# Evaluation of the Renewal of a Project Proposal, for 2027–2031, in the frame of the Theme 1119

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**Proposal details**

Theme 1119: "Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data"

Project Proposal: Methods of computational physics for the study of complex systems

Proposed by: M.G. Meshcheryakov Laboratory of Information Technologies (MLIT)

Leaders: E.V. Zemlyanaya, O. Chuluunbaatar

Deputies: Yu.L. Kalinovsky, A. Khvedelidze

Status: Renewal of the Project proposal, within the Theme 1119, for 2027–2031, to be analyzed and decided at the 63-th Meeting of the Program Advisory Committee for Condensed Matter Physics (CMP-PAC)

**Project evaluation**

The project was initially opened for three years, 2024 – 2026. The analysis of the renewal of project proposal for 2027 – 2031 shows that it closely follows the criteria of evaluation as discussed below.

**Criterion 1:** *Scientific merits, elements of novelty, timely nature of the research*

- The submitted renewal project proposal formulates ambitious interdisciplinary tasks the solutions of which will make heavy use of computing based methods and techniques. The outcome is intended to contribute to the progress of the JINR research as a whole during the Seven-Year Plan for the Development of JINR for 2024–2030.
- This undertaking rests on the occurrence of two strong MLIT opportunities (i) the existence of a top computing infrastructure (comprising the heterogeneous HybriLIT computing platform that involves a training and testing polygon and the "Govorun" supercomputer) enabling large scale and new approaches to highly performant computing and (ii) a highly qualified research team possessing a unique expertise in numerical, symbolic, or symbolic-numerical solution of scientific problems arising in applied and fundamental research.
- The proposal under review matches the research done in the MLIT, based on the existing local expertise, with complementary research effort done by groups from all the other JINR Laboratories. This is an indelible part of the conception of the Seven-Year Plan on 2024–2030 of giving top priority to the most important milestones of the research done in the JINR.

- The proposal strongly illustrates the golden idea that successful computational simulations of very different classes of physical phenomena are made possible by the intertwining of a solid specific mathematical background with skillful identification and exploitation of the available hardware features. The problematic of the effective utilization of powerful computing infrastructures like the "Govorun" supercomputer is emphasized and timely instances of actual scientific problems solved with modern mathematical algorithms are provided. In this context, it is to be noted the vigorous continuation of the development of the quantum computing methods.
- Having in mind the main directions of the JINR research program, the specific tasks of the project are grouped into five subject areas, each of which shows distinctive features concerning original development regarding, on the one side, methods of computational mathematics, high-performance computing and mathematical modeling and, on the other side, new physically significant results obtained on this basis:
  1. Development of methods, program packages and numerical studies of various interactions in complex systems of nuclear physics and quantum mechanics.
  2. Studies of intricate processes in condensed matter and materials subject to external fields.
  3. Solutions of modeling problems in the design of experimental facilities and optimization of their operating modes.
  4. Modeling of complex processes in dense nuclear matter, including astrophysical models and processes in experimental facilities.
  5. Modeling of quantum systems using methods of quantum information theory and hybrid quantum-classical programming methods.
- To summarize, this renewal of the previous research project proposal is comprehensive and well written. It aims at studying complex physical processes that ask for numerical solutions of difficult mathematical and computational physics problems involving wide ranges of values of the parameters of the models.
- The modeling of such processes are based on the use of systems of dynamic nonlinear, spatially multidimensional, integral, integro-differential, or differential equations. More often than not, the occurrence of critical regimes, bifurcations and phase transitions are intrinsic parts of the proposed studies.
- The coverage umbrella of the project problems stems from research projects defined in the Seven-Year Plan 2024–2030 to be of the first importance for the JINR.

**Criterion 2:** *Expertise of the group and technical feasibility of the project within the proposed timescale*

- The adequate expertise of the basic staff of the proposed project is probed by the existing high level of qualification (1 Academician, 14 DSc, 28 PhD – figures in continuous evolution). Besides the experienced scientists, the research team includes enthusiastic young scientists and engineers.
- The publication, during the project implementation (over the past two years), of more than 120 scientific papers in peer-reviewed scientific journals, 3 monographs and 2 textbooks, and the defense of 1 PhD thesis on the subject of the project, completes the statistics of the contribution to the JINR excellence trough publications. The leaders of the project prepared a review paper in Natural Science Review on the development

and use of iterative schemes based on the Continuous Analogue of Newton's Method, an important tool for solving a number of the project's tasks. In 2025, a series of works within the project entitled "Numerical methods and problem-oriented program complexes for solving some partial differential equations of physical processes and systems" was awarded the 3rd JINR Prize for Methodology, Research and Technology Papers of 2024. The development and implementation of 2 high-performance software packages in the Program Library JINRLIB are additional proofs of a lasting prestigious output simultaneously based on in-depth grasp of right computing paradigms and the formulation of breakthrough ideas.

- The project proposal assumes the promotion and support of a scientific environment in MLIT, which encourages and rewards a deep and extensive professional expertise along four critical directions: thinking as computer scientist with several computing paradigms; expert knowledge of the mathematical problems backing the topic of the collaboration; in depth grasp of the numerical analysis topics enabling the achievement of reduced computational complexity, robustness and reliability of the developed algorithms; deep knowledge of the physics side of the problem at hand as a precondition of significant mathematical modeling undertakings. The leadership of the project will put efforts to back the agreed cooperation with working groups the complementarity of the knowledge of the members of which secure the coverage of all the four mentioned critical directions. Inside the JINR ecosystem, the decisions will heavily rely on those of the JINR Directorate and of the Program Advisory Committees, the CMP-PAC in the first instance.

**Criterion 3:** *Compliance of the requested financial resources with the objectives of the project*

- The requested financial resources fully comply with the objectives of the project.

**Criterion 4:** *Availability of human resources at JINR and in the collaborating institutions*

- The existing human resources are of good quality, the MLIT is an attractor for young talents, both from Russian institutions and from JINR Member State institutions.

**Conclusions**

- My final conclusion is that the proposed tasks are well formulated, are ambitious, they continue addressing top difficult topics of the JINR research through feasible methods.
- I propose the CMP-PAC to approve the support of the present renewal project proposal for 2027–2031 with the first priority.

Date Signature



15.06.2026

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