Programme Advisory Committee for Nuclear Physics

60th meeting, 23–24 January 2025

Recommendations

I. Preamble

The Chair of the PAC for Nuclear Physics, V. Nesvizhevsky, presented an overview on implementing the recommendations taken at the previous meeting.

JINR Vice-Director S. Dmitriev informed the PAC about the resolution of the 136th session of the JINR Scientific Council (September 2024) and the decisions of the JINR Committee of Plenipotentiaries (November 2024).

The PAC heard with interest brief information on establishing a new scientific journal at JINR presented by A. Nezvanov.

The PAC is pleased to note that the recommendations of the previous PAC meeting concerning JINR research in the area of nuclear physics were accepted by the JINR Scientific Council and the JINR Directorate.

II. Large JINR research infrastructure “Baikal-GVD. Baikal Deep Underwater Gigaton Volume Neutrino Telescope”

The PAC heard with interest the report on the status of research with the neutrino telescope in Lake Baikal and the corresponding scientific results presented by B. Shaibonov. The gigaton-scale neutrino telescope Baikal-GVD, the largest operating neutrino telescope in the Northern Hemisphere, is capable of investigating cosmic neutrinos and identifying their sources, searching for neutrinos from the dark matter annihilation and other rare phenomena. For detection of neutrinos, the water of Lake Baikal is used. Optical sensors are deployed deep under water, they detect Cherenkov radiation of secondary particles resulting from interactions of high-energy neutrinos within the observed volume. In 2016–2024, the Baikal-GVD Collaboration deployed 13 fully functional clusters. At present, the underwater facility comprises 4104 optical modules placed on 114 garlands.

The analysis of data obtained in 2018–2023 confirms the diffuse astrophysical neutrino flux observed by the IceCube experiment with a significance of above 5σ. The results of searching for events from the neutrinos with energies of above 200 TeV demonstrate an unexpectedly large contribution of events from the galactic plane to the

observed diffuse flux, which contradicts the assumptions of many modern model-dependent predictions. Moreover, the analysis indicates a possible correlation between radio-bright blazars as possible sources of both galactic and extragalactic high-energy neutrinos.

The ongoing rate of production of detector components and deployment of further clusters in Lake Baikal will make it possible to reach by 2028 an observable water volume of 1 km^3 for detecting astrophysical neutrinos with about 6000 optical modules.

The PAC emphasizes a crucial role of the Baikal-GVD project along with the IceCube experiment in studying the high-energy neutrino flux and its sources.

Recommendation. The PAC deeply appreciates the scientific significance of the Baikal-GVD project and the leading role of JINR in its implementation. The PAC recommends continuing the development of the detector with testing its possible next-generation components. Also, the PAC notes the relevance of maintaining and developing both the shore infrastructure of the project and the production and research capabilities at the JINR sites.

III. Linear electron accelerator LINAC-200 as a core for a new test beam facility at DLNP JINR

The PAC heard the report on the status of the linear electron accelerator LINAC-200 as a core for a test electron beam facility at DLNP JINR presented by A. Trifonov. The initial phase of the work involves launching the first stage of the installation – the electron accelerator for an energy of 200 MeV, which will operate in test mode. In the future, it is planned to gradually put into operation the accelerator structures up to energies of 800 MeV. The start of commissioning work on the accelerator was preceded by a significant volume of preparatory work: a major overhaul of Building 118 was carried out, ventilation, electrical and water supply systems were put into operation, a modern system of radiation monitoring as well as blocking and signaling systems were developed and installed.

The accelerator, which was transferred to JINR from NIIKHEF (Netherlands), underwent a deep modernization. The key subsystems of the accelerator were designed anew, and four experimental beam extraction channels with energies of 24, 60, 133 and 207 MeV were designed and constructed, each channel equipped with an individual beam absorber.

Requests from the JINR Laboratories and research teams of JINR participating countries are the primary focus when forming the user research program at the

accelerator. It is planned to use the extracted beams of LINAC-200 for testing prototypes of electromagnetic calorimeters and coordinate detectors for the MPD and SPD experiments at the NICA collider, applied work in the field of radiation materials science, radiobiology and radiochemistry, experiments in the field of nuclear physics. In this respect, the role of the FLAP collaboration is important in conducting practical training for students and specialists from participating countries through the JINR University Centre.

Recommendation. The PAC notes the immense work to start the LINAC-200 facility at DLNP JINR, which is a part of the LINAC-800 accelerator, and wishes success with the LINAC-200 commissioning stage in 2025. The PAC recommends that the DLNP Directorate should concentrate its efforts on preparing the first experiments at LINAC-200.

IV. Study of chemical and physical properties of superheavy elements at the SHE Factory

The PAC heard the report on the study of the chemical and physical properties of superheavy elements at the SHE Factory of FLNR JINR presented by A. Svirikhin. During preparation for long-term experiments on the study of SHE properties, several experiments were conducted at the GRAND separator, commissioned in 2022, with the aim of investigating the capabilities of the setup. The experiments were carried out with heavy ion beams of Mg, Ar, and Ca extracted from the DC-280 cyclotron. The separator was tuned using complete fusion reactions with Nd, Sm, Pb, and Pu targets. In addition, several important research results were obtained. A new plutonium isotope ^{227}Pu was synthesized, and novel data were obtained on the radioactive decays of other yet-to-be-thoroughly investigated isotopes $^{228-231}$Pu. Production cross sections for neutron-deficient nobelium nuclei were measured, and data were updated on the decay modes (^{249}No) and the probability of isomeric state population (^{250}No). Short-lived isotopes ^{178,179,180}Hg produced in the ^{40}Ar + ^{144}Sm = $^{184-x}$Hg + xn reaction were used for tuning the Cryodetector setup designed for experiments on the study of the chemical properties of SHE.

In 2024, the gas-filled GRAND separator was equipped with a new target with a diameter of 480 mm (previously 240 mm), which was tested using the ^{48}Ca + ^{206}Pb = ^{252}No + 2n reaction. At a ^{48}Ca intensity of 6 p*μA, around 3 nobelium nuclei per second were registered in the focal plane of the GRAND separator.

The chemical properties of flerovium and copernicium are planned to be studied at the Cryodetector setup using the GRAND facility as a pre-separator. Changes to the detection system as well as improved beam intensity will make it possible to detect tens of flerovium atoms and its daughter nuclei during an experiment lasting about a month.

First long-term experiments on the spectroscopy of the isotopes of superheavy elements synthesized in the ^{48}Ca + ^{242}Pu reaction are planned at the GRAND separator for 2025. Analysis of the radioactive decay chains of the ^{286}Fl nucleus will provide valuable data on the structure of superheavy nuclei in the vicinity of the island of stability, in particular, on the deformation of nuclei in the ground state.

In addition, the capabilities of the SHE Factory allow experiments to be carried out to study the properties of spontaneous fission of superheavy nuclei. The first experiments are planned to study the properties of spontaneous fission of nuclei in the radioactive decay chains of ^{286,287}Fl isotopes synthesized in the ^{48}Ca + ^{242}Pu reaction.

Recommendations. The PAC acknowledges the tremendous efforts made to prepare for long-term experiments on spectroscopy of the isotopes of superheavy elements synthesized in the ^{48}Ca + ^{242}Pu reaction. The PAC greatly supports the proposed programme for studying the properties of the isotopes of superheavy elements. Given the unique and copious production of SHE at reach, the PAC advises exploring in more detail the possibility to design a station to detect the mass and TKE distributions of the fission fragments. This would greatly enhance the comprehension of the fission process in an unknown mass region. The chemical properties of flerovium and copernicium should be studied using the ^{48}Ca + ^{242}Pu reaction as well.

V. Scientific reports

The PAC heard with interest the report “The equivalence principle and the acceleration effect” presented by A. Frank. In experiments with ultracold neutrons (UCN), it was shown that the energy of UCNs passing through a refractive sample moving with acceleration actually changes. And although the energy change was only of the order of 10^{-10} eV, it was not only recorded, but also measured with an accuracy of several percent. It was then realized that we are talking about a very general optical phenomenon, the Accelerated Matter Effect (AME), the existence of which follows directly from the equivalence principle. The possibility of conducting an experiment to observe the evolution of the state when a UCN passes through a potential structure oscillating in space is currently being discussed. In addition, of considerable interest is the observation of AME when a wave passes through a doubly refracting sample, the

result of which should be the formation of a non-stationary state formed by two coherent states with different frequencies.

The PAC heard with interest the report “JUNO experiment: status and results” presented by M. Gonchar. The JUNO experiment is a flagship international project in neutrino physics, addressing fundamental questions about the properties of neutrinos and the nature of the Universe. The JINR group plays a decisive role in a wide range of tasks within JUNO, including hardware development, data analysis, simulation, and reconstruction. The PAC acknowledges the critical phase of the experiment as the detector is being commissioned. The PAC expresses its support and wishes a successful start to the operation of JUNO.

VI. Presentations by young scientists

The PAC reviewed 6 short presentations in the field of nuclear physics research by young scientists from FLNR. The PAC appreciates the high quality of all presented works and given talks. The Committee selected four best presentations: “Intense metallic ion beams for SHE synthesis” by D. Pugachev, “Experimental study of multi-nucleon transfer reactions in collisions of heavy nuclei at CORSET setup” by I. Vorobiev, “Study of the properties of elements with Z≥100” by A. Kuznetsova, and “Possibilities of producing medically relevant Auger electron emitter ^{195m}Pt” by A. Madumarov.

The PAC recommends the presentation “Intense metallic ion beams for SHE synthesis” to be reported at the session of the JINR Scientific Council in February 2025.

VII. Visit to VBLHEP

The members of the PAC thank the Directorate of the Veksler and Baldin Laboratory of High Energy Physics for the organization of the visit to this laboratory.

VIII. Next meeting of the PAC

The next meeting of the PAC for Nuclear Physics will be held on 19–20 June 2025. Its tentative agenda includes.

- reports on the results of projects to be completed in the second half of 2025 and 2026;
- reports and recommendations on themes and work on the projects to be completed in 2025;
- experiments at the SHE Factory and its scientific programme;

- consideration of new experiments and projects;
- status of research on the chemical properties of superheavy elements;
- scientific reports;
- short presentations of the new results and proposals by young scientists in the field of experimental and theoretical nuclear physics.

V. Nesvizhevsky

Chair of the PAC
for Nuclear Physics

N. Skobelev

Scientific Secretary of the PAC
for Nuclear Physics