INFORMATION TECHNOLOGY AND COMPUTER PHYSICS

In 2022, the "Govorun" supercomputer was modernized; the computing power of the supercomputer enhanced by 23.5%, which made it possible to reach a peak performance of 1.1 PFlops, the data processing and storage system was enlarged by 8 PB. Such a modernization will not only provide new opportunities for more efficient computing and Big Data intelligent processing within different JINR's scientific experiments, including the NICA megascience project, but will also enable the implementation of large-scale research projects within the National Research Computer Network (NIKS), which combines three Shared Use Centres (SUC), namely, the Joint Institute for Nuclear Research, the Joint Supercomputer Centre of the Russian Academy of Sciences (JSCC RAS) and Peter the Great St. Petersburg Polytechnic University (SPbPU).

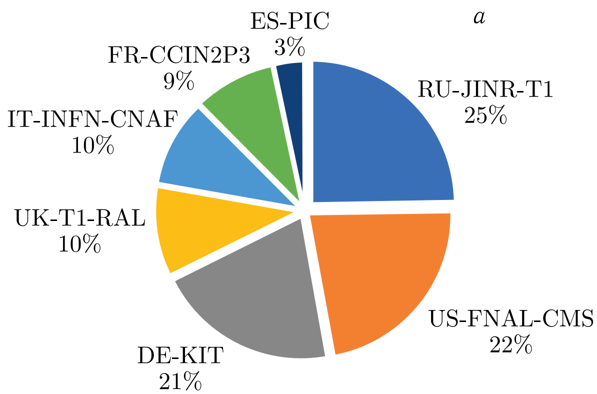
- The Performance of the "Govorun" Supercomputer at JINR Reached 1.1 PFlops. CNews Press Release; https://www.cnews.ru/news/line/2022-11-17_proizvoditelnost_superkompyutera.

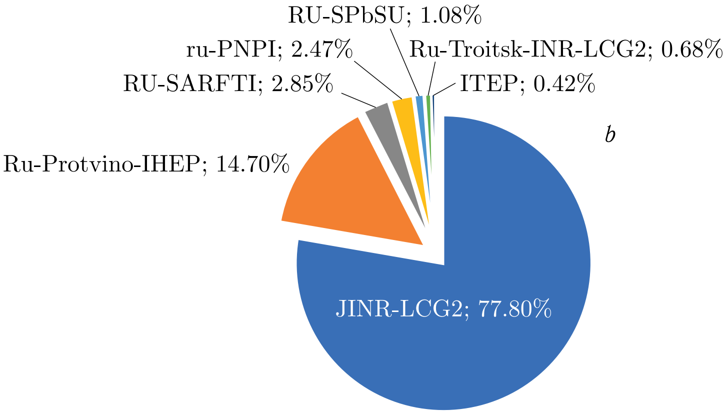
The JINR Tier1 centre demonstrates stable operation not only for the CMS experiment, but also for NICA MPD. In terms of performance, Tier1 ranks first among Tier1 centres for the CMS experiment in the world. 30% of all tasks performed on Tier1 are NICA MPD tasks. The Tier2 centre is the most productive in the Russian consortium RDIG (Russian Data Intensive Grid) and is used for data processing within the NICA, LHC, ILC, BIOMED, NOvA experiments, as well as by JINR local users.

- *Korenkov V. V.* Status and Development Prospects of the JINR Computer Complex // Proc. of the 16th Intern. Conf. on Parallel Computational Technologies (PCT 2022), Dubna, Russia, March 29–31, 2022.

To solve one of the important practical problems, namely, the control of the pressure and flow of liquid nitrogen of the superconducting magnets of the cryogenic system of the NICA accelerator complex, a software and hardware platform was developed on the basis of quantum fuzzy controllers embedded into the control loop. The multilevel control system comprises the existing lower executive level on top of the Tango Controls system and a new level, at which control actions are formed using a quantum fuzzy controller. At the same time, optimal parameters of control quality, such as temperature, nitrogen consumption, speed, the required pressure level and minimal complexity of the control implementation, are provided. The operability and efficiency of the developed intelligent remote-control system for the technological process of cooling a superconducting magnet with a guaranteed achievement of a stable superconductivity zone were experimentally demonstrated. The design of quantum fuzzy controllers is based on quantum information technologies and is carried out applying the QSCIT (Quantum Soft Computational Intelligence Toolkit) software toolkit developed by JINR MLIT specialists.

- *Butenko A. V., Zrelov P. V., Korenkov V. V., Kostromin S. A., Nikiforov D. N., Reshetnikov A. G., Semashko S. V., Trubnikov G. V.,*





Distribution by the normalized CPU load time in HS06 hours within 2022 for: *a*) Tier1 sites for the CMS experiment and *b*) Tier2 sites being part of the RDIG consortium

Ulyanov S. V. Intelligent System for Remote Control of Liquid Nitrogen Pressure and Flow in the Cryogenic System of Superconducting Magnets: Hardware and Software Platform // Phys. Part. Nucl. Lett. 2023. V. 20, No. 2.

- *Korenkov V. V., Reshetnikov A. G., Ulyanov S. V., Zrelov P. V., Zrelova D. P.* Self-Organized Intelligent Quantum Controller: Quantum Deep Learning and Quantum Genetic Algorithm — QSCOptKB^{TM} Toolkit // Proc. the 6th Intern. Workshop on Deep Learning in Computational Physics (DLCP2022), Dubna, Russia, July 6–8, 2022.

The KANTBP 3.1 program for calculating energy values, reflection and transmission matrices and the corresponding wave functions in the adiabatic coupled-channel approach was developed and published in the CPC Program Library. The advantage of this program in comparison with the widely used CCFULL program is the thorough processing of the boundary conditions to solve the system of coupled Schrödinger equations, which enables to maintain a high accuracy of computations that take into account a large number of coupled channels. Theoretical cross sections obtained with the KANTBP 3.1 program well describe experimental data for different heavy-ion fusion and fission reactions.

- *Chuluunbaatar O. et al.* KANTBP 3.1: A Program for Computing Energy Levels, Reflection and Transmission Matrices, and Corresponding Wave Functions in the Coupled-Channel and Adiabatic Approaches // Comp. Phys. Commun. 2022. V. 278. P. 108397.

To study the pion damping width (lifetime) of elementary particles, an algorithm for the calculation of multidimensional collision integrals based on the Monte Carlo method, which is optimized for the given specific task, is created. The algorithm is applied to calculate the pion damping width in hot nuclear matter, which is typical of heavy-nucleus collision processes. For this, all possible pion–pion scattering modes are taken into account. The scattering amplitude is calculated within the Nambu–Jona-Lasinio model. It is shown that a change in the medium temperature results in an increase in the pion width to a certain maximum value, after which the width starts decreasing and again very rapidly increases at a temperature close to that of the phase transition of hadronic matter to the state of quark–gluon plasma. This happens due to the fact that the pion at this temperature ceases to be a bound state and passes into a resonant state.

The calculations were performed on the HybriLIT heterogeneous cluster of the Meshcheryakov Laboratory of Information Technologies. To optimize the computation time, parallel computing based on OpenMP and CUDA technologies was used.

- *Friesen A. V., Goderidze D., Kalinovsky Yu. L.* Optimization of Monte Carlo Integration for Estimating of the Pion Damping Width // Phys. Part. Nucl. Lett. 2022. V. 19, No. 4. P. 337.