

I. Preamble

The Chairman of the PAC for Nuclear Physics, M. Lewitowicz presented an overview of the implementation of the recommendations taken at the previous meeting.

JINR Vice-Director M. Itkis informed the PAC about the Resolution of the 124th session of the Scientific Council (September 2018) and the decisions of the Committee of Plenipotentiaries (November 2018).

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

II. Development of a new neutron source at FLNP

The PAC took note of the report on the progress of the development of a new neutron source at the Frank Laboratory of Neutron Physics, presented by E. Lychagin. Two principle schemes are considered for such a source: 1) pulsed periodic reactor IBR-3 using neptunium fuel and 2) a proton accelerator hitting a non-multiplying tungsten target supplying neutrons for a subcritical booster with a plutonium dioxide core giving a criticality level of <0.98 . An estimated neutron flux is $>10^{14}$ n/cm²/s, a pulse length 150-200 μ s, and a repetition rate 10 Hz. Work on the conceptual project is carried out in cooperation with the Chief Designer NIKIET.

Recommendations. The PAC recommends that FLNP continue developing both concepts of the new neutron source, compare their parameters and cost between each other also with those of other existing or projected neutron sources, and formalize this activity under a specific theme of the Laboratory. The PAC also notes that a broader discussion on the possible nuclear physics programme for the new source with other laboratories is needed taking into account that the proton accelerator is considered to be included in one of the source options. The PAC recommends exploration of proposed neutron techniques and methods at the IBR-2 reactor.

III. Status of the Factory of Superheavy Elements

The PAC took note of the reports on the status of the Factory of Superheavy Elements (SHE Factory) presented by I. Kalagin (cyclotron DC-280), A. Popeko (separators for the SHE Factory) and V. Utyonkov (first experiments at the SHE Factory).

DC-280 cyclotron

The construction of the experimental building of the SHE Factory has been completed. A certificate of compliance of the constructed object with the requirements of technical regulations by the Federal Environmental, Industrial and Nuclear Supervision Service of Russia (Rostekhnadzor) has been obtained. Complex commissioning work has been conducted. On 26 December 2018, the first beam of accelerated krypton ions was produced inside the DC-280 cyclotron. On 17 January 2019, the first beam was successfully accelerated and extracted from the cyclotron. In the first quarter of 2019, it is planned to continue the work at DC-280 to obtain heavy-ion beams of design parameters, to complete the commissioning work for the GFS-2 separator, and to initiate the implementation of the experimental programme on the synthesis and study of the properties of SHE at the Factory.

Separators GFS-2 and GFS-3

The first experimental set-up at the SHE Factory, which is prepared for work with heavy-ion beams, is the GFS-2 gas-filled separator designed at FLNR and manufactured by SIGMAPHI (France). In 2018, the main assemblies of the GFS-2 separator and the power supply units were mounted; the beam transport channel was prepared. In the spring of 2019, tests of the detection unit and data acquisition system will begin. The highest priority should be given to the testing of GFS-2 with the DC-280 beam.

It is planned to use the gas-filled separator GFS-3 together with gas traps of reaction products in experiments aimed at studying the chemical properties of SHE, as well as in experiments on nuclear and mass spectrometry. The separator is also manufactured by SIGMAPHI. In April 2019, it is planned to install it on Channel 2 of the DC-280 cyclotron. The start-up of GFS-3 is planned for the first quarter of 2020.

The PAC recognizes efforts made by the Laboratory in order to prepare for the commissioning of the SHE Factory as well as the progress in the construction of GFS-2, appreciates this work, and supports its continuation. The PAC expects a report about the in-beam tests on the performance of the GFS-2 separator and on the optimal conditions of operation at the next meeting.

Programme of Day-1 experiments at the SHE Factory

At the first stage, in order to characterize the experimental setup, a set of test experiments will be carried out. They will be aimed at achieving the design parameters of the GFS-2 separator, using fusion reactions of rare-earth elements with ^{40}Ar , ^{48}Ca , ^{50}Ti ions accelerated at the DC-280 cyclotron. In this set of experiments, it is necessary

to study the transmission of GFS-2 at different thicknesses of the target, the resistance of targets to an increased beam intensity and accumulated dose, the clearing of background reaction products, etc.

The first commissioning experiments on SHE will concern the synthesis of moscovium isotopes in the $^{48}\text{Ca} + ^{243}\text{Am}$ reaction and at the later stage the study of the chemical properties of Fl and Cn. The programme will further be focused on preparing and conducting experiments on the synthesis of elements 120 and 119 in the reactions of ^{50}Ti beam with $^{249-251}\text{Cf}$ and ^{249}Bk targets, respectively.

Recommendations. The PAC congratulates the FLNR staff on the successful start-up of the DC-280 cyclotron and recommends that the Directorate concentrate efforts on completing all commissioning work, including the DC-280 cyclotron and the GFS-2 separator, and on preparing the test experiments.

Notwithstanding these remarkable achievements, starting with a completely new set-up there will certainly arise unexpected problems which should be solved before the first production runs can start. The removal of all problems will need time which has to be provided so that all follow-up experiments will profit from this preparation.

Therefore, at the next meeting the PAC expects a more detailed schedule of the phases of the experimental programme towards Day-1 experiment to be presented, taking into account potential challenges related to unforeseen problems in the commissioning and risk analysis.

The PAC supports the programme leading to first experiments at the SHE Factory.

General recommendation. The PAC congratulates the FLNR staff on the successful start-up of the DC-280 cyclotron and recommends that the Directorates of JINR and FLNR concentrate their efforts to complete all commissioning work, including the DC-280 cyclotron and the GFS-2 separator, and to prepare for the test experiments. The PAC approves the programme of first experiments at the SHE Factory.

The PAC requests, for the next meeting, a submission of detailed reports and/or presentations on the SHE Factory prepared by FLNR well in advance of the meeting in order to allow PAC members to prepare the full referee reports in due time.

IV. Status of the GALS set-up

The PAC heard the report on the progress of the construction of the separator of nuclear reaction products, GALS, presented by S. Zemlyanoy. GALS uses a two-step separation method, based on stopping of nuclei in a gas cell, resonance laser ionization and separation in a magnetic field. The GALS set-up is being built at FLNR and will

operate with the U-400M cyclotron beams. In test experiments, it is planned to obtain Os isotopes in order to approach and synthesize isotopes in the region of the shell with $N = 126$. The possibility of observing these isotopes has been predicted by model calculations carried out at FLNR. The PAC appreciates the work done in preparing for the start-up of this new separator.

Recommendations. The PAC endorses the proposed programme of actions necessary for the start-up of the GALS separator. However, the group would need more manpower including post docs and PhD students in order to ensure that this work finishes within shorter time than presented. Furthermore, the PAC expects a detailed progress report to be presented at its future meeting.

V. Scientific report

The PAC heard with interest the excellent report “Charged-current neutrino-nucleon reactions in the supernova neutrino-sphere” presented by A. Dzhiyev. The subject of study is very important. It is related to the processes (calculation of cross-sections) in stars or supernova explosions. Thermal QRPA mechanism is well known as is applied in the case of neutrino-nucleus interactions. The results presented in the talk include detailed calculations based on the above-mentioned mechanism. The PAC supports continuation of these research activities.

VI. Poster session

The PAC appreciated the high quality of 16 presentations of new results and proposals by young scientists in the field of nuclear physics research. The best posters selected are: “Upgrade of the GERDA experiment” presented by N. Rumyantseva, “Pygmy and Giant dipole resonances in $^{48,50}\text{Ca}$ and $^{68,70}\text{Ni}$ ” presented by N. Arsenyev, and “New systems based on extracting sorbents for the purification of low-background materials” presented by G. Marinov.

The PAC recommends the poster “Upgrade of the GERDA experiment” to be reported at the session of the Scientific Council in February 2019.

VII. Next meeting of the PAC

The next meeting of the PAC for Nuclear Physics will be held on 24–25 June 2019.

Its tentative agenda will include:

– reports and recommendations on themes and projects to be completed in 2019;

- status of the SHE Factory and its scientific programme;
- first results from ACCULLINA-2;
- new project of prototype linear accelerator;
- consideration of new projects;
- scientific reports;
- poster presentations of new results and proposals by young scientists in the field of nuclear physics research.



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Chairman of the PAC
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