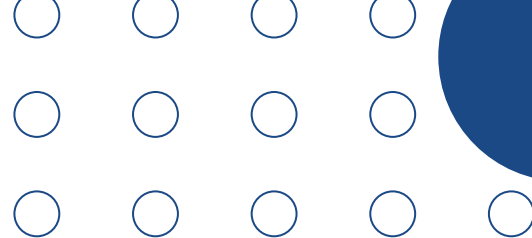




JOINT INSTITUTE
FOR NUCLEAR
RESEARCH



MESHCHERYAKOV LABORATORY OF INFORMATION TECHNOLOGIES



LCTA – MLIT



M.G. Meshcheryakov
(17.09.1910 - 24.05.1994)

The Laboratory of Computing Techniques and Automation (now MLIT) was founded in August 1966.

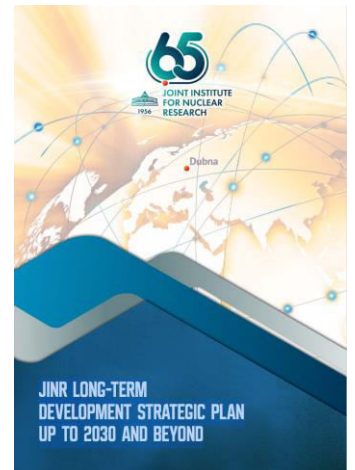
The main directions of the Laboratory's activities are connected with the provision of networks, computer and information resources, as well as mathematical support for a wide range of research at JINR in high-energy physics, nuclear physics, condensed matter physics, etc.



N.N. Govorun
(18.03.1930 - 21.07.1989)

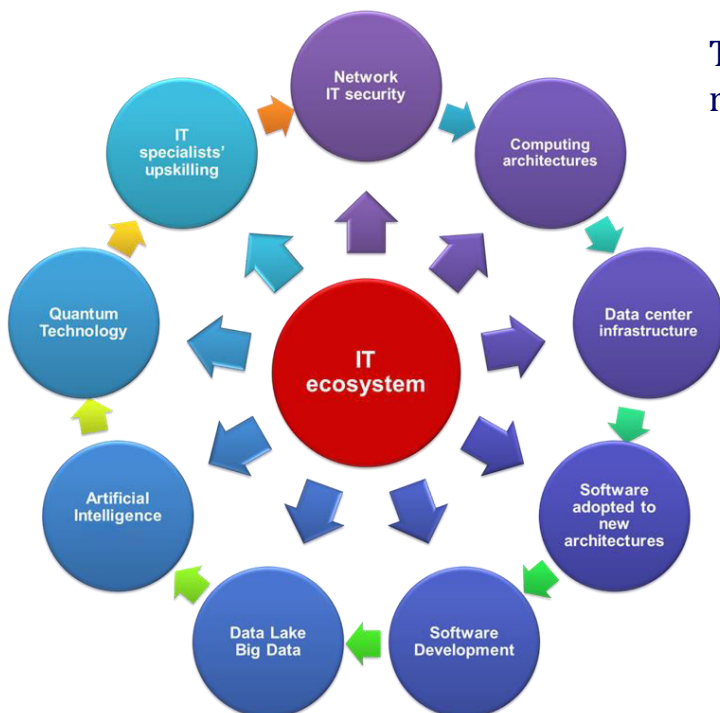
In accordance with the JINR long-term development strategic plan up to 2030 and beyond, the MLIT mission is two-fold:

- to serve the scientists of JINR and its Member States in the pursuit of their research projects by developing methods, algorithms, and software for physical systems modeling, the mathematical processing and analysis of experimental data;
- to assure that the IT infrastructure and IT know-how of JINR experts are always of latest state of the art as to performance and energy efficiency.



Scientific IT Ecosystem

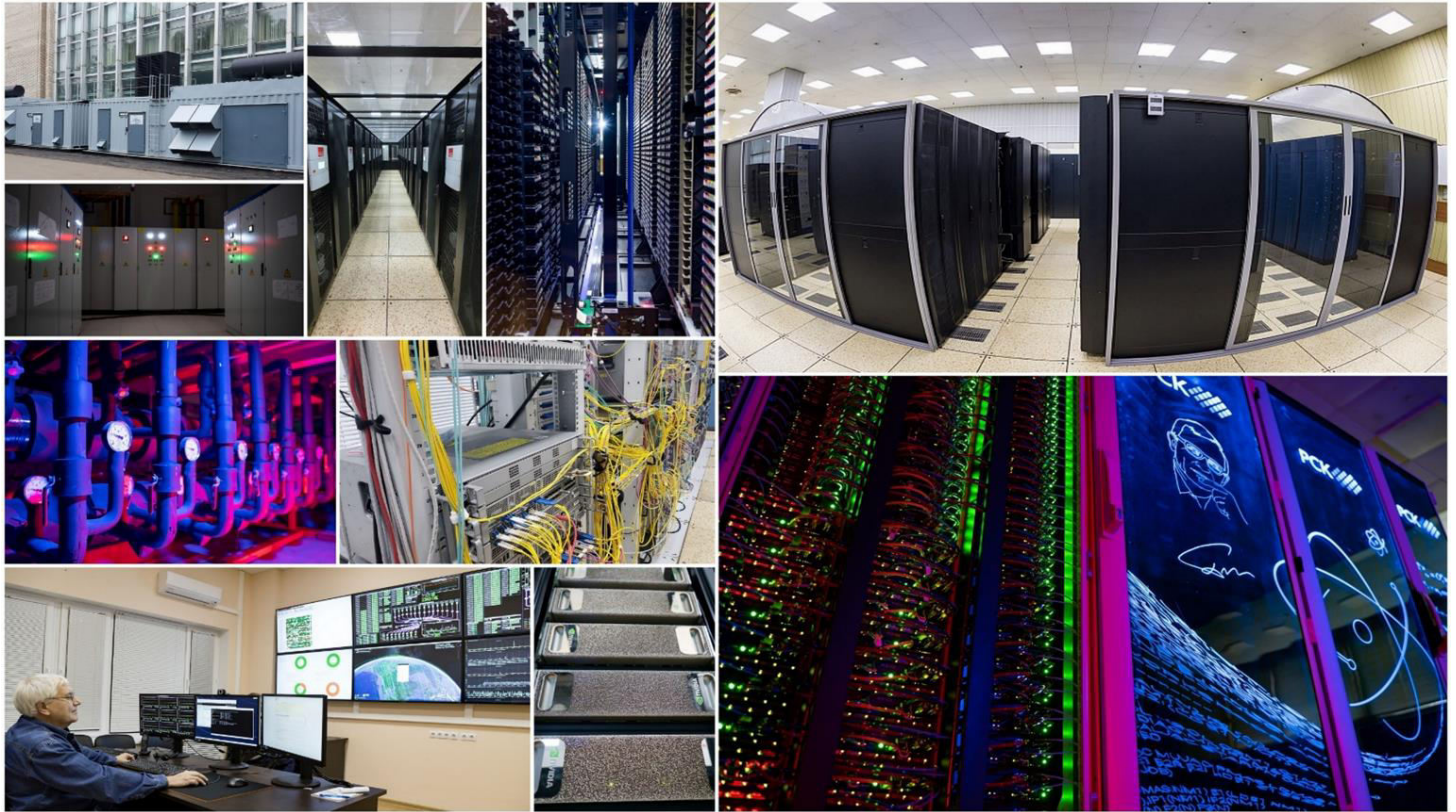
The concept of the development of information technology, scientific computing, and data science in the JINR Seven-Year Plan provides for the creation of a scientific IT ecosystem that implies the coordinated development of interconnected IT technologies and computational methods aimed at maximizing the range of JINR strategic tasks that require intensive data calculations.



The main directions of MLIT activities are related to

- Coordinated development of interconnected IT technologies and computational methods
- Provision of IT services necessary for the fulfilment of the JINR Topical Plan on Research and International Cooperation in an efficient manner
- 24x7 support of the computing infrastructure and services

Multifunctional Information and Computing Complex

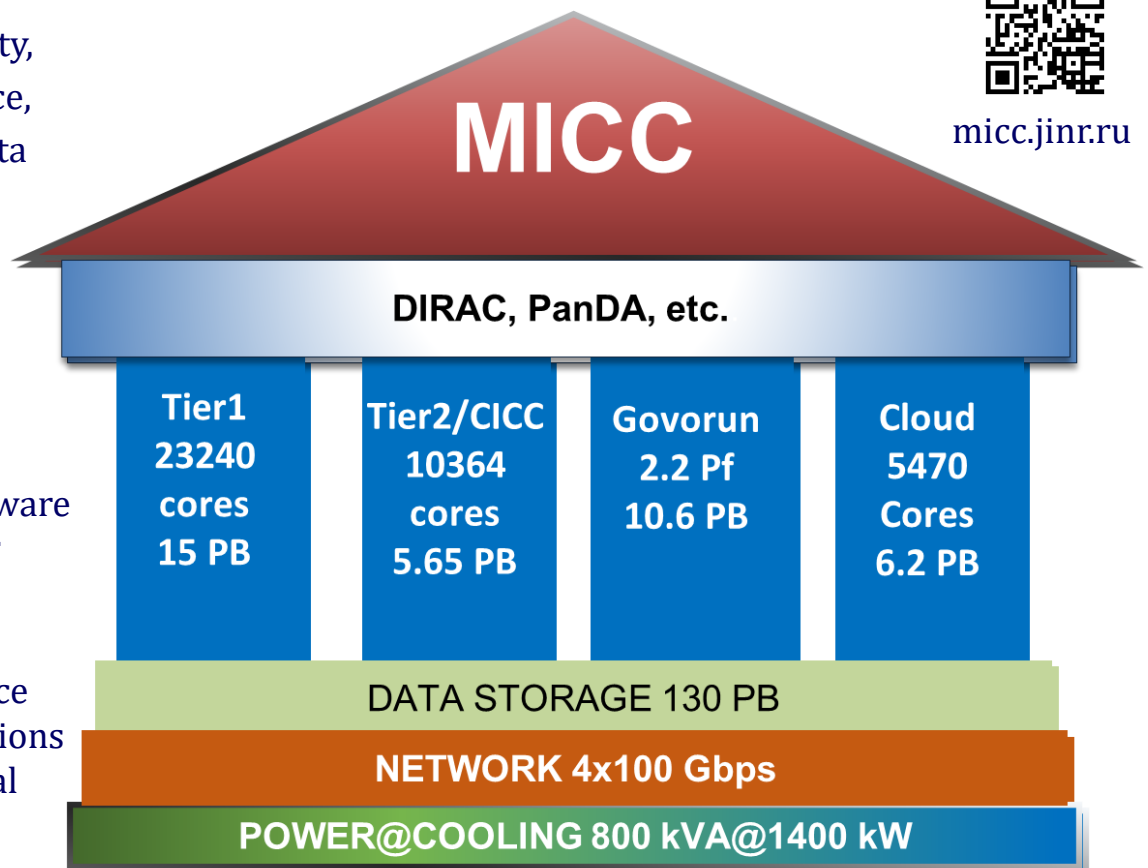


The IT infrastructure is one of JINR's basic facilities and JINR's large research infrastructure project.

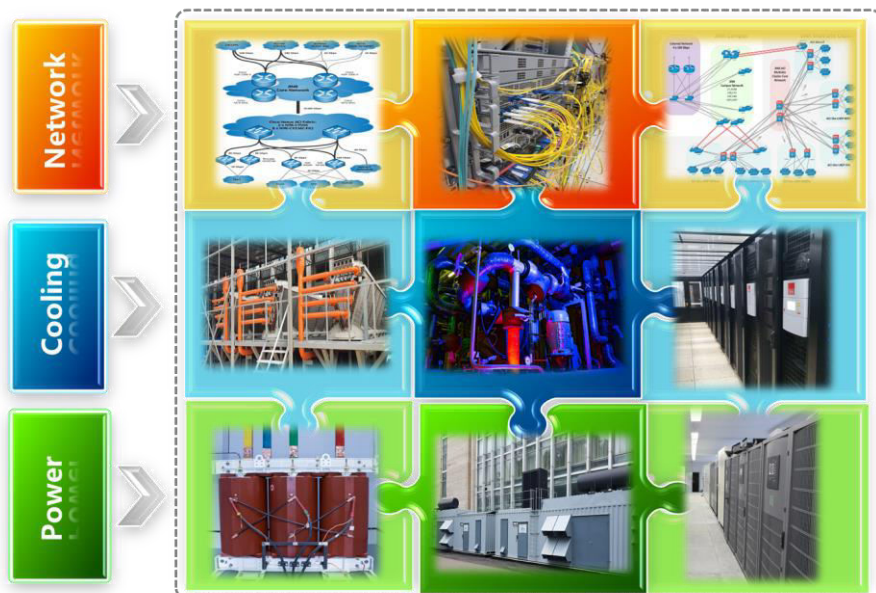
- multifunctionality,
- high performance,
- task-adapted data storage system,
- high reliability and availability,
- information security,
- scalability,
- customized software environment for different user groups,
- high-performance telecommunications and modern local network.



micc.jinr.ru



MICC Power @ Cooling @ Network

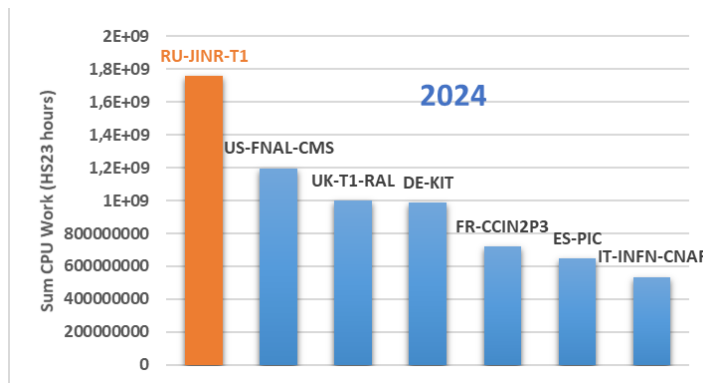


Wide Area Network 4x100 Gbps
Cluster Backbone 4x100 Gbps
Campus Backbone 2x100 Gbps

Dry chillers
In-row systems
Total cooling 1400 kW

Uninterruptible power supplies (UPS)
8x300 kVA
Diesel-generator units (DGU) 2x1500 kVA
Transformers 2x2500 kVA

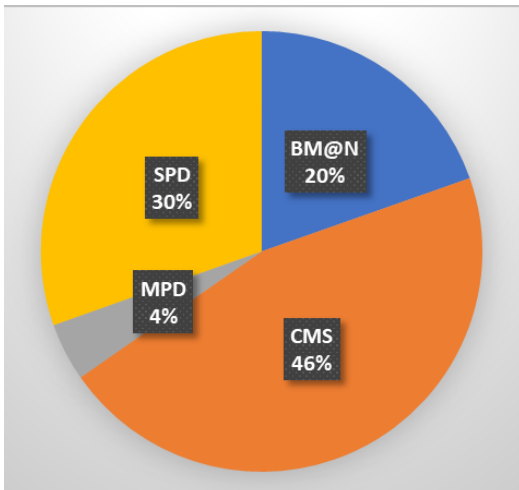
Grid Infrastructure



Tier1

- 23240 cores
- 428 kHS06
- 15.0 PB disks
- 100 PB tapes
- 100% reliability and availability

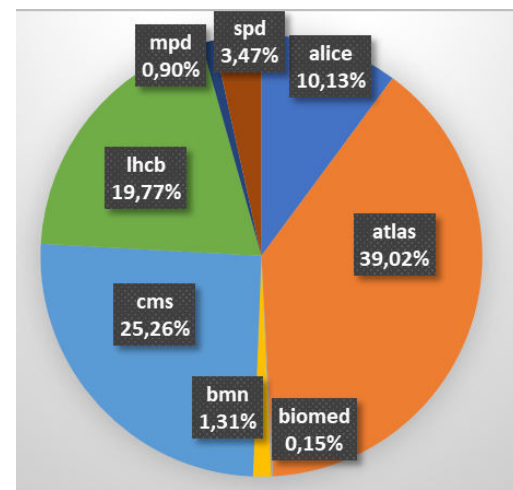
The Tier1 and Tier2 grid sites provide data processing and analysis within JINR's participation in the LHC projects at CERN, as well as tasks for modeling, processing and storing data from the BM@N, MPD and SPD experiments at the NICA accelerator complex.



JINR Tier1 is regularly ranked on top among world Tier1 sites that process data from the CMS experiment at the LHC.

The JINR Tier2 output is the highest in the Russian grid segment (Russian Data Intensive GRID, RDIG).

Distribution by the number of jobs completed on Tier1 by the CMS and NICA experiments



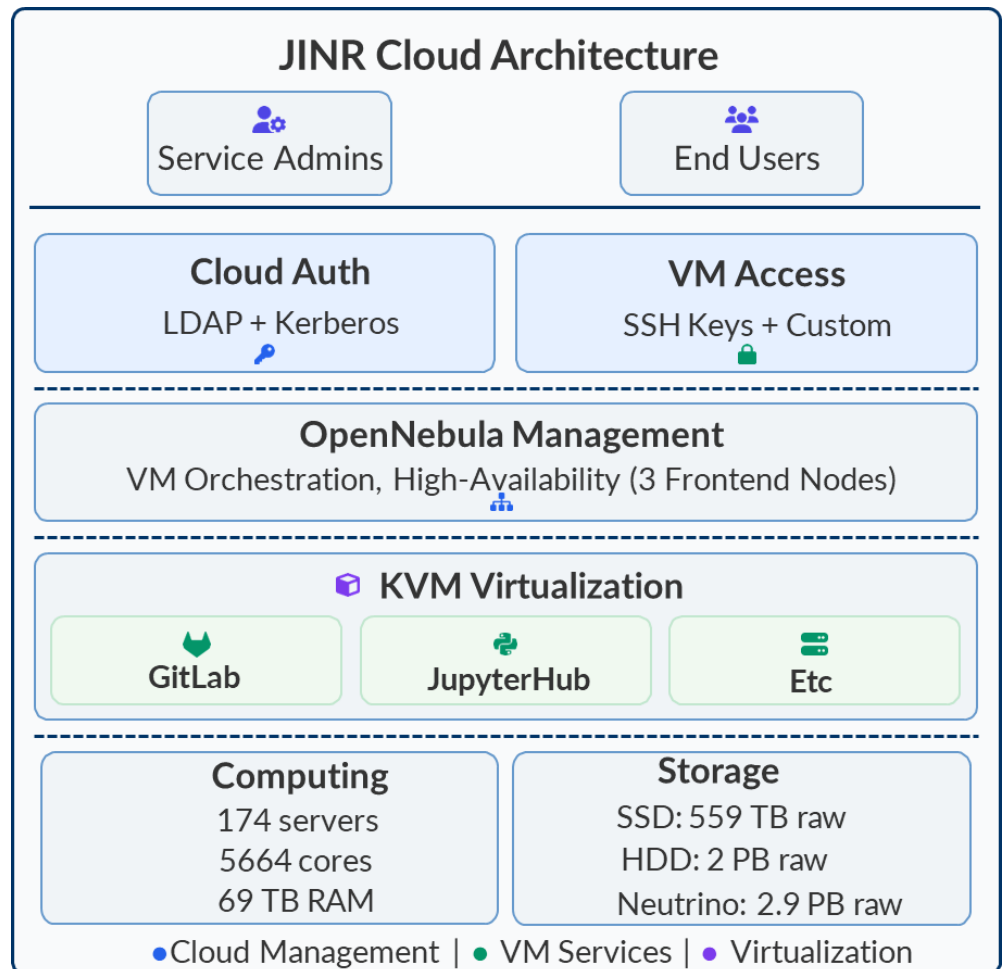
Usage of the JINR Tier2 site by virtual organizations within grid projects

Cloud Infrastructure

A universal computing resource that supports individual scientists and provides a variety of common services, ranging from simple websites to complex multi-user computational systems.

Utilization:

- Computational resources for neutrino experiments
- VMs for JINR users
- Testbeds for research and development in IT
- COMPASS production system services
- Data Management System of the European Air Pollution Programme (UNECE ICP Vegetation)
- System for diagnosing diseases of agricultural crops using modern machine learning methods
- Service for data visualization, Gitlab, and some others



DIRAC-based distributed information and computing environment integrating JINR Member State organizations' clouds



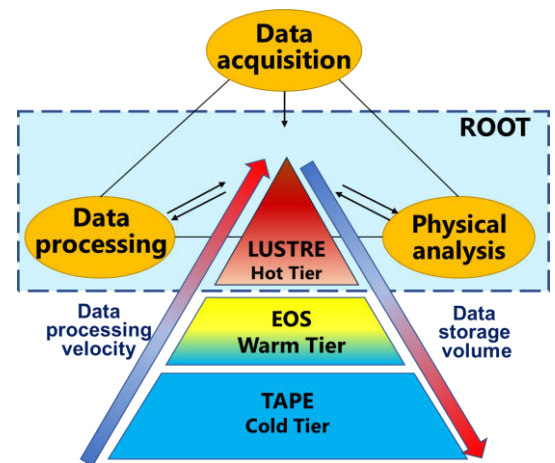
HybriLIT Platform and “Govorun” Supercomputer

The HybriLIT platform consists of two elements, namely, the education and testing polygon and the “Govorun” supercomputer, combined by a unified software and information environment. The supercomputer was named after N.N. Govorun.

- Hyperconverged software-defined system
- Hierarchical data processing and storage system with a capacity of 10.6 PB
- Scalable solution Storage-on-demand
- Total peak performance: 2.2 PFlops DP and 58 PFlops for AI tasks
- GPU component based on NVIDIA H100, V100, A100
- CPU component based on RSC Tornado liquid cooling solutions
- The most energy-efficient center in Russia (PUE = 1.06)
- Storage performance >300 GB/s

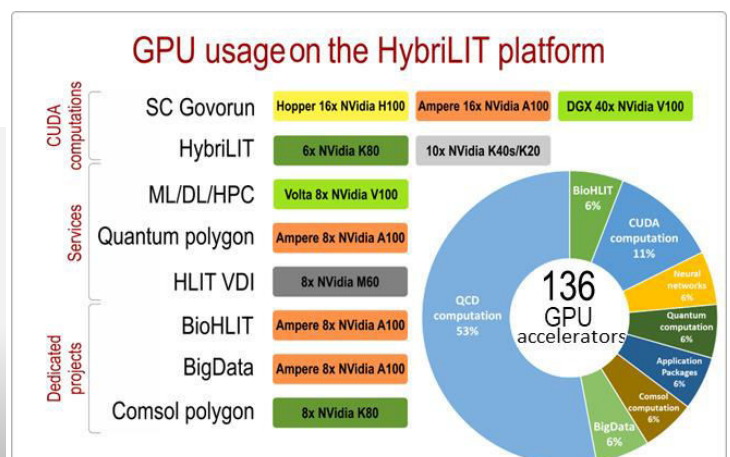
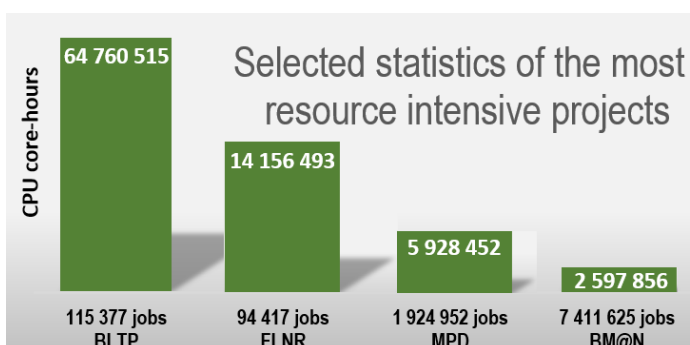


hlit.jinr.ru



“Govorun” SC resources are used by scientific groups from all the Laboratories of the Institute. **Key projects utilizing the resources of the “Govorun” supercomputer:**

- NICA megaproject,
- calculations of lattice quantum chromodynamics,
- computations of the properties of atoms of superheavy elements,
- studies in the field of radiation biology,
- calculations of the radiation safety of JINR’s facilities.



For all the time, HybriLIT platform users have published articles in various fields:

- physics of elementary particles and the atomic nucleus,
- high-energy physics,
- biophysics and chemistry,
- neural network approach, methods and algorithms of ML/DL, etc.

> 500 papers, two in Nature Physics



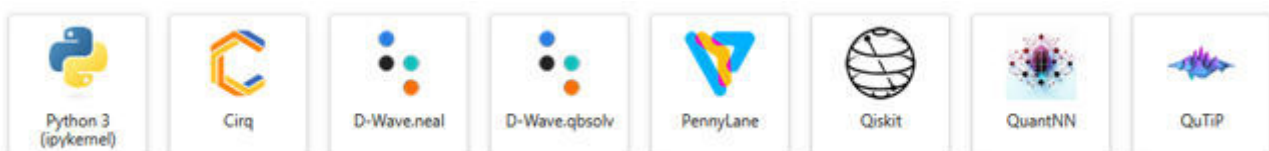
ML/DL/HPC Ecosystem

The ML/DL/HPC ecosystem is used for machine and deep learning tasks. At the same time, the accumulated tools and libraries can be more widely applied for scientific research, including numerical computations, parallel computing on CPUs and GPUs, results visualization, accompanying numerical results with the necessary formulas and explanations.

Component for educational purposes (without GPUs) For teaching students https://studhub1.jinr.ru For conducting workshops within JINR scientific events https://studhub2.jinr.ru https://studhub3.jinr.ru	Component for carrying out resource-intensive computations (with GPUs) https://jhub1.jinr.ru https://jhub2.jinr.ru	HPC component for scientific projects (with installed specialized libraries) BioHlit project https://cell.jinr.ru http://mostlit.jinr.ru http://bio-dashboards.jinr.ru/morris CVAT services http://159.93.36.88:8080 http://159.93.36.67:8080 Jupyter Books infrastructure http://studhub.jinr.ru:8080/jjbook http://studhub.jinr.ru:8080/books http://studhub.jinr.ru:8080/itschool2024 Polygon for brain CT data visualization https://hlit-th-ct.jinr.ru Polygon for quantum computing https://ampere05.jinr.ru

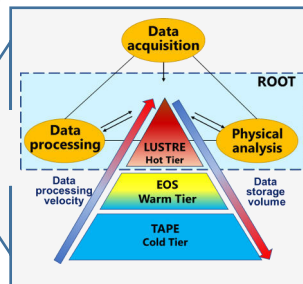
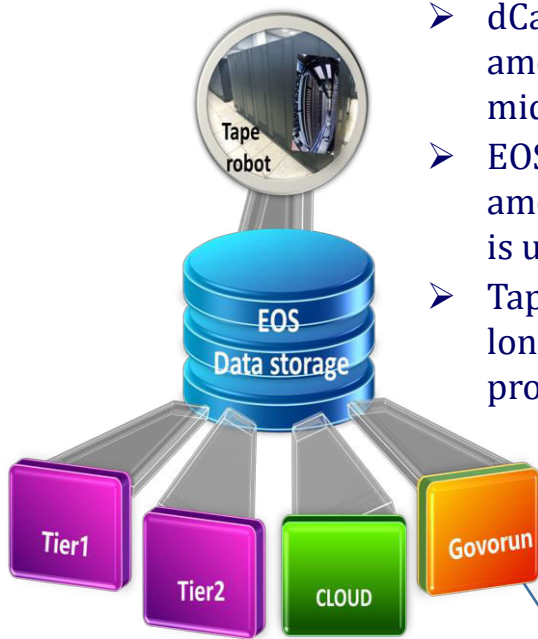
Quantum Computing Polygon

- ability to visually develop algorithms and visualize quantum circuits;
- available Python language materials can significantly speed up research.



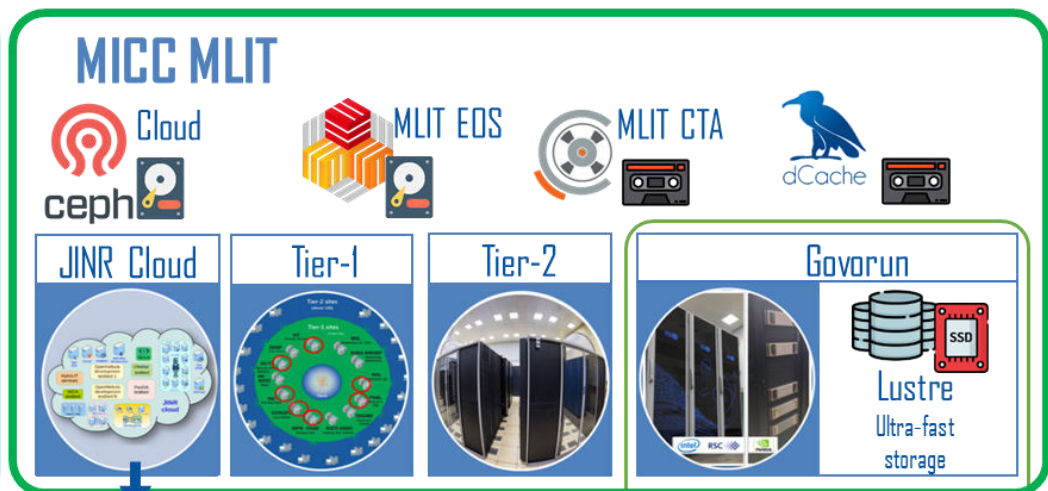
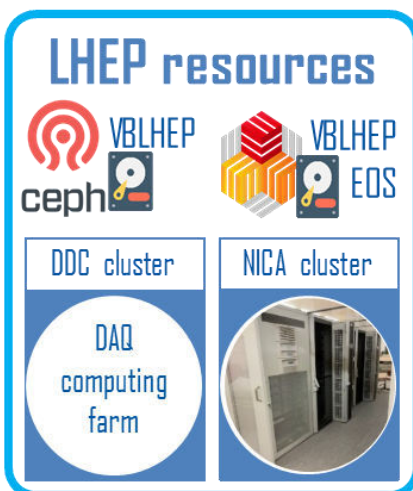
Distributed Multilayer Data Storage System

- Limited data and short-term storage – to store the OS itself, temporary user files
- AFS distributed global system – to store user home directories and software
- dCache is traditional for the MICC grid sites – to store large amounts of data (mainly the LHC experiments) for the middle-term period
- EOS is extended to all MICC resources – to store large amounts of data for the middle-term period. At present, EOS is used for storage by BM@N, MPD, SPD, Baikal-GVD, etc.
- Tape robotic systems – to store large amounts of data for the long-term period for CMS, BM@N, MPD, SPD, JUNO – in progress.

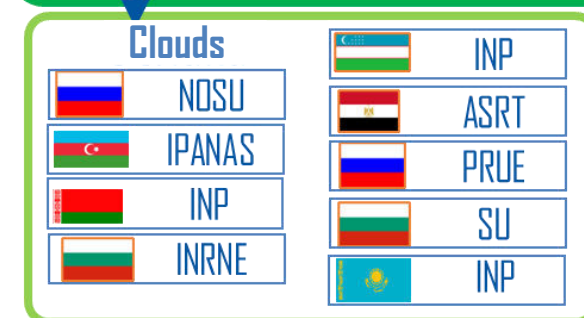


A special hierarchical data processing and storage system with a software-defined architecture was developed and implemented on the “Govorun” supercomputer.

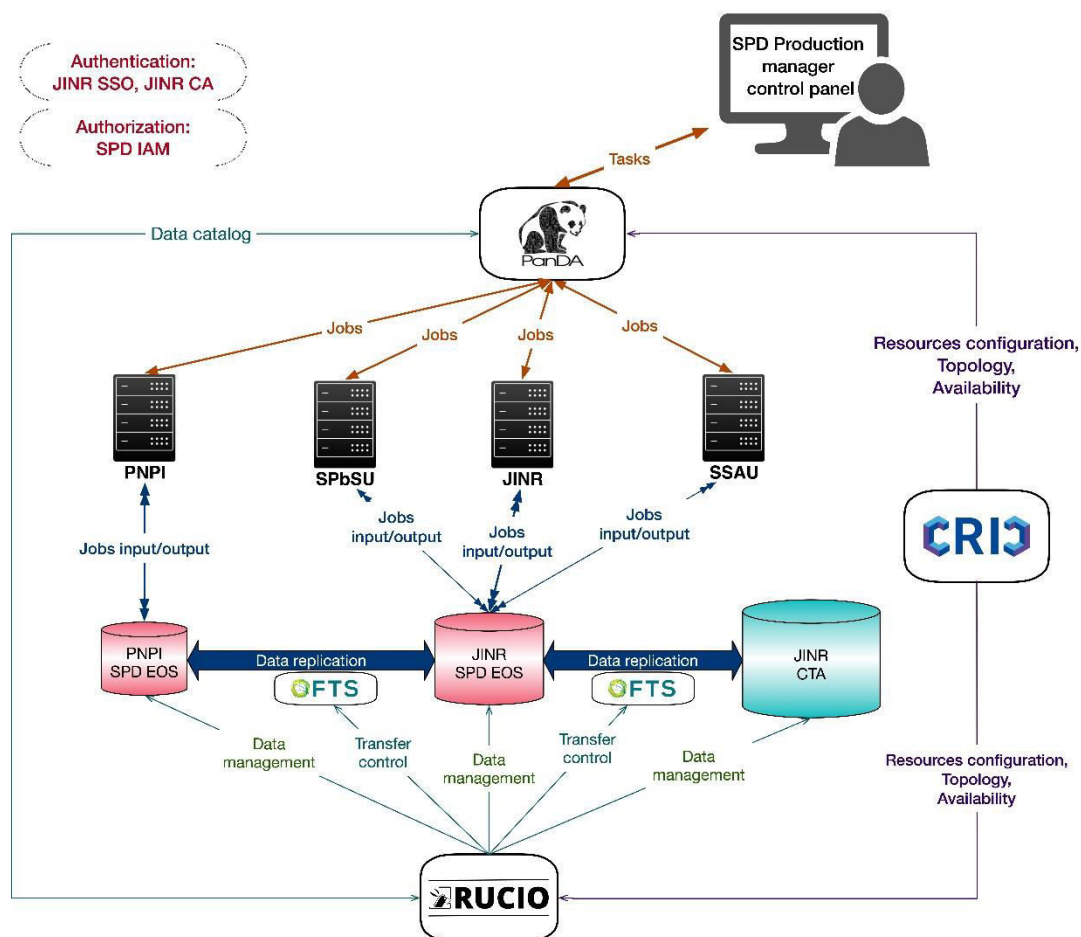
Integration of Heterogeneous Computing Resources



A heterogeneous computing environment (Tier1, Tier2, “Govorun” SC, cloud, etc.), based on the DIRAC platform, was created to process and store data from experiments conducted at JINR. The distributed infrastructure is used by MPD, Baikal-GVD, BM@N, SPD.



SPD Distributed Data Processing and Analysis System

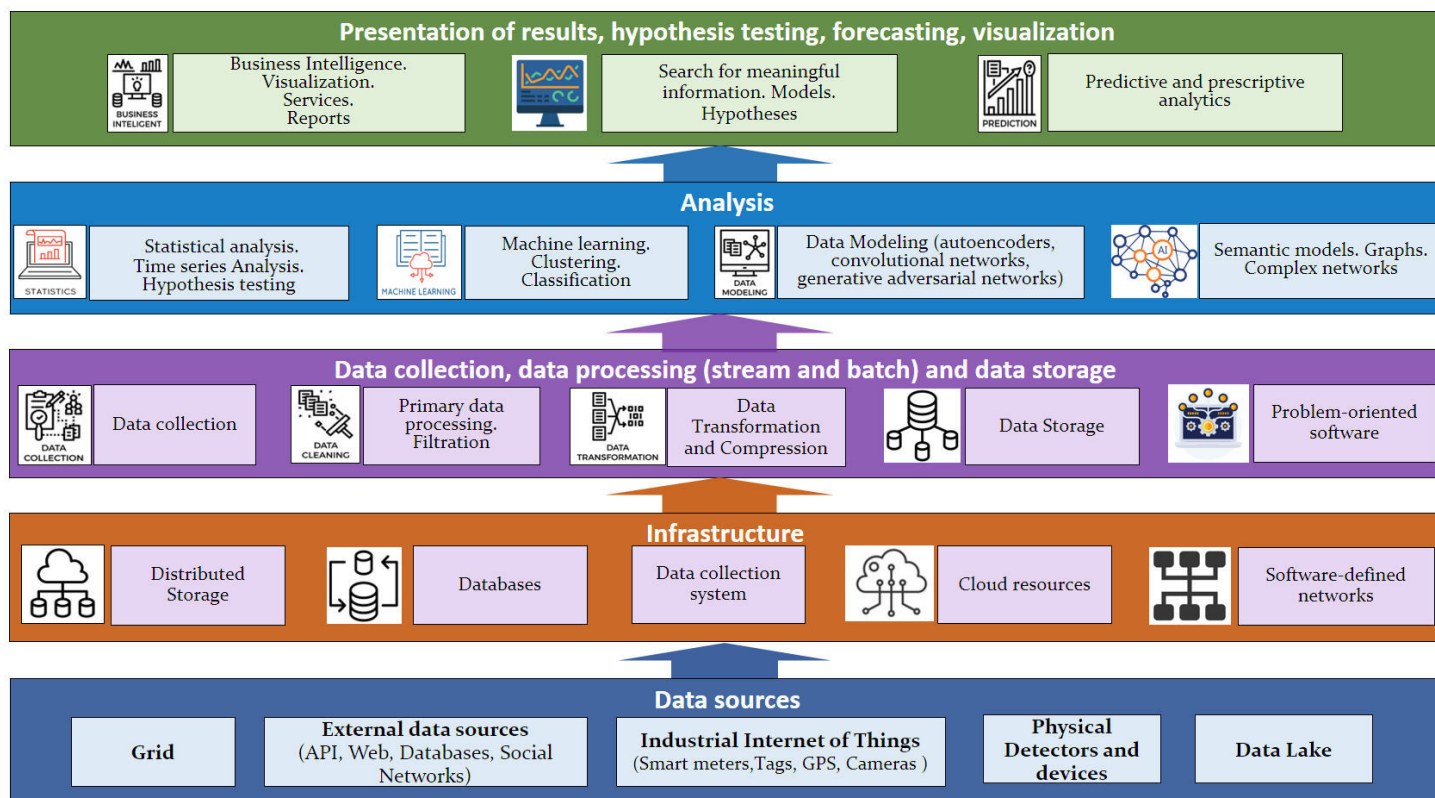


- distributed experimental data processing and storage system that integrates geographically remote computing centers: JINR, PNPI, and Samara Uni.
- PanDA + Rucio + CRIC are used to perform data processing and data management
- a dedicated EOS-based storage system

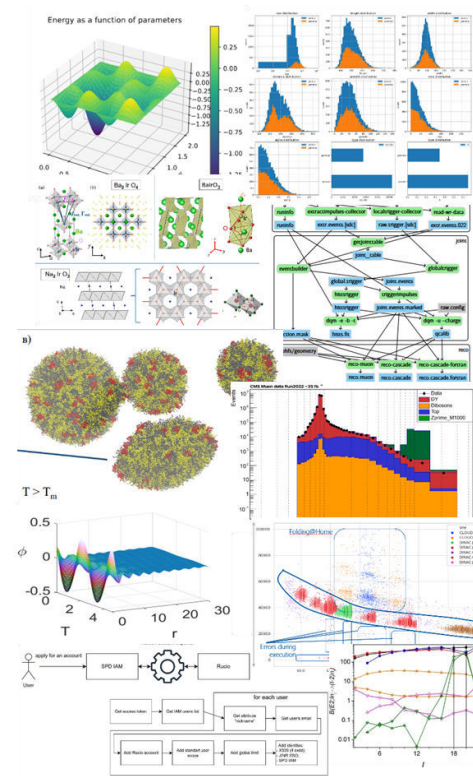
Big Data

- Bringing best of Big Data approaches to JINR practices
- Providing the Big Data infrastructure for users

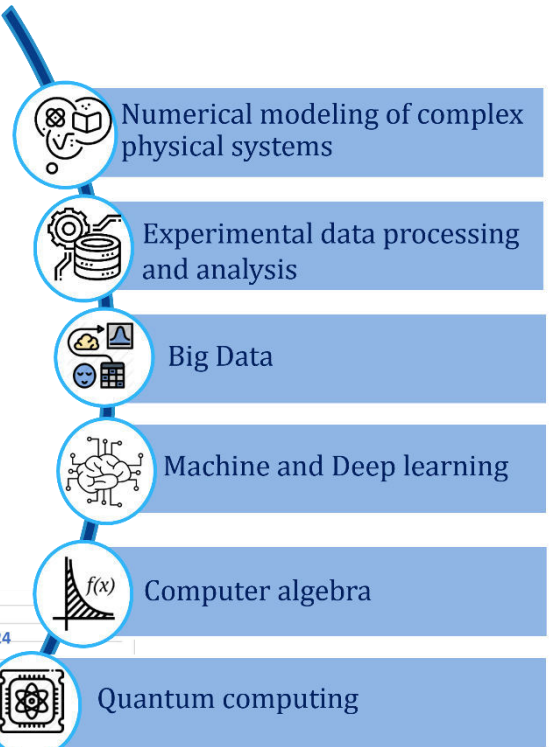
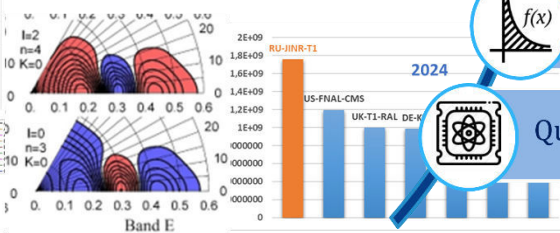
JINR Big Data Analytical Platform



Methods, Algorithms, and Software



The MLIT staff publish
>200 scientific publications,
>100 articles within
 international collaborations
 and
 present over **150 reports** at
 international and Russian
 conferences
 every year.

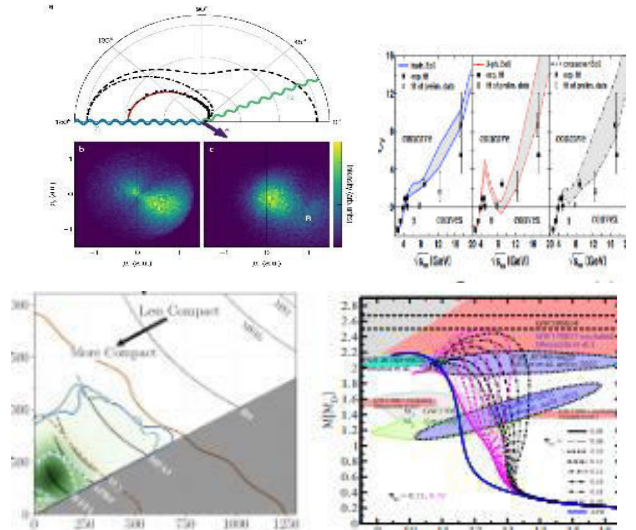


Methods and Software for Experimental Data Processing and Analysis

Simulation of Physics Processes and Facilities	Reconstruction and Data Analysis	Software Environment for Experiments
Physics event simulation	Particle trajectory reconstruction	Data processing and analysis models
GEANT-simulation of experimental setups	Particle identification	Data models
- mathematical methods and software, including those based on ML/DL algorithms, for modeling physics processes and experimental facilities, processing and analyzing experimental data in the field of elementary particle physics, nuclear physics, neutrino physics, radiobiology, etc. - creation of systems for the distributed processing and analysis of experimental data, as well as information and computing platforms to support research conducted at JINR and other research centers.	Reconstruction of physics processes	Software platforms and systems
	Experimental data analysis	Development and maintenance of DBs
		Event visualization

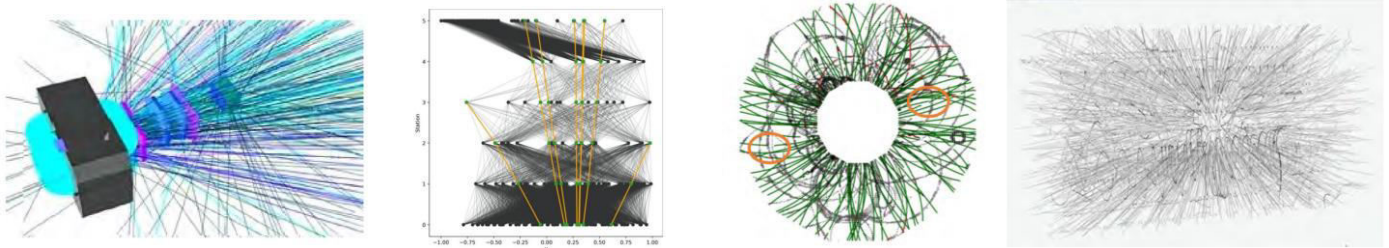
Methods of Mathematical Modeling, Computational Physics, and High-Performance Computing for Complex Systems Studies at JINR

- Simulating interactions of various types in nuclear-physical systems
- Studying multifactorial processes in models of complex systems with external influences
- Solving problems arising in the design and optimization of the operation of large-scale experimental facilities
- Modeling physical phenomena based on the state equation of dense nuclear matter

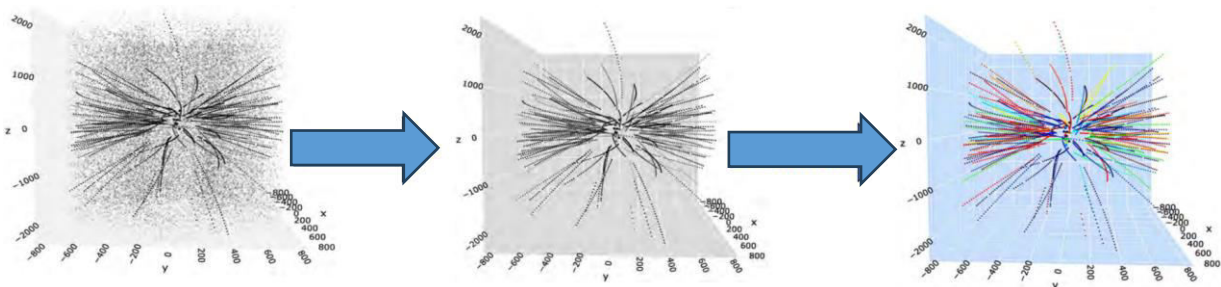


Machine Learning Algorithms for the Experiments at the NICA Accelerator Complex

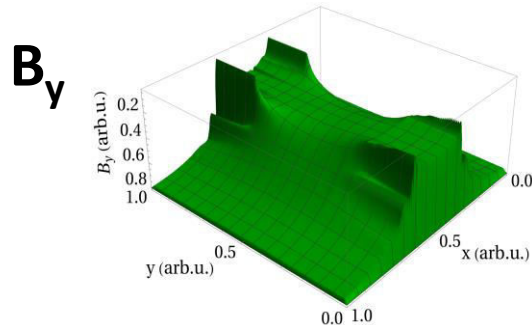
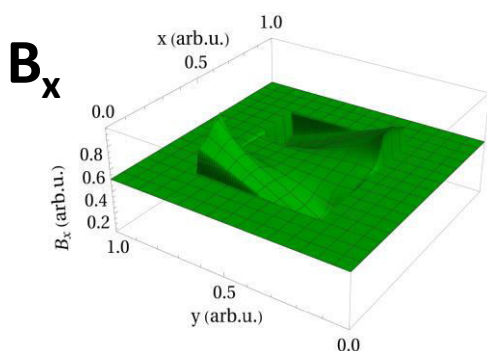
- Graphical Neural Network for the reconstruction of charged particle trajectories for the BM@N and MPD experiments



- Consecutive Neural Networks for SPD tracking

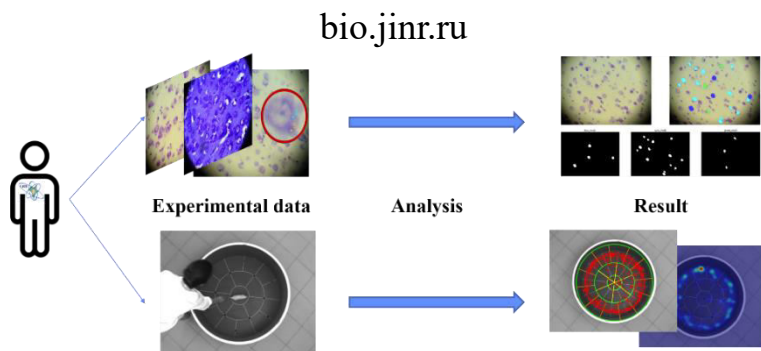


- Kolmogorov-Arnold neural network for approximation tasks such as magnetic field estimation, overlapped signals delimitation, etc.



Radiobiology and Life Science

Information System for Radiation Biology

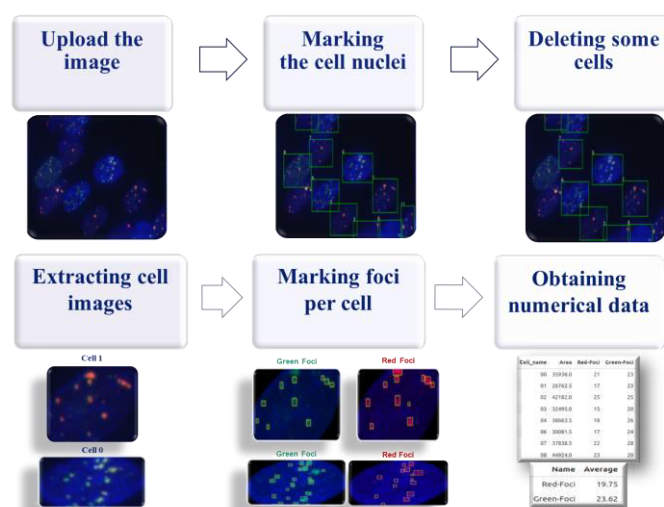


The IS allows one to store, quickly access, and process data from experiments at LRB using a stack of neural network and classical algorithms of computer vision, providing a wide range of possibilities for automating routine tasks. It gives an increase in productivity, quality, and the speed of obtaining results.

MOSTLIT. Service for FOCI detection and analysis

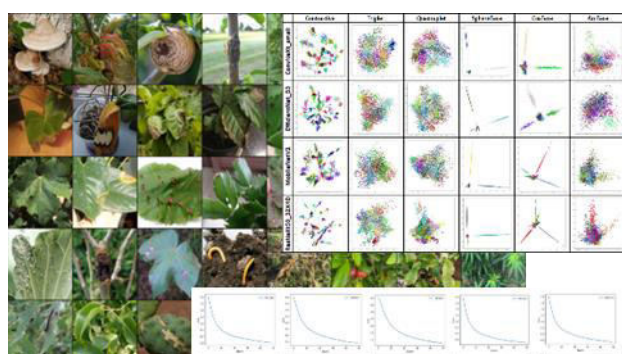
mostlit.jinr.ru

Web service to extract cells from each data image and count the number of radiation-induced foci. The service's functionality allows one to analyze a group of images of an experiment and provide analytical information on average foci per cell, foci area, and some other parameters.



Intelligent platform for determining the state of agricultural and decorative plants

doctorp.ru

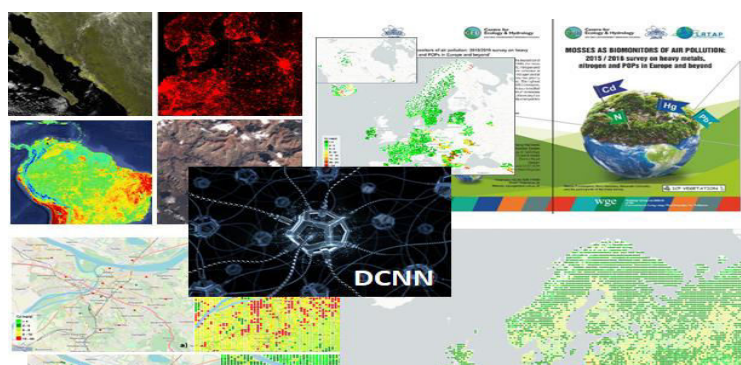


- image classification in conditions of a small training sample
- software and hardware solutions for organizing automated control and accounting in greenhouse complexes
- methods and means for organizing mobile object tracking complexes

Intelligent Environmental Monitoring Platform

moss.jinr.ru

Prediction of air pollution by heavy metals using biomonitring data, satellite imagery, and different technologies of machine and deep learning



JINR Digital EcoSystem (DES)

integrates existing and future services

to support

scientific,
administrative, and
social activities,
maintenance of the engineering
and IT infrastructures

to provide

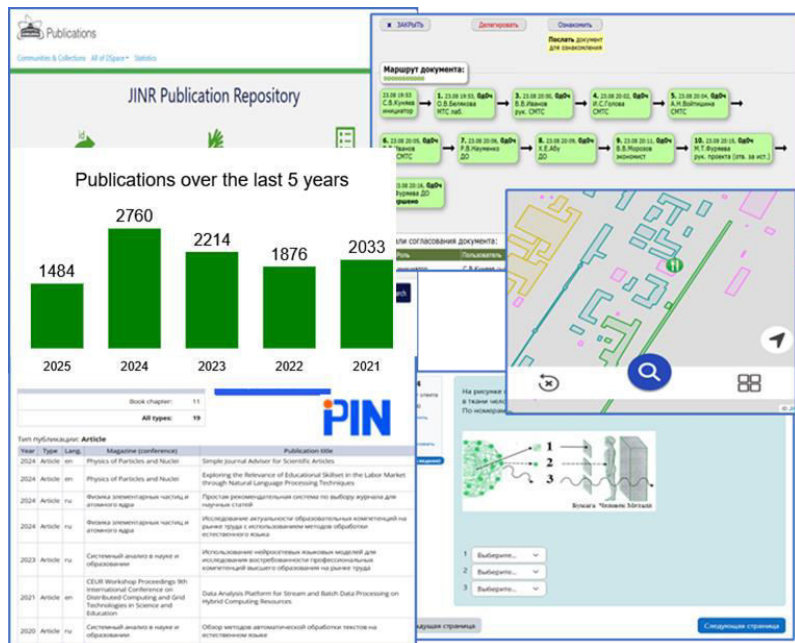
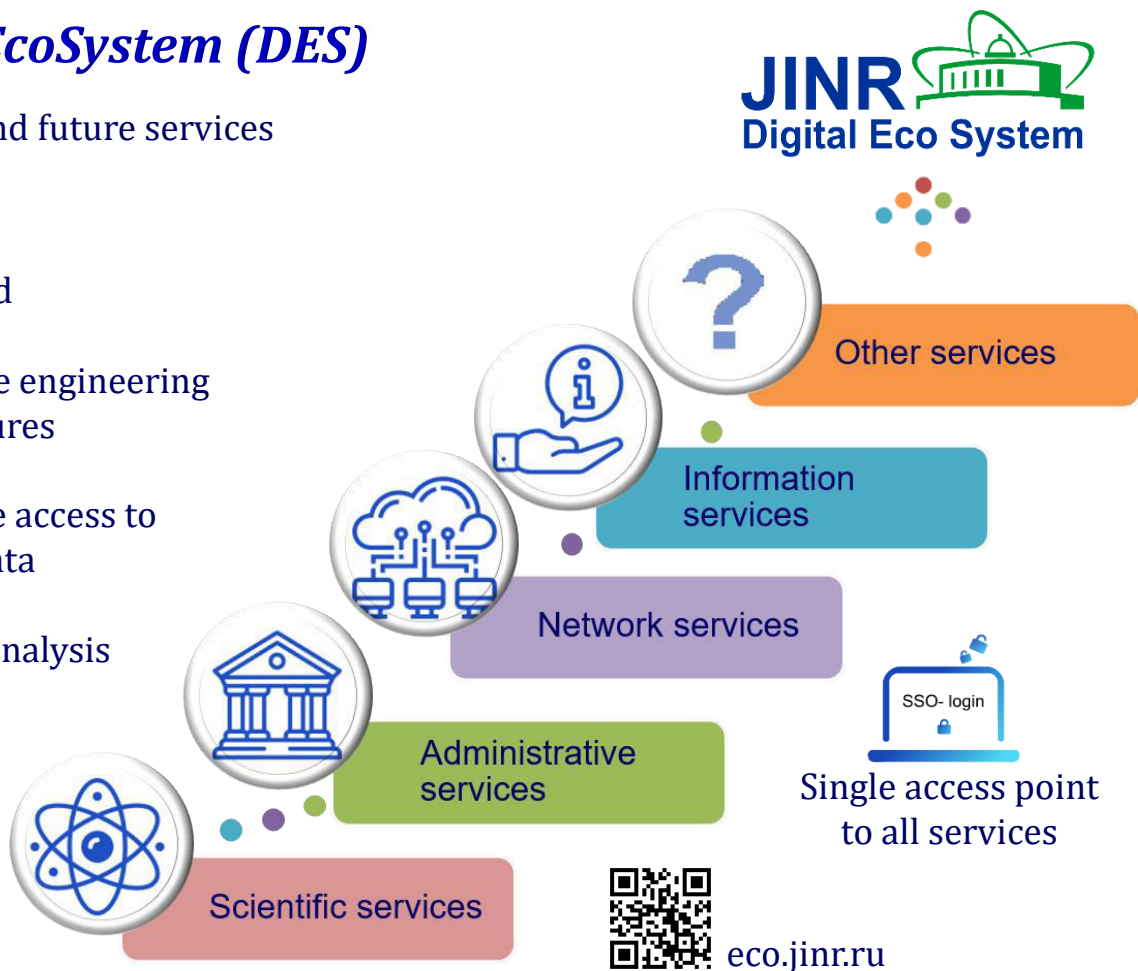
reliable and secure access to
various types of data

to enable

a comprehensive analysis
of information

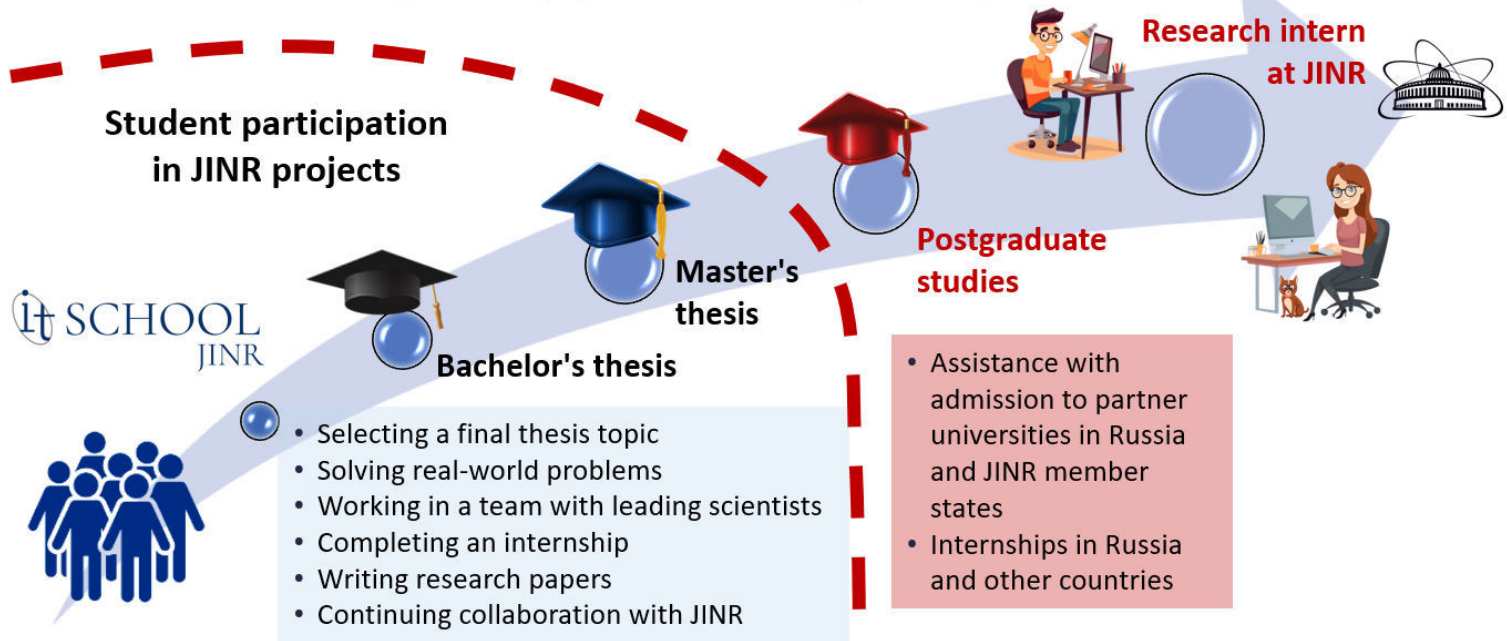
using

modern Big Data
technologies and
artificial
intelligence.



- Access to a comprehensive network of JINR's diverse information services
- Electronic document approval process, eliminating paperwork and office visits
- Access to all services through a single account
- Ability to initiate a request and obtain registration for the desired service
- Problem-free (seamless) switching of the user between various services included in the digital ecosystem
- Adaptive, user-customizable interface
- Easy access, convenient navigation, and information search
- Supports bilingualism: Russian and English
- Mobile version of the system

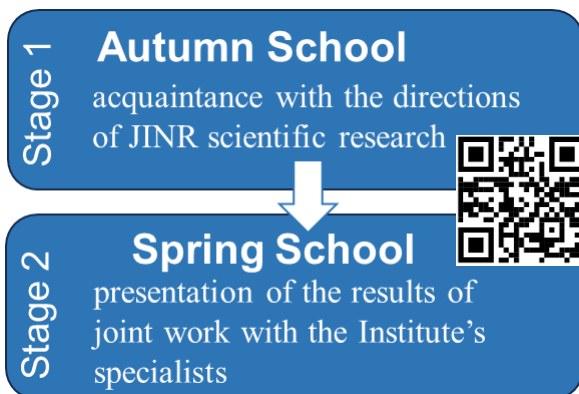
Educational Trajectory for Training IT Specialists



JINR School of Information Technologies

for Russian-speaking students

itschool.jinr.ru



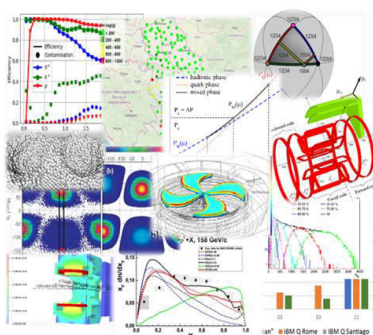
Involving young specialists in solving tasks that face JINR using high-performance and distributed computing, data analysis methods and algorithms, state-of-the-art information technologies

MSU Branch in Dubna

01/04/02 Applied mathematics and computer science

Head of the program: V. Korenkov

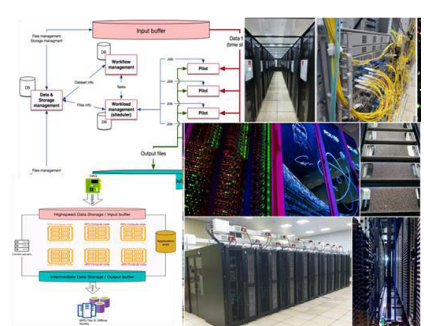
Master's program «Data Processing Methods and Technologies in Heterogeneous Computing Environments»



Mathematical modeling, numerical methods, and software packages



Deep machine learning and Big Data analytics



Computing (software and models) for megascience projects

International Conference “Distributed Computing and Grid Technologies in Science and Education”

- ✓ Distributed computing systems, grid and cloud technologies, storage systems
- ✓ Application software in HTC and HPC
- ✓ Computing for megascience projects
- ✓ Methods and technologies for experimental data processing
- ✓ Methods of artificial intelligence in life sciences



International Conference “Mathematical Modeling and Computational Physics”

- Mathematical methods and tools for modeling complex physical systems
- Mathematical methods in life sciences
- Modern methods for data processing and analysis in megascience projects
- Machine learning and Big Data analytics
- Methods of quantum computing and quantum information processing
- Numerical and analytical calculations in modern mathematical physics
- Methods and numerical algorithms in high-energy physics





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