Annex 1.

Form of opening (renewal) for Theme /
Large Research Infrastructure Project

APPROVED

JINR Vice-Director

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THEME PROPOSAL FORM

Opening/renewal of a theme/large research infrastructure project within the Topical plan of JINR

1. General information on the large research infrastructure project (hereinafter LRIP)
1.1. LRIP code – 2024 –

1.2. Meshcheryakov Laboratory of Information Technologies

1.3. Scientific field Networking, Computing, Computational Physics

1.4. The title of the LRIP Multifunctional Information and Computing Complex (MICC)

1.5. LRIP Leader(s) Korenkov V.V., Shmatov S.V.

1.6. LRIP Deputy Leader(s) Dolbilov A.G., Podgainy D.V., Strizh T.A.

2. Scientific case and theme organization
2.1. Annotation

The implementation of the JINR MLIT Multifunctional Information and Computing Complex (MICC) project in 2017-2023 laid foundation for its further development and evolution taking into account new requirements to the computing infrastructure for scientific research based on state-of-the-art information technologies according to the Seven-Year Plan for the development of JINR for 2024-2030.

It is noteworthy that the rapid development of information technology and new user requirements stimulate the development of all MICC components and platforms, which resulted in the adjustment of plans in the previous seven years. The uppermost achievement was the creation of a novel MICC component, namely, a hyperconverged computing system, the “Govorun” supercomputer. Thus, the MICC has become a unique computing complex that ensures multifunctionality, scalability, high performance, reliability and availability in 24x7x365 mode with a multi-layer data storage system for different user groups.

The MICC computing infrastructure encompasses four advanced software and hardware components: the Tier1 and Tier2 grid sites, the hyperconverged “Govorun” supercomputer, the cloud infrastructure and the distributed multi-layer data storage system. This set of components ensures the uniqueness of the MICC on the world landscape and allows the scientific community of JINR and its Member States to use all progressive computing technologies within one computing complex.

The MICC development and modernization for 2024-2030 is planned within the **large research infrastructure project (LRIP)** as a set of actions that entail considerable financial and organizational resources for the operation and reconstruction of the MICC basic facility and are aimed at the modernization and development of the major hardware and software components of the computing complex, the creation of a state-of-the-art software platform enabling the solution of a wide range of research and applied tasks in accordance with the JINR Seven-Year Plan.

Within the MICC LRIP, it is provided both to support the operation of all MICC hardware and software components, i.e., the Tier1 and Tier2 grid sites, the cloud infrastructure, the hyperconverged "Govorun" supercomputer, the multi-layer data storage system, the network infrastructure, the power supply and climate control systems, as well as to modernize/reconstruct the above components in accordance with new trends in the development of IT technologies and user requirements. In addition, it is required to ensure high-speed telecommunications, a modern local area network infrastructure and a reliable engineering infrastructure that provides guaranteed power supply and air conditioning for the server equipment.

The main objective of the project is to meet the needs of the JINR scientific community to the maximum extent possible within the allocated budgetary funding in order to solve urgent tasks, from theoretical studies and experimental data processing, storage and analysis to the solution of applied tasks in the field of life sciences. The tasks of the NICA project, the neutrino program, the tasks of processing data from the experiments at the LHC and other large-scale experiments, as well as support for users of the JINR Laboratories and its Member States will be the priorities. The HybriLIT platform with the "Govorun" supercomputer is considered as the major resource for high-performance hybrid computing.

For the development of all MICC components, the funding allocated for 2024-2030 amounts to 55,135.7 kUSD. The funding of the additional expansion (above the plan in the project) of computing resources and data storage systems for the neutrino program and the NICA project is provided at the expense of the budget of specific experiments and collaborations.

The project presupposes the inclusion of two activities, which, like the project, are aimed at meeting the requirements of a large number of research and administrative personnel:

— development of the digital platform "JINR Digital EcoSystem", which integrates existing and future services to support scientific, administrative and social activities, as well as to maintain the engineering and IT infrastructures of the Institute, which in turn will provide reliable and secure access to different types of data and enable a comprehensive analysis of information using modern technologies of Big Data and artificial intelligence;

— creation of a multi-purpose hardware and software platform for Big Data analytics based on hybrid hardware accelerators; machine learning algorithms; tools for analytics, reports and visualization; support of user interfaces and tasks.

2.2. Projects in the LRIP subprojects

Subprojects are not needed, since such an approach would disrupt the coherent functioning of the MICC. Two activities are planned: a digital ecosystem (Digital JINR) and a multi-purpose hardware and software platform for Big Data analytics.

2.3. Scientific case

The concept of the development of information technologies, scientific computing and Data Science in the JINR Seven-Year Plan provides for the creation of a scientific IT ecosystem that combines many different technological solutions, trends and methods. The IT ecosystem implies the coordinated development of interconnected IT technologies and computational methods aimed at maximizing the number of JINR strategic tasks to be solved that require intensive data computing.

The large research infrastructure project "Multifunctional Information and Computing Complex", including the "Govorun" supercomputer, holds a special place in this concept.

At present, the MICC is a unique computing complex integrating a multitude of architectural server solutions and technologies into a single whole on top of network and engineering solutions. The MICC embraces four main components: distributed grid computing, the "Govorun" supercomputer, cloud computing and the distributed data storage. The main objective of the project is to ensure multifunctionality, scalability, high performance, reliability and availability in 24x7x365 mode for different user groups that carry out scientific studies within the JINR Topical Plan.

All MICC components operate at the level of the best international standards in 24x7 mode. The Tier1 grid component is regularly ranked first among world Tier1 sites that process data from the CMS experiment at the LHC. The JINR Tier2 site is the best in the Russian Consortium "Russian Data Intensive Grid" (RDIG). The state-of-the-art hyperconverged "Govorun" supercomputer is built on liquid cooling and modern processors and, according to the results of 2022, reaches a performance of 1.1 PFlops with double precision, taking 35th place in the IO500 world rating. A mechanism for monitoring the functioning of all components has been developed and is constantly enhanced.

To attain the major goals of JINR's leading projects, it will be required to process a huge amount of experimental data. According to a very rough estimate, these are tens of thousands of processor cores. In particular, the NICA project requires Tier0, Tier1 and Tier2 grid infrastructures, while computing and storage resources, as well as a regional data center of the JUNO experiment, are needed for the JINR neutrino program. To maintain strategic research at JINR, it is essential to develop distributed multi-layer heterogeneous computing environments, including on top of the resources of the participants of other projects and collaborations.

The Tier0 and Tier1 centers for the NICA project and Tier1 for the JUNO experiment are expected to be built on JINR resources, including hundreds of petabytes of long-term raw data storage. This will ensure 25-30% of all computing resources in the distributed system, the provision and support of the main services for the distributed computing system (DIRAC, PanDA, etc.).

Distributed computing systems such as DIRAC, PanDA, etc. have shown their success within the WLCG project and not only.

The DIRAC Interware is a comprehensive networking solution for one or more user communities that need to exploit distributed heterogeneous resources. DIRAC creates a layer between the community and different computing resources, providing their optimized, transparent and reliable use. DIRAC enables the integration of computing resources, including networks, clouds, supercomputers, storage resources, catalog resources. Many communities use DIRAC, and the LHCb collaboration is the oldest and most experienced among them. Since 2016, a service for unified access to heterogeneous distributed computing resources based on the DIRAC Interware open platform, including all the major JINR computing resources, has been created at JINR. Moreover, the cloud infrastructures of the JINR Member States' scientific organizations, the cluster of the National Autonomous University in Mexico and the resources of the National Research Computer Network were integrated into the distributed information and computing environment based on the DIRAC platform. Currently, this service is used to solve the tasks of the collaborations of all three experiments at the NICA accelerator complex, namely, MPD, BM@N and SPD, as well as the Baikal-GVD neutrino telescope.

The PanDA (Production and Distributed Analysis) system was developed in accordance with the ATLAS requirements for production and analysis for a data-driven workload management system capable of operating at the LHC data processing scale. The PanDA scalability has been demonstrated at ATLAS due to the rapid growth in usage over the past decade. PanDA was designed to flexibly adapt to novel computing technologies in data processing and storage, networking and distributed computing middleware for distributed computing. At JINR, on the basis of this system, data processing within the COMPAS experiment was transferred to the distributed system. The application of PanDA to the system for collecting and processing data from the SPD experiment is currently being worked out.

Attention should be paid to the issue of financing resources for collaborations at NICA and the JINR neutrino program. The budget allocated for MLIT will only partially meet their requirements, and additional funding should be obtained from the funding of collaborations.

The capacity of the data storage and computing power for the WLCG (Worldwide LHC Computing Grid) project, aimed at solving tasks related to the participation of JINR in the CERN experiments, should expand annually by 10-20%, which will allow maintaining the required data processing speed.

The support and development of the high-performance computing infrastructure will be required for the elaboration of novel data processing and analysis algorithms based on deep and machine learning.

The “Govorun” supercomputer is a flexible, scalable, hyperconverged system that combines different types of computing architectures, the hierarchical data processing and storage system. The development of the “Govorun” supercomputer is aimed at creating an environment for supercomputer modeling and the solution of JINR’s resource-intensive theoretical and experimental tasks. Such a research environment is demanded for parallel computing, ML/DL/AI tasks, quantum computing, data analysis and visualization tools, application packages, web services for application programs, training courses and workshops.

One of the uppermost priorities of the Seven-Year Plan is the enlargement of the JINR cloud infrastructure and the creation of an integrated cloud environment for the experiments of JINR and its Member States on the basis of containerization technologies. Progress in this area will largely depend on the readiness of the experiments to transition to such a workflow.

The services of the lower level are essential for the MICC functioning. It should be mentioned that without the uninterrupted operation of the services, the functioning of the MICC and the JINR IT infrastructure is basically impossible. These services include:

- DNS and IPDB, services for registering and resolving addresses and names of network elements;
- time synchronization service on all JINR machines;
- [web]mail.jinr.ru, electronic mail;
- Kerberos and LDAP, services of IT infrastructure user registration, user authentication and authorization (in particular, the SSO service);
- AFS, a distributed file system, storage of user home directories;
- CVMFS and GIT, a system of distributed access and organization of software versions of collaborations and user groups;
- EOS, a system for storing and accessing large (tens and hundreds of PB) data volumes, provides a convenient and fast storage of experimental information and its processing on computing components and user workstations;
- a number of services for Grid at JINR and international collaborations.

The integration of the MICC components into a unified interdependent complex does not allow one to consider it as a set of subprojects with their own staffing and funding. Such an approach is risky and not justified from both an organizational point of view and the allocation of human and financial resources.

MICC engineering infrastructure

As a large research infrastructure project, the MICC ensures the functioning of computing components and data storage systems due to engineering systems common to all components. MICC engineering systems are designed to ensure the reliable, uninterrupted and fault-tolerant operation of the information and computing system and the network infrastructure. The use of the integrated approach to building the MICC engineering infrastructure enabled to work out algorithms of the equipment operation and the interaction of separate systems in both normal operation mode and emergencies, which provided the uninterrupted performance regardless of external factors. Such systems are uninterruptible power supply systems, power supplies, diesel generator units, climate control systems, cooling systems, special engineering systems, exhaust ventilation systems, fire protection and fire extinguishing systems, automatic warning systems, video surveillance, fire automation.

It should be emphasized that another integral feature of the engineering infrastructure is its scalability, the possibility of which was defined on the basis of an analysis of the growth prospects of the computing equipment for 3-4 years.

The main goal of the next stage of the modernization and development of the MICC engineering infrastructure is to ensure uninterruptible power supply, air conditioning and ventilation to all components of the complex in accordance with the increase in computing power.

The main efforts in the new Seven-Year Plan will be aimed at the modernization of MICC engineering systems related to the reconstruction of the machine hall on the 4^{th} floor of the MLIT building in conformity with modern requirements. This task comes to the fore due to the need to create a long-term data storage center for the experiments at NICA and the JINR neutrino program.

Together with this, the systems of guaranteed and uninterruptible power supply for the halls of the 2nd and 4th floors will be modernized. In terms of the development of the MICC power supply, it is proposed:

- to modernize the power supply to the capacities included in the infrastructure part of the MICC project (up to 8 x 300 kW UPS);
- to develop and install a power supply system for the hall on the 4th floor;
- to implement the project of an additional source of power supply from the Dubna hydroelectric power station to provide the MICC with power supply of the first category;
- to complete the reconstruction of the power supply of the refrigeration and climate control systems;
- to modernize the schemes and solutions of the uninterruptible power supply of MICC monitoring and control rooms.

The currently existing MICC refrigeration equipment is a complex of interconnected setups of different air and liquid cooling schemes, due to the coordinated work of which the corresponding temperature regime ensuring the functioning of the complex in 24x7x365 mode is created. The heat exchange equipment encompasses evaporators and condensers, as well as recuperators. They provide the implementation of important heat exchange processes involving a refrigerant and a coolant. Pumping stations are controlled automatically, which minimizes losses in the case of emergencies in the operation of pumps, mainly circulation ones. It is noteworthy that pipeline communications, refrigeration units quickly succumb to the corrosive process, and the restoration of individual damaged elements is periodically required.

The development and modernization of the climate control system should rely on novel technological solutions applied in modern computing centers to create the required indoor microclimate and satisfy the needs for the development of all MICC components. At present, the MICC climate control system comprises the following components: free cooling of the equipment with the cooled air of the machine hall; raised floor supply of cold air with a forced exhaust of hot air by ventilation panels; cooling of the cold corridor of the module by inter-row air conditioners; liquid cooling of computer elements. According to the type of heat removal, the MICC climate control system refers to a mixed type of execution that combines systems with the evaporation of a refrigerant and systems with an intermediate coolant.

The reconstruction of the climate control system of the machine hall on the 4th floor of the MLIT building will require both the project elaboration and the purchase of new equipment according to the project.

Within the planned modernization of Tier2 cold corridor cooling schemes using inter-row air conditioners, it is needed to replace the existing ASD 531 G air conditioners that have worked a 10-year period defined by the manufacturer. ALD 622 G air conditioners will have a lifespan of 10 years in 2026. To work according to the new scheme of these cold corridors, it is required to install an additional ring of pipes with a diameter of 250 mm and purchase freon inter-row air conditioners. It is also necessary to transfer Tier1 from self-cooling to shared water cooling. This transition is associated with the fact that the 10-year period of two ARAF 1205 chillers ends in 2024.

In connection with the expansion of the computing equipment in machine halls, it will be required to ensure the operability of additional cold corridors and purchase eight or more similar cooling units with a total capacity of 800 kW for redundancy.

The planned increase in power consumption and cooling supply is shown in Table 1.

Table 1.

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Power consumption, kVA	800	1000	1200	1400	1600	1800	2000
Cooling, kW	1400	1700	2000	2300	2600	2800	3000

JINR and MICC network infrastructure

The development of information technology and of the MICC project is directly related to the further development of the JINR network infrastructure, without which the creation of distributed data processing and storage systems within the JINR research program is inconceivable and which cannot be considered as a separate component. The network infrastructure within the MICC project ensures external telecommunication channels, communication between MICC users through the JINR local area network, communication and data exchange through the MICC local area network. The network infrastructure is an intricate complex of multifunctional network equipment and specialized software, which is the foundation for the JINR information and computing infrastructure that has been created and is constantly developing.

It consists of the following functional components: the external optical telecommunication data transmission channel JINR – Moscow, the backbone of the JINR local area network, the local area networks of the Institute’s subdivisions and the MICC local area network.

The MICC and JINR network has direct connections to a number of scientific, educational and public networks. Telecommunication channels have the following speed parameters: 2x100 Gbps with the LHCOPN network; 2x100 Gbps with the LHCONE network; 10 Gbps with the GEANT network; 10 Gbps with the RBnet network; 10 Gbps with the networks of Moscow and St. Petersburg; 10 Gbps for Public Internet.

Currently, the main optical transport medium (Campus Backbone) for data transmission operates at a speed of 2x100 Gbps. It comprises three optical rings.

The distributed multi-node cluster network (Cluster Backbone), operating between the DLNP and VBLHEP sites at a speed of 4x100 Gbps, is designed to ensure the reliable transmission and storage of physics data obtained from the main nodes of the computing equipment of the NICA complex for its processing and analysis on the MICC components.

The Seven-Year Plan presupposes support for state-of-the-art networking technologies: software-defined networks (SDN), content delivery networks (CDN), named data networks (NDN) and technologies for building distributed data centers, i.e., Data Center Interconnect (DCI).

The planned development of the backbone network (Campus Backbone) and the distributed multi-node cluster network (Cluster Backbone) is presented in Table 2.

Table 2.

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Cluster Backbone, Gbps	400	400	400	800	800	800	800
Campus Backbone, Gbps	200	200	200	200	400	400	400

MICC grid component development

For more than 15 years, the resources of the JINR MICC grid centers have been part of the WLCG global grid infrastructure created for the experiments at the Large Hadron Collider and providing distributed computing resources for annual data processing, analysis and storage. This work on the use of the grid infrastructure within the WLCG project is performed in cooperation with the CMS, ATLAS, ALICE collaborations and the major international centers, where both Tier1 centers for the CMS experiment (CH-CERN, DE-KIT, ES-PIC, FR-CCIN2P3, IT-INFN-CNAF, US-FNAL-CMS, UK RAL) and Tier2 grid centers, located in more than 170 computing centers in 42 countries, operate.

Since the beginning of the 2000s, MLIT JINR, jointly with world centers, has been working on both the creation and the expansion and modernization of computing clusters built on distributed grid technologies to process and store data from the experiments at the LHC. A Tier2 center was created at MLIT JINR; it ensured and ensures data processing and analysis for all experiments at the LHC, as well as the operation of all virtual organizations of experiments, in which JINR specialists participate. Today, Tier2 provides data processing for all experiments at NICA and is the most productive in the RDIG (Russian Data Intensive Grid) Russian consortium.

Since the beginning of 2015, a full-scale WLCG Tier1 site for the CMS experiment has been operating at MLIT JINR. The importance of developing, modernizing and expanding the computing performance and data storage systems of this center is dictated by the research program of the CMS experiment, in which JINR physicists take an active part within the RDMS CMS collaboration. The very fact of creating and maintaining the operation of the Tier1 site at JINR indicates the high level of qualification of JINR MLIT specialists who ensure the functioning of this MICC component. There exist only seven such centers for CMS worldwide, and the JINR site is consistently ranked first in terms of performance, demonstrating almost 100% availability and reliability.

In terms of hardware, a linear increase in the characteristics of Tier1, Tier2/CICC is planned in accordance with the figures in the Seven-Year Plan for the development of JINR within the MICC project.

It should be pointed out that due to the integration of the MICC resources on the DIRAC platform, the first batch of data simulation tasks for the MPD experiment was sent to the resources of the Tier1 and Tier2 grid sites in August 2019. Thus, these grid sites began to be regularly used to model data from the experiments of the NICA complex.

The infrastructure and services of the Tier1 (JINR-T1) and Tier2 (JINR-LCG2) sites ensure the operation of:

- computing service,
- data storage service,
- service of access to user home directories,
- service of access to user software versions,
- GRID support service,
- data transfer service,
- distributed computing control system,
- information service (monitoring, information sites).

Computing services are ensured by a set of special basic services. These contain the Slurm workload manager, which is a free open source task scheduler for Linux and Unix-like systems used by many world supercomputers and computing clusters. To organize computing in the grid environment, the Advanced Resource Connector (ARC), middleware for grid computing, is used. It provides a common interface for transferring computational tasks to various distributed computing systems and thus can embrace grid infrastructures of different size and complexity. The set of services and utilities that provide the interface is called the ARC Computing Element (ARC-CE), open source software released under the Apache 2.0 license. Like SLURM, the ARC-CE is used by most grid sites in the world.

For data management on grid sites, Rucio, i.e., a software platform that provides opportunities for organizing, managing and accessing large amounts of data using customizable policies, is used. Data can be distributed across globally distributed and heterogeneous data centers, combining different storage and networking technologies into a unified federated structure. Rucio offers advanced features such as distributed data recovery or adaptive replication and is highly scalable, modular and expandable. Rucio is beginning to be widely used on the grid sites of the WLCG project.

Software and data storage systems

The machines of the interactive cluster and computing farms have limited disk space designed to store the OS itself, some additional utilities, temporary user files with a short storage period.

The AFS distributed global system is used to store and access user home directories and software for a small number of users and user groups.

The globally available system of maintenance and access to large software complexes of collaborations and user groups operates on the basis of the software developed at CERN, i.e., CVMFS. GIT services are used for the automation of editing and building such software.

The dCache and EOS systems are used as the main software and data storage systems in the MICC.

dCache is a file system that is traditional for the MICC grid sites and focuses on storing large amounts of experimental data. The native dCache DCAP protocol or any file access protocol of the

GRID system is used for local access to files. User authentication is performed through the Kerberos protocol and certificates of virtual organizations. On all MICC machines, EOS is visible as a local file system, it allows authorized users to read and write data through the protocol of xrootd (xrdcp), scp, rsync, etc. This scheme of working with EOS is extended to all MICC resources. Global access to EOS is provided by the WLCG software (gridftp). At present, EOS is used for storage by BM@N, MPD, SPD, baikalgvd, danss, dayabay, dstau, er, fobos, genetics, juno, lgd, panda, etc.

In the coming years, it is required to significantly increase the amount of data storage on the EOS system. This data storage and access system should become the main system for all MICC components, and in the future for all JINR computing resources.

The CVMFS file system is used to deploy large software packages of collaborations involved in WLCG. CVMFS enables to launch applications for experimental data processing. Files and directories are hosted on standard web servers and mounted in the universal namespace /cvmfs. At the moment, the MICC stores the software versions of NICA, BM@N, MPD, dstau, er, jjnano, juno, baikalgvd.

With the start of sessions at the NICA complex, an intensive enlargement of long-term data storage systems on robotic tape libraries will be required. In addition to the tape robot for the CMS experiment in Tier1, in 2024-2030, it is needed to create a long-term data storage for the experiments at the NICA complex, the neutrino program and other user groups. To do this, it is necessary to provide for the upgrade of the existing IBM TS3500 tape library to the TS4500 level with an increase in its capacity to 30-40 PB in 2024-2025 and purchase new tape libraries as requested by the experiments.

A system for the long-term storage of user and collaboration data is being created on the basis of the software package developed at CERN, i.e., CTA (CERN Tape Archive). The system enables long-term data storage on different storage media, mainly on tape robotic systems. The system will be fully included in the MICC infrastructure. The major CTA component is EOS with the addition of an infrastructure for working with tape robots and manipulating the meta information of stored files.

The software of the MICC grid sites and storage systems are EOS, cvmfs, RUCIO, ALICE VObox, XROOTD 3, UMD-4, VOMS, WLCG standard program stack, BDII top, BDII site, glite, openafs, CentOS Scientific Linux release 7.9, GCC: gcc (GCC) 4.4.7, C++: g++ (GCC) 4.4.7, GNU Fortran (GCC), dCache-6.2, Enstore 6.3 for tape robot, CTA. Since there is a constant update of operating systems and basic software, the above versions will change.

For a simpler and more reliable update of various MICC system software, testbeds of most key components, including the Slurm batch processing system, dCache, EOS and CTA, have been installed and configured. This will allow one to perform software updates quickly and without significant problems in the main components.

Table 3 shows the planned increase in the resources of the grid sites and storage systems by year.

Table 3.

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Tier1 CPU, cores	1000	1000	7000	2000	6000	7000	5000
Tier1 disk, TB	1000	1500	2000	2000	2000	1000	2000
Tier2 CPU, cores	1000	1000	1000	1000	4000	6000	6000
MICC EOS, PB	10	8	3	15	5	13	12
MICC tapes, PB	20	20	40	0	40	0	20

The Tier1, Tier2/CICC software requires constant support and updates. This applies to both the WLCG middleware on Tier1 and Tier2 and the general CICC software.

The unified system of access to software, CVMFS, should be further developed. CVMFS is regarded in the same way as EOS, i.e., as a unified universal system of access to different software installed on one server and available on all interactive and computing machines of the MICC and JINR. CVMFS has been used for this purpose for a long time and highly successfully by many WLCG virtual organizations. In the near future, CVMFS will replace the custom software storage in AFS.

JINR cloud

The experience of operating cloud resources and storages based on the ceph software has been positively assessed by both individual users and scientific projects.

As part of this direction of the LRIP, it is planned to continue the development of the MICC cloud component in terms of increasing hardware resources (computing and storage ones) and expanding the range of tasks to be solved and the number of consumers.

In the course of implementing the tasks of the Seven-Year Plan for the development of the MICC cloud component, it is planned to transfer from using the ceph-based storage and spindle disks to using the storage based on the same software, but with SSD disks. The previous experience in operating the HDD-based ceph storage has revealed its insufficient performance at high loads (simultaneous operation of several thousand computing tasks on cloud resources and, in parallel, functioning of services of different service ranges (Institute, experiment or individual user). The SSD-based ceph storage is significantly more productive due to the higher number of I/O operations per unit of time, as well as due to lower latency.

Table 4 illustrates indicative figures for the increase in cloud resources planned for purchase at the expense of the Meshcheryakov Laboratory of Information Technologies by the end of the specified year.

Table 4.

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
CPU cores, pcs	1000	1000	1000	1000	1000	1000	1000
HDD-based ceph storage capacity, PB	0	0	0	0	0	0	0
SSD-based ceph storage capacity, TB	360	360	300	300	300	300	300

Information and computing environment for neutrino experiments with JINR's participation

The needs of modern neutrino experiments for the amount of data storage and computing power required to obtain a considerable scientific result have significantly increased. To effectively use the resources of the information and computing environment of neutrino experiments, in which JINR specialists participate, a unified neutrino information and computing platform (environment) based on the MICC resources was created by the collaboration of MLIT and DLNP.

At present and over the next several years, the following neutrino scientific experiments with JINR's participation are experiencing the greatest demand for storage resources and computing power: Baikal-GVD, JUNO, NOvA/DUNE.

Baikal-GVD

The Baikal-GVD telescope consists of garland clusters. In 2022, ten clusters were put into operation. Collaboration plans are to install two new clusters annually. About 3-5 TB of raw data is collected from each cluster per year. Raw data is stored on the EOS disk storage for fast reprocessing. A copy of data will be stored on tapes. In 2022, the total amount of raw data from the telescope was approximately 30 TB and will increase by 6-10 TB every year.

Processed data takes up about the same volume as raw data. Simulated data occupies a volume that exceeds the volume of raw data by 5 times.

The needs of the Baikal-GVD experiment in computing servers at the time of the full deployment of the facility are estimated at 2,500 CPU cores, which will be used for raw data processing, detector simulation and physics analyses.

At present, the Baikal-GVD experiment uses JINR cloud infrastructure resources as computing resources and cloud storage resources as intermediate resources for data storage (the major data storage of the experiment is EOS). Part of the computing resources is provided to the experiment in the form of allocated virtual machines with 320 CPU cores in total, and the other part is provided on the neutrino information and computing platform.

The plans of the experiment local group are to increase the amount of cloud resources allocated for the own needs of the experiment by 300 CPU cores, 3,000 GB of RAM and 200 TB of disk space per year.

The total planned amount of experiment resources available to users by year is shown in Table 5.

Table 5.

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
CPU cores, pcs	300	300	300	300	300	300	300
Disks, TB	200	200	200	200	200	200	200

JUNO

Within the JUNO experiment, 2 PB/year of raw data is expected after the launch of the facility. The experiment is scheduled for 20 years. Accordingly, the total amount of raw data by the end of the JUNO operation is estimated at 40 PB. Raw data will be permanently stored on tape drives.

Within the JUNO collaboration, it was agreed that raw data would be stored at least in two data centers, namely, one in China (IHEP) and one in Europe.

One full copy of raw data is planned to be stored in the JINR MICC.

Apart from raw data stored on tape drives, it is needed to provide disk storage used in data processing. The estimated disk storage volumes by data type are demonstrated in Table 6.

Table 6.

	Required volume, TB		
Data type	Permanent part	For every year	Total (for 20 years)
Reconstruction from raw data		10	200
Calibration data		1	20
MC simulation		150	3000
Data analysis	100		100
Total	100	161	3500

As seen from Table 6, the main part of the space is required for simulation (MC) data storage. MC data will be updated 2 times a year, and its volume will be proportional to the amount of data acquired.

Other types of data need an order of magnitude less volume. The supplementary volume of the space required to store secondary data, in addition to raw data, is estimated at 3.5 PB by the end of the experiment.

The needs of the JUNO experiment for computing servers are assessed at 12,000 CPU cores, which will be used for continuous raw data processing, simulation and analysis.

JINR's preliminary contribution by the end of the experiment is estimated at 4,000 CPU cores provided by the JUNO collaboration.

Moreover, graphics processing units (GPUs) are actively used for the needs of the experiment. They carry out data reconstruction using machine learning (neural networks and enhanced decision trees). GPU devices installed in the server, with the help of the corresponding technologies, become available for use by application software from within the cloud virtual machine.

The planned increase in experiment resources available to users by year is presented in Table 7.

Table 7.

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**

CPU cores, pcs	1500	1250	800	400	0	0	0
Disks, PB	5	5	5	5	5	5	5
Tapes, PB	5	5	5	5	5	5	5

NOvA/DUNE

The NOvA and DUNE experiments have been active users of JINR cloud infrastructure resources for several years, they also use cloud storage and dCache-based storage resources for data storage. In the DUNE experiment, JINR participates as a Tier2 grid site, which imposes additional obligations on JINR in terms of the amount of computing resources provided to the experiment.

The increase in resources is planned mainly for the needs of the DUNE experiment, since the NOvA experiment is about to complete. The DUNE experiment is still under construction, with the launch of the main detectors expected in 2028. At present, the needs for computing resources are mainly related to processing data from detector prototypes and testing and debugging different computing models. Upon completion of data processing based on prototype detectors in the period of 2026-2028, no increase in the needs of the experiment for computing resources is presupposed. The need for additional resources is expected only after the launch of the main detectors of the experiment. The total planned amount of resources required by users for the both experiments is shown in Table 8.

Table 8.

	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
CPU cores, pcs	1250	1500	1500	1500	1500	1500	1500
Disks, PB	1	1.3	1.5	1.5	1.5	1.5	1.7

Development of the HybriLIT heterogeneous platform including the “Govorun” supercomputer

The development of the HybriLIT heterogeneous platform will be performed both in terms of expanding the computing resources and data processing and storage resources of the “Govorun” supercomputer and in terms of elaborating and implementing novel computing architectures and IT solutions demanded by the user community.

The further development of the “Govorun” supercomputer will be based on the principles laid down during its creation. The architecture of the “Govorun” supercomputer was developed relying on modern trends in the development of scientific computing as a high-performance scalable liquid-cooled system with a hyperconverged and software-defined architecture. The current configuration of the “Govorun” supercomputer encompasses computing modules with GPU and CPU components, as well as the hierarchical data processing and storage system. The total peak performance of the “Govorun” supercomputer reaches 1.1 PFlops for double-precision calculations (2.2 PFlops for single-precision calculations) and a read/write speed of 300 Gbps for the hierarchical data processing and storage system. The hyperconvergent approach to building a computing complex, which is the foundation for the “Govorun” supercomputer, enables the creation of computing environments, the hardware and software configuration of which is optimized for specific user tasks, without changing the hardware of the compute nodes themselves. Hyperconvergence allows orchestrating computing resources and data storage elements, as well as creating computing systems on demand, taking into account the needs of user applications. Thanks to its hyperconvergence, the “Govorun” supercomputer has a flexible architecture that enables to build software-defined HPC subsystems, which qualitatively distinguishes it from other supercomputers having, as a rule, a “rigid” architecture and designed to effectively solve highly specialized classes of tasks.

The experience of operating the “Govorun” supercomputer has revealed the need to create tools for working with Big Data, primarily for the NICA megaproject. In this regard, the hierarchical data processing and storage system with a software-defined architecture was developed and implemented on the “Govorun” supercomputer. According to the speed of accessing data, the system is divided into layers, namely, very hot data, the most demanded data, to which it is currently required to provide the fastest access, hot data and warm data. Each layer of the developed data storage system can be used both independently and as part of data processing workflows. At the moment, as a layer of very hot data, the latest DAOS (Distributed Asynchronous Object Storage) technology for Big Data processing, which has shown its promise for deep learning tasks and for the operation of quantum simulators to emulate a larger number of qubits, is being implemented on the "Govorun" supercomputer. The tasks of mass generation and data reconstruction within the NICA MPD experiment actively use the hierarchical data processing and storage system of the "Govorun" supercomputer. At the same time, at different stages of workflows, there exists a need for different data access rates; for example, for long-term storage tasks, access speed is not an important factor, however, for reconstruction tasks, it plays a relevant role. In addition, for a number of MPD tasks, there was a need for a large amount of RAM, which resulted in the introduction of hyperconverged nodes with a large amount of memory in the supercomputer architecture. Thus, methodologically, to ensure all workflows for the tasks of the NICA megaproject, a system that combines both computing architectures of different types and the developed hierarchical data processing and storage system was created on the "Govorun" supercomputer. The computing resources and the hierarchical data processing and storage system of the "Govorun" supercomputer were integrated into a DIRAC-based distributed heterogeneous environment that includes the resources of JINR and its Member States. The experience of using different computing resources of JINR and other MPD collaboration institutes has shown that at present, the use of the "Govorun" supercomputer resources is the most efficient.

The flexible architecture of the "Govorun" supercomputer allows one not only to carry out calculations, but also to use the supercomputer as a research polygon for developing software-hardware and IT solutions for tasks underway at JINR. This feature made it possible to deploy polygons for quantum computing and LRB experimental data processing, to integrate the resources of the "Govorun" supercomputer into a unified heterogeneous environment based on the DIRAC platform for the NICA project and utilize its resources to implement the program of runs of data mass simulation within the MPD experiment. It is noteworthy that some tasks for modeling MPD experiment data can only be performed on the resources of the "Govorun" supercomputer. Table 9 illustrates the planned increase in the number of computing cores, the number of GPU accelerators and the enlargement of the volume of the hierarchical data processing and storage system.

Table 9.

HybriLIT heterogeneous platform. "Govorun" supercomputer.	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Total number of CPU cores	11000	11000	11000	14000	14000	14000	17000
Total number of GPU cores	40	64	64	64	64	88	88
Increase in the volume of the hierarchical data processing and storage system, PB	8	8	14	14	20	20	20

It should be pointed out that the increase in the number of computing cores, the number of GPU accelerators and the enlargement of the volume of the hierarchical data processing and storage system above the plan will be defined by the needs of users, including the needs of the NICA megaproject, and carried out by attracting financing from the budgets of the experiments, joint grants and other sources.

Development of the NICA information and computer complex for 2023-2030

One of the key elements of the NICA project is the information and computing complex. The data obtained at the facility should not only be processed to obtain physics results, but also stored for further processing and analysis. The Seven-Year Plan provides for the creation of a long-term data storage center on the MICC resources at MLIT (Tier0). The process of modeling, processing and analyzing experimental data obtained from the BM@N, MPD and SPD detectors will be implemented in a distributed computing environment based on the MICC and the computing centers of VBLHEP and collaboration member countries.

The information and computer unit of the NICA complex embraces:

1. **online NICA cluster**, designed for ultra-fast data reception from DAQ into a high-speed cyclic buffer, for 5-10% preliminary processing of the received data for the correctness of the received information, for the transmission of the received information for processing and storage to offline NICA clusters;
2. **offline NICA cluster at VBLHEP**, designed for processing and analyzing data received from the online NICA cluster to obtain a physics result, for the simulation of processes under study and facilities, for the monitoring of the nodes of the NICA complex;
3. all MICC components (Tier1, Tier2, “Govorun” supercomputer, cloud computing);
4. multi-layer **data storage system** for: raw data received from offline clusters for long-term storage (“cold” layer) on tape libraries; processed (reconstructed) and simulated data (“warm” layer) for subsequent analysis on the EOS system; fast reception of data processed on offline clusters at a specific point in time (“hot” layer). The amount of data related to the long-term storage of reconstructed and simulated data can reach 50-60% of the total amount of raw data received from the detector. Taking into account that raw data will be transferred to tapes as they are calibrated and reconstructed, it is the reconstructed and simulated data that will occupy the main volume of the “warm” data layer. Access to this data must be maintained throughout the duration of the experiment/collaboration in order to obtain new physics results. At present, the “cold” layer is implemented on robotic tape libraries, the “warm” layer is implemented on spindle disks, and the “hot” layer is implemented on solid-state drives.
5. **distributed computing network** designed for the ultra-fast integration of all elements and nodes of the information and computer unit of the NICA complex.

For the further 7-year development of the information and computer unit of the NICA complex and its compliance with annually growing physics data received from the facilities of the NICA complex, it is required: to enhance the performance of the offline cluster for data simulation, reconstruction and processing; to expand the disk (EOS) and tape storages; to modernize the computing network of the distributed NICA complex.

Table 10 demonstrates the annual need for computing power and storage resources; the numbers are indicated taking into account unprocessed events, reconstructed and simulated data, and considering that the facilities will not operate at the same time, i.e., part of the resources can be used jointly by the experiments, involving third-party organizations.

Table 10.

NICA Tier 0,1,2	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
CPU (PFlops)	2.2	2.6	8.6	8.6	15.6	15.6	15.6
DISK (PB)	17	24	47	75	96	119	142
TAPE (PB)	45	88	170	226	352	444	536
NETWORK (Gbps)	400	400	800	800	800	1000	1000

It should be underlined that the resources given in the table can be approximately satisfied by 20-25% of the budget allocated for the MICC.

MICC monitoring system

The successful functioning of the computing complex is ensured by the monitoring system of all MICC components, which must be up-to-date and state-of-the-art. For these purposes, it is planned:

- to expand the monitoring system by integrating local monitoring systems for power supply systems into it (diesel generators, power distribution units, transformers and uninterruptible power supplies);

- to organize the monitoring of the cooling system (cooling towers, pumps, hot and cold water circuits, heat exchangers, chillers);
- to create an engineering infrastructure control center (special information panels for visualizing all statuses of the MICC engineering infrastructure in a single access point).

The stable operation of certain types of equipment depends on monitoring a large number of parameters. For such tasks, approaches to setting fixed thresholds for detecting faults are not always effective. One of the solutions is to develop intelligent systems that will enable to detect anomalies in time series on the basis of training samples, which will result in the need to create a special analytical system within the monitoring system to automate the process.

The transition to the project planning of scientific activities and the planning of MICC resources at the request of users entails the development of a special accounting system for the use of the MICC resources by each project/user. Currently, such an accounting system is organized for user groups on the MICC grid infrastructure. It is planned to create a unified resource accounting system for all MICC components, from the “Govorun” supercomputer to data storage systems.

Information security

The activity to protect information, to ensure its confidentiality, availability and integrity, as well as to prevent its compromising lies at the heart of information security. In this regard, it is necessary to elaborate solutions that enable the formation and provision of information security policies for administrators, operators and users of information systems. For these purposes, it is planned:

- to develop a unified authentication service for users of the JINR resources and network;
- to implement authentication and authorization services for distributed data processing systems for the experiments of the NICA complex on the basis of the unified authentication service;
- to train users by conducting courses on information security and testing on a regular basis;
- to develop and implement user registration regulations, taking into account the specifics of users’ belonging to different groups associated with the staff structure and the JINR Topical Plan;
- to develop the JINR network monitoring and security system;
- to maintain regulations for the implementation of security requirements for digital services;
- to maintain a system of regular testing for vulnerabilities.

Activities

The project presupposes the inclusion of two activities which, like the project, are aimed at meeting the requirements of a large number of research and administrative personnel.

The first activity is related to the creation of a multi-purpose hardware and software platform for Big Data analytics based on hybrid hardware accelerators (GPU, FPGA, quantum systems); machine learning algorithms; tools for analytics, reports and visualization; support of user interfaces and tasks. One of the tasks that is planned to be solved on the platform is the development of a unified analytical system for managing the MICC resources and data flows to enhance the efficiency of using computing and storage resources and simplify data processing within new experiments.

The second activity is related to the start of work on the elaboration of the project of the Institute-wide digital platform “JINR Digital EcoSystem”. The main objective is the organization of a digital space with a single access and data exchange between electronic systems, as well as the automation of actions that previously required a personal or written request. The platform should ensure the integration of existing and future services to support scientific, administrative and social activities, as well as to maintain the engineering and IT infrastructures of the Institute.

The user will get the possibility of a single entry point for the JINR digital environment, through which access to a large-scale network of different services will be provided. The “Digital EcoSystem” interface will represent a “showcase” of digital services and resources with the ability to perform a certain set of actions (for example, account management) or switch to a fully functional version of the service. Examples of services are resources for users of basic facilities, library services, document servers, MICC computing resources, 1C administrative services (finance, personnel, electronic document management), etc.

Within the platform being created, registered users (with a JINR account, i.e., Single Sign-On, SSO) will be able to draw up and approve different documents in electronic form, to register and use scientific and administrative services without filling in paper forms and personally visiting the staff members responsible for them. A system of notifications from different services (for example, about documents that await signing) will be available in the personal account. The level of access to services will depend on the position of the staff member and his functional duties. A user-friendly interface allowing one to quickly update information will be organized for service administrators. Part of the resources will also be available to unregistered users: telephone directory, information on dissertation councils, scientific software, JINR map.

The JINR geoinformation system, including an interactive map, information on JINR buildings and other objects (plans of buildings, engineering and other networks, staff accommodation, accounting and analysis of the use of premises taking into account their class, type and purpose), etc. will be developed within the digital platform. The geoinformation system will enable to perform a quick and convenient search for information on both JINR buildings and staff members. It is expected to use the technology of mobile robots and quantum control elements to solve the tasks of premises’ automatic explication (creating plans for buildings) and object localization on the map.

The platform should provide reliable and secure access to different types of data that arise in the course of the Institute’s work, from open to confidential. A sample dataset from key services will be placed in storage for further joint analysis using Big Data and artificial intelligence technologies. The automated monitoring of performance indicators for both individual objects and the Institute as a whole will be possible on the basis of data such as information about staff members’ publications, financial information and the use of computing resources.

Conclusion

The above work on the modernization and further scaling of the MICC resources is driven by the rapid development of information technology and new requirements of experiments underway at JINR and with JINR’s participation.

Multifunctionality, high reliability and availability in 24x7 mode, scalability and high performance, a reliable data storage system, information security and an advanced basic software environment for different user groups are the main requirements that the MICC must satisfy as a modern scientific computing complex.

Table 11 provides the estimates of the resources of the MICC components, which can be achieved taking into account the prices for equipment in 2022-2023.

Table 11.

	2024	2025	2026	2027	2028	2029	2030
HybriLIT heterogeneous platform. “Govorun” supercomputer.							
Total number of CPU cores	11000	11000	11000	14000	14000	14000	17000
Total number of GPU accelerators	40	64	64	64	64	88	88
Total volume of the hierarchical data processing and storage system, PB	8	8	14	14	20	20	20
Tier1 grid site							
Tier1 performance HEPS06	350000	400000	500000	550000	650000	750000	850000
Total number of CPU cores	22000	23000	30000	32000	38000	45000	50000

Total data storage capacity, TB	14500	16000	18000	20000	22000	23000	25000
Tier2 grid site							
Tier2 performance HEPS06l	187000	204000	221000	238000	306000	408000	510000
Total number of CPU cores	11000	12000	13000	14000	18000	24000	30000
Data storage system							
Total volume of the Data Lake on EOS, PB	27	35	38	53	58	71	83
Total robotic tape storage capacity, PB	70	90	130	130	170	170	190
Cloud computing							
Total number of CPU cores	2072	3072	4072	5072	6072	7072	8072
SSD-based ceph storage capacity, TB	868	968	1068	1168	1268	1368	1468

Expected results:

1. Modernization of the JINR MICC engineering infrastructure (reconstruction in accordance with modern requirements of the machine hall of the 4th floor of MLIT).
2. Modernization and development of the offline distributed computing platform for the NICA project with the involvement of the computing centers of the NICA collaboration.
3. Creation of a Tier0 grid cluster for the experiments of the NICA megaproject to store experimental and simulated data. Expansion of the performance and storage capacity of the Tier1 and Tier2 grid clusters as data centers for the experiments of the NICA megaproject, the JINR neutrino program and the experiments at the LHC.
4. Enlargement of the JINR cloud infrastructure to broaden the range of services provided to users on the basis of containerization technologies. Automation of the deployment of cloud technologies in the JINR Member States' organizations.
5. Expansion of the HybriLIT heterogeneous platform, including the "Govorun" supercomputer, as a hyperconverged software-defined environment with a hierarchical data storage and processing system.
6. Design and elaboration of a distributed software-defined high-performance computing platform that combines supercomputer (heterogeneous), grid and cloud technologies for the effective use of novel computing architectures.
7. Development of a computer infrastructure protection system based on fundamentally new paradigms, including quantum cryptography, neurocognitive principles of data organization and data object interaction, global integration of information systems, universal access to applications, new Internet protocols, virtualization, social networks, mobile device data and geolocation.

Risks:

— Unpredictability of availability and prices of advanced equipment from leading manufacturers of computing architectures, low-latency network equipment and high-performance data storage elements.
— Rapid obsolescence of the computer and network equipment.
— Virus and hacker attacks from outside and inside due to user carelessness.
— Depreciation and moral obsolescence of the engineering equipment, the modernization of which is delayed due to the excessive bureaucratization of the decision-making procedure.

2.4. Participating JINR laboratories

VBLHEP (Gertsenberger K.V., Minaev Yu.I., Moshkin A.N., Rogachevsky O.V., Slepov I.P.)

FLNP (Sukhomlinov G.A.)

LRB (Chausov V.N.)

FLNR (Baginyan A.S., Polyakov A.G., Sorokoumov V.V.)

DLNP (Zhemchugov A.S., Ivanov Yu.P., Kapitonov V.A.)

BLTP (Sazonov A.A.)

UC (Semenyushkin I.N.)

2.5. Participating countries, scientific and educational organisations:

Organization	Country	City	Participants	Type of agreement
ADA	Azerbaijan	Baku	Adamov A.	Collaborations
IP ANAS	Azerbaijan	Baku	Mamedov N.T. + 5	Collaborations
IIAP NAS RA	Armenia	Erevan	Saakyan V.G.	Agreement
BSTU	Belarus	Misnk	Korotaev A.V.	Collaborations
INP BSU	Belarus	Misnk	Maslov V.A. + 4	Collaborations
UIIP NASB	Belarus	Misnk	Tuzikov A.V. + 2	Collaborations
JIPNR-Sosny NASB	Belarus	Misnk	Babichev L.F. + 4	Collaborations
INRNE BAS	Bulgaria	Sofia	Georgiev S.L. + 3	Collaborations
SU	Bulgaria	Sofia	Dimitrov V.	Collaborations
GRENA	Georgia	Tbilisi	Kvatadze R.	Collaborations
GTU	Georgia	Tbilisi	Prangishvili A.	Collaborations
TSU	Georgia	Tbilisi	Modebadze Z.	Collaborations
TSU	Georgia	Tbilisi	Elizbarashvili A.	Collaborations
CU	Egypt	Giza	Swailam N.	Collaborations
CU	Egypt	Giza	Elliti A.	Collaborations
ASRT	Egypt	Cairo	Allam A.	Collaborations
ASRT	Egypt	Cairo	AlSadeq M.	Collaborations
INFN	Italy	Bologna	Maron G..	Collaborations
INFN	Italy	Bologna	Sapunenko V.	Collaborations
INP	Kazakhstan	Alma-Ata	Burtebaev N.T.	Collaborations
INP	Kazakhstan	Alma-Ata	Sakhiev S.K.	Collaborations
BA INP	Kazakhstan	Astana	Zdorovets M.V.	Collaborations
IHEP CAS	China	Beijing	Lee W.D.	Collaborations
RENAM	Moldova	Chisinau	Bogatenkov P.P.	Collaborations
ИМИ	Moldova	Chisinau	Cojocaru S.	Collaborations
МолдГУ	Moldova	Chisinau	Baznat M.	Collaborations
IMDT MAS	Mongolia	Ulaanbaatar	Uuganbaatar D.	Collaborations
NOSU	Russia	Vladikavkaz	Kulaev R.Ch.	Agreement
NOSU	Russia	Vladikavkaz	Ogoev A.U.	Agreement
NOSU	Russia	Vladikavkaz	Tvauri I.V.	Agreement
IACP DVO RAS	Russia	Vladivostok	Romashko R.V.	Agreement
IACP DVO RAS	Russia	Vladivostok	Gribova V.V.	Agreement
NRC KI PNPI	Russia	Gatchina	Kiryanov A.K.	Collaborations
Dubna Univ.	Russia	Dubna	Kryukov Yu.A. + 5	Collaborations
Dubna Univ.	Russia	Dubna	Cheremisina E.N.	Collaborations
SEZ “Dubna”	Russia	Dubna	Rats A.A.	Collaborations
SCC “Dubna”	Russia	Dubna	Eleferov S.V.	Collaborations

SCC “Dubna”	Russia	Dubna	Kulikov A.A.	Collaborations
SCC “Dubna”	Russia	Dubna	Okulov Yu.N.	Collaborations
RSCC	Russia	Moscow	Buydinov E.V.	Collaborations
RSCC	Russia	Moscow	Prokhorov Yu.V.	Collaborations
KIAM RAS	Russia	Moscow	Afendikov A.L.	Collaborations
KIAM RAS	Russia	Moscow	Chetverushkin B.N.	Collaborations
IITP RAS	Russia	Moscow	Afanasiev A.P. + 2.	Collaborations
IITP RAS	Russia	Moscow	Voloshinov V.V.	Collaborations
IITP RAS	Russia	Moscow	Posypkin M.A.	Collaborations
ISP RAS	Russia	Moscow	Avetisyan A.I.	Collaborations
ITEP	Russia	Moscow	Gavrilov V.B.	Collaborations
ITEP	Russia	Moscow	Korolko I.E.	Collaborations
MSU	Russia	Moscow	Sokolov I.A.	Collaborations
MSU	Russia	Moscow	Riznichenko G.Yu..	Collaborations
MSU	Russia	Moscow	Smelyansky R.L.	Collaborations
MSU	Russia	Moscow	Sukhomlin V.A.	Collaborations
MSK-IX	Russia	Moscow	Voronina E.P. + 3	Collaborations
RCC MSU	Russia	Moscow	Voevodin V.V. + 4	Collaborations
SINP MSU	Russia	Moscow	Boos E.	Collaborations
SINP MSU	Russia	Moscow	Kryukov A.P.	Collaborations
SINP MSU	Russia	Moscow	Savrin V.I.	Collaborations
MPEI	Russia	Moscow	Toporkov V.V.	Collaborations
NRC KI	Russia	Moscow	Velikhov V.E.	Collaborations
NRC KI	Russia	Moscow	Ilyin V.A.	Collaborations
NRC KI	Russia	Moscow	Ryabinkin E.A.	Collaborations
PRUE	Russia	Moscow	Valentey S.D.	Collaborations
FRC IM RAS	Russia	Moscow	Sokolov I.A.	Collaborations
INR RAS	Russia	Moscow, Troitsk	Karavichev O.V.	Collaborations
INR RAS	Russia	Moscow, Troitsk	Stepanova L.I.	Collaborations
ICMMG SB RAS	Russia	Novosibirsk	Chernykh I.G.	Collaborations
BINP SB RAS	Russia	Novosibirsk	Anisenkov A.V.	Collaborations
BINP SB RAS	Russia	Novosibirsk	Levichev P.V.	Collaborations
BINP SB RAS	Russia	Novosibirsk	Skrinsky A.N.	Collaborations
BINP SB RAS	Russia	Novosibirsk	Tikhonov Yu.A.	Collaborations
SKIF	Russia	Novosibirsk	Zubavichus Ya.V.	Collaborations
SKIF	Russia	Novosibirsk	Levichev E.B.	Collaborations
SKIF	Russia	Novosibirsk	Poteryaev V.S.	Collaborations
PSI RAS	Russia	Pereslavl-Zalessky	Abramov S.M.	Collaborations
IHEP	Russia	Protvino	Gusev V.V.	Collaborations
IHEP	Russia	Protvino	Kotlyar V.V.	Collaborations
IHEP	Russia	Protvino	Minaenko A.A.	Collaborations
IMPB RAS	Russia	Pushchino	Lakhno V.D. + 2	Collaborations
IMPB RAS	Russia	Pushchino	Ustinin M.N.	Collaborations
FIP	Russia	St. Petersburg	Zarochentsev A.K.	Collaborations
FIP	Russia	St. Petersburg	Feofilov G.A.	Collaborations
FIP	Russia	St. Petersburg	Shabaev V.K.	Collaborations
SPbSPU	Russia	St. Petersburg	Boldyrev Yu.Ya. + 2	Collaborations
SPbSU	Russia	St. Petersburg	Bogdanov A.V. + 2	Collaborations
SPbSU	Russia	St. Petersburg	Degtyarev A.B.	Collaborations
ITMO Univ.	Russia	St. Petersburg	Bukhanovsky A.V.	Collaborations
SU	Russia	Samara	Soifer V.A.	Collaborations
LITP RAS	Russia	Chernogolovka	Shchur L.N.	Collaborations
SCC IPCP RAS	Russia	Chernogolovka	Volokhov V.M. + 2	Collaborations
Ун-т	Serbia	Belgrade	Despotovich C.	Collaborations

Ун-т	Serbia	Belgrade	Hadjiyoic M.	Collaborations
Ун-т	Serbia	Belgrade	Chosic M.	Collaborations
Ун-т	Serbia	Belgrade	Eric K.	Collaborations
IEP SAS	Slovakia	Kosice	Kopchansky P.	Collaborations
BNL	USA	Upton, NY	Klimentov A.	Collaborations
BNL	USA	Upton, NY	Panitkin S.	Collaborations
UTA	USA	Arlington, TX	De K.	Collaborations
Fermilab	USA	Batavia, IL	Rosen R.	Collaborations
Fermilab	USA	Batavia, IL	Holzman B.	Collaborations
ASGCCA	Taiwan	Taipei	Lin S.	Collaborations
CPPM	France	Marseille	Tsaregorodtsev A.	Collaborations
CERN	CERN	Geneva	Andreeva Yu.	Collaborations
CERN	CERN	Geneva	Compana S. + 5	Collaborations
UCT	South Africa	Cape Town	Becker B.	Collaborations

2.6. Key partners *(those collaborators whose financial, infrastructural participation is substantial for the implementation of the research program on the theme).*

3. Manpower

3.1. Manpower needs in the first year of implementation LRIP MICC, including activities

No.	Personnel category	JINR staff, FTE amount	JINR associated personnel, FTE amount
1.	research scientists	15.3	3
2.	engineers	69.45	4
3.	specialists	0	0
4.	workers	14	0
5.	leaders	10.5	0
	Total:	**109.25**	**7**

3.2. Available manpower

3.2.1. JINR staff (total number of participants, including activities)

No.	Personnel category	Division	Position	Amount FTE
1.	research scientists	MLIT	Trainee researcher Junior researcher Researcher Senior Researcher Leading Researcher Chief Researcher Heads of the sec., Sci. supervis., Dep. direct. Sci. sec., Dir. of the Lab.	3.1 1.5 2.7 3.2 0 0 4.8
2.	Engineers	MLIT	Laboratory assistant Leading Engineer Leading programmer Leading electronics engineer Engineer	2.25 0.5 14 1 12

			Software engineer 1st cat. software engineer 2nd cat. software engineer Electronics engineer 1st cat. electronics engineer 2nd cat. electronics engineer 3rd cat. electronics engineer Senior technician Technician	10.7 8 10 4 1 1 2 2 1
3.	specialists	-		0
4.	workers	MLIT		14
5.	leaders	MLIT		10.5
	Total:			**109.25**

MICC only

No.	Personnel category	ФИО	Подразделение	Должность
1.	Research scientists	Bezhanyan T. Zh.	DCC and DIS	Researcher
2.	Research scientists	Butenko Yu. A.	DCC and DIS	Junior researcher
3.	Research scientists	Voytishin N. N.	DCC and DIS	Researcher
4.	Research scientists	Derenovskaia O.Yu.	LIT Directorate	Scientific Secretary
5.	Research scientists	Zuev M.I.	DCC and DIS	Researcher
6.	Research scientists	Ilyina A.V.	DCC and DIS	Trainee researcher
7.	Research scientists	Korenkov V.V.	LIT Directorate	Scientific leader of the laboratory
8.	Research scientists	Kutovsky N. A.	DCC and DIS	Senior Researcher
9.	Research scientists	Mazhitova E.	DCC and DIS	Junior researcher
10.	Research scientists	Mitsyn V.V.	DCC and DIS	Senior Researcher
11.	Research scientists	Pelevanyuk I. S.	DCC and DIS	Researcher
12.	Research scientists	Podgainy D.V.	DCC and DIS	Head of the sector
13.	Research scientists	Pryakhina D.I.	DCC and DIS	Researcher
14.	Research scientists	Streltsova O. I.	DCC and DIS	Senior Researcher
15.	Research scientists	Strizh T. A.	LIT Directorate	Deputy Director of the laboratory for scientific work
16.	Research scientists	Sokolov I.A.	DCC and DIS	Trainee researcher
17.	Research scientists	Fariseev V. Ya.	ETD	Head of the sector

18.	Research scientists	Shmatov S.V.	LIT Directorate	Director of the laboratory
19.	Engineers	Angelov K. N.	ETD	Leading programmer
20.	Engineers	Anikina A.I.	DCC and DIS	Software engineer
21.	Engineers	Antonova O. A.	ETD	Senior technician
22.	Engineers	Balandin A.I.	ETD	1st cat. software engineer
23.	Engineers	Balashov N.A.	DCC and DIS	1st cat. software engineer
24.	Engineers	Baranov A.V.	DCC and DIS	1st cat. software engineer
25.	Engineers	Belyakov D.V.	DCC and DIS	Leading programmer
26.	Engineers	Bondyakov A.S.	DCC and DIS	2rd cat. software engineer
27.	Engineers	Golunov A.O.	DCC and DIS	2nd cat. software engineer
28.	Engineers	Gorodnicheva L.I.	ETD	Software engineer
29.	Engineers	Grafov E. A.	ETD	3rd cat. electronics engineer
30.	Engineers	Grafova E. N.	ETD	2rd cat. electronics engineer
31.	Engineers	Gromova N. I.	DCC and DIS	Leading programmer
32.	Engineers	Gushchin A.E.	ETD	Leading programmer
33.	Engineers	Evlanov A.V.	ETD	Engineer
34.	Engineers	Zhabkova S. E.	ETD	Engineer
35.	Engineers	Zakomoldin A. Yu.	ETD	1st cat. software engineer
36.	Engineers	Kalagin I.I.	ETD	electronics engineer
37.	Engineers	Kamensky A.S.	ETD	electronics engineer
38.	Engineers	Kashunin I.A.	DCC and DIS	2nd cat. software engineer
39.	Engineers	Kirakosyan M. Kh.	DCC and DIS	Software engineer
40.	Engineers	Kokorev A. A.	DCC and DIS	Software engineer
41.	Engineers	Kondratiev A.O.	DCC and DIS	2nd cat. software engineer
42.	Engineers	Korobova G.A.	ETD	Leading programmer
43.	Engineers	Kretova S.A.	DCC and DIS	Software engineer
44.	Engineers	Kudasova I.V.	ETD	Engineer
45.	Engineers	Kudryashova O. N.	ETD	Engineer
46.	Engineers	Kulpin E.Yu.	ETD	1st cat. software engineer
47.	Engineers	Lavrentiev A.A.	ETD	Leading programmer
48.	Engineers	Lensky I.I.	DCC and DIS	Software engineer
49.	Engineers	Lyubimova M. A.	DCC and DIS	Software engineer
50.	Engineers	Maksimov M.A.	ETD	Engineer

51.	Engineers	Markov V.N.	ETD	Engineer
52.	Engineers	Marchenko S.V.	ETD	Engineer
53.	Engineers	Matveev M. A.	DCC and DIS	2nd cat. Software engineer
54.	Engineers	Makhalkin A. N.	DCC and DIS	Software engineer
55.	Engineers	Medyantsev A.A.	ETD	Engineer
56.	Engineers	Mishchenko N.N.	ETD	Engineer
57.	Engineers	Nekrasova I.K.	DCC and DIS	Software engineer
58.	Engineers	Nechaevsky A.V.	DCC and DIS	Leading programmer
59.	Engineers	Oleinik D. A.	DCC and DIS	Leading programmer
60.	Engineers	Parzhitsky S. S.	ETD	Software engineer
61.	Engineers	Petrosyan A. Sh.	DCC and DIS	Leading programmer
62.	Engineers	Polezhaev D.S.	ETD	electronics engineer
63.	Engineers	Popov L.A.	ETD	Leading Engineer
64.	Engineers	Rozhkova T.V.	ETD	Software engineer
65.	Engineers	Rozenberg Ya.I.	ETD	Leading electronics engineer
66.	Engineers	Semenov R.N.	DCC and DIS	Leading programmer
67.	Engineers	Smolnikova A.S.	ETD	Technician
68.	Engineers	Solovieva E. V.	ETD	Engineer
69.	Engineers	Sorokin I.G.	ETD	Engineer
70.	Engineers	Stamat I.N.	ETD	Engineer
71.	Engineers	Toneeva E.V.	ETD	Senior technician
72.	Engineers	Torosyan Sh.G.	DCC and DIS	Software engineer
73.	Engineers	Trofimov V.V.	DCC and DIS	Leading programmer
74.	Engineers	Trubchaninov N.V.	ETD	3rd cat. electronics engineer
75.	Engineers	Tsamtsurov E.O.	DCC and DIS	Laboratory assistant
76.	Engineers	Chashchin S.V.	ETD	electronics engineer
77.	Engineers	Churin A.I.	ETD	1st cat. software engineer
78.	Engineers	Sheiko V.P.	ETD	1st cat. electronics engineer
79.	Engineers	Shpotya D.A.	DCC and DIS	Laboratory assistant
80.	Workers	Vedrov S.I.	ETD	Electrician
81.	Workers	Dergunov V.P.	ETD	Electrician
82.	Workers	Klochiev A.E.	ETD	Emergency repair worker

83.	Workers	Komkov A.V.	ETD	Electrician
84.	Workers	Kulakov V.I.	ETD	Repairman
85.	Workers	Levitin A. M.	ETD	Emergency repair worker
86.	Workers	Legashchev Yu.M.	ETD	Emergency repair worker
87.	Workers	Mityukhin A. N.	ETD	Emergency repair worker
88.	Workers	Nekrasov V.N.	ETD	Installer of sanitary systems and equipment
89.	Workers	Rogozin D. V.	ETD	Electric gas welder
90.	Workers	Stepanov B. B.	ETD	Emergency repair worker
91.	Workers	Usachev V.Yu.	ETD	Installer of sanitary systems and equipment
92.	Workers	Fetisov M. Yu.	ETD	Electrician
93.	Workers	Shvalev A. M.	ETD	Installer of sanitary systems and equipment
94.	Leaders	Vorontsov A.S.	ETD	Head of the group
95.	Leaders	Gavrilov S.V.	ETD	Head of the group
96.	Leaders	Gavrish A.P.	ETD	Head of the group
97.	Leaders	Goloskokova T. M.	DCC and DIS	Deputy Head of the Division
98.	Leaders	Dolbilov A.G.	LIT Directorate	Chief engineer of the laboratory
99.	Leaders	Karpenko N.N.	LIT Directorate	Deputy chief engineer of the laboratory
100.	Leaders	Ovechkin V.V.	ETD	Head of the group
101.	Leaders	Shishmakov M. L.	ETD	Deputy Head of the Division

3.2.2. JINR associated personnel

No.	Personnel category	Partner organization	Amount of FTE
1.	research scientists		
2.	engineers		
	Total:		

4. Financing
4.1. Total estimated cost of the theme / LRIP

No.	Items of expenditure	Cost	Expenditure per year (thousands of the US dollars)						
			2024	2025	2026	2027	2028	2029	2030
1.	International cooperation	1120.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0
2.	Materials	1750.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
3.	Equipment, Third-party company services	42683.0	5607.0	5675.0	5908.5	5575.0	6547.5	6185.0	7185.0

4.	Commissioning	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	R&D contracts with other research organizations	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.	Software purchasing	875.0	110.0	115.0	120.0	125.0	130.0	135.0	140.0
7.	Design/construction	5568.1	646.6	760.1	658.6	1169.9	379.8	929.1	1024.0
8.	Service costs (*planned in case of direct affiliation)*	1132.1	150.0	153.7	157.6	161.5	165.6	169.7	174.0
TOTAL:		**53128.2**	**6923.6**	**7113.8**	**7254.7**	**7441.4**	**7632.9**	**7828.8**	**8933.0**

4.2. Extra funding sources

Expected extra funding from partners/customers (total for all projects).

AGREED:

Chief Scientific Secretary

______________/________ ____________/

"_____"__________________ 202_г.

Head of BEPD

______________/________ ____________/

"_____"__________________202_г.

Head of DSOA

______________/________ ____________/

"_____"____________ 202_ г.

Head of HRRMD

______________/________ ____________/

"_____"____________ 202_г.

Laboratory Director

______________/____ _______________/

"_____"__________________202_г.

Scientific Secretary of the Laboratory

______________/____ _______________/

"_____"__________________ 202_г.

Laboratory Economist

______________/____ _______________/

"_____"__________________202_г.

LRIP leader

______________/____ _______________/

"_____"____________ 202_г.

LRIP leader

_________/___________________/

“_____“___________________202_г.

LRIP Deputy Leader

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“_____“___________________202_г.

LRIP Deputy Leader

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“_____“___________________202_г.

LRIP Deputy Leader

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“_____“___________________202_г.