UNIVERSITY OF ALBERTA

# Review of the Proposal for the Theme 1119 Extension during 2017-2019

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**Title of the theme:** 05-6-1119-2014/2019, "Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data"
Priority: 1 Status: Extended
**Leaders**: Gheorghe Adam, Petr V. Zrelov
**Theme beginning**: 2014

The present review concerning the proposal on the theme 1119 extension for 2017-2019 was prepared in close compliance with the received **criteria of evaluation**.

The main feature of the theme 1119 can be described as "unity in diversity", since it illustrates the participation of scientists from the Laboratory of Information Technologies (LIT) in solving computational tasks raised by more than 40 research projects of the Joint Institute for Nuclear Research (JINR). Unity is achieved through the unifying principles which follow from the existence of a common mathematical background of all these projects. The scientific focus of the research is the mathematical description of the key tasks, the search of solution algorithms, and their implementation in computer programs.

The research conducted within the theme 1119 includes the following four main directions: (1) Mathematical and computation methods for simulation of complex physical systems; (2) Software complexes and mathematical methods for processing and analysis of experimental data; (3) Numerical methods, algorithms and software computationally adapted to multicore and hybrid architectures; (4) Methods, algorithms and software of computer algebra.

The tasks solved in the framework of these directions are associated with a wide range of research conducted at JINR in the field of high energy physics, nuclear physics, condensed matter physics, biophysics, etc. Each task requires the development of new mathematical methods and approaches for modeling physical processes, processing and analysis of experimental data, including the work on the NICA project, the neutrino programme and other strategic goals of the Institute.

The theme includes the development and use of mathematical and computational methods for modeling new experimental facilities and accelerators, nuclear-physical processes of complex physical systems, the development of parallel algorithms and software packages for modern multiprocessor computer systems.

Among the priorities of the theme there are the development of mathematical methods and software systems for experimental data handling, including the development of new mathematical techniques able to extract the meaningful information from these experiments; algorithms and software packages for solving problems in high-energy physics, nuclear physics, condensed matter physics, radiation biology, the accelerator complexes LHC, NICA, FAIR included, and also experimental facilities of the JINR neutrino programme.

Special attention is paid to the development of numerical methods, algorithms and software packages based on parallel programming techniques which make efficient use of many-core and hybrid architectures. This enables the solution of resource-intensive tasks as well as the support of applied engineering and physical problems using appropriate software packages.

Among the main directions there are the development of methods of computer algebra for numerical solution of differential equations and simulation of quantum information processes; creation of algorithms and program packages for the symbolic-numerical solution of problems arising in experimental and theoretical studies, using the latest computational hardware resources, including heterogeneous ones.

These areas are connected primarily with the necessity of finding and obtaining fast and reliable solutions in the rapidly evolving hardware-software environment which is undergoing a transition to the many-core architectures and heterogeneous structures of the modern computing clusters, with the need for their effective use through the development of parallel algorithms and programs.

A distinctive feature of the foreseen research is the close cooperation of LIT with all JINR laboratories, with institutes from the JINR Member States and with other leading institutes in the world (from 32 different countries).

The proposal for the theme extension provides detailed description of the factors which strengthen the arguments in favor of the ability to complete the proposed tasks within the specified time schedule. Among them, there are the very high qualification level of the theme staff (24 DSc and 47 PhD, figures in continuous evolution), the existence in LIT of its own Dissertation Council promoting very high standards of evaluation, the presence of a variety of forms and means for the increase of the education level of all the LIT staff, especially young (through training courses, tutorials, dedicated conferences and workshops for young scientists and specialists, group and individual consultations, periodic scientific seminars, etc.). In this context, I should like to stress the important role played by the International Mathematical Modeling and Computational Physics (MMCP) Conferences, successfully organized by LIT and partner Institutes once every two years. As an invited lecturer at the last MMCP 2015 Conference, I was very impressed by its high scientific level, the rigor of the refereeing process of the Conference Proceedings (published in EPJ Web of Conferences, vol. 108, 2016), as well as by the tutorial on parallel programming on hybrid architectures.

A further strong point is the availability of the latest hardware and computational resources for high performance computing through the fast hybrid computing cluster HybriLIT which makes possible to address the theme tasks within the most favorable circumstances.

The requested financial resources correspond to the nature and complexity of the proposed tasks within the theme 1119.

In conclusion, the proposal for the theme 1119 extension is extremely well written and presented at the highest professional level. It covers a broad range of applied and discrete mathematics that are of extreme importance in the physics research. The proposed topics and the approach to their solution are very well thought out and sound.

I strongly and wholeheartedly recommend the approval of the extension of the theme 1119 for 2017-2019 with the first priority.

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