

**I. General considerations**

The Scientific Council takes note of the comprehensive report by JINR Director G. Trubnikov, covering the highlights of the year 2021 for JINR, the decisions of the latest session of the JINR Committee of Plenipotentiaries (Bansko and Sofia, Bulgaria, November 2021), the priority research programmes suggested for inclusion in the Seven-year plan for the development of JINR for 2023–2030 as well as recent events in JINR's international cooperation.

The Scientific Council notes the significance and timeliness of the Sofia declaration on the value of international integration in science and technology adopted at the session of the Committee of Plenipotentiaries which, in particular, emphasized the importance of basic sciences and the value of an open international scientific dialogue for resolution of global challenges confronting humanity, and supported the UNESCO initiative and the UN General Assembly decision to proclaim the International Year of Basic Sciences for Sustainable Development in 2022.

The Scientific Council encourages JINR for proactive work to build up an open science infrastructure and unite different countries and peoples for multinational dialogue in the name of peace and progressive scientific, technological and cultural development of humankind.

The Scientific Council highly appreciates the efforts of the JINR Directorate and staff of Laboratories to realize the current seven-year plan (2017–2023) and congratulates JINR on the achievements in major areas (NICA project, experiments at the Factory of Superheavy Elements, the Baikal-GVD project, User Programme at the IBR-2 spectrometers, operation of the Multifunctional Information and Computing Complex, theoretical physics, life sciences, and applied research and innovations).

The Scientific Council notes with satisfaction the accession to JINR of the Arab Republic of Egypt as a full member, which occurred at the session of the Committee of Plenipotentiaries in November 2021, and the pre-accession actions undertaken by the Republic of Serbia to enter JINR as well.

The Scientific Council takes note of the appointment of A. Nersesyan (Armenia) and A. Elhag Ali (Egypt) as new members of the Scientific Council, by decisions of the respective Plenipotentiaries of Member States.

## **II. Recommendations in connection with the PACs**

The Scientific Council takes note of the recommendations made by the PACs at their meetings in January 2022, as reported at this session by I. Tserruya, Chair of the PAC for Particle Physics, M. Lewitowicz, Chair of the PAC for Nuclear Physics, and D. L. Nagy, Chair of the PAC for Condensed Matter Physics. The Scientific Council requests the JINR Directorate to consider these recommendations while preparing the JINR Topical Plan of Research and International Cooperation for the year 2023.

### Particle physics

The Scientific Council seconds the PAC for Particle Physics in congratulating the NICA Booster team on achieving the design parameters and accelerating a beam of iron ions to the energy 578 MeV/nucleon. Electron cooling of a heavy-ion beam was first-ever achieved in Russia in the NICA Booster, and the development of the beam extraction and transport channel systems from the Booster to the Nuclotron was successfully completed in collaboration with the Budker Institute of Nuclear Physics. The Scientific Council acknowledges the start of operation of the SOCHI station equipment — an important component of the NICA applied research and innovations programme — designed for irradiating microchips using ion beams extracted from the HILAC. The Scientific Council also congratulates the NICA team on the installation of the first superconducting magnet in the collider tunnel, a very significant milestone marking the beginning of the collider assembly and the preparations for the machine commissioning.

The Scientific Council notes with satisfaction the progress in the infrastructure development including the clearance to operate eleven 6 kV modernized substations of total capacity up to 33.6 MW, the installation of a helium liquefier of a capacity of more than 1000 litres per hour, a helium refrigerator for cooling the Booster of 2000 W capacity at a temperature of 4.5 K, and four compressed helium purification units, and commissioning of large-scale cryogenics equipment located outdoors.

The Scientific Council seconds the PAC in congratulating the MPD team on launching the tests of the large superconducting solenoid. The Scientific Council notes the plan to produce 800 ECal modules in Russia and another 800 in China, representing 16 ECal sectors out of the 25 needed for the full azimuthal coverage, by the end of 2022. The Scientific Council notes the key role of the ECal in the MPD physics programme and joins the PAC in urging the MPD team and the JINR management to develop a plan ensuring that the remaining 9 ECal sectors are manufactured as soon as possible.

The Scientific Council appreciates the progress in preparing the BM@N detector for the forthcoming runs with heavy-ion beams scheduled for 2022, including manufacturing the Silicon Beam Tracker detectors and beam profilers, installation of the GEM detectors, the ZDC forward hadron calorimeter, the trigger detectors, the target station, and the carbon fibre vacuum tube inside BM@N. The Scientific Council notes the successful implementation of the PAC's longstanding recommendation of having a vacuum beam line in front of BM@N in order to reduce the otherwise huge background.

The Scientific Council endorses the PAC's recommendations to approve the SPD CDR and asks the SPD team to move forward to the TDR preparation. The Council appreciates the important role of the Detector Advisory Committee in the SPD project evaluation and thanks the DAC members for their work.

The Scientific Council, together with the PAC, notes with satisfaction the growing visibility and the increased involvement in physics analyses of the JINR teams participating in the ALICE, ATLAS, and CMS experiments at the LHC.

#### Nuclear physics

The Scientific Council takes note of the report considered by the PAC for Nuclear Physics on the scientific and methodological work which was carried out at FLNP during 2020–2022 under the theme “Investigations of Neutron Nuclear Interactions and Properties of the Neutron” which includes the TANGRA and ENGRIN projects.

In the study of neutron-induced nuclear reactions, a detailed analysis of the results from the previously performed measurements of P-even and T-odd correlations in the fission of  $^{236}\text{U}$  compound nuclei at neutron energies of 0.06 and 0.27 eV was carried out, which made it possible to compare the rotation angles of the fission axis at different neutron energies.

Within the framework of the TANGRA project, angular distributions and yields of gamma-rays in the  $(n,n'\gamma)$  reaction for 14-MeV neutrons for C, O, Mg, Al, Si, Cr, and Fe nuclei were measured using the Romasha detector system consisting of 18 BGO and HPGe (high-purity germanium) detectors.

In cooperation with physicists from the Czech Technical University in Prague, measurements of rare modes of spontaneous fission of  $^{252}\text{Cf}$  with a highly active sample (~400 kBq) were carried out. Timepix detectors were used to detect light particles for the purpose to observe the quaternary fission of  $^{252}\text{Cf}$ .

Significant progress was achieved in the development of first-ever efficient reflectors for ultracold neutrons based on powders of diamond nanoparticles.

A wide range of activities was carried out using various nuclear physics techniques to solve problems in ecology, materials science, archeology, art history, and medicine in cooperation with a large number of scientists from research centres of JINR Member States.

Within the framework of the theme in 2023, it is planned to implement a number of main scientific and methodological areas of research:

- to carry out measurements of gamma-ray spectra in s- and p-resonances, aimed at searching for P-even and T-odd effects in reactions with slow polarized neutrons;
- to measure mass-energy and angular distributions of fragments, neutrons and gamma rays from fission;
- to search for rare fission modes;
- to modernize the EG-5 electrostatic generator;
- to continue work on construction and development of neutron and gamma detectors for spacecraft.

The Scientific Council supports the PAC recommendation to extend the theme “Investigations of Neutron Nuclear Interactions and Properties of the Neutron” until the end of 2023.

In 2021, three series of experiments were performed at the new gas-filled separator DGFRS-2 of the Factory of Superheavy Elements at FLNR. The fusion reactions of  $^{243}\text{Am}$ ,  $^{242}\text{Pu}$ , and  $^{238}\text{U}$  isotopes with  $^{48}\text{Ca}$  ions accelerated at DC-280 with the formation of Mc, Fl, and Cn isotopes were measured and their daughter nuclei were used to determine the parameters of the new separator.

In the  $^{243}\text{Am} + ^{48}\text{Ca}$  reaction, 6 new decay chains of  $^{289}\text{Mc}$  (2n channel), 58 chains of  $^{288}\text{Mc}$  (3n channel), and 2 chains of  $^{287}\text{Mc}$  (4n channel) were registered, and a new isotope  $^{286}\text{Mc}$  (5n channel) was produced. The  $\alpha$ -decay of  $^{268}\text{Db}$  was detected for the first time, its branch and half-life were measured, and a new isotope  $^{264}\text{Lr}$  was produced. The spontaneous fission of  $^{279}\text{Rg}$  was registered for the first time.

In the experiment with  $^{242}\text{Pu}$  using intense beam of  $^{48}\text{Ca}$ , 25 and 69 decay chains of  $^{286}\text{Fl}$  and  $^{287}\text{Fl}$  were synthesized correspondingly. In irradiation of  $^{238}\text{U}$ , the intensity of  $^{48}\text{Ca}$  reached 6.5  $\mu\text{A}$  and 16 decay chains of  $^{283}\text{Cn}$  were observed.

In the entire series of experiments, 177 decay chains of Mc, Fl, and Cn were registered, the decay properties of about 30 isotopes of elements from Rf to Mc were measured with higher precision, and the reaction cross-sections were measured at different  $^{48}\text{Ca}$  energies. During the experiments, it was shown that the new gas-filled

separator DGFRS-2 was operating within design parameters, which makes it possible to conduct new experiments on the study of superheavy nuclei at a higher sensitivity level.

The Scientific Council congratulates the FLNR team for the spectacular results obtained at the SHE Factory on the synthesis and decay of superheavy nuclei and encourages the FLNR Directorate to publish the first results of these experiments as soon as possible.

#### Condensed matter physics

The Scientific Council notes the progress in replacing air heat exchangers of the secondary cooling circuit of the IBR-2 reactor and the preparation for obtaining a license to operate this facility. The Scientific Council shares the recommendation of the PAC for Condensed Matter Physics to support the FLNP plans to manufacture a new fuel load for IBR-2 in order to provide the conditions required for extending its service life for a period after 2032. Together with the PAC, the Scientific Council supports the FLNP activity on studying the mechanism of fluctuations in the IBR-2 power pulses and recommends continuing this work.

The Scientific Council shares the expectation of the PAC that the FLNP User Programme will be resumed soon after obtaining the license to operate IBR-2. The Scientific Council takes note of the changes in the set of neutron instruments operated under the User Programme in 2021 and notes with satisfaction the first experiments at the REGATA neutron activation analysis instrument available now to users.

The Scientific Council also supports the establishment of the User Committee and welcomes a closer exchange of opinions between this committee and the PAC. The Scientific Council shares the PAC's concern about the continuation of experiments with participation of students due to the temporary shut-down of IBR-2 and urges the JINR Directorate to take care of restoration of such experiments soon after resumption of the IBR-2 operation.

The Scientific Council is pleased with the further upgrade of the SKAT and EPSILON diffractometers, in particular during the temporary suspension of the IBR-2 operation. Together with the PAC, the Scientific Council recognizes that, despite the strong COVID-19 restrictions, the research programme of these instruments was successfully continued last year, owing to the scientists' in-house step-up efforts.

The Scientific Council encourages the joint activity for developing the new facility for neutron radiography and tomography at the WWR-SM reactor (INP, Tashkent, Uzbekistan) and notes that the parameters of the facility meet the requirements of a wide range of interdisciplinary research in the field of materials science, engineering

sciences, and cultural heritage.

The Scientific Council takes note of the recent progress in developing the new neutron source at JINR. In particular, it notes the studies carried out to calculate the vibrational stability of the projected NEPTUNE reactor (IBR-3) with neptunium-nitride fuel as well as to optimize the composition of the reactivity modulator of the NEPTUNE reactor by introducing additional reflectors to be made of nickel or beryllium. The Scientific Council concurs with the PAC that studies of the dynamics of pulsed reactors should be continued. It also shares the PAC's opinion that the NEPTUNE reactor core layout should be taken into account when developing the technical specification for the R&D of the development of neptunium-nitride fuel rods. The Scientific Council finds it feasible to proceed to the next stage in the design of the NEPTUNE reactor and agrees with the PAC that the R&D work to optimize the reactor vessel and reactivity modulator should be carried out jointly with the NIKIET Institute of the Rosatom State Corporation. The Scientific Council welcomes the intention of the PAC to hear detailed reports on the work for developing the new neutron source made by JINR jointly with VNIINM and NIKIET and on the analysis of performance of different cold moderators and design of primary neutron optics and shielding.

The Scientific Council welcomes the recent progress within the development of the SOLCRYS Structural Research Laboratory at the SOLARIS National Synchrotron Radiation Centre and notes that various parts of the laboratory are currently at different phases of accomplishment. The Scientific Council is pleased with the adoption of the technical parameters and preliminary design of the beamlines, the design and construction of which are approaching their bid phase this year. Together with the PAC, the Scientific Council expects that all three major parts of the activity will not get behind the initial schedule significantly, provided that they are duly executed through the three-years of the respective JINR theme. At the same time, it is assumed that some more time beyond this three-year term will be required for completing, integrating and commissioning the instruments and for getting to their operation by users.

#### Common issues

The Scientific Council is pleased with the activity of the PAC for Condensed Matter Physics on the elaboration of an approach to assigning reviewers for JINR themes and projects and expects to be informed on further experience of the PAC with application of a blind review assessment.

### Reports by young scientists

The Scientific Council followed with interest the reports by young scientists, selected by the PACs for presentation at this session:

- “Investigation of superconductivity and magnetism in layered nanostructures by polarized neutron reflectometry with secondary radiation registration”,
- “Deep learning methods and software for the reconstruction of elementary particle trajectories”,
- “Construction of ARIADNA applied stations based on the NICA accelerator complex”,
- “Detailed study of radioactive decay properties of No isotopes with  $\alpha$ ,  $\beta$ ,  $\gamma$ -spectroscopy method”.

The Scientific Council thanks the respective speakers: V. Zhaketov (FLNP), P. Goncharov (MLIT), A. Slivin (VBLHEP), and M. Tezekbayeva (FLNR), and welcomes such selected reports in future.

### **III. Membership of the PACs**

As proposed by JINR Director Grigory Trubnikov, the Scientific Council appoints M. Block (GSI, Darmstadt, Germany) as a member of the PAC for Nuclear Physics for a term of three years. The Scientific Council thanks S. Hofmann (GSI) for his dedicated work as member of this PAC since 2005 and for his outstanding contribution to the cooperation with the Flerov Laboratory of Nuclear Reactions in research on superheavy elements.

### **IV. Concept of the Seven-year plan for the development of JINR (2024–2030)**

The Scientific Council heard with interest the concept of the next plan for the development of JINR (2024–2030) presented in the reports by Vice-Director V. Kekelidze (particle physics and high-energy heavy-ion physics, and information technologies), by Vice-Director S. Dmitriev (nuclear physics, and applied and innovation research), and by Vice-Director L. Kostov (condensed matter physics and radiobiology).

The Scientific Council is pleased to note that these reports on the major areas reveal in full the architecture and logic of the strategic development of JINR as proposed by Director G. Trubnikov in his report.

The Scientific Council endorses in general the concept presented and requests the JINR Directorate to continue work towards developing a detailed draft of the plan and presenting it at the next session of the Scientific Council.

## **V. Scientific reports on the results of 2021**

The Scientific Council heard with interest the reports: “Biohybrid nanocomplexes and their potential application in biomedicine” and “Multiple facets of multiloop calculations” and thanks the speakers: Yu. Gorshkova (FLNP) and A. Bednyakov (BLTP).

## **VI. Awards and prizes**

The Scientific Council congratulates M. Waligórski (Poland) on the award of the Diploma “Honorary Doctor of JINR”.

The Scientific Council approves the proposal of JINR Director G. Trubnikov to award the title “Honorary Doctor of JINR” to C. Bréchnignac (France) and E. Burzo (Romania).

The Scientific Council approves the recommendations of the Jury presented by its Chair, A. Olshevskiy, to award the B. Pontecorvo Prize to T. K. Gaisser (USA) for his significant contributions to neutrino, astroparticle and high-energy cosmic ray physics, in particular to the atmospheric neutrino flux calculation from its early stage development.

The Scientific Council approves the Jury’s recommendations presented by JINR Vice-Director S. Dmitriev on awarding JINR annual prizes for best papers in the fields of theoretical and experimental research, methodology and technology research, and applied technology research (Appendix).

## **VII. Election and announcement of vacancies in the directorates of JINR Laboratories**

The Scientific Council elected A. Kisiel as Director of the Veksler and Baldin Laboratory of High Energy Physics (VBLHEP) for a term of five years. The Scientific Council thanks V. Kekelidze and R. Lednicky for their successful tenures as Directors of this Laboratory during 2014–2021 and 2021–2022 respectively.

The Scientific Council announces the vacancies of positions of VBLHEP Deputy Directors. The endorsement of appointments will take place at the 132nd session of the Scientific Council in September 2022.

The Scientific Council announces the vacancies of positions of Directors of the Frank Laboratory of Neutron Physics and of the Meshcheryakov Laboratory of Information Technologies. The elections will take place at the 133rd session of the Scientific Council in February 2023.

### **VIII. Next sessions of the Scientific Council**

The 132nd session of the Scientific Council is scheduled for 29–30 September 2022. The Scientific Council takes note of the proposal from the Plenipotentiary of the Government of the Republic of Kazakhstan, B. Karakozov, to hold the next session in Kazakhstan, which was announced by member of the Scientific Council M. Zdorovets.

The 133rd session of the Scientific Council is scheduled for 16–17 February 2023.



G. Trubnikov

Chair of the Scientific Council



S. Kilin

Co-chair of the Scientific Council



S. Nedelko

Secretary of the Scientific Council