delivers a report at the meeting of the RAS Council on Space

The Laboratory of Radiation Biology. Professor R. Hoover (USA)
is acquainted with the studies on the search for permineralized microorganisms in meteorites

Dubna, 25 June – 1 July. The School for Teachers of Physics from the JINR Member States

Dubna, 2 July. Students from European countries — participants of the second stage of the practice in JINR fields of research

Dubna, 2–6 October. The 21st International Conference of Young Scientists and Specialists of JINR

2017

CENTRAL SERVICES

JOINT INSTITUTE FOR NUCLEAR RESEARCH

JINR

PUBLISHING DEPARTMENT

In 2017, the Publishing Department issued 97 titles of publications and 48 titles of official documents.

Among the books of abstracts and proceedings of various conferences, schools and workshops organized by JINR that appeared in 2017 are the following ones: the Collection of Selected Papers presented at the seminar dedicated to the centenary of the birth of Fedor L. Shapiro, the Proceedings of the XXIV International Seminar on Interaction of Neutrons with Nuclei (ISINN-24), the Book of Abstracts of the conference "Compact Stars in the QCD Phase Diagram VI", the Book of Abstracts of the international conference "Condensed Matter Research at the IBR-2", the Proceedings of the conference "Modern Problems of General and Space Radiobiology", and others. The 3rd and 4th volumes of the "Review Series on Selected Topics of Atmospheric Sol Formation", edited by J. W. P. Schmelzer and O. Hellmuth, were issued.

The JINR Annual Report for the year 2016 (Russian and English versions) and the Annual Report of the Frank Laboratory of Neutron Physics of JINR for the year 2016 were published.

The book "The Veksler and Baldin Laboratory of High Energy Physics of the Joint Institute for Nuclear Research. The Results of 1956–2016" came out, which incorporated the most significant outcomes achieved over the 60 years of the Laboratory's existence.

The book by V. A. Bednyakov and N. A. Russakovich "The Joint Institute for Nuclear Research in Experimental Elementary Particle Physics" was published. It contains a brief summary of JINR's most important achievements and formulates the major tasks of the Institute in addressing the topical issues of elementary particle physics.

In 2017, six issues of the journal "Physics of Elementary Particles and Atomic Nuclei" (brief name "Particles and Nuclei") that included 131 reports came out. Seven issues of the journal "Physics of Elementary Particles and Atomic Nuclei, Letters" (brief name "Particles and Nuclei, Letters") that included 134 papers were published.

The information bulletin "JINR News" was continued to be published in Russian and English. Fifty-two issues of the JINR weekly newspaper "Dubna: Science, Cooperation, Progress" were published in 2017.

In the framework of exchange of scientific publications, the organizations in over 40 countries of the world that cooperate with JINR received the following JINR publications: JINR preprints and communications, the information bulletin "JINR News", JINR Annual Reports, the journals "Particles and Nuclei" and "Particles and Nuclei, Letters".

The Publishing Department forwarded over 160 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 the JINR Member States and in other countries. Papers by JINR staff members were submitted to the journals "Nuclear Physics", "Theoretical and Mathematical Physics", "Atomic Energy", "Instruments and Experimental Techniques", "Radiation Biology. Radioecology", "Radiochemistry", "Crystallography", "Journal of Surface Investigation. X-Ray, Synchrotron and Neutron Techniques", "Physics of the Solid State", and other periodicals.

To keep readers of the Science and Technology Library (STL) timely informed about new publications received, express bulletins of STL are issued by the Publishing Department. "The Bibliographic Index of Papers Published by JINR Staff Members in 2016" was issued. Publication of express bulletins of the Licensing and Intellectual Property Department was continued.

The Publishing Department fulfilled numerous orders of JINR laboratories to produce poster presentations of the Institute's staff members for submission to conferences and workshops.

At the request of the laboratories and other departments of JINR, the Publishing Department performed binding services and photocopying of scientific-technical and engineering-design documentation. Over 138 thousand various forms were printed.

SCIENCE AND TECHNOLOGY LIBRARY

In 2017, the JINR Science and Technology Library (STL) rendered services to 2000 readers. Implementation of an electronic loan system is launched. 7170 copies of publications were given out. As of 1 January 2018, the library stock amounted to 436 351 copies, 193 362 of them being in foreign languages. 379 publications ordered by readers were received via the interlibrary loan system. 89 requests from other libraries were completed. On the whole, the Library received 2383 copies of books, periodicals, preprints and theses from all compiling sources, including 1005 publications in foreign languages. All the new publications were registered in the central catalogues, branch catalogues, and in the automated library information system "Absotheque".

The weekly express bulletins "Books", "Articles", "Preprints" (156 issues) were published including 8123 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" http://lib.jinr.ru/ntb_mail/newslist.html. The exhibitions of new acquisitions of books, preprints, periodicals and theses were arranged weekly. 1905 publications were displayed on them. Four topical exhibitions were organized.

The electronic catalogues of books, journals, articles, preprints and theses are at http://lib.jinr.ru:80http://lib.jinr.ru:8080/OpacUnicode/80/OpacUnicode. The total number of requests to the electronic catalogues was 15 000. 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 2016" (1596 titles) was prepared by the JINR Science and Technology Library and published by the JINR Publishing Department. The Index is available on the library website, in the section "Services" http://lib.jinr.ru/buk/2016/ bibl_uk.php. The database of papers of JINR scientists is Internet-accessible. 1566 JINR preprints and communications have been scanned and added to the electronic catalogue.

The Library received 113 titles of periodicals. Due to the Library subscription to the foreign journals, JINR scientists have access to full-text electronic versions of these journals.

The Scientific Electronic Library is used by 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 the Ministry of Education and Science Consortia, JINR scientists are provided with the electronic access to the full-text versions of journals of the following publishing houses: Elsevier, Springer, Wiley, IEEE Digital Library, as well as to the journal "Nature" and information retrieval databases Web of Science, MathSciNet and Scopus.

Within the framework of the project "History of JINR and Dubna in Books, Journals and Central Newspapers", 107 new bibliographic records have been introduced. The information system "Literature about JINR Scientists" is available on the page of the website of JINR STL "Publications about JINR".

In 2017, in exchange for JINR publications printed by the JINR Publishing Department, the Library received 352 publications from 14 countries. Of them 54 issues were from Russia, 15 from Romania, 4 from Ukraine, 192 from Germany, 5 from France, 23 from Japan, and 22 from CERN.

In 2017, within the framework of the information system "Absotheque", the input of documents to electronic catalogue was for: books — 446 titles, journals — 1629 numbers, preprints — 1970 titles, theses and authors' abstracts — 827 titles, book articles — 625 titles, and journal articles — 7298 titles.

As of 1 January 2018, the total number of records in the automated library information system "Absotheque" was 280 446.

LICENSING AND INTELLECTUAL PROPERTY DEPARTMENT

In 2017, the activities of the Licensing and Intellectual Property Department (LIPD) were conducted in the following areas:

Industrial Intellectual Property Protection. In this area, work was done on applications for JINR patents that had undergone the formal Federal Institute of Industrial Property (FIIP) expertise of Rospatent in 2016–2017. Arrangements were done; changes, alterations and clarifications were agreed upon and included into 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 (IPC); analogues and prototypes were searched. Reports on patent studies were prepared; for seven elaborations, in collaboration with the authors, packages of submission documents were prepared and forwarded to RF Rospatent for patents on inventions:

— "A method to determine the Poisson coefficient for material of a leak-tight thin-walled polymer tube";

— "A method to determine space profiles of nuclear and magnetic potentials of interactions of polarized neutrons with laminated structure";

— "Energy-independent protection valve for drift chamber that works in vacuum";

— "A method of slow extraction of charged particles from a cyclic accelerator";

— "A prevention method to lower muscle strength in acute radiation injury in experiment";

— "A planar semiconductor detector";

— "A method of analysis of atomic composition of organic substances and a device for its application".

Six RF patents for invention were obtained:

— "An induction synchrotron with permanent field" by G. Dolbilov;

— "A method to obtain Ag radioisotopes without carrier" by V. Domanov, Tring Thi Thu Mi;

— "A method of synchronous acceleration of charged particles in permanent magnetic field" by G. Dolbilov;

— "A device for emission spectral analysis of organic substances" by V. Shalyapin, S. Tyutyunnikov;

— "A method of focusing of charged particle beams" by G. Dolbilov;

— "A method of prevention of psychoneurological status damage in acute radiation injury in experiment" by A. Ivanov, E. Krasavin, K. Lyakhova, Yu. Severyukhin, A. Molokanov.

As of 1 January 2018, JINR possesses 63 RF patents for invention in force.

The computer program "Program complex for simulation of distributed systems for storage and data processing on the basis of results of their monitoring" by the authors A. Nechaevsky, G. Ososkov, D. Pryakhina, V. Trofimov, A. Uzhinsky was registered in Pospatent.

Patents and Information. In 2017, 36 issues of the Federal state institution "Federal Institute of Industrial Property" of the bulletin "Inventions. Utility Models" were received at JINR and handled according to the JINR topics. The processing results were presented in 12 issues of the LIPD bulletins "Patents" distributed in departments of JINR. The LIPD stock is 3307 Rospatent bulletins.

An LIPD layout was worked out on current patents obtained by JINR staff members, and permanent contact was established with the JINR website on including this information into the chapter "JINR News".

The LIPD page on the JINR website is regularly updated.

Standardization. Standard library was supplemented with 55 new intergovernmental and state RF standard documents (GOSTs), 12 GOST directories and standard information directories for 2017, directories of national standards and technical conditions, guidelines, recommendations and regulations issued in 2017. 320 alterations were introduced into relevant documents of the standard library files and subscribers' copies on the basis of these norm documents (NDs). 16 GOST official copies and other norm documents were distributed in departments for permanent use. The access to the database of the standard library that contains about 11 700 positions on the LIPD internet page was supported. Information about new accessions and changes in NDs is regularly forwarded to the departments.

"The Catalogue of Normative Legal Acts and Norm Documentation Used at the Joint Institute for Nuclear Research" was regularly updated in the database. As of the end of 2017, the database contains over 6300 NDs that include technical regulations, federal laws norms and other regulation documents that correspond to Law on Technical Regulation of the Russian Federation. The electronic base contains a directory of documents and hyper references located on the sites: the Federal Agency of Technical Regulation and Metrology (ROSSTANDART) and the legal reference system KONSULTANT PLUS, the All-Russian Standard Nomenclature (ARSN).

In 2017, the base was replenished with international standards (ISO, IEC, CT, COMECON) and RF standards (GOSTs RISO, GOSTs).

"The Index of Norm Acts and Norm Documents Used by the Joint Institute for Nuclear Research to Exercise Activities in Use of Atomic Energy" was worked out and approved by JINR Director (JINR Index AE-2017), compiled on the basis of regulations of chapter "State Regulation of Safety in Use of Atomic Energy" of the Index of Norm Legislative Acts and Norm Documents Related to Activities of the Federal Office of Ecological, Technological and Atomic Survey (П-01-01-2017). The electronic version of the Index contains direct references to documents located on sites of the RF President, RF Government and servers of executive organs of the RF state power. The electronic version of the Index is located on the LIPD internet page. The printed version of the AE-2017 Index is published and distributed among responsible persons in departments.

Alterations were introduced into the index of licenses received from the RF federal bodies for authorization for business connected with accomplishment of JINR Charter functions.

2017

ADMINISTRATIVE ACTIVITIES

JINR

JOINT INSTITUTE FOR NUCLEAR RESEARCH

FINANCIAL ACTIVITIES

To implement the resolutions of the Finance Committee and the Committee of Plenipotentiaries (Protocols of 18–19 November and 21–22 November 2016), starting in 2017, recording of management accounts has been set up on cash basis; that is, actual revenue and expenditure are recounted in the record currency (US dollars), at the exchange rate of the date of the operation.

In 2017, a total of 256.0 M$ arrived in JINR, that makes 124% of the scheduled budget incomes. Over 95% of all actual revenue were contributions of the JINR Member States.

The main budget expenditure was stipulated for wages payment for the JINR staff members and provision of material expenditure to implement the main scientific projects:

— development of the NICA accelerator complex;

— development of the DRIBs-III cyclotron complex;

— the neutrino programme;

— development of the research nuclear facility IBR-2 and spectrometers;

— information, computer and network services for the JINR activities.

According to the accounting report, actual expenditure of 2017 totaled up to 194.5 M$ with 209.9 M$ scheduled, i.e., the budget expenses were executed to 93%.

The main budget expenditure was focused on two consolidated chapters: "Personnel" and "Material Inputs, Research&Development, Construction".

The consolidated chapter "Material Inputs, R&D, Construction" is the biggest in the budget expenditure, whose means were forwarded to construction, upgrading and development of basic experimental facilities.

Of 96.8 M$ of actual material expenditure, almost 90% (84.4 M$) was used to accomplish scientific projects of JINR, which is the main priority in spending budget means. Operation of basic facilities — 3.6 M$, infrastructure expenditure — 8.8 M$.

The actual expenditure for international cooperation was 8.4 M$. It was forwarded to finance business trips of staff members to the JINR Member States. A big part of expenditure was spent on trips of JINR staff members to CERN and other large scientific centres and to non-member countries of JINR due to concluded agreements on cooperation.

Budget (updated)	Actual	Execution
62.9 M$	65.3 M$	104%

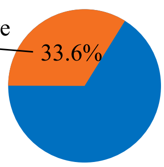


Fig. 1. Actual expenditure on personnel in 2017

Budget (updated)	Actual	Execution	
111.7 M$	96.8 M$	–14.9 M$	87%

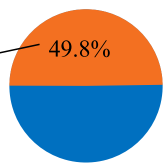


Fig. 2. Actual expenditure on material costs, R&D and construction in 2017

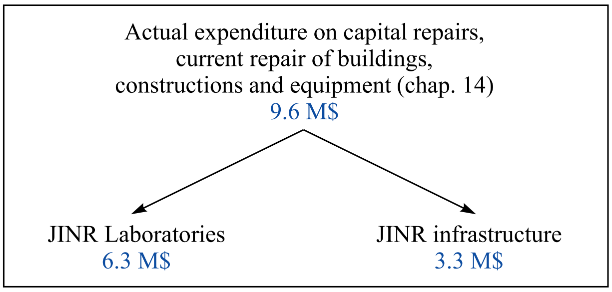


Fig. 3. Capital and current repair in 2017

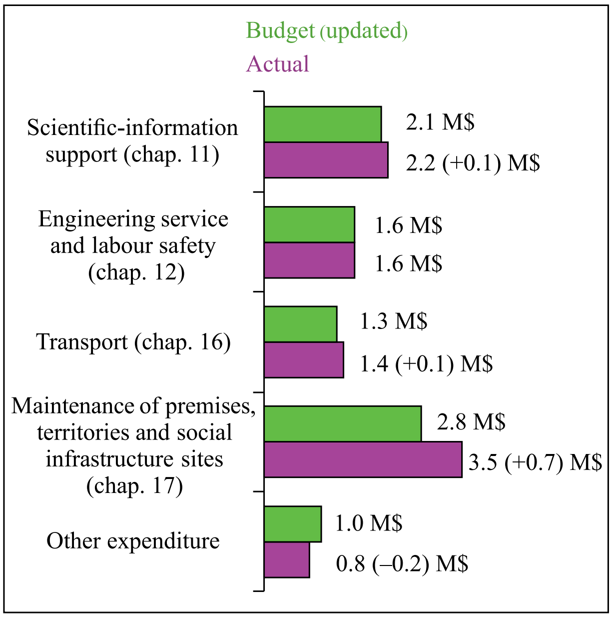


Fig. 4. Fulfillment of operational expenses in 2017

Expenses on electric energy, heating and water supply in 2017 totaled to 4.9 M$.

The expenditure for repair work was necessary to maintain buildings, constructions and equipment for operation, both at JINR sites and beyond them.

Other expenses in 2017 were mainly related to the infrastructure and included those for social sphere, transport service payment, communication, sites protection and others. As of 2017, they totaled up to 9.5 M$.

STAFF

As of 1 January 2018, the total number of the staff members at the Joint Institute for Nuclear Research was 4987.

Working at JINR are: RAS Academicians V. Matveev, Yu. Oganessian, M. Ostrovsky, G. Trubnikov, B. Sharkov; RAS Corresponding Members V. Aksenov, L. Grigorenko, D. Kazakov, E. Krasavin, I. Meshkov, A. Starobinsky, G. Shirkov; Members of other state Academies of Sciences I. Zvara, G. Zinoviev, B. Yuldashev; 241 Doctors of Science, 602 Candidates of Science, including 59 Professors and 24 Assistant Professors.

In 2017, 521 people were employed and 447 people and were discharged because of engagement period expiry and for other reasons.

AWARDS

For the services for JINR and international cooperation the Order ***"For Merit to the Fatherland", III class*** was awarded to 1 staff member; the Order ***"For Merit to the Fatherland", II class*** was awarded to 1 staff member; the National Order of France ***"Order of Merit"*** was awarded to 1 staff member; the Badge of Merit in Labour ***"Veteran of Atomic Energy and Industry"*** was awarded to 32 staff members; the title ***"Honorary JINR Staff Member"*** was conferred to 7 staff members. A number of staff members of the Institute received other departmental, city and Institute awards.

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Joint Institute for Nuclear Research. 2017

Annual Report

2018-13

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