RECOMMENDATIONS OF THE EXTRAORDINARY MEETING OF THE PROGRAMME ADVISORY COMMITTEE FOR CONDENSED MATTER PHYSICS OF 29 APRIL 2021

At its 53rd meeting, the PAC for Condensed Matter Physics proposed having an extraordinary meeting to prioritize the projects within the competence of this PAC.

Following the guidelines motioned by JINR Director G. Trubnikov, the prioritization aims at sorting the projects into three categories, using the scheme suggested jointly by the PAC for Particle Physics and PAC for Nuclear Physics based primarily on the scientific merit of the project, project performance, as well as impact and visibility of the JINR group. For that, the project leaders were requested to fill in a short questionnaire prepared by the PAC. Each project was reviewed by PAC members (at least one referee). The questionnaire forms and the referee(-s)'s reports were uploaded to the Indico webpage of the extraordinary meeting. The overall evaluation of each project was based on the opinions of the referees and the subsequent discussion of the project at the extraordinary meeting of the PAC.

Project "Development of an inelastic neutron scattering spectrometer in inverse geometry at the IBR-2 reactor"

At the 127th session of the JINR Scientific Council, the PAC recommendation was endorsed with regard to the PAC's statement that the two reviewed IBR-2 spectrometers no longer satisfy the requirements of all its users. Coherently, the Scientific Council supported the preparation of the new project for developing a new inelastic neutron scattering (INS) spectrometer and expected that a detailed proposal for this new project should be presented at a future PAC meeting, – which is executed within the project prioritization hereto.

The project report submitted for prioritization contains significantly more technical and manpower details than the version submitted a year ago. Particularly, the sophisticated neutron optics of the inverse-geometry INS spectrometer will increase the luminosity compared to the old spectrometers by more than two orders of magnitude, thereby resulting in a cutting-edge instrument worldwide. This will make performing INS experiments on minute samples possible, opening a gateway to a new generation of research.

The engaged research and engineering personnel as well as the involved companies are, in every respect, top-level and guarantee meeting the presented project timeline. The financial plan is justified and realistic.

Recommendation. Given the high importance of the expected impact of the project for the FLNP, the PAC acknowledges the preceding work of the project team and recommends continuing the project with ranking A.

Project "Construction of a complex of cryogenic moderators at the IBR-2 facility"

The project is aimed at the continuation of the work on creating, debugging and improving the moderators at IBR-2.

It should be noted that, at present, the source of cold neutrons developed and operated by FLNP at the IBR-2 reactor is the only cold neutron source in the Russian Federation. Its distinctive feature is the shape of the working substance and the way it is loaded into the moderator chamber using the pneumatic conveying of pellets at cryogenic temperatures. This operation principle is unique and unrivalled worldwide. In the process of project implementation, there have been developed some novel engineering units, devices, techniques, and software. The inventions are valuable not only for this project but also for the national economy and are protected with several patents, which enhances the significance of the project.

It is necessary to mention that the engineering decisions allowing to independently change the effective temperature of elements of the moderator complex in a wide range from 20 K to 150 K were developed. This actually leads to further optimization of the experiment conditions for particular work on neutron instruments.

However, the recent publications are scarce according to the presented questionnaire on the project. The document presents few details on the project status. The raised issues are as follows: what the results of the installation of Cold Moderator CM-201 are (beamlines 1, 4, 5, 9) and what the reason for suspending CM-203 is. The realization of the project seems to be still in its test stage. It is not clear whether the new system is reliable. The project is behind the schedule.

Recommendation. Considering the positive results of the CM-202 operation for physics experiments, development and construction of CM-201, modernization of the cryogenic system and other developments, with reference to the abovementioned concerns, the PAC recommends that the project report should be returned to the project leader for redrafting (without insisting on the previously distributed format). The final prioritization of the project should be shifted to the PAC meeting scheduled for June 2021.

Project "Construction of a wide-aperture backscattering detector (BSD) for the HRFD diffractometer"

The HFRD diffractometer is important for the IBR-2 instrument suite. It is following up the first stage of the project (2018–2020) that was successful in developing the technology and method of assembly for this upgrade. The project deals with replacing the current backscattering detectors with their new version of much increased angular coverage. The new detector will be based on a state-of-art scintillator detector design developed by FLNP. The upgrade will enable gaining factor 10 in solid angle coverage.

As mentioned in the previous reviews of this project, the project is of the just ambition level and scope. It is fraught with a significant scientific impact and enhances the output from IBR-2. The project is well-thought-through; the project plan and the schedule are realistic.

The last but not the least, the team is staffed, trained and working. The work must not be delayed, as any delay would pose a significant risk on the outcome.

Recommendation. Given the importance of the expected output and good results achieved on the previous stage of the project, the PAC acknowledges the preceding work of the project team and recommends continuing the project with ranking A.

Project "Raman microspectroscopy in the biomedical study" (Biophotonics)

The project is implemented by the Sector of Raman spectroscopy established as a self-acting structural unit of FLNP in 2015. The research activities of the Sector are aimed at solving original fundamental and practical problems in the field of Raman and upconversion luminescence spectroscopies and based on use of the multimodal optical platform (Confotec CARS multi-channel 3D-scanning laser microscope-spectrometer). The unique characteristics of the system have been significantly extended and supplemented with new functionalities in the last three years.

Expanding the collaboration activities beyond the Member States can be recommended in future for opening new opportunities to the Sector and promoting its visibility. The high quality of the Sector research activities is supported by a good record of publications and numerous presentations at international conferences. The Sector has excellent possibilities of professional development of its staff.

The project comprises two well-defined and well-balanced parts with fundamental and applied aspects. The basic understanding of the anomalous ratio of intensities of the anti-Stokes/Stokes components in the SERS spectra is one of the aims with a potential impact on the development of biosensors. Understanding such anomalies is crucial for reproducible signal registration required for the sensor implementation. The solution to

this problem will stimulate further development of the CARS system that is already on its way.

The applied research activities address two important and ambitious tasks: (i) the problem of lipid-protein interactions, in particular, the use of lipodiscs in studying the structure of membrane proteins, and (ii) the search for a Raman marker for early diagnosis of NETosis. Both topics are of high importance in their fields, and an excellent impact is expected.

Recommendation. Considering that the goals of the project look harmonious, interconnected and quite ambitious, the PAC notes that this is a good start for additional research using the methods of Raman spectroscopy and neutron scattering and recommends continuing the project with ranking A.

Project "Research on the biological effect of heavy charged particles with different energies"

The project team includes specialists in the field of molecular radiobiology, radiation genetics, cytogenetics, and physiology. The list continues with specialists in molecular radiobiological aspects of radiation therapy and mathematical modelling of radiation based on the induction of radioactive effects and data analysis, systematization and interpretation, and computer simulations. They do not overlook radiation safety upgrades and development of radiobiological stations for irradiation, science instruments for studying the nuclear planetology issues, and the student education programmes in radiobiology.

The project scope includes data mining, potential sources of information, data accessibility and methods of molecular biology, genetics, pharmacology, neurogenesis, morphology, and radioprotection during the research of heavy charged particles of induction, the damage in genetic structures of prokaryotic and eukaryotic cells (mammalian and human cell lines). The project depicts a well-developed strategy for meaningful results and clear assessment. The investigation model, tools, and methods of the project are realistic for the challenge and the requested funding is realistic for the estimated budget.

Recommendation. The PAC recommends continuation of the project with ranking A provided that a second independent referee will support this recommendation; the final decision should be shifted to the June 2021 PAC meeting.

Project "Research on the cosmic matter on the Earth and in nearby space; research on the biological and geochemical specifics of the early Earth"

The project is focused on the preparation and irradiation of meteorite matter and organic samples with hadron beams, clean room for prebiotic chemistry research handling the collection of meteorites and cosmic matter samples, the study of microfossils with electron scanning microscopy, data analysis, systematization and interpretation.

The project is following up the previous programme. Its objectives are clearly defined, they encompass the main topics of astrobiology including formation of the first prebiotic compounds, the role of meteorites as catalysts, the mineralogical origin and element (isotopical) composition of meteorites and cosmic dusts.

The technical side of the project is accurate and includes specific JINR facilities. A special-purpose database was developed. Overall, the technical side of the project appears to be adequate for achieving all proposed objectives within the indicated period of time. External collaborations further enhanced the feasibility of the proposal.

Recommendation. The PAC recommends continuation of the project with ranking A provided that a second independent referee will support this recommendation; the final decision should be shifted to the June 2021 PAC meeting.

Project "Further development of methods, technologies, schedule modes and delivery of radiotherapy"

The project research is innovative in terms of challenge in the scientific programme focused on medico-technical and clinical research for the therapy of cancer patients with beams of charged particles of the JINR Phasotron and the successive diagnosing, — which is first-ever practiced in Russia and Eastern Europe. JINR is Russia's top in in the field of proton therapy the annual capacity of approximately 100 patients. It has been successfully applying the method of conformal 3D irradiation of deep-seated tumours when the dose distribution is precisely localized at the target shape.

The achievement of the solvers in the group is valuable specialists in the field of radiotherapy, radiobiology, and technology of proton therapy. The scientific and technical impact of this research is on an excellent level. The measures maximizing the impact of the project will require future independent research based on using the JINR facility. The potency of the innovations versus risk ratio correlates with the team experience. The purposes of the project also include the development of a therapeutic method and device for protecting biological objects against radiation. The investigation model, tools, and methods of the project are realistic for solving the proposed challenge and the funding

request is realistic within the estimated budget. It includes clear overall responsibility of all staff resources for the activities.

The further research of medical beams at JINR require a wide range of main methods (from technical solutions and development of the proton therapy physical methods to methods of radiobiological studies), which result from clinical trials and experience. The planned timetable of work and resource-levelling the information proves the proposal is on adequate level of experience with the research team's preparation focused on this field.

Recommendation. The PAC recommends continuing the project with ranking A.

Project "The molecular genetics of radiation-induced changes at the gene, genome and transcriptome levels in *Drosophila melanogaster*" (Radiogene)

The stated problem, research, and significance of the project are innovative in the meaning of the challenge in the genetic risk estimation. The background of the prediction of the additional risk of genetic diseases in humans exposed to ionizing radiation occurs naturally because of spontaneous mutations.

The project considers the experience of the research team related to planned years are on the good level and a large amount of the coordination of all planned experiments by the JINR organization is the right place for conducting the proposed radiobiological studies.

The planned timetable, the balance between the time frames and costs, the work plan description, the benefits for JINR arising from this activity, the project structure and planned procedures are well-defined. The study of the radiation level risk using the technique of the gamma-radiation facilities is also meaningful for the use and application of JINR's experiment facilities, as it regards obtaining the worldwide level of the research results at JINR.

The working group will be theoretically capable to predict the potential human data on radiation-induced mutations and the risk of genetic diseases in humans, which makes a successful strength of the project.

The project contains a small number of young professionals, – which is its weakness – as well as yet unopened collaborations with other institutions.

Recommendation. The PAC recommends continuing the project with ranking A provided that a second independent referee will support this recommendation; the final decision should be shifted to the June 2021 PAC meeting.

Project "Study of the radioprotective properties of the Damage suppressor (Dsup) protein on a model organism *D. melanogaster* and human cell culture HEK293"

Due to a large number of the research projects applications in the field of biology and medicine submitted to the PAC coincidently, the PAC suggests that ranking this project should be postponed to the PAC meeting scheduled for June 2021.

Project "New semiconductor detectors for fundamental and applied research"

This project deals with novel semiconductor detectors. This is both as a member of the Medipix4 collaboration, and the use of these pixelated detectors, and as a member of the FCAL collaboration and the development of suitable GaAs material. The project is interdisciplinary and mostly targeting fundamental physics, though its topics of relevance are for application in microtomography, biology and radiomedicine.

The existence of adequate expertise of the core team of the project is proved by the high qualification of the DLNP staff, the established infrastructure, and the excellent results achieved in the evaluated term (2018–2021).

The planned goals for the next term (2021–2023) are realistic and met by the expertise of the DLNP staff.

There is no doubt that this project will make excellent and novel technological progress. It will produce significant technological gains and an advanced technology.

Where the PAC is in doubt is that the links to the CMP PAC are tenuous — it is mainly targeted at fundamental physics. The radiobiology and medicine aspects seem tagged on currently in the project as presented in the questionnaire. Additionally, the level of details on the project and what it is aiming to achieve (in particular in the relevant areas to this PAC) is limited.

It should be noted that there are many potential applications of this technology in the field of this PAC, where this technology could have impact.

Recommendation. The PAC notes that the proposed tasks are well formulated and ambitious, directed to the development of unique equipment for the needs of JINR and external scientific partners, and feasible. The PAC recommends that the project report should be returned to the project leader for redrafting (without insisting on the previously distributed format). The final prioritization of the project should be shifted to the PAC meeting scheduled for June 2021.

Project "Development of experimental techniques and applied research with slow monochromatic positron beams" (PAS)

Positron annihilation spectroscopy (PAS) is a well-established method of studying the density and momentum distribution of electrons in condensed matter, its most important application being to obtain information on voids and defects in solids. The initiative to use the LEPTA facility for PAS applications dates back to 2013. In June 2017, the PAC took note of the progress in the development of the PAS method at LEPTA including the construction of a specialized channel of slow monochromatic positrons (SCSMP) and the elaboration of a proposal for formatting the ordering flux of positrons based on SCSMP to be used for positron annihilation lifetime spectroscopy. Accordingly, in 2018–2020 the main purpose of the project was constructing and commissioning the positron transport channel and the experimental station and applying it to positron lifetime studies as well as optimizing the positron accumulation in the positron trap to achieve the intensity of 10^7 positrons per cycle.

Unfortunately, probably mainly due to some shortcomings of the questionnaire form, the submitted project report (a.k.a. 'filled-in questionnaire') gives insufficient information on several important points. Therefore, the project leaders a chance should be given to submit a more detailed report removing any ambiguities concerting the status of the project.

Recommendation. The project report should be returned to the project leader for redrafting in the light of the above points (without insisting on the previously distributed format). The project prioritization should be shifted to the PAC meeting scheduled for June 2021.

Project "Open information and educational environment for supporting fundamental and applied multidisciplinary research at JINR"

The project is an important continuation of the work started in 2017 and intends to create new educational and information resources related to the areas of JINR research. The project is implemented on the basis of the hardware located at the JINR UC, and the information is provided to the interested clients and community on several web portals. While the JINR group is the chief responsible and coordinator, the project involves a well-established collaboration of five JINR Member States and three Associate Members. The project team is experienced in creating a project-relevant content.

It is important that, along with the high-quality content creation, the activities for its dissemination and awareness about it are performed simultaneously in numerous reports

at international conferences and various events such as workshops, symposia and exhibitions.

The project has clear and ambitious plans for the period till 2023 that reflect all aspects of JINR activities: attraction of talented youth to JINR, integration of the research results obtained at JINR to the education process, collaboration with leading research centres for creating educational resources, promotion of JINR's research to a wide audience, educational and exhibition content improvement. The expected results are defined, relevant and potent to significantly impact on the educational process at JINR Member States and Associate Members.

Recommendation. The PAC recommends continuing the project with ranking A.

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