JOINT INSTITUTE FOR NUCLEAR RESEARCH

2023 ANNUAL REPORT

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2023

ANNUAL REPORT

Joint Institute for Nuclear Research

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JINR MEMBER STATES

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Republic of Armenia

Republic of Azerbaijan

Republic of Belarus

Republic of Bulgaria

Republic of Cuba

Arab Republic of Egypt

Georgia

Republic of Kazakhstan

Democratic People's Republic of Korea

Republic of Moldova

Mongolia

Romania

Russian Federation

Slovak Republic

Republic of Uzbekistan

Socialist Republic of Vietnam

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PAC for Condensed Matter Physics

Chairperson: D. L. Nagy (Hungary)
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INTERNAL ORGANIZATION OF THE JOINT INSTITUTE FOR NUCLEAR RESEARCH

Bogoliubov Laboratory of Theoretical Physics

Director D. Kazakov

Research in

- interactions and symmetry properties of elementary particles, field theory structure and its applications
- properties of exotic nuclei and nuclear systems, low-energy and relativistic nuclear dynamics, nuclear astrophysics
- mathematical models of complex systems, complex materials and nanostructures
- integrable systems, supersymmetry, quantum gravity and string theory

Veksler and Baldin Laboratory of High Energy Physics

Acting Director A. Butenko

Research in

- interactions of multicharged ions in a wide energy range
- relativistic nuclear physics
- structure of nucleons
- strong interactions of particles
- resonance phenomena in particle interactions
- electromagnetic interactions
- particle acceleration techniques
- applied science at NICA complex based on the ARIADNA infrastructure

Dzhelepov Laboratory of Nuclear Problems

Director E. Yakushev

Research in

- neutrino physics and rare phenomena
- strong, weak and electromagnetic interactions of particles
- nuclear spectroscopy
- charged particle acceleration techniques
- applied research and radiobiology

Flerov Laboratory of Nuclear Reactions

Director S. Sidorchuk

Research in

- synthesis of superheavy elements
- properties of heavy and superheavy elements, mechanisms of nuclear reactions with heavy ions
- reactions with radioactive-ion beams, structures of nuclei at the borders of nucleon stability
- interactions of heavy ions with condensed matter
- heavy-ion acceleration methods

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Vice-Director **L. Kostov**
Chief Scientific Secretary **S. Nedelko**
Chief Engineer **B. Gikal**

Frank Laboratory of Neutron Physics

Director E. Lychagin

Research in
- neutron-induced nuclear reactions
- fundamental properties of the neutron
- structure and dynamics of functional materials
- nanomaterials for energy storage
- materials by neutron scattering, neutron activation analysis, neutron radiography and complementary methods
- dynamic characteristics of the IBR-2 pulsed reactor and advanced neutron source

Meshcheryakov Laboratory of Information Technologies

Director S. Shmatov

Research in
- provision of operation and development of the JINR network, information and computing infrastructure
- optimal usage of international computer networks and information systems
- integration of the heterogeneous computing resources
- modern methods of computer physics, development of standard software
- digitalization of scientific and administrative activities of JINR

Laboratory of Radiation Biology

Director A. Bugay

Research in
- molecular radiobiology
- radiation genetics and cytogenetics
- medical radiobiology
- radiation physiology and neuroradiobiology
- radiation biophysics and mathematical modeling
- astrobiology

University Centre

Director D. Kamanin

Main activities:
- academic programme for senior students, preparation of Bachelor, Master, and PhD theses
- running of international student practices and schools
- popularization of achievements in modern science
- running of scientific schools for physics teachers
- career guidance for schoolchildren
- advanced training of the Institute personnel

Central Services

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

INTRODUCTION

2023 was the year of successful completion of the Seven-Year Plan for the Development of JINR for 2017–2023 for the large international staff of the Institute. Despite the difficult circumstances associated with the sharp deterioration of the geopolitical situation, JINR achieved impressive results both in the development of a large research infrastructure and in scientific research for the benefit of the Member States of the Institute.

An important result of the year is the approval of the new Seven-Year Plan for the Development of JINR for 2024–2030 by the JINR Committee of Plenipotentiaries. The Plan contains a full-scale interdisciplinary programme of scientific research that reflects the tasks of development of science and technology in the JINR Member States and is aimed at enlargement of the intellectual human resources and strengthening the position of JINR as one of the largest international scientific organizations in the world.

In 2023, very important scientific results in the wide trends of fundamental and applied research at JINR were obtained.

Studies by Dubna theoreticians were shown in two monographs and more than 400 papers in leading scientific journals, as well as proceedings of international conferences, and are aimed at the solution of most interesting and urgent problems of modern theoretical and mathematical physics, a considerable part of which is closely connected with the programme of experimental research at the Institute.

Active work was continued in the frames of the NICA megascience project. General construction work was practically finished in 2023. The injection complex of the collider was launched that included a cryogenic source and a linear accelerator of heavy ions, the synchrotrons Booster and Nuclotron, and a system of beam transport. The production and cryogenic testing of the modules of the collider magnetic system were concluded. The system of the collider power generation elements and a new cryogenic compressor station were prepared for launching. An educational programme was started to train the staff for commissioning and further functioning of the NICA equipment.

In the record in duration start-and-adjustment period, the BM@N experiment began its physics programme and accumulated more than half a milliard events. For the first time, the computer infrastructure of JINR was used to store and reconstruct experimental data of this experiment. As a result of the reconstruction of the BM@N experiment, statistically important signals of Λ and Ξ hyperons and K mesons were obtained for further physical analysis. A programme of ARIADNA applied research at NICA started on the basis of the SOCHI, SIMBA and ISCRA stations.

The production of all components of the MPD detector of the first stage proceeds according to the plan, with minimal delays. The SPD Collaboration worked out a renovated technical project of the SPD detector which will be considered by the new international expert committee — the Detector Advisory Committee (DAC) organized in December 2023.

Experiments on the synthesis of darmstadtium isotopes in the fusion reactions $^{48}Ca + ^{232}Th$ and $^{40}Ar + ^{238}U$ and ^{116}Lv isotopes in the reaction $^{54}Cr + ^{238}U$ were conducted for the first time in the world at the Factory of Superheavy Elements. The isotope ^{273}Ds was first obtained in the reaction of the cold and hot synthesis. The accomplished studies have principal importance for experiments on the synthesis of new elements of the Mendeleev Periodic Table. The modernization of the U-400M is close to the final stage. The first stage of work of assembling the new accelerator DC-140 for applied research was completed. In 2023, all preparatory work was finished, including boring and filling of 763 bored piles, and in December, the concrete placement was done into the footing of the new experimental building of the U-400R accelerator complex.

In 2023, the Baikal-GVD Collaboration installed two new clusters of optical modules within the Baikal expedition. Thus, the effective volume of the Baikal-GVD deep underwater neutrino telescope reached 0.6 km^3, and due to this fact, the detector keeps the position of the largest neutrino telescope of the Northern Hemisphere.

The successful participation of JINR in the collaborations at CERN (Switzerland) should be mentioned, in particular, in the experiment NA64 (SPS), as well as active participation of the Institute and fulfillment of its obligations in the programme of the second stage of upgrade of the ATLAS, CMS and ALICE detectors at the LHC.

Maintenance operations of the IBR-2 research reactor were timely accomplished, it will allow the continuation of the reactor exploitation in 2024. The complex of spectrometers of the Laboratory of Neutron Physics was considerably developed, in particular, the backscatter detector with wide aperture (BSD-A) for the Fourier diffractometer of high resolution, the detector of small-angle scattering of neutrons (SANSARA), and the spectrometer of inelastic scattering of neutrons in the inverse geometry (BJN).

Another important result of the year is the safe and stable operation of the nets and the whole Multifunctional Information and Computing Complex of JINR, including the Govorun supercomputer whose power enlarged efficiency. The GPU component of the supercomputer was extended with five new servers with eight graphic processors, each for the solution of tasks of computer and deep irradiation. The results of application of the DIRAC distributed platform for support of collaborations in the MPD, BM@N and SPD experiments at NICA and the Baikal-GVD neutrino telescope are very impressive. The JINR Digital Ecosystem functional was extended.

Radiobiologists of JINR developed a principally new method of strengthening biological efficiency of medial proton beams with the device “AraC”. It was shown that the introduction of the device makes the antitumour action of the proton radiation stronger. The analysis of forming chromosomal aberrations in carcinoma cells and normal lymphocytes of human blood was performed in irradiation with gamma quanta and protons.

Bright results were obtained by the Institute scientists in applied studies in life sciences and condensed matter physics on the basis of the interlaboratory research programme worked out at JINR. Using neutron activation analysis and the mass spectrometer with inductively coupled plasma, unique ecological studies were conducted of the Nile bottom deposits and the area of the Mediterranean and Red Sea for the Arab Republic of Egypt.

In 2023, a new architecture of the Topical Plan of JINR was completed that gives a clear presentation of the structure and resource provision of JINR scientific projects.

Landmark events occurred in the international cooperation. A Protocol on Strengthening Cooperation in fundamental scientific research was signed among the Chinese Academy of Sciences, JINR, and ministries of China and RF. A Coordinating Committee was organized, 18 projects were selected for phased joint implementation. An Agreement was signed with the National Council of Science and Technology of Mexico, four joint scientific projects were supported.

Cooperation has been developed with Brasil, India, Pakistan, and the Arab Atomic Energy Agency. In the headquarters of the latter in Tunis, an Information Centre of JINR was opened. The international cooperation with Armenia, Cuba, Egypt, Kazakhstan, RSA, Serbia, and Vietnam was further developed.

The Institute took an active part in the International Year of Basic Sciences for Sustainable Development declared by the UN and in the Decade of Science and Technology in the country of JINR’s location.

For JINR, highly qualified staff is the main element in achievement of important scientific results. Dissertation Councils of JINR successfully worked in 2023, 29 theses were defended.

In May, the MSU Branch in Dubna, formed on the initiative of JINR and MSU, has been certified and received the right under the general license of MSU to carry out educational activities in Master’s degree programmes: “Elementary Particle Physics” and “Fundamental and Applied Nuclear Physics”. The Master’s programme “Methods and Technologies of Data Processing in Heterogeneous Computing Environments” has also been concerted.

Educational programmes of the Institute are expanded, new formats of cooperation and attraction of young scientists are introduced. JINR staff prepared a new educational and methodological complex for the study of physics at the advanced level “Physics 7–9. Engineers of the Future”. A textbook, a task book, a training exercise book, a teacher’s manual, as well as various electronic educational resources have been prepared for each class. The textbooks have passed all the necessary examinations and are included in the Federal List of Textbooks for Russian Schools by Order of the RF Ministry of Education.

Positive changes took place in the social infrastructure. The activities of financial services of the Institute and business units were synchronized. Premises of the University Centre and the JINR Sport Centre were repaired. The plan of development of the Recreation Centre "Ratmino" was affirmed. Refurbishment of the main electrical station at the VBLHEP site was done. The station works for the NICA complex among other complexes, the reconstruction of the MSDS-2 station at the DLNP site is in full swing.

Another big infrastructural project is the repair work of the checkpoint for people, bicycles, and cars at the DLNP site, where a modern and comfortable checkpoint for people has already started its work.

At the end of May, an important event took place in the science city Dubna — in the Medical Unit No. 9 of the FMBA of Russia, at the support of JINR, an advanced centre of cardiovascular surgery was opened where more than 400 operations have already been done. Due to participation of JINR, the department of hemodialysis, a centre of medical rehabilitation, a smart ward and other services were opened.

Implementing the Seven-Year Plan, the Institute steadily enlarged its potential, invested resources into the construction of new facilities. Our scientists, engineers, and specialists were able to achieve bright results in these goals; they strived to gain the aims with maximum efforts, and due to this, the Institute managed to keep the position of stable development, playing the role of one of the leaders in the world and proving the principle "Science Bringing Nations Together" by its activities.

Thanks to this, we have every right to look forward to the future. The start of the new Seven-Year Plan opens a page of expectations for new achievements at the forefront of science.

G. TRUBNIKOV
Director
Joint Institute for Nuclear Research

GOVERNING AND ADVISORY BODIES

COMMITTEE of PLENIPOTENTIARIES of the GOVERNMENTS of the MEMBER STATES of JINR

SESSION OF THE COMMITTEE OF PLENIPOTENTIARIES, 24 March 2023

A regular session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held on 24 March in Dubna under the chairmanship of Plenipotentiary of the Government of Georgia A. Khvedelidze.

Having heard the report presented by G. Trubnikov, Director of JINR, the Committee of Plenipotentiaries took note of the information from the JINR Directorate about the recommendations of the 133rd session of the JINR Scientific Council, the implementation of the current Seven-Year Plan for the Development of JINR, the efforts of the Member States towards realization of JINR's large projects, the new scientific and technological results obtained, and about the most important events related to JINR's scientific research and educational activities and international cooperation.

The CP noted with satisfaction:

— the successful completion of the fourth technological cycle of the NICA accelerator complex, which became the longest run in the history of VBLHEP (> 3400 h), the successful commissioning of the injection chain, including the joint operation of all its elements, the optimization of the beam dynamics, the operation of the electron cooling, the testing of the SOCHI station with heavy ions, the calibration of the new diagnostic system, and the modernization of the vacuum system in the extracted beam line;

— the success of the Institute in ensuring long-term stable operation of the accelerator complex of the BM@N experiment for the first time in full configuration, registration of more than 550 million events with the Xe beam, which made it possible to begin the physical analysis of the recorded data;

— the successful work of the MPD Collaboration and the VBLHEP team on the construction of all the components of the MPD detector required for a technological launch in 2023, including the cryogenics, control and power supply systems, detector subsystems, and other equipment;

— the successful participation of the Institute in the work of collaborations at CERN and the high level of JINR's readiness to fulfill its obligations under the programme for the second phase of upgrade of the ATLAS, CMS and ALICE detectors at the LHC at CERN;

— the progress in developing the Baikal-GVD deep-water neutrino telescope for observing natural neutrino fluxes and the registration of 24 events indicating the presence of an isotropic neutrino flux of an astrophysical nature;

— the successful continuation of the experiments at the Factory of Superheavy Elements using the DGFRS-2 separator, in particular, on the synthesis of the new isotopes of darmstadtium and seaborgium, as well as the continuation of the preparations for the experiments to study the chemical properties of elements 114 (Fl) and 112 (Cn) at the DGFRS-3 (GRAND) separator in the second half of 2023;

— the information on the progress in the implementation of the work plan for the preparation of the continuation of the normal operation of the IBR-2 reactor. Along with this, the CP drew attention to the need to resume as soon as possible the international user programme of experiments at the IBR-2, hoping that the Russian Federation, as the residence country of JINR, will provide the necessary support;

— the further active development of fundamental and applied areas of research related to life sciences and condensed matter physics based on the development of an interlaboratory research programme on the basis of the Laboratory of Radiation Biology;

— the successful development of the JINR MICC, including the modernization of the Govorun supercomputer carried out in 2022, as a result of which its performance reached 1.1 PFlops, and the total capacity of the hierarchical data storage increased to 8.6 PB. In terms of Tier-1 productivity, JINR in 2022 ranked first in the world among other Tier-1 centres for the CMS experiment. Using the DIRAC distributed platform, a program of mass simulation sessions of the MPD experiment data is being run: more than 1.283 billion events have been simulated, 440 million events have been reconstructed, the total amount of received data exceeds 1.3 PB;

— the significant progress in developing the JINR Digital EcoSystem platform for the integration of the existing and future services to support scientific, administrative, financial and economic activities and maintain the engineering and IT infrastructure of the Institute. The CP supported the active introduction of the platform.

Dubna, 24 March. Session of the JINR CP

Dubna, 26 March. A festive meeting dedicated to the 67th anniversary of JINR at the Cultural Centre “Mir”

The Committee of Plenipotentiaries welcomed the signing of the Joint Declaration of Intent Concerning Cooperative Activities in the Area of Fundamental, Frontier and Applied Scientific Research between the National Council of Humanities, Sciences and Technologies — CONAHCYT (Mexico) and JINR in February 2023, and the Protocol between the RF Ministry of Science and Higher Education, the PRC Ministry of Science and Technology, JINR and the Chinese Academy of Sciences on Strengthening Cooperation in the Field of Basic Scientific Research at the governmental level in March 2023.

Having heard and discussed the report "Execution of the JINR budget for 2022 and draft of the revised budget of JINR for 2023" presented by N. Kalinin, Head of the JINR Budget and Economic Policy Department, the Committee of Plenipotentiaries approved the consolidated final adjustment of the JINR budget expenditure for 2022; the revised JINR budget for 2023 with the income amounting to US$ 203 485.9 thousand and the expenditure amounting to US$ 274 998.5 thousand, taking into account the positive opening balance amounting to US$ 49 021.9 thousand; the new structure of the JINR budget for budget planning, starting in 2024.

According to the report of the Chair of the Finance Committee A. Omelchuk "Results of the meeting of the JINR Finance Committee held on 22 March 2023", the Committee of Plenipotentiaries instructed the JINR Directorate and the Working Group under the CP Chair for JINR Financial Issues to finalize the draft of the new regulation for the lower limits of contributions of the Member States, which takes into account the share of staff costs in the JINR budget as well as the expenditure for the development of the Institute, and submit it for consideration at the meeting of the JINR Finance Committee and for approval at the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States in November 2023.

The CP approved the provisional contributions and scales of the Member States for 2024, 2025 and 2026, excluding the shares of the Member States which have withdrawn from JINR (Czech Republic, Republic of Poland, Ukraine) and the Member States with the suspended membership (Democratic People's Republic of Korea, Slovak Republic).

The CP determined the provisional size of the JINR budget for 2024 with the income amounting to US$ 215.9 million and the expenditure amounting to US$ 269.2 million, for 2025 with the income amounting to US$ 227.3 million and the expenditure amounting to US$ 269.9 million, for 2026 with the income amounting to US$ 239.3 million and the expenditure amounting to US$ 274.7 million.

The CP approved the proposal of the JINR Directorate to reduce the operating costs of JINR and to transfer part of the external engineering networks located outside the JINR sites to the Urban District Dubna.

The Committee of Plenipotentiaries approved the Procedure for the practical implementation of the decision by the JINR CP on the suspension of the rights, privileges and obligations of the Slovak Republic in JINR.

Having taken into account the information presented by the JINR Directorate on the selection of an audit organization to audit the financial activities of JINR for 2022 on a special assignment, the CP approved the Audit Plan of the financial activities of JINR and the LLC JSC "Korsakov and Partners" as auditor of JINR for 2022, authorizing it to audit the financial activities of the Institute for the specified period.

According to the report "Draft Seven-Year Plan for the development of JINR for 2024–2030" presented by G. Trubnikov, Director of JINR, the Committee of Plenipotentiaries took note of the opinion of the JINR Scientific Council that the presented revision of the draft Seven-Year Plan for the Development of JINR for 2024–2030, taking into account the recommendations of the 133rd session of the JINR Scientific Council, contains an ambitious international scientific programme, which fully complies with the JINR Long-Term Development Strategic Plan up to 2030 and beyond.

The Committee of Plenipotentiaries supported the recommendation of the 133rd session of the JINR Scientific Council to organize a joint working group, including representatives of all three JINR Programme Advisory Committees, for the final examination of the scientific programme of the Plan, and instructed the JINR Directorate to take into account the comments of this working group when preparing the final version of the Plan for approval in November 2023.

The CP agreed with an annual, at least 5%, increase in the amount of contributions of the Member States to financially support the Seven-Year Plan for the Development of JINR for 2024–2030.

SESSION OF THE COMMITTEE OF PLENIPOTENTIARIES, 10 November 2023

A regular session of the Committee of Plenipotentiaries of the Governments of the JINR Member States was held on 10 November in Almaty (Republic of Kazakhstan) chaired by Plenipotentiary of the Government of Georgia A. Khvedelidze.

Having heard and discussed the report "Results of the implementation of the Seven-Year Plan for the Development of JINR for 2017–2023. Seven-Year Plan for the Development of JINR for 2024–2030" presented by G. Trubnikov, Director of JINR, the Committee of Plenipotentiaries noted the achieved impressive results both in the development of the Institute's large research infrastructure and in scientific research based on this infrastructure despite the difficult working conditions associated with COVID-19 restrictions and the sharp deterioration

Almaty (Kazakhstan), 10 November. Session of the JINR CP


SOLIS


JOINT INSTITUTE
FOR NUCLEAR RESEARCH
Session of the Committee
of Plenipotentiaries
of the Governments of the JINR Member States
10–11 November 2023
Almaty, Kazakhstan
Science
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of the geopolitical situation; a significant contribution of JINR to international cooperation, especially at CERN; the steadily growing Institute's human resources potential.

The CP greeted that JINR keeps successfully developing as an international intergovernmental scientific organization, establishing new integration ties with a wide range of countries in different regions of the world, as well as the establishing and constant development of international experimental collaborations.

The CP noted with satisfaction the progress in the current research plan and development of JINR:

— for the first time at JINR, the successful use of the entire computing infrastructure integrated by DIRAC for the complete reconstruction of the raw experimental data recorded during the long-term stable operation of the accelerator complex of the BM@N experiment in full configuration, with registration of more than 550 million events with the Xe beam;

— the successful work of the MPD Collaboration and the VBLHEP team on the construction of all the components of the MPD detector;

— the development of the ARIADNA Collaboration, whose applied research programme was launched at the NICA complex at the beginning of 2023, as well as preparing a series of publications based on the results of the experiments;

— the successful participation of the Institute in the work of collaborations at CERN, in particular, in the NA64 experiment, as well as the high level of JINR's activity in the fulfilment of its obligations under the programme for the second phase of upgrade of the ATLAS, CMS and ALICE detectors at the LHC at CERN;

— the progress in developing the Baikal-GVD deep-water neutrino telescope, installation of 576 optical modules and two bottom cable lines in 2023, as well as approaching the effective volume to the value of 0.6 km^3, which provided the Baikal-GVD with the status of the largest neutrino telescope in the Northern Hemisphere;

— the successful continuation of experiments at the Factory of Superheavy Elements, in particular, the discovery of a new isotope ^{288}Lv;

— the progress in developing the DRIBs-III accelerator complex with the modernization of U-400M being close to the final stage, the completion of the first stage of construction work for DC-140, as well as the planned implementation of construction work in the new experimental hall of U-400R;

— the successful implementation of the work plan to prepare for continuing the regular operation of the IBR-2 reactor;

— the further active development of fundamental and applied areas of research related to life sciences and condensed matter physics based on the development of the interlaboratory research programme on the basis of the Laboratory of Radiation Biology;

— the successful work of the Bogoliubov Laboratory of Theoretical Physics and interesting results in particle physics, nuclear physics, condensed matter physics, and advanced mathematical physics;

— the successful development of the JINR MICC, including the expansion of the Govorun supercomputer, the use of the DIRAC distributed platform to support the collaborations of the MPD, BM@N and SPD experiments at the NICA complex, as well as the Baikal-GVD neutrino telescope;

— the successful development of the JINR Digital EcoSystem platform for the integration of the existing and future services to support scientific, administrative, financial and economic activities, and maintain the engineering and IT infrastructure of the Institute.

The CP took note of the information about the decision of the STRABAG SE concern (Republic of Austria) to limit the activities of its subsidiary and controlled organization STRABAG JSC in the territory of the Russian Federation and endorsed the efforts of the Directorate of the Joint Institute for Nuclear Research aimed at changing the general contractor for the implementation of the project "Installation of the heavy-ion collider NICA at the site of VBLHEP JINR in Dubna with a partial reconstruction of the building No. 1". The CP commissioned the JINR Directorate to search for a new general contractor and sign a contract with them paying special attention in agreeing on conditions with the new general contractor to ensuring the possibility of completing construction in 2024.

The CP supported the efforts of the JINR Directorate in working out the Programme for the Development of Infrastructure in Science Cities (Dubna and JINR as a pilot project).

Having highlighted the mutual value of decades-long JINR–CERN cooperation, during which the unique scientific infrastructure of CERN has been created through joint efforts with the participation of scientists from the JINR Member States, the CP expected that the achieved status of cooperation will be continued after January 2025, and scientists from the JINR Member States will be able to effectively participate in scientific research on the created infrastructure of international collaborations, in which they have invested significant intellectual and material resources.

Taking into account the external risks of suspension of some international agreements for JINR, the CP commissioned the JINR Directorate to work out scenarios for possible redistribution of resources to ensure effective participation of JINR and employees with JINR affiliation in promising international collaborations on priority areas of the Seven-Year Plan.

The CP approved the presented Seven-Year Plan for the Development of JINR for 2024–2030, commended by the Scientific Council and the JINR Finance Committee.

The CP approved the Topical Plan for JINR Research and International Cooperation for 2024.

Having heard and discussed the report "Draft budget of JINR for 2024, provisional contributions of the Member States for the years 2025, 2026, 2027" presented by N. Kalinin, Head of the JINR Budget and Economic Policy Department, the Committee

of Plenipotentiaries approved the JINR budget for 2024, in accordance with the new expenditure structure, with the income amounting to US$ 214 124.5 thousand and the expenditure amounting to US$ 253 672.8 thousand with the closing negative balance amounting to US$ 39 548.3 thousand.

The CP authorized the Director of JINR to make adjustments to the JINR budget for 2024, including adjustments to the personnel remuneration and costs for international cooperation within the approved budget in compliance with the Regulations for the Introduction of Adjustments to the Budget of JINR.

The CP approved the scale of contributions of the JINR Member States for 2024, as well as the provisional contributions of the Member States for the years 2025 and 2026.

The CP approved the budget for 2024 on the construction and exploitation of the NICA complex of superconducting rings for heavy-ion colliding beams with the special-purpose funds of the Russian Federation, provided in accordance with the Agreement between the Government of the Russian Federation and JINR, in the amount of 1 993 342.0 thousand rubles.

The CP approved the consolidated adjustment of the JINR budget for 2023 over nine months.

The CP authorized the Director of JINR to index the salary and tariff parts of the remuneration package of the Institute's employees, taking into account the possibilities of the JINR budget for 2024, in accordance with the JINR Collective Bargaining Agreement for 2023–2026.

Having heard and discussed the report "Results of the meeting of the JINR Finance Committee held on 9 November 2023" presented by A. Omelchuk, Chair of the Finance Committee, the Committee of Plenipotentiaries commissioned the JINR Directorate and the Working Group under the CP Chair for JINR Financial Issues to work out a quota mechanism for specialists from the Member States, provided for by the JINR Charter, and the issue of practical application of the regulation for the lower limits of contributions, and submit them for consideration at the meeting of the Finance Committee and the CP session in November 2024.

The CP commissioned the JINR Directorate to finalize proposals for amending the Rules of Procedure of the Finance Committee and the Rules of Procedure of the Committee of Plenipotentiaries of JINR and submit them for consideration at the meeting of the Finance Committee and for approval at the CP session in March 2024.

The CP approved the audit report based on the results of the audit of JINR's financial activities for 2022.

The CP included the representatives of the Republic of Armenia and the Arab Republic of Egypt in the Working Group under the CP Chair for JINR Financial Issues.

Having heard and discussed the report "Recommendations of the 134th session of the JINR Scientific Council (September 2023)" presented by S. Nedelko, Chief Scientific Secretary of JINR, the Committee of Plenipotentiaries approved the recommendations of the 133rd and 134th sessions of the JINR Scientific Council.

Having heard and discussed the report "Changes in the membership of the JINR Scientific Council" presented by G. Trubnikov, Director of JINR, the Committee of Plenipotentiaries elected Z. Vilakazi (Wits University, Johannesburg, Republic of South Africa) as a member of the JINR Scientific Council for the term of office of the current membership of the Scientific Council.

Having heard and discussed the report "Amendments to the Regulation on the Procedure for Awarding JINR Annual Prizes" presented by S. Nedelko, Chief Scientific Secretary of JINR, the Committee of Plenipotentiaries approved the amended text of the Regulation.

SCIENTIFIC COUNCIL

133rd SESSION OF THE JINR SCIENTIFIC COUNCIL, 16–17 February 2023

The 133rd session of the JINR Scientific Council was held on 16–17 February. It was chaired by JINR Director G. Trubnikov and Deputy Chairman of the Presidium of the National Academy of Sciences of Belarus S. Kilin.

The Scientific Council adopted the following Resolution.

General Considerations

Having taken note of the report of JINR Director G. Trubnikov, the Scientific Council expressed regret over the withdrawal of the Czech Republic, the Republic of Poland, and Ukraine from the JINR Member States from 1 January 2023, as well as high hopes that the geopolitical crisis in Eastern Europe will soon find a peaceful solution, which will allow JINR to recover the lost members.

The Scientific Council welcomed the participation in its session of the national delegation of the United Mexican States headed by His Excellency Eduardo Villegas Megías, Ambassador of the United Mexican States to the Russian Federation.

The Scientific Council listened with interest to the report "Expanding Mexico–JINR collaboration: Some areas of potential interest" presented by the President of the Mexican Physical Society, A. M. Cetto Kramis.

The Scientific Council welcomed the signing of the Joint Declaration of Intent Concerning Cooperative Activities in the Area of Fundamental, Frontier and Applied Scientific Research between the National Council of Humanities, Sciences and Technologies — CONAHCYT (Mexico) and the Joint Institute for Nuclear Research, and expressed hope for expanding the participation of Mexican researchers in JINR activities and for enhanced cooperation with the Mexican research community in general.

The Scientific Council approved the practical measures taken by the JINR Directorate to strengthen cooperation with scientific organizations and universities in China on the basis of partnership coordinated at the governmental level.

The Scientific Council noted with satisfaction the progress in implementing the current plan of research and development of the scientific infrastructure at JINR and JINR's achievements in the international collaboration projects:

— the successful completion of the fourth technological cycle of the NICA accelerator complex, which became the longest run in the history of VBLHEP (> 3400 h), the successful commissioning of the injection chain, including the common operation of all its elements, the optimization of the beam dynamics, the operation of the electron cooling, the testing of the SOCHI station with heavy ions, the calibration of the new diagnostic system, and the modernization of the vacuum system in the extracted beam line;

— the long-term stable operation of the accelerator complex for the BM@N experiment, for the first time in full configuration, as a result of which about 507 million events with the Xe beam at a kinetic energy of 3.8*A* GeV and 48 million events at an energy of 3*A* GeV were recorded, as well as the beginning of a physical analysis of the recorded data;

— the progress in the production of the magnets and their installation in the NICA collider tunnel, the completion of the installation of all the dipoles in the collider tunnel arches, the test assembly of the collider electron cooling system, performed in October 2022 at the Budker Institute of Nuclear Physics SB RAS (Novosibirsk), and the transportation of some parts to JINR;

— the work carried out by the MPD Collaboration and the VBLHEP team on the construction of the MPD detector, and the progress in the production of all the detector components required for a technological launch in 2023, including the cryogenics, control and power supply systems, detector subsystems, and other equipment;

— the presentation of the SPD TDR at the PAC for Particle Physics session in January 2023 and the ongoing developments and tests of the detector prototypes;

— the successful progress of work and the high level of JINR's readiness to fulfill its obligations under the programme for the second phase of the upgrade of the ATLAS, CMS and ALICE detectors at the LHC at CERN;

— the development of the Baikal-GVD neutrino telescope for observing natural neutrino fluxes and

Dubna, 16–17 February. The 133rd session of the JINR Scientific Council

the registration of 24 events — the candidates for being high-energy neutrinos, which indicated the observation of an astrophysical neutrino flux in the IceCube observatory, in the Southern Hemisphere. The presence of an isotropic neutrino flux of an astrophysical nature was indicated according to the Baikal-GVD data at a statistically significant level, taking into account the systematics of 3.05σ;

— the successful continuation of the experiments at the Factory of Superheavy Elements using the DGFRS-2 separator, in particular, on the synthesis of the new isotopes of darmstadtium (^{276}Ds), hassium (^{272}Hs), and seaborgium (^{268}Sg) in the reaction ^{48}Ca + ^{232}Th, as well as the continuation of the preparations for the experiments related to the chemical properties of elements 114 (Fl) and 112 (Cn) at the DGFRS-3 (GRAND) separator in the second half of 2023. The former experiments were carried out in December 2022;

— the implementation of the work plan at the IBR-2 reactor to replace the heat exchangers with the new ones and prepare a complete package of documentation for the licensing, and the important progress in the development of the IBR-2 spectrometers;

— the further active development of the fundamental and applied areas of research related to life sciences and condensed matter physics based on the development of an interlaboratory research programme on the basis of the Laboratory of Radiation Biology;

— the successful development of the JINR MICC, including the modernization of the Govorun supercomputer carried out in 2022, and the successful operation of the Tier-1 centre for the CMS and NICA-MPD Collaborations;

— the significant progress in creating the JINR Digital EcoSystem platform for the integration of the existing and future services to support scientific, administrative and social activities as well as the maintenance of the engineering and IT infrastructures of the Institute.

On the Draft Seven-Year Plan for the Development of JINR for 2024–2030

After hearing the report on updating the draft Seven-Year Plan for the Development of JINR for 2024–2030, presented by JINR Director G. Trubnikov, the Scientific Council agreed with the opinion of the JINR Directorate that the revised draft Seven-Year Plan fully corresponds to the architecture and logic of the JINR Long-Term Development Strategic Plan up to 2030 and beyond. The Scientific Council stressed that the presented Plan contains an ambitious international scientific programme, which requires optimal staff and financial resources. The Scientific Council approved the inclusion of a section on risk assessment in the revised Plan and also stressed that the reduction of the scientific programme and the resource provision of this Plan would inevitably lead to a decrease in the competitiveness of JINR among international scientific organizations.

In order to complete the process of expert evaluation of the Seven-Year Plan and optimize the implementation of its first stage in the current Topical Plan for JINR Research, the Scientific Council recommended organizing a joint working group, consisting of representatives of all three PACs, and taking into account the recommendations of the June 2023 sessions of the PACs.

Discussion of the Director's Reports

In the course of the discussion of the reports by JINR Director G. Trubnikov, members of the Scientific Council made the following recommendations:

— to maintain efforts to achieve gender balance at JINR;

— to include in the agenda of the Scientific Council a special presentation on the NICA project.

Recommendations of the Programme Advisory Committees

The Scientific Council took note of the recommendations made by the PACs at their meetings in January 2023, as reported at this session by I. Tserruya, Chair of the PAC for Particle Physics, V. Nesvizhevsky, Chair of the PAC for Nuclear Physics, and D. L. Nagy, Chair of the PAC for Condensed Matter Physics. The Scientific Council asked the JINR Directorate to consider these recommendations while preparing the Topical Plan for JINR Research and International Cooperation for 2024.

Particle Physics. The Scientific Council recognized the PAC's support of the steps taken by the JINR Directorate to emphasize the international status of the Institute and overcome the difficulties of this challenging time.

The Scientific Council endorsed the established priorities in the Seven-Year Plan for the Development of JINR for 2024–2030 in the area of particle physics and relativistic heavy-ion physics:

— the implementation of the physics programme to study hot and dense baryonic matter and phase transitions at the BM@N and MPD experimental facilities after the commissioning of the basic configuration of the NICA accelerator complex;

— the creation of the first stage of the SPD experimental setup for research in the field of spin physics;

— the launch and support of an international user programme for interdisciplinary applied research based on the NICA facility around the ARIADNA beam lines channels and irradiators, and the creation of the user infrastructure;

— the promotion of international cooperation around the JINR's major projects, the BM@N, MPD and SPD projects at the NICA complex, and the Baikal-GVD neutrino project.

The Scientific Council seconded the PAC's recommendation on the allocation of manpower within VBLHEP to ensure a timely completion of the NICA complex, including the experimental facilities, and the realization of their ambitious physical programme.

The Scientific Council highly appreciated the intensive work at VBLHEP on the experimental programme at the SRC and BM@N facilities, and together with the PAC, congratulated the NICA team on the successful completion and joint operation of several elements of the NICA complex — the ion source, the heavy-ion linear accelerator, the Booster, the Nuclotron, and the modernized 136-meter beam transport line, and on the installation of all the dipole superconducting magnets in the arcs of the collider tunnel.

The Scientific Council noted that the production of all the components of the MPD first-stage detector configuration was progressing well. The Scientific Council joined the PAC in congratulating the MPD team on finding the viable solutions for the critical issues arising in many aspects of the detector construction, assembly, and commissioning.

The Scientific Council, together with the PAC, highly appreciated the achievement of an important milestone in the realization of the BM@N project — the physics run with the 3.6*A* GeV Xe beam interacting with a CsI target, which started in November 2022 and continued until the end of January 2023. The data acquisition system recorded over 500 million Xe + CsI interactions. The experiment was running with the full set of detectors. The Scientific Council noted the successful operation of the long vacuum beam line and the beam profile meters between the Nuclotron and the BM@N setup, as well as inside the setup. It significantly reduced the beam background in the BM@N detectors.

The Scientific Council acknowledged the progress made by the SPD Collaboration in preparing the Technical Design Report (TDR) based on the results obtained during the development and testing of the prototypes of the SPD subsystems. The Scientific Council endorsed the PAC's recommendation to the JINR management to appoint a Detector Advisory Committee for a thorough review of the SPD TDR.

The Scientific Council acknowledged the leading role of the JINR group in the development and construction of the main subsystems of the COMET detector. It also noted with satisfaction the participation of the members of the JINR group in the management structures of the COMET Collaboration. The Scientific Council highly appreciated the participation of the JINR group in the T2K-II experiment and shared the PAC's concern, expressed in the recommendations of the 55th session of the PAC for Particle Physics, on the role, strategy and scientific visibility of the JINR group within the T2K-II project. The Scientific Council endorsed the PAC's recommendation on the continuation of the COMET project until the end of 2024 with ranking A and the continuation of the JINR's participation in the second phase of the T2K experiment until the end of 2024 with ranking B.

The Scientific Council noted with satisfaction the important scientific results obtained by the JINR teams participating in the ALICE, ATLAS and CMS experiments at the LHC at CERN, and the growing visibility and increased involvement in physics analyses of the three JINR teams.

Nuclear Physics. The Scientific Council took note of the reports considered by the PAC for Nuclear Physics on the proposals for the Seven-Year Plan for the Development of JINR for 2024–2030 in the field of nuclear physics.

Heavy-ion research at FLNR is aimed at completing the tasks outlined in two themes: "Synthesis and Properties of Superheavy Elements, Structure of Nuclei at the Limits of Nucleon Stability" and "Development of the FLNR Accelerator Complex and Experimental Setups (DRIBs-III)". The Scientific Council noted with satisfaction the discovery of five new isotopes in the reactions of ^{48}Ca beams with Th, U, Pu and Am targets at the SHE Factory. In particular, the alpha-decay branches of ^{268}Db were measured for the first time and new isotope ^{264}Lr was discovered.

One of the essential tasks of FLNR in 2024–2030 is the synthesis of new elements 119 and 120 in such reactions as ^{54}Cr + ^{248}Cm and ^{50}Ti + ^{249}Bk. The further experimental studies of the structure and mechanisms of production of nuclei near and beyond the limits of nucleon stability are planned at FLNR at the ACCULINNA-1, ACCULINNA-2 and MAVR setups. A project for upgrading the U-400 → U-400R accelerator and the new 1500 m^2 experimental hall was prepared. The Scientific Council supported the proposed strategy for the development of heavy-ion physics research at FLNR for 2024–2030.

Nuclear physics research with neutrons at FLNP is carried out within the framework of the scientific theme "Investigations of Neutron Nuclear Interactions and Properties of the Neutron" and three projects.

Physics research within the framework of the theme can be divided into three areas: 1) study of violations of fundamental symmetries in the interaction of neutrons with nuclei, obtaining nuclear data; 2) study of the fundamental properties of the neutron, physics of ultracold and very cold neutrons; 3) applied and methodological research.

The Scientific Council supported the PAC's recommendation to focus, for the seven-year period 2024–2030, on solving the following physical problems in the field of neutron physics: comprehensive study of the process of nuclear fission; study of the properties of neutron resonances; development and application of the method of tagged neutrons to study reactions of fast neutron interactions; development and application of neutron and nuclear methods for elemental analysis and applied research. The development of a new UCN source at the IBR-2 reactor will be one of the main tasks in this field.

The Scientific Council recommended the continuation of scientific research in the field of nuclear physics with neutrons using the FLNP neutron facilities, such as the IREN pulsed source of resonance neutrons and the IBR-2 pulsed reactor, and supported the planned increase in the intensity of the neutron flux of the IREN facility up to $3 \cdot 10^{12}$ s^{-1} over the seven-year period 2024–2030.

The Scientific Council took note of the research within the theme "Non-Accelerator Neutrino Physics and Astrophysics", devoted to the study of rare phenomena associated with the weak interaction

by the methods of modern nuclear spectrometry. The following research directions are distinguished within this theme: investigation of double beta decay; search for the neutrino magnetic moment, neutrino-nucleus coherent scattering; investigation of galactic and extragalactic neutrino sources, diffusive neutrino cosmic background, search for exotic particles.

The Scientific Council supported the proposal of the PAC and the DLNP Directorate to reorganize the structure of the theme. The Scientific Council underlined the importance of the efforts of DLNP to further improve the local infrastructure at JINR and on Lake Baikal.

Research in the field of low-energy nuclear physics at BLTP is carried out within the framework of the theme "Theory of Nuclear Systems". Study of the structure of nuclei far from stability, structure of superheavy nuclei, nucleus–nucleus collisions at low energies, fusion and fission dynamics, and reactions of astrophysical interest are the main research areas.

For the seven-year period 2024–2030, the research in the field of low-energy nuclear physics will be focused on the study of exotic nuclei in the regions of superheavy elements and light nuclear systems at the borders of stability and beyond.

The Scientific Council highly appreciated the results obtained and supported the recommendation to extend the theme "Theory of Nuclear Systems" until the end of 2030.

The development of reliable network and information and computing infrastructure is carried out within the theme "Information and Computing Infrastructure of JINR" and its project "Multifunctional Information and Computing Complex (MICC)" at MLIT. Another important activity of MLIT is related to the development and implementation of effective methods, algorithms and software for modeling physical systems, mathematical processing and analysis of experimental data for the successful implementation of the scientific programme. The Scientific Council supported the MLIT scientific programme for the seven-year period 2024–2030 related to the development of the information and computing infrastructure of JINR and methods, algorithms and software for modeling physical systems, mathematical processing and analysis of experimental data.

Condensed Matter Physics. The Scientific Council noted with satisfaction the progress in replacing the air heat exchangers of the secondary reactor cooling circuit of the IBR-2 reactor and obtaining the operating license for this facility. The Scientific Council concurred with the PAC that the manufacturing of the new fuel load for IBR-2 is one of the crucial points for years 2024–2030, which will provide the necessary conditions for extending the reactor's service life for the period after 2032. The Scientific Council welcomed the continuation of the activity towards studying the mechanism of the occurrence of fluctuations in the power pulses of the IBR-2 reactor in cooperation with JSC NIKIET and other organizations of Rosatom State Corporation. The Scientific Council supported the PAC's recommendation on the urgency of taking a decision on the choice of the manufacturer of the components for a new fuel load for IBR-2. The Scientific Council shared the PAC's opinion on the importance of obtaining the new license for operation of the reactor as soon as possible, which will give an opportunity to resume the operation of IBR-2 for physics experiments and to carry out the planned upgrade of the safety-related equipment and systems, including the suite of cryogenic moderators.

The Scientific Council supported the PAC's recommendation on the themes to be included in the Topical Plan for JINR Research and International Cooperation in the context of the Seven-Year Plan for the Development of JINR for 2024–2030. As regards the FLNP themes, the Scientific Council was pleased with the main areas suggested for the implementation within the theme "Investigations of Functional Materials and Nanosystems Using Neutron Scattering". The Scientific Council supported the activities aimed at the development of the experimental infrastructure of the IBR-2 reactor within the theme "Scientific and Methodological Research and Developments for Condensed Matter Investigations with IBR-2 Neutron Beams". The Scientific Council supported the implementation of research within the new theme "Optical Methods in Condensed Matter Studies". The Scientific Council appreciated the scope of activities within the theme "Development of the Conceptual Design of a New Advanced Neutron Source — Fast Pulse NEPTUNE Reactor at JINR" in terms of the current status and plans.

The Scientific Council approved the status and prospects for the development of the scientific programme of MLIT and noted that a distinctive feature of the research areas related to information technology is the close cooperation with all the JINR Laboratories and with organizations of the JINR Member States and other countries. Together with the PAC, the Scientific Council recommended further continuation of the IT-related research.

The Scientific Council noted the plans for the development of the BLTP theme "Theory of Complex Systems and Advanced Materials" and supported its general composition, constituted of four projects on the following topics: complex materials, mathematical models of statistical physics of complex systems, nanostructures and nanomaterials, and methods of quantum field theory in complex systems. The Scientific Council approved the basic scientometric information on the theme as well as the composition of the personnel and the proposed types of collaboration.

The Scientific Council welcomed the wide range of R&D studies carried out and the high quality of the results obtained within the DLNP themes "Development of Scientific DLNP Infrastructure for Research Using Semiconductor Detectors, Laser Metrology, Electrons, Positrons and Cryogenic Technology" and "Biomedical and Radiation-Genetic Studies Using Different Types of Ionizing Radiation" and supported further continuation of these activities. The Scientific Council also noted the progress in the development of the Linac-200 facility and works on laser metrology focused on the development and installation of the high-precision instruments at the NICA facility and in the laboratories of the JINR Member States.

The Scientific Council approved the implementation of research on the biological effects of ionizing radiation with different physical characteristics within the new LRB theme "Research on the Biological Effects of Ionizing Radiation with Different Physical Characteristics" and noted the planned studies of the mechanisms of action of ionizing radiation on the molecular, cellular, tissue and organismal levels of biological organization, as well as the research in astrobiology on the origin and persistence of life in the Universe using nuclear physics methods.

The Scientific Council positively assessed the structure of the new FLNR theme "Radiation Materials Science, Nanotechnological and Biomedical Investigations with Accelerated Heavy-Ion Beams", showing the relevance and demand of fundamental and applied research based on the use of accelerated heavy-ion beams for the studies of material properties and modifications, and supported the development of biomedical applications of track-etched membranes and research on nuclear isotopes and ecological investigations.

Common Issues

The Scientific Council approved the efforts of the JINR Directorate to update the approach to the formation of the Topical Plan for JINR Research and International Cooperation by implementing the Regulations on structuring and planning scientific research at JINR, as well as risk assessment and mitigation measures.

Reports by Young Scientists

The Scientific Council listened with interest to the reports by young scientists, selected by the PACs for presentation at this session: "A study of the correlation between the kinetic energy of a track and its energy response in the ZDC for run 7 of the BM@N experiment" by K. Alishina (VBLHEP) and "Structural studies of lithium-ion batteries in research of their functional characteristics" by M. Yerdauletov (FLNP). The Scientific Council thanked the speakers and welcomed the presentation of such selected reports in the future.

Awards and Prizes

The Scientific Council congratulated FLNR Senior Researcher P. Apel on the award of the V. Dzhelepov Prize for the development of a new generation of track membranes and their applications in medicine and ecology.

The Scientific Council approved the Jury's recommendations presented by Vice-Director V. Kekelidze on awarding the JINR annual prizes for best scientific, methodological, technological and applied research papers.

Election and Announcement of Vacancies in the Directorates of JINR Laboratories

The Scientific Council elected E. Lychagin as Director of the Frank Laboratory of Neutron Physics (FLNP) for a term of five years. The Scientific Council thanked V. Shvetsov for his successful tenure as Director of this Laboratory.

The Scientific Council elected S. Shmatov as Director of the Meshcheryakov Laboratory of Information Technologies (MLIT) for a term of five years. The Scientific Council thanked V. Korenkov for his successful tenure as Director of this Laboratory.

The Scientific Council endorsed the appointments of E. M. Anitas, N. Antonenko, and O. Teryaev as Deputy Directors of the Bogoliubov Laboratory of Theoretical Physics (BLTP) until the completion of the term of service of the current BLTP Director, D. Kazakov.

The Scientific Council announced the vacancies for the positions of FLNP and MLIT Deputy Directors. The endorsement of the appointments took place at the 134th session of the Scientific Council in September 2023.

In Memory of V. Rubakov

The Scientific Council expressed deep regret over the loss of RAS Academician V. Rubakov, member of the Scientific Council during 2013–2022. He was an outstanding scientist, one of the world's leading experts in the fields of quantum field theory, elementary particle physics, and cosmology, who made significant contribution to the development of JINR.

134th SESSION OF THE JINR SCIENTIFIC COUNCIL, 21–22 September 2023

The 134th session of the JINR Scientific Council was held on 21–22 September. It was chaired by JINR Director G. Trubnikov and Deputy Chairman of the Presidium of the National Academy of Sciences of Belarus S. Kilin.

The Scientific Council adopted the following Resolution.

General Considerations

The Scientific Council took note of the comprehensive report by JINR Director G. Trubnikov and welcomed the signing of the Protocol between the Ministry of Science and Higher Education of the Russian Federation, the Ministry of Science and Technology of the People's Republic of China, the Joint Institute for Nuclear Research and the Chinese Academy of Sciences on strengthening cooperation in the field of basic scientific research at the governmental level in March 2023, and endorsed the establishment of the JINR–China Joint Coordination Committee and the practical measures taken by the Committee to enhance JINR's collaboration with scientific organizations and universities in China.

Dubna, 21–22 September. The 134th session of the JINR Scientific Council


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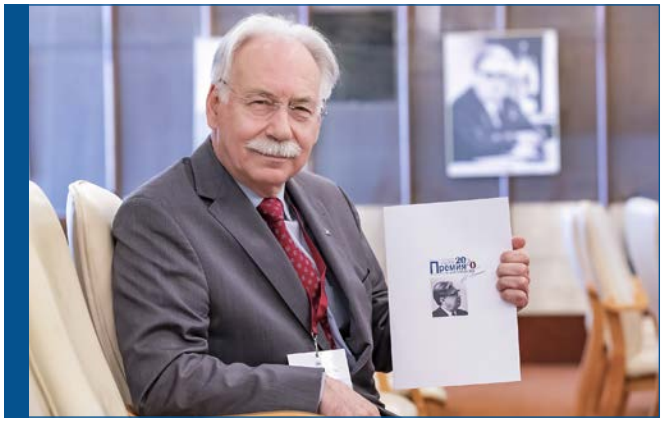


The Scientific Council noted with satisfaction the progress in implementing the current plan of research and development of the scientific infrastructure at JINR and JINR's achievements in the international collaboration projects and international cooperation:

— for the first time at JINR, the successful use of the entire computing infrastructure integrated by DIRAC for the complete reconstruction of the raw experimental data recorded during the long-term stable operation of the accelerator complex of the BM@N experiment in full configuration, when more than 550 million events with the Xe beam were registered;

— the successful work of the MPD Collaboration and the VBLHEP team on the construction of all the components of the MPD detector, including the cryogenics, control and power supply systems, detector subsystems, and other equipment;

— the dynamic development of the ARIADNA Collaboration, whose applied research programme was launched at the NICA complex at the beginning of 2023, and the preparation of a series of publications based on experimental results;

— the successful participation of the Institute in the work of collaborations at CERN, in particular, in the NA64 experiment at the SPS, as well as the high level of JINR's activity in the fulfilment of its obligations under the programme for the second phase of upgrade of the ATLAS, CMS and ALICE detectors at the LHC at CERN;

— the progress in developing the Baikal-GVD deep-water neutrino telescope, installation of 576 optical modules and two bottom cable lines in 2023, as well as an effective volume approaching 0.6 km^3, which ensures the Baikal-GVD status as the largest neutrino telescope in the Northern Hemisphere;

— the successful continuation of experiments at the Factory of Superheavy Elements, in particular, the first experiment on α-, β-, γ-spectroscopy and the discovery of a new isotope ^{227}Pu;

— the progress in developing the DRIBs-III accelerator complex with the modernization of U-400M being close to the final stage, the completion of the first stage of construction work for DC-140, as well as the beginning of construction work in the new experimental hall of U-400R;

— the successful implementation of the work plan to prepare for the continuation of the regular operation of the IBR-2 reactor and the progress in developing the concept of an intense source of ultracold neutrons (UCN) at a pulsed reactor of moderate power, based on the idea of pulsed filling of a trap for UCN;

— the progress in preparations for the commissioning of the Linac-200 linear accelerator at JINR, a new facility at DLNP constructed to provide electron beams to carry out particle detectors R&D for NICA and other projects, biological studies, applied research, and student training;

— the further active development of fundamental and applied areas of research related to life sciences and condensed matter physics based on the development of the interlaboratory research programme on the basis of the Laboratory of Radiation Biology;

— the successful work of the Bogoliubov Laboratory of Theoretical Physics and interesting selected results in particle physics, nuclear physics, condensed matter physics, and advanced mathematical physics;

— the successful development of the JINR MICC, including the Govorun supercomputer, as a result of which its total peak performance reached 1.7 PFlops with double precision. In terms of Tier-1 productivity, in 2023, JINR ranked second in the world among other Tier-1 centres for the CMS experiment; the DIRAC distributed platform is used to support the collaborations of the NICA experiments: MPD, BM@N, SPD, as well as the Baikal-GVD neutrino telescope;

— the successful development of the JINR Digital EcoSystem platform for the integration of the existing and future services to support scientific, administrative, financial and economic activities and maintain the engineering and IT infrastructure of the Institute.

Seven-Year Plan for the Development of JINR for 2024–2030

The Scientific Council noted with satisfaction the report on the prefinal revision of the draft Seven-Year Plan for the Development of JINR for 2024–2030 presented by JINR Director G. Trubnikov.

The Scientific Council emphasized that despite the difficult working conditions associated with COVID-19 and the dramatic deterioration of the geopolitical situation, in 2017–2023, JINR achieved impressive results both in the development of the Institute's large research infrastructure and in scientific research based on this infrastructure. The JINR's significant contribution to international collaborations, especially at CERN, should be also mentioned. JINR is successfully developing as an international intergovernmental scientific organization establishing new integration ties with leading scientific organizations in the world. The Scientific Council considered it timely and extremely necessary to extend and upscale frontier studies and developments in beam physics and accelerators, and supported the preparatory work of JINR on restructuring the JINR Topical Plan with opening the corresponding interlaboratory theme. In general, these achievements have established a very solid foundation for the further development of the Institute in the new seven-year period.

The Scientific Council appreciated the comprehensive consideration of the draft Seven-Year Plan for the Development of JINR for 2024–2030 by the joint working group of all three JINR Programme Advisory Committees, final examination of the scientific programme of the Plan and taking into account the constructive comments of this working group by the JINR Directorate when preparing the current version of the Plan. The Scientific Council supported the submission of the current version of the Plan, possibly with minor editorial corrections, to the CP

session in November 2023 for final approval for implementation in 2024–2030.

Recommendations of the Programme Advisory Committees Taken at the Meetings in June 2023

The Scientific Council took note of the recommendations made by the PACs at their meetings in June 2023, and thanked the PACs for their recommendations to open new projects and themes as well as extend the most important research contributed by the laboratories to the Seven-Year Plan for the Development of JINR for 2024–2030, discussed and supported at the meetings of the Committees.

Particle Physics. The Scientific Council recognized the PAC's support of the steps taken by the JINR Directorate to increase the participation of Mexican researchers in JINR activities, strengthen cooperation with scientific organizations and universities in China, maintain a high level of cooperation with research organizations from all European countries in order to promote the international status of the Institute and overcome the difficulties of this challenging time.

The Scientific Council congratulated the accelerator team of the Nuclotron–NICA complex for the successful fourth technical run. The Scientific Council took note of the development of the VBLHEP infrastructure, resulting in the doubling of the available power to 40.8 MW. It also noted the various delays due to the difficult geopolitical situation, among which the delays in the completion of infrastructure work at the collider building and in the construction of transfer lines from the Nuclotron to the NICA collider. The Scientific Council acknowledged the efforts of the JINR and NICA managements to mitigate these delays and took note of the resulting revised schedule, according to which the first beams at the NICA collider are now expected by 2025.

The Scientific Council noted that the development of the MPD detector is progressing and the work is ongoing towards the commissioning of the large superconducting solenoid of MPD. Although the schedule is delayed due to problems with supplies of many components from European companies, all components of the MPD first-stage detector remain on track to be installed in 2024.

The Scientific Council congratulated the BM@N Collaboration for the first and successful physics run of the BM@N detector in its full configuration with Xe beams and supported the PAC to concentrate its efforts on getting first physics results of this run.

The Scientific Council seconded the PAC in reiterating its recommendation to the JINR management on the need to resume the activities of the international SPD Detector Advisory Committee, which will allow the SPD team to proceed further with the preparation of the Technical Design Report.

The Scientific Council acknowledged the contribution of the JINR participants to obtaining physical results and upgrading the detectors in the experiments at the LHC.

The Scientific Council appreciated the involvement of the JINR team in the NA64 project, its theoretical motivation, its responsibilities in the detector operation, the development and support of the straw tracker, the DAQ operation, and the data taking and analysis. It endorsed the PAC's recommendation to continue the participation of the JINR team in the NA64 experiment for 2024–2026 with ranking A.

The Scientific Council supported the decision of the PAC to postpone the approval of the SCAN-3 project and to request the authors to present at the next session of the PAC a clear proposal outlining the original goals of the project, the achievements over the past four years, and its plans for the requested extension period.

The Scientific Council appreciated the important contributions of the JINR group in the BES-III experiment at IHEP (Beijing, China) and supported the plans to continue the study of charmed quarks in the future SPD experiment at NICA. It endorsed the PAC's recommendation to continue the JINR group's participation in the BES-III project for 2024–2028 with ranking A.

The Scientific Council noted the important role of the JINR team in the TAIGA Collaboration for the development and production of Imaging Atmospheric Cherenkov Telescopes (IACT). It supported the PAC in encouraging the JINR TAIGA team to collaborate with the JINR Baikal-GVD team in the data analysis, in particular, in the search for events with similar and complementary characteristics. The Scientific Council endorsed the PAC's recommendation to continue the participation in the TAIGA project for 2024–2028 with ranking A.

The Scientific Council appreciated the important contributions and the visible participation of the JINR team in the JUNO reactor neutrino experiment, which is at the commissioning stage, and supported the PAC's recommendation to continue the JINR's participation in JUNO for 2024–2027 with ranking A.

The Scientific Council acknowledged the significant contribution made by the JINR team to the accelerator neutrino NOvA experiment and the plans to contribute to the construction of the Near Detector of the new-generation DUNE experiment. Members of the JINR team hold prominent positions in the NOvA Collaboration, coordinating the processing of experimental data and analysis of exotic channels. The Scientific Council appreciated the important scientific missions of the NOvA and DUNE experiments and the strength of the JINR team participating in these two projects. The Scientific Council endorsed the PAC's recommendation to continue the JINR's participation in the NOvA experiment and supported the preparation work for the DUNE project for 2024–2027 with ranking A.

The Scientific Council appreciated the efforts aimed at providing modern computing facilities for the JINR scientists on the basis of the project "Multifunctional Information and Computing Complex (MICC)", including the Tier-1 and Tier-2 grid sites, cloud infrastructure, hyperconverged Govorun supercomputer, multilayer data storage system, network infrastructure, power supply and climate

control systems. The Scientific Council supported the PAC's recommendation to extend the MICC project for 2024–2030 with ranking A.

The Scientific Council recognized, together with the PAC, the ever-growing role that software, algorithms, machine learning techniques, and computational physics play in modern science, including high-energy physics, nuclear physics, and related fields. The Scientific Council endorsed the PAC's recommendation to open a new project "Mathematical methods, algorithms and software for modeling physical processes and experimental facilities, processing and analysing experimental data" aimed at developing general mathematical methods and software, targeting, first of all, the experiments of the JINR flagship project NICA and the JINR neutrino programme for 2024–2027 with ranking A.

The Scientific Council took note of the new project for JINR's participation in the AMBER fixed-target experiment at the CERN SPS, dedicated to the study of the internal structure and properties of hadrons. Taking into account the synergy between the rich physics programmes of the AMBER and NICA SPD experiments, including the benefit of training young researchers in the AMBER experiment while the SPD is under construction, the Scientific Council endorsed the PAC's recommendation on the participation of the JINR team in the AMBER experiment for 2024–2026 with ranking A.

Nuclear Physics. The Scientific Council supported the extension of the theme "Theory of Nuclear Systems", which includes four new projects: "Low-energy nuclear dynamics and properties of nuclear systems", "Microscopic models for exotic nuclei and nuclear astrophysics", "Quantum few-body systems", and "Relativistic nuclear dynamics and nonlinear quantum processes".

The main areas of scientific research on the theme "Synthesis and Properties of Superheavy Elements, Structure of Nuclei at the Limits of Nucleon Stability" for the period 2024–2030 are related to the study of the superheavy nuclei and atoms, as well as light nuclei far from the β-stability line. The Scientific Council supported the extension of this theme for the seven-year period and approved the opening of two new projects until the end of 2028: "Investigation of heavy and superheavy elements" and "Light exotic nuclei at the borders of nuclear stability".

The Scientific Council noted the high quality of the obtained scientific results in the following areas: the study of violations of fundamental symmetries in the interactions of neutrons with nuclei, obtaining nuclear data; studies of the fundamental properties of the neutron, the physics of ultracold and very cold neutrons; applied and methodical work, and supported the opening of a new theme "Nuclear Physics with Neutrons" and a new project "Investigations of neutron nuclear interactions and properties of the neutron" until the end of 2028 as well as extending the TANGRA project until the end of 2028 and the project "Modernization of the accelerator EG-5 and its experimental infrastructure" until the end of 2026.

The Scientific Council recommended extending the projects "Accelerator-driven subcritical reactor (ADSR)" until the end of 2027 and "Study of the nucleon spin structure in strong and electromagnetic interactions (GDH&SPASCHARM&NN)" until the end of 2028, and opening new projects "Radiochemistry and spectroscopy for astrophysics and nuclear medicine", "Investigations of reactor neutrinos on a short baseline", and "Nuclear spectrometry for the search and investigation of rare phenomena" until the end of 2028.

The Scientific Council endorsed the proposal of the JINR Directorate to reform the themes and projects into large research infrastructure (LRI), in particular, LRI "Development of the FLNR Accelerator Complex and Experimental Setups (DRIBs-III)", including the projects "Construction of the U-400R accelerator complex" and "Development of the experimental setups to study the chemical and physical properties of superheavy elements", and LRI "Baikal-GVD", representing the Baikal-GVD gigaton neutrino detector, the largest operating neutrino telescope in the Northern Hemisphere.

Condensed Matter Physics. The Scientific Council supported the PAC's recommendation to open a new LRI "Pulsed Neutron Source and Spectrometer Complex" and a project "Development of the IBR-2 facility with a complex of cryogenic neutron moderators". The Scientific Council took note of the main objective of the project, which is to increase the efficiency of using of the IBR-2 nuclear research facility while implementing the experimental research programme, and to ensure the operational reliability and safety of the reactor.

The Scientific Council endorsed the PAC's opinion to open a project "New advanced neutron source at JINR" and supported the PAC's recommendation to open a project "Scientific and methodological research and developments for condensed matter investigations with IBR-2 neutron beams", dedicated to improving the parameters and performance of experimental setups, expanding the scope of their applications, as well as to the development of their elements and components.

Together with the PAC, the Scientific Council supported the opening of a project "Investigations of functional materials and nanosystems using neutron scattering" with subprojects "Study of the structure and dynamics of functional materials and nanosystems at the IBR-2 spectrometer complex" and "Development of an inelastic neutron scattering spectrometer in inverse geometry BJN (Bajorek–Janik–Natkaniec) at the IBR-2 reactor". The Scientific Council also noted that the results of the authors, obtained since the beginning of 2021, have demonstrated the high efficiency of neutron scattering.

The Scientific Council shared the PAC's opinion to open a new project "Nanobiophotonics", considering its research programme to be interdisciplinary in nature and aimed at both fundamental and applied studies.

The Scientific Council supported the PAC's recommendation to extend the project "Novel semi-

conductor detectors for fundamental and applied research", noting that the project team is highly qualified and has a long-term experience in international cooperation and activities within the Medipix Collaboration.

Following the PAC's recommendation, the Scientific Council supported the extension of the project "Precision laser metrology for accelerators and detector complexes (PLI)", the goals of which being the long-term monitoring of the surface under the NICA accelerator and of the influence of microseismic noise, as well as installation of a network of inclinometers in the regions of seismic activity.

The Scientific Council shared the PAC's opinion on extending the project "Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)", concurring with the PAC that the implementation of the programme presented in the project will bring this facility to a qualitatively new level, opening up new opportunities for experimental research in the field of condensed matter physics and materials science.

The Scientific Council supported the opening of a project "Design and development of a test zone for methodological studies of detectors at the linear electron accelerator in DLNP", dedicated to the development of scientific infrastructure for experimental studies with accelerated electron beams of the Linac-200 accelerator.

The Scientific Council recommended the opening of a project "Protection against physical and chemical stresses with tardigrade proteins (TARDISS)", noting the ambitious goals of studying the radio- and cryoprotective properties of the Dsup protein in living systems and *in vitro* and perspectives for the development of model living systems with induced expression of the Dsup protein and high-tech materials modified with this protein.

The Scientific Council supported the PAC's recommendation to open projects "Molecular, genetic and organismal effects of ionizing radiation with different physical characteristics" and "Radiation biophysics and astrobiological research".

The Scientific Council supported the opening of projects "Radiation tolerance of materials to high-intensity heavy-ion beams impact" and "Nanocomposite and functional track-etched membranes". The Scientific Council especially noted that the existing and future heavy-ion accelerator facilities at FLNR JINR offer unique opportunities for interdisciplinary research.

The Scientific Council supported the PAC's recommendation regarding written reports on the projects "Methods of computational physics for the study of complex systems", "Complex materials", "Mathematical models of statistical physics of complex systems", "Nanostructures and nanomaterials", and "Quantum field theory methods in complex systems".

Dubna, 22 September. The 134th session of the JINR Scientific Council.
Academician A. Sergeev, Head of the Oganesson Prize Jury, announces the names of the first winners

Reports by Young Scientists

The Scientific Council followed with interest the reports by young scientists, selected by the PACs for presentation at this session: "The correction system of the NICA Booster guiding magnetic field" by M. Shandov (VBLHEP) and "Proximity effects at superconducting and ferromagnetic heterostructures" by V. Zhaketov (FLNP).

The Scientific Council thanked the speakers and welcomed such selected reports in the future.

Membership of the PACs

On the proposal by the representative to the JINR Committee of Plenipotentiaries from the Republic of South Africa, I. Patel, presented by JINR Director G. Trubnikov, the Scientific Council appointed M. V. Tshivhase (iThemba LABS, Somerset West, South Africa) as a member of the PAC for Nuclear Physics for a term of three years. The Scientific Council thanks Z. Vilakazi (Wits University) for his dedicated work as member of this PAC since 2009.

Regulation on the Procedure for Awarding JINR Annual Prizes

The Scientific Council endorsed the new edition of the Regulation on the procedure for awarding JINR annual prizes, proposed by the JINR Directorate, and recommended its approval at the CP session in November 2023.

Awards and Prizes

The Scientific Council approved the proposal of JINR Director G. Trubnikov to award the title "Honorary Doctor of JINR" to D. L. Nagy (Hungary) and V. Sadovnichy (Russia).

The Scientific Council welcomed the Jury's decision presented by its Chair, A. Sergeev, to award the Oganesson Prize to A. M. Cetto Kramis, M. Shvydkoy, V. Semin, and V. Pershina.

The Scientific Council congratulated BLTP Director D. Kazakov on the award of the N. N. Bogoliubov Prize for his outstanding contributions to the development of quantum field theory, renormalization theory and renormalization group revealing the renormalization properties of supersymmetric field theories and for his pioneering papers on multiloop calculations in quantum field theory.

The Scientific Council congratulated the winners of JINR annual prizes for best scientific, methodological, technological and applied research papers.

Election and Announcement of Vacancies in the Directorates of JINR Laboratories

The Scientific Council elected E. Yakushev as Director of the Dzhelepov Laboratory of Nuclear Problems (DLNP) for a term of five years. The Scientific Council thanked V. Bednyakov for his successful tenure as Director of this Laboratory.

The Scientific Council endorsed the appointments of Yu. Kopatch and S. Kulikov as Deputy Directors of the Frank Laboratory of Neutron Physics (FLNP) until the completion of the term of service of the current FLNP Director, E. Lychagin.

The Scientific Council endorsed the appointments of O. Chuluunbaatar, D. Podgainy, and N. Voytishin as Deputy Directors of the Meshcheryakov Laboratory of Information Technologies (MLIT) until the completion of the term of service of the current MLIT Director, S. Shmatov.

The Scientific Council announced the vacancies for positions of DLNP Deputy Directors. The endorsement of appointments took place at the 135th session of the Scientific Council in February 2024.

The Scientific Council announced the vacancy for the position of Director of the Laboratory of Radiation Biology. The election will take place at the 136th session of the Scientific Council in September 2024.

The Scientific Council supported the proposal of JINR Director G. Trubnikov to open the third position of FLNP Deputy Director and announced the vacancy for this position. The endorsement of appointment took place at the 135th session of the Scientific Council in February 2024.

FINANCE COMMITTEE

MEETING OF THE JINR FINANCE COMMITTEE, 22 March 2023

A regular meeting of the Finance Committee was held on 22 March in Dubna under the chairmanship of A. Omelchuk, a representative of the Russian Federation.

Concerning the report by G. Trubnikov, Director of JINR, the Finance Committee recommended the Committee of Plenipotentiaries:

— to take note of the information from the JINR Directorate about the recommendations of the 133rd session of the JINR Scientific Council, the implementation of the current Seven-Year Plan for the Development of JINR, the efforts of the Member States towards realization of JINR's major projects, the new scientific and technological results obtained, and about the most important events related to JINR's scientific research and educational activities and international cooperation;

— to endorse the work carried out by the JINR Directorate on the execution of the JINR budget for the implementation of the Topical Plan for JINR Research and International Cooperation in force majeure circumstances in 2022;

— to endorse the work of the JINR Directorate on revising the draft Seven-Year Plan for the Development of JINR for 2024–2030 and support the opinion of the JINR Scientific Council on the balance of the scientific programme laid down in this Plan, the development of scientific and engineering infrastructure, and the financial resources required for its implementation;

Dubna, 22 March. Meeting of the JINR Finance Committee

— to take note of the efforts of the JINR Directorate on strengthening strategic partnerships with scientific organizations in a number of countries in Asia, Africa, and Latin America at the governmental level. To welcome the signing of the Joint Declaration of Intent Concerning Cooperative Activities in the Area of Fundamental, Frontier and Applied Scientific Research between the National Council of Humanities, Sciences and Technologies — CONAHCYT (Mexico) and JINR, and the Protocol between the RF Ministry of Science and Higher Education, the PRC Ministry of Science and Technology, JINR and the Chinese Academy of Sciences on Strengthening Cooperation in the Field of Basic Scientific Research at the governmental level;

— to approve the proposal of the JINR Directorate to reduce the operating costs of JINR and to transfer part of the external engineering networks located outside the JINR sites to the Urban District Dubna.

Concerning the report "Execution of the JINR budget for 2022 and draft of the revised budget of JINR for 2023" by N. Kalinin, Head of the JINR Budget and Economic Policy Department, the Finance Committee recommended the Committee of Plenipotentiaries to approve the consolidated final adjustment of the JINR budget expenditure for 2022; to approve the revised JINR budget for 2023 with the income amounting to US$ 203 485.9 thousand and the expenditure amounting to US$ 274 998.5 thousand, taking into account the positive opening balance amounting to US$ 49 021.9 thousand; to approve the new structure of the JINR budget for budget planning, starting in 2024; to endorse the measures taken by the JINR Directorate to increase the efficiency of the Institute's supplementary divisions aimed at improving the financial indicators of their activities and achieving a balance in the calculations between the supplementary divisions and the JINR budget.

Concerning the report "Proposal for selecting an organization for auditing JINR's financial activities for the year 2022" by L. Kostov, Vice-Director of JINR, the Finance Committee recommended that the Committee of Plenipotentiaries should approve the LLC JSC "Korsakov and Partners" as JINR's auditor and the Plan for auditing the financial activities of JINR for 2022 presented by the JINR Directorate.

Concerning the report "Results of the meeting of the Working Group under the CP Chair for JINR Financial Issues held on 27 February 2023" by A. Díaz García, Chair of the Working Group under the CP Chair for JINR Financial Issues, the Finance Committee recommended the Committee of Plenipotentiaries:

— to commission the JINR Directorate and the Working Group to finalize the draft of the new regulation for the lower limits of contributions of the Member States, which takes into account the share of staff costs in the JINR budget as well as the expenditure for the development of the Institute, and submit it for consideration at the meeting of the JINR Finance Committee and for approval at the session of the Committee of Plenipotentiaries of the Governments of the JINR Member States in November 2023;

— to approve the provisional contributions and scales of the Member States for 2024, 2025, and 2026, excluding the shares of the Member States which have withdrawn from JINR (Czech Republic, Republic of Poland, Ukraine) and the Member States with the suspended membership (Democratic People's Republic of Korea, Slovak Republic);

— to take note of the information on the provisional size of the JINR budget for 2024 with the income amounting to US$ 215.9 million and the expenditure amounting to US$ 269.2 million, for 2025 with the income amounting to US$ 227.3 million and the expenditure amounting to US$ 269.9 million, for 2026 with the income amounting to US$ 239.3 million and the expenditure amounting to US$ 274.7 million;

— to approve the Procedure for the practical implementation of the decision by the JINR CP on the suspension of the rights, privileges and obligations of the Slovak Republic in JINR.

The Finance Committee thanked D. Naumov, Deputy Director for Science of the Dzhelepov Laboratory of Nuclear Problems, for his interesting report "The Baikal Neutrino Telescope: Status and Prospects".

MEETING OF THE JINR FINANCE COMMITTEE, 9 November 2023

A regular meeting of the Finance Committee was held on 9 November in Almaty (Republic of Kazakhstan) under the chairmanship of A. Omelchuk, a representative of the Russian Federation.

Concerning the report on JINR's results in 2023 by G. Trubnikov, Director of JINR, the Finance Committee recommended the Committee of Plenipotentiaries:

— to take note of the information from the JINR Directorate about the recommendations of the 134th session of the JINR Scientific Council, the implementation of the current Seven-Year Plan for the Development of JINR, the efforts of the Member States towards realization of JINR's major projects, the new scientific and technological results obtained, and the most important events related to JINR's scientific research and educational activities and international cooperation;

— to endorse the work carried out by the JINR Directorate on the execution of the JINR budget for the current year to implement the Topical Plan for JINR Research and International Cooperation in 2023;

— to take note of the work of the JINR Directorate aimed at strengthening strategic partnerships with scientific organizations in a number of countries in Asia, Africa, and Latin America. To welcome the

holding of sessions of the Joint Coordination Committees and the selection of priority projects for joint implementation with the Ministry of Science and Technology of the People's Republic of China and the National Council of Humanities, Sciences and Technologies (CONAHCYT, Mexico) within the framework of the previously concluded government-level agreements. To endorse the efforts of the JINR Directorate to strengthen cooperation of the Institute with scientific organizations of South Africa, as well as Brazil and India, aimed at increasing the level of interaction of JINR with these countries;

— to take note of the information about the decision of the STRABAG SE concern (Republic of Austria) to limit the activities of its subsidiary and controlled organization STRABAG JSC in the territory of the Russian Federation. To endorse the efforts of the Directorate of the Joint Institute for Nuclear Research aimed at changing the general contractor for the implementation of the project "Installation of the heavy-ion collider NICA at the site of VBLHEP JINR in Dubna with a partial reconstruction of the building No. 1". When agreeing on the conditions of the contract with the new general contractor, special attention should be paid to ensuring the possibility of completing construction in 2024.

Concerning the report "Preliminary results of the implementation of the Seven-Year Plan for the Development of JINR for 2017–2023 and the budget plan of the draft Seven-Year Plan for the Development of JINR for 2024–2030" by N. Kalinin, Head of the JINR Budget and Economic Policy Department, the Finance Committee recommended the Committee of Plenipotentiaries to approve the budget plan of the Seven-Year Plan for the Development of JINR for 2024–2030, including the development of JINR's scientific and experimental base, engineering and social infrastructure, as well as maintaining a competitive level of personnel remuneration.

Concerning the report "Draft budget of JINR for 2024, provisional contributions of the Member States for the years 2025, 2026, 2027" by N. Kalinin, Head of the JINR Budget and Economic Policy Department, the Finance Committee recommended the Committee of Plenipotentiaries:

— to approve the JINR budget for 2024, in accordance with the new expenditure structure, with the income amounting to US$ 214 124.5 thousand and the expenditure amounting to US$ 253 672.8 thousand with the closing negative balance amounting to US$ 39 548.3 thousand;

— to authorize the Director of JINR to make adjustments to the JINR budget for 2024 including adjustments to the personnel remuneration and costs for international cooperation within the approved budget in compliance with the Regulations for the Introduction of Adjustments to the Budget of JINR;

— to approve the contributions and the scale of contributions of the JINR Member States for 2024, as well as the provisional contributions of the Member States for the years 2025 and 2026, instructing the JINR Directorate and the Working Group under the CP Chair for JINR Financial Issues to work out and submit for consideration at the meeting of the Finance Committee and the CP session in November 2024 the issue of clarifying the methodology for calculating contributions after the end of the transition period.

The Finance Committee recommended the JINR CP to approve the budget for 2024 on the construction and exploitation of the NICA complex of superconducting rings for heavy-ion colliding beams with the special-purpose funds of the Russian Federation, provided in accordance with the Agreement between the Government of the Russian Federation and JINR, in the amount of 1 993 342.0 thousand rubles.

The Finance Committee recommended the JINR CP to approve the consolidated adjustment of the JINR budget for 2023 over nine months, as well as to authorize the Director of JINR to index the salary and tariff parts of the remuneration package of the Institute's employees, taking into account the possibilities of the JINR budget for 2024, in accordance with the JINR Collective Bargaining Agreement for 2023–2026.

Concerning the report "Results of the meeting of the Working Group under the CP Chair for JINR Financial Issues held on 10 July 2023" by Ye. Mukhamejanov, Chair of the Working Group under the CP Chair for JINR Financial Issues, the Finance Committee recommended the Committee of Plenipotentiaries:

— to commission the JINR Directorate and the Working Group to work out a quota mechanism for specialists from the Member States, provided for by the JINR Charter, and the issue of practical application of the regulation for the lower limits of contributions, and submit them for consideration at the meeting of the Finance Committee and the CP session in November 2024;

— to commission the JINR Directorate to finalize proposals for amending the Rules of Procedure of the Finance Committee and Rules of Procedure of the Committee of Plenipotentiaries of JINR and submit them for consideration at the meeting of the Finance Committee and for approval at the CP session in March 2024;

— to include the representative of the Arab Republic of Egypt in the Working Group under the CP Chair for JINR Financial Issues.

Concerning the report "Results of the audit of the financial activities of JINR performed for 2022 and analysis of implementation by the JINR Directorate of the Plan of activities resulting from the audit of the financial activities of JINR performed for 2021" by D. Korsakov, Director of the "Korsakov and Partners" audit company, the Finance Committee recommended that the Committee of Plenipotentiaries should approve the audit report based on the results of the audit of JINR's financial activities for 2022.

The Finance Committee thanked E. Yakushev, Director of the Dzhelepov Laboratory of Nuclear Problems, for his interesting and informative report "What is the dark side of the Universe and how do we study it?".

PROGRAMME ADVISORY COMMITTEES

56th MEETING OF THE PAC FOR CONDENSED MATTER PHYSICS, 17–18 January 2023

The 56th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 17–18 January. It was chaired by Professor D. L. Nagy.

The Chair of the PAC presented an overview of the implementation of the recommendations taken at the previous PAC meeting concerning the JINR research in the area of condensed matter physics. JINR Vice-Director L. Kostov informed the PAC about the Resolution of the 132nd session of the JINR Scientific Council (September 2022) and the decisions of the JINR CP (November 2022).

The PAC took note of the report on the status of the IBR-2 reactor in the framework of the Seven-Year Plan for the Development of JINR for 2024–2030 presented by V. Shvetsov. The PAC was satisfied with the progress in replacing the air heat exchangers of the secondary reactor cooling circuit and obtaining an operating license, and also recommended that FLNP make a decision on choosing a manufacturer of components for a new fuel load for IBR-2. The PAC approved the plans of FLNP for the years 2024–2030, which include the manufacture of a new fuel load for IBR-2 in order to provide the necessary conditions for the possibility of extending the life of the reactor for the period after 2032. The PAC noted a confirmation of the technical feasibility of the fuel load production and an estimate of the cost of the work. The PAC also positively assessed the continuation of work on the study of the mechanism of the occurrence of fluctuations in the power pulses of the IBR-2 reactor in cooperation with JSC NIKIET and other organizations of Rosatom State Corporation.

The PAC took note of the report on the problems and prospects for IBR-2 operation presented by A. Dolgikh. The PAC underlined the importance of obtaining a new license as soon as possible, which will give an opportunity to resume the operation of the IBR-2 facility for physics experiments, to carry out the planned upgrade of safety-related equipment and systems, including the further development of the suite of cryogenic moderators. The PAC considered it a major task to resume regular operation of the IBR-2 facility for physics experiments in 2023.

The PAC considered reports on the themes to be included in the Topical Plan for JINR Research and International Cooperation for 2024. The PAC was pleased with the main directions suggested for the implementation within the theme "Investigations of Functional Materials and Nanosystems Using Neutron Scattering", presented in the report by D. Kozlenko. The PAC supported the activities aimed at the development of the experimental infrastructure of the IBR-2 reactor within the theme "Scientific and Methodological Research and Developments for Condensed Matter Investigations with IBR-2 Neutron Beams", presented by V. Bodnarchuk. The PAC noted with satisfaction the progress made in experiments using optical methods and supported the implementation of research within the new theme "Optical Methods in Condensed Matter Studies", presented by G. Arzumanyan. The PAC appreciated the scope of activities within the theme "Development of the Conceptual Design of a New Advanced Neutron Source — Fast Pulse NEPTUNE Reactor at JINR", presented by M. Bulavin in terms of the current status and plans.

The PAC was pleased with the status and prospects for the development of the scientific programme of MLIT, presented by O. Derenovskaya, and noted that a distinctive feature of the research areas related to information technology is the close cooperation with all the JINR Laboratories as well as with organizations of the JINR Member States and other countries. The PAC recommended further continuation of the IT-related research.

The PAC noted the plans for the development of the BLTP theme "Theory of Complex Systems and Advanced Materials", presented by E. M. Anitas, and supported its general composition, constituted of four projects on the following topics: complex materials, mathematical models of statistical physics of complex systems, nanostructures and nanomaterials, and methods of quantum field theory in complex systems. The PAC was pleased with the basic scientometric information on the theme, the composition of the personnel, and the proposed types of collaboration.

The PAC appreciated the wide range of R&D studies carried out and the high quality of the results obtained within the DLNP themes "Development of Scientific DLNP Infrastructure for Research

Dubna, 17–18 January. The 56th meeting
of the Programme Advisory Committee for Condensed Matter Physics

Using Semiconductor Detectors, Laser Metrology, Electrons, Positrons and Cryogenic Technology" and "Biomedical and Radiation-Genetic Studies Using Different Types of Ionizing Radiation", presented by V. Glagolev, and supported further continuation of these activities. The PAC also noted the progress in the development of the Linac-200 facility and works on laser metrology focused on the development and installation of the high-precision instruments at the NICA facility and in the laboratories of the JINR Member States.

The PAC welcomed the implementation of research on the biological effects of ionizing radiation with different physical characteristics within the new LRB theme "Research on the Biological Effects of Ionizing Radiation with Different Physical Characteristics", presented by A. Bugay, and noted the planned studies of the mechanisms of action of ionizing radiation on the molecular, cellular, tissue and organismal levels of biological organization as well as the research in astrobiology on the origin and persistence of life in the Universe using nuclear physics methods.

The PAC positively assessed the structure of the new FLNR theme "Radiation Materials Science, Nanotechnological and Biomedical Investigations with Accelerated Heavy-Ion Beams", presented by P. Apel, which shows the relevance and demand of fundamental and applied research based on the use of accelerated heavy-ion beams for the studies of material properties and modifications, and supported the development of biomedical applications of track-etched membranes and research on nuclear isotopes and ecological investigations.

As a general recommendation, the PAC welcomed the intention of the JINR Directorate to update the approach to the formation of the Topical Plan for JINR Research and International Cooperation by setting the duration of themes equal to seven years. The PAC also supported the introduction of a new mandatory condition for a theme to be active, which is an obligatory presence of at least one ongoing project within such a theme.

The PAC heard with interest the scientific report "Diagnostics of socially significant diseases using affine track membranes modified with DNA aptamers", presented by E. Zavyalova, and thanked the speaker.

The PAC reviewed 10 virtual presentations made by young scientists in the field of condensed matter physics and related fields of information technology. The virtual poster presentation "Development of lithium-ion batteries with increased specific energy and power" by M. Yerdauletov was selected as the best presentation of the session. The PAC also noted two more virtual poster presentations of a high level: "BIOHLIT — information system for radiobiological research" by I. Kolesnikova and "Pressure-induced phase transition in a nanostructured zinc ferrite" by N. Belozerova. All three authors were awarded diplomas of the PAC.

57th MEETING OF THE PAC FOR PARTICLE PHYSICS, 23 January 2023

The 57th meeting of the Programme Advisory Committee for Particle Physics was held on 23 January via videoconference. It was chaired by Professor I. Tserruya.

The Chair of the PAC presented an overview of the implementation of the recommendations adopted at the previous meeting. JINR Vice-Director V. Kekelidze informed the members of the PAC about the Resolution of the 132nd session of the JINR Scientific Council (September 2022) and the decisions of the CP (November 2022).

The PAC was very pleased with the detailed presentation of the draft Seven-Year Plan for the Development of JINR for 2024–2030 made by V. Kekelidze. The Committee supported the priorities in the area of particle physics and relativistic heavy-ion physics established in the Plan.

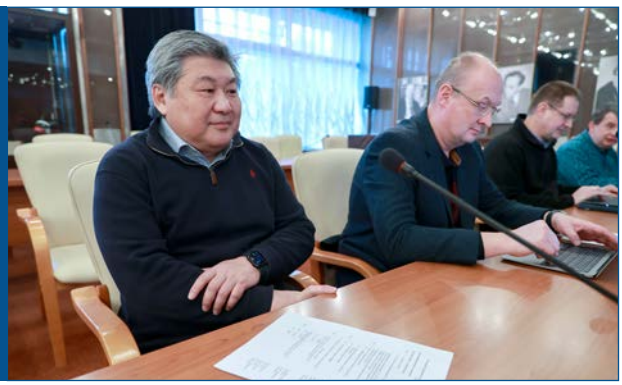
The PAC heard the progress report on the realization of the Nuclotron–NICA project presented by A. Sidorin. The Committee appreciated the intensive work of the VBLHEP accelerator complex for the experimental programme at the SRC and BM@N facilities. The PAC congratulated the NICA team on the successful completion and joint operation of several elements of the NICA complex — the ion source, the heavy-ion linear accelerator, the Booster, the Nuclotron, and the upgraded 136-meter transport line, as well as the completion of the installation of all dipole superconducting magnets in the arches of the collider tunnel.

The PAC took note of the progress report on the infrastructure developments at VBLHEP presented by N. Agapov. The Committee noted with satisfaction the plans for commissioning of the cryogenic complex and power substation to meet the needs of the NICA megaproject.

The PAC took note of the report on the implementation of the MPD project presented by V. Ryabov. The production of all components of the MPD first-stage detector configuration is progressing well. The production of 1600 modules of the electromagnetic calorimeter has been completed in Russia and China in equal shares. Test assembly of the first half-sectors using carbon fiber baskets has begun. 400 additional modules are being manufactured in Russia for installation in the detector. The timely delivery of the wavelength shifters will be a decisive factor. The most critical tasks for the first part of 2023 were cooling, current supply and tests of the MPD large superconducting solenoid followed by the magnetic field measurements.

The PAC appreciated the progress in the implementation of the BM@N project presented by M. Kapishin. An important milestone of the project is

Dubna, 23 January.
The 57th meeting of the Programme Advisory Committee for Particle Physics



the long physics run with the 3.6*A* GeV xenon beam interacting with a CsI target in which 507 million Xe+CsI interactions were recorded. The experiment was running with a full set of detectors, which included beam trackers, a central tracking system consisting of silicon and GEM detectors, outer tracker consisting of a cathode strip and drift chambers, time-of-flight system, trigger detectors as well as a hadron calorimeter and hodoscopes for the event centrality determination. The PAC noted the successful operation of the vacuum beam line, which has significantly reduced the beam background in the BM@N detectors.

The PAC took note of the report on the preparation of the Technical Design Report (TDR) of the SPD experiment presented by A. Guskov. A classical magnetic system with a solenoid magnet was chosen. The SPD project is expected to be implemented in two phases. The basic configuration will be used for measurements with the polarized proton and deuteron beams at low collision energies and below nominal luminosity (10^{32} $cm^{-2} \cdot s^{-1}$). It will include a muon system, a straw tracker, a central detector based on Micromegas, zero-angle calorimeters, and beam collision detectors. At the second stage, the complete configuration with a silicon vertex detector, a time-of-flight system, an electromagnetic calorimeter, and an aerogel detector will be built, which is necessary for the implementation of the main task of the SPD — the study of the polarized gluon structure of nucleons. The PAC encouraged the team to update the project, taking into account the current availability of materials and equipment as well as their cost. The Committee recommended that JINR management appoint a Detector Advisory Committee for a thorough review of the SPD TDR.

Following the request made at the 55th session, the PAC heard the progress reports from the two JINR groups participating in the T2K-II and COMET projects, presented by Yu. Davydov and Z. Tsamalaidze. The PAC appreciated the participation of the JINR group in the T2K-II experiment. The PAC reiterated its previous concern on the role, strategy and scientific visibility of the JINR group within the T2K-II project. The PAC recommended continuation of JINR's participation in the second phase of the T2K experiment until the end of 2024 with ranking B. The PAC acknowledged the leading role of the JINR group in the development and construction of the main subsystems of the COMET detector. The PAC also noted with satisfaction the participation of members of the JINR group in the management structures of the COMET Collaboration. The PAC recommended continuation of the project until the end of 2024 with ranking A.

The PAC took note of the reports on the scientific results obtained by the JINR groups participating in the LHC experiments, presented by B. Batyunya (ALICE), I. Yeletskikh (ATLAS), and V. Karjavin (CMS). The PAC noted with satisfaction the growing scientific significance and more active participation of JINR groups in the physical analysis of experimental data.

56th MEETING OF THE PAC FOR NUCLEAR PHYSICS, 26 January 2023

The 56th meeting of the Programme Advisory Committee for Nuclear Physics was held on 26 January. It was chaired by Professor V. Nesvizhevsky.

At the meeting, the detailed reports on the status of research in the field of nuclear physics and on the draft Seven-Year Plan for the Development of JINR for 2024–2030 were presented by the Directors of Laboratories S. Sidorchuk (FLNR), V. Shvetsov (FLNP), V. Korenkov (MLIT), Deputy Director of BLTP E. Antonenko, and Head of Department of DLNP E. Yakushev.

The heavy-ion research at ***the Flerov Laboratory of Nuclear Reactions*** is aimed at completing the tasks outlined in two themes: "Synthesis and Properties of Superheavy Elements, Structure of Nuclei at the Limits of Nucleon Stability" and "Development of the FLNR Accelerator Complex and Experimental Setups (DRIBs-III)". The SHE Factory, a facility based on the high-current DC-280 cyclotron and the new-generation separators DGFRS-2 and GRAND (DGFRS-3), was commissioned at JINR in 2020. The first time, five new isotopes were discovered in the reactions of ^{48}Ca beams with Th, U, Pu, Am targets. Of particular relevance is the first detection of the alpha-decay branch of ^{268}Db and of the new isotope ^{264}Lr.

The first experiments are currently conducted for studying the chemical properties of superheavy elements Cn and Fl using the GRAND separator. A number of gamma- and neutron-spectroscopy experiments with a series of Rf and Fm isotopes were performed at the upgraded SHELS-GABRIELA setup.

The U-400M accelerator is being upgraded and will be recommissioned. A project for upgrading the U-400 → U-400R accelerator and a new 1500 m^2 experimental hall is prepared. The U-400R cyclotron will allow one to smoothly vary the energy of accelerated beams in the range of 1–28 MeV/*A* and increase beam intensity up to uranium.

One of the essential tasks of FLNR is the synthesis of new elements 119 and 120 in such reactions as ^{54}Cr + ^{248}Cm and ^{50}Ti + ^{249}Bk. The production of high-intensity ^{50}Ti and ^{54}Cr beams is underway at the SHE Factory.

To study the chemical properties of the heaviest known elements 113–115, a superconducting solenoid separator will be constructed at the SHE Factory. The facility will allow focusing the reaction products in the focal plane into a spot not exceeding 1 cm in diameter and their efficient isolation from the projectile beam. This will make it possible for the first time to carry out experiments with isotope lifetimes less than 0.5 s. In 2024–2030, further experimental studies of the structure and mechanisms of production of nuclei near and beyond the limits of nucleon

Dubna, 26 January.
The 56th meeting of the Programme Advisory Committee for Nuclear Physics

stability are planned at FLNR at the ACCULINNA-1, ACCULINNA-2 and MAVR setups.

The PAC supported the proposed strategy for the development of heavy-ion physics research at FLNR for 2024–2030.

Nuclear physics research with neutrons at ***the Frank Laboratory of Neutron Physics*** is carried out within the framework of the scientific theme "Investigations of Neutron Nuclear Interactions and Properties of the Neutron" and three projects.

Physics research with neutrons can be divided into three areas: study of violations of fundamental symmetries in the interaction of neutrons with nuclei, obtaining nuclear data; study of the fundamental properties of the neutron, physics of ultracold and very cold neutrons; applied and methodological research.

For the seven-year period 2024–2030, it is proposed to focus on solving the following physical problems in the field of neutron nuclear physics:

— comprehensive study of the process of nuclear fission: measurement of mass-energy and angular distributions of fission fragments, prompt neutrons and gamma rays, etc.;

— study of the properties of neutron resonances, measurement of gamma-ray spectra for resonances with different spins, parities and angular momenta;

— development and application of the method of tagged neutrons to study reactions of interaction of fast neutrons with nuclei;

— development and application of neutron and nuclear methods for elemental analysis and applied research.

The development of a new UCN source at the IBR-2 reactor will be one of the main tasks in this field for the period 2024–2030. Its creation will make it possible to improve the accuracy of measuring the neutron lifetime and improve the limitation on the electric dipole moment of the neutron.

Over the seven-year period 2024–2030, it is planned to increase the intensity of the neutron flux of the IREN facility up to $3 \cdot 10^{12}$ s^{-1}, as well as to increase the beam current of the EG-5 accelerator to 50 μA, and its energy to 4.1 MeV.

The PAC recommended continuing scientific research in the field of nuclear physics with neutrons using the FLNP neutron facilities, such as the IREN pulsed source of resonance neutrons, the IBR-2 pulsed reactor, and the EG-5 electrostatic generator, by opening several new projects.

Scientific research at ***the Dzhelepov Laboratory of Nuclear Problems*** within the framework of the theme "Non-Accelerator Neutrino Physics and Astrophysics" is devoted to the study of rare phenomena associated with the weak interaction by the methods of modern nuclear spectrometry. The following research areas are distinguished:

— investigation of double beta decay by different calorimetric and track calorimetric methods;

— search for the neutrino magnetic moment, neutrino-nucleus coherent scattering (CEνNS);

— investigation of galactic and extragalactic neutrino sources, diffusive neutrino cosmic background, search for exotic particles, search for sterile neutrinos;

— development of new methods for the detection of charged and neutral particles;

— development of modern radiochemistry for astrophysics and nuclear medicine.

The PAC supported the proposal of the DLNP Directorate to reorganize the structure of the theme and recommended that the DLNP Directorate should prepare new joint larger-scale projects reflecting real involvement of personnel and resources. The PAC recommended presenting these projects at the PAC meeting in June 2023.

Research in the field of low-energy nuclear physics at ***the Bogoliubov Laboratory of Theoretical Physics*** is carried out within the framework of the theme "Theory of Nuclear Systems". Structural features of nuclei far from stability, structure of superheavy nuclei, nucleus–nucleus collisions at low energies, fusion and fission dynamics, reactions of astrophysical interest, ect. are the main research areas.

In the seven-year period 2024–2030, research will be focused on the study of exotic nuclei in the regions of superheavy elements and light nuclear systems at the borders of stability and beyond, which is relevant for experimental research at the SHE Factory of FLNR JINR and in other world research centres.

Models will be developed to predict the rates of various nuclear reactions for astrophysical purposes. The mechanisms of transfer of nucleons and clusters between nuclei, and of the decay of a nucleus in the field of another one, will be analyzed.

The PAC also appreciated the BLTP educational activities and the connection between theoretical studies and the JINR experimental programme.

The PAC appreciated the results obtained in the main areas of research and recommended the extension of the theme "Theory of Nuclear Systems" until the end of 2030.

The development of reliable network and information and computing infrastructure, as well as mathematical and software support for the research and production activities of the Institute and its Member States at ***the Meshcheryakov Laboratory of Information Technologies*** is carried out within the theme "Information and Computing Infrastructure of JINR" and its project "Multifunctional Information and Computing Complex (MICC)". The JINR MICC is a basic facility of the JINR computing infrastructure and plays a defining role in scientific research that requires modern computing power and data storage systems. Another activity of MLIT is related to the development and implementation of effective methods, algorithms and software for modeling physical systems, mathematical processing and analysis of experimental data for the successful implementation of the scientific programme by scientists of JINR and its Member States (within the theme "Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data"). A distinctive feature of MLIT's activities is close cooperation with all JINR Labora-

tories, organizations of the JINR Member States and other countries.

The PAC supported the MLIT scientific programme for the seven-year period 2024–2030 related to the development of the information and computing infrastructure of JINR, as well as the development and implementation of algorithms and software for modeling physical systems, methods of mathematical processing and analysis of experimental data.

57th MEETING OF THE PAC FOR CONDENSED MATTER PHYSICS, 15–16 June 2023

The 57th meeting of the Programme Advisory Committee for Condensed Matter Physics was held on 15–16 June. It was chaired by Professor D. L. Nagy.

The Chair of the PAC presented an overview of the implementation of the recommendations taken at the previous PAC meeting concerning the JINR research in the area of condensed matter physics. JINR Vice-Director L. Kostov informed the PAC about the Resolution of the 133rd session of the JINR Scientific Council (February 2023) and the decisions of the Committee of Plenipotentiaries of the Governments of the JINR Member States (March 2023).

The PAC heard the reports on projects to be included in the Topical Plan for JINR Research and International Cooperation from 2024. The PAC supported the proposal to open a new large research infrastructure project "Pulsed Neutron Source and Spectrometer Complex" and a project "Development of the IBR-2 facility with a complex of cryogenic neutron moderators" for 2024–2028, presented by E. Lychagin. The main objective of the projects is to increase the efficiency of the use of the IBR-2 nuclear research facility in implementing the experimental research programme, to ensure the operational reliability and safety of the reactor. During the period of implementation of the project, scientific and technical support services will be provided to ensure the safe operation of the reactor facility, and a large amount of scientific and technical work and experimental studies related to the commissioning of the cryogenic moderator complex will be performed.

The PAC recommended opening a project "New advanced neutron source at JINR" for 2024–2028, presented by M. Bulavin. In accordance with the work plans, the following research and development work is being carried out: study of the pulsed reactor dynamics, development of neptunium nitride fuel and the fuel rods based on it, optimization of the design of the reactivity modulator and the reactor vessel in terms of reducing thermal loads and shape changing, development and implementation of a list of R&D to support the development of a preliminary design, including the main systems of the reactor facility, a complex of cryogenic moderators, development of a scientific programme and a complex of spectrometers on its basis.

The PAC supported the proposal on opening the project "Scientific and methodological research and developments for condensed matter investigations with IBR-2 neutron beams" for 2024–2028, presented by V. Bodnarchuk. The project is dedicated to improving the parameters and performance of experimental setups, expanding the scope of their applications as well as to the development of their elements and components.

The PAC supported the proposal on opening a project "Investigations of functional materials and nanosystems using neutron scattering" with subprojects "Study of the structure and dynamics of functional materials and nanosystems at the IBR-2 spectrometer complex" and "Development of an inelastic neutron scattering spectrometer in inverse geometry at the IBR-2 reactor" for 2024–2028, presented by D. Kozlenko.

The PAC recommended opening a new project "Nanobiophotonics", presented by G. Arzumanyan, for 2024–2028. The PAC considered the research programme of the proposed new project as promising and modern, interdisciplinary in nature, and aimed at both fundamental and practical studies.

Dubna, 15–16 June. The 57th meeting of the Programme Advisory Committee for Condensed Matter Physics

The PAC welcomed the start of closer collaboration on these topics with other JINR Laboratories and with external biomedical organizations as well.

The PAC recommended extending the project "Novel semiconductor detectors for fundamental and applied research", presented by G. Shelkov, for the period 2024–2028. The PAC noted that the project team is highly qualified and has a long-term experience in international cooperation and activities within the Medipix Collaboration. The proposed activities mainly focus on the development of the in-house microchip and the manufacture of new energy-sensitive semiconductor X-ray image detectors and devices.

The PAC supported the extension of the project "Precision laser metrology for accelerators and detector complexes (PLI)", presented by M. Lyablin, for 2024–2028. The proposed activities are a continuation of the ongoing support project for the NICA collider complex. The project has two goals: first, long-term monitoring of the surface under the NICA accelerator and of the influence of microseismic noise, and second, the installation of a network of inclinometers in the regions of seismic activity.

The PAC recommended extending the project "Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)", presented by A. Sidorin, for 2024–2028. The PAC noted the high demand for PAS methods, including the Doppler broadening of the annihilation line (DBAL) method on a beam as well as the positron annihilation lifetime spectroscopy (PALS) method in the classical formulation. The implementation of the programme presented in the project will bring this facility to a qualitatively new level, opening up new opportunities for experimental research in the field of condensed matter physics and materials science.

The PAC recommended opening a project "Design and development of a test zone for methodological studies of detectors at the linear electron accelerator in DLNP", presented by S. Abou El-Azm, for 2024–2028. The project is dedicated to experimental studies with accelerated electron beams of the Linac-200 accelerator. The two channels of Linac-200 will be used for equipment testing and for other applied and educational purposes.

The PAC supported opening a project "Protection against physical and chemical stresses with tardigrade proteins (TARDISS)", presented by M. Zarubin. The PAC noted the ambitious goals of studying the radio- and cryoprotective properties of the Dsup protein in living systems and *in vitro*, developing model living systems with induced expression of the Dsup protein, and creating high-tech materials modified with this protein.

The PAC recommended opening projects "Molecular, genetic and organismal effects of ionizing radiation with different physical characteristics" and "Radiation biophysics and astrobiology research", presented by P. Lobachevsky and A. Chizhov, respectively, for their implementation in 2024–2028. The aim of the first of these projects is to study the regularities and mechanisms of molecular, genetic and organismal effects of ionizing radiation with different physical characteristics. The second project is aimed at solving a number of fundamental problems in radiobiology and astrobiology, as well as practical tasks related to the development of radiation medicine.

The PAC supported the proposal to open projects "Radiation tolerance of materials to high-intensity heavy-ion beams impact" and "Nanocomposite and functional track-etched membranes", presented by P. Apel, for their implementation in 2024–2028. The first project is focused on the systematic study of the structural effects caused by swift heavy ions in materials with potential nuclear and nanotechnological applications in order to shed light on the fundamental mechanisms and sub-picosecond kinetics of the resulting excitations. The second project on track-etched membranes (TMs) demonstrates an example of industrial application of ion-track technology. The PAC considered the applications of TMs in biotechnology and medicine to be particularly important. The project outcomes will include the implementation of new and elaboration of existing routes of membrane modification for the production of composite and hybrid TMs for targeted applications in nanofluidics, sensing technologies, green energy harvesting, and biomedicine.

The PAC took note of the written proposals to open or extend the projects "Methods of computational physics for the study of complex systems" for 2024–2026, and "Complex materials", "Mathematical models of statistical physics of complex systems", "Nanostructures and nanomaterials", "Quantum field theory methods in complex systems" for 2024–2028. The PAC recommended that these projects be opened or extended for the requested periods.

The PAC heard with interest the scientific report "Neutron-diffraction studies of structural phase transition in alloys", presented by T. Vershinina. The PAC thanked the speaker for the excellent report.

The PAC reviewed 12 virtual presentations made by young scientists in the field of condensed matter physics and information technology. The virtual poster presentation "Proximity effects at superconducting and ferromagnetic heterostructures", made by V. Zhaketov, was selected as the best presentation of the session. The PAC also noted two more virtual poster presentations of a high level: "High pressure effect on crystal, magnetic structure and vibrational spectra of van der Waals material" by O. Lis, and "The effects of high pressure on the crystal structure and vibration spectra of layered perovskite-like $Nd_2Ti_2O_7$" by A. Asadov.

58th MEETING OF THE PAC FOR PARTICLE PHYSICS, 21–22 June 2023

The 58th meeting of the Programme Advisory Committee for Particle Physics took place on 21–22 June via videoconference. It was chaired by Professor I. Tserruya.

The Chair of the PAC presented an overview of the implementation of the recommendations adopted at the previous meeting concerning the research at JINR in the field of particle physics. JINR Vice-Director V. Kekelidze highlighted the Resolution of the 133rd session of the JINR Scientific Council (February 2023) and the decisions of the JINR Committee of Plenipotentiaries (March 2023).

The PAC supported the steps taken by the JINR Directorate to increase the participation of Mexican researchers in JINR activities, strengthen cooperation with scientific organizations and universities in China, maintain a high level of cooperation with research organizations from all European countries in order to promote the international status of the Institute.

The PAC heard the progress report on implementing the Nuclotron–NICA project presented by A. Sidorin. The Committee congratulated the accelerator team on the very successful fourth technical run and thanked the speaker for the detailed analysis of the resources and equipment, including the electron cooling, that were put into operation and improved the performance of the accelerator complex. The PAC noted various delays, among which the delays in the completion of infrastructure work in the collider building and in the construction of transfer lines from the Nuclotron to the NICA collider, and took note of the resulting revised schedule, which now expects the first beams at the NICA collider in 2025.

The PAC took note of the progress report on the infrastructure developments at VBLHEP presented by N. Agapov. The Committee noted with satisfaction that the available power of the main substation has been doubled to 40.8 MW. The NICA cryogenic subsystems are now combined into a single complex using cryogenic pipelines, a significant part of which has been tested for leaks and is ready for operation. The installation of engineering and research equipment in the new buildings of the NICA complex — the collider and the new compressor station — is nearing completion.

The PAC took note of the report on the implementation of the MPD project presented by V. Ryabov. The production of all components of the MPD first-stage detector is progressing, even though the schedule is delayed due to problems with supplies of many components from European companies, the lack of technical documentation for the delivered components, and the necessity to look for additional qualified manpower. The most critical task is still cooling and current supply of the large superconducting solenoid of MPD. The temporary cryogenic system for the solenoid cooling has been assembled, vacuum tested and operated in manual mode.

The PAC appreciated the progress in the implementation of the BM@N project presented by M. Kapishin. An important milestone of the project was physics run with the 3.8*A* GeV and 3.0*A* GeV xenon beam interacting with a CsI target in which 507 million Xe + CsI interactions were recorded. The identification of Λ hyperons, K^0_S mesons and charged particles was considerably improved after alignment, calibration of tracking and time-of-flight detectors, and the first data reprocessing. The PAC emphasized the lack of manpower for ongoing analysis of the recorded data. At the same time, the PAC encouraged the BM@N team to concentrate its efforts on getting the first physics results for the Xe run.

The PAC took note of the report on preparing the Technical Design Report (TDR) of the SPD experiment presented by A. Guskov. The layout of the detector has been adopted taking into account new opportunities opened up by the increased permissible load on the floor of the experimental hall. The SPD team is making efforts to find and develop substitute equipment, components, and technical solutions needed to build the detector. Preparation of documentation

Dubna, 21–22 June. The 58th meeting of the Programme Advisory Committee for Particle Physics

for the superconducting SPD solenoid is underway. The PAC reiterated its recommendation to the JINR management on the need to resume the activities of the international SPD Detector Advisory Committee. The PAC encouraged the SPD team to proceed with the preparation of the TDR.

The PAC took note of the reports on the scientific results obtained by the JINR groups participating in the LHC experiments presented by B. Batyunya (ALICE), T. Lyubushkina (ATLAS), and V. Karjavin (CMS). The PAC noted active participation in physics analyses of the three JINR groups.

The PAC appreciated the involvement of the JINR team in one of the leading experiments searching for new physics below the electroweak scale — the NA64 project (CERN), its theoretical motivation, its responsibilities in the detector operation, the development and support of the straw tracker, the DAQ operation, and the data taking and analysis, presented by D. Peshekhonov. The PAC supported further participation of the JINR team in the NA64 experiment and recommended its continuation for the period 2024–2026.

The PAC took note of the activities of the JINR group in the BESIII experiment presented by I. Denisenko and appreciated the important contributions of the JINR group, and, in particular, the plans to continue the study of charmed quarks in the future SPD experiment at NICA, and recommended that JINR continue its participation in the BESIII project for the period 2024–2028.

The PAC took note of the report presented by A. Borodin on JINR's participation in the TAIGA experiment. Since the last presentation at the PAC, JINR's participation in data analysis has been strengthened by attracting young researchers. The PAC encouraged the JINR TAIGA team to collaborate with the JINR Baikal team, in particular, in the search for events with similar and complementary characteristics, and recommended that JINR continue its participation in the TAIGA project for the period 2024–2028.

The PAC took note of the report on the status of JINR team's involvement in the preparation of the JUNO experiment (China) presented by D. Naumov. The JUNO experiment is focused on determining the neutrino mass ordering with the goal to reach a significance of at least three to four standard deviations after six years of data collection. The PAC appreciated the important contributions and the visible participation of the JINR team in the JUNO reactor neutrino experiment, which is at the commissioning stage, and recommended that JINR continue its participation in JUNO for the period 2024–2027.

The PAC heard the report on JINR's participation in the accelerator neutrino NOvA experiment and in the preparation of the new-generation DUNE experiment (USA) presented by L. Kolupaeva. The JINR group has made a significant contribution to the NOvA experiment and could take part in the construction of the Near Detector of the DUNE project, including a light collection system in liquid argon, a tube-based tracking system, as well as data analysis algorithms and methods. The PAC recommended the continuation of JINR's participation in the NOvA experiment and supported the preparation work for the DUNE project for the period 2024–2026.

The PAC recognized the decisive role of the project "Multifunctional Information and Computing Complex (MICC)", presented by V. Korenkov, in the scientific research and the needs of modern computing power and data storage systems. The PAC recommended extending the MICC project for the period 2024–2030.

The PAC heard the proposal to open a new project "Mathematical methods, algorithms and software for modeling physical processes and experimental facilities, processing and analyzing experimental data", presented by S. Shmatov. The project is aimed at developing general mathematical methods and software with the widespread use of artificial intelligence and machine learning techniques for modeling physical processes and experimental facilities, processing and analyzing experimental data in close cooperation with the users. The PAC recommended opening the project in 2024 for the period 2024–2026.

The PAC took note of the new project for the participation of the JINR group in the fixed-target AMBER experiment at the SPS (CERN) presented by A. Guskov. The experiment is dedicated to the study of the internal structure and properties of hadrons. The basis of the AMBER facility is the upgraded COMPASS spectrometer. Taking into account the synergy between the rich physics programmes of the AMBER and NICA SPD experiments, including the benefit of training young researchers in the AMBER experiment while the SPD is under construction, the PAC recommended the participation of the JINR group in the AMBER experiment for the period 2024–2026.

57th MEETING OF THE PAC FOR NUCLEAR PHYSICS, 29–30 June 2023

The 57th meeting of the Programme Advisory Committee for Nuclear Physics was held on 29–30 June. It was chaired by Professor V. V. Nesvizhevsky.

The Chairman of the PAC presented an overview of the implementation of the recommendations taken at the previous meeting. JINR Vice-Director S. Dmitriev informed the PAC about the Resolution of the 133rd session of the Scientific Council (February 2023) and about the decisions of the Committee of Plenipotentiaries (March 2023).

The PAC took note of the report by N. Antonenko on the structure of the extended theme "Theory of Nuclear Systems", which includes four projects. The PAC heard proposals to open new projects "Low-energy nuclear dynamics and properties of nuclear

Dubna, 29–30 June. The 57th meeting of the Programme Advisory Committee for Nuclear Physics

systems", "Microscopic models for exotic nuclei and nuclear astrophysics", "Quantum few-body systems", and "Relativistic nuclear dynamics and nonlinear quantum processes", presented by heads of the projects N. Antonenko, A. Dzhioev, A. Motovilov, and S. Bondarenko, respectively.

The PAC highly appreciated the current state of research on the theme and four projects proposed for implementation in 2024–2028, as well as the connection between theoretical research and the experimental programme of JINR, and recommended to open these four new projects for five years and supported the proposed structure of the extended theme "Theory of Nuclear Systems".

The PAC heard a proposal to extend the theme "Synthesis and Properties of Superheavy Elements, Structure of Nuclei at the Limits of Nucleon Stability", presented by S. Sidorchuk. The main directions of scientific research for the period 2024–2030 within the framework of the theme are related to the study of the heaviest nuclei and atoms as well as light nuclei far from the β-stability line. The PAC also heard reports on the opening of two new projects "Investigation of heavy and superheavy elements" (A. Karpov) and "Light exotic nuclei at the borders of nuclear stability" (G. Kaminski). The PAC highly appreciated the proposals of FLNR for the development of research in the field of heavy-ion physics and recommended to open those two new projects for five years until end of 2028. In order to be able to open and implement new projects, as well as to conduct other experiments in the field of heavy-ion physics, the PAC recommended to extend the theme "Synthesis and Properties of Superheavy Elements, Structure of Nuclei at the Limits of Nucleon Stability" for a period of seven years until the end of 2030.

The PAC heard a report on the theme "Development of the FLNR Accelerator Complex and Experimental Setups (DRIBs-III)" and proposals for its reformation into a large research infrastructure project (LRIP) presented by I. Kalagin.

The PAC heard the proposals to open two new projects presented by A. Eremin. The project "Construction of the U-400R accelerator complex" includes the modernization of the existing U-400 accelerator into U-400R, construction of a new experimental building, development of new experimental setups of the complex. The project "Development of the experimental setups to study the chemical and physical properties of superheavy elements" is aimed at implementing the tasks of developing new experimental facilities of the SHE Factory.

The PAC recommended that the theme "Development of the FLNR Accelerator Complex and Experimental Setups (DRIBs-III)" be reformed into a large research infrastructure project with the same title for the period 2024–2030. The PAC recommended opening two new projects "Construction of the U-400R accelerator complex" and "Development of the experimental setups to study the chemical and physical properties of superheavy elements" until the end of 2028.

The PAC heard a report on the main results obtained in 2023 within the framework of the theme "Investigations of Neutron Nuclear Interactions and Properties of the Neutron" and the projects "Tagged neutrons and gamma rays (TANGRA)", "Investigation of prompt fission neutron emission in fission (ENGRIN)", and "Modernization of the accelerator EG-5 and its experimental infrastructure", presented by Yu. Kopatch. The PAC noted the high quality of the results obtained. The PAC recommended the completion of the ENGRIN project and closing the theme "Investigations of Neutron Nuclear Interactions and Properties of the Neutron".

The PAC heard proposals to open a new project "Investigations of neutron nuclear interactions and properties of the neutron" and a new theme "Nuclear Physics with Neutrons", presented by V. Shvetsov. The PAC noted the promising outlook of the proposed scientific programme of the new project and the TANGRA project. The PAC recommended opening the new project "Investigations of neutron nuclear interactions and properties of the neutron" for a period of five years until the end of 2028. The PAC also recommended extending the TANGRA project for a period of five years until the end of 2028 and the project "Modernization of the accelerator EG-5 and its experimental infrastructure" for a period of three years until the end of 2026. In connection with the proposals to open the new project, to extend two other projects, as well as to open the new activity,

the PAC recommended opening the new theme "Nuclear Physics with Neutrons" until the end of 2030.

The PAC heard proposals to open three new projects "Radiochemistry and spectroscopy for astrophysics and nuclear medicine", "Investigations of reactor neutrinos on a short baseline", and "Nuclear spectrometry for the search and investigation of rare phenomena" within the framework of the theme "Non-Accelerator Neutrino Physics and Astrophysics".

Scientific research in the project "Radiochemistry and spectroscopy for astrophysics and nuclear medicine" (A. Baimukhanova) is devoted to the development of nuclear spectroscopy and radiochemistry methods to study rare phenomena associated with the weak interaction and a number of problems in astrophysics, as well as the development of radiopharmaceuticals and their application in nuclear medicine. The project "Investigations of reactor neutrinos on a short baseline" (I. Zhitnikov) combines research on the fundamental properties of neutrinos in the DANSS, νGeN, and Ricochet experiments. The project "Nuclear spectrometry for the search and investigation of rare phenomena" (E. Yakushev) combines research on the fundamental properties of neutrinos and the search for dark matter particles in the experiments. The PAC noted the significant contribution of JINR scientific groups to the above experiments and recommended opening these projects until the end of 2028.

The PAC heard a progress report on implementing the project "Baikal-GVD" and a proposal for its extension presented by I. Belolaptikov. The project is being implemented within the framework of the theme "Non-Accelerator Neutrino Physics and Astrophysics". During 2016–2023, the Baikal Collaboration deployed 12 full-scale clusters with about 3500 optical modules. The analysis of the data taken during 2018–2021 confirms for the first time the IceCube observation of an astrophysical diffuse neutrino flux with a significance of 3σ, which is, indeed, a promising result.

Current rates of production and deployment of additional clusters on Baikal will make it possible to achieve, by 2028, a detection volume of 1 km^3 with about 6000 optical modules for detecting high-energy astrophysical neutrinos. The PAC underlined the important role played by the project "Baikal-GVD" together with the IceCube experiment to study high-energy neutrino flux from all directions of the sky. The PAC appreciated the high scientific importance of the project "Baikal-GVD" and JINR's leading role in its implementation. The PAC recommended extending the project "Baikal-GVD" as a large research infrastructure project until the end of 2028.

The PAC took note of the report on the E&T&RM project and the proposal for its extension with the new title "Accelerator-driven subcritical reactor (ADSR)", presented by M. Paraipan. The project is aimed at developing new principles for simulating the regimes of accelerator-driven subcritical systems, which are neutron sources for a wide range of nuclear studies. The PAC supported its extension for the period 2024–2027 with updated content and the title "Accelerator-driven subcritical reactor (ADSR)".

The PAC heard a report on the project "Study of the nucleon spin structure in strong and electromagnetic interactions (GDH&SPASCHARM&NN)" and a proposal for its extension presented by Yu. Plis. This project includes three independent experiments related to the study of the spin structure of the nucleon in strong and electromagnetic interactions. The PAC recommended extending the project until the end of 2028.

The PAC heard a report on extending the BECQUEREL2023 project at the Nuclotron–NICA accelerator complex to study peripheral interactions of relativistic nuclei presented by P. Zarubin. The PAC recommended that the work on the BECQUEREL2023 project be extended in the status of "activity".

JINR PRIZES

The V. Dzhelepov Prize was awarded to Senior Researcher of the Flerov Laboratory of Nuclear Reactions P. Apel for the development of a new generation of track membranes and their applications in medicine and ecology.

WINNERS OF THE JINR SCIENTIFIC AND RESEARCH WORKS COMPETITION

For Theoretical Research Papers

First Prizes

"Exactly Solvable Models of Statistical Mechanics and Quantum Field Theory".

Authors: S. Derkachov, G. Sarkissian, V. Spiridonov.

"Mechanism of Complete Fusion by Nucleon Transfer in Heavy Ion Collisions".

Authors: A. Nasirov, G. Adamian, Sh. Kalandarov, G. Giardina, G. Mandaglio, B. Kayumov, O. Ganiev, G. Yuldasheva.

Second Prize

"Theoretical Support of Experiments for Colliders".

Authors: A. Arbuzov, S. Bondarenko, Ya. Dydyshka, V. Yermolchyk, Yu. Yermolchyk, L. Kalinovskaya, A. Kampf, L. Rumyantsev, R. Sadykov.

Third Prize

"Weak Decays of Heavy Hadrons in Light of Search for New Physics".

Authors: G. Ganbold, M. Ivanov, A. Issadykov, V. Lyubovitskij, Tran Chien Thang, Zh. Tyulemissov.

For Experimental Research Papers

First Prizes

"Diffuse Neutrino Flux Measurements with the Baikal-GVD Neutrino Telescope".

Authors: I. Belolaptikov, K. Konishchev, A. Korobchenko, E. Pliskovskiy, B. Shaibonov.

"New Isotope ^{276}Ds and Its Decay Products ^{272}Hs and ^{268}Sg from the ^{232}Th + ^{48}Ca Reaction".

Authors: F. Abdullin, A. Voinov, D. Ibadullayev, N. Kovrizhnykh, A. Polyakov, R. Sagaidak, D. Solovyev, V. Utyonkov, Yu. Tsyganov, M. Shumeiko.

Second Prize

"Magnetic States of Rare Earth Metals at High Pressure".

Authors: N. Golosova, D. Kozlenko, E. Lukin, B. Savenko, V. Yushankhai.

Third Prize

"Search for Light Dark Matter with NA64 at CERN".

Authors: P. Volkov, S. Gninenko, T. Enik, G. Kekelidze, V. Kramarenko, N. Krasnikov, V. Matveev, D. Peshekhonov, V. Polyakov, K. Salamatin.

For the Methodology, Research and Technology Papers

First Prize

"The SFiNx Detector System".

Authors: A. Isaev, R. Mukhin, A. Yeremin, A. Kuznetsova, O. Malyshev, A. Popeko, Yu. Popov, B. Sailaubekov, A. Svirikhin, E. Sokol.

Second Prizes

"Development of a Software and Algorithmic Complex for the Reconstruction, Identification and Selection of High-Energy Muons in the CMS Experiment at the LHC".

Authors: N. Voytishin, A. Zarubin, V. Karjavin, A. Kamenev, V. Korenkov, A. Lanev, V. Matveev, V. Palchik, V. Perelygin, S. Shmatov.

"Development and Application of New Experimental Techniques at the Complex ACCULINNA-2@U-400M".

Authors: A. Bezbakh, S. Belogurov, M. Golovkov, A. Gorshkov, S. Krupko, E. Nikolskii, G. Ter-Akopian, A. Fomichev, V. Chudoba, P. Sharov.

Third Prize

"On a ^{3}He Refrigerator Based on Closed-Cycle Cryocooler Cooling".

Author: A. Chernikov.

For Applied Research and Technology Papers

First Prize

"The Study of Nanolayer Materials and Artificial Diamonds by Positron Spectroscopy Using a Unique in Russia Slow Monochromatic Positron Injector".

Authors: A. Sidorin, O. Orlov, V. Hilinov, I. Meshkov, E. Akhmanova, M. Eseev, I. Kuziv, R. Laptev, P. Horodek, K. Siemek.

Second Prizes

"Neutron Non-Destructive Structural Analysis of Cultural Heritage Materials: Applied Interdisciplinary Studies".

Authors: B. Abdurakhimov, B. Bakirov, A. Zhomartova, S. Kichanov, D. Kozlenko, E. Lukin, K. Nazarov, B. Savenko, I. Saprikina, V. Smirnova.

"Study of Hardening Mechanisms, Residual Stresses and Microstructure of High-Strength Aluminum Alloys".

Authors: G. Bokuchava, Yu. Gorshkova, I. Papushkin, V. Turchenko, R. Fernández, G. González-Doncel, L. Millán, G. Bruno, G. Kronberger, P. Halodova.

Third Prize

"Evaluation of the Modern Radiopharmaceuticals' Stability Using Nuclear Spectrometric Methods".

Authors: D. Filosofov, E. Kurakina, A. Velichkov, D. Karaivanov, O. Kochetov, A. Salamatin, V. Timkin, J. Khushvaktov.

RESEARCH AND EDUCATIONAL PROGRAMMES

BOGOLIUBOV LABORATORY of THEORETICAL PHYSICS

In 2023, at the Bogoliubov Laboratory of Theoretical Physics (BLTP), studies were carried out on the following four themes: Fundamental Interactions of Fields and Particles; Theory of Nuclear Systems; Theory of Complex Systems and Advanced Materials; Modern Mathematical Physics: Gravity, Supersymmetry and Strings. 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 and Dubna-based experimental programmes of JINR Laboratories. The research resulted in about 430 publications in peer-reviewed journals and proceedings of international conferences, 88 articles of large international collaborations with the participation of BLTP researchers, and two monographs. Most of the results were obtained in cooperation with scientists from the JINR Member States, Brazil, China, Germany, India, Italy, South Africa, and other countries.

Every year, BLTP is a venue for scientific events of the highest level: nine conferences and workshops and two schools for students and young scientists were organized by BLTP in 2023. These events were held in person or in a mixed format (in person/remote). BLTP researchers and visitors made 99 reports at the Laboratory seminars.

International collaboration was supported by grants of the Plenipotentiaries of the Governments of Belarus, Bulgaria, Egypt, Kazakhstan, Poland, and the JINR Directorate, by joint programmes with Serbia and South Africa. The Bogoliubov Laboratory continued cooperation with APCTP (South Korea) and ITP CAS (Beijing) under cooperation agreements, as well as with theorists from CERN. Seven research projects were supported by the RSF grants and one by the RFBR.

Traditionally, much attention was paid to recruiting young researchers, students, and postgraduate students to BLTP within the research and education project "Dubna International Advanced School of Theoretical Physics" (DIAS-TH). The Laboratory plays the role of the training centre for young scientists and students from many countries. Currently, about one third of the BLTP scientific staff are young scientists and PhD students. In 2023, two candidate and two doctoral theses were defended by BLTP researchers.

SCIENTIFIC RESEARCH

Fundamental Interactions of Fields and Particles

Theoretical investigations in 2023 were carried out as part of the following projects:

- Quantum field theory and physics beyond the Standard Model;
- QCD and spin/3D hadron structure;
- Strong interaction phenomenology and precision physics;
- Theory of hadronic matter under extreme conditions;
- Theory of electroweak interactions and neutrino physics.

In the framework of analytic QCD, it was shown that in the time-like case, the inverse logarithmic expansion is applicable for all values of the argument of the analytical coupling. Two different approaches were presented, one based mainly on trigonometric functions and the second on dispersion integrals. The results obtained up to the 5th order of perturbation theory had a compact form and were applied to study the Higgs boson decay into a $b\bar{b}$ pair. In addition, the experimental data obtained for the polarized Bjorken sum rule $\Gamma_1^{(p-n)}(Q^2)$ at small values of Q^2 was approximated by the predictions of analytical QCD up to the 5th order of perturbation theory. Excellent agreement was found between the experimental data and the predictions of analytical QCD, as well as a strong difference between these data and the results obtained within the framework of standard QCD [1].

For the first time, the method of large-charge expansion was applied to gauge theories. In particular, in scalar QED, an all-loop result was obtained for gauge-independent critical indices of operators

carrying a $U(1)$-charge Q in the form of an expansion in inverse powers of Q. A comparison with the perturbative calculation in the Landau gauge made it possible not only to determine the form of the corresponding operators, but also to shed light on the controversy in determintation of the gauge-invariant order parameter in superconductivity [2].

A generalized renormalization group equation was obtained for scalar theory with a potential of an arbitrary form, which sums the leading logarithms in the effective potential. This equation was applied to nonrenormalizable potentials of power and exponential types. In addition, the generalized renormalization group equation was used to study inflation potentials in slow-roll cosmologies. In particular, the potential of alpha-attractor T-models was studied, where the emergence of additional minima and the preservation of classical asymptotic behavior were discovered [3].

The nonleptonic decay $\Xi_c^0 \to \Lambda_c^+ \pi^-$ with $\Delta C = 0$ was systematically studied in the framework of the covariant confined quark model accounting for both short- and long-distance effects. The short-distance effects are induced by four topologies of external and internal weak $W^\pm$ exchange, while long-distance effects are saturated by including the so-called pole diagrams with intermediate $1/2^+$ and $1/2^-$ baryon resonances. The contributions from $1/2^+$ resonances were calculated straightforwardly by accounting for single charmed Σ_c^0 and $\Xi_c'^+$ baryons, whereas the contributions from $1/2^-$ resonances were calculated by using the well-known soft-pion theorem in the current-algebra approach. This allowed us to express the parity-violating S-wave amplitude in terms of parity-conserving matrix elements. It was found that the contribution of external and internal W-exchange diagrams was significantly suppressed by more than one order of magnitude in comparison with data. The pole diagrams play a major role in getting consistency with experiment [4].

The nonfactorizable (NF) contribution of a charm loop to the FCNC B-decay amplitude is given through the three-particle Bethe–Salpeter amplitude (3BS) of the B meson. This 3BS contains one heavy-quark field and two light fields (a light quark and a gluon). The factorization theorem was proven for the NF charm contribution to the FCNC B-decay amplitude, and it was demonstrated that the dominant contribution of the nonfactorizable charm to the FCNC B-decay amplitude was given in the heavy-quark limit by the convolution of some hard kernel and the B-meson 3BS in a "double-collinear" light cone (LC) configuration: one of the light degrees of freedom $x^2 = 0$ lies in the (+)-direction of the LC, whereas the other light degree of freedom $x'^2 = 0$ lies along the (−)-direction [5].

Forbidden electric dipole transitions in the homonuclear molecular ion H_2^+ were studied. It was shown that transition rates for $\Delta v = 1$ were of the order of magnitude comparable with the rate of quadrupole transitions in H_2^+. This allows us to hope that ortho-para transitions in H_2^+ can be induced and accurately studied by precision laser spectroscopy [6].

New manifestations of the kinematic vortical effect found earlier at BLTP were studied. This effect was calculated for fields with spin 3/2 within the framework of the extended Rarita–Schwinger–Adler theory. It was shown that despite the unusual values of the transport coefficients, 53 and 5, the current exactly satisfies the gravitational chiral anomaly found earlier. The analysis was also extended to the medium with acceleration and curvature. As a result, the Unruh effect, being one of the possible explanations of fast thermalization in heavy-ion collisions,

20–22 February. The 9th JINR–Armenian workshop "Supersymmetry in Integrable Systems" (SIS'23)

was substantiated in an unexpected way in curved space-time [7].

Explicit expressions were derived for the elements of the {β}-expansion for the nonsinglet Adler D_A function and Bjorken polarized sum rules S^{Bjp} in the N^{4}LO. The properties of the {β}-expansion for D_A and S^{Bjp} at higher orders were discussed, which follow from the Crewther and the Broadhurst–Kataev relations that hold true. Independent confirmation of our results was presented within pure QCD for the elements d_3[.] (c_3[.]) and d_4[.] ($c4$[.]) of {β}-expansion, which was obtained earlier in the N^{4}LO for the calculation in the $\overline{\text{MS}}$ scheme in the framework of extended QCD [8].

The two-point massless QCD correlator of nonlocal (composite) vector quark currents with chains of fermion one-loop radiative corrections inserted into gluon lines was calculated. The correlator depends on the Bjorken fraction "x" related to the composite current and, under large β_0 approximation, gives the main contributions at each order of perturbation theory. In the mentioned approximation, these contributions dominate the endpoint behavior of the leading-twist distribution amplitudes of light mesons in the framework of QCD sum rules. Based on this, the endpoint behavior of these distribution amplitudes for pions and longitudinally polarized rho mesons was analyzed, and inequalities for their moments were found [9].

A series of the four-particle tau-lepton decays with three pseudoscalar mesons in the final state was investigated in the framework of the Nambu–Jona-Lasinio model. The obtained results are in satisfactory agreement with the experimental data. The dominating role of the axial vector channel of such processes was demonstrated [10].

Sum rules that connect the phenomenological values of the masses of pseudoscalar mesons with the light-quark mass ratios were obtained. It was shown that the combined use of sum rules and experimental data on the $\eta \to 3\pi$ decay width imposes strict restrictions on the values of quark mass ratios: $0.41 < m_u/m_d < 0.59$, $18.16 < m_s/m_d < 20.26$, and $22.67 < m_s/m_{ud} < 28.55$. The inequalities consistently take into account the first $1/N_c$ correction to celebrated Weinberg's current-algebra result [11].

A new method was proposed for measuring the ratio of electromagnetic proton form factors $\mu_p\, G_E/G_M$ in the electron–proton scattering reaction with the transfer of polarization from the initial target proton to the final electron. Numerical analysis was performed for the conditions of the SANE experiment using form factors parameterization of Kelly and Qattan. It was shown that the difference between the results for the cases with the preservation of scaling and with its violation reaches 70%, which makes it possible to clearly distinguish between these two cases in experiment [12].

Within the framework of quantum electrodynamics, a systematic study of unpolarized parton distributions in electrons was carried out. The QED evolution equations were solved explicitly in the next-to-leading logarithmic approximation. The formulas were obtained in both the space-like and time-like domains for the transferred momentum. The found parton distributions will be used to calcu-

11–15 July. International workshop "Superconducting and Magnetic Hybrid Structures"

late higher-order radiative corrections enhanced by powers of the logarithm of the ratio of the characteristic energy scale to the electron mass [13].

Using first-principle numerical simulations, a new spatially inhomogeneous phase was found in rigidly rotating gluon plasma. This mixed phase simultaneously possesses both confining and deconfining phases in thermal equilibrium. Analytic continuation of our results to the domain of real angular frequencies indicates a profound breaking of the Tolman–Ehrenfest law in the vicinity of the phase transition, with the confining (deconfining) phase appearing far (near) the rotation axis [14].

A broad range of problems associated with phase transitions in systems characterized by the strong interaction between particles and the formation of structures was reviewed. A general phenomenological mean-field model was constructed describing phase transitions of the first and the second order to the homogeneous and inhomogeneous states. A transition to an inhomogeneous state can occur even in the case when the interaction is translation-invariant. Mean fields and fluctuations were studied. Applications to various equilibrium and nonequilibrium nuclear systems were considered [15].

Ring structures that appear in Au + Au collisions at collision energies $\sqrt{s_{NN}}$ = 3–30 GeV were studied. The calculations were performed within the model of three-fluid dynamics. It was demonstrated that a pair of vortex rings was formed, one at forward and the other at backward rapidities, in ultracentral Au + Au collisions at $\sqrt{s_{NN}} > 4$ GeV. The vortex rings carry information about the early stage of the collision, in particular, about the stopping of baryons. It was shown that these rings can be detected by measuring the ring observable R_Λ even in the rapidity range $0 < y < 0.5$ (or $-0.5 < y < 0$) at the level of 0.5–1.5% at $\sqrt{s_{NN}}$ = 5–20 GeV. At forward/backward rapidities, the R_Λ signal is expected to be stronger [16].

Using the PHSD transport model to simulate heavy-ion collisions at energies of the NICA accelerator complex, the yield of hyperons and the thermodynamic characteristics of the medium in which they were produced or last interacted were analyzed. It was found that there are two main thermodynamic sources of hyperons and only one of antihyperons. It was revealed that the freeze-out time of particles and antiparticles cannot be directly related to the different polarization of particles and antiparticles. It was shown that antiparticles are predominantly created in a hotter and rotating medium, which is the reason for the difference in the polarization of particles and antiparticles [17].

Theory of Nuclear Systems

In 2023, investigations were carried out in accordance with four projects:

- Microscopic models for exotic nuclei and nuclear astrophysics;
- Low-energy nuclear dynamics and properties of nuclear systems;
- Quantum few-body systems;
- Relativistic nuclear dynamics and nonlinear quantum processes.

The gross structure of the strength distribution of giant monopole resonances (GMR) in the region near the doubly magic nucleus ^{208}Pb was described in good agreement with experimental data using the idea of random coupling between one- and two-phonon states. Based on the QRPA one-phonon states obtained from the Skyrme energy density functional, the coupling and two-phonon states were generated by means of the Gaussian orthogonal ensemble distribution. The spreading widths of GMR were described by means of a random matrix approach on two energy scales. A quantitative description of the width of resonances was determined by both a small number of two-phonon states, strongly coupled to low-energy surface vibrations, and a vast majority of two-phonon states responsible for the fine structure of the resonance [18].

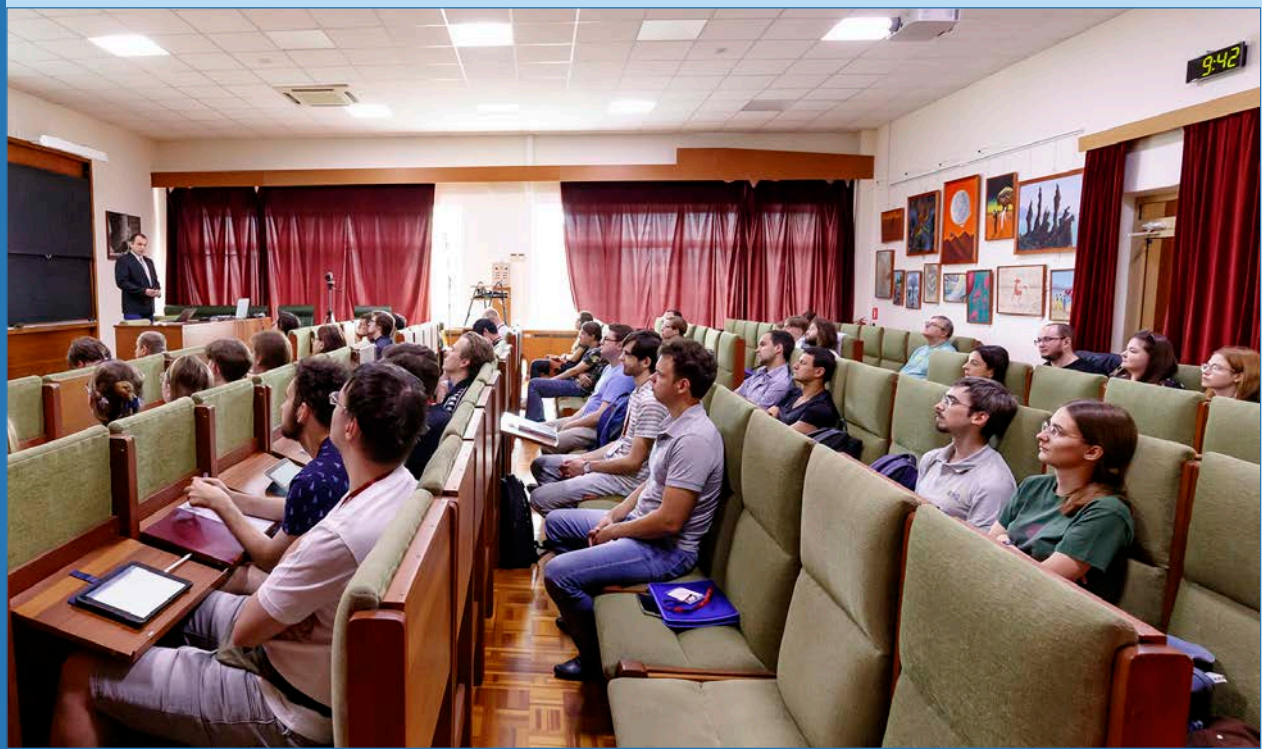
The theoretical basis underlying the physics of the Bohr–Mottelson collective model was considered at the algebraic level. It was shown how the irrotational-flow dynamics of Bohr–Mottelson type can obtain a microscopic interpretation in the two-component proton–neutron shell-model theory of atomic nuclei within the framework of the proton–neutron symplectic model. Some simple examples that illustrate the theory were presented for two nuclei ^{110}Cd and ^{110}Ru that are supposed to exhibit such irrotational-flow dynamics. The ground-state quadrupole irrotational-flow collectivity in these two nuclei was well described without the use of an effective charge [19].

(Anti)neutrino luminosities and spectra arising from neutral- and charged-current weak reactions with a hot nucleus ^{56}Fe were computed for pre-supernova conditions and compared with the contribution of thermal processes. It was found that a thermodynamically consistent consideration of thermal effects within the TQRPA approach produces a few times higher total luminosity of electron neutrinos compared to the standard technique based on the shell-model calculations. It was shown that in the context of electron antineutrino generation, the neutrino–antineutrino pair emission via nuclear de-excitation (ND) is at least as important as the electron–positron pair annihilation process. It was also shown that flavor oscillations enhance the high-energy contribution of the ND process to the electron antineutrino flux. This could potentially be important for pre-supernova antineutrino registration by the Earth's detectors [20].

Systematic calculations of the excitation spectra, structure of the wave functions, and the γ-transition probabilities of odd-proton nuclei with Z = 97–109 were performed. It was shown that the structure of nuclear states in the considered nuclei is mainly exhausted by one-quasiparticle components [21].

Within the improved scission-point fission model, it was shown that an average neutron number per

23–28 July. International school “Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems”



proton is not the same in fission fragments and is not equal to that in a fissioning nucleus. For the induced fission of ^{238}U, ^{240}Pu, ^{244}Cm, and ^{250}Cf, the dependences of the fission-fragment neutron-excess ratio on the shell structure and excitation energy of the fragment were studied [22].

A new mechanism for incomplete nuclear fusion was proposed and substantiated as an alternative to the known mechanism involving the disintegration of a projectile nucleus and capturing one of the fragments by a target nucleus [23].

The cross sections for the formation of evaporation residues in the emission channels of light particles were calculated in the framework of the dinuclear system model. It was shown that, in fusion reactions leading to the formation of compound nuclei with Z = 80–90, *pxn* and *αxn* channels are as strong as *xn* channels [24].

The probabilities of *xn*-, *pxn*-, and *αxn*-evaporation channels in excited superheavy nuclei were evaluated using the Monte Carlo method. An analytical formula was introduced to estimate the average kinetic energy of emitted particles in multi-step processes [25].

Nondipole terms in the atom–laser interaction arising due to the presence of a magnetic component in an electromagnetic wave and its inhomogeneity lead to the nonseparability of the center-of-mass (CM) and electron variables in the neutral atom and, as a consequence, to its acceleration. This effect and the accompanying excitation and ionization processes were investigated for the hydrogen atom in strong (10^{12}–$2 \cdot 10^{14}$ W/cm^2) linearly polarized short-wavelength ($5 \lesssim \hbar\omega \lesssim 27$ eV) electromagnetic pulses with duration of about 8 fs. The study was carried out within the framework of a hybrid quantum–quasi-classical approach in which the coupled time-dependent Schrödinger equation for an electron and the classical Hamilton equations for the CM of an atom were simultaneously integrated [26].

A system of two identical spinless fermions on the two-dimensional lattice was considered under the assumption that the first and second nearest-neighboring interactions between the fermions are only nontrivial and that these interactions are of magnitudes λ and μ, respectively. A partition of the (λ, μ) plane was established such that in each its connected component the two-fermion Schrödinger operator corresponding to the zero quasi-momentum of the center of mass has a definite (fixed) number of eigenvalues, which are situated below the bottom of the essential (continuous) spectrum and above its top. Moreover, for each connected component, a sharp lower bound was established on the number of isolated eigenvalues for the two-fermion Schrödinger operator corresponding to any admissible nonzero value of the center-of-mass quasi-momentum. The results obtained help one to understand the mechanism of emergence of eigenvalues of a two-fermion lattice Schrödinger operator from the essential spectrum as λ and μ vary [27].

Binding of two heavy fermions interacting with a light particle via the contact interaction is possible only for a sufficiently large heavy-to-light mass ratio. The two-variable inequality was derived to deter-

mine a specific value μ^* providing that there are no three-body bound states for the mass ratio smaller than μ^*. The value of $\mu^* = 5.26$ was obtained by analyzing this inequality for a total angular momentum and parity $L^P = 1^-$. For other L^P sectors, the specific mass-ratio values providing the absence of three-body bound states were found in a similar way. For generality, the method was extended to determine the corresponding mass-ratio values for a system consisting of two identical bosons and a distinct particle for different L^P ($L > 0$) sectors [28].

Within the framework of the PHSD (Parton Hadron String Dynamics) transport model, noncentral collisions of gold nuclei were simulated at the energies of the NICA collider. The properties of the velocity and vorticity fields, as well as hydrodynamic helicity, were studied depending on the impact parameter and energy. Quadrupole structures of the vorticity field were obtained, the effect of helicity separation was discovered in the PHSD model in both momentum and coordinate space, and the polarization of Λ hyperons was calculated in the thermodynamic and anomalous approaches, which turned out to be close to that found in the STAR experiment at energy $\sqrt{s} = 7.7$ GeV [29].

A relativistic study of elastic pD backward scattering based on the one-nucleon exchange diagram was performed. Calculations were made using relativistic deuteron wave functions obtained by solving the Bethe–Salpeter equation in the Minkowski space with relativistic separable potentials Graz-II and MY6. The unpolarized differential cross section and some polarization observables of the reaction for the initial proton momentum up to 7.3 GeV/c were calculated [30].

The applicability of effective models to the description of baryons and the behavior of ratios of strange baryons to pions was discussed. In the framework of the EPNJL model, the Bethe–Salpeter equation was used to find masses of baryons, which were considered to be in a diquark–quark state. Baryon melting was studied at a finite chemical potential, and a flavor dependence of the hadronic deconfinement temperature was pointed out. It was shown that the description of the diquark–quark state at a finite chemical potential is limited due to the occurrence of the Bose condensate. This effect is strongly manifested in the description of light diquarks and baryons. Both the Λ^0/π^+ and Ξ^-/π^+ ratios show a sharp behavior as functions of the T/μ_B variable, where T and μ_B are calculated along the melting lines [31].

Theory of Complex Systems and Advanced Materials

Theoretical investigations in 2023 were carried out in the framework of the following projects:

- Complex materials;
- Nanostructures and nanomaterials;
- Mathematical models of statistical physics of complex systems;
- Methods of quantum field theory in complex systems.

The variational theorem for the scattering length in the presence of the dipole–dipole interaction was proven. The theorem was applied to the spinless dipolar Bose gas in three dimensions. The long-range tails of the single-particle momentum distribution and static structure factor, and the pair distribution function at short distances were calculated analytically. The momentum distribution is inversely proportional to q^4 with the anisotropic prefactor. In the absence of the dipole–dipole interaction, Tan's adiabatic sweep theorem was reproduced as a particular case. For the homogeneous dilute Bose gas, all the relations were calculated analytically. The predicted physical effects can be verified both numerically and experimentally [32].

Magnetic phase transitions of the model of $BaCo_2(AsO_4)_2$ were studied. The region of parameters was found that can match an experimentally observed cascade of magnetic phase transitions, and calculations of magnetization were compared with experimental data [33].

A general statistical theory of mixed states was formulated and illustrated by a number of systems from condensed matter to quark–hadron matter. A review of experimentally studied mixed materials was given [34].

A theory of quantum crystals with dislocation nets was developed, where inside the dislocation cores a superfluid fraction can appear [35].

Exact finite-size corrections for the free energy F of the Ising model on the $M \times 2N$ square lattice with Brascamp–Kunz boundary conditions were derived. The ratios $r_p(\rho)$ of pth coefficients of F for the infinitely long cylinder and the infinitely long Brascamp–Kunz strip at varying values of the aspect ratio $\rho = (M + 1)/2N$ were calcualted. As previous studies showed for a two-dimensional dimer model, the infinite p limiting values of $r_p(\rho)$ exhibit abrupt anomalous behavior at certain values of ρ. These critical values of ρ and the limiting values of the finite-size-expansion-coefficient ratios differ, however, between the two models [36].

A parafermionic generalization of the hyperbolic hypergeometric function, appearing as the most important part in the fusion matrix for Liouville field theory and the Racah–Wigner symbols for the Faddeev modular double, were studied. This generalized hypergeometric function is a limiting form of the rarefied elliptic hypergeometric function. Its transformation properties and a mixed difference-recurrence equation were derived. The simplest case corresponds to the supersymmetric hypergeometric function related to the fusion matrix of super Liouville field theory and the Racah–Wigner symbols of the quantum algebra $U_q(osp(1|2))$. A relation to the standard Regge symmetry was discussed, and some known conjectures for the supersymmetric Racah–Wigner symbols were proven [37].

A general relation between the solitons and statistical mechanics was discussed, where soliton

phase shifts coincide with the Coulomb energy of charged particles with nontrivial boundary conditions. It was shown that the partition function of the normal random matrix model can be obtained from the multi-soliton solutions of the two-dimensional Toda lattice hierarchy in a special continuous limit [38].

It was shown that the topological Kitaev model can be placed in the context of phenomena associated with strongly correlated electron systems. Within that approach, neither spin-orbit coupling nor time-reversal symmetry breaking is needed to produce such an effect. This provides a new platform in realizing a nontrivial topological phase [39].

An ordinary (superconductor–insulator–superconductor) Josephson junction cannot exhibit chaos in the absence of an external ac-drive, whereas in the superconductor–ferromagnet–superconductor Josephson junction, known as the φ_0 junction, the magnetic layer effectively provides two extra degrees of freedom that can facilitate chaotic dynamics in the resulting four-dimensional autonomous system. It was shown that, due to the conservation of magnetic moment magnitude, two of the numerically computed full-spectrum Lyapunov characteristic exponents are zero. Two-dimensional bifurcation diagrams, which are similar to traditional isospike diagrams, were computed to display the different periodicities and synchronization properties. It was found that, as current is reduced, the onset of chaos occurs shortly before the transition to the superconducting state [40].

The temperature dependence of the band gap $E_g(T)$ in zigzag single-walled carbon nanotubes at maximum (50%) fluorination and hydrogenation was theoretically investigated for three coating versions. It was shown that the character of coating dramatically affects the dependence $E_g(T)$, which can vary over a wide range from very weak (typical of pure carbon nanotubes) to strong (typical of bulk semiconductors). The character of the temperature behavior $E_g(T)$ is directly related to the formation of one-dimensional alternating chains in nanotubes. The main factors determining this dependence are the diameter of the carbon nanotube, impurity position, and impurity type [41].

The critical properties of the phase transition towards superfluid order were analyzed, which were proposed to occur in $SU(N)$ fermionic systems. The bosonic field theory was considered for fluctuations of the complex skew-symmetric rank-2 tensor order parameter close to the transition. Then the scale dependence of the couplings of the theory was nonperturbatively determined by means of the functional renormalization group. A fluctuation-induced first-order phase transition in the $SU(N > 2)$ system was established. In the weak-coupling regime, the jump in the order parameter is small and a new superfluid phase occurs almost continuously, while in the strong one the discontinuity of the transition is well detectable [42].

For the first time, three terms of the epsilon expansion of the critical exponents of the percolation model were calculated using the renormalization group method. A Borel resummation of the resulting expansions was carried out. The found values of critical exponents are in good agreement with the results of computer modeling [43].

The problem of particles' random walks on a fluctuating "rough" surface was studied in a homo-

4–8 September. Participants of the Workshop on High Energy Spin Physics (DSPIN)

27 February – 3 March. Workshop “Infinite and Finite Nuclear Matter” (INFINUM-2023)

geneous gravitational field. The surface was modelled by the Edwards–Wilkinson stochastic equation. It was shown by means of the field-theoretic renormalization group that various Green functions of the full-scale model exhibit scaling behavior in the infrared (long-wavelength) range. Power laws for spreading of a cloud of particles with exponents different from those for ordinary random walk were obtained. Exact values for all critical dimensions were derived [44].

Modern Mathematical Physics: Gravity, Supersymmetry and Strings

The topics of main focus in the theme in 2023 were:

- Quantum groups and integrable systems;
- Supersymmetry;
- Quantum gravity, cosmology and strings.

Using holographic duality, Wilson loops described by open strings in a Kerr-AdS$_5$ black hole were calculated for the model of rotating quark–gluon plasma (QGP) in the $\mathcal{N}$ = 4 SYM theory. The potential of the interquark interaction and the jet-quenching parameter of a fast parton were studied; it was shown that at temperatures above the phase transition temperature, the interquark potential has Coulomb-like behavior. It was found that an increase in the temperature and/or rotation leads to a decrease in the distance between quarks. At high temperatures, the values of the interquark potential are close to the case of the nonrotating $\mathcal{N}$ = 4 SYM QGP; it was shown that the rotation of the medium increases the value of the jet-quenching parameter. At high temperatures, the jet-quenching parameter has a cubic dependence on temperature, as for the case in the nonrotating $\mathcal{N}$ = 4 SYM QGP studied by Liu et. al. (Phys. Rev. Lett. 2006. V. 97. 182301) [45].

A series of works devoted to the construction (from first principles) of all possible physically interesting unitary irreducible representations of the 4D Poincaré group, which are realized on the spaces of relativistic covariant local fields, was completed. Previously obtained results for massive representations were generalized to the case of massless representations with continuous spin and to the case of massless helicity representations. The main results of these works were: a) a new explicit formula for the continuous spin field, which is realized as a function of the 4-momentum on the mass shell and two complex-conjugate commuting Weyl spinors (formulas of this type can be used to construct scattering amplitudes of processes containing particles of continuous spin); b) construction of generating functions of higher-spin gauge fields directly from the Wigner wave functions [46].

The correct definition of the moduli space of Bohr–Sommerfeld Lagrangian submanifolds was found, which is compatible with the previously introduced notions of *D*-exact Lagrangian cycles, Lagrangian shadows, and components of Weinstein skeletons of Shtein domains. New examples of the moduli space were constructed where the conjecture was verified which says that these moduli spaces are algebraic varieties themselves [47].

A general approach was developed to constructing a deformation that describes the mapping of a dynamical system with first-class constraints in the phase space into another dynamical system with first-class constraints. It was shown that such a deformation problem can be efficiently embedded in the Batalin–Fradkin–Vilkovisky formalism by using

the (super)canonical transformations. It was proven that the generating function of the corresponding (super)canonical transformations is determined by a single function which depends only on the coordinates of the intitial phase space. To illustrate the developed approach, a nonlocal deformation of the Abelian gauge theory into nonlocal non-Abelian gauge theory was constructed whose local sector coincides with the standard Yang–Mills theory [48].

The off-shell structure of the two-loop effective action in 6D, $\mathcal{N}$ = (1,1) supersymmetric gauge theories in $\mathcal{N}$ = (1, 0) harmonic superspace was studied. An off-shell effective action involving all fields of the 6D, $\mathcal{N}$ = (1,1) supermultiplet was constructed by the harmonic superfield background field method. The gauge and the hypermultiplet-mixed divergences were explicitly calculated as the coefficients of $1/\varepsilon^2$, and it was demonstrated that the corresponding expressions are nonlocal in harmonics [49].

Fermionic modes localized on the static spherically symmetric self-gravitating non-Abelian monopole were studied in the *SU*(2) Einstein–Dirac–Yang–Mills–Higgs theory. The dependence of the spectral flow on the effective gravitational coupling constant was considered, and it was shown that, in the limiting case of transition to the Reissner–Nordström black hole, the fermion modes are fully absorbed into the interior of the black hole [50].

The relations between elliptic hypergeometric integrals and complex hypergeometric functions were considered. Exactly computable type-I elliptic beta integrals, describing superconformal indices of certain confining four-dimensional non-Abelian gauge theories, were taken and reduced to the level of complex hypergeometric functions in the Mellin–Barnes representation. A connection of the complex hypergeometric functions to integrable many-body problems was indicated as well [51].

Recent progress was reported in constructing off-shell 4D, $\mathcal{N}$ = 2 supersymmetric integer higher-spin theory in terms of unconstrained harmonic analytic gauge superfields and their cubic interaction with the matter hypermultiplets. For even superspins, a new equivalent representation of the hypermultiplet couplings in terms of analytic omega superfield was presented. It involves both cubic and quartic vertices [52].

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

As part of the DIAS-TH educational programme, a school for students and young scientists “Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems” was organized in 2023 (23–28 July). The main topics of the school were field-theoretical, functional and statistical methods in nonequilibrium quantum and classical systems, gravitational waves, holographic models, and geometric quantization. More than 50 people from leading scientific centres in Russia and Slovakia, universities in Moscow, St. Petersburg, and Tomsk took part in the school.

The educational series of lectures on gravitational physics was continued at BLTP. Seminars were held for undergraduate and graduate students, the DIAS-TH website was supported, and video recording of lectures was continued.

CONFERENCES AND MEETINGS

Nine conferences and workshops and two schools for students and young scientists were organized in 2023:

- JINR–Armenian joint workshop “Supersymmetry in Integrable Systems”, 20–22 February, Dubna;
- International workshop “Infinite and Finite Nuclear Matter”, 27 February – 3 March, Dubna;
- School on Physics of Quark–Gluon Matter, 20 March – 3 April, Dubna;
- BLTP JINR–APCTP joint workshop “Modern Problems in Nuclear and Particle Physics”, 9–15 July, Pohang, Republic of Korea;
- International workshop “Superconducting and Magnetic Hybrid Structures”, 11–15 July, Dubna;
- International school “Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems”, 23–28 July, Dubna;
- BLTP JINR–KLTP CAS joint workshop “Physics of Strong Interactions”, 3–9 September, Yerevan, Armenia;
- XIX International Workshop “High Energy Spin Physics” dedicated to the 90th anniversary of Professor A. V. Efremov, 4–8 September, Dubna;
- XXV International Baldin Seminar on High Energy Physics Problems “Relativistic Nuclear Physics and Quantum Chromodynamics”, 18–23 September, Dubna;
- International seminar “Selected Problems in Quantum Field Theory” dedicated to the memory of Professor E. A. Kuraev, 17–18 October, Dubna;
- II South Africa–JINR Joint Workshop on Theory and Computation, 5–8 December, Gqeberha, South Africa.

COMPUTER FACILITIES

In 2023, five new PCs with 12-generation Intel processors were installed in workplaces. The theor5.inr.ru server with two 18-core processors was put into operation. Two high-end PCs with Intel i9-13900K processors were purchased to replace obsolete shared PC servers. Maple and OriginPro programs were updated, and subscriptions on updates and technical support for this software were extended to the end of 2024. The 10 Gbit/s switch was installed in the core of the BLTP local network. This led to the improvement of switches interconnection topology, thus reducing delays in data transmission, and simplified management. The introduction of multi-gigabit Ethernet started. This made possible data transmission rates 2.5 and 5 Gbit/s over existing UTP wiring to workplaces. The deployment of faster wireless communication standard 802.11ax equipment was started. The microclimate in the server room was made more stable after installation of a semi-industrial air conditioner.

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VEKSLER and BALDIN LABORATORY of HIGH ENERGY PHYSICS

In 2023, the activity of the Veksler and Baldin Laboratory of High Energy Physics was aimed at construction, development and commissioning of separate units of the accelerator complex "Nuclotron–NICA" and MPD, BM@N and SPD experimental facilities. Experiments were also continued at external accelerators.

MOST IMPORTANT RESULTS IN THE IMPLEMENTATION OF THE NUCLOTRON–NICA PROJECT

On 2 February, the **fourth commissioning cycle** was completed, aimed at accelerating Ar and Xe ion beams produced by the Krion-6T source. The following work was performed during the run:

— optimization of Krion-6T together with HILAC for producing and accelerating Ar and Xe ions with different charges;

— testing of the Station Of CHip Irradiation (SOCHI) with Ar^{12+} ion beams; the ion beam with a diameter of 100 mm was produced with homogeneity of dose distribution higher than 10% on a 20 × 20 mm chip. The microchips XC6SLX16 were irradiated, and the cross section of single event effects (SEE) was $1.9 \cdot 10^{-2}$ cm^{-2} at an ion fluence of $3.5 \cdot 10^4$ ion/cm^2;

— installation of two other stations for applied research, namely, SIMBO and ISCRA, was completed;

— tuning of the Booster for Ar^{12+} and $^{142}Xe^{28+}$ beam acceleration, dynamic correction of the beam orbit during the entire acceleration cycle; the intensity of the accelerated $^{142}Xe^{28+}$ beam was about $2 \cdot 10^7$ particles per spill;

— sequential testing of two stripping targets made of copper and titanium; the Booster–Nuclotron transport channel was optimized for transporting fully stripped Xe^{54+} ions;

— obtaining of a beam circulation in the Nuclotron ring;

— acceleration of the beam at the 4th harmonics of accelerating RF voltage to an energy of about 4 GeV/nucleon; the intensity of the accelerated $^{142}Xe^{54+}$ beam was up to $1 \cdot 10^7$ particles per spill;

— slow extraction of the Xe beam during 2 s;

— irradiation of emulsions according to the BECQUEREL project;

— calibration of the new diagnostic system; installation of the vacuum system of the extracted beam channel;

— transportation of the beam to the BM@N zone; the beam's intensity was up to $5 \cdot 10^5$ particles per spill according to BM@N triggers, which meets the requirements of the experiment; studies were performed under the BM@N programme at energies 3.8 and 3 GeV/nucleon;

Stations SIMBO (left) and ISCRA (right)

Dubna, 22 December. The festive events dedicated to the 70th anniversary of the Veksler and Baldin Laboratory of High Energy Physics


директор лаборатории - В.И. Векс
Д.И. Блохинцев, В.И. Векслер, Ф. Жолио
ных проблем вошла в с
ей Высоких Энергий
Первый директор - В.И. Ве

— conducting experiments on electron cooling of the $^{142}Xe^{28+}$ beam in the Booster at an injection energy.

The production and cryogenic testing of the regular elements of the collider's magnetic system are completed. All arc dipole magnets of the collider are installed and adjusted inside the tunnel, the production and testing of other elements of the cryomagnetic system are in the final stage. Installation work continues as the building engineering infrastructure located in the main premises is being completed.

The magnetic cryostat and vacuum systems of the collider are being installed and tested. Elements of RF-1 and RF-2 systems are installed into the operation position, the annealing process and vacuum tests were conducted. The power supply system of the collider's structural elements is ready for commissioning. Preparations for the launch of a new

Installation of the HTS magnets winding. Preventive inspection of the base for the magnet

A general view of the technological platform of the MPD solenoid cryogenic cooling system with the equipment installed

cryogenic compressor station and a complex of cryogenic setups in building 1B are being completed. The concept of the magnetic synchrotron system "New Nuclotron" was developed.

During the implementation of the project, two PhD theses were defended based on the results of the work carried out, a number of scientific papers were presented at conferences and published [1–5]. An educational programme for the training of operators involved in the commissioning and operation of the NICA complex is being implemented.

The goal of the **MPD project** at this stage is to construct a universal detector for operation with colliding beams at NICA. The results of work on the main MPD systems performed in 2023 are presented below.

In the summer of 2023, the ***components of the cryogenic cooling system*** of the MPD solenoid ordered in the Russian Federation were received. All system elements were placed on the technological platform and the piping of the equipment was carried out using flexible cryogenic pipelines. Installation of warm pipelines with a total length of 500 m for direct and reversed flows of helium and nitrogen was completed. Zip line suspensions were mounted, on which flexible pipelines were placed. This allows moving the magnet without warming it and maintaining temperatures of 80 K in any of its position. Flexible and rigid pipelines were tested for strength and leakage, including tests at cryogenic operating temperatures.

The satellite refrigerator was unpacked and assembled by MPD Department employees. The ILK company did not fulfill its obligations under the contract and withdrew from the assembly and commissioning of the refrigerator and did not provide software. VBLHEP employees together with LLC "Extended Range Systems Limited" carried out the development of a scheme and the preparation of new software with telemetry visualization and the ability to work in manual mode based on existing controllers.

Solenoid Magnet. The control Dewar was installed on the technological platform and its piping with the solenoid pipelines was carried out. Additional temperature sensors were added to the SC cable in the connection unit with the control Dewar (the most heat-loaded part) to determine the temperature of the cable during current input and in stationary operation mode. Sensors from the solenoid and vacuum system are connected to the Master control and monitoring system (more than 500 cables). The vacuum cavity of the solenoid was pumped out to a working vacuum of $5 \cdot 10^{-5}$ Torr. The pumping time was 48 h. The leak tests were passed — no leakage was detected. During the tests, helium was supplied to the pipelines of the solenoid cooling system under operating pressure. The cryogenic tests of the

5–6 December. A technological transfer of the 800-ton MPD experiment solenoid in the pavilion of the multipurpose detector of the NICA accelerator complex

magnet were divided into several stages. The first stage involves the circulation of working gases in the cooling system loops in warm operation mode. The second stage involves cooling the solenoid magnet to 80 K. The third stage involves cooling the solenoid to operating temperatures of 4.5 K. The cooling process is also aimed at performing additional checks of systems in stationary operation mode at 4.5 K.

The assembly of the ***TPC*** frame and ***ROC*** chambers continued [6–8]. Two flanges and a high-voltage (HV) electrode were installed on the inner cylinders C1–C2. The relative nonparallelism of the two flanges and the HV electrode between each other is no more than 0.5 mm. Twenty-four pipes of the field cage system are installed on the inner diameter of TPC. ROCs for the launch version of MPD are based on multi-wire proportional chambers (MWPC) with pads readout. Twenty-eight serial ROCs were manufactured and tested.

Two flanges and the HV electrode glued with the cylinders C1–C2

To minimize the error in the absolute measurement of the coordinates of particle tracks, a laser calibration system is being developed. Eight planes with 28 secondary laser beams in each are generated inside TPC using the primary laser beam distribution system. A laser beam position detector was produced at the Palacký University Olomouc (Czech Republic). The detector was tested with a working laser. A framework for the installation of micro-mirror bundles and computer control software of two working lasers of the laser calibration system were developed. The cooling system is used for temperature stabilization of the TPC detector within 0.5 °C. The system uses 180 PT100 sensors placed on the detector frame and providing temperature measurement with an accuracy of ~ 0.1 °C. Distilled water is used as a coolant. To prevent water leaks inside the MPD facility, all water in the pipelines is under pressure below atmospheric pressure (leakless system). Automatic devices provide control and monitoring of the state of the entire system. The technical solutions adopted are being tested at a specialized stand and the equipment layout is being coordinated between the contractor (INP BSU, Minsk) and JINR.

FEC modules are based on specialized chips (SAMPA ASIC), FPGA, and high-speed serial interfaces. At the time of 2023, 65% of the required number of modules have been produced. There are 500 sets of printed circuit boards available, which covers the remaining part for production, including the necessary reserve. The RCU controller is designed to control and receive data from 62 FEC modules installed on a single ROC chamber. In 2023, debugging was completed and tests of the first version of the controller began. They demonstrated the operability of the main functions of the device. The design process of the preproduction version of the device is being completed.

A stand for testing ROC chambers with readout electronics

Joint JINR–CRISM team after the completion of the delivery of the support frame for the MPD detectors (*photo by N. Topilin*)

March. Regular large supply of modules of electromagnetic calorimeter for the MPD detector at NICA to JINR from China

In 2023, the assembly of MPD ***ToF modules*** was completed [9]. Twenty-eight modules are ready to be installed into MPD. At the same time, the assembled modules are being additionally tested and refined. The equipment for integrating ToF modules into MPD was produced. The assembly of the most complex ToF service subsystem — the detector gas supply system — has begun. After commissioning of the MPD electronics platform, this equipment will be installed in racks on the 3rd floor of the platform. A system for cleaning the gas mixture from impurities of water vapor and oxygen with recirculation was produced and tested. As a result of the evaluation of the effectiveness of MPD trigger systems, it was decided to use ToF detectors as trigger detectors. For this purpose, the front-end electronics based on NINO ASIC was upgraded and the production of trigger logic modules for the time-of-flight system began.

All 800 ***electromagnetic calorimeter (ECal)*** modules produced were tested using cosmic muons [10]. Twenty of them were returned for testing and then to the cluster making site. No modules were rejected. Calibration data are constantly being analyzed, and the distribution of calibration coefficients is being studied. All modules were installed into the baskets of ECal half-sectors. Therefore, 66% of the entire calorimeter is ready for electronics installation and mounting into MPD.

All the main elements of the calorimeter electronics are fully produced. The electronics and its cooling system are being installed into heat-insulated boxes, various operation modes of the cooling system are being tested. Using the developed LED monitoring system, the stability of the calorimeter operation is being monitored (at the half-sector level). Programs for online monitoring of the calorimeter and slow monitoring of the detector are being developed.

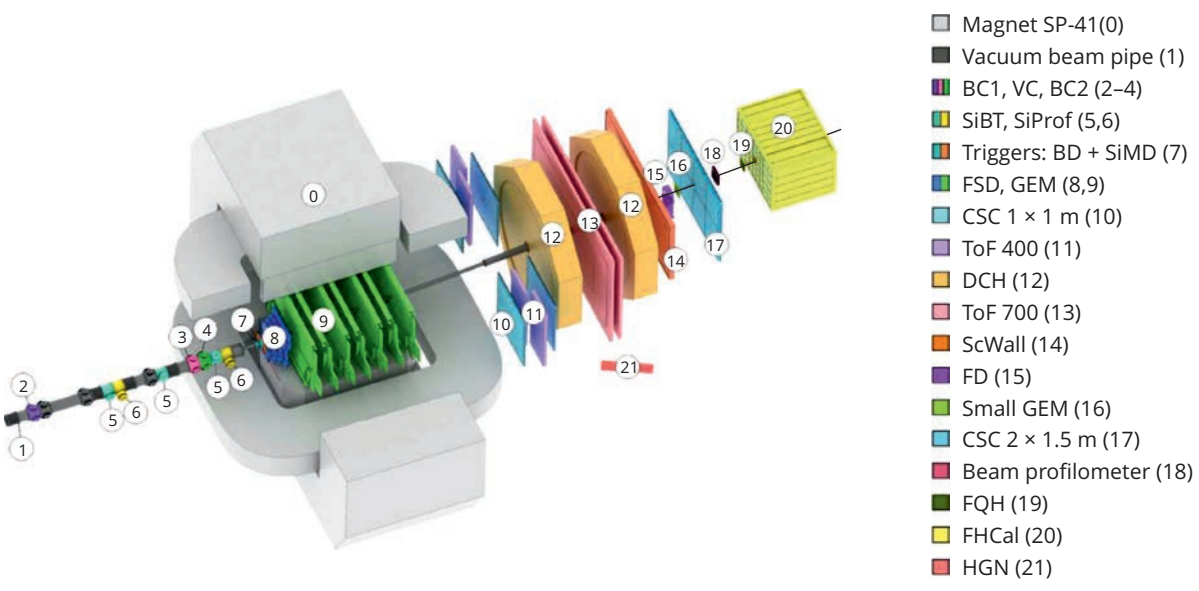
The development and construction of the ***NICA–MPD-Platform*** is in full swing. Twenty-five racks for the equipment with ventilation panels and 13 coolers were installed on each floor of the Platform. The power supply of the Platform is isolated on each floor. An access control and management system was installed, integrated with the existing system with DAQ-Data Centre. CCTV (video-surveillance) and an autonomous fire extinguishing system based on reducing oxygen concentration by injecting non-flammable gas were installed on each floor of the Platform. A water-cooling system for the Platform was developed, the required equipment was purchased and its installation has begun.

While preparing the ***luminosity detector*** for setting up beam convergence and determining luminosity in the standalone mode, two detector planes were assembled with new FE electronics. A test bench for test measurements was assembled, work is underway to coordinate time signals from the collider and MPD detector systems [11]. Preparations have begun for test measurements at the electron accelerator in Troitsk.

In 2023, the MPD Collaboration published 11 scientific papers and presented more than 30 reports at various conferences.

From December 2022 to February 2023, the physical run was carried out in the **BM@N experiment** to take data on interactions between $^{124}Xe^{54+}$ ion beam and the CsI target. For the first time, the experimental facility was operating in the full configuration of the tracking system, which completely overlapped the aperture of the analyzing magnet SP-41. The full configuration of BM@N detectors in the Xe + CsI run is shown in Fig. 1. A scientific paper on BM@N detectors is ready for publication [12]. The BM@N team collected 507 million events with the Xe beam at a kinetic energy of 3.8 *A* GeV and 48 million events with the Xe energy of 3 *A* GeV.

Fig. 1. The full configuration of BM@N detectors in the Xe + CsI run



The BM@N team optimized the algorithm for particle track reconstruction in the central tracking system, determined the exact position of the coordinate detectors using software-based methods, calibrated ToF detectors and detectors for the collision centrality determination. The complete processing and reconstruction of events at the Xe energy of 3.8 *A* GeV were performed using the DIRAC system at Tier-1 and Tier-2. As a result of the physical analysis of 10 million interactions, statistically significant decay signals of Λ hyperons ($\Lambda \to p\pi^-$) and K^0_S mesons ($K^0_S \to \pi^+\pi^-$) were obtained (Fig. 2).

The ToF data analysis resulted in determining charged mesons and light nuclear fragments: $\pi^\pm$, K^+, p, ^{3}He, d, t. The identified V^0 and charged particles are a basic tool for studying the properties of nuclear matter produced in Xe + CsI collisions.

In 2023, the first physical paper of the BM@N Collaboration on studying π^+- and K^+-meson production in argon-nucleus interactions at energy of 3.2 *A* GeV [13] was published. A paper on studying the yields of protons, deuterons and tritons in argon-nucleus interactions is being prepared for publication. Figures 3 and 4 show, respectively, the yields of π^+ and K^+ mesons depending on the rapidity and the inverse slopes of the transverse momentum spectra for π^+ and K^+ mesons depending on the rapidity.

Collaboration members made a number of reports at international conferences: "Nucleus-2023" (Sarov, two reports), "The Actual Problems of Microworld Physics" (Minsk, two reports), the International Baldin Seminar (Dubna, six reports), NICA-2023 Workshop (Dubna, two reports).

In 2023, the **SPD** Collaboration continued finalizing the Technical Design Report. Compared to the first version of the document presented at the win-

Fig. 2. Signals of decays $\Lambda \to p\pi^-$ and $K^0_S \to \pi^+\pi^-$ in the invariant mass spectra of $(p + \pi^-)$ and $(\pi^+ + \pi^-)$

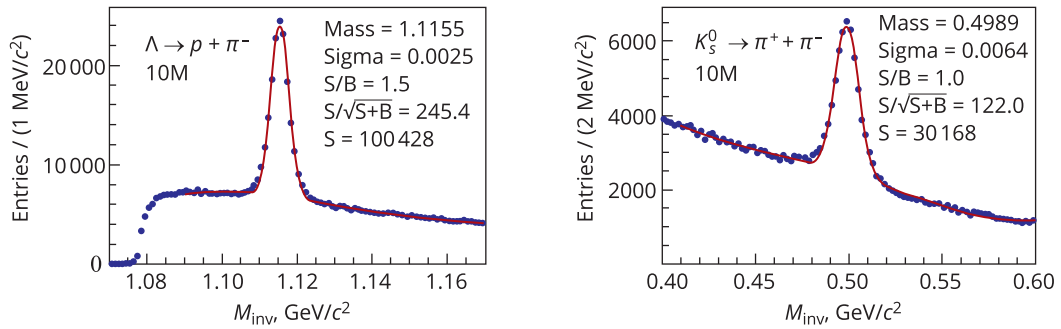
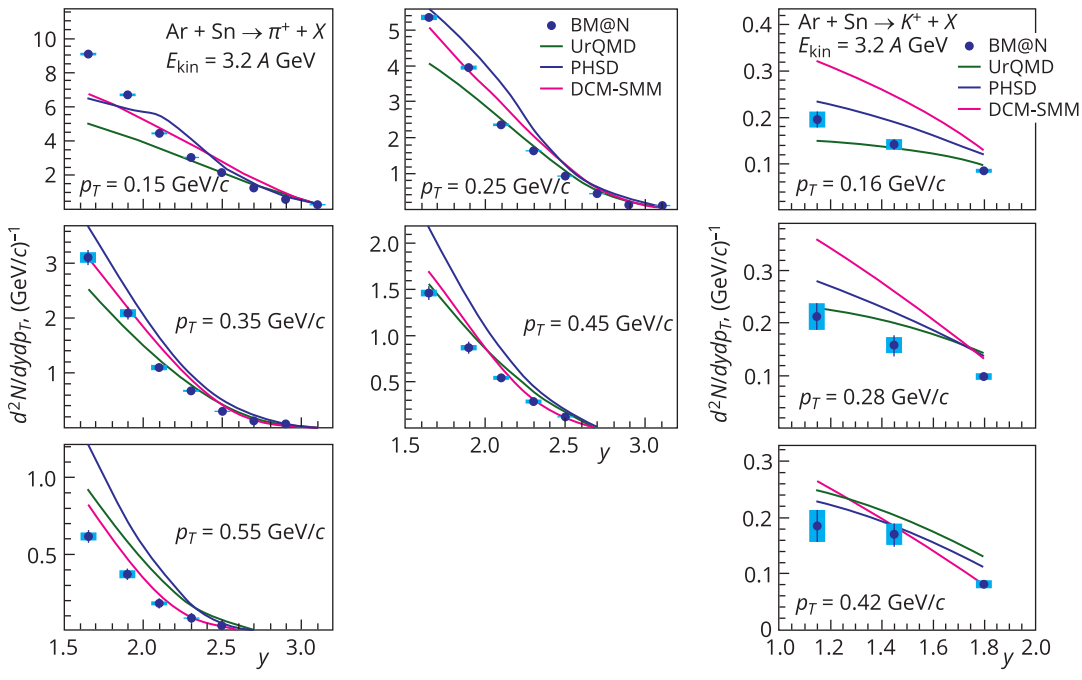
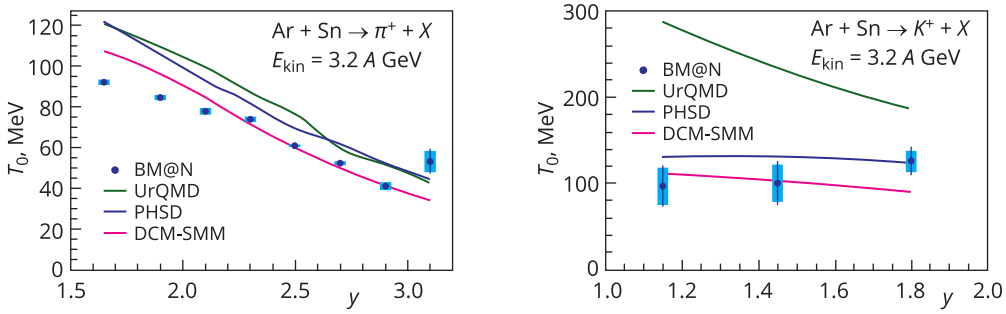


Fig. 3. The yields of π^+ and K^+ mesons depending on the rapidity in different intervals of the transverse momentum. The data are compared with predictions of the UrQMD, DCM-SMM and PHSD models of nucleus–nucleus interactions



Saint Petersburg, 15–19 May. Participants of the 10th Collaboration Meeting of the BM@N Experiment

Fig. 4. The inverse slopes of the transverse momentum spectra for π^+ and K^+ mesons depending on the rapidity. The data are compared with predictions of the UrQMD, DCM-SMM and PHSD models of nucleus–nucleus interactions



ter session of the PAC for Particle Physics, the following major changes were made:

— according to the calculations performed by COMETA JSC, it was possible to increase the weight of the detector from 1200 to 1500 tons, which resulted in an increase of 10 cm in the external radius of the facility and 30 cm in its longitudinal dimension. Accordingly, the size change affected such subsystems as the muon system, the superconducting solenoid, and the electromagnetic calorimeter;

— the aerogel-based threshold Cherenkov detector was replaced by the focusing Cherenkov ring detector (FARICH) to enhance the secondary particle identification capabilities;

— the beam–beam counter (BBC) was redesigned; the radial and azimuthal granularity was increased to enhance the detector's capabilities when operating in the first phase of the experiment in the ion–ion collision mode;

— the design of the Micromegas-based central tracker for the first phase of the SPD experiment was simplified;

— optimization of technical solutions based on the availability of detector components and equipment was performed, and the reassessment of the project cost, taking into account the proposed changes and current prices, was done.

In 2023, two new groups officially joined the SPD Collaboration: a group from Budker Institute of Nuclear Physics SB RAS (Novosibirsk) and a group from the Higher School of Economics (Moscow). Six new institutes signed Memoranda of Understanding. In the reporting year, the SPD Collaboration held two meetings in a hybrid format, which were attended by more than 160 people. During this period, JINR SPD participants published 10 papers in refereed scientific journals [14–17].

In 2023, the applied research programme **ARIADNA** was launched using high-energy accelerated ion beams of the NICA complex. As part of the

24–27 April. Participants of the 4th SPD Collaboration Meeting

four-month run of the accelerator complex with the beam at the BM@N spectrometer exit, in parallel operation with the main experiment, a prototype of a mobile test bench equipped with dosimetric equipment and a diagnostic system for charged particle beams with energies of about several GeV/nucleon was constructed. The first experiments were carried out according to the programme of the ARIADNA Collaboration [18], the scientific programme of seven research institutes, members of the ARIADNA Collaboration, was completed. Research continued at the SOCHI station [19].

As part of a series of experiments conducted by the ARIADNA-LS Collaboration with the sample of human skin fibroblast cells, new information about the molecular mechanisms of DNA repair was obtained following low-dose exposure to X-rays [20]. Compelling evidence was obtained for the predominant activation of the error-free repair pathway of DNA double-strand breaks (DSBs) — homologous recombination — after such exposure. Scientists discovered the presence of threshold levels of radiation doses to human fibroblast cells by induction of the most important markers of DNA DSB repair: RAD51, γ-H2AX foci and their co-localization.

OTHER EXPERIMENTS AT THE NUCLOTRON

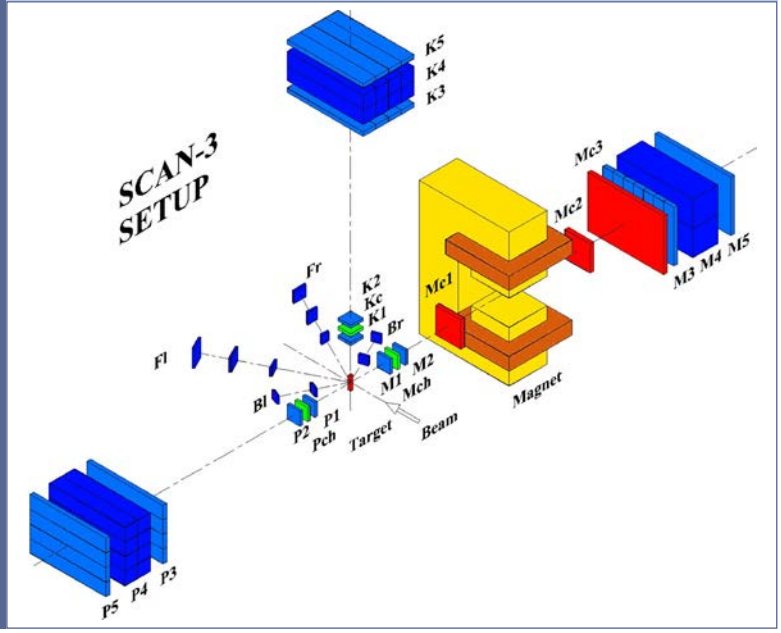
The **SCAN-3 project** is aimed at studying highly excited nuclear matter formed in nuclei as a result of the *d*A interaction. A new precision hybrid magnetic spectrometer SCAN is assembled for achieving this goal. This spectrometer allows detecting both charged ($\pi^{\pm}$, $K^{\pm}$, p) and neutral (n) particles produced at the Nuclotron internal target. The production of detectors for the SCAN-3 spectrometer was completed within a year. The main parts of three independent arms were developed. A schematic view of the spectrometer is shown in Fig. 5.

One arm of the spectrometer is produced as a magnetic spectrometer optimized for recording and measuring charged particles of protons and mesons. The other two arms are scintillation-non-magnetic spectrometers designed to register protons and neutrons. Identification and spectrometry of particles are performed by recording the time of flight and energy release in the detectors. In 2023, the following detectors were produced in addition to the existing ones — the vertex ToF counter and the vertex silicon detector, and drift chambers of the track system and multilayer neutron counters were installed [21].

An experiment on the production of nuclear fragments of ultralow energies was carried out at the **Nuclotron internal target**. Light nuclear fragments from Li to B were registered in Xe + W collisions. The goal of the experiment is to tune and test new equipment, including Si detectors (detector thickness — 8 and 300 μm) and the DAQ system.

Dynamic profiles of circulating beams were measured using a new two-coordinate profilometer based on microchannel plates in the warm section of the Nuclotron ring in the area of the internal target station. Using this profilometer, the temporal structure of the beam was studied, and data on particles scattered into the backward hemisphere on the Nuclotron internal target were obtained.

Fig. 5. A schematic view of the SCAN-3 spectrometer



During the reconstruction of the experimental zone of the spectrometric channel 7B of the **MARUSYA** setup at the extracted Nuclotron beams, a test experiment was prepared and carried out to determine the energy and type of ions (and accompanying fragments) based on Cherenkov radiation with a thin diamond target. Spectra in the visible range were measured at an angle of 90° with remote rotation of the target in the vacuum target station. The DAQ system was developed with the minimum configuration for conducting experiments with extracted Nuclotron beams, as well as for using secondary beams in applied research of the SPD Test Zone programme. A prototype calorimeter for detecting muons from rare charm particle decays was prepared for testing and placed in the SPD Test Zone. Prototypes of neutron detectors based on stilbene and the fast scintillator FS-03 were developed, produced and tested with electron beams of the linear accelerator Linac-200 [22–24].

26 July. A visit to JINR by representatives of the Embassy of the Republic of Moldova in Russia. On an excursion to VBLHEP

PARTICIPATION IN EXPERIMENTS AT EXTERNAL ACCELERATORS

The JINR group participating in the **ALICE** experiment prepared and published two scientific papers on studying K^+K^- interactions via femtoscopy in Pb–Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV [24] and femtoscopic correlations of identical charged pions and kaons in *pp* collisions at $\sqrt{s_{NN}}$ = 13 TeV with event-shape selection [25]. New results [26] were also obtained for kaon emission time (τ) with 3D femtoscopic analysis of the identical charged kaon for *p*–Pb collisions at 5.02 TeV, using the formulas (from the iHKM model) for longitudinal source radius (R_{long}):

$$R^2_{\text{long}}(m_T) = \tau^2\lambda^2\left(1+\frac{3}{2}\lambda^2\right), \quad \lambda^2 = \left(\frac{\lambda_i}{\tau}\right)^2 = \frac{T}{m_T}\sqrt{1-\bar{v}_T^2},$$

λ_i — longitudinal homogeneity length, T — temperature, m_T and v_T — transverse mass and collective velocity. The τ value was obtained by the combined fit using R_{long} versus m_T and particle spectra. The mean τ value ($(2.7 \pm 0.25_{\text{syst}} \pm 0.15_{\text{stat}})$ fm/*c*) coincides (Fig. 6) with the one found for Pb–Pb data at the same charged particle multiplicity which corresponds to the same source of particle emission. Also, the dependences of 3D and 1D source radii on transverse pair momentum and event centrality were obtained and compared with EPOS model results. One can see the radii increase for more central events and smaller pair momenta. The results were presented at the EPS-HEP2023 Conference.

The event analysis of four pions ($\pi^+\pi^+\pi^-\pi^-$) coherent photo-production in the UPC Pb–Pb collisions at an energy of 5.02 TeV was continued. The results confirmed [27] that the best description of four pions invariant mass distribution is obtained using two Breit–Wigner (B–W) functions (Fig. 7). With this description, the resonance states (green and blue lines) have the masses near the PDG table ones of $\rho(1450)$ and $\rho(1700)$. A scientific paper on the development of the thermal model for different hadron productions in the different *A*–*A* collisions is being prepared for publication. The elliptic flows and other characteristics were obtained in Pb–Pb and Xe–Xe collisions at the LHC energies. The group members presented two reports at international conferences and made a significant contribution to obtaining the results published by the ALICE Collaboration [28, 29].

As part of the ALICE upgrade programme, the group participates in the production and testing of modules of the PHOS electromagnetic calorimeter. In the autumn of 2023, 12 calorimeter and electronics cells were produced, and amplitude and time resolution measurements were carried out at the T9 PS CERN channel. The energy resolution results turned out to be very close to the data of the Hamamatsu APD S8664-1010 avalanche photodetectors, and the time resolution for one channel is approximately 70 ps.

The JINR group taking part in the **CMS** experiment was involved in the processing and analysis of the experimental data of LHC Run-2 (2015–2018) with the proton beams at $\sqrt{s}$ = 13 TeV, as well as the first data obtained in Run-3, which began in mid-2022 at $\sqrt{s}$ = 13.6 TeV. Using Run-2 data, a search was continued for signals of new physics beyond the Standard Model with lepton-flavour violation channels. The invariant mass spectra of *ee*, *μμ*, *eμ*, *eτ* and *μτ* pairs were studied in the dataset at $\sqrt{s}$ = 13 TeV, corresponding to a total integrated luminosity of 138 fb^{-1} (Fig. 8). The new stringent limits were set to the parameters of *R*-parity violating supersymmetric models, to the theories with the lepton flavor violating decays of heavy *Z'* gauge bosons, and to the scenarios of nonresonant quantum black hole production in models with extra spatial dimensions [30].

To search for Dark Matter (DM) candidates [31, 32], simulation was performed for production of the mediator between the SM and the DM in the extended two-Higgs-doublet models with scalar and pseudo-scalar singlets (2HDM + s/a). The cross sections of these processes were estimated.

Fig. 6. Emission time of charged kaons versus mean charged particle multiplicity

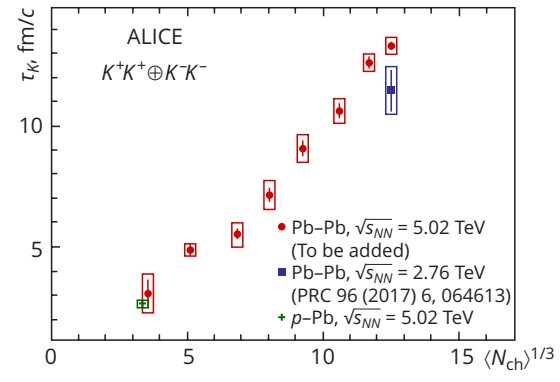
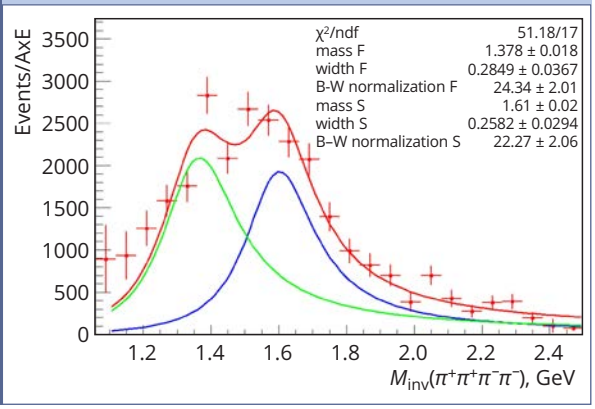


Fig. 7. Invariant mass distribution of four pions in the UPC Pb–Pb collisions at 5.02 TeV



Dubna, 23 October. A visit to JINR by Dr. R. Nemutudi, Deputy Director of the iThemba LABS accelerator centre (RSA). An excursion to VBLHEP

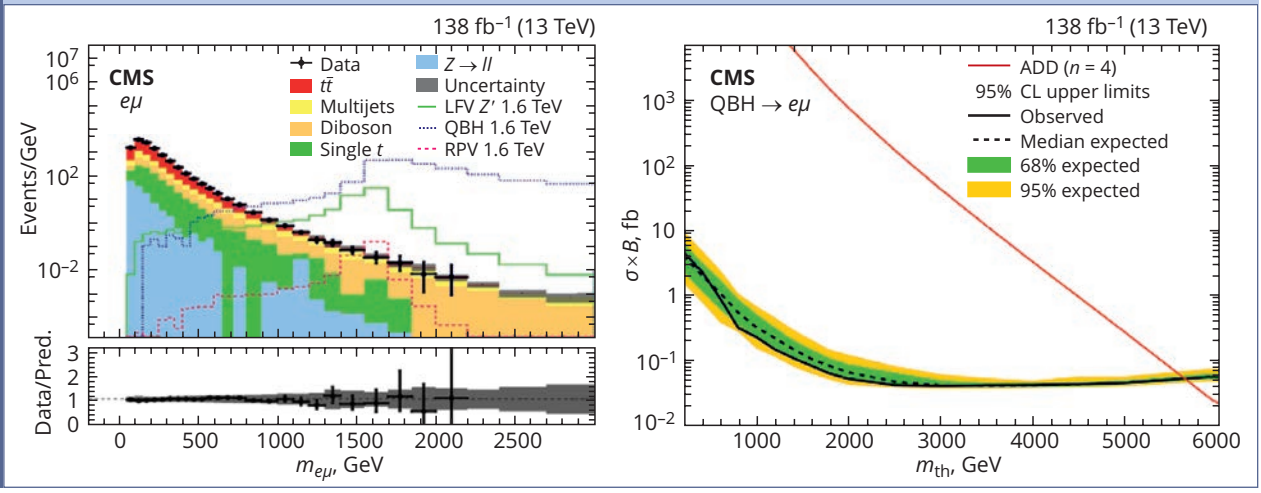
A new method for measuring the fractions of quark ("q") and gluon ("g") jets is proposed based on averaging of measurements in each bin of the distribution of q/g jets over an arbitrary jet macro-parameter [33]. Analytical expressions were obtained for measuring the q/g-jets characteristics using the measured q/g fractions.

One-loop electromagnetic and electroweak radiative corrections to dilepton production in hadron collisions via photon–photon fusion are studied, the most attention is paid to hard bremsstrahlung. Detailed numerical analysis is performed for electromagnetic and electroweak radiative effects to observable differential cross sections of the Drell–Yan process in a wide kinematical region, corresponding to ultrahigh energies and dilepton invariant masses [34, 35].

The maintenance and performance testing of the CMS detectors, which JINR is responsible for, have been fully completed. The detectors show stable and efficient operation during the Run-3 data taking. Data loss in hadron calorimetry does not exceed 1% (~ 210 pb^{-1}). The analysis of Run-3 experimental data shows efficient operation of cathode strip chambers (CSC) at the CMS Endcap muon system (ME). The CSC spatial resolution values obtained for ME stations in 2023 are in good agreement with previous year's data and indicate the stability of the CSC operation.

The JINR group actively participates in the construction of the high granularity calorimeter HGCal

Fig. 8. Invariant mass distribution for the $e\mu$ channel (left); 95% CL upper limits on the product of the cross section and the branching fraction for quantum black hole production in an ADD model with n = 4 extra dimensions, in the $e\mu$ channel (right)



and the upgrade of the muon system within CMS Phase-2 Upgrade for operation at the HL–LHC. To construct a testing setup for silicon and scintillation HGCal cassettes at CERN, JINR specialists have started the installation of low-temperature rooms supplied from JINR and special racks for testing HGCal cassettes. The large-area plastic scintillator trigger planes of the test bench were assembled and tested.

The JINR grid infrastructure including Tier-1 and Tier-2 centres is extensively used for processing and storing data from the CMS experiment. The Tier-1 data processing system was increased to 20 064 cores, and in 2023, more than 3.7 billion events were successfully processed by JINR Tier-1 centre, which puts it in the first place among all world Tier-1 centres for the CMS experiment.

In 2023, JINR physicists made a significant contribution to the preparation of 24 scientific papers. The results of the work were presented in 28 reports at various conferences.

The VBLHEP group participating in the **ATLAS** experiment continued the analysis of the associative production of the Standard Model Higgs boson with an electroweak vector boson V (W or Z) using machine learning algorithms. The scientific paper is being prepared. Work continued within the framework of the 2nd phase of the ATLAS Upgrade Programme. To test the FE electronics of the liquid-argon calorimeter, fiber-optic cables and patch cords were developed together with colleagues from LPI RAS. The products manufactured by the UNICORD company (Moscow) were delivered to CERN and are already being used at the test bench.

During a Long Shutdown (LS2) at CERN, the **NA61/SHINE** facility was significantly upgraded [36]. The JINR group made a significant contribution to the upgrade of the facility regarding the development, assembling and commissioning of the time-of-flight (ToF) system with a high time resolution (~ 50 ps) based on MRPC detectors and DRS4 readout system. One arm (1728 channels) of the system worked successfully in the runs of 2023. The construction of the second arm of the ToF system is being successfully completed. It will allow one to completely overlap the acceptance of the facility. During the 2023 data-taking period, a new online quality-assessment service was launched in order to have proper data monitoring in real time from all detector systems.

The JINR group studied the inclusive spectra of pions and kaons produced in nuclear collisions as a function of their transverse momentum in the central rapidity region, calculated by using a modified approach based on the assumption of the similarity of the hadron inclusive spectra. The similarity of these distributions with those observed for pp collisions in a wide range of initial energies is shown. Within the framework of this approach (BMLZ — Baldin–Malakhov–Lykasov–Zaitsev) [37], the ratio of kaon yields to pion yields produced in pp and BeBe collisions is calculated as a function of $\sqrt{s}$ and compared with other models (Fig. 9). The possibility of using this approach to describe inclusive hadron spectra for heavier colliding systems (PbPb and AuAu), in which a nonmonotonic increase in the K^+/π^+ ratio is observed, as one of the signatures of quark–gluon plasma is intriguing.

In 2023, a number of new physical results on studying the beginning of deconfinement, fireball and the search for a critical point were published [38–40].

The **NA62** experiment at CERN is aimed at studying a very rare charged kaon decay into charged pion, neutrino, and antineutrino. As part of this experiment, the JINR and CERN groups are jointly responsible for the NA62 Magnetic Spectrometer development, production, calibration, and maintaining, as well as for the software development for simulation and reconstruction of the events recorded in the spectrometer. In addition, the JINR group participates in the NA48/2 and NA62 experimental data analysis. Final results of the $K^+ \to \pi^0 e^+ \nu\gamma$ decay analysis based on the NA62 data were published [41]. A sample of $1.3 \cdot 10^5$ $K^+ \to \pi^0 e^+ \nu\gamma$ candidates with less than 1% background was collected by the NA62 experiment at the CERN SPS in 2017–2018. Branching fraction measurements are obtained at percent relative precision in three restricted kinematic regions, improving the existing results by a factor larger than two. An asymmetry, possibly related to T violation, is studied with no evidence observed within the achieved precision.

Fig. 9. Comparison of experimental data on the yield of kaons and pions in pp and BeBe collisions with calculations of the JINR group (BMLZ), as well as other models (Epos 1.99, UrQMD 3.4, PHSD 4.0, AMPT 1.26, SMASH 1.6)

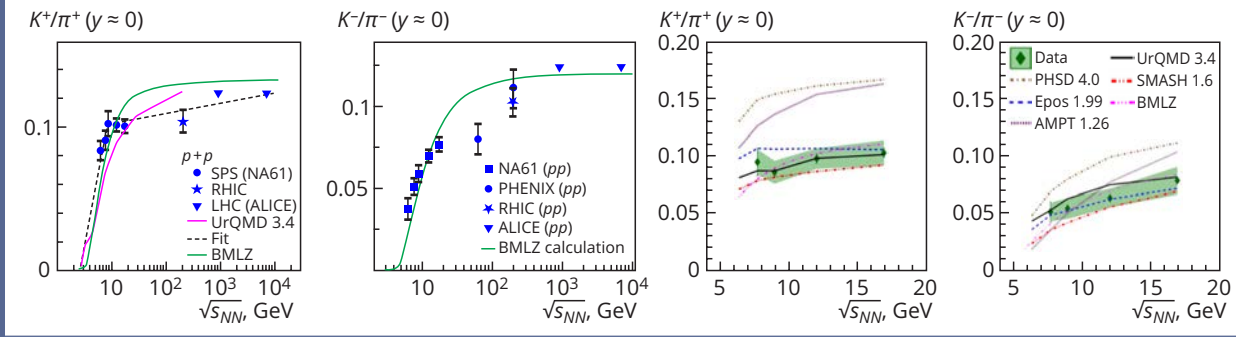
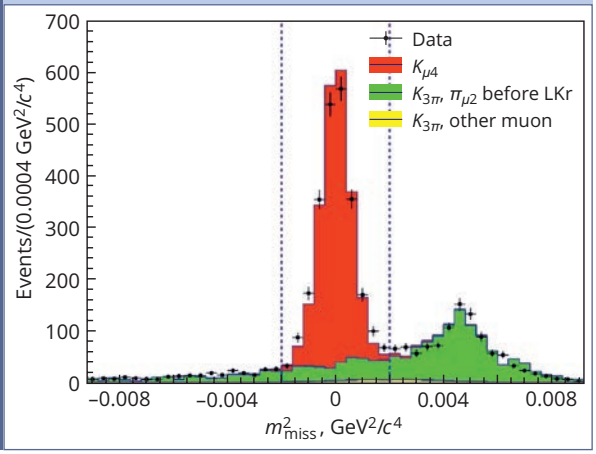


Fig. 10. Distribution of squared missing mass for the selected experimental data (markers), simulated background and signal contributions (histograms). Vertical lines show the signal region



Final results of the analysis of the rare $K^{00}_{\mu 4}$ decay, which has never been observed earlier, are prepared for the journal publication [42]. From 2437 detected signal candidates with a S/B ratio of about 6 (Fig. 10), the branching ratio of the decay is determined with high precision. In the region of squared dilepton mass above 0.03 GeV^2/c^4, the branching ratio is found to be BR($K^{00}_{\mu 4}$, $S_l > 0.03$) = $(0.65 \pm 0.03) \cdot 10^{-6}$. The full phase space result BR($K^{00}_{\mu 4}$) = $(3.4 \pm 0.2) \cdot 10^{-6}$, depending on the decay model extrapolation, is in a reasonable agreement with the *R* form factor prediction from one-loop Chiral Perturbation Theory.

The Dubna group took part in the SPS test beam runs. Mass production of straws with a length of 2.5 m, a diameter of 5 mm and a wall thickness of 20 mm has begun. Prototype electronics for the new NA62 straw chamber was tested both with the beam and in the laboratory. A new gas gain monitor with a new interface was designed. A new device was developed to measure the tension of the anode wire. In 2023, employees prepared and published nine scientific papers and presented five reports at conferences.

The JINR group taking part in the **NA64** experiment at the CERN SPS is responsible for the coordinate detectors based on thin-walled straw tubes and participates in the development of the software system for their online monitoring and DAQ, simulation, reconstruction and analysis of data aimed at searching for the dark photon, other dark matter manifestations, and physics beyond the Standard Model. The Collaboration permanently works on the experimental facility upgrade. The analysis of all data obtained on the search for the sub-GeV χ production through the interaction mediated by the dark photon *A′* in collisions of 100-GeV electrons with the active target was completed. With $9.37 \cdot 10^{11}$ electrons on target collected during 2016–2022 runs, NA64 probes for the first time the well-motivated region of the parameter space of benchmark scalar and fermionic thermal dark matter models. No evidence for dark matter production has been found. This allowed setting the most sensitive limits on the *A′* couplings to photons for masses $m_{A'} \lesssim 0.35$ GeV, and excluding scalar and Majorana light dark matter with the χ–*A′* coupling $\alpha_D \leqslant 0.1$ for masses $0.001 \lesssim m_\chi \lesssim 0.1$ GeV and as long as $3m_\chi \leqslant m_{A'}$ [43].

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DZHELEPOV LABORATORY of NUCLEAR PROBLEMS

NEUTRINO PHYSICS AND RARE PHENOMENA, ASTROPHYSICS

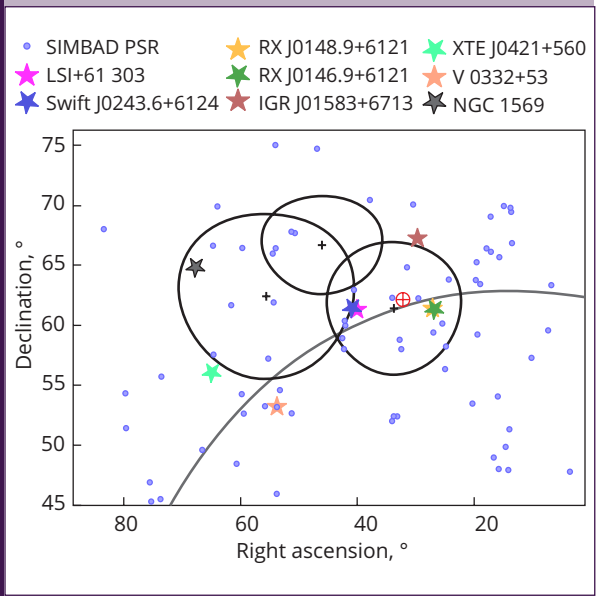
With the commissioning of two new clusters in April 2023, the working volume of the **Baikal-GVD** deep-water neutrino telescope exceeded the value of ≈ 0.5 km^3 for detecting events from high-energy neutrinos (over 100 TeV). The detector contains 12 clusters of deep-sea strings of recording and control equipment (3456 optical modules) and holds the position of the largest neutrino telescope in the Northern Hemisphere.

When analyzing the data obtained during the detector's operation in the 2018–2022 configurations, correlations with radio-bright blazars of cascading events with energies exceeding 100 TeV were investigated. Although no statistically significant effects were found on the current dataset, the analysis points to a number of possible associations with both extragalactic and galactic sources (Fig. 1). In particular, the analysis of the observed triplet of neutrino candidates in the galactic plane is presented. Its potential connection with certain galactic sources has been investigated, and the coincidence of the directions of arrival of cascading events with several bright blazars has been considered [1].

Assembly of the largest liquid scintillator reactor antineutrino detector **JUNO** continues in China. To date, more than half of the planned 18 000 photomultiplier tubes (PMTs) with a diameter of 20 in. and 25 000 PMTs with a diameter of 3 in. have been installed. All these photomultipliers are provided with high-voltage power supply using specialized modules developed and manufactured by JINR, including their testing and commissioning. The completion of the assembly and the start of filling the detector with liquid scintillator are scheduled for spring 2024.

Baikal, March. Working moments of the expedition for the construction of the Baikal-GVD deep-water neutrino telescope

Fig. 1. Three Baikal-GVD high-energy cascading events, GVD190216CA, GVD190604CA and GVD-210716CA, near the galactic plane (gray line) and errors in determining their directions (black lines). The point of statistically most significant excess of the IceCube flux over the isotropic one in the Northern Hemisphere is shown as a red plus



In parallel, preparation for the assembly and installation of the Top Tracker (TT) is underway [2]. The manufacturing plant has started to fulfill the order for the production of supporting structures developed by JINR. The detector data acquisition software, also developed by JINR, is currently being debugged on a TT prototype at IPHC (Strasbourg, France).

The main result of measuring neutrino oscillation parameters in the **Daya Bay** experiment on the basis of the complete dataset has been published. The parameters $\sin^2 2\theta_{13} = 0.0851 \pm 0.0024$ and $\Delta m^2_{32} = (2.466 \pm 0.060) \cdot 10^{-3}$ eV^2 obtained after 3158 d of data taking have the world's best precision [3]. This result was achieved with an active participation of the JINR group. The precision of $\sin^2 2\theta_{13}$ (2.8%) will dominate for at least a few decades, since up to now there are no confirmed experiments that are able to improve the result.

Within the **NOvA** project, the DLNP staff have prepared reviews on the current status of determining the neutrino oscillation parameters within the framework of a model with three types of neutrinos [4, 5]. The individual and joint sensitivities of the NOvA/T2K/DUNE accelerator experiments to determination of the neutrino oscillation parameters were also assessed [6].

For the **DUNE** experiment, the possibility of applying the DUNE-PRISM method to the largest background (muon neutrino background) in the mode of disappearance of muon antineutrinos in the far detector was investigated. DLNP developed a prototype of a full-size light-reading module for the liquid argon HPC of the DUNE near detector. The module was tested at a testbed at the University of Bern.

In the **Borexino** experiment, a group from DLNP carried out work on joint analysis of data from three phases of the experiment. The analytical model for new energy variables was revised and included in

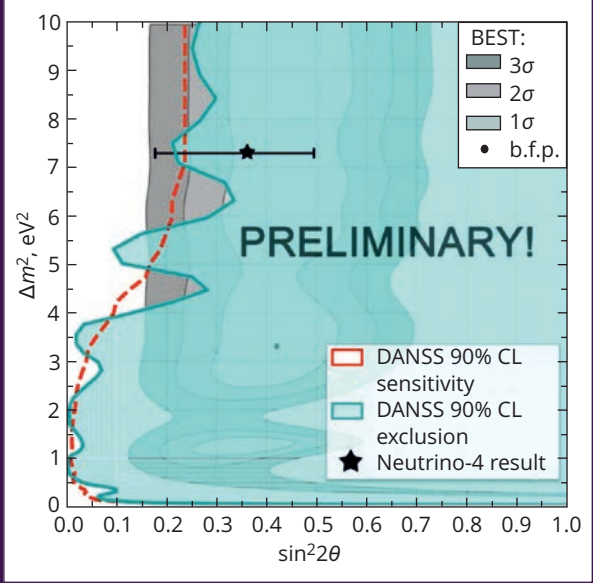
3 October. A delegation of the NAS of the Republic of Kazakhstan (NAS RK), headed by the President of the Board of NAS RK K. Zakarya, on an excursion at the Dzhelepov Laboratory of Nuclear Problems

the standard code. A phenomenological model was proposed to describe the contribution of the intrinsic resolution to the total energy resolution in the scintillation detectors [7]. The analysis of data collected on the **DarkSide-50** detector is close to completion. The results of the search for light dark-matter particles have been published in a series of papers. The search for the two-neutrino double electron capture process on ^{36}Ar using the DarkSide-50 data continues.

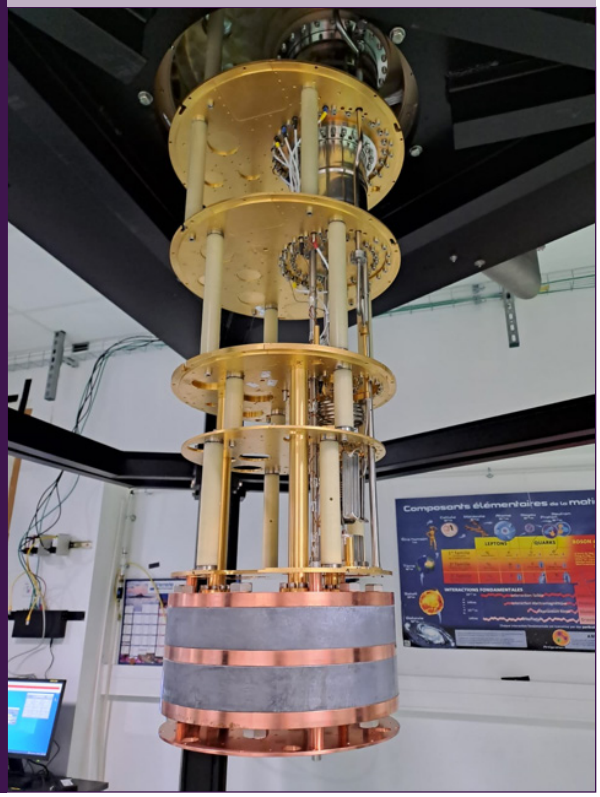
The ***ν*GeN** experiment is aimed at studying the fundamental properties of neutrinos using the Kalinin Nuclear Power Plant reactor core, which allows working with a giant antineutrino flux of $(3.6–4.4)\cdot 10^{13}$ $cm^{-2}\cdot s^{-1}$. Currently, more than 1200 kg · d of data have been collected. A comparison of the data collected while the reactor was on and off (154 and 39 d, respectively) has not yet revealed signs of the expected signal from coherent neutrino scattering. This made it possible to impose a limit on an important parameter of ionization losses in germanium (quenching) at the level of $k < 0.23$ (90% CL) [8].

A new analysis of the data of the **DANSS** experiment for the period from 2016 to 2023 has included the absolute antineutrino count rate information (ratio 0.98 ± 0.04 to the predicted values using the Huber and Müller model and a conservative estimation of the systematic uncertainty at 7%) [9]. For large ($\gtrsim 10$ eV^2) values of the parameter Δm^2_{41}, the values of $\sin^2 2\theta_{ee} > 0.26$ are excluded at the 90% confidence level. Also, the use of absolute values of the neutrino flux allowed us to exclude the best point $\Delta m^2_{41} = 7.3$ eV^2, $\sin^2 2\theta_{ee} = 0.36$, obtained in the Neutrino-4 experiment, and almost the entire region of the acceptable parameters of the BEST experiment (Fig. 2).

Fig. 2. Exclusion area at 90% CL in parameter space for sterile neutrino calculated with the raster scan method (blue area) and the sensitivity area (red dotted line)



^{3}He–^{4}He Ricochet dilution cryostat during the final commissioning phase at IP2I (Lyon) before its delivery to the ILL site



Additionally, a methodological study of the aging of the plastic scintillators used in the experiment was carried out (decrease in the light yield is (0.55 ± 0.05)% per year) [10]. Also, the study of the influence of the atmospheric parameters on the cosmic muon flux was continued [11].

The **Ricochet** project, started more than twenty years ago as the EDELWEISS project for the direct search for dark matter with HPGe bolometer detectors, is now searching for new physics in three directions: direct search for dark matter [12], precision studies of CE*ν*NS (Ricochet) [13, 14], and investigation of double beta decay of ^{100}Mo using Li_2MoO_4 scintillation crystals (CUPID-Mo) [15].

In 2023, intensive preparation of the Ricochet phase in the ILL (Grenoble, France) was continued. In November 2023, installation of the Ricochet setup at the ILL research reactor site was started. JINR participates in mounting of the cryogenic low-background setup (^{3}He–^{4}He dilution cryostat), selection of low-background materials, background measurements, and construction of the active veto system. It is planned that results of the first measurements with Ricochet will be obtained in 2024.

In 2023, the LEGEND Collaboration was taking data with 101 germanium detectors (~ 140 kg of ^{76}Ge) within the LEGEND-200 experiment at the Gran Sasso National Laboratory (Italy). This setup

12 April. The ceremonial meeting dedicated
to the 110th anniversary of the birth of V. P. Dzhelepov

22 August. Opening of an exhibition dedicated to the 110th anniversary
of the birth of an outstanding Italian and Soviet physicist B. Pontecorvo

30 October – 3 November. XXVII International Scientific Conference of Young Scientists
and Specialists (AYSS-2023), devoted to the 110th anniversary of the birth of B. Pontecorvo

was assembled and commissioned in 2022 with a strong participation of JINR specialists. The first estimates of the background based on 10.1 kg · yr of LEGEND-200 data were presented at the TAUP conference. The achieved background index of $4.1 \cdot 10^{-4}$ counts/(keV · kg · yr) is compatible with the LEGEND-200 background goal.

The aim of the **MONUMENT** project is experimental measurements of muon capture on several daughter candidates for neutrinoless 2β decay. In October 2023, ordinary muon capture measurements with the enriched ^{48}Ti target were carried out at the meson factory at PSI. The measurement of this isotope is not directly related to 2β-decay daughter nuclei, but is intended to help theoretical groups (ab-initio and nuclear shell models) to understand the problem of possible suppression of the axial form factor G_A. In 2024, muon capture measurements with light ^{12}C and ^{13}C nuclei are planned.

The **SuperNEMO Demonstrator** with 6.5 kg of enriched ^{82}Se is aimed to achieve sensitivity $T_{1/2}$ $(0\nu\beta\beta) > 6.5 \cdot 10^{24}$ yr within 2.5 years of measurement. The Demonstrator continuously runs with 99% of live channels and takes background and calibration data. A preliminary measurement of the radon level in the tracker based on identification of the characteristic BiPo β–α decay chain of ^{214}Bi and its daughter ^{214}Po has successfully reproduced the ^{214}Po half-life, and indicates an activity of (6 ± 2) mBq/m^3. To further reduce background, an antiradon tent has been installed around the detector, which will be filled with radon-reduced air.

ELEMENTARY PARTICLE PHYSICS

Within the **ATLAS** project, a search for quantum black holes (QBH) in the lepton + jet invariant mass spectrum was performed with 140 fb^{-1} of the data collected from $\sqrt{s}$ = 13 TeV pp collisions at the LHC. The observed invariant mass spectrum of lepton + jet pairs is consistent with the Standard Model expectations. Upper limits are set at 95% confidence level on the production cross-sections times branching fractions for the QBH decaying into a lepton and a quark in a search region with the invariant mass above 2.0 TeV. The resulting lower QBH mass threshold limit is 9.2 TeV in the ADD model and 6.8 TeV in the RS model (Fig. 3) [16].

Also, JINR participated in the search for high-mass charged and neutral bosons decaying to $W\gamma$ and $Z\gamma$ final states. The analysis uses a data sample of $\sqrt{s}$ = 13 TeV pp collisions at the LHC. The sensitivity of the search was determined using models of the production and decay of spin-1 charged bosons and

Fig. 3. The 95% CL model-independent upper limits on $\sigma \times$ Br for the non-SM signal production with decay into the lepton + jet (combined channel)

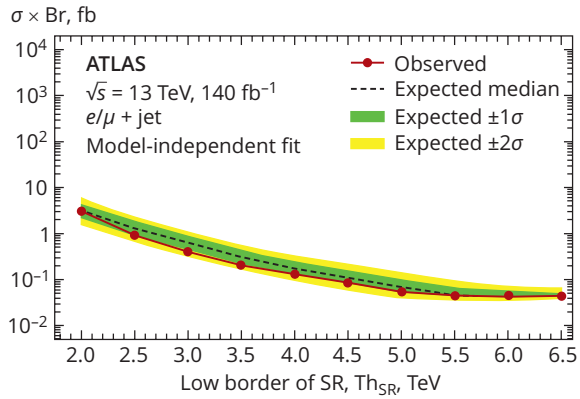
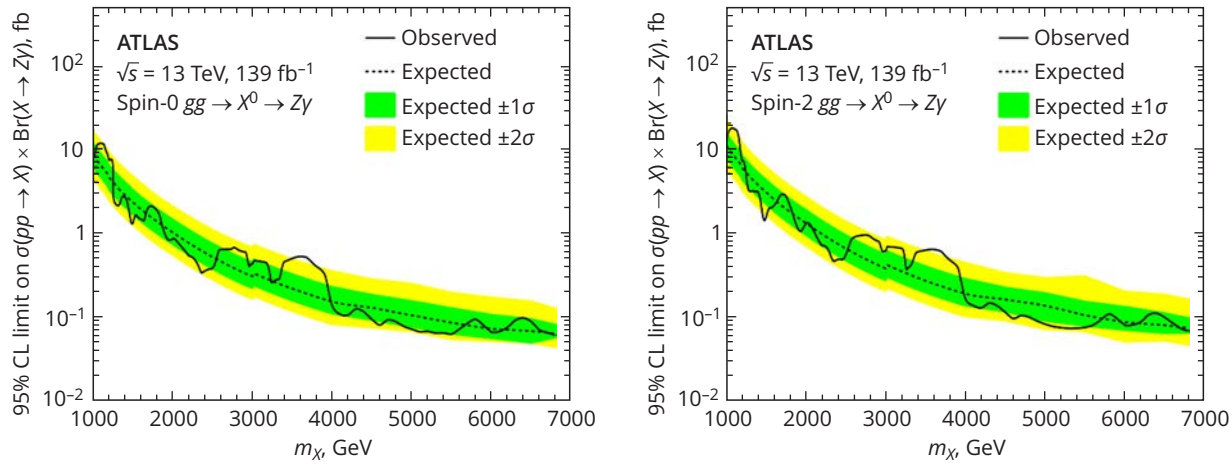


Fig. 4. The 95% CL upper limits on $\sigma(pp \to X) \times \mathrm{Br}(X \to W/Z\gamma)$ as a function of m_X for spin-0 $gg \to X^0 \to Z\gamma$ (left), spin-2 $gg \to X^0 \to Z\gamma$ (right)



Bolshie Koty (Irkutsk Region), 11–18 July.
Participants of the XXIII Baikal Summer School on Physics of Elementary Particles and Astrophysics

spin-0/2 neutral bosons. The range of resonance masses explored extends from 1.0 to 6.8 TeV. No evidence of a signal above the Standard Model backgrounds is observed, and upper limits on the production cross sections of these bosons times their branching fractions to *Wy* and *Zy* are derived for various boson production models (Fig. 4) [17].

Within the **BESIII** project on the basis of the e^+e^- annihilation data with an integrated luminosity of 5.85 fb^{-1} collected at the center-of-mass energies from 4.61 to 4.95 GeV, the production cross sections of $e^+e^- \to K^+K^-J/\psi$ have been measured with an unprecedented precision. A new resonance structure Y(4710) has been observed for the first time in the cross section line shape around 4.7 GeV with a statistical significance larger than 5 standard deviations [18]. The mass and width of the resonance were measured to be $(4708^{+17}_{-15} \pm 21)$ MeV/c^2 and $(126^{+27}_{-23} \pm 30)$ MeV, respectively. The search for exotic tetraquark states, dubbed Z_{cs}, was also conducted in this process. While no significant structure was observed, a small excess with a statistical significance of 2.3 standard deviations is seen around 4.05 GeV in the $K^\pm J/\psi$ mass distribution.

The CRV system is one of the most important parts of the **COMET** experiment, and the purpose of its use is to detect cosmic muons with an efficiency of at least 99.99%. The DLNP staff have designed and manufactured the first scintillation strip subsystem module for the COMET CRV system, the so-called SCRV-LS-0. At the State Technical University (Tbilisi), it is planned to study the change in light collection over time and the long-term stability of the strips obtained from JINR (Dubna).

For a prototype calorimeter made on long LYSO:Ce crystals, inhomogeneity of the detector response was measured along the length of the crystals and at the angles of incidence of cosmic muons of 9° and 19° relative to the end plane of the crystals. An estimate of the energy resolution of the calorimeter was obtained as a function of the inhomogeneity of the scintillator response along the length and angle, which was 4% for straight tracks and 6% for tracks at an angle of 19° [19]. Strow tubes were also manufactured in the required quantity to create a prototype of a Phase II straw tracker with 64 channels.

Within the **TAIGA** project, the signal from the Crab Nebula was examined. Three methods were used and mutually verified: Single (TAIGA-mono), Stereo (TAIGA-stereo) and Hybrid (TAIGA-hybrid) developed by the TAIGA collaboration. The last method is supposed to use data simultaneously detecting an event with a gamma-ray energy of more than 80 TeV by one telescope and several wide-angle detectors. The results are in good agreement with the data from other gamma observatories and make it possible to use the hybrid method in future studies of gamma rays with energy above 100 TeV using Cherenkov radiation [20]. Observations and data collection from various gamma radiation sources continue.

At DLNP, a ^{44m}Sc/^{44g}Sc radionuclide generator for production of the medical daughter radionuclide ^{44g}Sc used in positron tomography has been developed. The resulting yield of ^{44g}Sc (80%) from the fraction of conversion during the isomeric transition reveals the general dependence of autoradiolysis processes on Z [21].

The characteristics of SiC detectors irradiated with various fluxes of ^{132}Xe ions and fast neutrons have been studied. It was shown that the energy resolution of the detectors decreases by an order of magnitude after irradiation with fluxes of Xe ions (10^9 cm^{-2}) and neutrons (10^{14} cm^{-2}) [22].

By using electron spectroscopy methods, the energy of the low-energy nuclear transition $M_1 + E_2$ 9406.3(5) eV in ^{83}Kr was determined with high precision. Shifts in the binding energies of electrons in the K, L and $M_{1,2,3}$ subshells of Kr determined by the state of krypton atoms relative to the free states were established [23].

Within the project "Precision Laser Metrology for Accelerators and Detector Complexes", several Compact-sized Precision Laser Inclinometers (**CPLI**) were manufactured for work in geophysical centres in Russia and abroad. A study of an evacuated prototype of the PLI is currently underway. In October 2023, a CPLI was installed at the Geophysical Monitoring Centre of the National Academy of Sciences of Belarus "Naroch". Monitoring of microseismic activity and comparison of PLI readings with a standard seismometer began. CPLI has significant potential in terms of accuracy and the low-frequency measurement range [24, 25].

At **LINAC-200**, an extensive user programme is being created to be used for: beam tests and calibration of detectors for the MPD and SPD experiments (EM calorimeters, straw detectors, vertex detectors), elements of the NICA collider beam diagnostic system and detectors for other experiments; development of an accelerator source of terahertz radiation with a tunable spectrum for radiobiological research (LRB); irradiation of biomaterials and detectors for space experiments (DLNP, IBMP); study of photonuclear reactions (FLNR, DLNP, BLTP, MSU, University of Novi Sad (Serbia)); and radiation materials science (Sarov, Tomsk University). The accelerator hall contains the 5th and 6th stations with energies up to 400 MeV.

Within the **PAS** project, the positron transportation channel was upgraded to a specialized experimental station, and processes such as source temperature measurement, control of longitudinal magnetic field power supplies, and switching pumps on/off were automated. More than 130 samples

24 October. DLNP general laboratory seminar on the topic "Genomic Research at JINR Facilities"

from Russian scientific institutes, such as TPU and SAFU, and from JINR Member States, namely from Vietnam, Azerbaijan, and Cuba, were studied by using the Doppler broadening of the annihilation line (DUAL) on the beam. For the first time, measurements of powdered samples were carried out at the facility. More than 70 samples were studied using the method of measuring the lifetime of positrons in matter (PALS) at an autonomous source [26, 27].

In the **DLNP Sector of Molecular Genetics of the Cell**, an increase in resistance of model organisms to ionizing radiation due to the tardigrade protein Dsup (Damage Suppressor) has been demonstrated [28].

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FLEROV LABORATORY of NUCLEAR REACTIONS

FLNR ACCELERATOR COMPLEX

The operation and development of the FLNR accelerator complex in 2023 can be summarized in the following way.

DC-280

In 2023, the DC-280 cyclotron provided over 6000 h of beamtime for research, including 4500 h for experiments aimed at the synthesis of superheavy elements and study of their chemical properties at the DGFRS-2 and GRAND setups. For the first time, long-term experiments were conducted with 2.5-pμA ^{54}Cr beams [1].

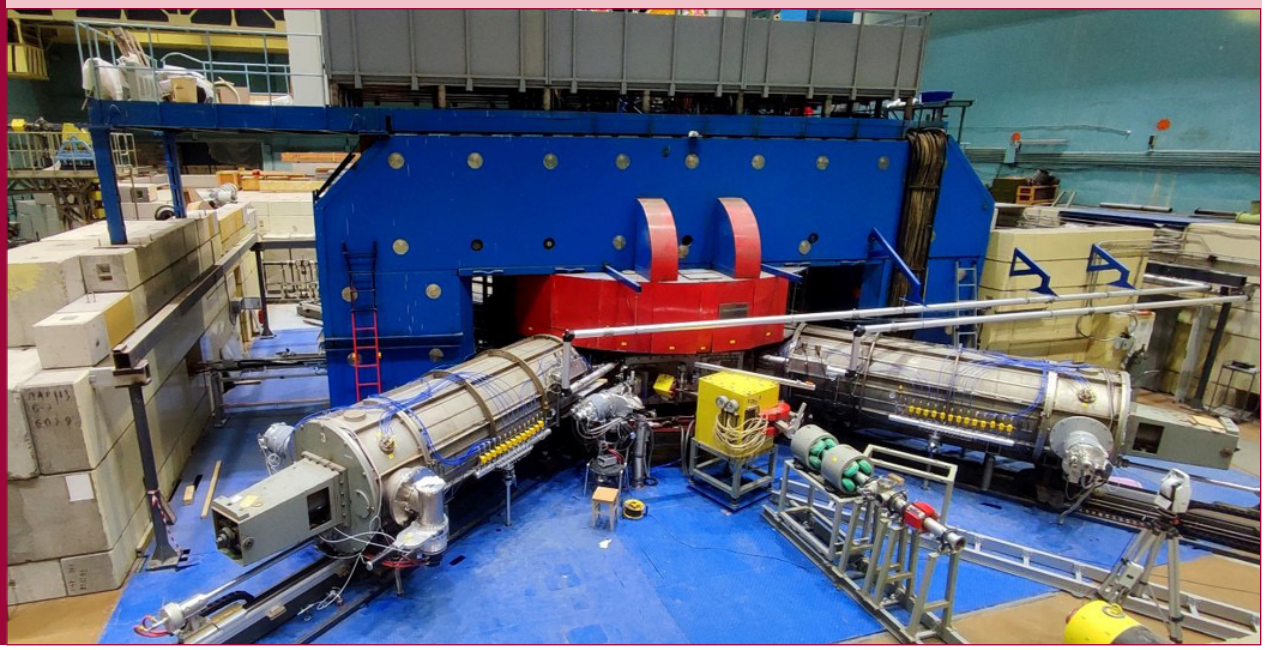
A novel technique was tested for producing ion beams of refractory elements provided by the ECR ion source in SF_6 plasma. As a result, a 3.2-pμA beam of ^{48}Ti ions was produced. The design of the flat-top system resonators was optimized to improve the quality and increase the intensity of ion beams delivered by the DC-280 cyclotron.

U-400M

As part of the U-400M cyclotron upgrade, assembly of the acceleration system with new resonator drives and the RF power supply system was completed. The vacuum, water cooling, radiation safety and access control systems, axial injection system, beam-channel system, as well as control system were mounted. The internal cyclotron equipment was installed: components of the beam extraction system and the beam current-measuring system. Commissioning work is ongoing.

27 March. A visit to JINR by Director General of the Rosatom State Corporation A. Likhachev. Excursion to the SHE Factory

U-400M accelerator



Installation of DC-140

U-400

A wide variety of scientific and applied investigations in heavy-ion physics were conducted using the U-400 cyclotron. In 2023, the facility provided over 6400 h of beamtime. Experiments were carried out with the beams of ^{7}Li (MAVR), ^{24,26}Mg (CORSET, SHELS), ^{40}Ar (MAVR, VASSILISSA), ^{40,48}Ca (MAVR, SHELS), and ^{52,54}Cr (VASSILISSA, CORSET). Applied studies with Ne, Ar, Kr, Xe and Bi beams were performed.

IC-100

The IC-100 accelerator complex used for the implementation of the FLNR applied research programme provided over 2900 h of beamtime in 2023. Ions from oxygen to xenon accelerated up to 1.0–1.2 MeV/nucleon were used to irradiate graphene samples, AlN, Si_3N_4, MgO, $MgAl_2O_4$, ODS steels, and HTSC alloys of Ti (in collaboration with the South Africa, Serbia, Belarus, and Kazakhstan).

In November 2023, the operation of the IC-100 accelerator complex was stopped, and the facility was dismantled. A new DC-140 accelerator complex for applied research is under construction and will eventually replace IC-100.

DC-140

Experimental areas are reconstructed to accommodate the DC-140 equipment and technical infrastructure. The main magnet and the vacuum chamber of the DC-140 cyclotron were mounted. The ceiling, wall and partition assemblies of the cyclotron hall were built. The accelerator and experimental setup control rooms were prepared. The cyclotron and experimental channel equipment was delivered by the manufacturers and is ready for installation [2, 3].

MT-25

The electron accelerator, MT-25 microton, ran for 800 h. The facility was employed to irradiate biological samples — research conducted for LRB JINR. The electronic components were tested in cooperation with NIIKP and SPE Detector LLC. In collaboration with scientists from Vietnam, the properties of zeolites were examined. In a joint effort with DLNP JINR and Tomsk State University, techniques for measuring electron energies and electron beam parameters were worked out.

SYNTHESIS AND PROPERTIES OF NUCLEI AT STABILITY LIMITS

Experiments at the Dubna Gas-Filled Recoil Separator (DGFRS-2)

In 2023, experiments aimed at synthesizing Ds isotopes in the ^{232}Th + ^{48}Ca reaction were pursued at DGFRS-2 of the SHE Factory located at FLNR JINR. The properties of nuclei in the decay chains of ^{275,276}Ds are of great importance for identifying new element 120 in the ^{245}Cm(^{54}Cr, 3–4n)^{295,296}120 reaction. One more decay chain of ^{276}Ds discovered in 2022 was detected at two maximum ^{48}Ca projectile energies (Fig. 1), and six decay chains of the new isotope ^{275}Ds were synthesized. ^{275}Ds was for the first time produced in the reaction of ^{48}Ca with the nuclei of the actinide element and identified through sequential α decays leading to the known nuclei ^{271}Hs, ^{267}Sg, and ^{263}Rf previously synthesized in the ^{248}Cm(^{26}Mg, 3n)^{271}Hs reaction.

For the first time since 1983, when first experiments were performed on the synthesis of Ds isotopes in direct reactions of ^{40}Ar, ^{48}Ca and the isotopes of actinide elements (^{232}Th, ^{235,236,238}U), the reaction cross section was measured and turned out to be an order of magnitude lower than that for the ^{226}Ra(^{48}Ca, 4n)^{270}Hs reaction. When moving to heavier elements (Z > 110), the cross section increases (Fig. 2), reaching a maximum for elements 114–115, and subsequently decreases by approximately a factor of 30 for element 118. The result is in line with theoretical models predicting the filling of nucleon shells at Z = 108, N = 162 and Z = 114, N = 184.

Two decay chains of ^{273}Ds with a cross section of 0.2 pb (see Fig. 1) were registered in the ^{238}U + ^{40}Ar reaction. The properties of nuclei synthesized in both reactions point to the existence of isomeric states in ^{267}Sg, ^{271}Hs, ^{273}Ds and their daughter nuclei.

A new isotope ^{288}Lv was synthesized for the first time in the reaction of ^{54}Cr with actinide target nuclei. Amounting to 70 fb, the cross section for the ^{238}U + ^{54}Cr reaction will enable precise measure-

Fig. 1. Cross sections for the ^{232}Th + ^{48}Ca reaction (closed symbols) and the ^{238}U + ^{40}Ar reaction (open symbols)

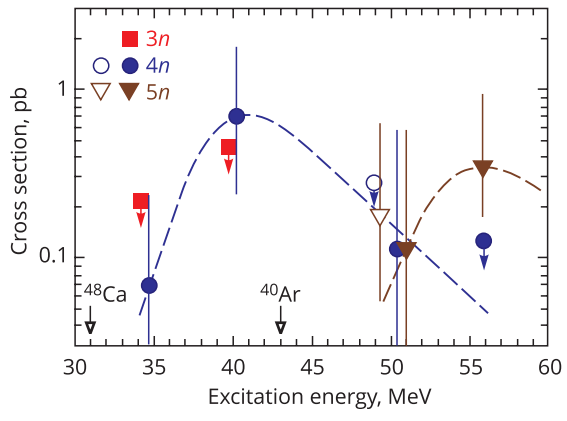
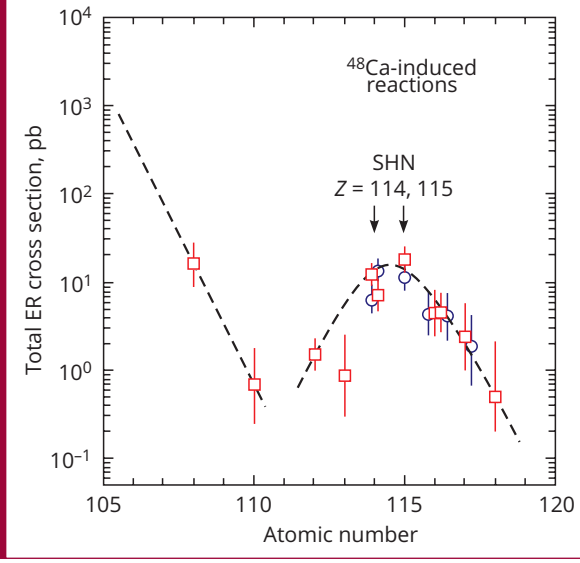
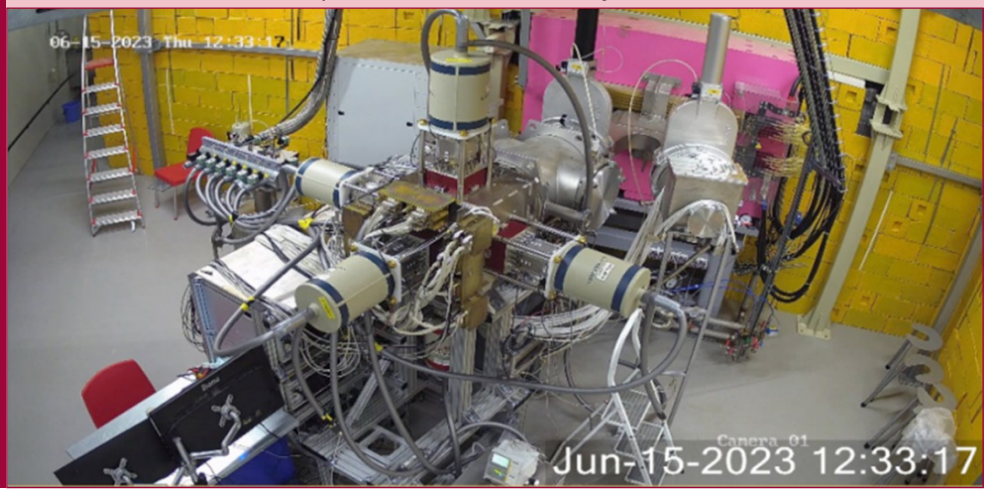


Fig. 2. A maximum of the cross section for the reactions between ^{48}Ca ion beams and targets made of ^{226}Ra–^{249}Cf nuclei. The results obtained at FLNR are indicated by red squares



The combined detection system GABRIELA-III in the focal plane of the GRAND (DGFRS-3) separator at the SHE Factory



ments of reaction cross sections leading to the production of new elements 119 and 120 in reactions of ^{54}Cr with the target nuclei of ^{243}Am and ^{245,246,248}Cm, respectively.

The results are presented in [4, 5].

Spectroscopy of Heavy and Superheavy Nuclei

The SHELS separator and the SFiNX detector system [6] were used for running experiments aimed at studying the properties of spontaneous fission of nuclei in the transfermium region. New data were obtained on the spontaneous fission of the short-lived nuclei ^{244}Fm, ^{260}Rf, and ^{260}Sg. Prompt neutron yields were measured for the first time from the spontaneous fission of ^{260}Rf and ^{260}Sg.

The gas-filled separator GRAND (DGFRS-3) of the SHE Factory was equipped with an upgraded detection system GABRIELA-III for registering gamma quanta. The system comprises a large focal multistrip detector (100 × 100 mm) combined with five clover high-purity germanium (HPGe) gamma detectors and is among the world leaders in providing efficiency for the detection of gamma quanta.

The GRAND separator was used to study the complete fusion reactions ^{26}Mg + ^{204,206,208}Pb leading to the production of short-lived neutron-deficient isotopes of plutonium ($^{226-231}$Pu). The reaction cross sections were measured, the data on the radioactive decay of $^{228-231}$Pu were updated, and the events that can be assigned to the radioactive decay of the previously unknown isotopes ^{226,227}Pu were detected.

Another GRAND experiment was aimed at studying the isomeric states of a short-lived neutron-deficient nucleus ^{250}No in the complete fusion reaction ^{48}Ca + ^{204}Pb. The excitation function reached a maximum corresponding to the emission of four neutrons [7]. A new isotope ^{248}No can be produced in this reaction channel. The experimental data are processed.

Chemistry of Transactinides

An experimental complex, combining the gas-filled GRAND separator and the Cryodetector chemical setup, was constructed at the SHE Factory for studying the chemical properties of superheavy elements. The analysis of the results of the first chemistry experiment carried out at the SHE Factory at the end of 2022 revealed a 3–4 orders of magnitude better purity of the ions of the superheavy element flerovium (Fl) from unwanted byproducts. This significantly improved the statistical validity of spectrometric data, setting a new standard for SHE chemistry studies. It was also found that after being pre-separated, the separation efficiency of recoil nuclei in the chemical setup decreases significantly owing to an increased gas volume in the recoil transfer chamber. Thus, research in 2023 focused primarily on studying the stopping range of ^{254}No recoil nuclei produced in the ^{208}Pb(^{48}Ca, *xn*)$^{256-x}$No reaction in a mixture of inert gases at the GRAND separator. Besides the studies of gas dynamic flows in both the recoil transfer chamber and the thermochromatography detector, novel modules of the chemical setup were modeled and are currently designed. *Online* experiments behind the separator will be pursued in 2024 and promise to confirm an increase in the separation efficiency of short-lived mercury radioisotopes governing the behaviour of Fl, while retaining the advantages of experiments behind physics separators.

A theoretical approach was developed on the basis of microscopy and with due regard for atom–surface interaction potentials for modeling the gas-phase adsorption of heavy and superheavy atoms [8]. The model incorporates the quantum mechanical approach to calculating *atom–atom* and *atom–surface* interaction potentials, the molecular dynamics method for estimating gas kinetics parameters, and the Monte Carlo method for modeling the chromatographic distribution of atoms along the detector strips.

Dubna, 3 March. Laying flowers at the monument to G. Flerov, the founder and first Director of FLNR, in honor of the 110th anniversary of his birth

The analysis of data obtained during seven years of research at the U-400 accelerator complex was finalized. The series of *online* experiments with the recoils of light homologues were aimed at examining the conditions for the formation of volatile compounds of the superheavy elements nihonium (Nh) and tennessine (Ts) [9, 10]. After pre-separation of nuclei of the short-lived thallium and astatine radioisotopes in the complete fusion reactions ^{141}Pr(^{48}Ti, *xn*)$^{189-x}$Tl at the kinematic SHELS separator, the chemical species of both astatine and thallium, having differences in their adsorption behaviour and volatility, were found on quartz and gold surfaces by isothermal chromatography and thermochromatography. Nowadays, the results of these investigations are of critical importance in planning research on the chemical properties of Nh in collaboration with the Institute of Modern Physics (Chinese Academy of Sciences) in Lanzhou (China). The studies under consideration will be an extension of the FLNR pioneering research on the chemical identification of ^{284}Nh in the ^{288}Mc decay chain. First joint experiments were carried out in Lanzhou. The collaborative work will be pursued in 2024 using a new setup at the upgraded HIRFL accelerator complex.

Dynamics of Heavy-Ion Interaction, Fission of Heavy and Superheavy Nuclei

In 2023, the analysis of mass, energy and angular distributions of fragments formed in the ^{90}Zr + ^{90}Zr reaction was completed [11]. The probability of the formation of a compound nucleus at energies near the Coulomb barrier was found to be a mere ~ 20%. Our previous investigations of the ^{36}Ar + ^{144}Sm and ^{68}Zn + ^{112}Sn reactions [12], leading to the formation of the very same ^{180}Hg composite system at similar excitation energies and introduced angular momenta, showed that fusion probability was about 100% and 30%, respectively. To thoroughly study the factors affecting the competition between the formation of a compound nucleus and quasifission, mass and energy distributions of fragments formed in the ^{124}Xe + ^{nat}Fe (92% ^{56}Fe) reaction, also leading to ^{180}Hg, were measured. A comprehensive analysis of the entire experimental data will reveal the dependence of quasifission yield upon interaction energy, introduced angular momentum, entrance channel mass asymmetry, and a charge product of interacting nuclei.

The studies continued on the properties of the multimodal fission of actinide nuclei. The analysis of the mass and energy distributions of the fission fragments of ^{238}Np produced in the ^{6}Li + ^{232}Th reaction was conducted [13]. Furthermore, the mass and energy distributions of fission fragments were measured for ^{224}Th synthesized in the ^{16}O + ^{208}Pb reaction in a wide energy range of the compound nucleus. These high-precision measurements were carried out with beams extracted from the U-400 accelerator using the double-arm time-of-flight CORSET spectrometer. They enable studies of the effect of the introduced angular momentum and the excitation energy of the compound nucleus on the fission mode yields as well as allow the measurement of the dependence of fragment mass distribution variance upon angular momentum and excitation energy.

A prediction suggesting possible synthesis of new isotopes of heavy and superheavy nuclei in multinucleon transfer (MNT) reactions has spurred interest in this process over the last few years. With the aim

The Bogoliubov Laboratory of Theoretical Physics, 21 April.
A grand seminar dedicated to the 90th anniversary of the birth of Academician Yu. Oganessian

Dubna, 25 January. A meeting of FLNR Scientific Leader Academician Yu. Oganessian
with students of the Kadyshevsky Physics and Mathematics Lyceum
in the frames of the school project "One Hundred Questions to a Leader"

of studying the properties of MNT fragments, such as their production cross sections, excitation energies, and survival probabilities, the products of the $^{136}Xe + ^{238}U$ and $^{209}Bi + ^{238}U$ reactions were measured with the 1.11-GeV ^{136}Xe and 1.85-GeV ^{209}Bi ion beams using the CORSET setup at the U-400 cyclotron. The primary and secondary mass and energy distributions of projectile-like fragments (PLF) were measured in coincidence with either survived target-like fragments (TLF) or with both fragments of

Dubna, 4 May. Vice-President of the Cuban Academy of Sciences C. de Jesús Rodríguez-Castellanos on an excursion at FLNR

sequential fission of excited TLF. This allowed us to restore the primary mass distribution of fissioning MNT fragments. The heaviest fragments formed in the $^{136}Xe + ^{238}U$ reaction and observed in the mass distribution of fissioning MNT fragments have masses around 263 a.u. (Lr isotopes) and cross sections of a few hundred microbarns. The experimental data regarding the $^{209}Bi + ^{238}U$ reaction are processed. Such experiments aimed at the simultaneous measurement of mass and energy distributions of PLF in coincidence with either survived TLF or both fragments of sequential fission of excited TLF have never been carried out before. This technique paves the way for a detailed experimental study of the properties of MNT fragments.

Multinucleon transfer reactions were also studied at the GRAND separator of the SHE Factory. Reaction products formed in the interaction of ^{48}Ca and ^{136}Xe with ^{238}U and ^{198}Pt were registered at forward angles. The experimental data are processed.

Structure of Exotic Nuclei

The data obtained in previous experiments performed at the ACCULINNA-2 separator of the U-400M accelerator complex were further analyzed. As part of the programme aimed at studying the neutron-rich $^{6,7}H$ nuclei produced in the $^{2}H(^{8}He, ^{4}He)^{6}H$ and $^{2}H(^{8}He, ^{3}He)^{7}H$ reactions at the ^{8}He beam energy of 26 MeV/nucleon, the data on the reference reactions $^{2}H(^{10}Be, ^{4}He)^{8}Li$ and $^{2}H(^{10}Be, ^{3}He)^{9}Li$ were processed using the ^{10}Be radioactive beam (44 MeV/nucleon) and the same setup [14, 15]. The following important methodological results were obtained:

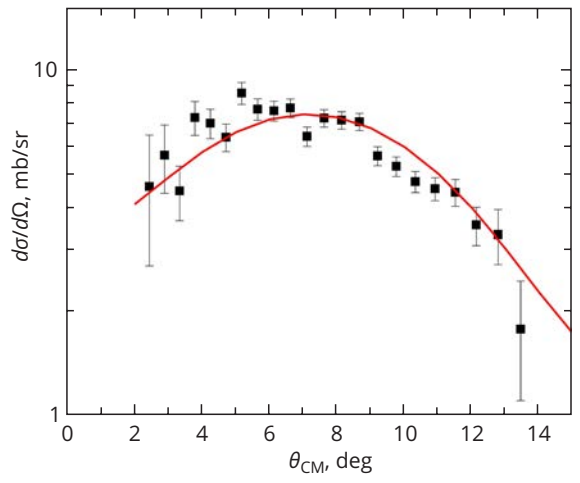
1) using the level scheme of the ^{9}Li nucleus known from the literature, absolute energy calibration was attained in the missing mass spectrum, which is key to analyzing the $^{6,7}H$ spectra;

2) experimental excitation energy resolution of the setup was defined as a function of thickness of the deuteron gas target; experimental values were compared with Monte Carlo simulations;

3) experimental data on the ^{9}Li ground state populated in the $^{2}H(^{10}Be, ^{3}He)^{9}Li$ reaction provided information on the detection efficiency of the setup.

The analysis of the differential cross sections $d\sigma/d\Omega_{CM}$ (Fig. 3) with the FRESCO code allowed for a spectroscopic factor of ≈ 1.7 for the $^{10}Be(g.s.) = p + ^{9}Li(g.s.)$ clustering, which was consis-

Fig. 3. The differential cross section for the ground state of ^{9}Li populated in the $^{2}H(^{10}Be, ^{3}He)^{9}Li$ reaction (points) and one-step FRESCO code calculation (red curve)



tent with theoretical calculations assuming one-step process. The energy spectrum of ^{8}Li populated in the ^{2}H(^{10}Be, ^{4}He)^{8}Li reaction showed the population of the second excited state (2.255 MeV, 3+). The absence of the ground and first excited states of ^{8}Li is consistent with the Shell Model predictions used for interpreting the ^{8}Li spectrum with regard to the structures of the ^{10}Be ground state and ^{8}Li levels at low excitation energies.

CONSTRUCTION OF NEW AND DEVELOPMENT OF EXISTING EXPERIMENTAL SETUPS

Gas Ion Catcher

The construction of the cryogenic gas ion catcher, a new setup for the SHE Factory, continued in 2023.

- The mechanical part of the radio-frequency quadrupole transport system (RFQ-guide) was assembled.
- The radio-frequency system of both the gas cell and transport system, including transformers, was assembled and tested. Resonances were tuned at a frequency of ~ 1 MHz.
- The registration system with a silicon detector and original software at its heart was mounted at the RFQ-guide exit and adjusted. The system was designed for measuring the efficiency of the ion catcher and the extraction time of alpha radioactive products.
- The cooling system of the inner chamber was launched, and a temperature of 40 K was attained at a helium pressure of 10 mbar.
- The system for measuring the composition of residual gases, whose key element is the mass spectrometer PrismaPro (Pfeiffer), was adjusted. The measurement of residual gas spectra showed a drop in impurities in helium gas on cooling the buffer gas to a temperature of 40 K.
- Aimed at simulating efficiency and the time of extraction from the cryogenic gas ion catcher, studies continued with products synthesized in the following complete fusion reactions: ^{40}Ar + ^{144}Sm $\rightarrow$ ^{184}Hg*, ^{40}Ar + ^{166}Er $\rightarrow$ ^{206}Rn*, ^{48}Ca + ^{197}Au $\rightarrow$ ^{245}Es*, ^{48}Ca + ^{208}Pb $\rightarrow$ ^{256}No*, ^{48}Ca + ^{209}Bi $\rightarrow$ ^{257}Lr*, ^{48}Ca + ^{242}Pu $\rightarrow$ ^{290}Fl*.

In collaboration with the Institute for Analytical Instrumentation of RAS (Saint Petersburg), work continued on designing the multireflection time-of-flight mass spectrometer for precision measurements of the masses of heavy and superheavy nuclei. Upon approval of the preliminary design, tender documents were prepared for getting ready construction documents (CDs) and manufacturing the mass spectrometer. A contract was concluded for the purchase of a test bench for investigating the possibility

21 December. Pouring the first cubic meters of concrete into the foundation of the U-400R experimental building

Dubna, 3–4 March. Visit of the delegation of rectors of universities of the Republic of Uzbekistan to JINR. Excursion to the FLNR Nanocentre

of using ionized fullerene fragments as calibration ions. Its key elements are a furnace ion source with electron ionization and a quadrupole mass spectrometer. Contracts were prepared for developing CDs for the time-of-flight analyzer and manufacturing precision power sources and commutators. Purchase agreements were prepared for the main serial production equipment.

Superconducting Gas-Filled GASSOL Separator

For expanding the range of superheavy elements and their isotopes accessible for experiments on the study of the chemical properties of SHE, the GASSOL separator based on a superconducting gas-filled solenoid is developed at FLNR [16, 17]. The main advantage of the novel separator over other gas-filled separators of the SHE Factory will be a small image size of SHE beams in the focal plane, which will allow the use of a much smaller recoil transfer chamber, thereby leading to a many-fold increase in the operation speed. In 2023, a contract was signed for preparing documentation and manufacturing the setup. The equipment is scheduled to be delivered to Dubna at the end of 2024.

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

Exploratory research was conducted on the use of track membrane materials primarily in biology and medicine related fields.

Self-organized silver and gold nanostructures were generated on the surfaces of track membranes (PET and PI) by magnetron sputtering. The enhancement factor and the reproducibility of the giant Raman light scattering signal across the surface of functionalized membranes were evaluated. The detection limit of human metapneumovirus was estimated using aptasensors based on track-etched membranes with silver coatings.

Intended for rapid detection of the influenza virus, track membranes were fabricated with nanostructured golden layer deposited by magnetron sputtering and functionalized with aptamers for the use in biosensors based on electrolyte-gated organic field-effect transistors.

Track membranes (TMs) were functionalized using a protein suppressing the damage of nucleic acids (Dsup) by covalent binding. The modified TMs can thus capture an available cell-free DNA (cfDNA) from a solution during filtration. The obtained TM-based biomaterial can be used in devices for filtration, separation and accumulation of cfDNA molecules from biological media and the surrounding environment.

Microfiltration TMs were fabricated with silver nanoparticles (AgNPs) and curcumin immobilized

onto their surfaces. The obtained hybrid membranes were used for filtering herpes, stomatitis, influenza, and encephalomyocarditis viruses. The membranes under consideration were found to be highly efficient in inhibiting the activity of airborne viruses.

A technique was developed for fabricating a scaffold for an implantable bioreactor using nanoporous TMs, which provides selective isolation of tissue-engineered structures from the recipient's cells and biofluids.

Membrane sorption material was developed using ion-track etching in polymers, vacuum deposition, electrospinning of polymer nanofibers, and targeted chemical modification. The microfilter allows purification of water from cesium ions adsorbed on the surfaces of inorganic particles, colloids, and biological objects. The results laid the foundation for the development of novel membrane sorption materials for low-pressure water purification devices designed to remove radioactive decay products.

Techniques were developed for hydrophilization of TMs by deposition of nanoscale silicon dioxide coatings from a mixture of silane and nitrous oxide in inductively coupled plasma and for the modification of track membranes with water-soluble amino and mercapto silanes. The techniques under consideration were developed to enable the functionalization of the surfaces of track membranes with biologically active compounds.

In addition, the photoluminescence emission spectra of magnesium aluminate spinel single crystals irradiated with swift heavy ions were examined using confocal laser scanning microscopy [18]. Luminescence in the range of 370–800 nm stems mainly from antisite defects in the cation sublattice of $MgAl_2O_4$. Numerical methods were used for studying the formation kinetics of high-energy heavy-ion tracks in polycrystalline materials (Al_2O_3, MgO, Si_3N_4, $Y_3Al_5O_{12}$) as a factor of grain size. The recrystallization processes in Al_2O_3, MgO were shown to substantially affect grain morphology and the boundaries within the ion track. Stresses and oxygen vacancies were shown to play a significant role in the stabilization of tetragonal nanocrystalline regions in individual ion tracks produced in ZrO_2. Using numerical and experimental methods, heavy-ion irradiation was found to form through nanochannels in thin films of graphene oxide and tungsten oxide [19, 20].

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FRANK LABORATORY of NEUTRON PHYSICS

In 2023, the scientific programme of the Frank Laboratory of Neutron Physics was aimed at obtaining new results within the framework of six research themes of the JINR Plan for Scientific Research and International Scientific and Technical Cooperation: in condensed matter physics ("Investigations of functional materials and nanosystems using neutron scattering", 04-4-1142-2021/2025, leaders — D. P. Kozlenko, V. L. Aksenov, and A. M. Balagurov; "Modern trends and developments in Raman microspectroscopy and photoluminescence for condensed matter studies", 04-4-1133-2018/2023, leaders — G. M. Arzumanyan and N. Kucerka); in neutron nuclear physics ("Investigations of neutron nuclear interactions and properties of the neutron", 03-4-1128-2017/2023, leader — E. V. Lychagin); in the development of the FLNP basic facilities ("Development of the IBR-2 facility with a complex of cryogenic neutron moderators", 04-4-1105-2011/2023, leaders — A. V. Vinogradov and A. V. Dolgikh); in the development of the IBR-2 spectrometers and computation complex ("Scientific and methodological research and developments for condensed matter investigations with IBR-2 neutron beams", 04-4-1143-2021/2025, leaders — V. I. Bodnarchuk and V.I. Prikhodko); in the development of the design of a new neutron source ("Development of the conceptual design of a new advanced neutron source at JINR", 04-4-1140-2020/2023, leaders — V. N. Shvetsov and M. V. Bulavin).

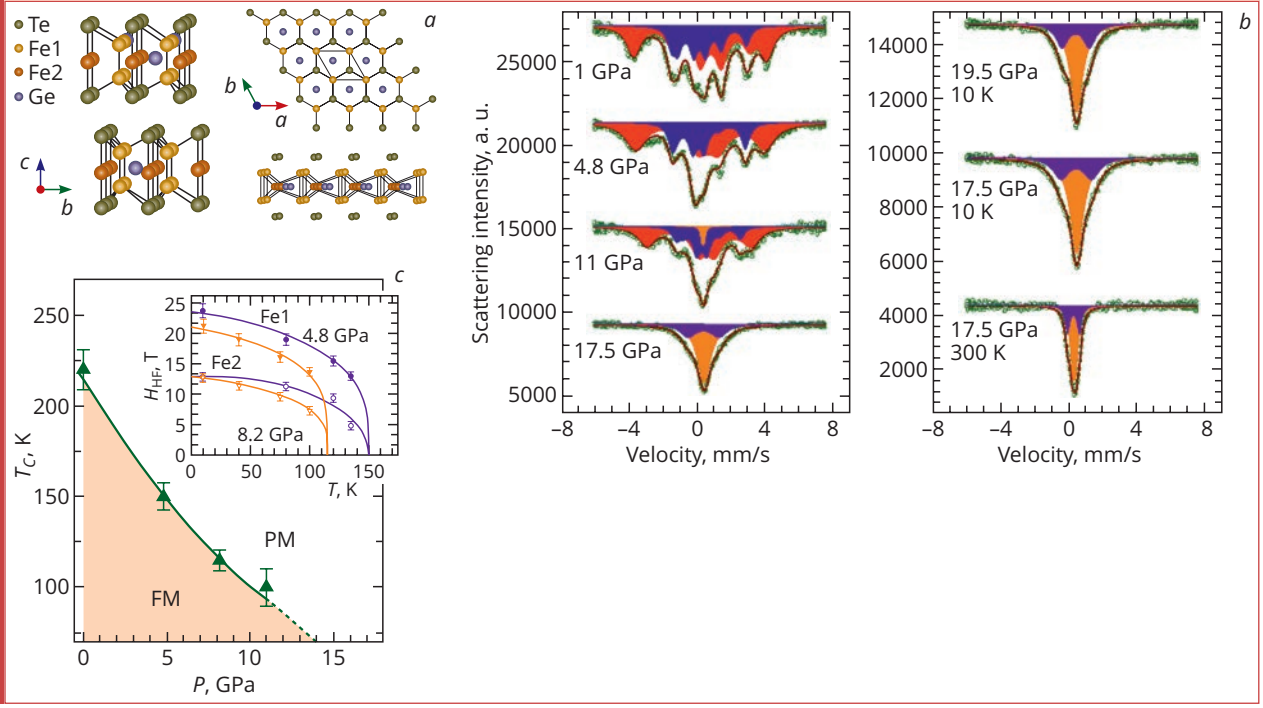
Young scientists of the FLNP Sector of Neutron Activation Analysis and Applied Research — the winners of the 15th European Exhibition of Creativity and Innovation "Euroinvent-2023"

NEUTRON INVESTIGATIONS OF CONDENSED MATTER

Structure Investigations of Novel Oxide, Intermetallic and Nanostructured Materials

The discovery of graphene gave impetus to an active search for two-dimensional magnetic materials with a similar structure and unusual physical properties. Among them, the most promising are multilayer two-dimensional van der Waals magnetic systems, which provide wide possibilities for control and manipulation of magnetic properties up to the monolayer limit. Fe_3GeTe_2 (FGT), which is an itinerant ferromagnet with a high Curie temperature of $T_C \approx 220$ K, is of particular interest, since it demonstrates extreme sensitivity to changes in thermodynamic parameters, causing the occurrence of a number of new unusual phenomena. The low-di-

Fig. 1. Hexagonal crystal structure of Fe_3GeTe_2 (*a*), synchrotron Mössbauer spectra obtained at various temperatures and pressures (*b*), pressure dependence of the Curie temperature and temperature dependences of hyperfine magnetic fields at various pressures (inset) (*c*)



mensional nature of FGT suggests the possibility of realizing quantum critical phenomena. To search for them, the magnetic and structural properties of Fe_3GeTe_2 were studied by means of synchrotron Mössbauer spectroscopy, X-ray diffraction and Raman spectroscopy in the pressure range of 0–20 GPa and temperatures of 10–290 K, as well as theoretical DFT calculations [1]. A rapid suppression of ferromagnetic ordering and the emergence of a paramagnetic state were observed when pressure exceeds a critical value, $P_{PM} \approx 15$ GPa (Fig. 1). Also, the anomalous pressure dependence of structural parameters and vibrational modes was observed at lower pressures ($P_C \approx 7$ GPa) and attributed to an isostructural phase transformation. The obtained results show that high pressure is the driving force for magnetic quantum criticality in multilayer van der Waals magnetic systems.

Perovskite-like manganites exhibit a wide range of physical phenomena that have been actively studied in recent years, including the colossal magnetoresistance effect, dielectric-metal transition, magnetoelectric effect, charge and orbital ordering, structural and magnetic phase transitions. The realization of these phenomena is associated with a strong correlation of spin, charge, lattice and orbital degrees of freedom. A convenient model system for studying the mechanisms of their formation is lanthanum manganite $LaMnO_3$. At normal pressure in this compound below $T_{JT} \approx 750$ K, the static cooperative Jahn–Teller effect and the emergence of orbital ordering are observed, which are due to the lifting of double degeneracy of the energy levels of the e_g orbitals of Mn^{3+} ions and lead to a pronounced distortion of the orthorhombic structure with *Pnma* symmetry. At temperatures below $T_N = 140$ K, antiferromagnetic (AFM) A-type ordering is formed. Earlier, under high pressure, a gradual suppression of the static cooperative Jahn–Teller effect and orbital ordering was observed, accompanied by structural changes in the range of 7–18 GPa, and at $P \approx 32$ GPa, a dielectric-metal transition was revealed. However, possible changes in the magnetic state remained unexplored. To investigate the relationship between changes in the long-range magnetic order and the crystal structure of $LaMnO_3$ at high pressures, studies were conducted using neutron diffraction methods in the range up to 39 GPa (DN-6 diffractometer), as well as X-ray diffraction and Raman spectroscopy in the range up to 50 GPa [2]. By following the changes in the Raman spectra measured at $T = 50$ K, a gradual structural phase transition from the orthorhombic phase with static cooperative Jahn–Teller distortion of oxygen octahedra to the orthorhombic phase, in which Jahn–Teller distortions are local, was detected in the pressure range of 4–17 GPa. This transition was accompanied by a gradual suppression of the A-type AFM phase and a decrease in the ordered magnetic moment of Mn ions. In the pressure range of 30–39 GPa, where the dielectric-metal transition occurs, complete suppression of local structural Jahn–Teller distortions and A-type AFM phase was observed. The results obtained suggest the magnetically disordered nature of the pressure-induced metal phase of $LaMnO_3$.

Using the HRFD diffractometer, a neutron diffraction study of the features of structural and magnetic phase transformations in the magnetostrictive stoi-

chiometric Fe_3Ge alloy with different initial states was carried out in a wide temperature range up to 1000 K. A complementary analysis based on the Rietveld method using X-ray diffraction data made it possible to separate the nuclear and magnetic contributions to the intensity of diffraction peaks and refine the characteristics of the magnetic structure of the alloy. It was found that the two main structural phases present in Fe_3Ge are ferromagnetic with $T_C = 629$ K (hexagonal, $D0_{19}$) and $T_C = 714$ K (cubic, $L1_2$). In $D0_{19}$, a spin-flip transition occurs ($T_{sf} = 385$ K) with a change in the orientation of magnetic moments between the hexagonal axis and the basal plane. It was also shown that the transformation between the ordered $L1_2$ and $D0_{19}$ structural states, predicted by the equilibrium-phase diagram, includes three stages: two diffusive stages ($L1_2 \rightarrow A1$, $A3 \rightarrow D0_{19}$) and the displacive one ($A1 \rightarrow A3$). The obtained structural data suggest that in Fe–Ge, as well as in Fe–Ga alloys, direct transitions between ordered phases are impossible. They should include a transition between disordered states [3].

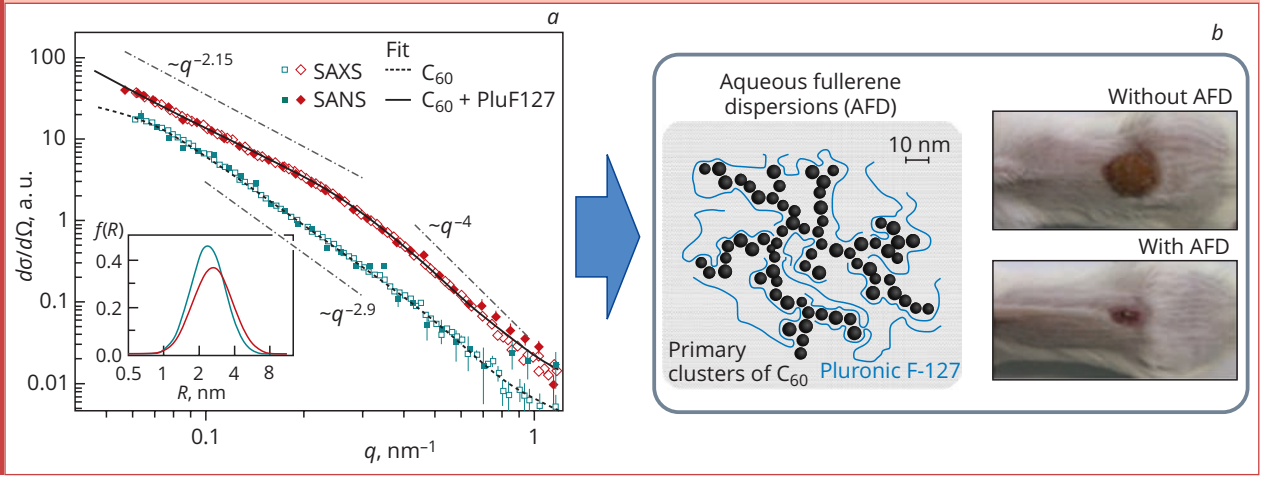
In situ-operando studies of commercial sodium hexacyanoferrate "Prussian White" (PW), a cathode material for sodium-ion current sources, were performed using X-ray diffraction [4]. The advantage of this compound is its high energy capacity and charge/discharge rate, and the disadvantage is rapid degradation during battery operation, which is associated with the presence of water in the structure, which affects the stability of the crystal lattice. Therefore, removing water from the structure is an important stage in the manufacture of electrodes from this cathode material. The effect of changes in the morphology of commercial PW material after mechanical milling in a ball mill on its dehydration during heating and electrochemical properties was determined. Upon dehydration of the initial PW powder, the hydrated rhombohedral structure ("R", space group R-3) at 100°C changes into the cubic phase (space group *Fm*-3*m*), which, with a further increase in temperature to 113 °C, begins to transform into a dehydrated rhombohedral phase (*d*-R) and completely disappears at temperatures above 190 °C. The powder, ground for 6 h, which before milling has a predominantly rhombohedral structure (volume fraction ~ 85%) with a fraction of cubic structure due to the absorption of water from the environment during milling, completely transforms into the cubic phase. When heated, the cubic phase begins to transform into the *d*-R phase already at 82 °C. More efficient dehydration of the ground powder results in higher capacity and more stable operation compared to the initial material. The achieved capacities, especially at high charge-discharge rates, exceed those previously reported in the literature for a similar commercial material.

Investigation of Carbon Nanomaterials

The structure of aqueous dispersions of fullerenes, which were produced at the National Research Centre — Institute of Immunology of the Federal Medical-Biological Agency of Russia (Moscow) to explore the wound-healing effect of fullerene C_{60}, was studied [5]. To improve the stability of

Yekaterinburg, 25–28 September. Participants of the National Conference on Neutron Scattering in Condensed Matter Research (RNIKS-2023)

Fig. 2. *a*) An example of SAXS/SANS data for aqueous dispersions of C_{60} fullerene with the addition of Pluronic F-127. *b*) A schematic structure of dispersions from SAXS, SANS, DLS, and UV-Vis data with an illustration of the wound-healing effect of fullerene in *in vivo* experiments



the solutions, the surfactant Pluronic F-127 was added. A broad spectrum of instrumental techniques available at FLNP were used, including small-angle scattering of X-rays and neutrons, dynamic light scattering, optical spectroscopy, etc. As a result of the experiments, it was found how C_{60} molecules are grouped into clusters when interacting with surfactants (Fig. 2). These dispersions were used as a regenerating component of healing ointment. Experiments on mice show performance parameters that compete well with those of such well-known commercial drugs as Bepanten and Dexapanthenol. At the same time, the fullerene-based drug has no side effects such as hemolytic activity and toxicity.

Investigation of Multilayer Nanostructures

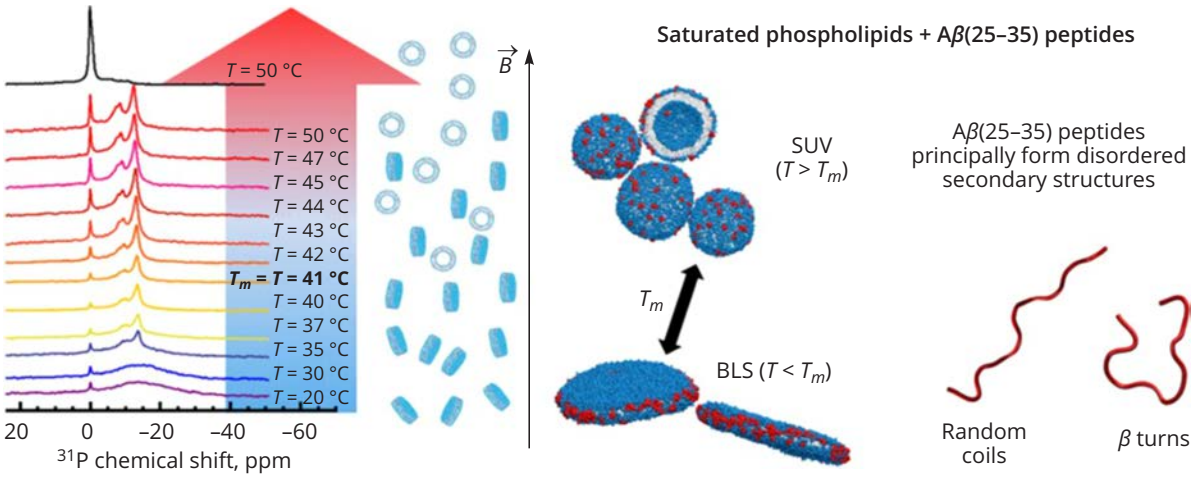
Investigations continued to study the interaction of magnetic and superconducting order parameters at interfaces in $Al_2O_3(11^-02)$/Nb(40 nm)/$[Dy(6\ nm)/Ho(6\ nm)]_{34}$/Nb(10 nm) multilayer nanostructures [6]. Compared to previous studies, what is new here is the use of magnetic helical layers of dysprosium and holmium. Neutron measurements were carried out using the REMUR time-of-flight polarized neutron reflectometer at a glancing angle of the neutron beam at the sample position of $\theta = 19.1$ mrad in the neutron wavelength range of $\lambda_n = 1$–10 Å. The sample was cooled in magnetic field $H = 1$ kOe; the measurement was carried out in the same field. It can be seen that spin asymmetry S grows with the decreasing temperature indicating that the helical magnetic ordering transforms into the fan-shaped ordering, because the collinear component of magnetization grows. But at $T = 1.5\ K < T_c$ (Nb), the inverse behavior is observed, i.e., a decrease in S, which indicates that the helical magnetic phase is recovered from the fan-shaped phase. This behavior is associated with the fact that the helical magnetic phase is energetically more advantageous for the existence of superconducting correlations. The integral macroscopic value of magnetic induction in a helical magnetic material is zero, while for a magnetic material with fan-shaped magnetic ordering, this value is not zero. It is obvious that the former is more advantageous for superconducting correlations, therefore, magnetic ordering adjustment takes place in magnetic layers.

Investigation of Biological Nanosystems, Lipid Membranes and Lipid Complexes

Alzheimer's disease (AD) is a conformational disease caused by the development of senile plaques consisting predominantly of amyloid-beta peptides (ABPs). Amyloid-beta peptide has been considered a key pathological factor of AD since its discovery. However, recently, understanding the damaging effect of the peptide has shifted from large fibrils observed in the intercellular environment to small oligomers interacting with the cell membrane. In 2023, studies were continued on the previously discovered effect of reorganization of the lipid membrane under the influence of ABP (Aβ(25–35)) incorporated into it, namely, the study of changes in the morphology of the system, varying between bicelle-like structures (BLSs) that appear below the temperature of the phase transition of lipids in the membrane (T_m) and small unilamellar vesicles (SUVs), emerging above this temperature. This effect is explained by the membrane-disrupting properties of the peptide. Using solid-state ^{31}P nuclear magnetic resonance (NMR) spectroscopy, the presence of morphological BLS–SUV transformations in the samples when heated through T_m was shown due to the effect of BLS alignment along the magnetic field of the NMR spectrometer [7]. Also, the lipid-peptide structure of BLSs was determined and the arrangement of peptides in BLSs was studied (Fig. 3).

To be more specific, part of the lipids cover the BLS rim, covering the hydrophobic part of the lipids located in the BLS plane. At the same time, Aβ(25–35)

Fig. 3. ^{31}P NMR spectra of the lipid-peptide system DPPC + Aβ(25–35) at different temperatures, as well as visualization of the structure of the observed BLSs obtained using molecular dynamics simulations, and the secondary structure of the peptides



peptides, mixed with lipids, are also located along the rim of BLS to maintain its entire structure. And as shown by circular dichroism and Raman spectroscopy measurements, Aβ(25–35) peptides predominantly form random coils and β turns (unordered secondary structure) both in SUVs above T_m and in BLSs below T_m. Using SANS and molecular dynamics simulations, it was shown that an attempt to control the membrane-disrupting effect of the amyloid-beta peptide using cholesterol and melatonin molecules, namely, to control the mentioned morphological BLS–SUV reorganization by adding cholesterol and melatonin to the lipid membrane, does not affect the ability of Aβ(25–35) peptides to cause this reorganization, despite the fact that cholesterol and melatonin influence the structural and dynamic properties of the lipid membrane [8].

Investigation of Polymer Materials and Films

In collaboration with the Faculty of Physics of MSU, the structure and chemical composition of polyacrylamide polymer brushes synthesized using the "grafting-through" approach on planar surfaces (silicon dioxide) were investigated [9]. The brushes were synthesized in three steps: surface activation, surface modification by grafting anchor monomers, and attachment of growing polymer chains to the surface. At each step, changes in the chemical composition of surfaces were analyzed by photoelectron and infrared spectroscopy. Using X-ray reflectometry, it was shown that the thickness of the dried brush can be tuned from 1 to 10 nm by varying the polymerization temperature from 60 to 30 °C and thus changing the length of the macromolecules. The scaling dependence of the thickness of the dried brush on the length of the polymer $d \sim L^{0.85}$ was determined by comparing the reflectometry data for polymer brushes on the surface and dynamic light scattering data for identical polymer coils in solution. The value of the exponent $\nu = 0.85$ corresponds to an intermediate grafting density between a mushroom-like ($\nu \approx 1/3$) and a fully stretched polymer brush ($\nu \approx 1$). It was shown that the proposed approach based on the "grafting-through" technique makes it possible to synthesize rather thick polymer brushes with high grafting density and good stability. This opens up a relatively simple way for the modification of surfaces with films of controlled thickness, consisting of synthetic polymers of different vinyl monomers and their copolymers.

Atomic and Molecular Dynamics

The researchers of the NERA group continued their traditional investigations into the structure and dynamics of biologically active substances. The intramolecular dynamics of known representatives of nonsteroidal anti-inflammatory drugs (Ibuprofen, Ketoprofen) was studied using DFT calculations and semi-empirical quantum chemical methods [10]. The choice of the functional and the basis set (BP86/def2-SVP) for further studies in the DFT approximation was substantiated. Satisfactory linear correlations were obtained between the experimental and calculated vibrational frequencies for the bioactive enantiomers of Ibuprofen and Ketoprofen.

Applied Research

In addition to macroscopic residual stresses that arise in a product during various technological processes, there are also microstresses that vary between neighboring grains. The assessment of the level of residual microstresses is of great technological importance, since they can cause fatigue damage and/or stress corrosion cracking of various structural elements. An original method has been proposed for calculating residual microstresses in cylindrical samples made of nonaging aluminum alloy 5083Al (Al–Mg), which occur during quenching in fresh wa-

Installation for magnetron sputtering of boron carbide films on substrates made of various materials

ter from a temperature of 530 °C [11, 12], using a genetic algorithm (GA), which is one of the varieties of artificial intelligence — evolutionary calculations. The input data for GA included microstructural parameters (area, aspect ratio and slope of an individual crystallite, number of neighboring crystallites) obtained by electron backscattering diffraction (EBSD), as well as the neutron diffraction peaks from crystallites with a certain orientation ⟨*hkl*⟩ measured on the Fourier stress diffractometer. Using GA, the problem of symbolic regression — a search for a mathematical function that describes the dependence of the interplanar spacing d^{n}_{hkl} (*n* is the crystallite number) on the above-mentioned microstructural parameters of crystallites — was solved. As a result of GA calculations, a map of residual microstresses was obtained for crystallites with the orientation ⟨111⟩. It was shown that the GA-based model makes it possible to obtain reasonable values of residual microstresses for each crystallite ⟨111⟩, which in a quenched cylindrical sample of 5083Al alloy can vary within very significant limits: from –263 to 301 MPa [12].

The global crystallographic texture of fossil wood and nodules was compared using the neutron diffraction method at the SKAT instrument, as well as using complementary techniques. The organic matter of the wood was replaced with the mineral pyrite. Pyrite was found to have a cubic crystalline structure with space group Pa-3. A comparison was made of the distribution of pyrite crystal orientations in the fossil wood and spherical pyrite nodules of the Mesozoic era of the Jurassic period from the same locality in the Oryol region of Russia. Nodules are an inorganic substance of abiogenic origin. Using X-ray tomography, it was revealed that there are no wood remains inside the nodules, that is, their formation occurred without an organic matrix. It was found that mineral crystals replacing fossil wood are more ordered than these mineral crystals in the nodules, and a quantitative characteristic of this ordering is the maximum sharpness of the pole density on the pyrite pole figures of ⟨111⟩ and ⟨200⟩. A comparison was made with the crystallographic texture of calcite filling the inner cavity of the shell of the gastropod mollusk *Bellerophon sp.* from the carboniferous deposits of the Moscow region. It was revealed that the features of the crystallographic textures of calcite and pyrite from the nodules are similar, since the mineral crystals did not grow on a biological (organic) matrix. This fact confirms the idea that using an organic matrix, it would be possible to grow crystals in given directions, planning the properties of new materials in advance [13].

Nowadays, structural studies of archaeological metal materials are focused on the search for characteristic structural markers that can help to restore information about the location of a mine or forge, routes of import of metal raw materials, as well as to identify the features of the casting processes of metal artifacts. In this regard, cast iron products are not only cultural and historical monuments, but also convenient model objects for studying the processes of the spread of corrosion and cracks in metal products, the features of casting and stamping, and methods of chemical processing of metal products. From this point of view, neutron methods of non-

destructive structural diagnostics, such as neutron tomography and diffraction, provide sufficient penetration depth into massive metal objects to study the internal volume of metal artifacts.

Large fragments of cast iron cauldrons from the medieval Golden Horde were studied using neutron tomography [14]. Based on the obtained 3D data, it was possible to identify the internal pores of these cast iron products. The universality of gas-shrinkage porosity processes in ancient cast iron products allows one to consider pore space features as structural markers for determining the location of cast iron production, the presence of additional forging of cast iron products, as well as the features and composition of casting molds.

Methodological Results

Work continued on the development and construction of a new inelastic scattering spectrometer in inverse geometry. In cooperation with Atomgraf AG LLC, work was carried out to produce plates from highly oriented pyrolytic graphite (HOPG) and optimize their production technology to obtain the required parameters. In collaboration with FracoTerm firm (Poland), work was carried out on the engineering development of design documentation (graphic design, drawings and list of materials) and the manufacture of a model element of the spectrometer prototype. The model consists of one row of HOPG crystals, but without a beryllium filter, since its role in eliminating higher-order reflections from HOPG is not significant for the experimental assessment of the parameters of the secondary spectrometer. The creation of the prototype model of the spectrometer will make it possible to test the technology for manufacturing HOPG holders, including a 2-mm boron carbide spacer plate, and their fastening with a constant Bragg angle.

RAMAN SPECTROSCOPY IN CONDENSED MATTER RESEARCH

The theme with the project "Biophotonics" was aimed at fundamental and applied research in the field of spontaneous and enhanced Raman microspectroscopy. One block of tasks was related to the study of the mechanisms and nature of the anomalous ratio of the intensities of the anti-Stokes (aSt) and Stokes (St) component lines in surface-enhanced Raman spectroscopy (SERS) spectra. The second major block of research focused on a number of challenges in the life sciences using Raman spectroscopy and fluorescence microscopy. In particular, this concerned the fundamental problems of identifying the mechanisms and signaling pathways of photo-induced NETosis — programmed cell death, the search for spectral markers of this phenomenon, as well as some features of lipid-peptide interactions in various membrane mimetics.

Study of the Features of the Intensity Ratio of Raman aSt/St Peaks in SERS Spectra as a Function of Pump Radiation Power

SERS spectra, along with the intense signal, show a number of distinctive features compared to the spectra of spontaneous Raman scattering. Specifically, this refers to the intensity ratios of aSt and St spectral lines.

The dependences of the ratios of line intensities for three corresponding pairs of vibrational bands of 2-nitrobenzoic acid thiolate (TNB) on the power density of the excitation radiation in the SERS spectra were obtained. Using these data, we clarified and quantified the contributions responsible for the discrepancies in the obtained ratios determined by the thermal equilibrium populations of the upper and lower vibrational levels corresponding to Raman transitions. These contributions are (i) spectral profile of the local electromagnetic field enhancement factor (LFEF) contour, (ii) local heating of the reporter molecule/AgP conjugates by 785-nm radiation, (iii) optical (Raman) pumping of the upper vibrational levels of the transitions involved.

It was experimentally demonstrated that Raman spectra of TNB reporter molecules on a randomly nanostructured SERS-active AgP/por-Si surface are reproducible at excitation intensities of a continuous laser at a wavelength of 785 nm in the range of 3–105 $\mu W/\mu m^2$. This demonstrates the stability of the investigated sample and makes it possible to measure the intensity dependence of the simultaneously recorded amplitudes of the aSt and St lines. The measurements show that in the reproducibility range of the TNB St and aSt lines, the intensity ratios of the bands with wave numbers ± 1070, ± 1388, and ± 1570 cm^{-1} follow a linear and quadratic dependence on the excitation intensity, respectively.

Identification of Conformational Transformations in Raman Spectra of Peptides Present in Membrane Mimetics

Normalized Raman frequencies show that the intensity/spectral weight of the Amide *I* band at 1671 cm^{-1} (β turn) drops markedly by the fourth day of measurements, indicating that the protein conforms to a more stable structure with a characteristic Raman frequency of 1656 cm^{-1} (α helix). It is known that aggregation of multiple β sheets/β turns can lead to protein aggregation and fibril formation, which is a precursor to Alzheimer's disease. It is logical to assume that the copolymer that shingles the lipodisc/peptide system leads to the ordering of the carboxyl chains of the bilayer and thereby affects the secondary structure of the Aβ42 peptide.

Photoinduced NETosis upon Excitation of Neutrophil Cells by UV-A and Visible Light: Identification of Mechanisms and Signaling Pathways

Understanding the mechanisms of release of neutrophil extracellular traps (NETs) under UV-A and visible light is important for controlling the consequences of the damaging effects of electromagnetic radiation. In study [15], Raman spectroscopy was used to record characteristic vibrational frequencies of various reactive oxygen species (ROS), as well as low-frequency vibrational modes of the citrulline lattice.

For the first time, it was demonstrated that the formation of NETs is activated not only by UV-A radiation, but also by three spectra of the visible range (blue, green, and orange) in a dose-dependent manner. Using inhibition assays, the signaling pathways of photoinduced NETosis were found to be via NADPH oxidase and PAD4.

The primary ROS in activated neutrophils are superoxide anions $O_2^{\bullet -}$, which, not being strong oxidants, rapidly dismutate to hydrogen peroxide H_2O_2. The latter, in turn, can undergo further processing, resulting in the formation of more active metabolites, such as hydroxyl radical ($OH^{\bullet}$) and hypochlorous acid (HOCl). The use of highly sensitive Raman spectroscopy made it possible to defect and record the spectra of the above radicals.

In this study, using fluorescence microscopy, the quantitative yield of NETs was found to be dose-dependent on the irradiation of neutrophils in both the UV-A and visible ranges. To reveal the involvement of NADPH oxidase in the formation of photonetosis, a specific NADPH-oxidase inhibitor, apocynin, was used.

The results showed that apocynin inhibited the output of nontotic cells induced by UV-A and three wavelengths of visible light, indicating the involvement of NADPH oxidase in photoinduced NETosis. As for the PAD4 inhibitor, it caused a more moderate suppression of NETosis, which, however, also indicates the involvement of PAD4 in the formation of NETs.

Studying the role of radiation with different wavelengths from UV-A to red light in the formation of NETs in a human neutrophil model, it was found that not only UV-A, but also visible light induce photonetosis. Thus, using Raman spectroscopy, the possibility of applying this method to detect oxidative burst (H_2O_2 and HOCl) and activate the PAD4 signaling pathway (citrulline release) was demonstrated for the first time.

NEUTRON NUCLEAR PHYSICS

In 2023, the scientific activity in the field of neutron nuclear physics was carried out in the following traditional directions: investigations of time and space parity violation processes in neutron-nuclear interactions; studies of the fission process; experimental and theoretical investigations of fundamental properties of the neutron; gamma spectroscopy of neutron-nuclear interactions; studies of atomic nuclear structure, obtaining of new data for reactor applications and nuclear astrophysics; experiments with ultracold neutrons, applied research using NAA, resonance analysis, infrared spectroscopy and other methods. The scientific programme to study the inelastic scattering of fast neutrons (TANGRA project) is being successfully implemented.

A number of experiments in the field of fundamental physics and ultracold neutron physics were carried out at instruments of foreign nuclear research centres.

TANGRA Project

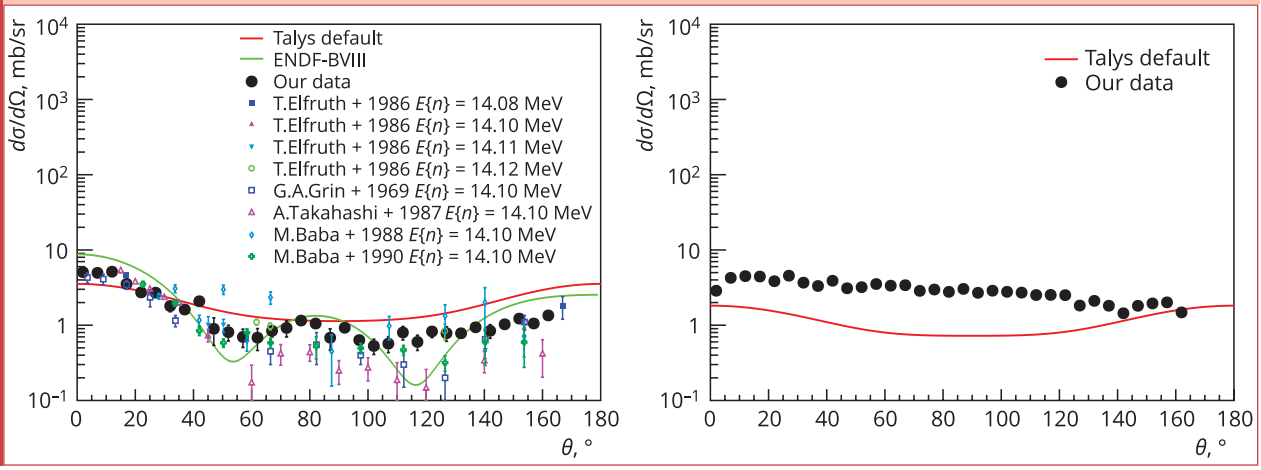
In 2023, within the framework of the TANGRA Collaboration, the analysis of previously obtained data on inelastic neutron scattering by O, P, S nuclei continued. Experiments were performed to study the angular distributions of scattered neutrons from carbon nuclei.

The source of neutrons used in the experiments within the TANGRA Collaboration is the ING-27 neutron generator, mass-produced at the N. L. Dukhov All-Russian Scientific Research Institute of Automation (FSUE VNIIA). The main structural element of the neutron generator is a sealed maintenance-free neutron tube, which is a compact deuteron accelerator, a tritium-enriched titanium hydride target and an α detector, combined in one sealed metal-glass or metal-ceramic housing. Neutron generation occurs as a result of the fusion reaction of deuterons and tritons, causing the emission of neutrons and α particles. Detection of α particles by a position-sensitive detector with a small target size makes it possible to determine the direction of neutron emission and obtain timing to the moment of its generation, that is, to "tag" it.

Within the framework of the TANGRA project, a new experiment was also performed to measure the angular distributions of scattered neutrons. A stacked block of graphite plates measuring 44 × 44 × 2 cm was used as a target. The large sample area was dictated by the desire to use all beams of tagged neutrons when placing the target at a distance of 27 cm from the generator. The measurement time was 48 h. The measurement was also carried out without a sample for 28 h.

The processing of data on angular distributions of neutrons scattered by carbon made it possible to determine the areas of peaks in time-of-flight spectra for detectors at different angles, corresponding to elastic scattering and inelastic scattering with excitation of the first five excited states (Fig. 4). The

Fig. 4. Obtained angular distributions of scattered neutrons for (n, n_2) (left) and (n, n_4) (right) for excited states of the ^{12}C nucleus



preliminary results obtained for angular distributions, in general, are in good agreement with other experimental data, and for (n, n_4), these data were measured for the first time.

Development of the Concept of a UCN Source on a Pulsed Reactor

In 2023, work continued on developing the concept of an intensive source of ultracold neutrons (UCN) on a moderate-power pulsed reactor. A source based on the idea of F. L. Shapiro on pulsed filling of a UCN trap is considered as the main variant. It was realized [16] that in the case of a large reduction in the neutron energy by some local decelerating device — a decelerator and, accordingly, a large initial energy and speed of the neutron, the spread of flight times δt from the pulsed source to the decelerator and, accordingly, to the trap, for such neutrons can be much less than the flight time itself $t = L/V$, where L is the length of the transport neutron guide.

On the basis of these ideas, the concept of a UCN source with a decelerator designed for a large reduction in neutron energy was developed. It is proposed to use an adiabatic spin flipper as a decelerator, in which a spin flip occurs under the action of an alternating high-frequency magnetic field directed perpendicular to a large permanent (but coordinate-dependent) magnetic field. The change in energy during a spin flip is $ED = 2\mu B$, where μ is the magnetic moment of the neutron, and B is the magnitude of the permanent magnetic field in the region of the spin flip. Due to the initial spread of velocities, a dispersion of deceleration times will occur, since slower neutrons will take longer to slow down in the decelerator. To compensate for the resulting dispersion of deceleration times, it is proposed to use a time lens in front of the decelerator, which can change the energy of neutrons arriving at it according to a certain given law so that neutrons with lower velocities leave the lens first. The proposed principle of operation of the time lens is based on a neutron changing its energy when passing through a magnetic field that is uniform in space and changes in time. The calculations showed that in this way it is possible to completely compensate for the spread of deceleration times. A manufacturing company has been found that can produce the main component of the facility — a high-temperature superconducting magnet with a field of about 10 T.

Applied Research

In 2023, the researchers of the Sector of Neutron Activation Analysis and Applied Research (SNAA&AR) carried out a multi-element analysis of about 2500 samples, including vegetation, soil, technological, biological and geological samples, within the framework of programmes and grants of the JINR Member States and Protocols on scientific and technical cooperation with the JINR Non-Member States.

Within the framework of the international programme "Atmospheric Deposition of Heavy Metals in Europe — Estimates Based on the Analysis of Moss Biomonitors", work was completed to assess the level of air pollution in North Macedonia, a number of provinces of Vietnam, and several regions of Russia. For the first time, biomonitoring was conducted throughout the entire territory of the Tver Region. Using the inductively coupled plasma–optical emission spectrometry, the concentrations of 15 elements (Al, S, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Cd, Ba, Hg, and Pb) in mosses were determined. To identify possible sources of air pollution, the multivariate factor analysis was used, which revealed three factors with 60% of the total variance. The first factor (natural-anthropogenic) included the following elements: Al, Co, Cr, Cu, Fe, Pb, S, and V. The second factor is represented by Cd, Mn, Ni, and Zn. Increased concentrations of these elements are observed along highways and near large cities. Thus, transport and industrial enterprises can be considered the main sources of emission of the elements. The elements of the third factor (Ba and Sr) may be related to soil erosion and transport. A comparison of the results obtained with the data acquired in 2004 and

Experimental hall No. 1 of the EG-5 accelerator after modernization

2014 (biomonitoring was not carried out throughout the entire territory of the region) showed that there were no significant changes in the concentrations of the elements.

In the group of Neutron Activation Analysis (NAA) at IREN, work continued on the mass study of samples of various origins. Elemental analysis was carried out using NAA and X-ray fluorescence analysis. Mineral and molecular composition was studied using Fourier transform infrared spectroscopy and Raman spectroscopy. Additionally, stratigraphy, polarization and optical microscopy, as well as droplet microanalysis were used. Methods of mathematical statistics were applied to process the obtained data. The major part of the objects under study were various components of ancient Russian wall painting (pigments, binders, and plaster bases), medieval building materials, environmental and geological samples.

The work was carried out within the framework of Cooperation Agreements with the Federal State Budgetary Research Institution "State Institute for Art Studies", Interregional Agency for Scientific Restoration of Works of Art, Institute of Archeology of the Russian Academy of Sciences, Federal State Budgetary Institution of Culture "State Historical and Cultural Museum-Reserve 'Moscow Kremlin' ", State Budgetary Cultural Institution of the Leningrad Region "Staraja Ladoga Historical-Architectural and Archaeological Museum-Reserve", INP, Institute of Geology and Geophysics of the National Academy of Sciences of Azerbaijan, as well as within three joint projects with Egypt and one joint project with Vietnam.

A comprehensive study of the painting of the Christ's Transfiguration Cathedral of the Mirozhsky Monastery (Pskov) was carried out [17]. The obtained data from physical and chemical studies are included in the restoration project for this monument.

To find ways to solve the problem of changes in the color of wall paintings, experiments were carried out to simulate the effect of high temperatures on fresco painting. A scale of temperature transitions was constructed for five main pigments of the XII century from the St. George Cathedral of the Yuryev Monastery in Veliky Novgorod [18].

FLNP BASIC FACILITIES

IBR-2 Pulsed Reactor

In 2023, the IBR-2 nuclear research facility was operated in a temporary shutdown mode due to the expiration of the Rostechnadzor license. In October 2022, in accordance with the Administrative Regulations for the provision of state services for licensing activities in the field of atomic energy use by the Federal Environmental, Industrial and Nuclear Supervision Service of Russia, a set of documents justifying the safety of the IBR-2 reactor was sent to Rostechnadzor to obtain a new license. During 2023, the

Backscattering detector for the high-resolution Fourier diffractometer (HRFD) of the IBR-2 reactor

specified documents underwent examination at the Scientific and Engineering Centre for Nuclear and Radiation Safety, which is an expert organization.

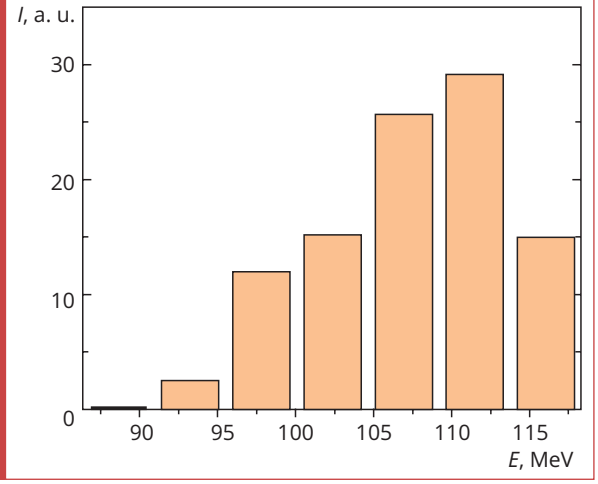
In 2023, at the IBR-2 reactor, personnel of the FLNP technological departments carried out maintenance and repair of equipment for the systems of the IBR-2 nuclear research facility in order to maintain it in working condition.

IREN Facility

In 2023, the LUE-200 accelerator, the driver of the IREN neutron source [19], routinely operated at a pulse repetition rate of 50 Hz with an electron energy increased to 110–115 MeV. The increase in beam power was about 40%. At the accelerator, studies continued on the influence of the discrepancy (deviation) between the frequency of the microwave power entering the accelerating structure and the natural (resonant) frequency of the structure on the rate of gain of beam energy [20]. The accelerator operated for experiments for more than 2300 h.

The beam energy at the output of the accelerator was increased as a result of a systematic search for the optimal frequency of the generator and careful adjustment of the natural frequencies of the resonators of the SLED systems. In 2023, at the LUE-200 accelerator of the IREN facility, the effect of changing the frequency of the master oscillator of the microwave power source and adjusting the natural frequencies of the resonators of the SLED microwave power compression systems on the energy characteristics of the electron beam was measured in order to determine optimal operating modes. Such a task for the accelerator as a whole is complicated by the fact that several objects should be "coordinated" simultaneously: two accelerating sections with two resonators in the SLED systems of each section. At the same time, the frequency characteristics of the SLED sections and resonators differ significantly (Fig. 5).

Fig. 5. Energy spectrum of accelerated electrons. By adjusting the frequency of the master oscillator, the natural frequencies of the SLED systems, the phase of the second accelerating section and the startup delay of the electron beam in relation to the microwave "phase reversal", the average beam energy at the output of the accelerator can be brought to a value of more than 100 MeV



Discussion of the results obtained after the successful test run of the Linde 1800 refrigerator

During the initial stages of operation of the LUE-200 accelerator, the frequency of the master oscillator for klystrons (microwave power sources of accelerating sections) was set at the level of 2855.7–2856.5 MHz, and, most likely, differed from the optimal one, which reduced the efficiency of delivering microwave power to the beam and led to a lower rate of energy gain by particles of the accelerated beam.

NEW NEUTRON SOURCE

Development of Fuel for the New Neutron Source

The technical specifications for the implementation of research, development and experimental technological work "Preparatory work for the development of neptunium nitride fuel and neptunium-nitride-based fuel rods for the NEPTUNE reactor" are being approved. Within its framework, it is planned to prepare documentation for obtaining 4 kg of nuclear material — neptunium-237, as well as to make preparations for conducting experiments on the production of fuel pellets from neptunium nitride at JSC VNIINM.

Optimization of Reactor Design

In cooperation with JSC NIKIET (Rosatom State Corporation), technical specifications were agreed upon and a contract was concluded for the implementation of R&D "Computational justification of design solutions for the reactivity modulator and the vessel of the NEPTUNE pulsed reactor". Based on the results of the R&D, the degree of operability of the most highly used components of the reactor will be determined and the feasibility of shifting to a draft design of the reactor facility will be assessed.

At the FLNP Sector of the New Source and Complex of Moderators, in cooperation with JSC NIKIET, heat load calculations of the reactivity modulator are being carried out in order to determine the maximum heating of titanium hydride in the operating mode of the NEPTUNE reactor and the conditions under which titanium hydride retains its properties. Technical solutions are being developed that create conditions preventing possible overheating of titanium hydride: inserts made of nickel, boron carbide, thermal insulation gaskets, etc.

A Model of Pulsed Reactor Dynamics

A model of dynamic bending of a fuel rod has been developed, which describes the dynamics of the NEPTUNE reactor for the variant of the rod-by-rod configuration of the core or the mono-core version and allows analyzing the stability and reliability of the operation of the NEPTUNE reactor. A method is being developed to quantitatively describe the evolution of the reactor within the framework of this model.

The main objective of investigations at the experimental facilities of the RFNC-VNIITF is to directly observe the phenomenon of dynamic bending of a fuel rod in a neutron field, as well as to measure the effect of energy release in the fuel on the motion of the fuel rod.

Work has been completed on the computational justification of experiments simulating the main features of thermomechanical processes in the fuel rods of the NEPTUNE reactor, which was carried out under the R&D agreement with RFNC-VNIITF "Study of thermomechanical processes in fuel rods of the NEPTUNE pulsed reactor. Stage 1".

Design documentation has been prepared and work has begun on the manufacture of an experimental stand for periodic heating of a fuel rod model in the FLNP workshops.

EVENTS

- 15 March — FLNP Seminar "On verification of the principle of relativity in the β decay of the neutron" (V. R. Skoy)
- 23 March — FLNP Seminar. Presentation of the collection of A. I. Frank "Problems of optics of long-wavelength neutrons"
- 21 April — Seminar dedicated to the 60th anniversary of the birth of V. R. Skoy "Neutron spin-filter with spin-exchange interaction of ^{3}He nuclei with atoms of a saturated ferromagnet" (V. R. Skoy)
- 24 May — FLNP Seminar "Features of the dynamics of pulsed reactors, the effect of coolant flow" (E. P. Shabalin)
- 29 May – 2 June — 29th International Seminar on Interaction of Neutrons with Nuclei "Fundamental Interactions and Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics" (ISINN-29)
- 14 June — FLNP Seminar "New tracking detectors based on scintillating fibers (SciFi) and their application in high energy physics, astrophysics, and medicine" (A. G. Malinin)
- 26 June — FLNP Seminar "Multi-purpose fast research reactor MBIR with sodium coolant. Technical characteristics of the reactor. Experimental possibilities inside and outside the core" (D. A. Klinov)
- 5 October — FLNP Seminar "Importance, mechanism and application of inertial electrostatic confinement fusion (IECF) device and designing an optimum shield for it. Calculation of nuclear level density using statistical partition function method" (Mehdi N. Nasrabadi)
- 4–6 December — Conference of FLNP Young Scientists and Specialists
- 19 December — FLNP JINR–JSC NIKIET Working Meeting on the new neutron source NEPTUNE
- 21 December — FLNP JINR–RFNC VNIITF Working Meeting on the dynamics model of the NEPTUNE pulsed reactor
- 27 December — FLNP Seminar "Neutrino physics at nuclear reactors" (E. A. Yakushev)

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MESHCHERYAKOV LABORATORY of INFORMATION TECHNOLOGIES

The activity of the Meshcheryakov Laboratory of Information Technologies (MLIT) in 2023 was focused on ensuring the reliable functioning and growth of the JINR network, information and computing infrastructure (theme 05-6-1118-2014/2023 "Information and Computing Infrastructure of JINR"), as well as on developing mathematical support and software for the research and production activities of the Institute and scientific centres of its Member States (theme 05-6-1119-2014/2023 "Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data") on the basis of the JINR Multifunctional Information and Computing Complex (MICC). A distinctive feature of ongoing research directions is close cooperation with all the Laboratories of the Institute, institutes of the JINR Member States and other countries.

In 2023, the MLIT staff published over 200 scientific papers, 5 monographs and more than 100 articles within international collaborations, presented over 150 reports at international and Russian conferences.

MULTIFUNCTIONAL INFORMATION AND COMPUTING COMPLEX OF JINR

To attain the main objectives of JINR flagship projects, it is needed to ensure the high performance, reliability and availability in 24/7/365 mode of all components of the Multifunctional Information and Computing Complex (MICC) as a large research infrastructure project.

In 2023, work to modernize and enhance the performance of the hyperconverged Govorun supercomputer, distributed computing and data storage systems based on grid technologies and cloud computing was underway. The work was based on reliable engineering components and a state-of-the-art network infrastructure with a bandwidth of up to 4 × 100 Gbit/s.

In 2023, the active use of the MICC resources for JINR research and applied tasks continued. The HybriLIT platform, which includes the Govorun supercomputer and the education and testing polygon, was actively used to perform investigations within the JINR Topical Plan. The application of grid technologies based on the DIRAC Interware enabled to integrate not only the allocated computing resources of all MICC components, but also the clusters of the Member States' organizations. Such an approach made it possible for the first time at JINR to carry out a full cycle of processing experimental data obtained during the 8th run of the BM@N experiment, as well as to successfully perform simulation sessions for the MPD experiment. The Tier-1 grid site for the CMS experiment at the LHC continued to be a leader among similar world sites. Tier-2/CICC provided data processing for the experiments at the LHC, NICA and for other large-scale experiments, as well as support for users from the JINR Laboratories and the Member States. The cloud environment of JINR and its Member States was mainly used for computing within the JINR neutrino programme.

JINR Network Infrastructure

The JINR local network infrastructure and telecommunication channels are the foundation for the JINR information and computing infrastructure, which is constantly developing, providing access to the computing resources and the data storage systems both within the Institute and in external scientific organizations cooperating with JINR.

In 2023, the JINR telecommunication channels functioned reliably. First of all, the reliable functioning of the Moscow backup channel with a bandwidth of 4 × 100 Gbit/s was ensured. To operate the Tier-1 grid site, one must be a full member of the LHCOPN network to communicate with Tier-0 (CERN) and other Tier-1 sites. This connection is provided by the 100 Gbit/s JINR–CERN direct channel and its 100 Gbit/s backup channel passing through Moscow and Amsterdam. JINR Tier-2 connectivity is ensured by the LHCONE external overlay network designed for Tier-2 grid sites. The RU-VRF technology is employed for communication with Russian institutes

3 October. Delegation of the NAS of the Republic of Kazakhstan (NAS RK), headed by President of the Board of NAS RK K. Zakarya on an excursion at the Laboratory during a visit to JINR

involved in processing data from the LHC. The National Research Computer Network of Russia (NIKS), created as a result of integration of the federal university computer network RUNNet (Russian UNiversity Network) and the network of organizations of the Russian Academy of Sciences RASNet (Russian Academy of Science Network), provides communication with scientific and educational organizations of the Russian Federation. The DWDM (Dense Wave Division Multiplexing) technology is used for data transfer via the external optical telecommunication channel.

The distribution of the incoming and outgoing traffics by the JINR subdivisions in 2023 (exceeding 25 TB by the incoming traffic) is shown in the Table.

Subdivision	Incoming traffic, TB	Outgoing traffic, TB
MLIT	639.8	519.5
HRC	459.46	75.97
VBLHEP	406.14	191.04
DLNP	253	111.8
FLNR	156.41	30.47
FLNP	155.12	48.98
Dubna State University	147.03	37.45
JINR Directorate	121.02	64.59
Remote Access Node	88.18	12.76
UC	52.73	9.84
BLTP	35.78	11.76
LRB	30.98	3.8
SIMO	30.4	4.55
CPED	29.59	2.08

The overall incoming traffic of JINR, including the general-purpose servers, Tier-1, Tier-2, the Govorun supercomputer and cloud computing, amounted to 41.45 PB in 2023, while the overall outgoing traffic reached 27.28 PB. The traffic with the scientific and educational networks, accounting for 96.21% of the total, is overwhelming.

The local area network (LAN) is based on the JINR backbone network with a bandwidth of 2 × 100 Gbit/s and the distributed multinode cluster network between the DLNP and VBLHEP sites (4 × 100 Gbit/s).

The JINR Network Operation Centre (NOC) regularly updates software on 20 servers (webmail.jinr.ru, indico.jinr.ru, mail.jinr.ru, maillist.jinr.ru, mx1.jinr.ru, mx2.jinr.ru, auth-1.jinr.ru (login.jinr.ru), auth-2.jinr.ru, etc.), which keeps the systems up to date.

In 2023, over 1400 requests from JINR users regarding the network operation, email services, VPN, DNS, electronic libraries, WiFi, security, etc., were processed. The NOC IPDB database was modernized, namely, the search system was expanded, new registration tools were added. The general database contains 40 thousand elements (users and equipment). About 60 incidents with violations of JINR network security were processed, 25 local websites were checked for vulnerabilities, more than 30 servers and virtual machines of the NOC were supported, and over 800 network devices were monitored.

The JINR LAN comprises 12 803 network elements, 21 640 IP addresses in IPv4 format, 1385 IP addresses in IPv6 format, 5750 network users, 4554 @jinr.ru email addresses, 1165 users of electronic libraries, 854 users of the remote access service and 130 users of the EDUROAM service.

MICC Engineering Infrastructure

In 2023, the work on the replacement and enhancement of the MICC engineering infrastructure, designed to ensure the reliable, uninterrupted and fault-tolerant operation of the information and computing systems and the data storage resources, was in progress. The power supply system is provided by two transformers of 2500 kVA each, two diesel generator units of 1500 kVA, and a system of uninterruptible power supplies (8 × 300 kVA).

The climate control system of the grid components is built according to a mixed type and combines the raised floor supply of cold air with a forced exhaust of hot air by ventilation panels and the cooling of the cold corridor of the module with inter-row air conditioners. The total cooling supply consumption is 1400 kW.

In 2023, taking into account the need to expand the computing resources and the data storage systems, the enlargement of the server room by reconstructing the machine hall on the 4th floor of the MLIT building started.

The DCIM (Data Centre Infrastructure Management) system is utilized for controlling and accounting the MICC equipment.

JINR Grid Environment (Tier-1 and Tier-2 sites)

In 2023, the successful operation of the JINR grid sites continued, and their on average 100% availability and reliability were ensured [1]. The creation of an accelerator complex at JINR within the NICA megascience project and experimental facilities on it entailed the extension of the functions of the JINR grid sites with the introduction of their resources in the system for modeling, processing and storing data from the BM@N, MPD and SPD experiments.

At present, the Tier-1 site provides:

— acquiring data of the CMS experiment from the Tier-0 site at CERN to the extent defined by an agreement with WLCG (Worldwide LHC Computing Grid);

— archiving and responsible storage of initial experimental data transferred from Tier-0;

— consistent and continuous data processing;

— additional processing (skimming) of raw data, RECO (reconstructed) data and AOD (analysis object data) data;

— data reprocessing and launch of production processing using new software or new calibration and alignment constants for the CMS detector parts;

— access to AOD datasets to the Tier-1 and Tier-2 sites involved in CMS experiment data processing;

— sending RECO and AOD datasets to other Tier-1/Tier-2/Tier-3 sites for their duplicate storage (replication) and physics analysis;

— obtaining modeled events and analyzing data written during the operation of the CMS experiment;

— secure storage of modeled events;

— obtaining modeled events and analyzing data for the experiments at NICA;

— acquiring and processing experimental data from the BM@N experiment.

The functioning of the Tier-2 site ensures:

— processing and analyzing data from all experiments at the LHC and providing resources to perform computing jobs to the participants of the experiments;

— acquiring modeled data and analyzing them for all virtual organizations registered in the Russian consortium RDIG (Russian Data Intensive Grid);

— acquiring modeled data and analyzing them for the experiments at NICA;

— acquiring and processing experimental data from the BM@N experiment.

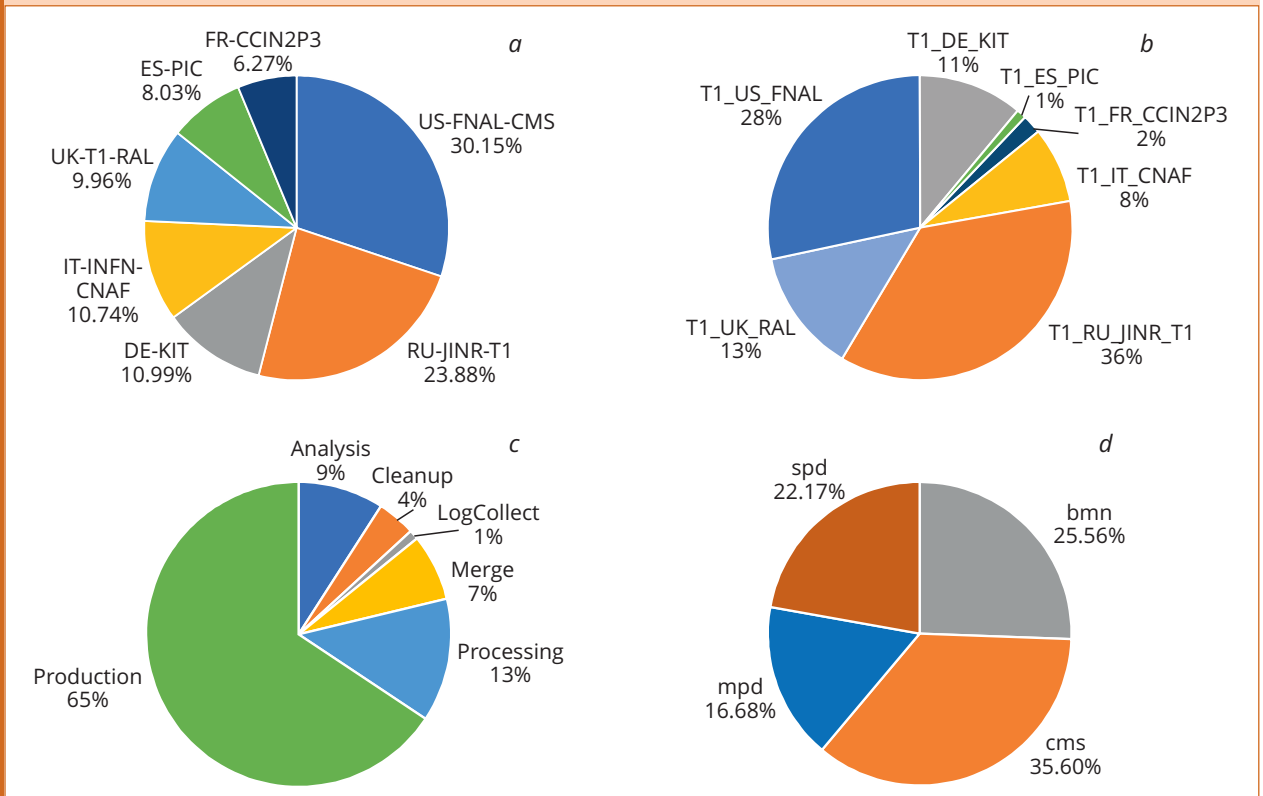
Tier-1 and Tier-2 Resources

The functioning of the computing resources of the JINR grid sites is provided by the SLURM (Simple Linux Utility for Resource Management) workload manager. To organize computing in the grid environment, the advanced resource connector (ARC), middleware for grid computing, is employed. It provides a common interface for transferring computing jobs to different distributed computing systems and can include grid infrastructures of varying sizes and complexity.

One of the uppermost elements of the JINR grid infrastructure, as well as the entire MICC, is the data storage system. This system is built on a hierarchical principle, and the level of storage depends on the duration of data storage and their volume. Computing cluster machines have limited disk space intended for storing the operating system (OS) itself, some additional utilities and temporary user files of a limited size. The AFS distributed global system is used to store and access user home directories and small volume software. The globally available system of maintenance and access to large software complexes of collaborations and user groups operates on the basis of the software developed at CERN, i.e., CVMFS. The dCache and EOS systems are utilized as the main data storage systems. These are systems for medium-term data storage. The latter should become the main data storage system in the MICC. EOS as a system for storing extremely large data amounts is optimal in terms of cost/storage capacity, supports multiple access protocols (POSIX when installed on the user computer, xroot and http for fast remote access) and is designed to provide high-speed data access thanks to parallel copying from many servers, etc.

With the start of sessions at the NICA complex, an intensive enlargement of long-term data storage systems on robotic tape libraries will be required. In addition to the tape robot for the CMS experiment on Tier-1, it is needed to create a long-term data storage for the experiments at the NICA complex, the neutrino programme and other user groups. This system is being created on top of the software

Fig. 1. Contribution of the world Tier-1 centres to CMS experimental data processing in 2023: *a*) distribution by the normalized CPU time in HEP-SPEC06 hours; *b*) number of processed events; *c*) statistics on the use of the JINR Tier-1 centre by the CMS Collaboration by different types of data stream processing; *d*) distribution by the number of jobs completed on Tier-1 by the CMS, BM@N, MPD and SPD Collaborations



developed at CERN, i.e., CTA (CERN Tape Archive). It will be fully included in the MICC infrastructure. The major CTA component is EOS with the addition of an infrastructure for working with tape robots and manipulating the meta information of stored files. In 2023, EOSCTA was put into trial operation.

Currently, Tier-1 embraces 468 compute nodes (20 096 cores) with a performance of 323 820.54 HEP-SPEC06. The launch of jobs for CMS experiment data processing is carried out by 16 nuclear pilots, and all computing resources are available to them. Data storage is provided by the 12.4 PB dCache system and the robotic tape storage with a capacity of 51.5 PB. The TS4500 robot runs the Enstore and dCache software. The TS3500 robot employs the EOSCTA system. To work with tapes, a 2.65 PB disk array is used to cache data.

In terms of performance, the JINR Tier-1 site is behind only the Tier-1 centre of Fermi National Accelerator Laboratory (USA) in the ranking of world Tier-1 sites that process data from the CMS experiment at the LHC (Fig. 1, *a*–*c*).

The JINR Tier-1 site is involved in performing jobs for the experiments at NICA (Fig. 1, *d*).

Fig. 2. Statistics on the use of the EOS system by user groups and Collaborations

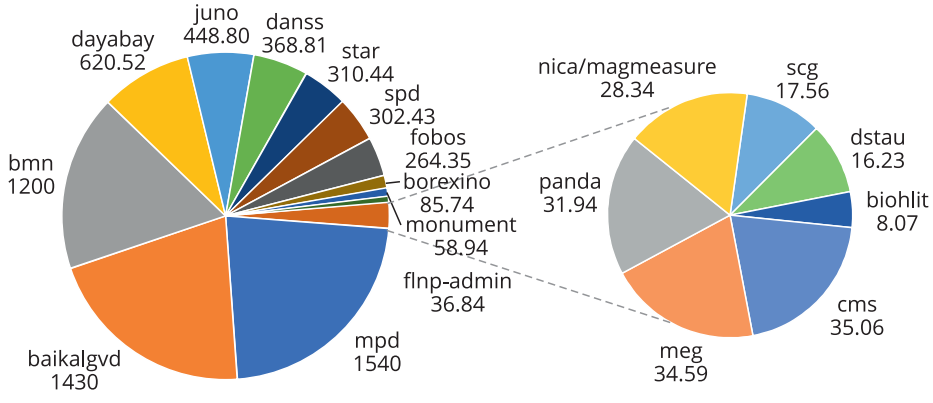
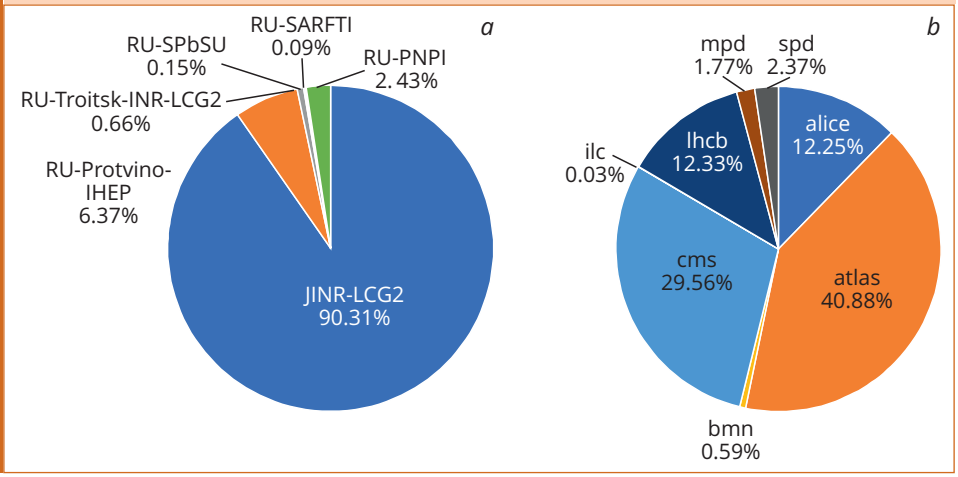


Fig. 3. *a*) Distribution of RDIG jobs completed on the grid sites; *b*) use of the JINR Tier-2 site (JINR-LCG2) by virtual organizations within grid projects



The Tier-2 site embraces 486 compute nodes (10 356 cores) with a total performance of 66 788.4 HEP-SPEC06. Data storage is provided by the 5.62 PB dCache system and EOS as a common distributed data storage system for all MICC users with a capacity of 23.3 PB (Fig. 2).

The JINR Tier-2 output is the highest in the Russian grid segment (Fig. 3).

DIRAC at JINR

At present, the DIRAC Interware (Distributed Infrastructure with Remote Agent Control) is the only system that integrates all MICC components. DIRAC acts as a middle layer between users and different computing resources, ensuring their efficient, transparent and reliable usage by providing a common interface to heterogeneous resources.

In 2023, DIRAC was employed to solve the tasks of Collaborations on all three experiments at the NICA accelerator complex, as well as on the Baikal-GVD neutrino telescope (Fig. 4).

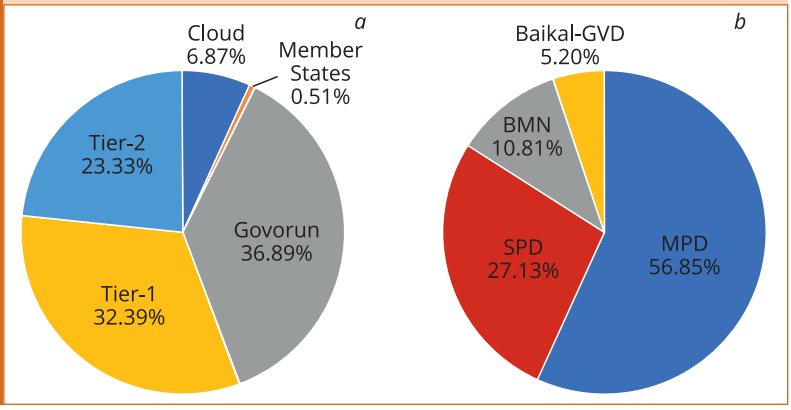
In 2023, for the first time at JINR, the complete processing of raw data from the 8th run of the BM@N experiment was performed on the distributed heterogeneous computing infrastructure integrated using the DIRAC platform [2]. During the run, 430 TB of data was collected in the form of ~ 30 000 files. Throughout the year, after changes made to the BmnRoot package, which is used for data reconstruction, this procedure was applied to initial data reprocessing several times. In total, five large and seven small data reconstruction/generation sessions were completed within a year.

A prototype of a critical web application for an automated system that collects and processes data on the resources used at JINR and integrated into a unified infrastructure with the help of DIRAC was implemented. The application being developed provides valuable data for optimizing the operation of computing resources integrated in DIRAC [3].

Cloud Infrastructure

The JINR cloud is one of the MICC components, and its resources are utilized in the distributed information and computing environment (DICE) of the

Fig. 4. Distributed heterogeneous environment based on the DIRAC platform for JINR tasks by the normalized CPU time in HEP-SPEC06 hours: *a*) share of use of the MICC components; *b*) distribution by Collaborations



JINR Member States [4]. The main users of cloud infrastructure resources in 2023 were collaborations of neutrino experiments and MLIT.

JINR cloud infrastructure servers run the CentOS 7.9.2009 operating system, the support period of which expires in the middle of 2024. In this regard, a number of works were performed to develop the procedure for transferring cloud servers and part of the services to another binary compatible distribution, for which AlmaLinux OS versions 8 and 9 were chosen (the specific version depends on the availability of this or that software for it). Work to update the cloud infrastructure configuration management service based on Foreman (from version 2.5.4 to version 3.8.0) and Puppet (from version 6 to version 7) software products was completed. The OS on this service was updated to AlmaLinux 8.9. Foreman templates and Puppet configuration files were enhanced for installation on AlmaLinux 9 OS cloud infrastructure nodes. For the same reasons, the OS is gradually being transferred to virtual machines (VMs) deployed in the cloud, including DLNP neutrino experiment VMs.

As part of expanding the range of cloud services provided, a service for publishing custom Docker containers in CernVM-FS [5] was developed and put into operation to ensure the possibility of their use in batch processing systems for the tasks of the neutrino platform, the NICA cluster, and all MICC components.

To meet the increasing needs of neutrino experiments for disk space for storing experimental data, the cloud storage capacity of the neutrino platform was increased from 1.5 to 3.1 PB of raw disk space through the purchase of new equipment.

Within the JINR DICE, on the basis of the resources of the JINR Member States' organizations, the following work was performed:

- update of the OpenNebula cloud platform software from version 6.4.0.1 to version 6.6.0 on the cloud of the Institute of Nuclear Physics of Uzbekistan;
- support and development of the cloud infrastructure at Khetagurov North Ossetian State University (Vladikavkaz) (network infrastructure, storage);
- addition of an interactive map that displays the geographic location of DICE participating organizations to the http://dice.jinr.ru web portal.

In 2023, 45 208 jobs were successfully completed on the DIRAC.JINR-CONDOR.ru resource (neutrino platform cloud resources available in the DICE), which corresponds to 325 056 CPU hours. All completed jobs were launched by the Baikal-GVD Collaboration.

A prototype of a computing system to develop a distributed computing environment for the SPD experiment based on PanDA WFMS/WMS is being created in the JINR cloud. The FTS file transfer service and the Rucio data management service were deployed.

Heterogeneous Infrastructure

In 2023, the HybriLIT heterogeneous platform, which is a component of the JINR MICC, was actively developing. The next stage of modernization of the Govorun supercomputer, associated with the enhancement of the GPU component, took place. Five high-performance servers, each of which contains two AMD EPYC 7763 processors with 2 TB of RAM and eight NVIDIA A100 graphics accelerators with 40 GB of memory were introduced in the supercomputer. As a result, the total peak performance of the Govorun supercomputer reached 1.7 PFlops for double-precision operations (or 3.4 PFlops for single-precision operations), the total capacity of the hierarchical storage is 8.6 PB. The enhancement of the GPU component opened up new opportunities for lattice quantum chromodynamics computations, quantum computing using simulators, Big Data analytics, the development of algorithms based on a neural network approach for LRB experimental data analysis, data processing and analysis within the experiments at the NICA accelerator complex.

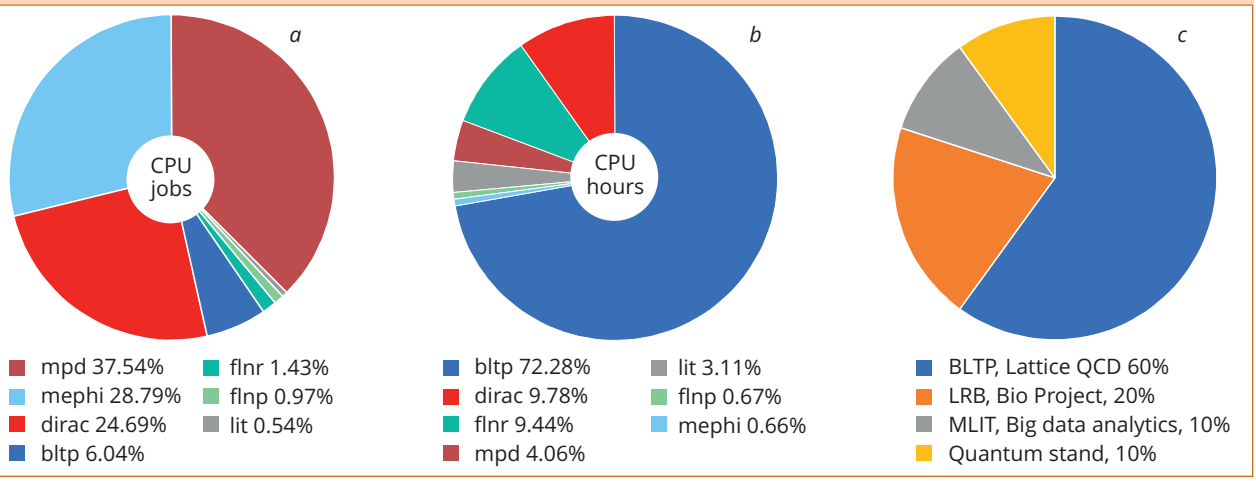
Within the task of creating a distributed data storage and processing system for the NICA project, a testing polygon was deployed. It comprises three Lustre distributed file systems and combines the Govorun supercomputer and the NCX computing cluster (VBLHEP). The Lustre distributed file system was built using disk resources and servers located on the MLIT and VBLHEP sites, and contains two disk pools, OST0 (server at MLIT) and OST1 (server at VBLHEP), integrated into one disk pool with the function of data mirroring between the OST0 and OST1 disk pools. This mechanism enables to write data to one pool and obtain a full copy of these data to the other pool, which significantly simplifies the procedure for transferring data from one computing resource to the other.

A quantum computing polygon with installed quantum computing simulators, namely, Cirq, Qiskit, PennyLane, was deployed on the resources of the ML/DL/HPC ecosystem of the HybriLIT platform. Expanding the polygon allows conducting research in the Jupyter environment, which makes it possible to visually work with quantum circuits and perform computations in the browser.

In 2023, there was made a transition to new software with the TurboVNC remote access client of the HLIT-VDI service, designed to organize user work in a graphical mode of access to software packages such as COMSOL, MAPLE, MATHEMATICA, MATLAB, etc. At the request of users, 113 software modules were installed and updated taking into account versioning.

The total number of Govorun supercomputer users is currently 312, of which 255 are JINR staff members, and 57 are from the Member States. Within 2023, all groups of Govorun supercomputer users completed 640 861 jobs on the CPU component, which corresponds to 16 million core hours, and 7808 jobs on the GPU component, which corresponds to 45 400 GPU hours. Figure 5 demonstrates

Fig. 5. Distribution of the resources of the CPU component of the Govorun supercomputer by user groups: *a*) by the number of jobs; *b*) by the number of core hours. Statistics on the GPU component usage (*c*)



the distribution of the resources of the CPU component of the Govorun supercomputer by user groups. The average load of the CPU component was 96.4%, while the GPU component load was 91.2%.

Monitoring and Accounting System

The successful functioning of the MICC is ensured by the monitoring and accounting system, which must be up-to-date. For these purposes, it is planned to enhance the monitoring system by integrating local tracking systems for power supply systems (diesel generators, power distribution nodes, transformers and uninterruptible power supplies) into it and create an engineering infrastructure control centre (special information panels for visualizing all statuses of the MICC engineering infrastructure in a single access point). The transition to the project planning of the scientific activity and resource planning on user requests entails the elaboration of a special accounting system for the use of the MICC resources by each project/user. At present, such an accounting system is organized for user groups on the MICC grid infrastructure. The Grafana system is employed to visualize accounting data. In 2023, a new database for storing monitored equipment characteristics was put into operation in the LITMon monitoring system. The use of the InfluxDB2 database made it possible to optimize the process of transferring data to the Grafana visualization system and organize data replication to enhance the security of the storage system.

Information Services

In 2023, work on the Digital JINR platform was intensively performed. The testing, deployment and integration of software packages for services and the basic infrastructure of the Digital EcoSystem (DES) (planning and project management, electronic help desk, authorization, digital archives, scientific information management, etc.) were carried out; a software environment and documentation for the development of digital services and their integration were prepared. Within the development of the DES shell and services, two-way communication with the GLPI system (project maintenance) to process user requests was implemented; the integration of the electronic document management system (EDMS) and the geographic information service (GIS) to link repair and construction contracts and capital construction contracts to specific buildings or premises was completed; a built-in service "Forms" was elaborated; some functions of the EDMS, ADB2, Document Database, etc., were connected to the DES in the form of separate services.

As part of the development and maintenance of the "Dubna" EDMS, the EDMS core was significantly modernized: a subsystem for archival storage of completed documents in PDF was developed, a subsystem for defining access rights was upgraded; a system for protection against hacker attacks and unauthorized access was enhanced; the user interface was modernized, its design was updated, and its operation was accelerated; seven new types of documents (Correspondence of JSC STRABAG, Technical conditions for design, Technical solutions for design and construction work, etc.) were elaborated; a new module "Statistics" was developed; adaptation to the new accounting and financial policy for projects and activities was completed.

Within the development of information services in the cloud infrastructure, a service for planning events, newdle.jinr.ru, was deployed on top of the Newdle system (analog of the popular Doodle service), and the JINR SSO login was implemented in it.

The support and development of the website hosting infrastructure (www.jinr.ru, flnph.jinr.ru, flerovlab.jinr.ru, micc.jinr.ru, mpdroot.jinr.ru, etc.) were in progress. The support and development of the infrastructure of administrative servers (pin.jinr.ru, adb2.jinr.ru, sed.jinr.ru, etc.), the pm.jinr.ru service (automated project management system), and the disk.jinr.ru service (cloud storage service for JINR staff members) were provided.

The work on the maintenance and modernization of central information servers, portals and databases for information support and software for the activities of MLIT (lit.jinr.ru) and JINR (www.info.jinr.ru, dissertations.jinr.ru, pepan.jinr.ru, etc.) was underway.

METHODS, ALGORITHMS AND SOFTWARE FOR MODELING PHYSICAL SYSTEMS, MATHEMATICAL PROCESSING AND ANALYSIS OF EXPERIMENTAL DATA

One of the main activities of MLIT is to provide mathematical, algorithmic and software support for experimental and theoretical research underway at JINR. In 2023, the design, development, implementation and maintenance of a user-friendly computing environment on the MLIT heterogeneous computing platform, which involves the HybriLIT cluster and the Govorun supercomputer, were of paramount importance. Highly needed and appreciated contributions were brought to the three-dimensional simulation asked by the NICA magnet validation, highest-level solutions of specific tasks within the BM@N, MPD and SPD experiments, the development of data processing system software for the Baikal-GVD experiment. The software development within the JINR contribution to the CMS and ATLAS Phase 3 experiments at CERN summarizes the best results produced within Theme 1119 for experimental data processing.

A summary of selected results is presented below.

A modern paradigm of test-driven development (TDD) to verify the MPD data reconstruction mechanism in the MPDRoot framework was implemented. Necessary changes to the codebase architecture, the diagnostic environment and data analysis are shown to enhance the potential for future developments of the reconstruction mechanism. The first results of a comparison of different modules are presented [6].

The first results within a study of the application of machine learning in the charged particle identification task in the MPD experiment were obtained [7]. A variation of the gradient boosting algorithm on decision trees, implemented in the CatBoost library, was used. A comparison of the algorithm with the n-sigma method, which is currently implemented in the MpdRoot software environment, evidenced the better capabilities of gradient boosting at small and large momentum values. The ongoing research was made possible thanks to the computing resources of the HybriLIT heterogeneous platform.

In 2023, the initial design and prototyping of the SPD online filter was completed. A workload management system [8], one of the key components of the online filter, was implemented. It comprises a server component responsible for data processing by generating and executing a sufficient number of jobs and an agent application that monitors and manages job execution on the compute node.

A data processing system for the Baikal-GVD experiment was developed and continues to be enhanced. It is characterized by simplicity, modularity and parallelism, corresponding to the physical properties of the neutrino telescope under construction. The modular architecture of the system enables to easily modify individual components, without compromising their integrity, and add new ones. The parallelism of the system consists of several levels. Firstly, the processing of individual clusters occurs in parallel on different virtual machines. Secondly, the processing of one cluster is performed in two sequential workflows: fast and offline processing. In both workflows, some jobs are also executed in parallel. The current state of the processing system has already made it possible to produce astrophysical results.

A web application that resolves the tasks of fitting data obtained on the small-angle neutron scattering spectrometer at the IBR-2 reactor and studying the shape and size of sample nanoparticles was developed [9]. The fitting process is parallelized using implicit multithreading and vectorization.

A new method for studying two-particle transverse momentum (P_T) correlations in soft hadronic interactions was proposed [10]. It is shown that Monte Carlo models, namely, PYTHIA 6 and Geant4 FTF (FRITIOF), give different predictions for the correlations in proton–proton interactions. The correlations are connected with the Schwinger mechanism of particle production and can be studied in current and future high-energy physics experiments, in particular, at NICA.

The mutual cancellation of contributions from the channels of attraction and repulsion in the scalar interaction in a thermal pion gas at finite temperatures was investigated [11]. The pressure of the interacting pion gas was calculated using the Beth–Uhlenbeck approach to the relativistic virial expansion with Breit–Wigner phase shifts for σ- and ρ-meson resonances. The result of the investigation explains the absence of the σ meson in the hadronic resonance gas model at low temperatures and the need to take it into account in the statistical model of chemical freezeout in heavy-ion collisions.

The review paper [12] devoted to modeling the process of electron hydration based on the approach developed by the authors within the dynamic polaron model was presented. The mathematical formulations of problems and computational schemes were elaborated, complexes of problem-oriented programs were created using MPI parallel programming technology. The results of the numerical

modeling and calculation of the observed physical characteristics of the electron hydration process under study were considered. The agreement of the obtained numerical results with the corresponding experimental data confirms the adequacy of the proposed approaches and the prospects for their further application and development.

The numerical simulation of experimental data accumulated at FLNP on the interaction of beta-amyloid peptide Aβ(25–35) with DPPC phospholipid membranes, which is devoted to the clarification of the role of beta-amyloid peptide (Aβ) as a key factor in Alzheimer's disease, enabled to elucidate the dynamic properties of lipid membranes regulated by the addition of melatonin, cholesterol and beta-amyloid peptide [13].

Investigations on the analysis of pion-nucleus scattering data for a number of target nuclei based on a microscopic model of the pion-nucleus potential were performed [14]. It is shown that the developed approach provides an adequate description of experimental data on pion-nucleus scattering in the energy region of the pion-nucleon (3,3) resonance and enables the study of the influence of the nuclear medium on pion-nucleon scattering. The developed theoretical approach and the numerical study procedure were adapted to the case of proton-nucleus scattering.

A modification of the thermal peak model (TPM) based on a system of two coupled hyperbolic heat conduction equations was proposed [15]. The action of the laser in the electron gas was taken into account through the source function, which was chosen in the form of a double femtosecond laser pulse. In the hyperbolic TPM, in contrast to the parabolic TPM, there are additional parameters that characterize the relaxation times of the heat flux in the electron gas and the crystal lattice. A numerical study of the solutions of the parabolic and hyperbolic equations of the TPM for the same physical parameters and a comparative analysis of the results obtained were carried out.

An original approach and an algorithm in the Maple system for solving the scattering problem in the single-channel approximation of the close-coupling method of the optical model, described by a second-order ordinary differential equation with a complex-valued potential and regular boundary conditions, were developed [16]. The efficiency of the proposed approach is shown by numerically solving the scattering problem and calculating the reference fusion cross section and metastable states for a pair of heavy ions $^{16}O + ^{144}Sm$ in the single-channel approximation of the close-coupling method.

Numerical simulations were carried out on a microscopic statistical model of a superfluid quantum solid, where regions of disorder, such as dislocation networks or grain boundaries, can coexist within the crystal lattice [17]. This model gives the opportunity to answer the question which real quantum crystals can exhibit the property of superfluidity and which cannot.

Using specific input validation procedures, a recursive algorithm for the automatic adaptive quadrature of one-dimensional Riemann integrals based on the Bayesian inference was developed to provide stable and reliable automatic solutions at critical stages of the solution path [18]. The Bayesian predictor-corrector algorithm provides an automatic solution to the integrand function conditioning at the ends of a subrange decision tree root. The new subrange partition strategy enables the highest accuracy available output under cancellation by subtraction.

The functional reduction method for Feynman integrals, developed at MLIT, was employed to calculate one-loop integrals corresponding to diagrams with four external lines [19]. The integrals that emerge in the calculations of radiative corrections to the amplitudes of light scattering by light, photon splitting in an external field and the Delbruck scattering were considered. For an arbitrary value of the space dimension d, new analytical results were produced for master integrals. For $d = 4$, compact expressions are given in terms of dilogarithms.

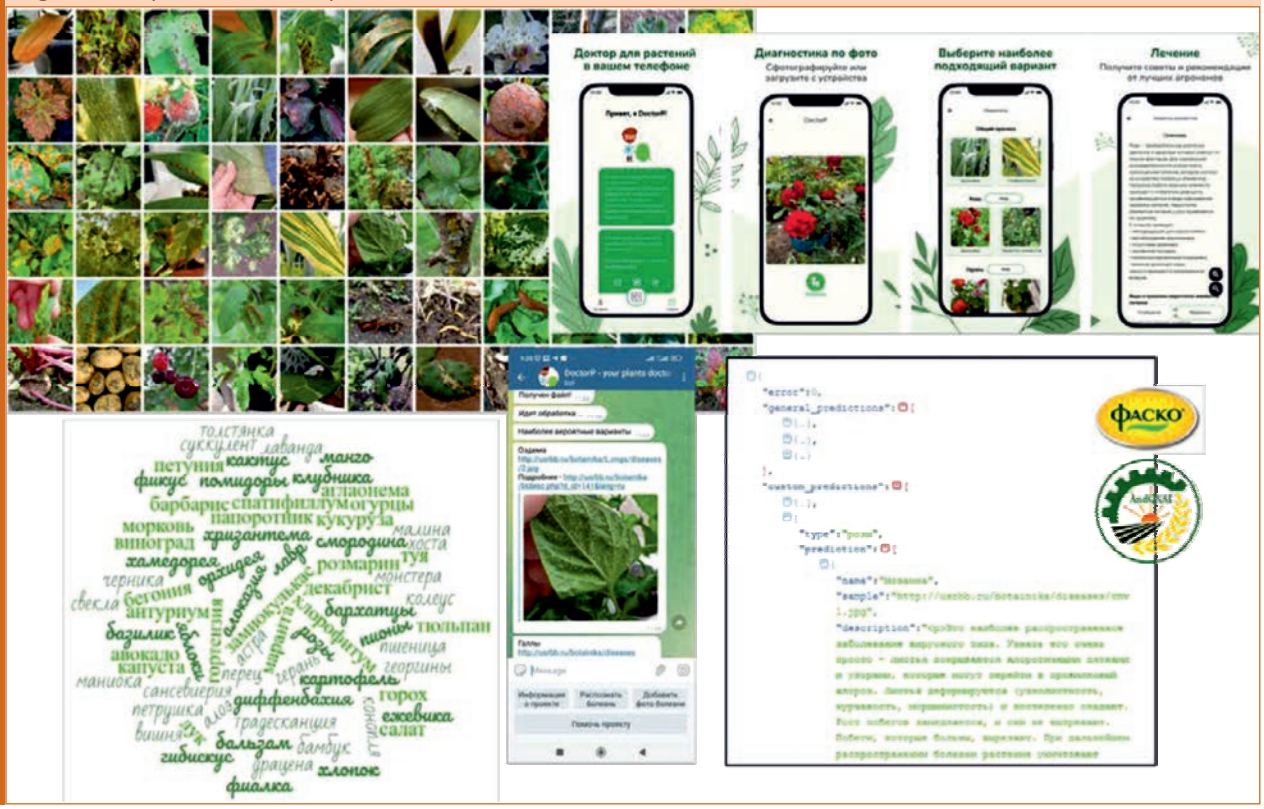
The interrelation between classicality/quantumness and symmetry of states was addressed within the phase-space formulation of finite-dimensional quantum systems [20]. It was found that the quantum states ordered with respect to their "symmetry" also exhibited the ordering with respect to their "classicality": the larger the symmetry, the more classical the quantum states are.

APPLIED RESEARCH

The design of embedded intelligent control systems based on fuzzy logic, neural networks, genetic and quantum algorithms for the task of nitrogen pressure stabilization in the cryogenic system of the test stand of the JINR VBLHEP magnet factory was completed. The efficiency of the system functioning was demonstrated experimentally [21].

Within the BIOHLIT joint project (MLIT and LRB), an algorithm for tracking a laboratory animal in the "Morris Water Maze" behavioral test was developed on the basis of computer vision methods. A web service prototype for the "Morris Water Maze", which enables to monitor the correctness of the generated trajectory on video and form a dataset in different representations, and a web service prototype for the "Open Field" behavioral test, the functionality of which allows one to resolve the laboratory animal tracking task, build a heat map, count the sectors covered and provide the user with summary analytics, were elaborated.

Fig. 6. Examples of DoctorP platform interfaces



In 2023, within a joint project between MLIT and BLTP, the development of a service for modeling systems based on Josephson junctions was in progress. The service was supplemented with materials for modeling the Josephson junction dynamics under the influence of external radiation using the example of a superconductor–insulator–superconductor type transition [22]. Algorithms to calculate the current-voltage characteristic (CVC) of a Josephson junction under the influence of external radiation and find the Shapiro step width on the CVC curve were developed using Python in the Jupyter Book environment. A parallel algorithm to compute the dependence of the Shapiro step width on the external radiation amplitude was implemented, and the efficiency of the parallel implementation was demonstrated.

A platform and a mobile application (DoctorP) (Fig. 6) for detecting plant diseases and pests are being developed at MLIT [23]. Both a general model capable of detecting 68 disease classes and specialized models for 29 ornamental and agricultural crops are available. In 2023, the platform processed over 70 000 user requests. To obtain a prediction and treatment recommendations from experienced agronomists, one just needs to send a photo showing the problem. The platform can be accessed by third-party applications and services. Garden Retail Service (formerly Fasko) and the Andijan Institute of Agriculture and Agrotechnology (Uzbekistan) have already took advantage of this opportunity.

A software complex for creating digital twins of distributed data acquisition, storage and processing centres (DDCs) was developed and registered in the Register of Russian Computer Programs [24]. The uniqueness of this program is that the digital twins created with its help effectively monitor the DDC functioning in terms of data flows and related tasks. A DDC digital twin is a virtual copy of a data centre that demonstrates how it operates under any possible scenario. A successful verification of the simulation program was performed using the example of the operation of the computing infrastructure of the BM@N experiment at the NICA accelerator complex during the 8th physics run in 2023.

INTERNATIONAL COOPERATION

The first in the Republic of Kazakhstan and 11th JINR cloud computing cluster was introduced in the JINR distributed information and computing environment. Staff members of scientific institutes and universities of Kazakhstan will be able to use the resources of the INP cloud cluster within their own research and as part of cooperation with JINR, participating in the NICA and Baikal-GVD megascience projects. The cluster, included in the DICE of JINR and the JINR Member States' organizations, allows

Almaty, 11 November. A festive opening of the new JINR cloud computing cluster at the INP

accessing a larger number of hardware resources than in the case of using the INP cloud only locally, which opens up opportunities for scientists to produce scientific results in a shorter time.

As part of the collaborative programme with the University of Cape Town (RSA), a study of the structure and properties of spherically symmetrical, time-periodic, spatially localized objects of a finite radius in the ϕ^4 model depending on the size of the radius and the frequency of oscillations was carried out at MLIT [25]. A parallel version of the Matlab script developed to enhance the performance of computations of Floquet multipliers enabled to reduce the computation time by more than 10 times. The computations were performed on the HybriLIT platform and using the Govorun supercomputer.

With the active participation of MLIT specialists, a catalog of events of the ATLAS experiment (LHC),

18–19 April. JINR Spring School of Information Technologies

20 October. JINR Autumn School of Information Technologies. Winners of the Parallel Computing Hackathon

EventIndex, was created and is dynamically developing [26]. MLIT specialists were actively involved in the modernization of the system: the monitoring system was significantly enhanced; the transition to the Grafana platform was made; a new service for the automatic search and collection of events (Event Picking Service) was created, which made it possible to collect events for the second stage of the analysis of the production of *W* gauge boson pairs during the interaction of two photons ("$\gamma\gamma \to WW$") with the least amount of manual labor.

Within the JINR–Bulgaria Collaboration, periodic approximate solutions to the three-body problem were resolved with high accuracy [27]. Investigations were performed on the Govorun supercomputer and the Nestum cluster (Sofia, Bulgaria). A high-precision database of 462 choreographic orbits, including 397 new ones, was established.

EDUCATIONAL PROGRAMME ON THE EDUCATION AND TESTING POLYGON

In 2023, the education and testing polygon of the HybriLIT platform was actively used for conducting semester-long training courses and within schools and workshops. On the basis of the polygon, training courses were held within the JINR Autumn School of Information Technologies, the Workshop "Modern Information Technologies in Biology and Medicine", the V International Summer School of Young Scientists "Computer Technologies for Scientific and Applied Tasks" (NOSU), the XVI International Internship for Young Scientists from the CIS Countries, in which 210 students participated. To conduct offsite training courses and seminars at Dubna State University, the HybriLIT mobile cluster was deployed. It is noteworthy that semester-long training courses in the IT disciplines "Architecture and Technologies of High-Performance Systems", "Parallel Distributed Computing", "Languages and Technologies of Data Analysis", "High-Performance Computing Technologies", "Mathematical Computing Software", held at Dubna State University and Tver State University, were attended by 310 students. In addition, five Bachelor's and seven Master's theses were prepared on the basis of the HybriLIT platform.

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LABORATORY of RADIATION BIOLOGY

In 2023, the Laboratory of Radiation Biology (LRB) continued studies within the framework of Themes 04-9-1077-2009/2023 "Research on the Biological Effect of Heavy Charged Particles of Different Energies" and 04-9-1112-2013/2023 "Research on Cosmic Matter on Earth and in Nearby Space; Research on the Biological and Geochemical Specifics of the Early Earth".

MOLECULAR RADIOBIOLOGY

The modifying effect was studied of the inhibitor of DNA repair synthesis, cytosine arabinoside (AraC), on the formation of radiation-induced DNA double-strand breaks (DSBs) in normal and tumor cells *in vitro* [1]. It has been shown that upon irradiation with protons in the presence of AraC, the number of DNA DSBs increases with post-irradiation incubation time up to 24 h by six and three times in the nuclei of fibroblasts and glioblastoma, respectively, compared with the number of DNA DSBs in cells without an inhibitor. The dose change factor (DCF) according to the criterion of the lethal effect of protons on glioblastoma cells in the presence of AraC is 1.75, which indicates a significant radiosensitizing effect of AraC on U87 glioblastoma cells (Fig. 1).

A DNA comet assay was performed of DNA DSB induction and repair in human peripheral blood lymphocytes after X-ray exposure at doses of 0–10 Gy *in vitro* at a Precision CellRad facility (5 mA, 130 kV, 1.5 Gy/min) under normal conditions and in the presence of AraC. It has been shown that DNA DSB formation is more efficient in the presence of AraC; the DCF was 1.39. During 6 h of post-irradiation incubation in the presence of the inhibitor, the number of DNA DSBs continuously increased; by the 6th h, it exceeded the control level of damage by 9.2 times.

The combined effect of AraC and SCR7, an inhibitor of the repair enzyme ligase IV, on DNA DSB induction in B16 mouse melanoma cells was assessed *in vitro* after 1.25-Gy proton irradiation. A significant increase in the number of DNA DSBs was observed in the presence of a combination of the two modifiers. A comparative analysis shows that after proton exposure, in the presence of AraC and a combina-

Fig. 1. *a*) Formation and elimination kinetics of γH2AX/53BP1 foci in the nuclei of human skin fibroblasts irradiated with protons at 1.25 Gy under normal conditions (•) and in the presence of AraC (■); *b*) formation and elimination kinetics of γH2AX/53BP1 foci in the nuclei of U87 glioblastoma cells irradiated with protons at 1.25 Gy under normal conditions (•) and in the presence of AraC (■); *c*) U87 glioblastoma cell survival after irradiation with spread-out Bragg peak protons in the presence of AraC (20 μM)

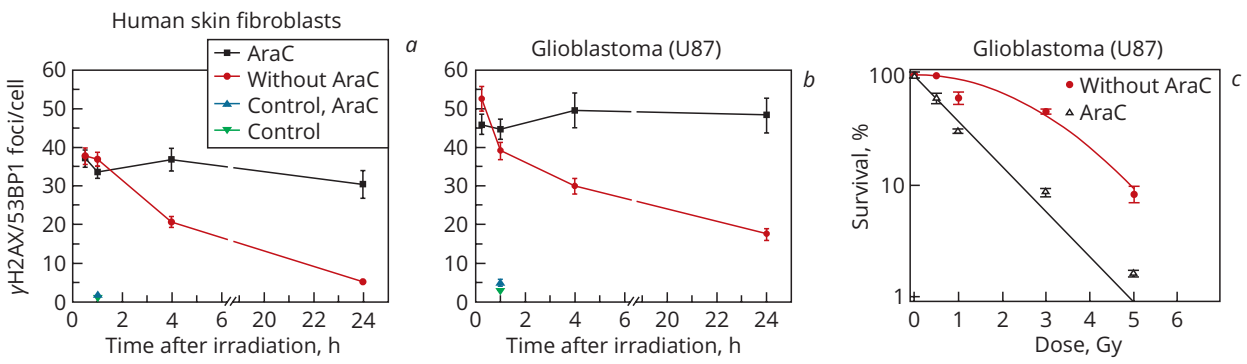
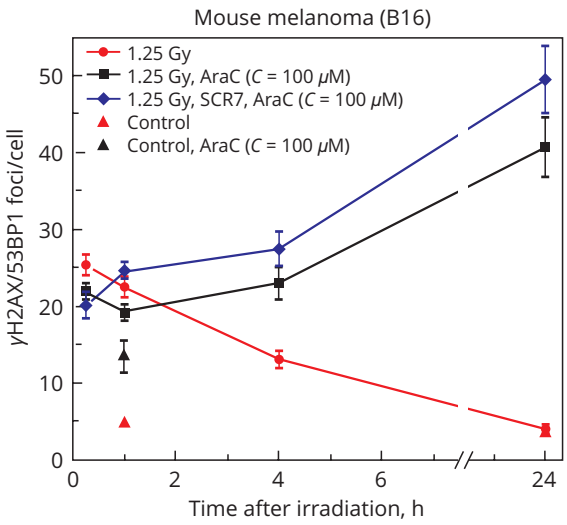


Fig. 2. Formation and elimination kinetics of γH2AX/53BP1 foci in the nuclei of B16 mouse melanoma cells irradiated with protons at 1.25 Gy under normal conditions (•), in the presence of AraC at a concentration of 100 μM (■) , and in the presence of a combination of AraC (100 μM) and SCR7 (♦)



tion of the inhibitors AraC (100 μM) and SCR7, the number of DNA DSBs in melanoma cells sharply increases after 24 h: 10- and 12.5-fold, respectively (Fig. 2).

The molecular and cellular mechanisms of the combined effect of AraC and fractionated proton radiation on the B16 mouse melanoma were studied *in vivo*. For combined exposure, compared with proton irradiation alone, the mean volume of tumors decreased by 1.7–3.4 times at different observation periods ($p < 0.05$) (Fig. 3, *a*). In the combined exposure group, 13% of animals showed short-term regression of the primary melanoma focus and long-term survival until the end of observation. At the molecular level, it has been found that the number of DNA DSBs in tumor cells two days after the completion of irradiation sessions significantly exceeds that after exposure without a modifier (Fig. 3, *b*). It has also been found that the introduction of AraC enhances the antitumor effect of proton radiation through several mechanisms, including a decrease in the number of tumor stem cells and inhibition of cell proliferation and angiogenesis in the tumor against the background of changes in the immune response in the primary focus and its infiltration by lymphocytes [2, 3].

An analysis was performed of DNA DSB formation in mature neurons and neural stem cells (NSCs) of a primary rat hippocampal culture after 1.25-Gy irradiation with ^{15}N ions (180 keV/μm). The kinetics of DNA DSB formation is characterized by a curve with a maximum at 4 h, followed by a decrease in the number of DNA DSBs, occurring at the same rate in both cell types. After 24 h, the residual DNA DSB level is 35% and 40% of the maximum for mature neurons and NSCs, respectively. The patterns were studied of the formation of clusters of radiation-induced foci (RIF) in mature neurons of a primary rat hippocampal culture after exposure to radiation with different physical characteristics. It has been shown that with increasing LET, the RIF formation peak shifts to later times after irradiation, and RIF cluster complexity also increases (Fig. 4).

Fig. 3. *a*) Changes in the size of the primary B16 melanoma focus at different times after proton irradiation and combined exposure to proton radiation and AraC in comparison with the control. The 10-Gy irradiation sessions are marked with vertical arrows. * — $p < 0.001$ compared with the control. *b*) The number of DNA DSBs in the primary focus of the murine B16 melanoma two days after irradiation with protons and combined exposure to AraC and protons at 10 Gy

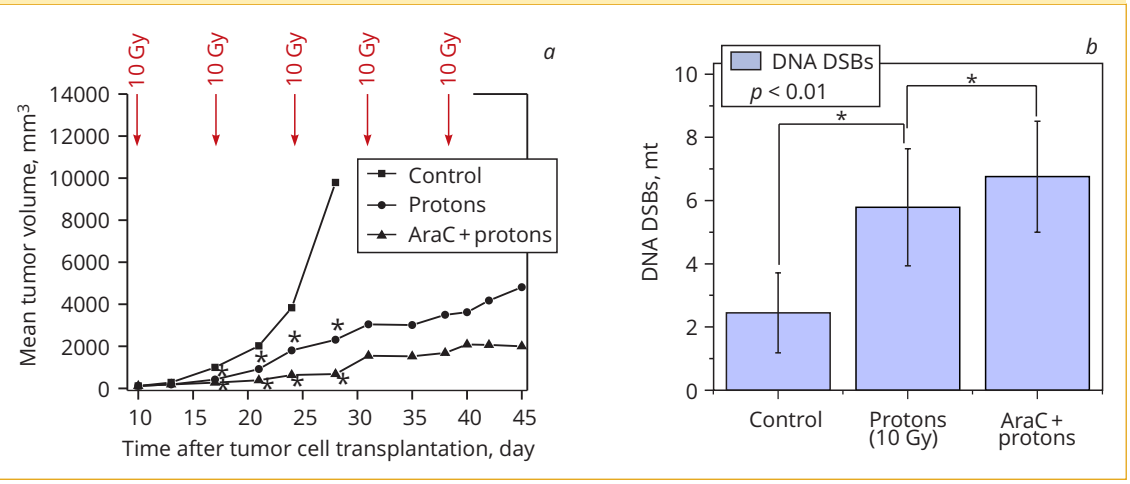
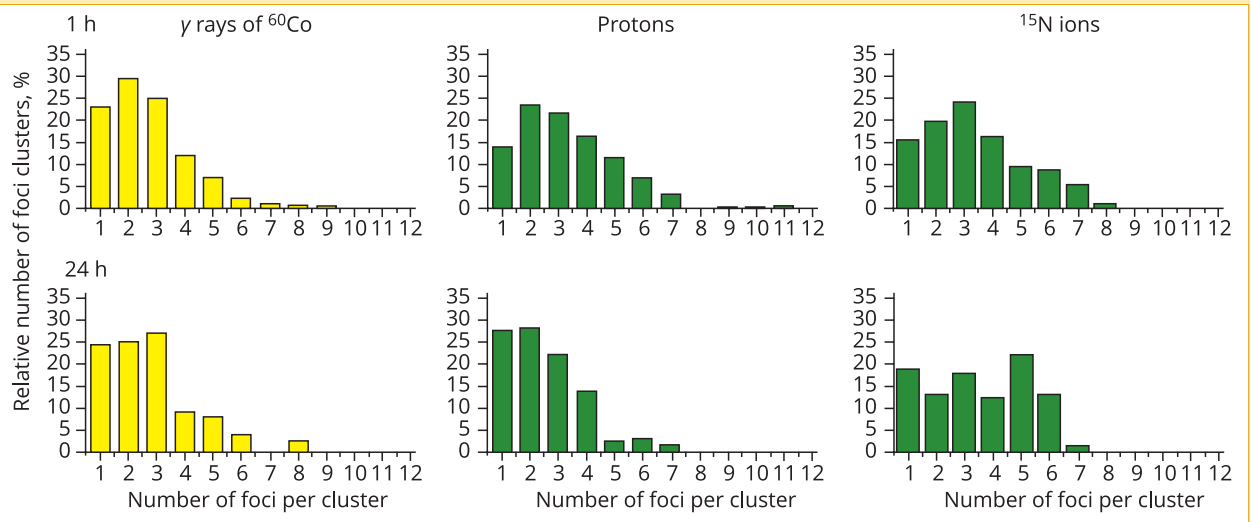


Fig. 4. The structure of complex foci clusters in mature neurons of a primary rat hippocampal culture 1 and 24 h after irradiation with *y* rays, 170-MeV protons, and ^{15}N ions (180 keV/μm) at 1.25 Gy. The abscissa is the number of individual foci in a complex cluster, the ordinate is the relative number of clusters of a certain complexity from the total RIF yield analyzed in 3D geometry



RADIATION GENETICS AND CYTOGENETICS

A metaphase analysis was performed of chromosomal aberration formation in human Cal51 carcinoma cells and normal human peripheral blood lymphocytes after irradiation with photons and protons (150 MeV and Bragg peak). Using the method of premature chromosome condensation, the proportion of successfully repaired chromatin breaks was assessed 12 h after irradiation. After exposure to *y* rays, a more effective repair of chromatin breaks was observed in tumor cells compared with normal cells than after proton irradiation (Fig. 5). These results indicate the preference for the use of proton beams in radiation therapy for breast carcinoma [4].

In collaboration with the A. Tsyb Medical Radiological Research Centre (Obninsk, Russia), a cytogenetic study of the side effects of radioiodine therapy for thyroid tumors was conducted [5]. Using the mFISH method, it has been shown for the first time that the iodine radiopharmaceuticals induce in blood cells predominantly unstable chromosomal aberrations, while the level of stable chromosomal aberrations, which are a possible trigger of secondary carcinogenesis, increases slightly (Fig. 6).

The yield of cells with chromosomal aberrations was assessed at different observation times (up to 40 days) after 0.5–7-Gy irradiation of Chinese ham-

Fig. 5. Effectiveness of chromatin break repair in normal human lymphocytes and Cal51 carcinoma cells

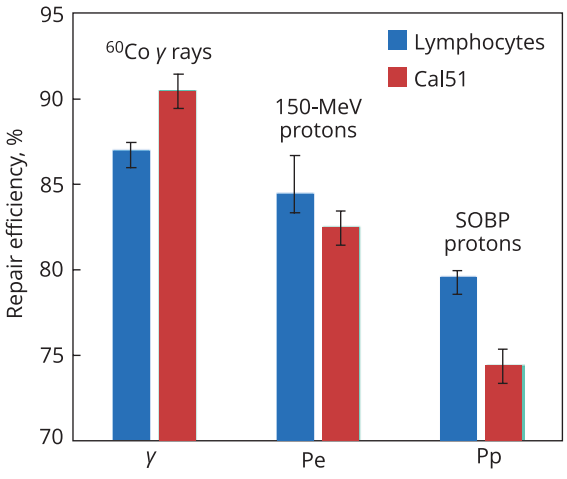


Fig. 6. The frequency of aberrant cells in blood lymphocytes after four-time administration of ^{131}I (open symbols denote the proportion of stable aberrant cells; dark ones — the proportion of aberrant cells)

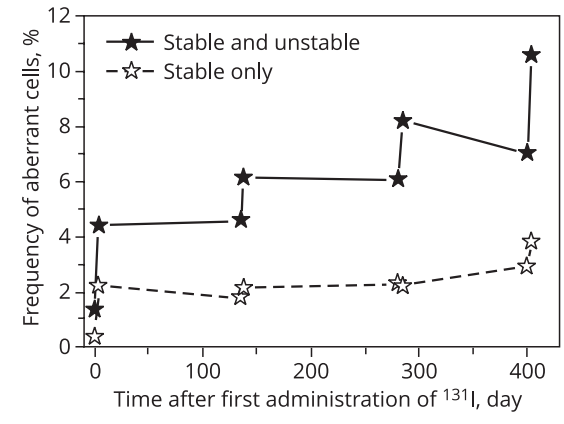


Fig. 7. Dose dependences of the formation frequency of cells with chromosomal aberrations (*a*) and the total number of chromosomal aberrations (*b*) in Chinese hamster cells at different times in the post-radiation period

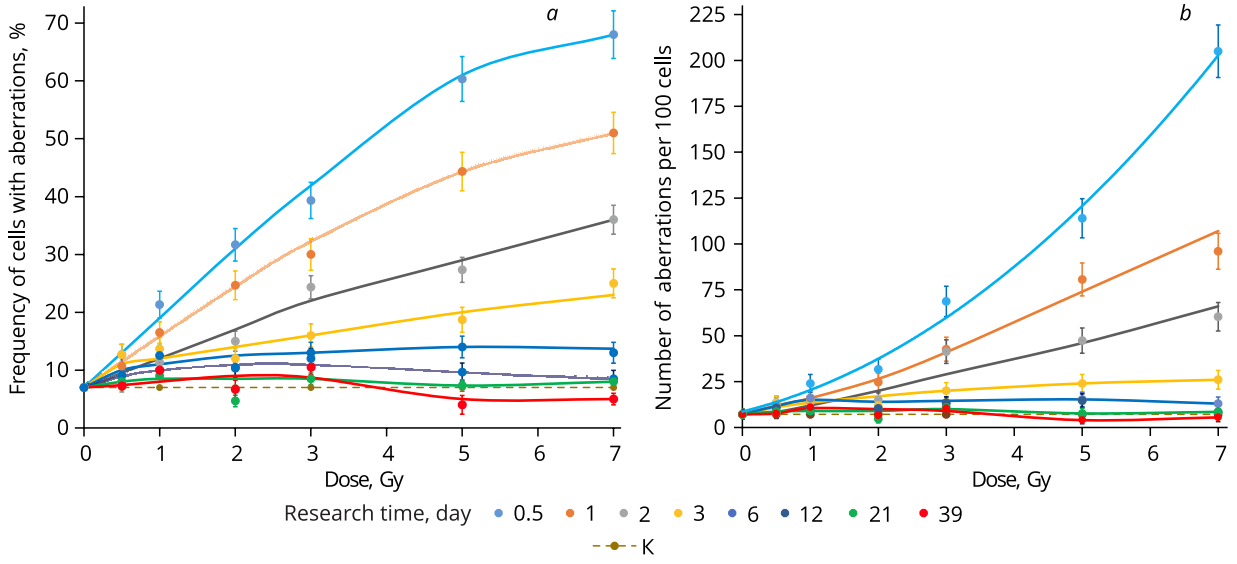
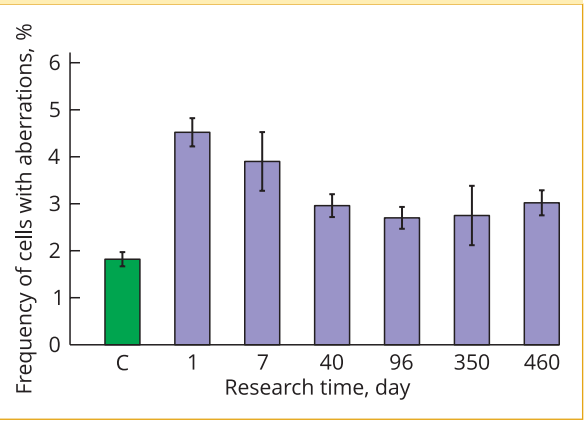


Fig. 8. Dynamics of the yield of cells with chromosomal aberrations after local irradiation of the hippocampal region of *Macaca mulatta* monkeys with ^{78}Kr ions. C denotes the control level

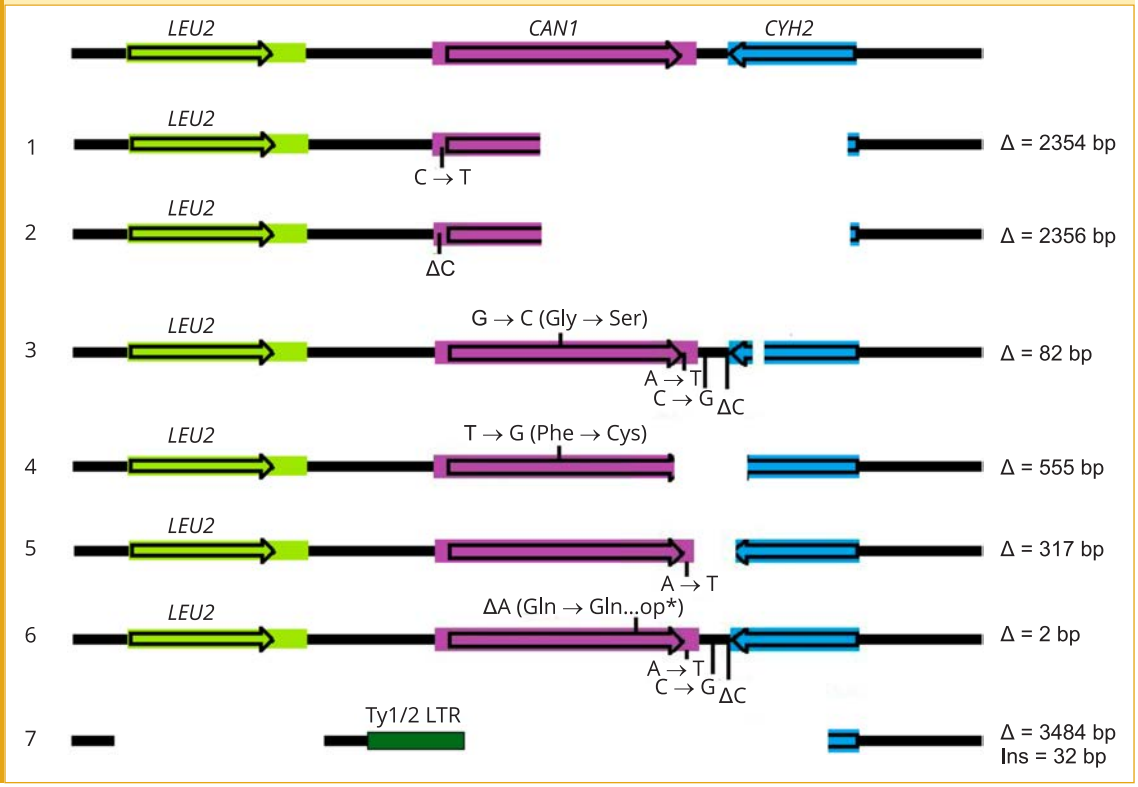


ster cells with ^{60}Co *y* rays. The maximum yield of aberrations was observed 12 h after exposure (Fig. 7).

A study was conducted of cytogenetic abnormalities that occur in the blood lymphocytes of *Macaca mulatta* monkeys after cranial irradiation with accelerated ^{78}Kr ions at a dose of 3 Gy (Fig. 8). Cytogenetic analysis of peripheral blood lymphocytes of the irradiated animals showed the maximum level of chromosomal abnormalities 24 h after irradiation (2.5 times higher than the control level). During subsequent observation periods, the level of aberrations decreased, but by the 460th day of the study it was still 1.7 times higher than the control level. The analysis of biochemical and hematological parameters of the animals' blood and neurological manifestations revealed a correlation between some biochemical and hematological parameters with the manifestation of neurological reactions, expressed in deviations from the standard behavior in some of the irradiated animals.

An analysis of gene mutation spectra induced by *y* rays and accelerated heavy ions was conducted. The mutation spectra were dominated by base pair substitutions, single nucleotide deletion, and complex mutations, which are a combination of substitution and deletion within one DNA turn. Heavy ions have been shown to induce complex mutations more effectively. A plasmid system was used to analyze structural rearrangements. Using genetic, electrophoretic, and restriction analysis, the size and location of induced lesions were determined. Sequencing of plasmid DNA from 9 mutants that lost DNA parts involving two (8 mutants) and three (1 mutant) genes showed the exact location and size of the deletions (Fig. 9).

Fig. 9. A scheme of deletions involving two (1–6) or three (7) genes on the YCpL2 plasmid (13.8 thousand base pairs). Significant base pair substitutions are indicated at the top, neutral ones — at the bottom; insertion of a Ty1/2 LTR fragment is shown in green

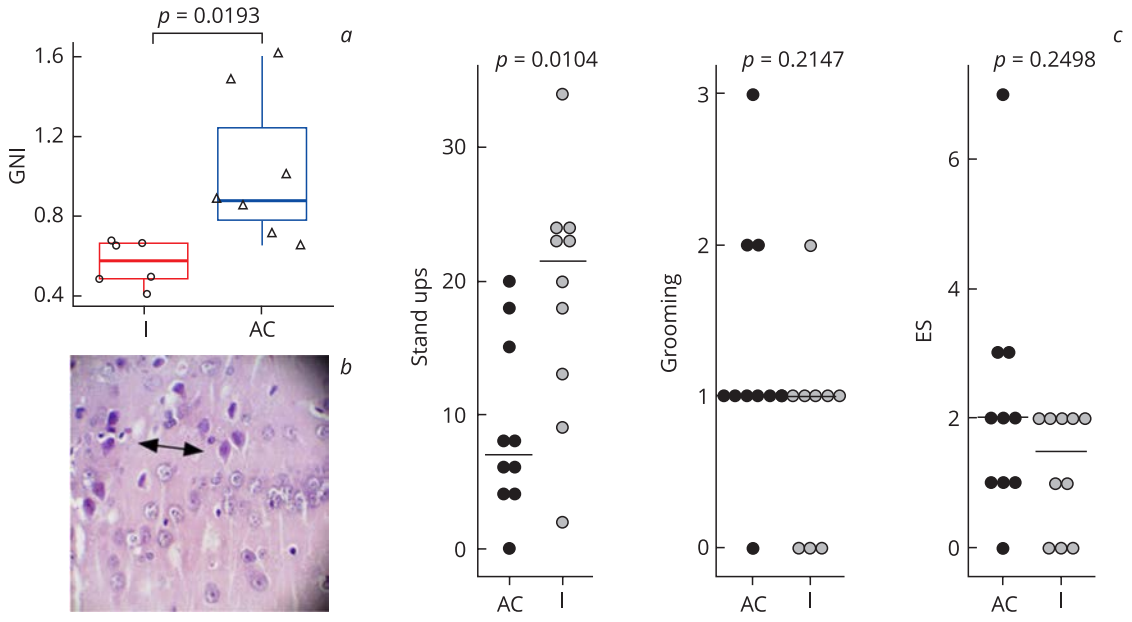


RADIATION PHYSIOLOGY

The effect of 2-Gy ^{60}Co *γ*-ray irradiation on behavioral reactions, immunohematological status, and morphofunctional changes in neurons in the central nervous system of seven-month-old ICR mice was studied [6]. Deviations in the behavior of irradiated animals using an open field test were revealed, expressed in an increase in the number of rearings and a change in the strategy of motor activity. After irradiation, the development of leukopenia and a decrease in the glioneuronal index in the brain parenchyma of mice were observed (Fig. 10).

Radiobiological research related to the study of the effects of radiation on the behavioral reactions of laboratory animals

Fig. 10. The effect of a single irradiation with ^{60}Co *γ* rays at 2 Gy on seven-month-old male ICR mice 30 days after irradiation: *a*) glioneuronal index (GNI); *b*) diffusely scattered dark neurons in the CA1 region of the hippocampus; *c*) changes in rearings, grooming, and emotional status (ES) of rodents. AC — aged control, I — irradiation

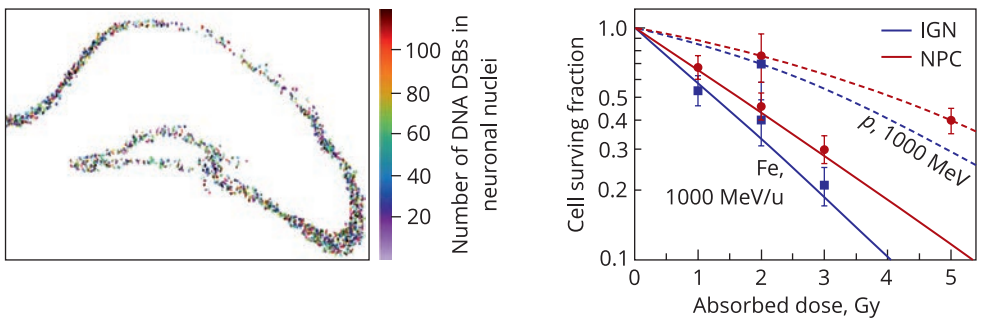


The software product "Intelligent System for Analysis of Behavioral Patterns" is being developed. Software based on neural network algorithms for automated processing of video data obtained in behavioral experiments with small laboratory animals using specialized stands allows for automatic detection and classification of specific forms of behavior.

MATHEMATICAL MODELING OF RADIATION-INDUCED EFFECTS

Based on a model developed using the Geant4-DNA software toolkit, formation patterns and the composition of radiation-induced DNA damage clusters in mammalian and human cells were analyzed. The damaging effect of the hadronic component of the galactic cosmic rays on the cellular structures of the rodent brain hippocampus was modeled (Fig. 11). It has been shown that more than 70% of DNA single-strand breaks are induced by protons, while complex clusters of DNA double-strand breaks (DSBs) — mainly by iron ions [7]. Based on data on DNA damage in the nuclei of nerve cells, the survival

Fig. 11. Spatial distribution of DNA DSB induction in the nuclei of hippocampal neurons after irradiation with iron ions at a fluence of $1.7 \cdot 10^5$ cm^{-2} (left) and the survival of neural progenitor cells (NPC, red lines, •) and immature granule neurons (IGN, blue lines, ■) after irradiation with 1000-MeV protons (dashed lines) and 1000-MeV/nucleon iron ions (solid lines) (right)



rates were calculated of the radiosensitive population of undifferentiated neurons of the subgranular zone of the hippocampus after exposure to heavy charged particles (Fig. 11, *b*).

Using an LRB's own mathematical model of radiation impairment of neurogenesis, a long-term change was calculated in the number of newly formed neurons after irradiation of adult C57BL/6J mice with accelerated ^{12}C (1000 MeV/nucleon), ^{28}Si (300 MeV/nucleon), and ^{56}Fe (1000 MeV/nucleon) ions [8].

A mathematical model has been proposed that combines two main concepts of the tumor growth theory: stochastic growth and the presence of a subpopulation of tumor stem cells [9]. Based on the model, experimental data on the inhibition of B16 melanoma tumor growth *in vivo* upon proton irradiation in combination with AraC were interpreted.

Molecular dynamics modeling of NMDA and AMPA receptors containing modified amino acid residues was carried out. In the course of modeling, the electrophysiological activity of neurons with a modified structure of glutamate receptors, changes in the conductivity of the ion channel of glutamate receptors and in the local potential were determined depending on damage type and location. With modifications of *Tyr731Niy* and *Cys765Ocs* to NMDA, as well as *Met407Omt* and *Met585Omt* to AMPA glutamate receptor, an increase in the amplitude of the theta rhythm is observed in the neural network. In the case of damage to one *Tyr732Niy* in AMPA and double damage to *Tyr731Niy–Tyr732Niy* and *Cys765Ocs–Met585Omt* in NMDA and AMPA, there is an increase in the rhythm amplitude of the gamma-frequency range.

ASTROBIOLOGY

The micropaleontological study of the Murchison, Allende, Jbilet Winselwan, Orgueil and other carbonaceous chondrite meteorites, as well as samples of Lower Proterozoic gneisses, was continued using a scanning electron microscope with an X-ray microanalyzer. New discoveries of remains of prokaryotic (threads and sheaths) and eukaryotic (deformed rounded shapes with crumpled folds) microorganisms were made in meteorite samples. It has been shown that fossilized microorganisms can be preserved in metamorphic rocks. Reviews of research on the problems of bacterial paleontology, the emergence of homochirality, and abiogenic synthesis of prebiotic compounds have been made [10, 11].

RADIATION PROTECTION PHYSICS AND RADIATION RESEARCH

The development of new approaches to modeling the mixed radiation field at charged particle accelerators for radiobiological experiments continued. Software has been registered [12] for optimizing the parameters of a model of an irradiation installation that simulates the mixed radiation field at charged particle accelerators. This software includes all the necessary functionality for processing data obtained using Monte Carlo programs for ionizing radiation transport simulation, bringing them into the required format, optimizing parameters, and determining the quality of the model, and also includes tools for visualization, plotting, and automatic report generation based on the results obtained.

A prototype of a dosimeter with a proportional helium counter of high-energy neutrons (100 eV – 1 GeV) has been created to measure the ambient neutron dose in the radiation fields of JINR accelerators. A new method has been developed for reconstructing the energy spectrum of a neutron flux from the readings of a Bonner spectrometer based on the regularized decomposition of a spectrum into Legendre polynomials [13, 14].

Calculations are underway of radiation conditions at the NICA accelerator complex facilities and in the Measurement Hall of Building No. 1 for applied research at the ISCRA and SIMBO stations during scheduled sessions.

CONFERENCES AND EDUCATION

In 2023, LRB staff members took part in 27 international and Russian scientific conferences.

On 19–20 October, an International Conference entitled "Current Problems in Radiation Biology. Molecular Genetic Research in Radiobiology. To the 70th Anniversary of DNA Structure Discovery" was held in Dubna. It was participated by more than 100 radiobiologists from Armenia, Azerbaijan, Belarus, Russia, and Serbia. The Proceedings of the Conference were published at its beginning (Dubna: JINR, 2023. 129 p.).

19–20 October. Participants of an International Conference “Current Problems in Radiation Biology. Molecular Genetic Research in Radiobiology. To the 70th Anniversary of DNA Structure Discovery” on an excursion at the Laboratory

The educational process continued at the Department of Biophysics of Dubna State University. The Department’s current total enrollment is 24 students and six postgraduates. Five students successfully completed their programmes and received a Master’s degree in physics.

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UNIVERSITY CENTRE

A festive opening of a new building of the JINR University Centre

EDUCATIONAL PROCESS ON THE BASIS OF JINR

In 2023, an educational process was organized for students from the basic departments of MSU, MEPhI, MIPT, Dubna State University, St. Petersburg State University, and Kazan (Volga Region) Federal University. 550 undergraduate and graduate students from universities of the JINR Member States completed internships and practical training at JINR.

In 2023, the UC organized the programme for the examination of PhD students of the JINR Basic Department at MIPT "Fundamental and Applied Problems of Microworld Physics" for nine JINR employees attached to the Department. Since 2018, 44 people have passed candidate exams at the Department.

Six people are assigned to JINR to prepare dissertations for the scientific degree of Candidate of Sciences without mastering postgraduate training programmes.

INTEREST Programme

In 2023, 71 students and postgraduate students of scientific and technical specialties from Armenia, Belarus, Brazil, Cuba, Egypt, Great Britain, Hungary, India, Mexico, Russia, Saudi Arabia, Serbia, Uzbekistan, and Vietnam took part in two stages of the online programme INTEREST (INTErnational REmote

Participants of the START programme get acquainted with the Govorun supercomputer

Student Training at JINR). The programme involves working on scientific projects online. The number of programme participants has reached 327 since 2020. Find more details about the programme on the UC website: http://interest.jinr.ru/.

START Programme

In 2023, 62 students from universities in Armenia, Belarus, Cuba, Egypt, France, Great Britain, India, Kuwait, Mexico, Russia, and Uzbekistan took part in the winter and summer sessions of the programme known as START — STudent Advanced Research Training at JINR (students.jinr.ru). For 6–8 weeks, participants personally carried out research projects under the guidance of JINR staff. Since 2014, 376 people have participated in the programme.

International Student Practice

In May and June, two stages of International Student Practice were organized for students from Egypt and for students from South Africa. In total, 50 people participated in the programme in 2023. An eventful cultural and educational programme has been prepared for the students. They worked on scientific projects in theoretical physics, life sciences, radiobiology, computing and machine learning, biophysics and particle physics, some were engaged in the engineering workshop at the UC. As a result of work in collaboration between the Egyptian students and FLNP specialists, an article was published in the "Nanomaterials" journal.

Workshops for Students

On 30 March – 3 April and 16–20 November, two Schools on the physics of quark-gluon matter were held at JINR. The event was organized by the JINR University Centre and the JINR Basic Department at MIPT "Fundamental and Applied Problems of Microworld Physics". The Schools were attended by 65 students of 1st–4th year studying elementary particle physics. They represented MIPT, MSU, MEPhI, Bauman MSTU, state universities of St. Petersburg, Tomsk, Voronezh as well as Novosibirsk State Technical University, FEFU, and Belarusian State University. The participants had lectures and excursions to the NICA collider and MLIT. The main purpose of the School is to make young scientists curious about the science being developed at JINR, to describe scientific prospects of participation in experiments at the NICA complex: some are being prepared for the upcoming launch by a large international team of the MPD (Multi-Purpose Detector) and SPD (Spin Physics Detector) Collaborations, some are already being carried out at the BM@N (Baryonic Matter at Nuclotron) facility.

The Summer Scientific School "Physics and Technology of Accelerators" was organized by JINR in collaboration with Tomsk Polytechnic University (TPU) in July for students of 3rd–4th year from technical universities of the JINR Member States who major in engineering and physics and are interested in modern accelerator technologies. There were 32 students from Gomel (Belarus), Kazan, Moscow,

16 May. The first stage of the International Student Practice of the UC for young specialists from the Arab Republic of Egypt. Introductory lecture at FLNR

7–23 June. The second stage of the International Student Practice of the UC for young specialists from RSA

30 March – 3 April. Intensive School on Physics for MIPT students

Novosibirsk, Petrozavodsk, St. Petersburg, Saratov, Voronezh, and Yakutsk. During the four days of the event, the participants attended lectures given by leading scientists and professors from JINR, Tomsk Polytechnic University, Institute of High Current Electronics SB RAS (Tomsk), Institute of Nuclear Physics SB RAS (Novosibirsk). The programme was prepared together with TPU and covered a wide range of topics in the field of accelerator technology, introduction to the NICA accelerator complex, the DC-280 cyclotron and the Factory of Superheavy Elements.

SA–JINR Summer School

On 16 January – 4 February, the traditional South Africa–JINR Summer School was held in the Republic of South Africa (RSA). The School's three-week programme included lectures on accelerator technologies, nuclear physics, swift heavy ions in radiation materials science, nuclear medicine, computing in high-energy physics, the use of neutrons in life sciences, nanoscience, and many more.

Thirty-six students from 10 South African universities gathered at iThemba LABS, the School's traditional venue.

Nineteen specialists from VBLHEP, FLNR, FLNP, DLNP, and the UC introduced the participants to the history of JINR, the educational programmes and opportunities for young people at JINR, held lectures, seminars, workshops, and JINR exhibition activities. All this was complemented by lecturers from 11 African universities and educational institutions.

Educational Issues and Training Programmes at International Meetings

Reports on international scientific cooperation and training programmes, as well as mutual visits and opportunities for students and young scientists were presented at the following international meetings:

- 22nd International Training Programme for Decision-Makers in Science and International Scientific Cooperation (JEMS) (24–28 April);
- 8th Academic Conference on Natural Science for Young Scientists, Master and PhD Students from ASEAN Countries (Association of South East Asian Nations) in Vinh (Vietnam) (28–30 August);
- 23rd International Training Programme for Decision-Makers in Science and International Scientific Cooperation (JEMS) (11–15 September);
- Expanded Meeting of the JINR–Mexico Joint Coordination Committee at CONAHCYT (National Council of Humanities, Sciences and Technologies of Mexico, Mexico City) (17 October);
- 5th Meeting of the BRICS Working Group on Research Infrastructure (BRICS GRAIN) (Stellenbosch, South Africa) (23–25 October).

JINR Information Centres

UC specialists organized lectures and excursions both personally and online for the Information Centres of FEFU, KamSU, TPU, SOGU, NArFU, as well as for groups from Dubna, Moscow, Novgorod, Solnechnogorsk, Tver, etc.

Events

In 2023, UC employees, together with representatives of the Institute's Laboratories, organized and participated in exhibitions, lectures, excursions, workshops, and physical demonstrations at various events:

- All-Russian Science Festival "NAUKA 0+" in Moscow at the Expocentre and Moscow State University;
- Festival of Science, Technology and Art "Geek Picnic" in the Muzeon art park;

18 May. International Workshop “Open Information and Educational Environment to Support Fundamental and Applied Interdisciplinary Research at JINR”

- Physics Workshop “Element 105” (Summer School);
- Day of JINR Basic Departments at Dubna State University;
- Career Day at MIPT;
- Career Booster at MIPT;
- Career Day at MEPhI;
- Forum “Physics Career 2023” at St. Petersburg State University.

INTERACTION WITH PUPILS AND TEACHERS

Collaboration with Educational Organizations of Dubna

Physics and Mathematics Open Classroom, UC Physics Workshop, and Yandex Lyceum are organized and run in Dubna with the support of JINR.

To finish its 20th academic year, on 19 May, the Physics and Mathematics Open Classroom traditionally held the XXXIII Open Olympiad for school children in grades 6–7. Over 50 students from nine educational institutions of Dubna and Logos Gymnasium of Dmitrov participated in the Olympiad.

In the 2023/24 academic year, the Physics and Mathematics Open Classroom organized classes in physics and mathematics for students in grades 6–8. Classes in experimental physics and preparation for the Unified State Exam in physics were organized for 10-grade students.

Starting from 14 August, schoolchildren and students from colleges and polytechnics could apply for a full-time programming course in Python at the Yandex Academy Lyceum based at Lyceum No. 6 named after G. N. Flerov. The two-year course covers the basic concepts, constructs and libraries of Python. New online programmes are also available at the Lyceum.

Schools for Teachers at JINR

On 3–7 April, the Scientific School for Physics Teachers from Kamchatka was held at JINR. Fourteen teachers came to Dubna from different districts of this region. The visit was organized with the support of the JINR Information Centre at Kamchatka State University.

On 3–7 July, 20 teachers from 18 regions of Russia and one representative of Armenia took part in the International Scientific School for Physics Teachers held at JINR.

The programme of the Schools included exhibition “JINR Basic Facilities”, introductory lectures and visits to VBLHEP, FLNR, and MLIT, Virtual Laboratory Research Workshop and practice in the Virtual Lab for nuclear physics studies, demonstration

of physics experiments, tours around the Blokhintsev Library, Dubna State University, and the Kadyshevsky Physics and Mathematics Lyceum.

Summer Schools

In July, the UC took part in organizing and conducting the VII Summer School "Physics. Mathematics. Informatics" at Dubna State University and the Summer Session of "Dialogue" School.

At the beginning of July, the 35th Summer International Computer School (ICS-2023) named after V. Volokitin and E. Shirkova took place. Fourty-six students in grades 5–11 from Moscow and the Moscow Region, Saint Petersburg, Krasnodar, and Primorsky Territories were selected based on the results of a creative competition and took part in the event.

On 25–29 September, the 3rd Science School for Students of the Children's University of the Egyptian Academy of Scientific Research and Technology was held at JINR. The schoolchildren actively explored the Laboratories and projects of the Institute and also had hands-on physics practicums at the JINR University Centre.

Physics Days 2023

On 24 November, the 8th Festival "Physics Days", organized by the JINR University Centre, took place in Dubna. Partners of the event included Dubna State University, the Kadyshevsky Physics and Mathematics Lyceum, and Lyceum No. 6 named after G. N. Flerov.

The events took place at two venues, the UC building on Vavilova St. and at Lyceum No. 6. The Festival programme included natural science and technical carousel for students, a quiz for young physicists, a quest, scientific demonstrations, an interdisciplinary team battle, and physics, biology, ecology and robotics workshops. More than 180 students in grades 3–10 from Dubna, Dmitrov and Dolgoprudny educational institutions participated in the Festival.

Open Robotics Tournament "CyberDubna-2023" and Hackathon "Dubna-2023"

On 22–23 April, the Kadyshevsky Lyceum became the venue for the Open Robotics Tournament "CyberDubna-2023" organized by the JINR University Centre. The Tournament was a team competition based on the Arduino platform. Teams from Dolgoprudny, Dubna, Pravdinsky (Pushkino District), Protvino, Taldom, Zaprudnya (Taldom District) competed in the tournament.

Sixteen teams from the Moscow Region took part in the competition in designing and programming robots. Fourty-five children, mostly school students in grades 7–10 from Dolgoprudny, Dubna, Korolev, Moscow, Orudyevo, Protvino, Taldom, and Zaprudnya participated in the qualifying stage, which took place at the Kadyshevsky Lyceum.

3–7 April. Teachers of physics from the Kamchatka Region — participants of the Scientific School at JINR

24 November. The 8th Festival “Physics Days” at Lyceum No. 6, organized by the JINR University Centre

Teaching Manuals for School

UC specialists prepared a set of school textbooks for advanced study of physics in grades 7–9. The set includes a textbook, a problem book, a workbook, as well as virtual workshops and methodological support. The textbooks were published by the Prosveshchenie Publishing House in 2023 and approved by the commission of the Ministry of Education of the Russian Federation. Textbooks for high-school students are in progress.

Visits

As part of career guidance work with school and university students and teachers, the UC organized introductory tours for a group of teachers participating in the “Path to the Stars” Scientific School, for a group of Moscow pupils as part of the “Popular Science Tourism” initiative of the Decade of Science and Technology, and for a group of students from the Khoroshevsky School in Moscow.

PROFESSIONAL AND QUALIFICATION TRAINING

Over the 2023/24 academic year, 81 JINR employees are taking course of the English language, and 17 foreign specialists are studying in Russian language groups.

Training courses for personnel servicing facilities under the jurisdiction of Rostechnadzor were organized for 80 JINR industrial employees.

Thirty-nine students from Dubna University College, Moscow Power Engineering Institute College and Dmitrov Technical School undertook their internship at JINR.

Engineering Training

Sixty-six people from Russia (Dubna State University, St. Petersburg State University, Far Eastern Federal University, Chechen State University, MEPhI) and South Africa took part in the UC engineering workshops in 2023. Development plans include expansion of training capacity for more people, work on the Linac-200 training site is also to be continued.

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 2023 are reflected in the following data:

— joint research was conducted with scientific centres in the Member States, as well as with international and national organizations in other countries, on 42 topics of first priority and one topic of second priority;

— the Joint Institute sent 1419 specialists to solve cooperation issues and issues of participation in scientific meetings and conferences;

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

— 49 international scientific conferences and schools, 19 workshops, and 13 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 18 January, in Moscow in the A. Alexandrov Scientists Club at an extended meeting of the Scientific Council of NRC KI, Scientific Leader of the Joint Institute V. Matveev was awarded the Academician A. Alexandrov Medal, 1st degree, a new award of the NRC "Kurchatov Institute", for his contribution to the development of atomic science and technology.

President of the Russian Academy of Sciences G. Krasnikov and Scientific Leader of the NIKIET E. Adamov also won the 1st degree medal. The medal of the 2nd degree was given to A. Kuzmin, Director-General of the Joint Institute for Power and Nuclear Research – Sosny of the National Academy of Sciences of Belarus. The awards were presented

Moscow, 18 January. JINR Scientific Leader Academician V. Matveev is awarded the Academician A. Alexandrov Medal instituted by the NRC "Kurchatov Institute". The Medal was handed by President of NRC KI M. Kovalchuk (right) and Director of NRC KI M. Kambolov (left) (*photo: NRC "Kurchatov Institute"*)

by President of the Centre M. Kovalchuk and Director of the Centre M. Kambolov.

In the year of its 80th anniversary, the NRC "Kurchatov Institute" established its own medals: Academician A. Alexandrov Medal and Academician I. Kurchatov Gold Medal.

On 18 January, the Council of Heads of National Groups of the JINR Member States resumed its work at the International Conference Centre. The new Head of the national group of Kazakhstan, Ye. Mukhamedzhanov, was elected Chairman of the Council, and Heads of the national groups of Moldova and Cuba C. Hramco and K. Shtejer Díaz were elected his deputies. Senior Specialist of the International Cooperation Department P. Benesova became the Secretary of the Council.

During the meeting, besides the discussion of organizational issues, it was decided to develop a new Regulation on the Council. The meeting was attended by the leaders of all national groups of the JINR Member States, with the exception of Georgia, as well as by representatives of the Institute's Leadership, namely, JINR Chief Scientific Secretary S. Nedelko, Head of the International Cooperation Department D. Kamanin, Deputy Chief Scientific Secretary of the Institute O.-A. Culicov, Head of the Human Resources and Records Management Department E. Kolganova, and Deputy Head of the International Cooperation Department A. Kotova.

On 8 February, during his visit to JINR, Head of the RF Ministry of Science and Higher Education V. Falkov took part in the meeting with young scientists of the Institute, which was held in the format of a round-table discussion. The main topics of the discussion were the achievements and results of the last run at the accelerator complex, as well as targeted support for young and experienced researchers in work on the megascience-class facility.

The event was attended by JINR employees from Russia, Belarus, Bulgaria, Cuba, Kazakhstan who worked at the NICA run and participate in the development and implementation of the physical programme of the complex, as well as representatives of Russian scientific organizations: Petersburg Nuclear Physics Institute of the National Research Centre "Kurchatov Institute", National Research Nuclear University MEPhI, Moscow Institute of Physics and Technology, and Moscow State University.

The Head of the Ministry congratulated the scientists of the Joint Institute on the Day of Russian Science and talked about the results of the eighth stage of the megagrant competition in 2022. The participants of the discussion spoke about the programme of youth laboratories that is being developed in Russia. The Minister suggested that staff members of the NICA complex join it. Currently, 740 such laboratories have been established in the country, and 900 in total are planned. If the laboratory being created passes a competitive selection, it receives long-term support. In conclusion of the visit, V. Falkov visited the site of the NICA complex, where he got acquainted with the progress of the project.

On 8 February, in Kolkata (India), an inception meeting was held in preparation for the G20 Research and Innovation Ministers' Meeting. The meeting was aimed at a general discussion of the given topics and their elaboration for discussion at the upcoming forum. Research and innovations for a just society were the main topic of the discussion. Scientific Secretary of FLNR JINR A. Karpov took part in the meeting.

During the meeting, the following priority areas were discussed: materials for sustainable energy; scientific challenges and opportunities to achieve a sustainable blue economy; biodiversity and bioeconomics; eco-innovations in the energy sector.

A. Karpov spoke on the first two topics. He highlighted the importance of fundamental scientific research and international cooperation for sustainable socio-economic development. This year's G20 events are being held under the motto "One Earth. One Family. One Future."

On 11–15 February, a JINR delegation led by Deputy Head of the Department of Science Organization Activities A. Zhemchugov visited Egypt to participate in the 7th Cairo International Exhibition of Innovation. The JINR stand was placed at the exhibition, which arosed great interest among visitors and participants.

The organizers of the exhibition were the Egyptian Academy of Scientific Research and Technology and the Ministry of Higher Education and Scientific Research of Egypt. The strategic partners were JINR and the Egyptian Science and Technology Development Fund (STDF). Since 2014, the Academy of Scientific Research and Technology has annually (with a break from 2019 to 2023) held International Exhibitions of Innovation in Cairo, where scientists, inventors, employees of technology transfer centres, and representatives of high-tech companies meet and share their innovative ideas.

On the opening day of the event, at the invitation of Plenipotentiary of the Government of Egypt to JINR Professor M. Sakr, the JINR stand was visited by Minister of Higher Education and Scientific Research of Egypt M. Ashour accompanied by Minister of Higher Education and Scientific Research of Sudan M. Dahab and Minister of Science, Technology and Higher Education of Portugal E. Fortunato. M. Ashour welcomed the members of the JINR delegation and asked questions about the research areas of the Institute and the participation of Egyptian scientists in joint scientific projects.

The JINR stand was of great interest to visitors and participants. The audience of the exhibition and participants of panel discussions and round tables spoke warmly about the country of the Institute's location. The members of the delegation noted the high level of qualification of many visitors who asked academic questions and demonstrated interest and

Dubna, 13–14 February.
Ceremonial presentation of the Order of Friendship to Academician-Secretary of the Department of Physics, Mathematics and Informatics of the National Academy of Sciences of Belarus A. Shumilin according to the Decree of the President of the Russian Federation

high level of awareness about the activities of the Institute.

On the same day, a thematic round-table "JINR: Unlimited opportunities for international cooperation" was held, at which members of the JINR delegation made presentations on the topics of the Institute's international activities and training programmes, and also spoke about innovative projects both in general at JINR and, in particular, within the NICA project and at the FLNR cyclotron complex.

On 12 February, JINR representatives visited the National Research Centre located in the central district of Cairo Dokki, where they discussed the prospects of cooperation with the President of the Centre Professor H. Darwish and Vice-President for Research and International Cooperation Professor M. Moawad Ali.

On 14 February, the JINR delegation participated in the panel discussion "Scientific diplomacy in a changing world", in which E. Badawy made a presentation on the JINR experience as a platform for the implementation of scientific diplomacy.

On 13–14 February, Academician-Secretary of the Department of Physics, Mathematics and Informatics of the National Academy of Sciences of Belarus A. Shumilin visited Dubna. From 2014 to 2022, A. Shumilin was Plenipotentiary of the Government of the Republic of Belarus to JINR. At the meeting with the JINR Directorate, in a festive setting, A. Shumilin received the Order of Friendship for his contribution to the strengthening of scientific and technical cooperation between Russia and the Republic of Belarus.

During the visit, several working meetings were held on the issues of strengthening cooperation between the Institute and the Department of NAS of Belarus. A. Shumilin visited the JINR Laboratories of Information Technologies, Nuclear Reactions, and High Energy Physics.

On 16 February, at the 133rd session of the JINR Scientific Council, an official ceremony of signing a Joint Declaration of Intent was held between the National Council of Humanities, Sciences and Technologies of Mexico (CONAHCYT) and the Joint Institute for Nuclear Research. The document, which reflects plans of the parties to work together in the field of advanced fundamental and applied scientific research, was signed by JINR Director G. Trubnikov in the presence of Ambassador Extraordinary and Plenipotentiary of the United Mexican States to Russia E. Villegas Megías. CONAHCYT Director-General M. E. Álvarez-Buylla Roces signed the document on the part of Mexico.

A report by President of the Mexican Physical Society and Professor of the Physics Institute of the National Autonomous University of Mexico (UNAM) A. M. Cetto Kramis preceded the signing of the Declaration. Dr. Cetto Kramis dedicated her report to the expansion and promising areas of cooperation between Mexico and JINR, such as the use of synchrotron radiation to study the characteristics of new materials, theoretical and experimental studies in the field of plasma physics, nuclear, radiological safety, dosimetry, as well as radiation physics and chemistry.

On 22–24 February, a JINR delegation, led by Vice-Director V. Kekelidze, was in Belgrade, where it took part in the 8th meeting of the Joint Coordination Committee on Cooperation. The meeting was dedicated to the celebration of the 75th anniversary of the Vinča Institute of Nuclear Sciences, the main

Dubna, 16 February.
The signing ceremony of a Joint Declaration of Intent between the National Council of Humanities, Sciences and Technologies of Mexico (CONAHCYT) and JINR at the 133rd session of the Scientific Council

Serbian partner of JINR. The events were held at the Serbian Academy of Sciences and Arts.

On 22 February, during the festive ceremony, V. Kekelidze handed over to the leadership of the Vinča Institute an image of one of the architectural symbols of Dubna — the JINR Administrative Building, familiar to all Dubna residents and guests of the Institute, noting that the long-term cooperation with the Vinča Institute covers a number of scientific areas, including radiobiology, accelerator technologies, radiation materials science, analytical methods, theoretical physics, as well as the educational sphere.

On 23 February, the Vinča Institute hosted the 8th meeting of the JINR–Serbia Joint Coordination Committee on Cooperation, at the opening of which the audience was greeted by the co-chairs of the meeting — Director of the Vinča Institute S. Pajović and Vice-Director of JINR V. Kekelidze.

Representatives of scientific organizations and universities of Belgrade and Novi Sad took part in the meeting from Serbia. JINR was represented by LRB Director A. Bugai and FLNP Deputy Director O.-A. Culicov, who made presentations on the state of cooperation at their laboratories and the prospects for its further growth. R. Rymzhanov, a senior researcher at FLNR, also participated in the work of the Committee, representing one of the oldest mainline joint projects using the accelerator capabilities

Belgrade, 23 February.
The 8th meeting of the JINR–Serbia Joint Coordination Committee on Cooperation at the Vinča Institute

of both FLNR and the Vinča Institute for work on materials science with accelerated heavy ions.

The Committee noted the high efficiency of most of the 24 existing projects, as well as the high demand for the possibilities of cooperation between research teams of Serbia and JINR, in connection with which, along with the distribution of funds from the next contribution of Serbia to existing projects, the possibility of launching new promising joint research was provided.

On the same day, State Secretary V. Grozdić received the JINR delegation at the Ministry of Science, Technological Development, and Innovation. They talked about mutually beneficial cooperation between Serbian scientific organizations and JINR, and further steps for its development.

On 24 February, the JINR delegation visited the Astronomical Observatory of Belgrade, which is one of the oldest scientific institutes in Serbia. The Observatory's Directorate expressed great interest in expanding cooperation with the Joint Institute.

The work of the delegation in Belgrade finished with a meeting of JINR representatives with the Vice-President of the Chamber of Commerce and Industry of Serbia, Z. Vujović, who visited Dubna the day before, toured JINR laboratories and took part in the 133rd session of the Scientific Council, and also discussed practical steps to expand cooperation with the JINR Directorate. The signing ceremony of the decisions of the Joint Coordination Committee on Cooperation took place in the presence of Z. Vujović.

On 2 March, a regular meeting of the JINR Science and Technology Council took place online and at the International Conference Centre in person. The key topic of the event was the results of the past meetings of the JINR governing bodies and the discussions of the JINR Seven-Year Plan. The scope of the Council's activities over the past five years was presented at the end of the JINR STC meeting in its current membership.

The meeting was opened by the report of JINR Director G. Trubnikov. The speaker said that the first in-person meetings of PACs after the pandemic were held with membership of participants considerably renewed. At the meetings of all PACs, detailed reports were made on the draft of the new Seven-Year Plan for the Development of JINR for 2024–2030 that will undergo thorough expertise for the next meetings of the PACs.

The Scientific Council of the Institute also met in a new membership. Among its participants are researchers from scientific centres in Argentina, Brazil, Chile, China, Mexico, Russia, the USA, and European countries. An intergovernmental agreement with Mexico was signed. The Scientific Council highly appreciated the achievements of JINR laboratories, highlighting the physical experiments at the NICA complex and the bright results of the Baikal-GVD project. The active work of the JINR UC with the universities of the Member States and Partner Countries was noted.

The report on the work of the JINR STC for 2018–2022 was represented by Chairman of the Council R. Jolos. The Council held from four to five meetings a year, excluding the period of the coronavirus pandemic. During this period, such issues as expanding the horizons of international scientific and technological cooperation, preparation of the concept of JINR innovation activities, the formation of scientific qualification certification systems at JINR based on the right to independently confer academic degrees, the creation of a higher engineering school at Dubna University, the progress of the NICA project, and many others were considered. Concluding the report, R. Jolos highlighted that the JINR STC is the only body under the Directorate representing the research team of the Institute.

At the end of the meeting, G. Trubnikov expressed gratitude for the work done to the current membership of the JINR STC and its leaders: Chairman R. Jolos, Deputy Chairman E. Strokovsky, and Scientific Secretary of the STC E. Kolganova.

On 3 March, in honour of the 110th anniversary of the birth of the famous scientist Georgy N. Flerov (2.03.1913–19.11.1990), the founder and first Director of the Laboratory of Nuclear Reactions of JINR, members of the JINR Directorate and leadership of the Laboratory of Nuclear Reactions laid flowers at the monument to G. Flerov on Veksler Street. The key event of the celebration was a special seminar dedicated to the memory of the scientist, as well as a presentation of the book issued in commemoration of the anniversary of Academician Flerov's birth.

JINR Director Academician G. Trubnikov opened the seminar with a welcoming speech. He highlighted that Flerov was gifted with brilliant scientific intuition and, at the same time, with perseverance, which allowed him to defend the ideas and experiments in which he believed, involving people around him in them, starting with students and ending with the leaders of the country.

S. Dmitriev, JINR Vice-Director, highlighted that the main memory of Flerov are the achievements of FLNR JINR and the name of element 114, flerovium, of the Periodic Table.

At the seminar, speakers devoted their reports to different stages of the scientist's life path. Yu. Oganessian, Scientific Leader of the JINR Laboratory of Nuclear Reactions and an outstanding student of G. Flerov, spoke about the beginning of Flerov's career, his student years, about the history of the discovery of uranium spontaneous fission in 1940 and work with I. Kurchatov, whom Flerov considered his teacher all his life.

Academician R. Ilkaev, Honorary Scientific Leader of the Russian Federal Nuclear Centre – All-Russian Scientific Research Institute of Experimental Physics (RFNC-VNIIEF, Sarov), spoke about the role of G. Flerov in the Soviet atomic project and his contribution to the development of the VNIIEF. During a short period, the scientist created a school of experimental physics at this institute and laid the

foundations for creating a unique base of facilities for nuclear physics and radiation research. In the atomic project, Flerov's group was responsible for creating methods and conducting critical mass measurements, and organized about a thousand experiments. After the first test of the atomic project, Flerov was awarded the title of Hero of Socialist Labour.

Advisor to the Presidium of the Russian Academy of Sciences Academician B. Myasoedov (Vernadsky Institute of Geochemistry and Analytical Chemistry of RAS) delivered to participants of the seminar a welcoming message by President of the Russian Academy of Sciences G. Krasnikov and Vice-President of the Russian Academy of Sciences S. Kalmykov, in which they wish FLNR further success in the scientific activity. Academician Myasoedov devoted his report to the synthesis and study of superheavy elements by G. Flerov.

As part of the special event, a presentation of the photo book "Academician Georgy Nikolaevich Flerov. Portrait against the Background of the Epoch" was held. The book of the RMP (Real Modern Pictures) Publishing House, which publishes biographical and corporate books, is dedicated to the life and path in science of the famous scientist. It was prepared at the suggestion of Director of the Flerov Laboratory of Nuclear Reactions S. Sidorchuk. Yu. Oganessian, the editor of the JINR Weekly Newspaper "Dubna: Science, Community, Progress" E. Molchanov, and the JINR Scientific Information Department under the leadership of B. Starchenko helped to publish the book.

The publication includes a large number of previously unpublished photographs and documents from the JINR and FLNR archives, as well as from personal archives.

On 3–4 March, a delegation of rectors of universities of the Republic of Uzbekistan visited JINR. The delegation included Rector of the Mirzo Ulugbek National University of Uzbekistan I. Madjidov, Assistant Rector of the National University of Uzbekistan A. Aripov, and Vice-Rector for Science and Innovations of Samarkand State University H. Khushvaktov.

The goal of the visit was to get acquainted with the Institute and discuss the prospects for the development of the cooperation between JINR and leading universities of Uzbekistan. At the meeting with the Institute's Directorate, JINR and Samarkand State University signed an agreement.

The meeting participants discussed nuclear medicine and theoretical physics as areas for expanding cooperation in personnel training, as well as scientific cooperation. Uzbek representatives expressed their interest in applied studies and capacities of the JINR computer cluster. The possibilities of joint work on the modernization and expansion of the scientific infrastructure of the universities of Uzbekistan, which would be an excellent base for training highly qualified staff members and the development of cooperation with JINR, were discussed. The participants of the meeting also paid attention to the format of JINR Information Centres.

The delegation visited a number of laboratories of the Institute. There were working meetings with the Institute's specialists, a visit to the interactive exhibition "JINR Basic Facilities", as well as a visit to the Dubna University.

On 6 March, at the Shore Centre of the neutrino telescope on Lake Baikal, Minister of Science and Higher Education of Russia V. Falkov met with representatives of JINR and eight leading scientific institutes and universities of Russia: INR RAS, Irkutsk State University, Lebedev Physical Institute of RAS, MEPhI, Skobeltsyn INP of MSU, Novosibirsk National Research State University, Tomsk Polytechnic University, and Kabardino-Balkarian State University. The participants discussed the establishment of a nationwide development programme in neutrino physics and astrophysics, the results and prospects for the development of the Baikal deep underwater neutrino telescope and the intermediate results of the current expedition.

More than 60 people are involved in research on the telescope, and about 30 are regularly present on the ice of Lake Baikal. Among the tasks of the expedition in 2023 are the installation of two new clusters of optical modules and three service buoy stations with calibration lasers, continuation of work on the development of a data transmission system via optical lines inside the facility, as well as laying two bottom cable lines of cluster power supply. By 2030, eight to ten more telescope clusters will be installed, which will ensure the registration of high-energy astrophysical neutrinos with an effective volume of up to 1 km^3. In addition, it is planned to develop microbiological studies of the benthos communities of Lake Baikal using genetic analysis methods by JINR and the Limnological Institute of the Siberian Branch of RAS.

Based on the physical data already collected by the telescope, the project participants were able to confirm the presence of a neutrino flux of astrophysical nature, previously detected by the IceCube neutrino telescope. The collaboration article with the first results of the search for astrophysical neutrinos in the Baikal-GVD project was published in the high-rank scientific journal "Physical Review D." The authors analyzed data for the last four years and identified 25 candidate events for neutrinos of astrophysical nature.

In Russia, five scientific and educational organizations joined their efforts to create the Baikal-GVD Neutrino Telescope: INR RAS, Skobeltsyn INP of MSU, Irkutsk State University, Nizhny Novgorod State Technical University, and Saint Petersburg State Marine Technical University. Together with JINR, the collaboration includes the Comenius University (Bratislava, Slovak Republic), the Czech Technical University (Prague), and the Institute of Nuclear Physics of the Ministry of Energy of the Republic of Kazakhstan.

Irkutsk, 7 March. Opening of the JINR Information Centre at Irkutsk State University (*photo: Irkutsk State University press office*)

On 7 March, the JINR Information Centre opened at Irkutsk State University. The same day, a cooperation agreement was signed between JINR, Irkutsk State University, and the Institute of Nuclear Physics of the Russian Academy of Sciences on the opening of the astrophysical laboratory in Irkutsk. In addition, an agreement was signed between Irkutsk State University and Tomsk Polytechnic University on participation in the TAIGA and Baikal-GVD projects. The first events, i. e., a lecture by the JINR Director and the opening of the "Do Science in Dubna" exhibition, took place at the IC site.

The Infocentre will become a venue for scientific, educational, and popular scientific events in the field of modern physics. The JINR IC will allow online tours of all of the Institute's main facilities and introduction to megascience projects. The Infocentre will host lectures, laboratory works, and trainings by scientists from Dubna for students, schoolchildren and their teachers.

As part of the programme of events in Irkutsk, JINR Director G. Trubnikov delivered a lecture in the Governor's Hall of the ISU White House. Academician Trubnikov spoke about the NICA megascience project and its scientific tasks.

On 9 March, the 4th Coordination Meeting of JINR and the Arab Atomic Energy Agency (AAEA) was held via videoconference. The meeting was co-chaired by Special Representative of the JINR Director for Cooperation with International and Russian Scientific Organizations B. Sharkov and AAEA General Director S. Hamdi.

In her speech, JINR Deputy Chief Scientific Secretary O.-A. Culicov presented in detail the specialized "JINR for AAEA Fellowship Programme", thanks to which young scientists from the AAEA member states will have the opportunity to participate in international research and gain access to the unique scientific infrastructure of JINR. The parties agreed on the terms of submission and consideration of applications, conditions, and other organizational issues related to the implementation of the Programme.

Head of the Department for Elaboration and Development of Educational Programmes of the University Centre Yu. Panebrattsev presented the capabilities of the virtual laboratory and related educational programmes. They are expected to become one of the areas of cooperation on personnel training and an important part of the activities of the planned Information Centre at the headquarters of the Arab Agency located in Tunis. The AAEA representatives expressed confidence that the organization of the JINR Information Centre would become an impetus for the development of JINR cooperation with the countries of the Middle East region and North Africa in matters of knowledge transfer and personnel training.

On 21 March, a Protocol on Strengthening Cooperation in the Field of Basic Scientific Research between the Joint Institute for Nuclear Research, the Chinese Academy of Sciences, the Ministry of Science and Technology of the People's Republic of China, and the Ministry of Science and Higher Education of the Russian Federation was signed. This doc-

ument lays the foundation for further development of mutually beneficial cooperation between JINR and scientific and educational organizations of China, indicating the parties' intentions to increase the level of participation of the People's Republic of China in JINR activities. The signing took place during the visit of President of the People's Republic of China Xi Jinping to Russia.

The organization and planning of joint activities under the Protocol and the solution of current tasks will be handled by a Joint Coordination Committee, which will include an Expert Working Group. The Committee will consist of an equal number of representatives of JINR and China, including two co-chairs, one from each of the parties. The Expert Working Group will also be composed half of JINR researchers and half of scientists from Chinese research centres. Its tasks will include advising on specific areas and topics of scientific cooperation, as well as making proposals for joint projects for consideration by the Committee. If necessary, the major issues will be submitted for consideration by the Sub-Commission on Scientific and Technological Cooperation of the Russian–Chinese Commission for Preparation of Regular Meetings between Heads of the Governments.

On 22 March, Plenipotentiary of the Government of Vietnam to JINR, Vice-President of the Vietnam Academy of Science and Technology Trần Tuấn Anh, who arrived in Dubna to participate in the meetings of the JINR Finance Committee and the Committee of Plenipotentiaries, met with JINR Director G. Trubnikov.

During the conversation, the parties expressed a common opinion on the need to increase the number of Vietnamese employees working at JINR. To disseminate information about JINR's capabilities among the Vietnamese scientific community, the parties agreed to continue the participation of representatives of Vietnam in the proven JEMS training programme. Opportunities for training highly qualified personnel in the field of nuclear technologies and accelerator engineering, as well as for the implementation of projects for the development of scientific infrastructure, were discussed. Theoretical physics and information technologies were singled out among promising scientific areas for the development of cooperation.

At the end of the meeting, G. Trubnikov and Trần Tuấn Anh signed an agreement that regulates certain aspects of the work of Vietnamese employees at the Institute, as well as the implementation of cooperation programmes and grants of the Plenipotentiary of the Government of Vietnam to JINR.

On 27–31 March, the JINR delegation visited the Republic of South Africa, where meetings were held with representatives of the Department of Science and Innovation and the National Research Foundation, as well as with partners at the University of Pretoria, the University of the Western Cape, the University of Cape Town, iThemba LABS, and representatives of other organizations. Meetings with current and potential partners in South Africa were

Dubna, 22 March. Signing of an agreement on the implementation of cooperation programmes by Plenipotentiary of the Government of Vietnam to JINR Trần Tuấn Anh and JINR Director G. Trubnikov

devoted to studying possibilities to expand cooperation across the full range of priority research areas of the Institute, including information technology. A researcher of JINR MLIT I. Pelevanyuk held a series of seminars at universities and scientific organizations in Pretoria and Cape Town.

On 30 March, the 17th session of the Joint Intergovernmental Committee on Trade and Economic Cooperation between the Russian Federation and the Republic of South Africa was held in Pretoria. The JINR delegation took part in the meeting of the Joint Russian–South African Commission on Scientific and Technological Cooperation held as part of intergovernmental consultations. Participants noted the importance of the potential of the multilateral cooperation format implemented within JINR for strengthening the scientific and technological cooperation between Russia and South Africa.

At the end of March, about 300 modules of the electromagnetic calorimeter (Ecal) for the MPD detector at NICA were delivered to JINR from China. This supply was the third in a row. In total, 800 modules were produced in China.

Ecal is a tool for measuring the energy of electrons, positrons, and photons. Chinese colleagues from five leading centres of Tsinghua University joined the Ecal production for the NICA MPD. Equipment Plant "Tensor" in Dubna and two enterprises in Moscow and Protvino designed another 800 modules. The MPD detector at NICA requires 2400 Ecal modules in total. Cooperation with Chinese and Russian organizations in the field of Ecal production continues.

In addition to the production of modules of the calorimeter, Chinese specialists significantly contribute to their installation and adjustment. At present, a young specialist of Tsinghua University Linmao Li is involved in the work on Ecal for MPD at VBLHEP.

Tsinghua University has been involved in the NICA project for about ten years. Its specialists are not only jointly working on electromagnetic calorimeter for MPD, they are also creating the time-of-flight SPD detector. Another Chinese centre, the China Institute of Atomic Energy, is interested in cooperation on the SPD project in the field of the development of Micromegas detectors.

The creation of microelectronics for the NICA project is an important area of cooperation with China. In total, about 20 Chinese organizations are already involved in activities within the framework of the megascience project.

On 24 April, Professor A. El-hag Ali, Chairman of the Egyptian Atomic Energy Authority (EAEA), Member of the JINR Scientific Council, arrived at the Joint Institute with a reconnaissance visit. The programme of his 4-day acquaintance visit included discussions of joint plans for cooperation enhancement, a number of working meetings, including with representatives of the Rosatom State Corporation, as well as acquaintance with the infrastructure and scientific fields of JINR's activities within the JEMS training programme.

Dubna, 24 April. Visit to JINR of Professor A. El-hag Ali, Chairman of the Egyptian Atomic Energy Authority, Member of the JINR Scientific Council (centre)

Dubna, 28 April. Director General of the Physics Centre of Excellence of the National Centre of Pakistan Professor I. Ahmad and JINR Vice-Director L. Kostov signed a Letter of Intent for cooperation during the 22nd International Training Programme JEMS

JINR Director Academician G. Trubnikov welcomed Professor A. El-hag Ali at the Directorate of the Institute. He noted a long-standing history of cooperation between the Joint Institute and EAEA. The parties noted neutron studies, reactor technologies and joint infrastructural projects as the fields of mutual interest. Taking into consideration a special role of JINR as an international intergovernmental scientific centre, it was proposed to organize a platform on the Institute's basis for training specialists from other atomic agencies, as well as for sharing experience and technology.

Participation in the JEMS-22 programme allowed Professor A. El-hag Ali to get acquainted with activities of the Laboratories in detail and discuss the aspects of collaboration with their heads and specialists.

On 24–28 April, the 22nd International training programme for decision-makers in science and international scientific cooperation "JINR Expertise for Member States and Partner Countries" (JEMS) was held. Heads and specialists of national research and educational organizations from Egypt, Russia, South Africa, Vietnam, and for the first time from Pakistan were participants of JEMS-22. The training programme was attended by Professor A. El-hag Ali, Chairman of the Egyptian Atomic Energy Authority (EAEA), Member of the JINR Scientific Council from the Arab Republic of Egypt.

The JEMS-22 programme was divided into thematic sections one for each day of training, namely, "Heavy Ion Physics and Accelerator Technologies", "Research with Neutrons and the Nanoworld", "Theory, Information, Education", "Life Sciences on Earth and in Space", and "Neutrino". The participants visited Laboratories and facilities of the Institute, and listened to lectures on the areas of scientific studies from leading specialists of JINR.

Heads of the national groups of Egypt, South Africa, and Vietnam were taking an active part in working with delegates of the training programme. They were assisting in establishing working contacts, identifying new areas of cooperation with JINR and organizations of its partner network.

In the light of new opportunities opened up by the admission of the Arab Republic of Egypt to JINR as a full member, another seminar devoted to the prospects of cooperation between JINR and the Egyptian Atomic Energy Authority was held as part of the JEMS-22 training programme. Chairman of EAEA Professor A. El-hag Ali introduced the representatives of the JINR Laboratories and JEMS-22 participants to the structure of his organization and research in progress. Following the results of the seminar, a memorandum on the further development of cooperation was signed.

On 26 April, within the framework of JEMS-22, a presentation of the National Centre for Physics (NCP) of Pakistan was held with the participation of JINR specialists headed by Vice-Director L. Kostov.

Director General of the Physics Centre of Excellence of NCP of Pakistan Professor I. Ahmad spoke in detail about the structure and tasks of NCP, re-

search areas and research facilities, outlined potential areas of cooperation with JINR, such as accelerator physics, theoretical physics, materials science, computing, and also stressed the readiness of the Centre to join the work on the NICA collider project. The speaker highlighted the educational component of the Centre's activities and the international meetings, conferences, schools, practices for foreign students taking place on its basis, and told about academic exchange programmes. It was noted that NCP participates in a number of international projects and cooperates with national organizations — JINR partners, one of which is iThemba LABS (South Africa), whose representatives also participated in the meeting. The presentation sparked a lively discussion.

On 28 April, a traditional round table with the participation of representatives of the JINR Directorate, dedicated to the results of the JEMS-22 training programme, was held. The result of a comprehensive discussion of the possibilities of cooperation between the Joint Institute and the National Centre for Physics of Pakistan was the signing of a Letter of Intent by I. Ahmad and L. Kostov. The work of the round table was completed by the solemn presentation of certificates and traditional JINR souvenirs "Science Brings Nations Together" to the participants of the internship.

On 29 April, in Yerevan, a meeting of JINR Director Academician G. Trubnikov and Scientific Leader of the Flerov Laboratory of Nuclear Reactions Academician Yu. Oganessian was held with President of Armenia V. Khachaturyan. President of the National Academy of Sciences of the Republic of Armenia (NAS RA) A. Sagyan, Director of the Institute for System Programming of RAS A. Avetisyan, Rector of the Moscow Aviation Institute M. Pogosyan, and NAS RA Academician R. Harutyunyan took part in the event. Special Representative of Russian President on International Cultural Cooperation M. Shvydkoy moderated the discussion.

The high-level meeting took place within the international conference "Heaviest Nuclei and Atoms" dedicated to the 90th anniversary of Yu. Oganessian, held under the auspices of the International Union of Pure and Applied Physics at NAS RA from 25 to 29 April.

The President of the Republic of Armenia congratulated Yu. Oganessian on his anniversary and wished him good health and new scientific achievements.

A wide range of issues on strengthening and expanding scientific and cultural ties was discussed at the meeting. In particular, the participants discussed unlocking of the existing potential in high technologies and in other fields of science, as well as the formation of a substantive agenda for cooperation. Following the meeting, the participants reached an agreement on regular holding of international multidisciplinary conferences and joint cultural events in Armenia.

Yerevan, 29 April. At the meeting of JINR Director Academician G. Trubnikov and Scientific Leader of FLNR Academician Yu. Oganessian with President of Armenia V. Khachaturyan (*photo: © https://www.president.am/*)

Paris, 16 May.
B. Sharkov at the meeting with the leaders of the UNESCO science unit

On 4 May, Vice-President of the Cuban Academy of Sciences C. de Jesús Rodríguez-Castellanos visited the Joint Institute for Nuclear Research. He got acquainted with the JINR scientific infrastructure and met with representatives of the Cuban community.

The exhibition "JINR Basic Facilities" at the JINR Cultural Centre "Mir" was the first destination of the Vice-President of the Cuban Academy of Sciences during his visit to Dubna. Then the guest visited the Laboratory of Nuclear Reactions, where he learned more about the DC-280 cyclotron and attended the Nanocentre. The visit continued with a meeting with JINR representatives at the Laboratory of Theoretical Physics. At the end of the visit, the Vice-President of the Cuban Academy of Sciences went on excursion to the sights of Dubna.

In 1977–1982, C. de Jesús Rodríguez-Castellanos worked at the Joint Institute for Nuclear Research and became the first Cuban scientist to defend a doctoral degree at JINR.

On 16 May, in Paris, alongside the 216th session of the UNESCO Executive Committee, JINR Director's Special Representative for Cooperation with International and Russian Scientific Organizations B. Sharkov met with leaders of the UNESCO science unit. The UNESCO party was headed by Director of the Division of Science Policy and Basic Sciences Shaofeng Hu, Chief of the Section for Science, Technology, and Innovation Policy E. Clark, as well as Chief of the Section for Basic Science, Research, Innovation, and Engineering A. Kasry.

B. Sharkov reminded the participants about the history of cooperation between the two international organizations. It began with the signing of the Cooperation Agreement of 1997, which was expanded in 2017 to include a joint internship programme. He highlighted such important joint events as the establishment of the Mendeleev International Prize, the JINR's active participation in the International Year of Basic Sciences for Sustainable Development, the upcoming opening of the UN Decade of Science, etc., introduced the participants of the meeting to the JINR scientific programme, flagship projects, the unique research infrastructure of the Institute as well as the Dubna science city.

During the discussion, it was stressed that the JINR–UNESCO cooperation programme should be aimed at its early resumption and activation. It was noted that JINR is a valuable partner actively working in the priority areas of UNESCO's mandate to develop science, technology, innovation and to strengthen human capital in many countries of the world under the motto "Science Brings Nations Together". The leaders of the UNESCO science unit expressed interest in continuing to participate as an observer in important meetings in Dubna. B. Sharkov held introductory discussions with RF Ambassador to UNESCO R. Alyautdinov and Second Secretary of the Representative Office G. Enayeva, who is responsible for science.

On 19 May, a regular meeting of the JINR Science and Technology Council (STC JINR) took place. The key topic of the Council's meeting was the discussion of the Institute's plans in the fields of improving the status of an international organization and personnel policy. E. Kolganova, Leading Researcher, Head of the Human Resources and Records Management Department (HRRMD) became the new Chairman of STC JINR. N. Kučerka, FLNP Deputy Director, was elected Deputy Chairman of STC JINR.

JINR Director Academician G. Trubnikov opened the meeting. He welcomed former Chairman of STC JINR Professor R. Jolos and expressed gratitude to

him for his effective work during many years in this post.

In his speech, G. Trubnikov defined two most important tasks of the Institute in the coming months: to improve the status of JINR as an international organization by ensuring effective work with the JINR Member States and to attract young scientists from other countries to Dubna. G. Trubnikov noted the planned events aimed at the implementation of these tasks. A meeting of the Working Group under the CP Chairman on Financial Issues, dedicated to the budget of the next seven-year period, will be held in Irkutsk. As part of active efforts in the development of international cooperation, a large number of conferences in various countries are planned, as well as the first official visit of JINR to Mexico. In cooperation with China, specialists are preparing the first meeting of the JINR–China Joint Coordination Committee, at which its participants will discuss the development of the cooperation between the countries.

At the end of the meeting, members of the Council defined the main future areas of their work. It is planned to discuss a strategy and necessary steps to implement the basic projects of the Institute on time, operation strategies for the JINR University Centre, the JINR Dissertation Councils, and the Association of Young Scientists and Specialists. In addition, members of the Council made a decision to organize a special Committee under STC JINR aimed at opening up more possibilities of providing feedback between the Laboratories, between employees of the scientific and technical sector and administrative departments, and considering issues raised at meetings of STC JINR.

On May 19, the JINR delegation headed by Director's Special Representative for Cooperation with International and Russian Scientific Organizations B. Sharkov took part in the technical opening of the first JINR Information Centre at the headquarters of the Arab Atomic Energy Agency (AAEA) in Tunis within the framework of a partnership agreement between AAEA and JINR. The opening was attended by representatives of the Tunisian Ministry of Foreign Affairs and the leadership of the Institute of Nuclear Sciences and Technologies on behalf of the Tunisian Ministry of Higher Education and Scientific Research, with extensive coverage by local media.

The event was opened by W. Badawy, FLNP senior researcher and the liaison officer of JINR to AAEA. He congratulated the colleagues on this event. Director General of AAEA Professor S. Hamdi gave a welcoming speech.

In his speech, B. Sharkov stressed in particular the essential role that the Infocentre and the Virtual Laboratory play in attracting young scientists from AAEA member countries and African countries to gain advanced scientific knowledge and skills.

The technical launch of the Infocentre was preceded by a presentation of the Virtual Laboratory (VLab) project. At the presentation, N. Sidorov (VBLHEP) demonstrated the capabilities of the project and the performance of the VLab using the example of an experiment. After that, the participants of the event had a chance to test the virtual experiments themselves.

The participants of the ceremony shared their impressions and discussed plans for the future. The leaders of the delegations ceremonially signed the Protocol of the Joint Coordination Committee that recently took place by videoconference, which implies the interaction between AAEA and JINR. The Committee consolidated the planned steps for the opening and launch of the JINR Information Centre at AAEA.

On 26 May, a meeting of the Committee on Non-Energy Application of Nuclear Technologies under the Advisory Board of the International Research Centre based on the MBIR reactor (Dimitrovgrad, Russia) was held in Tashkent (Uzbekistan) on the basis of the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan. At the meeting, JINR Vice-Director L. Kostov represented the Joint Institute. He said that the Institute together with colleagues had already started working on the research programme of the facility under construction.

President of the Academy of Sciences of the Republic of Uzbekistan, RAS Foreign Member, Plenipotentiary of the Government of the Republic of Uzbekistan to JINR B. Yuldashev opened the event with a welcoming speech.

Speaking to the audience, RAS Vice-President, a representative of the IRC MBIR Advisory Board, Doctor of Chemical Sciences S. Kalmykov noted that research at the MBIR reactor would open the way to multilateral scientific collaborations.

JINR Vice-Director, Doctor of Physics and Mathematics L. Kostov noted a growing interest in neutron studies around the world and spoke about JINR's participation in large-scale international research projects of the megascience class, one of which is the IRC MBIR project. L. Kostov added that JINR, together with the Institute of Physics and Power Engineering, conducts preparations developing the research programme at extracted channels of MBIR.

More than 40 representatives of the largest Russian and foreign enterprises of the atomic sector took part in the event in person and online. Leading scientific and educational organizations of Algeria, Armenia, Brazil, China, Kazakhstan, the RSA, Uzbekistan, as well as IAEA representatives, also joined the event. The participants discussed aims and tasks of the MBIR project, prospects for the collaboration development, as well as engagement of students into scientific work within MBIR.

On 29 May, the opening of the 16th International Internship for Young Scientists and Specialists from the CIS Countries took place at the JINR International Conference Centre. Young scientists and specialists from Armenia, Azerbaijan, Belarus, Kazakhstan, Kyr-

gyzstan, Russia, Tajikistan, and Uzbekistan gathered to participate in the Internship.

The Internship is organized by the International Innovative Nanotechnology Centre of the CIS countries (ININC CIS), established in 2010 with the participation of the Joint Institute for Nuclear Research and 12 other scientific and educational organizations from eight countries. ININC CIS annually conducts internships with the support of the Intergovernmental Foundation for Educational, Scientific, and Cultural Cooperation of the CIS and JINR Member States.

JINR Assistant Director for Development Projects, ININC CIS Director A. Ruzaev told the trainees about the history of the Centre's creation, its aims, and fields of work. From 2010 to 2023, about 400 people took part in internships, and more than 180 young scientists and specialists received ININC CIS grants for the development of scientific and innovative projects. He also added that over the years of such internships, a positive practice had appeared. Having visited Dubna, trainees from various countries continue joint work and make joint publications in journals.

Chief Scientific Secretary S. Nedelko, Senior Specialist of the International Cooperation Department E. Badawy, Head of the Innovations and Intellectual Property Department I. Lensky, and Chief Engineer of the Institute B. Gikal delivered lectures to the participants of the Internship. An informal meeting of trainees with representatives of the national groups of JINR employees took place.

During the Internship, which lasted until 27 June, the participants visited the JINR Laboratories and a number of enterprises of the city. The participants worked in international teams of 4–5 people. They prepared joint scientific and technical or innovative projects. The authors of the brightest works were able to apply for grants from the ININC CIS in the future.

On 29 May, a JINR delegation headed by Director G. Trubnikov arrived in Mexico to participate in a meeting on the preparation of the Joint Cooperation Committee JINR–Mexico within the framework of the implementation of the Joint Declaration of Intent between JINR and the National Council of Humanities, Sciences and Technologies of Mexico (CONAHCYT) signed during the JINR Scientific Council on 16 February 2023.

Prior to the meeting, JINR Director G. Trubnikov had a talk with CONAHCYT Director-General M. E. Álvarez-Buylla Roces. Both parties shared their thoughts on the current state of the cooperation between researchers from Mexico and Dubna, and how they see it in the near future and long-term. The meeting was attended by JINR Vice-Director V. Kekelidze and former President of the Mexican Physical Society and Professor at the Institute of Physics at the National Autonomous University of Mexico (UNAM), member of the JINR Scientific Council A. M. Cetto Kramis, cooperation coordinators A. Ayala (UNAM) and D. Kamanin (UC JINR), as well as Communications Coordinator and International Cooperation Director H. Chavira (CONAHCYT).

The parties discussed the plans and expected approaches concerning the work of the Committee in terms of the selection of joint projects, recommendations to particular Mexican scientists for long-term internships at JINR, allocation of resources, as well as information dissemination. The cooperation coordinators informed the participants of the meeting about the solid experience that had been gained

Mexico City (Mexico), 29 May. Organizational meeting on JINR–Mexico cooperation with the participation of the JINR delegation headed by Director G. Trubnikov

Vladikavkaz, 17 June. A Memorandum of Understanding was signed on the entry of the K. L. Khetagurov North Ossetian State University into the ARIADNA collaboration (*photo: press service of NOSU*)

in the past five years through the NICA project collaboration and about the current opportunities for expanding the cooperation in a wide range of subjects.

The meeting participants paid special attention to the issues of interaction between JINR and Mexican organizations in the area of radiobiology and radiation medicine. The importance of training the highly qualified personnel was also emphasized; in particular, the successful experience of participation of students and postgraduates of the country in the JINR's programmes INTEREST and START was noted. The JINR representatives commented on the interesting opportunities for cooperation in the areas of information technologies, use of track membranes and nuclear analytical methods.

The JINR delegation was warmly welcomed at the National Autonomous University of Mexico, where presentations, seminars and round-table meetings were held for two days for students and researchers of the University. The reports made by the JINR delegation members covered a wide range of issues, thereby demonstrating the diversity of JINR's fields of activity.

On 31 May, the JINR delegation visited the School of Sciences (FC) and the Institute of Physics (IF) at UNAM, where they had two parallel workshops with students and researchers from UNAM. The delegation was welcomed by the IF Director, Dr. M. Rodríguez Villafuerte, after which they went on a tour around the laboratories, where the JINR delegation was shown what the IF has to offer to its researchers, as well as some of the projects they are working on. The parallel round-table sessions took place, where members of the JINR delegation discussed research and cooperation opportunities. One of these sessions was addressed to undergraduate students, who posed questions on how to contact JINR, what steps to follow to participate in training and internships at JINR, and what are the working conditions at JINR.

On 2 June, the work programme continued in Morelia, at the Michoacan University of Saint Nicholas of Hidalgo (UMSNH). JINR representatives made reports about the Institute, its projects and opportunities for research and internships, and also took part in a round table on scientific cooperation and training opportunities. In addition to researchers, the event attracted the attention of university students, and each presentation was followed by numerous questions from researchers and students.

The JINR delegation held a series of presentations at the seminar centre "Unidad de Seminarios Dr. Ignacio Chávez" of UNAM. This event attracted attention of the researchers and university professors from UNAM, UMSNH, the University of Puebla (BUAP), the National Oncology Institute (INCAN), the Centre for Research and Advanced Studies (Cinvestav), the Metropolitan Autonomous University (UAM), the University of Colima (UCol), the Autonomous University of Sinaloa (UAS), and the University of the Americas in Puebla (UDLAP).

On 17 June, in Vladikavkaz, JINR and the K. L. Khetagurov North Ossetian State University (NOSU) signed a Memorandum of Understanding on the admission of NOSU to the ARIADNA Collaboration for carrying out the applied research programme at the NICA accelerator complex. The ceremony took place at the JINR Information Centre in the South of Russia at NOSU. On the same day, a three-day workshop "Applied Research at the NICA

Complex: Prospects for Cooperation between North Ossetia–Alania Region and JINR" started. At the opening of the event, JINR Director G. Trubnikov and NOSU Rector A. Ogoev made welcoming speeches.

During the meeting, V. Lebedev made a report on the status of the NICA project. O. Belov spoke about the ARIADNA scientific programme in his message. A. Slivin highlighted the process of creating irradiation stations for applied research. The participants listened to reports on radiation materials science, research in life sciences and relevant tasks in modern radiation techniques, exchanged views on the status of the implementation of the NICA project, the ARIADNA scientific programme, and the creation of an appropriate infrastructure for conducting experiments.

A round table was held with representatives of NOSU, the North Caucasus Institute of Mining and Metallurgy, as well as scientific and production companies LLC Vladikavkaz Technological Centre "BASPIK" and the Scientific and Research Institute of Electromechanics. They presented information about the activities of their organizations.

The participants of the meeting visited the Collective Use Centre of NOSU, where they got acquainted with existing analytical equipment.

On 5 July, a meeting of the Science and Technology Council of JINR chaired by E. Kolganova was held. The STC members heard a report by JINR Director G. Trubnikov on the results of the Institute's activities for the first half of 2023. They also reviewed a report on the work of the Association of Young Scientists and Specialists of JINR, presented by its Chairman V. Rozhkov.

The JINR Director informed the audience about significant scientific results obtained at the Institute Laboratories. He indicated that the infrastructure is being updated and work of departments and offices is undergoing optimization. The AYSS Chairman reported on the expansion of the range of its activities, new events and work on updating of the Regulations on Prizes for Young Scientists and AYSS Regulations.

On 8 July, Dr. G. Walwyn Salas, the new Plenipotentiary of the Government of the Republic of Cuba to JINR, Director of the Centre for Radiation Protection and Hygiene (CPHR), visited JINR. The parties discussed prospects for the development of cooperation and the key priorities in collaboration with JINR — the development of educational and exchange programmes for young scientists and specialists.

During the visit, Dr. Walwyn Salas was introduced to the infrastructure objects of the Joint Institute. The Plenipotentiary of Cuba visited the NICA accelerator complex at the Laboratory of High Energy Physics, the Nanocentre of the Laboratory of Nuclear Reactions, as well as the control room of the JINR Multifunctional Information and Computing Complex and the interactive exhibition "JINR Basic Facilities". The guest took part in the meeting of the Working Group on Financial Issues under the Chairman of the Committee of Plenipotentiaries of JINR.

On 24 July, a delegation of the South Ural State University (SUSU) (Chelyabinsk) headed by Rector A. Vagner visited JINR. At the meeting with JINR Director G. Trubnikov, the team from Chelyabinsk presented the bright results of the project carried out within the framework of the agreement on scientific cooperation between JINR and SUSU. The teams of SUSU and LRB JINR are jointly developing the software product called the Intellectual System of Behavioural Patterns Analysis. For several months of cooperation, a prototype of software based on neural network algorithms for automated video data processing was created. The software being created will make it possible to significantly reduce the labour intensity of data processing of radiobiological experiments conducted by LRB JINR for the purpose of studying the mechanisms of action of ionizing radiation on the central nervous system and the development of neurodegenerative diseases.

After discussing the results of the project, the parties signed an act on the status of completed works. The parties outlined steps to upgrade and promote the software product being developed, which may be of interest to a wide range of organizations working in the field of biology, medicine, and pharmaceutical testing. The University and the Institute agreed to further strengthen and expand interdisciplinary scientific cooperation, organize scientific and educational events involving students and postgraduates.

On 26–28 July, the 42nd Meeting of INIS Liaison Officers was held in IAEA headquarters in Vienna. INIS IAEA Secretariat, INIS Liaison Officers from 62 Member States and two international organizations, including JINR represented by S. Kruglova, participated in the meeting.

In the opening, INIS IAEA Coordinator B. Bales and Director of IAEA Division of Planning, Information, and Knowledge Management W. Huang welcomed the participants. In addition, M. Chudakov, Deputy Director General of IAEA Department of Nuclear Energy, greeted the attendees in a video address.

The consolidated efforts and noteworthy contribution of INIS national centres and INIS IAEA Secretariat were acknowledged: in 2022, almost 125 000 new records were added to the collection. The number of bibliographic records tallies approximately 4.6 mln, the number of full-text documents accounting for 2.17 mln.

INIS actively supports ideas of open science and open access. H. Mahmoud (IAEA INIS) spoke about IAEA participation in SCOAP3 (Sponsoring Consortium for Open Access Publishing in Particle Physics) project, JINR also being a partner of SCOAP3. In 2020, SCOAP3 introduced Books Programme, resulting in the users being able to access not only journals, but also books in the field of particle physics. INIS, keen to provide researchers with such resources, pro-

posed to provide access to all those books through INIS platform.

The issue of women participation and gender gap in nuclear science was pointed out by M. Naydenova (IAEA), who presented IAEA Marie Sklodowska-Curie Fellowship Programme, which aims to help increase the number of women in the nuclear sphere, supporting an inclusive workforce of both men and women who contribute to and drive global scientific and technological innovation.

Presentations on INIS activities at the local level were given by representatives of Bulgaria, Canada, Chile, Indonesia, Russia, USA, Zambia, and JINR.

A photo album issued in honor of the celebration of the 65th JINR anniversary was presented as a memorable gift from JINR to INIS IAEA Coordinator B. Bales. The first agreement between JINR and IAEA on JINR membership in INIS and creation of a working group to make input into the database was signed in 1973.

In the second half of August, at the invitation of the leadership of the National Centre for Physics of Pakistan, a working visit of JINR's delegation to Islamabad took place. The JINR delegation visited the National Centre for Physics of Pakistan, the Plasma Institute, and the Pakistan Institute of Nuclear Science and Technology, where the sides discussed possible trends of developing cooperation. Meetings with the leadership of the Higher Education Commission, which governs activities of all universities of the country, and of the National Electronics Complex of Pakistan took place. Possible projects in the fields of nuclear physics, high energy physics, materials science, information technology, and personnel training were discussed. The parties outlined practical steps to further strengthen cooperation.

On 22 August, the day of the 110th anniversary of the birth of an outstanding Italian and Soviet physicist Bruno Pontecorvo, an exhibition, organized by DLNP JINR, was opened in the exhibition hall of the JINR Cultural Centre "Mir". The exhibition presented friendly caricatures by M. Bilenky created in 1988, photographs of different years by Yu. Tumanov, and documents of the Memorial Office of the scientist in the Laboratory of Nuclear Problems at JINR. In addition, the event included the presentation of a brochure with memories of the outstanding scientist.

JINR Director G. Trubnikov inaugurated the exhibition. He welcomed the guests and thanked the organizers for the great work carried out carefully and with reverent attention to the memory of the famous physicist.

DLNP JINR Deputy Director D. Naumov noted that the Laboratory still preserves Pontecorvo's office in its original form, and for many years the Pontecorvo Prize has been awarded, as well as grant support for young people named after the outstanding scientist.

DLNP JINR Chief Researcher V. Komarov, a colleague of the famous physicist, presented to the audience a brochure with memories of B. Pontecorvo.

At the end of the festive evening, a documentary film "Bruno Pontecorvo" directed by E. Vlasova ("Nauka-video", 2003) was shown. The filming took place in Pisa, where the scientist was born, in Rome, where he studied, and in Dubna, where he lived most of his life. The great scientist is recalled by his relatives, friends, and colleagues, namely, his brother, a famous director Gillo Pontecorvo, sons Gil and Tito, a friend and colleague of the scientist S. Bilenky. In the film, you can see B. Pontecorvo himself. He talked about his teacher Enrico Fermi, and how Fermi and his students, including B. Pontecorvo, made an epoch-making discovery of neutron deceleration.

Vinh (Vietnam), 28–30 August. JINR delegation at the meeting with the leadership of the Vinh University

Dubna, 12 September. Representatives of
the Embassy of the Republic of South Africa in Russia on an excursion at VBLHEP

On 28–30 August, the JINR delegation headed by Special Representative of the JINR Director for Cooperation with International and Russian Scientific Organizations B. Sharkov was in Vinh (Vietnam), where it took part in the 8th Academic Conference on Natural Science for Young Scientists, Master and PhD Students from ASEAN (Association of South East Asian Nations) countries.

Students and young scientists were introduced to the advanced projects, major achievements, and opportunities available at JINR. They also learnt about the training programmes by the JINR University Centre aimed at attracting foreign students and about the programmes by Dubna University that provide an opportunity for foreign students and postgraduates, coming to study at the University, to carry out a research project at JINR in order to defend a thesis and obtain a degree in the future.

At the conference, the participants had a chance to attend a JINR mobile multimedia exhibition to get acquainted with the main projects and "visit" the main facilities of the Institute by taking a virtual tour.

The JINR delegation had a number of meetings to develop a long-term cooperation programme with scientific and educational institutions of Vietnam, including Vinh University, in the field of personnel training. As a JINR Member State, Vietnam intends to actively develop cooperation, as well as coordinate the scientific and educational agenda in the countries of Southeast Asia.

At a meeting with the President of the University, Nguyen Hai Bang, the representatives of JINR discussed possible joint projects in education, in particular, regional student internships for scholarship holders, Master's, and PhD students. They also agreed to prepare a memorandum of understanding, to strengthen bilateral relations between Vinh University and JINR.

On 10–11 September, a delegation of the People's Republic of China headed by Vice Minister of Science and Technology of China, CAS Academician Wu Zhaohui visited the Joint Institute for Nuclear Research. On the first day of the visit, the Chinese colleagues gained knowledge on the scientific infrastructure of JINR. They visited the Laboratory of High Energy Physics and the Laboratory of Nuclear Reactions.

On 11 September, the first meeting of the Joint Coordination Committee took place under the Protocol between the Ministry of Science and Higher Education of Russia, the Ministry of Science and Technology of China, JINR, and the Chinese Academy of Sciences on strengthening cooperation in basic scientific research.

JINR Director, RAS Academician G. Trubnikov and Vice Minister of Science and Technology of the People's Republic of China, CAS Academician Wu Zhaohui opened the first meeting of the Committee. The parties provided each other with information on the

Dubna, 10–11 September. Visit to JINR by the People's Republic of China delegation headed by Vice Minister of Science and Technology of China, CAS Academician Wu Zhaohui

state of development of their fundamental research and discussed joint work on scientific projects of mutual interest.

G. Trubnikov presented the achievements of the Institute to the Chinese colleagues, including implemented and planned major scientific projects and operating experimental facilities. In turn, his Chinese counterpart, Wu Zhaohui, spoke about the support provided to basic scientific research in China in the framework of a special ten-year plan.

The co-leaders of the Expert Work Group (EWG) operating under the Committee, JINR Scientific Leader, RAS Academician V. Matveev, and a researcher at the Institute of High Energy Physics of the Chinese Academy of Sciences, CAS Academician Chen Hesheng presented the results of the first EWG meeting, held on 4 September, to the PRC–JINR Joint Coordination Committee. The Work Group considered 18 projects proposed jointly by JINR and Chinese universities and research centres. All the projects were recognized as being of great scientific interest and importance for basic research in JINR and China. The parties discussed and approved the plan for the implementation and financing of joint projects recommended by the Expert Work Group.

The Committee highlighted the many-year successful and mutually beneficial cooperation between JINR and scientific and educational organizations of the People's Republic of China as part of the preparation of the MPD and SPD experiments at the NICA heavy ion collider being under construction now, as well as cooperation in the framework of the BESIII and JUNO experiments, the ones in the fields of heavy ion physics, neutron physics, R&D of medical accelerators, and research in theoretical physics. At the end of the event, the parties signed the protocol of the first meeting of the PRC–JINR Joint Coordination Committee.

On 15 September, a regular round table with the JINR Directorate summed up the results of the 23rd International Training Programme (JEMS-23). JEMS was specially organized for representatives of universities and research centres of the Republic of South Africa for the first time. Growing mutual interest in developing cooperation, in particular regarding matters of personnel training, impelled an RSA-only JEMS programme.

Opening the JEMS-23 round table, Vice-Director of the Joint Institute V. Kekelidze greeted representatives of 11 universities and two scientific centres of RSA, and noted the more than 30-year history of cooperation between JINR and South African scientists. JINR Scientific Leader V. Matveev wished the participants new successes in their scientific organizations after completing the JEMS internship. On behalf of the JINR Directorate, Chief Scientific Secretary S. Nedelko also took part in the round table. The South African delegation was headed by R. Nchodu, Deputy Director of iThemba LABS and Coordinator of the South African Council for Cooperation with JINR.

During the round table, representatives of South Africa shared their impressions of the training programme and spoke about their activities, identifying the main areas of research in their institutions. Many JEMS-23 participants noted the useful experience gained and new knowledge and ideas for improving educational and research activities.

An important addition to JEMS-23 was the participation of representatives of technological institutes of South Africa — the Central University of Technology (CUT) and the Tshwane University of Technology (TUT), who had not previously had joint projects with JINR. Head of the Department of Mathematics, Science and Technology Education G. Beukes from CUT thanked JINR for the opportunity to learn about ideas for developing scientific initiatives in the country and ways to improve the skills of specialists.

The round table was concluded with a momentous ceremony of presenting participants with completion certificates of the JEMS-23 internship.

On 22 September, the first winners of the Oganesson Prize were announced at the 134th session of the Scientific Council of the Joint Institute for Nuclear Research. The award was instituted at the suggestion and expense of FLNR Scientific Leader Academician Yu. Oganessian with the support of the Sberbank. The award's founders are Yu. Oganessian and JINR.

A jury of international experts, headed by Scientific Director of the National Centre for Physics and Mathematics Academician A. Sergeev, made the decision to present the award in 2023 to:

• A. M. Cetto Kramis, a physics professor at the National Autonomous University of Mexico and member of the JINR Scientific Council, for outstanding scientific works in quantum mechanics and theoretical physics, for great personal contribution to the strengthening of global scientific cooperation for peace and sustainable development;

• M. Shvydkoy, Doctor of Arts, Art Director of the Moscow Musical Theatre, cultural, public, and state figure, for his outstanding personal contribution to the development of international scientific and cultural cooperation, and the popularization of modern science achievements in mass media;

• V. Pershina, a chemistry professor at GSI, Darmstadt, Germany, for theoretical studies of the electronic structure and chemical properties of superheavy elements of Mendeleev's Periodic Table;

• V. Semin (nominated in the young laureates category), Head of the Scientific and Technological Department of Accelerators of the Laboratory of Nuclear Reactions at JINR, for his significant personal contribution, made at the beginning of his scientific career, to the creation of new primary experimental facilities at JINR, providing breakthrough scientific results in nuclear physics.

The Oganesson Prize is given annually for significant achievements in theoretical and experimental research in physics, chemistry, biology, and applied problems, and for creative endeavours that popu-

Dubna, 28 September. Visit to JINR by
a delegation from the Sultanate of Oman, seen here during a tour of VBLHEP

larize science by means of educational and scientific activities. Individual scientific, engineering, and technical specialists or teams (no more than three people), whose contribution was decisive in solving scientific problems and popularization projects, can participate in the competition for the award.

On 2–3 October, a delegation of the National Academy of Sciences of the Republic of Kazakhstan (NAS RK), headed by President of the Board of NAS RK K. Zakarya, visited JINR.

At the meeting in the JINR Directorate, participants discussed issues of cooperation in the field of staff training, expansion of the scope of joint research, and Kazakhstan's participation in the JINR distributed computing network. It was noted that the Kazakh national group was the largest at JINR. At the moment, from 80 to 100 people from Kazakhstan are working at the Institute. Representatives of Kazakhstan are engaged in projects of all laboratories of the Institute.

Staff training in nuclear technology and cooperation in the fields of creating reactors and accelerators for industry, nuclear medicine, and biotechnology were identified as key areas of joint cooperation. The JINR distributed cloud infrastructure on the DIRAC platform, to which the Almaty Institute of Nuclear Physics is connected as well, is another point of interaction between Kazakhstan and JINR. As additional projects on expanding the range of topics for cooperation, the participants proposed the use of nuclear physics methods in biomonitoring, as well as JINR's participation in the creation of interdisciplinary centres in Kazakhstan in the areas of JINR research. The representatives of the Republic of Kazakhstan highly appreciated JINR's expertise in the creation of accelerator technology and experimental facilities on extracted neutron beams.

An Agreement of Intent was signed between JINR and NAS RK on the results of the meeting, which, according to the opinion of the sides, will give a new impetus to the development of cooperation not only with the Institute of Nuclear Physics in Almaty, its branch in Astana and universities, but also with other scientific centres of Kazakhstan.

The representatives of NAS RK visited JINR laboratories where they got acquainted with JINR flagship projects. In addition, a meeting was held with members of the national group of the Republic of Kazakhstan in JINR.

From 2 to 6 October, a representative delegation of JINR was in Belgrade (the Republic of Serbia), where it took part in the international school "NICA Days 2023" held on 2–3 October in a mixed format at the Vinča Institute of Nuclear Sciences before the 12th Collaboration Meeting of the MPD Experiment, which was held in Belgrade on 4–6 October. The organizers of the event were the Vinča Institute of Nuclear Sciences and JINR.

On 2 October, the JINR delegation met with high-ranking science leaders of the Republic of Serbia in Belgrade. The meeting focused on discussing a wide range of issues related to enhancing the scientific and practical cooperation between JINR and Serbian scientific organizations with the primary goal of

gradually advancing Serbia's status in JINR from an Associate Member to a fully-fledged Member State.

Both parties highlighted historically warm and close ties between JINR and Serbia and the positive experience of the participation of specialists from Serbia in the MPD experiment, in which they study the collective effects in collisions of heavy nuclei through the measurement of multiparticle correlations. Representatives of JINR and Serbia made proposals to increase the mobility of groups of participants in joint research and organize student exchanges to attract young specialists to ongoing research more effectively. In conclusion, a need to schedule regular meetings and maintain constant contacts was noted.

Representing Serbia, State Secretary of the Ministry of Education, Science, and Technological Development V. Grozdić, Senior Advisor S. Bogdanović, Director of the Vinča Institute of Nuclear Sciences S. Pajović, and Acting Assistant Minister for International Cooperation and European Integration I. Vukašinović took part in the meeting. JINR was represented by Vice-Director of the Joint Institute V. Kekelidze, VBLHEP JINR Deputy Director for Scientific Work A. Sorin, Chairman of the JINR Programme Advisory Committee for Particle Physics I. Tserruya, Chairman of the Council of Institutes of the MPD collaboration A. Ayala, Head of the MPD collaboration V. Ryabov, as well as an employee of the JINR International Cooperation Department O. Korotchik.

The same day, the international school "NICA Days 2023" , aimed at the attraction of new scientists and students to the megascience project to develop the NICA accelerator complex, started in a mixed format at the Vinča Institute of Nuclear Sciences. At the opening of the school, JINR Vice-Director V. Kekelidze and S. Pajović, Director of the Vinča Institute of Nuclear Sciences, greeted the participants. S. Pajović stressed that in the year of the 75th anniversary of the Vinča Institute its scientists took part in the organization of the "NICA Days 2023".

Leading scientists spoke about the status of the NICA project and its experimental facilities: BM@N, MPD and SPD. A course of lectures was given devoted to the review of physical phenomena in heavy-ion collisions and of experimental methods used to measure signals related to the NICA project that are of interest for physicists.

On 16–19 October, a workshop "India–JINR: Frontiers of Basic and Applied Research" was held at the JINR International Conference Centre. A delegation of scientists from leading universities and scientific centres of India, such as VECC (Kolkata), TIFR (Mumbai), NISER (Bhubaneswar), IITs (Delhi, Bhilai, Bombay, Indore, Kanpur, Madras), NITs (Jalandhar, Patna), universities (Delhi University, Panjab University, Banaras Hindu University, Cotton University, Assam), and many other educational institutions representing almost every geographical region of India, came to Dubna to participate in the event. In total, the event brought together more than 200 participants. The goal of the event was to confirm the great mutual interest and to find new promising forms of cooperation, including to establish a more intensive scientific exchange between scientists and graduate students of India and JINR.

On the opening day of the meeting, Ambassador of India to Russia P. Kapoor, who arrived on a visit to JINR, and JINR Director G. Trubnikov addressed the participants with a welcoming speech, highly appreciating the effectiveness of cooperation between Indian physicists and JINR scientists and prospects for the development of partnership relations between JINR and India.

During the meeting, JINR scientists and Indian colleagues heard and discussed about 90 reports on the theoretical and experimental aspects of the studies of particle and nuclear physics, condensed matter physics, information technology, as well as in the areas of applied research.

An excursion to the basic facilities of the JINR scientific infrastructure was organized for Indian delegation to get acquainted with the flagship projects, leading studies, and future experiments.

On 17 October, an expanded meeting of the JINR–Mexico Joint Coordination Committee (JCC) took place in a hybrid format at CONAHCYT in Mexico (Mexico). During the JCC meeting, the members of the Committee heard reports delivered by representatives of universities and research centres of Mexico and the Joint Institute for Nuclear Research, which were focused on promising areas for the JINR–Mexico cooperation development.

JINR Vice-Director and Co-Chairperson of the Committee V. Kekelidze headed the JINR delegation. Following the meeting, the JCC members identified five projects as the basis for the JINR–Mexico cooperation development. Topics of the projects cover high-energy physics, materials science, radiation and radiochemical research, radiobiology, nuclear physics, and accelerator technologies. The projects involve mutual visits and include opportunities for students and young scientists.

On 23 October, Dr. R. Nemutudi, Deputy Director of the accelerator centre of the Republic of South Africa, iThemba LABS, visited JINR. The visit started with excursions to the scientific infrastructure of JINR laboratories. In addition, a round-table discussion between R. Nemutudi and representatives of the JINR leadership took place.

Special Representative of the JINR Director for Cooperation with International and Russian Scientific Organizations B. Sharkov, Head of the International Cooperation Department O.-A. Culicov, and Head of the Group of South African Employees at JINR A. Rossouw attended the round table. The parties considered the most relevant areas of expanding cooperation between JINR and iThemba LABS, among which the opportunities for participation of South African young scientists in the JINR Fellowship

Mexico City (Mexico), 17 October.
Participants of the expanded meeting of the JINR–Mexico Joint Coordination Committee

Programme and the JEMS training programme are of particular interest.

From 23 to 25 October, the 5th Meeting of the BRICS Working Group on Research Infrastructure (BRICS GRAIN) took place in Stellenbosch, the Republic of South Africa. Chief Scientific Secretary of JINR S. Nedelko, Director of the University Centre D. Kamanin, and Deputy Chief Scientific Secretary A. Zhemchugov represented the Joint Institute for Nuclear Research at the event.

Information on the current state of the JINR research infrastructure and plans for its further development was presented at the meeting. Participants of the event heard presentations on opportunities for international scientific cooperation and training programmes. The head of the JINR delegation S. Nedelko made a report on the status of the NICA accelerator complex implementation and four collaborations of this megascience project. In particular, for the first time, members of the BRICS GRAIN Working Group had an opportunity to learn about the works, plans, and prospects of the ARIADNA applied research collaboration. The delegation of the Joint Institute held a number of meetings aimed at developing a partner network in the BRICS countries.

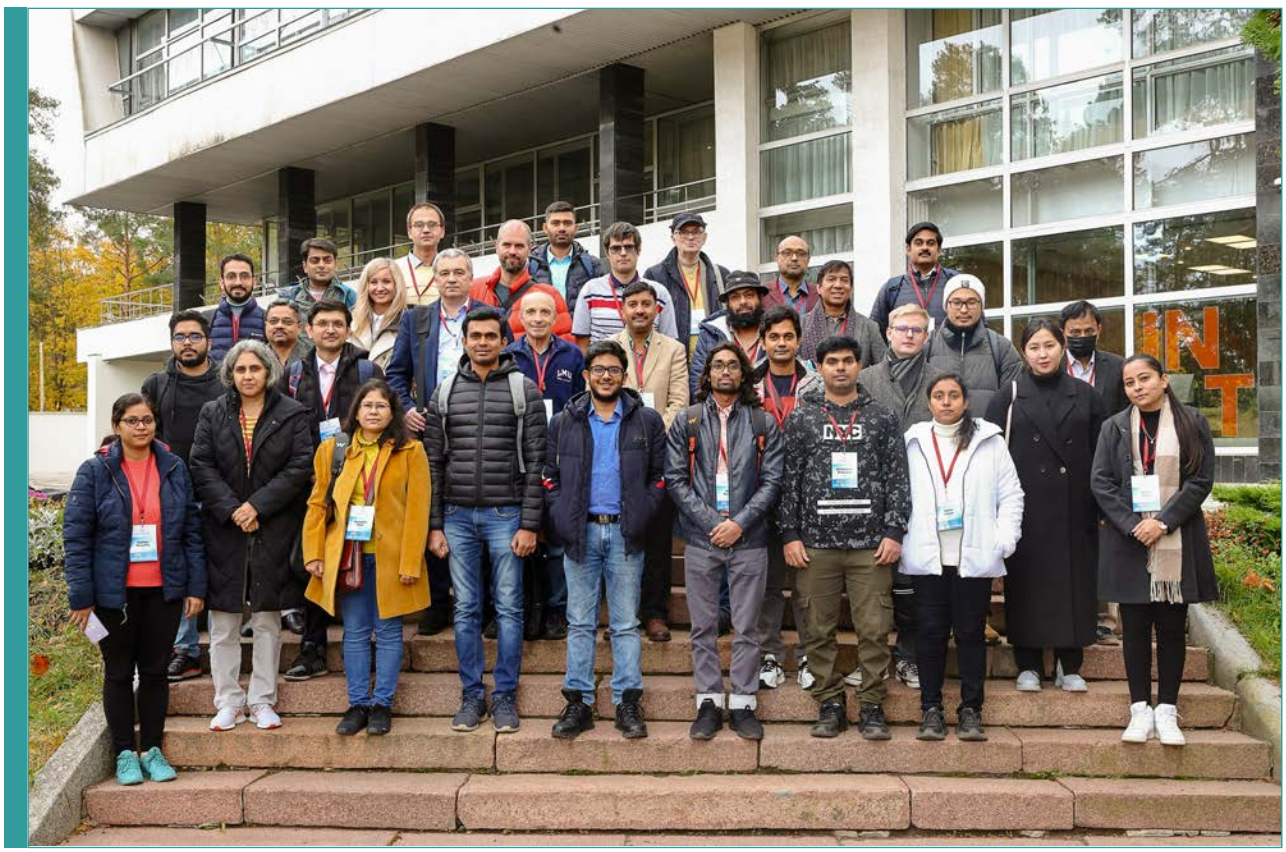
The delegation's programme included work visits to research infrastructure facilities in the Cape Town area: the iThemba LABS accelerator laboratory, the Centre for High Performance Computing (CHPC), and the South African Population Research Infrastructure Network (SAPRIN) office.

At the end of October, a JINR delegation led by Vice-Director L. Kostov visited the Arab Republic of Egypt (ARE), where a number of meetings took place at the Academy of Scientific Research and Technology (ASRT), the Egyptian Atomic Energy Authority (EAEA), Zewail City of Science, Technology, and Innovation, and the National Research Centre (NRC). The delegation included FLNP Director E. Lychagin, FLNP Deputy Director S. Kulikov, Head of the ARE National Group in JINR W. Badawy, Chairman of the JINR Science and Technology Council E. Kolganova, and Head of the International Cooperation Department O.-A. Culicov.

During the visit to the Egyptian Atomic Energy Authority, the JINR delegation met with its leaders and got acquainted with the existing infrastructure based on the multifunctional ETRR-2 reactor, namely, a neutron activation analysis and neutron tomography facility, a laboratory for the production of medical isotopes, and a workshop for the production of fuel assemblies for the reactor. The parties discussed the need to train staff to calculate, create, operate, and carry out experiments at the planned new neutron scattering stations at the ETRR-2 reactor, and the possibility of conducting joint experiments and scientific events.

The second meeting of the Joint Coordination Committee (JCC) on Cooperation with the Arab Republic of Egypt took place under the leadership of Plenipotentiary of the Government of the Arab Republic of Egypt to JINR M. Sakr and JINR Vice-Director L. Kostov. The JCC members summed up the results of cooperation with Egyptian scientific partners over

Dubna, 16–19 October.
Workshop “India–JINR: Frontiers of Basic and Applied Research”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Tashkent (Uzbekistan), 2 November. After signing of the Letter of Intent between AYSS JINR and the Council of Young Scientists of the Academy of Sciences of the Republic of Uzbekistan

the past two years. In addition, they outlined further steps to develop new interaction mechanisms.

The delegation from Dubna visited with special interest the National Research Centre, which is involved in a number of joint projects, met with leaders of the Centre, namely, its President Professor H. Darwish and Vice-President M. Moawad Ali, and visited some laboratories working at the intersection of physics, chemistry, and biology to solve interdisciplinary problems in materials science, medicine, food and environmental safety.

From 2 to 8 November, the RSA–JINR Board Coordinator for Nuclear Physics, Dr. I. Usman from the University of Witwatersrand (Wits) in Johannesburg, South Africa, visited the Joint Institute for Nuclear Research. During her visit, Dr. Usman presented a report at the Joint Low-Energy Nuclear Physics Seminar at the Bogoliubov Laboratory of Theoretical Physics and visited the Flerov Laboratory of Nuclear Reactions, where she got acquainted with experimental facilities of the SHE Factory: MAVR, SHELLS, CORSET, and ACCULINNA-2. While there, she discussed with the leaders of the Laboratory the possibility of new joint projects between Wits and FLNR researchers and opportunities for other RSA universities as well.

New scientific projects and joint experiments of mutual interest were discussed, such as the Giant Dipole Resonances at the MAVR spectrometer and theoretical analysis in collaboration with BLTP. Numerous publications in leading scientific journals demonstrate the success of the collaboration. During the meetings, the sides discussed the plan of cooperation for the following three years: it is planned to continue the analysis of the experimental data obtained by iThemba LABS and work out potential areas for further projects. The National Research Foundation of South Africa also encourages the collaboration and exchange of scientists from South Africa with those of JINR and has ongoing calls for proposals of new joint projects. It suggested several ideas for new joint projects that would allow the continuation of mutual fruitful cooperation, reciprocal visits and enrich knowledge amount in nuclear research.

On 3 November, a meeting between JINR Director G. Trubnikov and President of the Academy of Sciences of the Republic of Uzbekistan, Plenipotentiary of the Government of Uzbekistan to JINR B. Yuldashev was held at the JINR Directorate. The meeting was attended by JINR Vice-Director L. Kostov and the Head of the National Group of Uzbekistan at JINR A. Inoyatov. As a result of the discussions, an agreement was reached on the implementation of a joint research programme with the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan (INP AS RUz) on the radiation modification of the conductive properties of high-temperature superconducting tapes for JINR accelerator complexes.

At the meeting, the dynamic development of cooperation in the field of nuclear analytics, structural analysis, information technology and seismology was noted, as well as JINR's contribution to the training of national personnel for academic institutions and universities of Uzbekistan. A unique highly sensitive facility for the structural analysis of substances

by neutron radiography and tomography was created at the INP AS RUz together with specialists from FLNP JINR; with the support of JINR MLIT specialists, a cloud computing system was implemented, which made it possible to increase the efficiency of using hardware resources and integrate the INP computing centre into the JINR cloud network; installation and commissioning of precision inclinometers developed at DLNP JINR are planned at the control sites of the Institute of Seismology of AS RUz.

During the meeting, B. Yuldashev, being one of the authors, presented to G. Trubnikov a five-volume textbook "Nuclear Technologies", the publication of which was timed to coincide with the 80th anniversary of the Academy of Sciences of the Republic of Uzbekistan. Among the reviewers of the publication are leading scientists of BLTP, FLNR and FLNP JINR.

In early November, in Kazakhstan, a festive signing of the Letter of Intent between the Association of Young Scientists and Specialists (AYSS) of JINR and the Council of Young Scientists of the Academy of Sciences of the Republic of Uzbekistan took place at a meeting of the Council of Young Scientists of the International Association of Academies of Sciences as part of the "Week of Innovative Insights of Young Scientists: Shaping the Future of Science and Technology". M. Shandov, an AYSS Council member from the Laboratory of High Energy Physics at JINR, and S. Gulyamov, Chairman of the Council of Young Scientists of the Academy of Sciences of Uzbekistan, signed the document.

The purpose of the Letter of Intent is to establish long-term cooperation between the parties aimed at effective coordination of research activities of young scientists, exchange of experience, joint implementation of scientific projects, and other activities in the interests of science development.

During the week, the participants were actively discussing cooperation and exchange of experience in artificial intelligence and machine learning, nanotechnology, development of new materials, application of virtual and augmented reality technologies, innovative developments in medicine, etc. Young scientists from Uzbekistan, Russia, Belarus, Armenia, Azerbaijan, Kyrgyzstan, JINR, Moscow State University, and the Kurchatov Institute took part in the event.

Dubna, 3 November.
Meeting of JINR Director G. Trubnikov and President of the Academy of Sciences of the Republic of Uzbekistan, Plenipotentiary of the Government of Uzbekistan to JINR B. Yuldashev

Astana (Kazakhstan), 7 November. At the meeting of JINR Director G. Trubnikov with Minister of Science and Higher Education of the Republic of Kazakhstan S. Nurbek (centre)

On 7 November, in Astana, Director of the Joint Institute G. Trubnikov met with Minister of Energy of the Republic of Kazakhstan A. Sätqaliev and Minister of Science and Higher Education of Kazakhstan S. Nurbek. At the meetings, the JINR delegation was represented by JINR Vice-Director L. Kostov, Head of the International Cooperation Department O.-A. Culicov, JINR Chief Engineer B. Gikal, FLNR JINR Director S. Sidorchuk, and Head of the National Group of Kazakhstan Ye. Mukhamedzhanov. Kazakhstan's side included Deputy Chairman of the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan A. Bibosinov, Director General of the Institute of Nuclear Physics of the Ministry of Energy of Kazakhstan, Plenipotentiary of the Government of Kazakhstan to JINR S. Sakhiyev, and Head of the Astana branch of the INP of the Ministry of Energy of Kazakhstan M. Zdorovets. During the meetings, they discussed scientific and technological cooperation between JINR and Kazakhstani scientific and higher educational institutions.

At the meeting with Minister of Energy A. Sätqaliev, the prospects of conducting joint applied research, particularly that in the field of ecology, were considered. Thus, the Minister expressed interest in JINR's experience in developing environmental projects with other Member States of the Institute.

On the same day, a meeting took place with Minister of Science and Higher Education of Kazakhstan S. Nurbek, during which he stressed the important role of the Joint Institute in the advancement of science in Kazakhstan. S. Nurbek emphasized the significance of developing science in universities and increasing the number of private investments in science.

On 11 November, the Institute of Nuclear Physics of the Ministry of Energy of the Republic of Kazakhstan officially launched the work of a new JINR cloud computing cluster at the INP as part of the guest CP JINR session. Representatives of the National Academy of Sciences under the President of the Republic of Kazakhstan and Al-Farabi Kazakh National University took part in the events.

The first JINR cloud computing cluster in the Republic of Kazakhstan and the 11th in the series was included in the distributed information computing environment (DICE) of the Joint Institute. The resources of the cloud cluster at the INP are available for employees of scientific institutes and universities of Kazakhstan for their own research and in the framework of the participation in the JINR mega-science projects — NICA and Baikal-GVD.

INP Director General, Plenipotentiary of the Government of the Republic of Kazakhstan to JINR S. Sakhiyev highlighted that the opening of JINR cloud infrastructure clusters made it possible to join the efforts and resources of the JINR Member States in solving fundamental and applied problems, in order to quickly perform complex calculations and ensure high-precision research results.

On the same day, an opening ceremony of the JINR Information Centre at the INP of the Ministry of Energy of the Republic of Kazakhstan took place. The Centre became the tenth in the family of JINR Information Centres.

A tour of the laboratories of the Institute of Nuclear Physics and its facilities, namely, the WWR-K Nuclear Research Reactor, the Radiopharmaceutical Production Centre, and the ILU-10 Pulsed Linear Electron Accelerator, was organized for the participants of the CP JINR session.

On 15 November, AYSS JINR and the Council of Young Scientists of the National Academy of Sciences (CYS NAS) of Belarus signed a cooperation agreement. The document was signed at a working session of CYS chairmen that was part of the International Science Festival of the Union State of Russia and Belarus.

The agreement is to stimulate cooperation between young scientists of JINR and NAS of Belarus in order to achieve significant scientific output and promote science through efforts to organize joint events, exchange specialists, and inform each other about ongoing schools and conferences.

The Science Festival, held from 14 to 16 November in Minsk, was aimed to intensify cooperation and involve young researchers in solving socially significant tasks of the development of the Union State. The working session of CYS chairmen was attended by representatives of JINR, NAS of Belarus, the Project Office "Russia–Belarus", and Russian universities and associations, including the Peoples' Friendship University of Russia, St. Petersburg State University of Architecture and Civil Engineering, the Northern (Arctic) Federal University, and CYS of the Nizhny Novgorod Region. During the meeting, the two sides outlined the main areas of cooperation and identified the most significant short- and long-term tasks and projects.

On 20 November, at a joint meeting of the Scientific Council of Lomonosov Moscow State University and JINR, a cooperation agreement was signed between JINR and MSU. The document was signed by JINR Director G. Trubnikov and Rector of Moscow State University V. Sadovnichy. The document

Minsk, 15 November. After signing of the cooperation agreement between AYSS JINR and the Council of Young Scientists of NAS of Belarus

Moscow, 20 November. MSU Rector V. Sadovnichy and JINR Director G. Trubnikov signed an agreement on cooperation between JINR and MSU

expands cooperation between JINR and MSU in the implementation of joint research projects and the use of IT infrastructures in the educational field, and also provides for the active development of the MSU branch in Dubna.

In accordance with the agreement, joint research will be conducted on the physics of elementary particles and the atomic nucleus, condensed matter physics using nuclear physics methods, astrophysics, radiobiology, ecology; Grid segments of JINR and Moscow State University will be created, and the potential of the new supercomputer MSU-270 will be used to solve joint tasks in the field of information technology.

JINR Director Academician G. Trubnikov presented plans for the development of the MSU branch in Dubna to the Scientific Council of MSU. He also thanked V. Sadovnichy and his team for their support in organizing the work of the branch. G. Trubnikov presented the Rector of Moscow State University with the mantle and diploma of the Honorary Doctor of JINR.

MSU Rector Academician V. Sadovnichy noted in particular that one of the important reasons for signing the agreement with JINR is the efforts of MSU to create an Innovative Scientific and Technological Centre "Vorobyovy Gory", where high-tech companies, in conjunction with scientists from MSU, will implement applied projects in the most advanced areas of science.

The Deputy Director of the MSU branch in Dubna, A. Olshevsky, informed about the branch's activities, tasks and plans. JINR Scientific Leader Academician V. Matveev devoted his speech to the history of successful cooperation between MSU and JINR on the basis of the MSU branch in Dubna and the need to further strengthen creative scientific and educational ties. He highlighted that the communication of students with world-class scientists and participation in research at advanced physical facilities remains the most serious motivation for scientific youth today. FLNP Senior Researcher W. Badawy spoke about the JINR educational programme implemented in student practices and internships, programmes for young scientists presented at UC JINR and at 13 JINR basic departments in 6 Russian universities, as well as at the site of 11 Information Centres of the Institute in many regions of Russia and a number of other JINR Member States.

The Joint Institute at the joint meeting of the MSU Scientific Council and JINR was represented by about 50 employees, including the directors of the Institute's laboratories and scientists involved in joint projects and research — representatives of Russia, Belarus, Bulgaria, Egypt, and Kazakhstan.

On 28–30 November, leaders and young scientists of JINR took part in III Congress of Young Scientists in the Sirius Park of Science and Art (Krasnodar Region, Russia).

JINR Director Academician G. Trubnikov made reports at four sessions of the Congress dedicated to the infrastructure of the megascience class in the Russian Federation, development of science cities in Russia, the role of fundamental scientific research in the scientific and technological development of the country, and the role of women in science.

Scientific Leader of FLNR Academician Yu. Oganessian answered questions of young scientists in the format of an online broadcast. The audience learned that to be famous "distracts more than helps", how to motivate pupils to science, and got advice for those who started doubting scientific ideals and considered if it is worth pursuing their path in science.

A Declaration of Intent between JINR and NRC "Kurchatov Institute" was signed aimed at joint and full participation in the development and use of megascience-class research infrastructure: the megaprojects of JINR and MCNR PIK, as well as readiness to work out a joint research programme.

On 30 November and 1 December, the 9th meeting of the JINR–Serbia Joint Coordination Committee on Cooperation (JCC) took place in Belgrade as part of the visit of the Institute's delegation to the Republic of Serbia. JINR Chief Scientific Secretary S. Nedelko headed the delegation. The JINR delegation included JINR Chief Engineer B. Gikal, Co-Head of the joint project on cooperation in the field of accelerator technologies, LRB Director A. Bugay, Head of the JINR International Cooperation Department O.-A. Culicov, and UC JINR Director D. Kamanin.

The JINR delegation started the visit from the Vinča Institute of Nuclear Sciences where its Director S. Pajović welcomed the JINR delegation. The sides exchanged views on issues of cooperation between the Institutes. The visit continued with a working meeting that brought together over 30 leaders of ongoing and new joint projects from Belgrade, Novi Sad, Niš, and Kragujevac. The participants of the meeting put forward a number of initiatives aimed at developing cooperation and discussed organizational issues related to project financing, student participation, involvement of third parties, and evaluation of the effectiveness of projects. All parties showed active interest in continuing and deepening cooperation.

The final session of the Committee included a meeting with State Secretary V. Grozdić at the Ministry of Science, Technological Development and Innovation of the Republic of Serbia. The State Secretary confirmed the Ministry's intention to further strengthen scientific ties with JINR, particularly in the field of education and personnel training. The participants of the meeting noted the good results of joint research projects in 2023 and the noticeable progress in the development of overall scientific and technical cooperation. The 9th meeting of the Joint Coordination Committee launched 12 new projects.

On 1 December, in Minsk, representatives of JINR took part in the international scientific and practical conference "Topical Issues of Ensuring Scientific and Technological Safety" dedicated to the 30th anniversary of the establishment of the State Committee for Science and Technology (SCST) of the Republic of Belarus. The speakers from JINR presented the NICA megascience project and the large IT infrastructure of JINR.

The JINR delegation was represented by the Director of the Institute G. Trubnikov, Vice-Director V. Kekelidze, MLIT Scientific Leader V. Korenkov, Special Representative of the JINR Director on Educational Policy S. Arutyunian and Deputy Chief of the LHEP Department on Science O. Belov.

In his congratulation on the anniversary, G. Trubnikov stressed that SCST had been a partner of JINR since the day of its foundation and a participant of

Belgrade (Serbia), 30 November – 1 December.
The 9th meeting of the JINR–Serbia Joint Coordination Committee on Cooperation

the Dubna International Innovation Nanotechnological Centre. SCST promoted the development of JINR cooperation with higher education institutions of Belarus: several thousands of high-quality researchers have been trained for 30 years.

From the JINR side, several reports were made at the conference. O. Belov told how the issues of ensuring the national scientific and technological safety are solved on the example of the megascience complex NICA. The report of V. Korenkov was devoted to geographically distributed computer infrastructure for large-scale scientific projects. S. Arutyunian spoke about the role of net research universities in training of high-quality scientific staff.

On 4 December, the JINR Information Centre and Virtual Laboratory officially opened at the headquarters of the Arab Atomic Energy Agency (AAEA) in Tunis. JINR Director G. Trubnikov and AAEA General Director S. Hamdi signed a Memorandum of Understanding due to the expiration of the previous one signed in 2016. The parties concluded they had successfully implemented all the provisions of the 2016 Memorandum and signed a new, permanent agreement. On the same day, G. Trubnikov participated in an AAEA Executive Board meeting and made a report on the Institute's focus areas.

At the opening ceremony, G. Trubnikov noted that a new educational programme, the three-month ASPYRE internship for young scientists and engineers of the AAEA member countries, would be launched in the near future as part of the work of the Infocentre.

S. Hamdi stressed that the JINR–AAEA cooperation was on the rise and called the opening of the JINR Information Centre and Virtual Laboratory at the Agency's headquarters a historic moment. The Head of the new IC, I. Khalifa, has undergone training at the JINR University Centre in order to study the potential of the Virtual Laboratory. During the opening ceremony, he delivered a speech on joint plans of JINR and AAEA for 2024 and outlined opportunities provided by the JINR IC to the Agency's member countries. N. Sidorov, a software engineer at VBLHEP JINR, made a report on the work of JINR Information Centres, principles of operation of the Virtual Laboratory, and the activities of the JINR University Centre.

In early December, DLNP Director E. Yakushev took part in the conference "Modern Trends in Physics – 2023", organized by Baku State University (Azerbaijan). During the visit to Baku, E. Yakushev held a series of meetings and spoke at a scientific seminar, where he familiarized the audience with the activities of the Institute and the scientific research at DLNP.

During the meeting with the Plenipotentiary of the Government of the Republic of Azerbaijan to JINR, Academician of the National Academy of Sciences of Azerbaijan Arif Mamed oglu Hashimov, the parties discussed JINR cooperation with scientific organizations of the Republic of Azerbaijan.

On 12–13 December, representatives of JINR took part in jubilee events in Tashkent on the occasion of the 80th anniversary of foundation of the Academy of Sciences of the Republic of Uzbekistan (AS RUz) and became participants of the international conference "Science Is the Basis of the New

Tunis, 4 December. At the opening ceremony of the JINR Information Centre and Virtual Laboratory at the headquarters of the Arab Atomic Energy Agency

Tashkent, 12 December. JINR Vice-Director L. Kostov speaks at the solemn meeting on the occasion of the 80th anniversary of foundation of the Academy of Sciences of the Republic of Uzbekistan

Uzbekistan". They also visited the exhibition of innovation elaborations and the exposition about the history of AS RUz.

Congratulating AS RUz on behalf of the multinational community of JINR, Head of the JINR delegation Vice-Director L. Kostov stressed that scientists of Uzbekistan take an active part in implementation of the scientific programme of JINR and make big contribution to its scientific achievements of the world level.

On 25 December, a regular meeting of the STC JINR was held at the JINR International Conference Centre. Results achieved during the year and plans for the near future were discussed at the event, as well as the establishment of a peer-reviewed scientific journal in electronic format at JINR. Several JINR staff members were presented municipal awards.

The JINR Director spoke about the latest bright achievements of the Institute's laboratories. On the second issue of the agenda, FLNP researcher A. Nezvanov made a report "On Approaches to the Establishment of a New Scientific Journal of JINR". In the discussion of the necessity to establish a new journal, the following persons took part: V. Kekelidze, S. Shmatov, D. Peshekhonov, D. Kazakov, I. Meshkov, V. Aksenov, O. Teryaev, T. Strizh, A. Bednyakov, A. Aparin, and A. Novoselov.

In conclusion of the STC meeting, awards were presented to the staff members of the Institute. The Certificate of Honour of Dubna city district was awarded to FLNP Director E. Lychagin, VBLHEP Scientific Secretary A. Cheplakov, BLTP Scientific Secretary A. Andreev, Advisor to the DLNP Directorate D. Pontecorvo, Head of the Sector of Ion Collisions Reconstruction of VBLHEP O. Rogachevsky, VBLHEP Leading Specialist in Office Work N. Gorelikova, and Leading Electronic Engineer of VBLHEP A. Kirichenko. Head of the Heat and Water Supply and Ventilation Group of VBLHEP V. Chernyaev was marked with Gratitude of the Council of Deputies of Dubna city district.

CONFERENCES and MEETINGS

Ten conferences were the largest among the scientific conferences and workshops held at JINR in 2023.

On 18–20 April, ***the 11th Collaboration Meeting of the MPD Experiment at the NICA Facility*** was held at the Veksler and Baldin Laboratory of High Energy Physics and online. More than 150 participants gathered to discuss the progress in the implementation of the project.

Opening the meeting, JINR Vice-Director, Leader of the NICA project V. Kekelidze noted the successful outcome of the longest commissioning run in the history of the facility, which was completed in February 2023, and reported that all the magnets of the collider were ready for operation and that 80 dipole magnets had already been installed in the arches of the tunnel. Construction works at the facility have been completed and the delivery of engineering equipment is expected. The cryogenic complex of the NICA project will be put into operation within the next few months. The main electrical substation is already functioning. V. Kekelidze also expressed hope that by the end of 2023 it will be possible to start the technical launch of the collider.

The collaboration's spokesman V. Riabov (PNPI) reported on the current status of the collaboration and progress in the implementation of the MPD project. The project brings together more than 500 participants from 34 institutes of 10 countries. The number of publications is increasing. Thus, about 200 articles on physical research, equipment, and software of the experiment have already been published. Head of the MPD project at the NICA ac-

The Veksler and Baldin Laboratory of High Energy Physics,18–20 April.
Participants of the 11th Collaboration Meeting of the MPD Experiment at the NICA Facility

celerator complex of JINR V. Golovatyuk spoke in more detail about the project and plans of the team up to the beginning of 2024. Reports on each system of the first stage of the MPD experiment were presented at the meeting. The participants discussed the software and computing infrastructure of the detector, as well as reconstruction of events in the experiment. Speakers of physical working groups delivered progress reports. As part of the meeting programme, the participants got acquainted with the status of the works during an excursion to the Nuclotron and MPD Halls, which took place on 19 April. Recordings of reports are available on the event's website.

On 15–19 May, ***the 10th Collaboration Meeting of the BM@N Experiment at the NICA Facility*** was held at Saint Petersburg State University (SPbSU) in a mixed format. The participants considered results of the first physical experiment that a team of the project conducted during the 4th commissioning run at the NICA complex. They also discussed fur-

Cape Town (RSA), 16 January – 4 February. Participants of the RSA–JINR Summer School

Dubna, 26 June.
Young scientists and specialists from CIS countries — participants of the 16th JINR International Internship

ther plans of the collaboration. Representatives of scientific centres of Russia, Bulgaria, and Israel took part in the meeting.

The current collaboration meeting focused on the reconstruction and identification of strange particles, as well as analysis of event topologies of Xe + Cs interactions collected during the 4th commissioning run at the NICA complex. The participants reviewed the physics analysis of previously collected argon–nucleus interactions. In addition, they discussed a physics programme and experimental setup in the next BM@N experimental run. The agenda of the event also included a meeting on the BM@N software status.

The BM@N Institutional Board Meeting was held separately, which focused on organizational issues of the collaboration, as well as consideration of the application of the Almaty group from the Institute of Physics and Technology to the BM@N collaboration.

Moreover, on 16 May, within the framework of the meeting, scientists delivered lectures on the status of the NICA complex and physics of relativistic nuclear collisions at the Faculty of Physics of SPbSU in Peterhof.

The annual ***International Seminar on Interaction of Neutrons with Nuclei (ISINN-29)*** opened with a year delay on 29 May 2023 simultaneously in Dubna and Lanzhou (China). Like the two previous seminars, it was co-organized by the Frank Laboratory of Neutron Physics of JINR, the State Key Laboratory of Intense Pulsed Radiation Simulation and Effect of the Northwest Institute of Nuclear Technology (NINT, Xi'an, China) and the School of Nuclear Science and Technology of Lanzhou University. The seminar was held in a hybrid format, bringing together in Dubna more than 90 participants from FLNP, FLNR and VBLHEP JINR, NRC "Kurchatov Institute", PNPI (Gatchina), SINP MSU, INR, INP (Novosibirsk), ITP (Chernogolovka), Moscow, Novosibirsk, Voronezh, Perm universities, scientific centres of Belarus, Egypt, Kazakhstan, and Russia. Nearly 100 attendees representing universities and research centres of China gathered in Lanzhou, and a number of participants, including those from Argentina, Bulgaria, France, India, Romania, Serbia, Singapore, Turkey, USA, Uzbekistan, and Vietnam joined the seminar via the Internet.

Opening the seminar in Dubna, JINR Vice-Director L. Kostov reminded that the history of ISINN dates back to 1993, and if not for the force majeure interruption last year, this seminar would have become a jubilee one. During its thirty-year history, ISINN seminars have brought together specialists of various fields of neutron physics from many countries. Professor Hei Dongwei (NINT) and Academician Yan Chunhua (Lanzhou University) greeted the participants and wished them a successful and productive meeting. Plenary and section reports of the seminar covered its traditional topics: from the fundamental properties of the neutron to modern neutron sources, from promising experiments in the field of nuclear fission and nuclear reactions induced by fast neutrons to the physics of reactors and experimental

Dubna, 29 May. Participants of the 29th International Seminar on Interaction of Neutrons with Nuclei (ISINN-29)

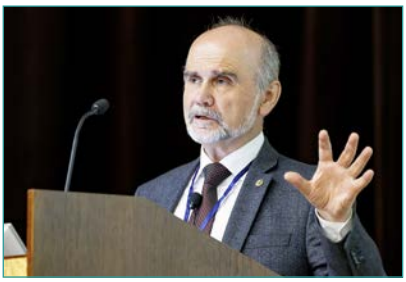
Alushta (Crimea), 4 June. Participants of the International Conference of Young Scientists and Specialists

Lipnya Island, 19–23 June. The 1st School of Accelerator Physics

methodology. As usual, investigations using nuclear and related analytical techniques in the environmental and materials sciences were widely represented.

A total of 108 oral and 38 poster presentations were made. Due to the large volume of presented results and the large time difference with Chinese and other Asian representatives, it became necessary to organize parallel session meetings, as well as online and in-person poster sessions. Most of the reports, the Programme of the seminar and the Book of Abstracts can be found at http://isinn.jinr.ru/past-isinns/isinn-29/program.html.

The Meshcheryakov Laboratory of Information Technologies, 3–7 July. The 10th International Conference “Distributed Computing and Grid Technologies in Science and Education” (GRID’2023)



On 3–7 July, the anniversary 10th International Conference ***"Distributed Computing and Grid Technologies in Science and Education" (GRID'2023)*** was held at the Meshcheryakov Laboratory of Information Technologies in a mixed format.

The conference traditionally attracted a large community of Russian and foreign experts ready to discuss emerging challenges and prospects related to the use and development of distributed grid technologies, heterogeneous and cloud computing in different fields of science, education, industry and business. In 2023, the list of conference topics was complemented with computing for megascience projects, machine and deep learning, Big Data analytics and quantum computing.

More than 280 scientists (210 in person, over 70 remotely) from research centres of Armenia, Azerbaijan, Belarus, Bulgaria, the Czech Republic, Egypt, Georgia, Germany, Iran, Kazakhstan, Mexico, Moldova, Mongolia, Serbia, Switzerland, and Uzbekistan took part in the conference. Russia was represented by participants from 40 universities and research centres.

JINR Director G. Trubnikov opened the conference with a report on JINR's research areas and flagship projects. MLIT Scientific Leader V. Korenkov spoke about the status of the JINR Multifunctional Information and Computing Complex and perspectives for its development. The talk by A. Fedorov, Skolkovo Quantum IT Group Leader, on the control of quantum many-body systems evoked great interest among the audience.

A new feature in the conference programme was the student scientific session, at which students who had passed the selection at the JINR Spring School of Information Technologies delivered talks on the results of their work.

The GRID'2023 programme embraced two workshops. One of them, devoted to the issue of modelling and creating digital twins for new-generation reactors, was organized jointly by MLIT JINR, FLNP JINR and the MBIR Consortium. The second workshop, on computing for radiobiology and medicine, was organized by the JINR MLIT and LRB team together with Serbian colleagues. In addition, round tables were held on the development of IT education with the participation of numerous representatives of universities and on the RDIG-M (Russian Data-Intensive Grid Certificate Authority) distributed infrastructure for data processing, storage and analysis within large-scale scientific projects in Russia.

A total of 30 plenary and over 135 sessional talks were delivered within GRID'2023. Fruitful discussions were held by the conference participants, new IT projects aimed at the development of distributed and high-performance computing were proposed, and new areas emerged in collaboration of MLIT with organizations and universities of Russia and the JINR Member States.

At the closing of GRID'2023, words of gratitude were expressed to the organizing committee for the high level of holding the conference.

The presentations of the talks and photos are available at grid2023.jinr.ru. Selected proceedings of the conference will be published in the journal "Physics of Elementary Particles and Atomic Nuclei".

On 4–8 September, a traditional Dubna event, ***Workshop on High Energy Spin Physics (DSPIN)***, was held in a hybrid format at JINR. This meeting was dedicated to the 90th anniversary of the birth of A. Efremov (1933–2021), an outstanding physicist, a world-renowned specialist in the field of quantum field theory and elementary particle physics, a world-known expert and leader of spin physics in Dubna. The Joint Institute for Nuclear Research, the Konstantinov Petersburg Nuclear Physics Institute, the Logunov Institute of High Energy Physics, and the National Research Nuclear University MEPhI organized the event.

The First Workshop on High Energy Spin Physics, chaired by Professor L. I. Lapidus, took place in Dubna in 1981. This was followed by the series of biennial workshops in the odd years in between Spin Symposia.

The workshop covered a wide range of spin phenomena at high and intermediate energies, such as recent experimental data on spin physics, nucleon spin structure, transverse momentum distributions (TMDs) and generalized parton distributions (GPDs), spin physics and QCD, spin physics in the Standard Model, fundamental symmetries beyond the Standard Model, polarization and heavy-ion physics, spin in gravity and astrophysics, spin physics at NICA (SPD and MPD), polarimeters for high-energy polarized beams, acceleration and storage of polarized beams, new polarization technologies, spintronics of nanostructures.

Moreover, the workshop offered an opportunity to a large group of physicists and students from Russia and other JINR Member States to get acquainted with the most recent experimental and theoretical results in spin physics. Almost 90 scientists from research centres of different countries took part in the event.

On 18–23 September, the 25th anniversary Baldin International Seminar on Problems of High-Energy Physics ***"Relativistic Nuclear Physics and Quantum Chromodynamics"*** was held at JINR within the programme of the International Year of Basic Sciences for Sustainable Development.

This series of seminars started in 1969 with the support of Academician M. Markov. The jubilee 25th seminar was held in the year marked with important dates related to the Veksler and Baldin Laboratory of High Energy Physics (VBLHEP) and outstanding scientists, whose names are connected with the laboratory. Seventy years ago, a Hydrotechnical Laboratory was established under the guidance of V. Veksler, which later was called the Laboratory of High Energies and was included in JINR, established in 1956. In 1957, the largest accelerator at the time, the Synchrophasotron, was launched under the di-

Dubna, 18–23 September. The 25th International Baldin Seminar on High-Energy Physics Problems "Relativistic Nuclear Physics and Quantum Chromodynamics"

rect guidance of V. Veksler. First studies in the new field of high energy physics — relativistic nuclear physics (RNP) — were started there, and unique experiments were conducted until 2002. A. Baldin was one of the founders of RNP. Another jubilee date is connected with his name — 30 years ago the world's first accelerator of nuclei on the basis of magnets with superconducting techniques, the Nuclotron, started to operate at LHE. The Nuclotron continues to operate now as it is one of the key elements of the NICA accelerator complex that is being developed at VBLHEP.

JINR Vice-Director V. Kekelidze opened the seminar and noted that the previous Baldin seminar was held five years ago due to the pandemic and other factors, while during this time, science was developing. Very interesting results were achieved. That is why the seminar, held this year under the support of IUPAP, continues to be important for the scientific community.

The seminar was attended by 230 scientists and specialists from 11 countries. The agenda included 153 reports, 83 of which were presented at the plenary sessions. Eighty-three young scientists and specialists (under 35 years old) took part in the seminar. The majority of them made reports about their research and methodical elaborations, and had a bright chance to participate in scientific discussions and establish scientific contacts with colleagues from other research centres. Among the speakers and listeners were students from Dubna State University.

The latest results obtained at the largest facilities from around the world were presented. The participants discussed current advances in the development of theoretical models and the results of applied research using technologies and methods developed in research in high energy physics and nuclear physics. A number of reports were devoted to the status of the implementation of the NICA megascience project, as well as the results obtained in experiments at the LHC at CERN.

A special section of the seminar was dedicated to the memory of Professor Valery Burov (1949–2022), one of the permanent organizers of the Baldin Autumn since 1969, first as scientific secretary, then as co-chairman of the organizing committee. This section was addressed by scientists who knew V. Burov well and by his students.

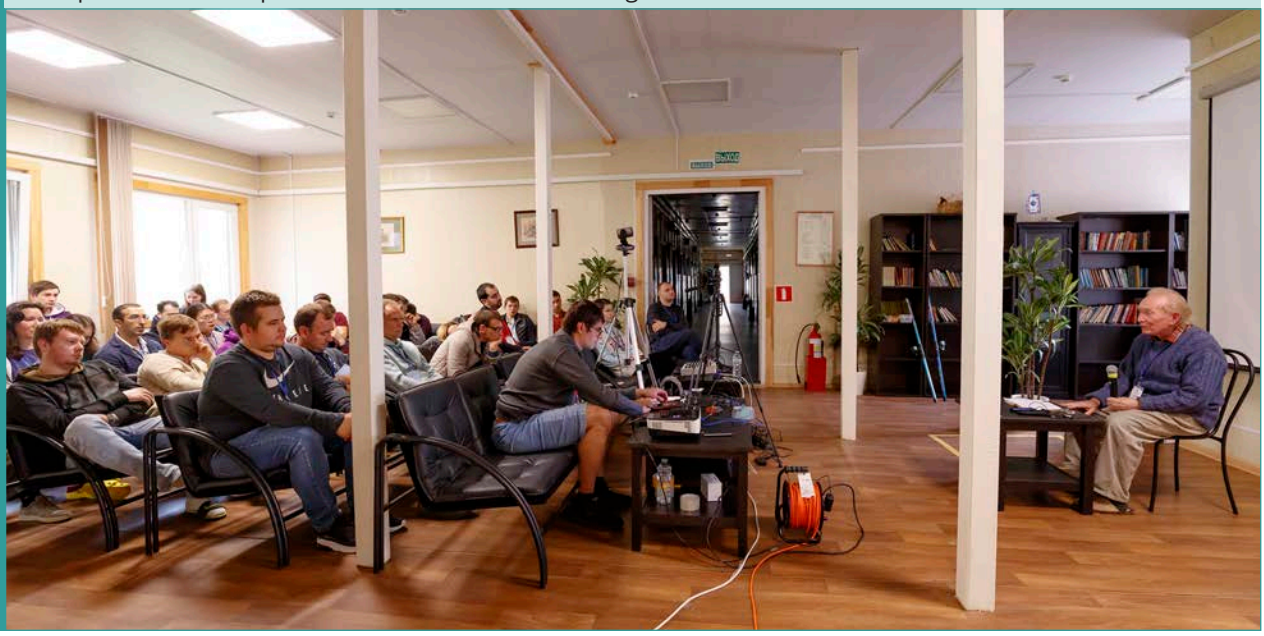
Six days of intensive work of the seminar were concluded with a cultural programme — an instrumental concert in the JINR Scientists Club and excursions free of the scientific programme. Some participants of the seminar visited the city of Tver, in particular, the travel palace of Catherine II; others visited the NICA accelerator complex at VBLHEP.

On 4 October, ***the 12th Collaboration Meeting of the MPD Experiment at the NICA Facility*** started at the Vinča Institute of Nuclear Sciences in Belgrade.

Opening the meeting, JINR Vice-Director, Leader of the NICA project V. Kekelidze noted the successful outcome of the longest commissioning run in the history of the experiment completed in February 2023. Member of the Governing Council of the Vinča Institute of Nuclear Sciences L. Hadžievski spoke at the meeting about the participation and scope of activities of the Serbian colleagues in the MPD collaboration.

Leader of the collaboration V. Riabov (PNPI) reported on the status of the collaboration and progress in the implementation of the MPD project. The project brings together more than 500 participants from 35 institutes in 11 countries. Moreover, two

Lipnya Island, 14 July. XXVII Summer School for Young Scientists and Specialists. Participants of the school at the meeting with FLNP Chief Researcher E. Shabalin



Belgrade, 4 October. Participants of the 12th Collaboration Meeting of the MPD Experiment at the NICA Facility

new scientific organizations joined the collaboration — Saint Petersburg Polytechnic University and the Institute of Physics and Technology (Almaty, Kazakhstan).

The reports of the physical groups on the work done were presented at the meeting. Reports were presented on each system of the MPD experimental facility. The participants also discussed the software and computing infrastructure of the detector, as well as the reconstruction of events in the experiment.

More than 120 scientists and specialists from research centres of Bulgaria, China, Egypt, Georgia, Israel, Mexico, Mongolia, Russia, and Serbia participated in the event.

On 19–20 October, an international conference ***"Current Problems in Radiation Biology. Molecular Genetic Research in Radiobiology. To the 70th Anniversary of DNA Structure Discovery"*** was held in Dubna. The conference was organized by the RAS Scientific Council on Radiobiology, RAS Radiobiological Society, and LRB JINR.

The year 2023 marked the 70th anniversary of the publication in the scientific journal "Nature" of J. Watson and F. Crick's paper "Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid," which first proposed a model of the spatial structure of DNA. The discovery of the DNA structure was made possible through the interaction of the major natural science disciplines — physics, chemistry, and biology — and initiated the ongoing development of new scientific directions.

The conference was held both offline and online. It was attended by more than 100 radiobiologists from Armenia, Azerbaijan, Belarus, Russia, and Serbia. The proceedings of the conference were published by its beginning (Dubna: JINR, 2023. 129 p.). Two introductory plenary and 24 oral reports were made; seven poster presentations authored by young scientists were considered.

The conference participants were welcomed by JINR Director Academician G. Trubnikov, who noted that the round date in the title of the conference is a good occasion to discuss current problems not only in genetics, but also in molecular and radiation biology. He specially thanked the RAS Department of Physiological Sciences and LRB JINR for organizing the event with the direct presence of a maximum number of participants.

In his opening speech, RAS Corresponding Member E. Krasavin, Chairman of the RAS Scientific Council on Radiobiology and LRB Scientific Leader, recalled prominent scientists whose discoveries formed the basis for understanding the phenomenon of DNA and the development of the concept of genome repair and stability.

President of the Radiobiological Society Academician I. Ushakov noted the great interest in the conference on the part of all radiobiologists who, to one degree or another, use molecular genetic methods in research.

The scientific programme of the conference included reports by leading Russian scientists and specialists who raised topical issues in various areas of research — from molecular DNA damage to genetic and epigenetic changes, gene expression, and mitochondrial genetics under radiation exposure.

As a result of the discussion, the conference participants decided to approve the holding of annual

Dubna, 19–20 October. An international conference “Current Problems in Radiation Biology. Molecular Genetic Research in Radiobiology. To the 70th Anniversary of DNA Structure Discovery”

Minsk (Belarus), 28 August – 3 September.
Participants of the 15th International School-Conference “The Actual Problems of Microworld Physics”

Dubna, 15 September.
Organizers and participants of the 23rd International Training Programme JEMS

international scientific conferences in the series “Current Problems in Radiation Biology”.

On 30 October – 3 November, ***the XXVII International Scientific Conference of Young Scientists and Specialists (AYSS-2023)***, dedicated to 110th anniversary of the birth of the outstanding physicist Bruno Pontecorvo, was held in Dubna.

This year, the conference hosted a record number of participants — more than 240 people, of which about 150 participants made oral presentations, and 80 made posters. The geography of the participants is extensive — representatives of 45 universities and scientific organizations from seven countries came to Dubna to present their work and get acquainted with the scientific research of their colleagues.

The conference programme included overview lectures on the work and life of B. Pontecorvo, the Standard Model in modern science, dark matter research, accelerator development and technology, astronomy and cosmology. A large block was devoted to neutrino research and related experiments. The entire scientific programme — both plenary and parallel sections — was broadcast to JINR Information Centres located in different parts of the world.

Young participants presented reports in nine thematic sections of the conference: theoretical physics, mathematical modeling and computational physics, high energy physics, particle accelerators and nucle-

The Veksler and Baldin Laboratory of High Energy Physics, 28–30 November.
The 11th Collaboration Meeting of the BM@N Experiment at the NICA Facility

ar reactors, experimental nuclear physics, information technology, condensed matter physics, applied research, and life sciences. The jury members selected the best reports in each thematic section, as well as the best poster presentation. The winners were awarded memorable prizes.

JINR Scientific Leader V. Matveev noted: "The level of the lecturers, who spoke vividly and meaningfully about the current state of science, and the level of the participants themselves, who asked deeply thoughtful questions, are very impressive. It's nice that we have such a growing generation. Young scientists are ready to make discoveries and are eager to work, so it is very important for us to help them enter real science as soon as possible." A rich cultural programme was organized for all participants of the conference.

On 28–30 November, ***the 11th Collaboration Meeting of the BM@N Experiment at the NICA Facility*** was held at VBLHEP. The participants discussed the current status of the BM@N experiment, the results achieved since the 10th meeting of the collaboration in May, and future plans.

The meeting was devoted to the analysis of the events of interactions of xenon (Xe) nuclei with an energy of 3.8*A* GeV with caesium iodide (CsI) target nuclei, identification of strange neutral particles, as well as charged mesons and nuclear fragments recorded during the BM@N experiment in a xenon ion beam. The results of the physical analysis of previously recorded data on argon-nuclear interactions were discussed at the meeting. Much attention was paid to the discussion of the physical programme and the development of the experimental setup for the next experimental session of BM@N.

JINR Vice-Director V. Kekelidze opened the meeting. Head of the collaboration M. Kapishin made a report on the work of the collaboration, plans and results achieved since the previous collaboration meeting. He informed the meeting participants that two more organizations had been accepted into the collaboration: the Institute of Physics and Technology of the Academy of Sciences of Uzbekistan and the National Research University Higher School of Economics. At the moment, the BM@N collaboration includes 13 institutes and 206 participants from five countries.

The speaker reported on the progress made in optimizing the algorithm for reconstructing particle tracks in the central and external BM@N track system using a recently measured magnetic field map. A version of the experimental data reconstruction programme has been prepared and a complete reconstruction of the events recorded in the session in a xenon ion beam has been carried out using the DIRAC system on the MLIT Tier computer cluster.

Deputy Head of the VBLHEP Scientific and Experimental Department of Multipurpose Detector S. Piyadin spoke about the modernization of the BM@N detectors. Chief Engineer of the NICA complex E. Syresin reported on the status of the NICA project, the current development of the Booster and the Nuclotron. Within the framework of the meeting, a session of the institutional council was held, at which organizational issues of the BM@N collaboration were discussed.

Conferences, Schools, and Meetings Held by JINR in 2023

No.	Name	Place	Date	Number of participants
1.	Student Programme START-2023, Winter Session	Dubna	January – May	14
2.	Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	17–18 January	75
3.	Meeting of the Programme Advisory Committee for Particle Physics	Dubna	23 January	70
4.	Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	26 January	70
5.	School for Students and Young Scientists on Physics at the NICA Accelerator Complex at JINR	Yerevan, Armenia	3–24 February	38
6.	133rd Session of the JINR Scientific Council	Dubna	16–17 February	110
7.	Technical Hackathon “Dubna-2023”	Dubna	18–19 February	100
8.	9th JINR–Armenia Workshop “Supersymmetry in Integrable Systems” (SIS 2023)	Dubna	20–22 February	40
9.	Meeting of the Working Group under the CP Chair on JINR Financial Issues	Yerevan, Armenia	27–28 February	25
10.	Workshop “Infinite and Finite Nuclear Matter” (INFINUM-2023)	Dubna	27 February – 3 March	60
11.	Solemn Seminar Dedicated to the 110th Anniversary of the Birth of Academician G. Flerov	Dubna	3 March	100
12.	Meeting of the JINR Finance Committee	Dubna	22 March	90
13.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Dubna	24–25 March	110
14.	JINR Foundation Day	Dubna	25 March	
15.	Workshop “NICA Accelerator Complex: Problems and Prospects – 2023”	Vladikavkaz	28 March – 3 April	60
16.	School on Physics of Quark–Gluon Matter	Dubna	30 March – 3 April	50
17.	Scientific School for Physics Teachers from Kamchatka	Dubna	3–7 April	15
18.	Grand Seminar Dedicated to the 90th Anniversary of Academician Yu. Oganessian	Moscow	14 April	100
19.	11th Collaboration Meeting of the MPD Experiment at the NICA Facility	Dubna	18–20 April	160
20.	Grand Seminar Dedicated to the 90th Anniversary of Academician Yu. Oganessian	Dubna	21 April	100
21.	Technical Hackathon “Dubna-2023”	Dubna	21–23 April	100
22.	12th Open Robotics Tournament “CyberDubna-2023”	Dubna	23 April	100
23.	Seminar Dedicated to the 85th Anniversary of Professor, Doctor of Physics and Mathematics I. Puzynin	Dubna	24 April	50
24.	Meeting of the SPD Collaboration	Dubna	24–28 April	85
25.	22nd Intrnational Training Programme “JINR Expertise for Member States and Partner Countries”	Dubna	24–28 April	30
26.	IUPAP Conference “Heaviest Nuclei and Atoms”	Yerevan, Armenia	24–30 April	70
27.	10th Collaboration Meeting of the BM@N Experiment at the NICA Facility	Saint Petersburg	15–19 May	120
28.	Stage 1 of the International Student Practice in JINR Fields of Research for Students from Egypt	Dubna	15 May – 2 June	30
29.	16th International Internship for Young Scientists and Specialists from CIS Countries	Dubna	28 May – 27 June	25
30.	29th International Seminar on Interaction of Neutrons with Nuclei “Fundamental Interactions & Neutrons, Nuclear Structure, Ultracold Neutrons, Related Topics” (ISINN-29)	Dubna	29 May – 2 June	120

No.	Name	Place	Date	Number of participants
31.	Baikal Collaboration Workshop	Dubna	30 May – 2 June	55
32.	XII Conference of Young Scientifics and Specialists "Alushta-2023"	Alushta, Crimea	4–11 June	60
33.	Stage 2 of the International Student Practice in JINR Fields of Research for Students from RSA	Dubna	5–23 June	40
34.	NICA-MPD/IT Seminar on China–Russia Cooperation	Wuhan, China	14–17 June	16
35.	5th International Summer School for Young Scientists "Modern Information Technologies for Solving Scientific and Applied Problems"	Vladikavkaz	14–17 June	80
36.	Meeting of the Programme Advisory Committee for Condensed Matter Physics	Dubna	15–16 June	75
37.	Workshop "Applied Research at the NICA Complex: Prospects for Cooperation between North Ossetia–Alania Region and JINR"	Vladikavkaz	16–20 June	50
38.	1st School of Accelerator Physics	Lipnya Island	19–23 June	70
39.	Meeting of the Programme Advisory Committee for Particle Physics	Dubna	21–22 June	70
40.	Meeting of the Programme Advisory Committee for Nuclear Physics	Dubna	29–30 June	70
41.	35th Summer International Computer School (ICS-2023)	Dubna	1–18 July	80
42.	12th International Scientific School for Physics Teachers	Dubna	3–7 July	24
43.	10th International Conference "Distributed Computing and Grid Technologies in Science and Education" (GRID'2023)	Dubna	3–7 July	250
44.	Summer Science Intensive School "Physics and Technology of Accelerators"	Dubna	3–8 July	40
45.	2nd Coordination Workshop on Swift and Highly Charged Ions in Materials Science	Petropavlovsk-Kamchatsky	4–6 July	20
46.	Summer School and Workshop "Element 105"	Dubna	6–16 July	40
47.	Meeting of the Working Group under the CP Chair on JINR Financial Issues	Irkutsk	10–11 July	25
48.	International Workshop "Superconducting and Magnetic Hybrid Structures"	Dubna	11–15 July	60
49.	XXIII Baikal International Summer School on Physics of Elementary Particles and Astrophysics, Devoted to the 110th Anniversary of the Birth of B. Pontecorvo	Bolshiye Koty, Irkutsk Region	11–18 July	50
50.	XXVII Summer School for Young Scientists and Specialists "Lipnya-2023"	Lipnya Island	14–16 July	80
51.	International School "Advanced Methods of Modern Theoretical Physics: Integrable and Stochastic Systems"	Dubna	23–28 July	55
52.	21st Lomonosov Conference on Elementary Particle Physics	Moscow	24–30 August	up to 400
53.	XV International School-Conference "The Actual Problems of Microworld Physics"	Minsk, Belarus	27 August – 3 September	100
54.	Seminar "The Use of New Methods for Processing Data of a Physical Experiment. Application of Machine Learning Methods on the NICA Complex"	Saint Petersburg	28–29 August	80
55.	BLTP JINR – KLTP CAS Joint Workshop "Physics of Strong Interactions"	Yerevan, Armenia	3–9 September	60
56.	XIX Workshop on High Energy Spin Physics (DSPIN), Dedicated to the 90th Anniversary of the Birth of A. Efremov	Dubna	4–8 September	140
57.	23rd International Training Programme "JINR Expertise for Member States and Partner Countries"	Dubna	11–15 September	30
58.	3rd International Workshop "The Use of Nuclear Physics Methods for Cultural Heritage Research"	Tashkent, Ulugbek, Uzbekistan	12–14 September	50

No.	Name	Place	Date	Number of participants
59.	XXV International Baldin Seminar on High-Energy Physics Problems “Relativistic Nuclear Physics and Quantum Chromodynamics”	Dubna	18–23 September	250
60.	134th Session of the JINR Scientific Council	Dubna	21–22 September	110
61.	Science School for Students of the Children’s University of the Egyptian Academy of Scientific Research and Technology	Dubna	24–30 September	18
62.	Seminar Dedicated to the 70th Anniversary of Professor, Doctor of Technical Sciences, MLIT JINR Scientific Leader V. Korenkov	Dubna	26 September	150
63.	12th Collaboration Meeting of the MPD Experiment at the NICA Facility	Belgrade, Serbia	4–6 October	120
64.	XVIII All-Russian Science Festival NAUKA 0+	Moscow	6–8 October	1000
65.	Scientific Student Practice “Control Processes in Scientific Projects, Participation of Students in Scientific Research”	Dubna	9–13 October	26
66.	Workshop “India–JINR: Frontiers of Basic and Applied Research”	Dubna	16–18 October	80
67.	Autumn School of Information Technologies	Dubna	16–20 October	80
68.	Seminar “Selected Problems in Quantum Field Theory”, Dedicated to the Memory of Professor E. Kuraev	Dubna	17–18 October	40
69.	International Conference “Current Problems in Radiation Biology. Molecular Genetic Research in Radiobiology. To the 70th Anniversary of DNA Structure Discovery”	Dubna	19–20 October	100
70.	XXVII International Scientific Conference of Young Scientists and Specialists (AYSS-2023)	Dubna	30 October – 3 November	200
71.	Scientific School for Physics from TPU	Dubna	30 October – 3 November	16
72.	Meeting of the JINR Finance Committee	Almaty, Kazakhstan	9 November	55
73.	Session of the Committee of Plenipotentiaries of the Governments of the JINR Member States	Almaty, Kazakhstan	10 November	77
74.	Autumn School on the Physics of Quark–Gluon Matter	Dubna	16–20 November	50
75.	Workshop “Modern Information Technologies in Biology and Medicine”	Dubna	22–24 November	50
76.	Physics Days – 2023	Dubna	24 November	150
77.	11th Collaboration Meeting of the BM@N Experiment at the NICA Facility	Dubna	28–30 November	120
78.	9th Meeting of the JINR–Serbia Joint Coordination Committee on Cooperation	Belgrade, Serbia	30 November – 1 December	12
79.	Baikal Collaboration Workshop	Dubna	5–8 December	55
80.	2nd South Africa–JINR Workshop on Theory and Computation	Port Elizabeth, RSA	5–8 December	55
81.	Visiting seminar “Scientific Activities of JINR”	Dubna	6–12 December	69
82.	Seminar on Results of the MLIT Activities in 2023	Dubna	27 December	150

INNOVATIVE ACTIVITY

INNOVATIVE ACTIVITY

In 2023, work continued on the development of the R&D infrastructure aimed at creating an innovation centre for nuclear physics research in the field of life sciences, biomedical technologies, radiation biology and radiation materials science, as well as ecology and information systems:

— formation of a user infrastructure based on the beams ejected from the NICA accelerator complex is in the completion stage (ARIADNA);

— in partnership with NIIEFA of Rosatom, the medical superconducting cyclotron MSC-230 is being developed;

— premises and equipment for the DC-140 accelerator complex have been prepared for installation (testing of electronic components, radiation materials science, development of the technology of track membranes and their production).

During the run at the NICA accelerator complex at VBLHEP, a unique technology for the long-term (lasting up to several months) radiation processing of materials with accelerated high-energy ions was implemented. The first experiments to test the long-term irradiation modes were conducted as part of the ARIADNA scientific collaboration programme aimed at a wide range of advanced radiation technologies. In particular, the experiments on radiation modification of composite materials, polymers, and high-temperature superconductors (HTSs) were performed.

The JINR scientific team is developing breakthrough technologies for the production of pulsed HTS magnets for charged particle accelerators and megawatt-energy storage systems. The structure, technology, and cable machines for manufacturing unique impregnated twisted HTS cables with flow cooling (Nuclotron type) have been developed and constructed, enabling the production of magnet winding with a bending radius from 40 mm and a current of up to tens of thousands of amperes. The increase in critical current of HTS tapes in magnetic fields by 3–4 times at temperatures of 50–80 K has been achieved by creating pinning centres through irradiation of tapes with protons and ions. The scheme to connect the ends of HTS cables with a

The Veksler and Baldin Laboratory of High Energy Physics. The Station Of CHip Irradiation (SOCHI) as part of the ARIADNA research infrastructure

The climate control cabin
of the Station of Investigation of Medico-Biological Objects (SIMBO)

transient resistance of just a few nanoohms at a current of 10–15 kA and temperature of 30–65 K has been developed. A composition of epoxy compound ensuring long-term stability and optimal cooling conditions for winding has been determined.

To increase critical currents, a series of irradiations of short HTS tape sections with different fluences of Xe ions with an energy of 150–170 MeV per ion has been conducted at the FLNR IC-100 cyclotron. The achieved increase in critical current of HTS tapes in a 2-Tl field at 50 K by 3.5 times will allow designing the magnetic system of a new nuclotron operating at 50 K with the yoke of magnets cooled by liquid nitrogen. On the basis of these studies, the development of a technology for irradiating long pieces of HTS tapes at the U-400M and DC-140 cyclotrons got underway. The results led to the prioritization of cyclotron ion beams in developing the radiation pinning technology due to their efficiency and lack of residual background. The dynamically growing and constantly upgraded cyclotron complex of FLNR JINR is a unique base for such a development.

As part of the implementation of the cooperation agreement between JINR and the FMBA of Russia in 2023, consultations began on the formation of a medical and technical task for the joint project of the Proton Centre for Biomedical Research of the FMBA of Russia and JINR in Dubna.

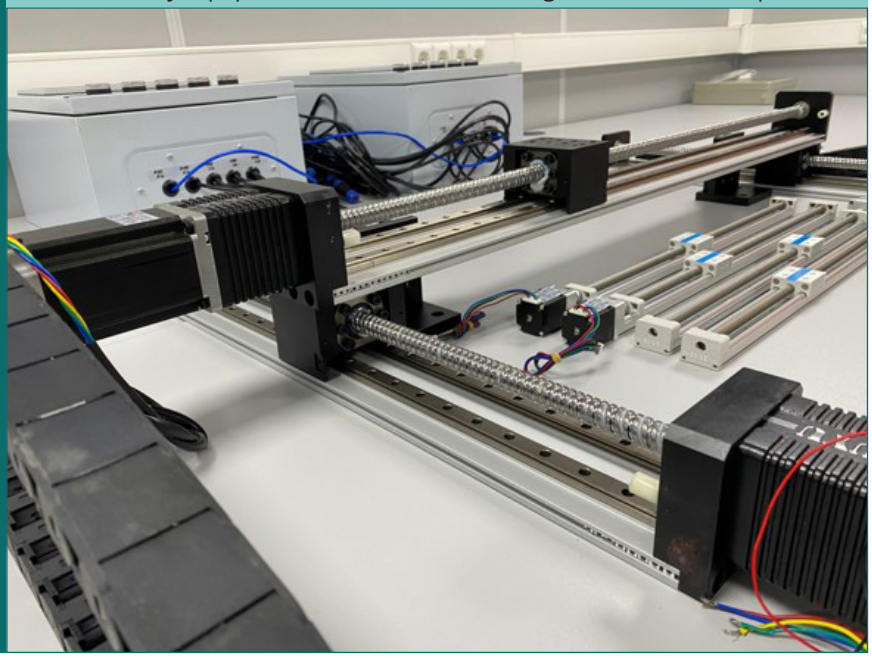
At the FLNR Centre of Applied Physics (CAP), new avenues of exploratory research and developments aimed at designing products and technologies on the basis of track membranes are being elaborated. In collaboration with the National Medical Research Centre for Endocrinology, the studies have been launched aimed at developing an implantable bioreactor for subsequent loading with tissue engineering material and nutrient medium to evaluate the applicability of track membranes as a material for creating a tissue-engineered construction (pancreas) with various insulin-producing cells.

The collaboration with innovative companies, including residents of the Dubna SEZ, is underway. At the CAP FLNR, a project is being implemented to develop new materials for hydrogen energy aiming to overcome the limitations of existing commercial proton-conducting membranes. This project explores the possibility of designing hybrid membranes based on modified fluorinated films for the use as proton-conducting membranes in hydrogen-air and methanol fuel cells. For the use in dentistry, a bone graft material (barrier membrane) based on track membranes coated with a layer of collagen using the electrospinning method is under development. The potential of microplates, obtained by using ion-track technology, and modified track membranes capable of differentially accumulating DNA macromolecules — developed in collaboration with the specialists from the DLNP Molecular Genetics Group — for laboratory diagnostics, particularly for analyzing bacterial resistance to antimicrobial drugs, is being explored.

In collaboration with a partner from Dubna SEZ, FLNP and CAP FLNR are elaborating the design of affordable biocompatible corneal grafts for long-term storage, suitable for primary types of keratoplasty and possessing a high degree of biocompatibility, which will, as expected, fully replace human donor material in ophthalmology. The parameters of the method being developed were optimized according to the results of the experiments with small-angle

The Irradiation Station of Components of Radioelectronic Apparatus (ISCRA)

Development of a sample positioning system
and dosimetry equipment at the station for long-term radiation exposure



X-ray scattering (SAXS) at the USAXS/SAXS/WAXS XEUSS 3.0 station.

The infrastructure of a sample environment for research in the field of hydrogen energy is being established at the FLNP neutron radiography and tomography facility. At the request of a business partner, the internal structure of promising proton-conducting materials is being studied using X-ray small-angle scattering.

At DLNP JINR, the development and application of hybrid matrix semiconductor X-ray detectors in the single quantum counting mode with energy thresholds are underway. These detectors enable the implementation of "colour" computed tomography, which allows differentiating areas not only by density but also by elemental composition. The design of a hybrid pixel detector, consisting of a semiconductor sensor and a specially developed ASIC chip connected via bump-bonding, is at the cutting edge of advancements in computed tomography and is carried out in interaction with developers of a new dual-source electron-beam computed tomograph.

Dubna, 25 May. Meeting of the visiting board of the FMBA of Russia “Industrial Medicine, the Basis of Labour Longevity”, within which a festive opening of the Vascular Centre, created with the support of JINR, took place

The radionuclide generator ^{44m}Sc/^{44g}Sc developed at DLNP has significant prospects considering the development of medical diagnostic technologies providing a high efficiency in obtaining the radionuclide used in positron emission tomography (PET).

Nano-sized multilayer structures consisting of alternating layers of zirconium and niobium have been investigated at the positron source created at DLNP in collaboration with Tomsk Polytechnic University. These coatings exhibit a high radiation resistance and are considered as prospective materials for shields of nuclear reactor cores. The interest in these materials has already been expressed by the Rosatom State Corporation and the Huawei company. Along with the Lomonosov Northern (Arctic) Federal University, the defect structure of samples of synthetic diamonds doped with nitrogen has been investigated. Such diamonds are used in the development of quantum-optical converters and design of solid-state spin qubits in quantum electronics.

The development of a network of compact precision laser inclinometers (CPLIs) is going on. In December 2023, the second inclinometer with improved design and new electronics was installed in Kamchatka. A new system of collecting data from the inclinometers has been developed on the basis of open-source software. In 2023, DLNP specialists elaborated a modification of CPLIs — an interferometric inclinometer. The proposed design of the inclinometer allows for significant simplification of the device and the reduction of its cost. A prototype device has been manufactured, and its testing is underway at the DLNP Laboratory of Metrology.

LRB and MLIT continue implementing the joint innovative BIOHLIT project “Artificial Intelligence and Computer Vision”. The information system is being designed for storing and analyzing biological data, allowing the accumulation of heterogeneous data from different experiments into a single information space and also their structuring. A data storage subsystem and the modules for analyzing behavioural test data were implemented in the system. The animal detection in test arena setups has been improved, compared to existing software analogues, allowing for a more accurate processing of experimental data.

In collaboration between LRB and VBLHEP, a prototype measuring complex for measuring the grip strength of rodents’ forelimbs has been constructed. The new complex consists of a hardware platform and special software for visualization, processing, and storage of measurement results. The complex is at the patent application stage.

The experience of MLIT staff in creating the plant disease recognition platform pdd.jinr.ru was used in developing a service for remote diagnostics of viral and other diseases of potato ordered by one of the

FLNR Centre of Applied Physics

high-tech agribusiness companies (at the company's experimental base).

MLIT expertise in creating and using digital twins of information systems, and in building automated control systems based on quantum algorithms have a high potential in the field of technology transfer.

In collaboration with an industrial partner and specialized institutes, FLNP goes on with developing a mobile setup and mastering the methodology for determining soil carbon content which can be applied to monitor emissions and absorption of greenhouse gas, as well as to elaborate more environmentally friendly agro-industry technologies and climate projects.

The development of the JINR detector technology information resource has been launched. The Institute accumulated a vast experience in implementing projects on design and application of detector systems, sample environment systems, data registration and processing, as well as in interacting with manufacturers of components, materials, and nonstandard equipment, scientific and technological partners with complementary competencies in the field of detector technologies. The resource will make it possible to inventory and systematize the information about such experience, about the detector system R&D infrastructure available at JINR, and also will enable the contextual search for current information about JINR technologies, competencies, and up-to-date equipment. Primarily aimed at JINR specialists, the resource will also become a tool for efficient interaction with external partners.

The start for creating a similar information resource dedicated to scientific and technological competencies in particle accelerator development and operation has been prepared. JINR is a leading accelerator centre among the JINR Member States. At the Institute, the NICA accelerator complex is nearing its physical launch, two new cyclotrons are being constructed for applied research, and the commissioning of a 200-MeV linear electron accelerator at VBLHEP is planned for 2024. Moreover, the running accelerators are being operated, and the research on ejected beams from the Nuclotron at VBLHEP is being conducted; the DC-280 Heavy-Ion Cyclotron, the largest in Eastern Europe, designed and constructed at FLNR, continues to operate successfully. The electron accelerator within the IREN setup is functioning well at FLNP. The information resource which accumulates the expertise and data about capabilities and infrastructure of JINR subdivisions in this field will enhance the efficiency of collaborative interaction between the laboratories and will contribute to the promotion of JINR as a centre of expertise in accelerator technologies.

Intellectual Property Protection

The Innovation and Intellectual Property Department (IIPD) of JINR continued its interaction with the Federal Institute of Industrial Property (FIPS) of the

Federal Service for Intellectual Property (Rospatent) on JINR patent applications that passed the formal examination by FIPS Rospatent in 2022–2023. To determine the technical level of new developments by JINR employees for patentability, an examination of several project developments was carried out, including the identification of objects for legal protection and their classification according to the International Patent Classification (IPC), searching for analogs and prototypes. The reports on patent research were prepared in collaboration with the staff of the laboratories.

Jointly with the authors, the application documents for 10 developments have been prepared and submitted to Rospatent RF to obtain patents for inventions.

Ten Russian patents for inventions have been obtained:

— (RU) 2792202 "Device for producing ultracold neutrons" by S. Dolya;

— (RU) 2787744 "Device for obtaining cold and ultracold neutrons" by S. Dolya and Yu. Nikitenko;

— (RU) 2793964 "Device for detecting solid spherical fragments of a ball-type cold neutron moderator" by A. Galushko, M. Bulavin, A. Yskakov, K. Mukhin, V. Skuratov, I. Smelyanskiy;

— (RU) 2797497 "Position-sensitive gas detector for thermal and cold neutrons" by A. Kolesnikov, B. Zalikhanov, V. Bodnarchuk, Yu. Kryukov;

— (RU) 2798227 "Tellurium-loaded liquid scintillator" by I. Nemchenok, I. Suslov, A. Bystryakov;

— (RU) 2800058 "Device for monitoring the re-emission ability of wavelength-shifting optical fibers" by M. Petrova, M. Podlesny, V. Milkov;

— (RU) 2803544 "Ring neutron accumulator" by Yu. Nikitenko and V. Aksenov;

— (RU) 2810718 "Device for measuring tilt angle" by M. Lyablin;

— (RU) 2806879 "Heat-conducting panel for liquid cooling systems of detector modules and its manufacturing method" by T. Lygdenova, A. Voronin, V. Zherebchevsky, S. Igolkin, G. Feofilov, Yu. Murin;

— (RU) 2810721 "Device for measuring tilt angle" by M. Lyablin.

Additionally, at the end of 2023, a positive decision from Rospatent RF was received to grant a patent for the application 2023100496 "Method for assembling supermodules for detecting ionizing radiation" by V. Elsha, D. Dementiev, A. Sheremetyev, A. Voronin, Yu. Murin.

In the Register of Computer Programs for Electronic Computing Machines of Rospatent, 10 computer programs and a database were registered:

— 2023610870 "PIT-Viewer program for monitoring and data accumulation of the measurement system for the currents of superconducting magnets of the Booster and Nuclotron synchrotrons" by A. Panfilov, V. Karpinsky, S. Kirov, A. Kozlyakovskaya, A. Sergeyev, V. Tovstukha;

— 2023670014 "JINR international cooperation accounting database";

— 2023661580 "Program for analyzing work of websites of organizations cooperating with JINR" by V. Eliseev and T. Tyupikova;

— 2023618835 "Sys_Monit current measurement program for superconducting structural magnets of the Booster and Nuclotron synchrotrons" by A. Panfilov, V. Karpinsky, S. Kirov, A. Sergeyev, V. Tovstukha;

— 2023662830 "Program for processing and visualisation of information on the state of magnetic optics in the measuring pavilion" by A. Zorin and N. Blinov;

— 2023662831 "Program for remote monitoring of warm magnet protections activation in the experimental hall" by A. Zorin and N. Blinov;

— 2023664342 "Monte Carlo Simulation of nanodispersed extraction systems for low-energy neutrons (MCSnes)" by A. Nezvanov and E. Teymurov;

— 2023667401 "Program for creating a reference directory of international organizations cooperating with JINR and verifying data on the admission and secondment of specialists" by V. Eliseev and G. Volodina;

— 2023667305 "Software suite for creating digital twins of distributed data collection, storage, and processing centres" by V. Korenkov, D. Pryakhina, V. Trofimov;

— 2023667527 "Program for optimizing the parameters of a radiation installation model simulating a mixed radiation field at charged particle accelerators" by I. Gordeev;

— 2023686688 "Program for determining and configuring the computer model setup for irradiation with a mixed radiation field at charged particle accelerators" by I. Gordeev;

In the Register of Integrated Circuit Topologies (ICT) of Rospatent, the following was registered:

— 2023630250 "Eight-channel chip for reading and processing signals from resistive planar chambers" by E. Usenko, E. Atkin, D. Normanov, S. Yamaliev, A. Serazetdinov, A. Solin.

The information on the obtained patents and registered programs, databases, and ICT was submitted to the JINR Accounting Department for the payment of author's royalties.

In 2023, 82 JINR patents were supported. Work was carried out with Laboratories to identify patents with a priority of more than 10 years, the need for further maintenance of which is absent.

In 2023, JINR received 36 issues of the Rospatent bulletin "Inventions. Utility Models" in the electronic form. The information published in these bulletins has been processed taking into account the JINR topics. The results of processing are presented in 12 issues of the IIPD bulletin "Patents", which are sent to departments of the Institute to subscribers in both electronic and paper form. The electronic database of the IIPD bulletins is also available on the Department website (https://oliis.jinr.ru/).

The information sheets of IIPD on the receipt of new patents by the Institute and the state registration of other objects of industrial intellectual property (computer programs, databases, and ICT) are being prepared. This information is regularly included in the "Patents" section on the JINR website (http://www.jinr.ru/posts/category/patents-ru/), as well as in the sections of the IIPD website "Valid Patents" (https://oliis.jinr.ru/index.php/patentovanie-2/8-russian/25-dejstvuyushchie-patenty-oiyai) and "Computer Programs Registered by JINR" (https://oliis.jinr.ru/index.php/patentovanie-2/8-russian/28-programmy).

CENTRAL SERVICES

PUBLISHING DEPARTMENT

In 2023, the Publishing Department issued 68 titles of publications and 38 titles of official documents.

The books published in 2023 include the collection "Professor Budagov Julian Aramovich", the monograph by Z. Ya. Sadygov "The Physics of Solid-State Photoelectric Multipliers", the collection of memoirs "Anatoly Grigorievich Artyukh: Experimenter. Organizer. Optimist", the book by Evgeny and Natalia Soloviev "Memoirs", and the book by A. V. Beklemishchev "How Dubna Was Built".

Abstracts and proceedings of the XXIX International Seminar on Interaction of Neutrons with Nuclei ISINN-29 (Dubna, May 29 – June 2, 2023), a book of abstracts of the international workshop "Superconducting and Magnetic Hybrid Structures" (Dubna, July 11–15, 2023), and proceedings of the international conference "Current Problems in Radiation Biology. Molecular Genetic Research in Radiobiology. To the 70 Anniversary of DNA Structure Discovery" (Dubna, October 19–20, 2023) were issued.

JINR Annual Reports for 2022 in Russian and English were published in an updated design. The Seven-Year Plan for the Development of JINR for 2024–2030 was published in Russian and English.

In 2023, six issues of the journal "Physics of Elementary Particles and Atomic Nuclei" (brief name "Particles and Nuclei"), including 125 papers, were published. Issues 3 and 4 contain the materials of the LXXI International Conference "Nucleus-2021. Nuclear Physics and Elementary Particle Physics. Nuclear Physics Technologies" (Saint Petersburg, September 20–25, 2021). Issue 5 includes the materials of the XXXIV International (Online) Workshop on High Energy Physics "From Quarks to Galaxies: Elucidating Dark Sides" (Protvino, November 22–24, 2022). Issue 6 contains the materials of the XVIII International Conference "Symmetry Methods in Physics" (Yerevan, July 10–16, 2022) and of the International Workshop "Supersymmetries and Quantum Symmetries" (Dubna, August 8–13, 2022). Six issues of the journal "Physics of Elementary Particles and Atomic Nuclei, Letters" (brief name "Particles and Nuclei, Letters"), which include 283 papers, were published. Issue 3 contains the proceedings of the International Conference on Quantum Field Theory, High-Energy Physics, and Cosmology (Dubna, July 18–21, 2022). Issue 4 provides the proceedings of the XIV International Scientific Workshop in Memory of Professor V. P. Sarantsev "Problems of Colliders and Charged Particle Accelerators" (Alushta, September 20–25, 2022). Issue 5 contains the materials of the international conference "Modern Problems of Condensed Matter Theory" (Dubna, October 17–22, 2022). The materials of the XXVI International Conference of Young Scientists and Specialists (AYSS-2022) (Dubna, October 24–28, 2022) are included in Issues 5 and 6.

The information bulletin "JINR News" continued to be published in Russian and English.

In 2023, 50 issues of the JINR weekly newspaper "Dubna: Science, Cooperation, Progress" were published.

As part of the exchange of scientific publications, the following JINR publications were sent to organizations cooperating with the Institute all over the world: 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 310 papers containing the results of research of Dubna 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 of JINR staff members were submitted to the journals "Nuclear Physics", "Bulletin of the Russian Academy of Sciences: Physics", "Instruments and Experimental Techniques", "Nuclear Physics and Engineering", "Crystallography", "Journal of Surface Investigation. X-Ray, Synchrotron and Neutron Techniques", etc.

Work continued on placing periodicals and non-periodicals produced at JINR in the Russian Science Citation Index (RSCI) database on the platform of the Electronic Library System of the Scientific Electronic Library.

The Publishing Department fulfilled orders for printing photo posters and poster presentations of the Institute's staff members for submission to scientific forums. Information materials such as programmes, notebooks, badges, diplomas and certificates were printed for conferences and meetings.

At the request of the Laboratories and other JINR departments, bookbinding, photocopying and scan-

Publications issued in 2023

ning of scientific-technical and engineering-design documentation were carried out. More than 118 thousand various forms were printed.

The fleet of printing machinery of the Publishing Department was renewed by purchasing equipment for the production of hardcover books.

SCIENCE and TECHNOLOGY LIBRARY

In 2023, the JINR Science and Technology Library (STL) rendered services to 1650 readers. An electronic loan system has been implemented. Four thousand copies of publications were given out. As of 1 January 2024, the Library stock amounted to 430 632 copies, 195 483 of them being in foreign languages. Via the interlibrary loan system, 131 publications ordered by readers were received. Fourteen requests from other libraries were completed. On the whole, the Library received 1242 copies of books, periodicals, preprints and theses from all acquisition sources, including 224 publications in foreign languages. All new publications were registered in the central catalogues, branch catalogues and in the information system "Absotheque".

There were 96 issues of the express bulletins "Books", "Articles", and "Preprints" published, including 5034 titles. Electronic versions of the bulletins are available on the page "New Acquisitions" of the JINR STL website and are distributed by e-mail. Subscription is available via the Library website in the section "Services" (http://ntb.jinr.ru/ntb_mail/newslist.html).

Weekly bibliographic lists of papers of JINR scientists with abstracts and URL references have been prepared for the Office of Chief Scientific Secretary.

The exhibitions of new acquisitions of books, preprints, periodicals and theses were arranged regularly, where 949 publications were displayed. Eight topical exhibitions were organized, which displayed 530 publications.

The electronic catalogues of books, journals, articles, preprints and theses are available on Internet at http://lib.jinr.ru:80http://lib.jinr.ru:8080/OpacUnicode/80/OpacUnicode. In the electronic catalogue in the personal account, the readers can order required literature and look through their reader's register forms.

The Bibliographic Index of Papers Published by JINR Staff Members in 2022 (1434 titles) was prepared by the Library and published by the JINR Publishing Department. The Index is available on the STL website, in section "Services" (http://ntb.jinr.ru/buk/2022/bibl_uk.php).

Three biobibliographic indexes have been prepared. The database of papers of JINR scientists is

Literature exhibition dedicated to the 110th anniversary of the birth of B. Pontecorvo

available online. A total of 5613 JINR preprints, author's abstracts of theses and deposited publications have been scanned and added to the electronic catalogue.

The Library received 58 titles of Russian periodicals.

Due to the national electronic subscription of the RCSI, JINR scientists have the electronic access to the full-text versions of journals of the following publishing houses: Springer, American Physical Society, American Mathematical Society, Wiley, as well as journals "Nature", "Science", RAS journals, databases "Questel" and "EBSCO eBooks".

As part of the project "History of JINR and Dubna in Books, Journals and Central Newspapers", 53 new bibliographic records have been introduced. The information system "Literature about JINR Scientists" (1055 records) has been put into service, which is available on the page of the site of STL "Publications about JINR" (http://who-is-who.jinr.ru/catalog3/main.html/).

In 2023, within the information system "Absotheque", the input of documents to electronic catalogue was for: books — 378 titles, journals — 1460 numbers, preprints — 552 titles, theses and author's abstracts — 189 titles, book articles — 488 titles, and journal articles — 5528 titles.

As of 1 January 2024, the total number of records in the information system "Absotheque" was 350 685.

On requirements of the JINR Directorate, briefing notes and statistics of indicators of publication activity of JINR scientists and their co-authors from other countries and organizations with the usage of Web of Science, Scopus, and RSCI have been prepared.

PUBLICATION ACTIVITY OF JINR STAFF MEMBERS

According to the international database "Scopus" as of 12 February 2024, the total number of publications is 1304.

Table 1. Joint publications with authors from JINR Member States

State*	Number of publications
Armenia	149
Azerbaijan	204
Belarus	65
Bulgaria	206
Cuba	63
Egypt	86
Georgia	179
Kazakhstan	77
Moldova	9
Mongolia	144
Romania	282
Slovakia	230
Uzbekistan	66
Vietnam	18

*In alphabetical order.

Table 2. Joint publications with authors from JINR Associate Members

State*	Number of publications
Germany	432
Hungary	161
Italy	389
Serbia	197
South Africa	203

*In alphabetical order.

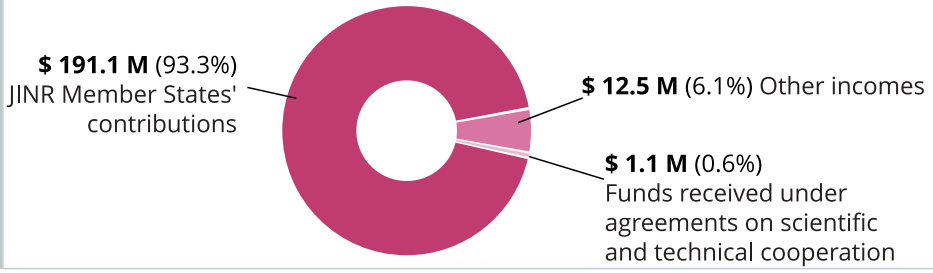
Table 3. Joint publications with authors from other states and regions

State/Region*	Number of publications	State/Region*	Number of publications
USA	428	Morocco	117
China	380	Hong Kong	114
Poland	365	UAE	111
United Kingdom	360	Palestine	102
Turkey	330	Philippines	99
France	308	Belgium	79
Czech Republic	304	Cyprus	70
Netherlands	272	Iran	65
Switzerland	272	Estonia	63
Brazil	266	Latvia	63
Sweden	264	Lithuania	62
Austria	246	Malaysia	62
Greece	243	Indonesia	61
India	236	Peru	61
Japan	222	Ecuador	60
Chile	212	Ireland	60
Thailand	208	Sri Lanka	60
Pakistan	207	Kuwait	58
Spain	203	Montenegro	56
Taiwan	197	Qatar	49
Norway	189	Puerto Rico	43
South Korea	188	New Zealand	30
Portugal	186	Saudi Arabia	8
Colombia	181	Tajikistan	5
Denmark	178	Jordan	4
Australia	168	Nigeria	2
Canada	145	North Macedonia	2
Ukraine	138	Albania	1
Croatia	136	Algeria	1
Finland	133	Bosnia and Herzegovina	1
Mexico	132	Botswana	1
Israel	122	Kyrgyzstan	1
Slovenia	121	Lebanon	1
Argentina	117	Sudan	1

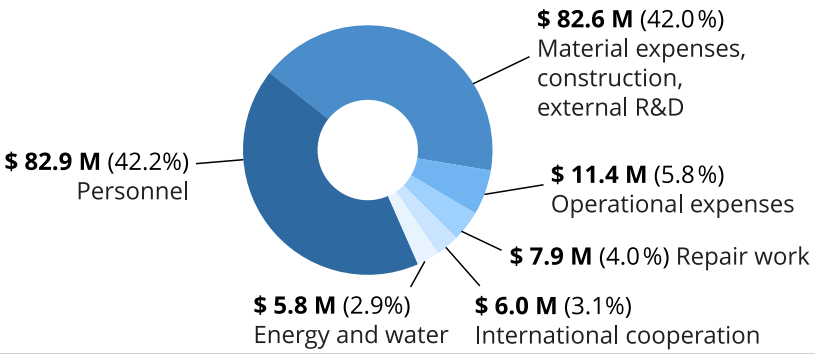
*In decreasing order of the number of publications.

FINANCIAL ACTIVITIES

Execution of the JINR budget for 2023 in income — a total of **US$ 204.7 million**:



Execution of the JINR budget for 2023 in expenses — a total of **US$ 196.6 million**:



Contributions of JINR Member States for 2023 (in percent)

State	%	State	%
Republic of Armenia	0.12	Republic of Moldova	0.09
Republic of Azerbaijan	0.36	Mongolia	0.10
Republic of Belarus	0.66	Republic of Poland**	4.97
Republic of Bulgaria	0.68	Romania	1.90
Republic of Cuba	0.74	Russian Federation	78.71
Czech Republic**	2.40	Slovak Republic*	1.21
Arab Republic of Egypt	2.66	Ukraine**	1.51
Georgia	0.15	Republic of Uzbekistan	0.49
Republic of Kazakhstan	1.46	Socialist Republic of Vietnam	1.60
Democratic People's Republic of Korea*	0.19		
Total:			100.0

* JINR membership suspended.
** JINR membership terminated.

In 2023, for the implementation of a number of 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 Ministry of Science and Higher Education of RF.

RFBR financed JINR scientific projects within the framework of international competitions in cooperation with the organizations and government institutions listed below: State Committee for Science of the Ministry of Education and Science of the Republic of Armenia (1 project); Belarusian Republican Foundation for Fundamental Research (1 project); Ministry of Culture, Education, Science and Sports of Mongolia (1 project); German Research Foundation (2 projects).

RSF rendered financial support to JINR scientific projects within the framework of the following competitions: "Conducting Fundamental Scientific Research and Exploratory Scientific Research in Separate Scientific Groups" (5 projects), "Conducting Fundamental Scientific Research and Exploratory Scientific Research in Small Separate Scientific Groups" (7 projects), "Conducting Fundamental Scientific Research and Exploratory Scientific Research by International Scientific Teams" — NSPC (China) and DFG (Germany) (1 project each), "Conducting Independent Research by Young Scientists" (2 projects), "Conducting Research by Scientific Groups under the Guidance of Young Scientists" (1 project).

The RF Ministry of Science and Higher Education financed two projects: "Superheavy nuclei and atoms: Limits of nuclear mass and boundaries of D. I. Mendeleev's Periodic Table" and "Development and creation of elements of experimental stations based on pulsed and permanent neutron sources".

STAFF

Dubna, 26 July.
Participants of the solemn awarding ceremony of diplomas on conferring academic degrees

As of 1 January 2024, the total number of the staff members at the Joint Institute for Nuclear Research was 5070 (without temporary staff members).

Working at JINR are: RAS Academicians V. Matveev, I. Meshkov, Yu. Oganessian, G. Trubnikov, B. Sharkov; RAS Corresponding Members V. Aksenov, A. Belushkin, L. Grigorenko, D. Kazakov, V. Kekelidze, E. Krasavin, G. Shirkov; Members of other state Academies of Sciences B. Yuldashev, O. Chuluunbaatar; 40 Professors, 28 Assistant Professors, 220 Doctors of Science, and 594 Candidates of Science.

In 2023, 468 people were employed and 554 people were discharged because of engagement period expiry and for other reasons.

AWARDS

For the services for JINR and international cooperation, the Honourable Mention of the Mayor of the Dubna city was awarded to 13 staff members; the Honourable Mention of the Governor of the Moscow Region, to 1 staff member; the JINR Honorary Letter, to 51 staff members; the RAS Presidium Diploma, to 1 staff member; the A. P. Alexandrov Medal "For Contribution to the Development of Atomic Science and Technology", to 1 staff member; the JINR Honorary Certificate, to 64 staff members; the RANS Honourable Medal "For Achievements in Economics" named after W. Leontief, to 1 staff member; the JINR Honorary Medal, to 4 staff members; the JINR Honorary Diploma, to 16 staff members; the Honorary Badge "For Services to Dubna", to 2 staff members; the Jubilee Medal "75 Years of the RTU NEIW", to 9 staff members; the Jubilee Honourable Letter of the Trade Union CC, to 7 staff members; the title "Honorary JINR Staff Member" was conferred on 1 staff member.

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Joint Institute for Nuclear Research. 2023

Annual Report

2024-8

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