Referee report on the project

"Mathematical methods, algorithms and software for modeling physical processes and experimental facilities, processing and analysis of experimental data"

for the period 2024-2026 within the theme 05-6-1119-2014/2026

The solution of the ambitious tasks, which are outlined in the Seven-Year Plan Plan for the Development of JINR for 2024–2030 and in the Strategic Plan for the Long-Term Development of JINR for the period up to 2030 and beyond, is unthinkable without the use of modern information technologies, scientific computing and Data Science. The Meshcheryakov Laboratory of Information Technologies (MLIT) is focused on the development of new data processing and analysis algorithms based both on the well-known approaches, Big Data methods, modern methods of machine and deep learning. The proposed project is aimed at the provision of mathematical, algorithmic and software support for experimental and theoretical research conducted at JINR. It comprises of:

- development of algorithms based on recurrent, convolutional and graph neural networks as well as gradient boosted decision trees, designed primarily for solving various problems in particle physics experiments, including the NICA megaproject and large neutrino experiments;
- development of scalable algorithms and software for processing multi-parameter, multi-dimensional, hierarchical exabyte datasets;
- development of software and analytical complex for distributed data processing, analysis and data management for the experiments with JINR participation at various research centers;
- development of information and computing systems for the analysis and processing of experimental data in the field of radiobiology and life science;
- development of modern research tools for international collaborations (NICA, JINR neutrino program, experiments at the LHC).

Three principal aspects of experimental physics related to information technology are addressed in the proposal: (i) simulation of physical processes and experimental facilities, (ii) reconstruction of physical objects and analysis of experimental data, and (iii) development of the software environment for experiments. It has applications in a wide range of science research in particle physics, nuclear physics, condensed matter physics, biophysics, information technologies, etc. Development of analytical methods, event generators and library of the matrix elements is assumed for simulation of collisions of heavy ions, highly compressed nuclear matter, the physics processes beyond the Standard Model. It also implies further development of the Geant4 physics lists and geo-models. NICA and LHC experiments will benefit from the novel algorithms of track reconstruction and particle

identification. Development of the modern approaches for data processing is foreseen for TAIGA gamma-ray observatory, proton digital calorimeter used for proton therapy, for processing and analysis of neutron noise of the IBR-2M reactor and for data processing of the YuMO small-angle neutron scattering spectrometer.

Success of the project will be based on consolidating efforts on development of common solutions for various experiments, both in terms of the methods for data processing and software environment. A close cooperation of MLIT with other Laboratories of the Institute is very important. The authors of the project have extensive scientific experience in the development of mathematical methods, algorithms, and software for large scale experiments (BM@N, MPD and SPD at the NICA, ATLAS and CMS at the LHC, CBM at the FAIR, Geant4 package, etc). The list of participants includes 8 doctors of science and 17 candidates of science. It is worth noting the interlaboratory origin of this project as well as involvement of physicists from many JINR member-states. All these make realization of the project very feasible.

To provide the expected results (significant for JINR), the project, in my opinion, should be supplemented with a description of the organizational structure and a roadmap to achieve synergy of the efforts of the participants and work coordination in various areas.

In general, the project "Mathematical methods, algorithms and software for modeling physical processes and experimental facilities, processing and analyzing experimental data" deserves a positive assessment, the requested funding looks reasonable, and I recommend the project to be adopted for the period of 2024-2026 with high priority.

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