Научная программа Лаборатории информационных технологий им. М.Г. Мещерякова ОИЯИ

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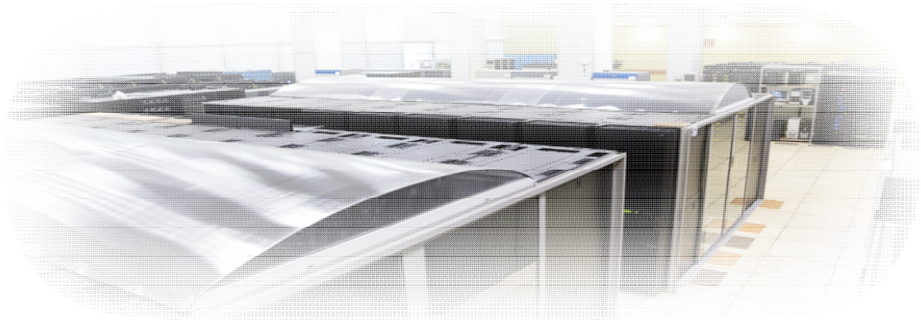
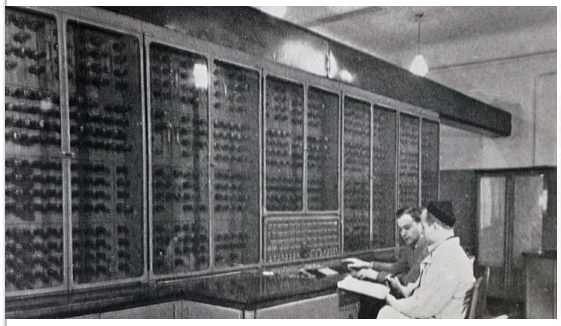


Осенняя школа по информационным технологиям ОИЯИ,
16-20 октября 2023 года, Дубна, ЛИТ ОИЯИ

Meshcheryakov Laboratory of Information Technologies

M.G. Mesheryakov
(17.09.1910 - 24.05.1994)



N.N. Govorun
(18.03.1930 - 21.07.1989)

Meshcheryakov Laboratory of Information Technologies of the Joint Institute for Nuclear Research in Dubna was founded in August 1966. The main directions of the activities at the Laboratory are connected with the provision of networks, computer and information resources, as well as mathematical support of a wide range of research at JINR.

MLIT today

Staff: 325
Scientists: 100
Doctors of Science: 24
Candidates of Science: 61
Campus network 2x100 Gbps
Multisite network 4x100 Gbps
Telecommunication channel 3x100 Gbps
Grid Tier1 and Tier2 for global data processing
JINR Cloud computing
JINR Member States' Cloud environment
"Govorun" supercomputer

MLIT Fundamentals:

* **Provide** IT services necessary for the fulfillment of the JINR Topical Plan on Research and International Cooperation
* **Building** world-class competence in IT and computational physics
* **24/7** support of computing infrastructure and services such availability is called nonstop service.

Информационные технологии

Крупный инфраструктурный проект
Многофункциональный информационно-вычислительный комплекс

Тема
1119: Методы, алгоритмы и программное обеспечение для моделирования физических систем, математической обработки и анализа экспериментальных данных

Активность
Многоцелевая программно-аппаратная платформа аналитики Больших данных

Активность
Цифровая экосистема ОИЯИ

Проект
Математические методы и программное обеспечение для моделирования, обработки и анализа экспериментальных данных

Проект
Методы вычислительной физики для исследования сложных систем

Активность
Интеллектуальное управление технологическими процессами и физическими установками в ОИЯИ и квантовые вычисления в квантовой химии и физике

Активность
Подготовка специалистов в области вычислительной физики и информационных технологий

Cooperation with All JINR Laboratories

Particle Physics and HEP

- NICA computing
- Methods and algorithms for data analysis
- Intelligent control systems
- …

Nuclear Physics

- Computations of the properties of atoms of superheavy elements
- Analysis of fine structures in the mass distribution of nuclear reaction products
- Sub-barrier fusion and fission reactions of heavy nuclei
- …

Information Technologies

(Scientific directions and information systems)

Life Science

- Information System for Radiation Biology tasks
- Analysis of Small-Angle scattering data from nanodrugs
- Environmental monitoring
- …

Theoretical Physics

- Calculations of lattice QCD
- Numerical simulation within effective theories of QCD
- Compton scattering
- …

Condensed Matter

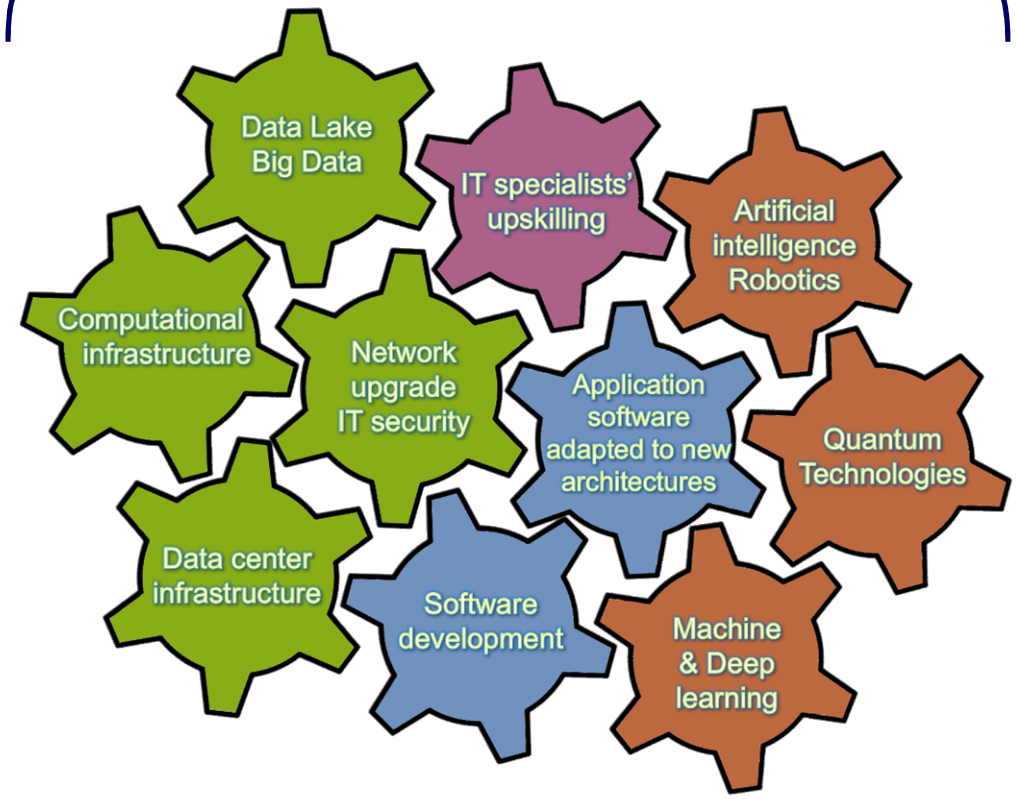
- Analysis of polydisperse populations of phospholipid vesicles
- Study of nanocomposite thin films using neutron and X-ray reflectometry methods
- Simulation of thermal processes occurring in materials
- …

Neutrino Physics and Astrophysics

- Support of the JINR neutrino program
- Data acquisition system software for Baikal-GVD
- …

Strategy for Information Technology and Scientific Computing at JINR

Scientific IT ecosystem:



Coordinated development of interconnected IT technologies and computational methods

It will be a **steady implementation/upgrades** of

- Networking (**Tb/s** range),
- Computing infrastructure within the Multifunctional Information & Computing Complex (MICC) and
- "Govorun" Supercomputer,
- Data center infrastructure,
- Data Lake & long-term storage

for all experiments.

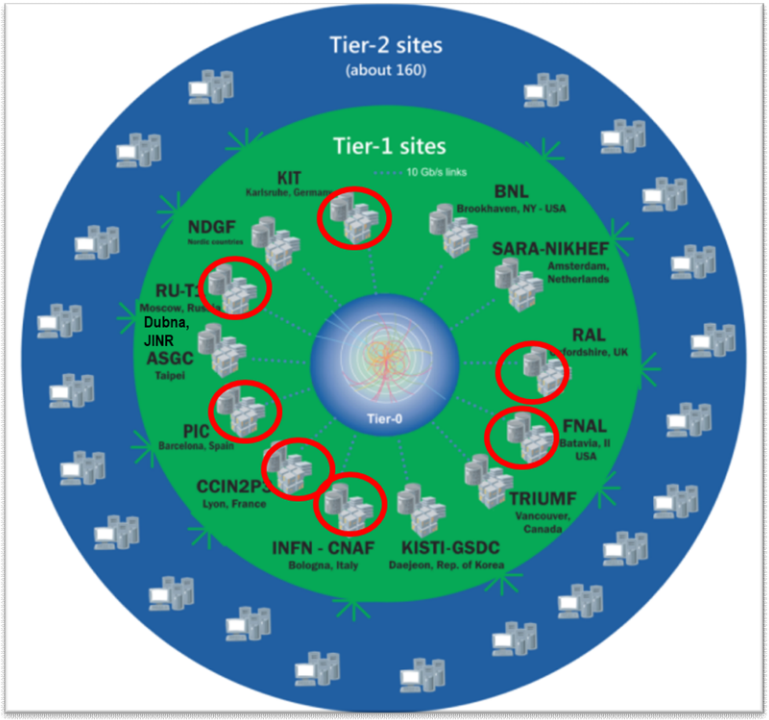
The **development of new data processing and analysis algorithms** based on

- ML/DL,
- Artificial intelligence,
- Big Data
- Quantum technologies.

A variety of means will be used for IT specialists' upskilling.

The Worldwide LHC Computing Grid

WLCG: an International collaboration to distribute and analyse LHC data. Integrates computer centres worldwide that provide computing and storage resource into a single infrastructure accessible by all LHC physicists



The mission of the WLCG project is to provide global computing resources to store, distribute and analyze the ~50-70 Petabytes of data expected every year of operations from the Large Hadron Collider.

WLCG computing enabled physicists to announce the discovery of the Higgs Boson.

- **170 sites**
- **42 countries**
- **> 12k physicists**
- **~1.4 M CPU cores**
- **1.5 EB of storage**
- **> 2 million jobs/day**
- **100-250 Gb/s links**

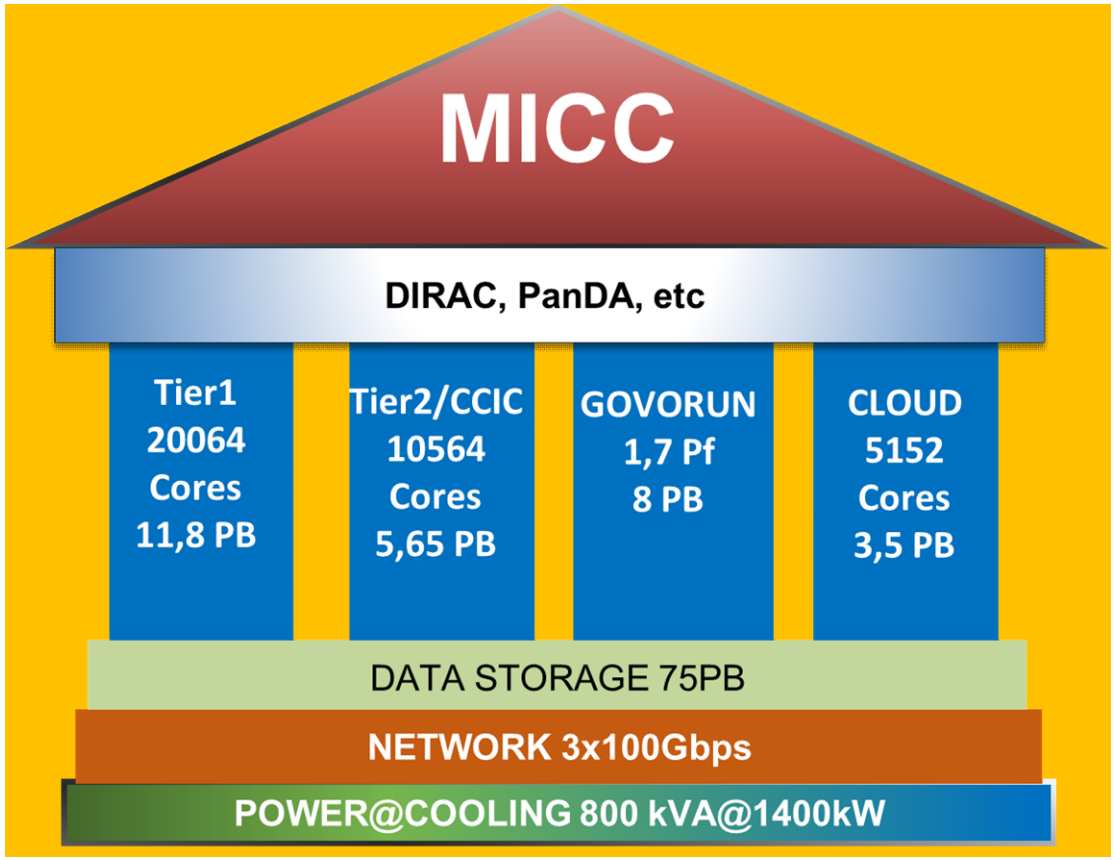
Worldwide LHC Computing Grid - 2019

Tier0 (CERN): data recording, reconstruction and distribution

Tier1: permanent storage, re-processing, analysis

Tier2: Simulation, end-user analysis

Multifunctional Information and Computing Complex (MICC)



4 advanced software and hardware components

- Tier1 grid site
- Tier2 grid site
- hyperconverged “Govorun” supercomputer
- cloud infrastructure

Distributed multi-layer data storage system

- Disks
- Robotized tape library

Engineering infrastructure

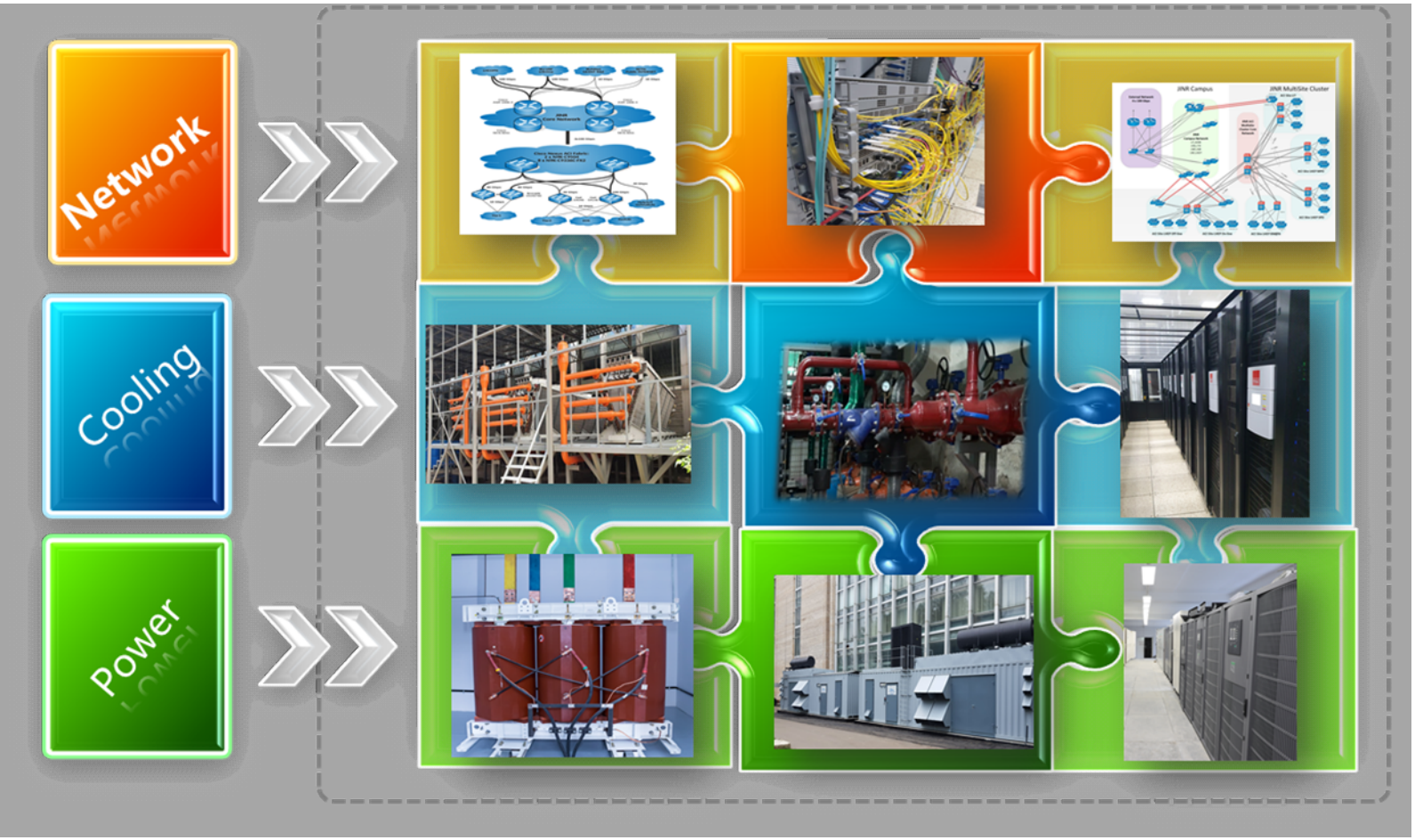
- Power
- Cooling

Network

- Wide Area Networkr
- Local Area Network

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

MICC Power @ Cooling @ Network



Wide Area Network 3x100 Gbps
Cluster Backbone 4x100 Gbps
Campus Backbone 2x100 Gbps

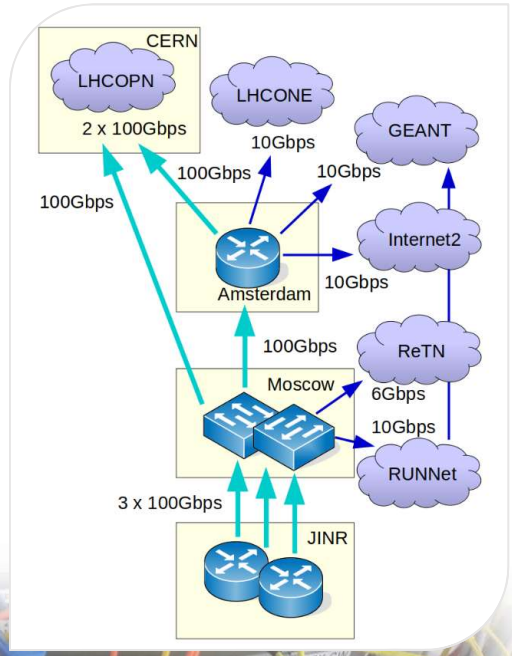
Dry chillers
InRow systems
Total cooling 1400 kW

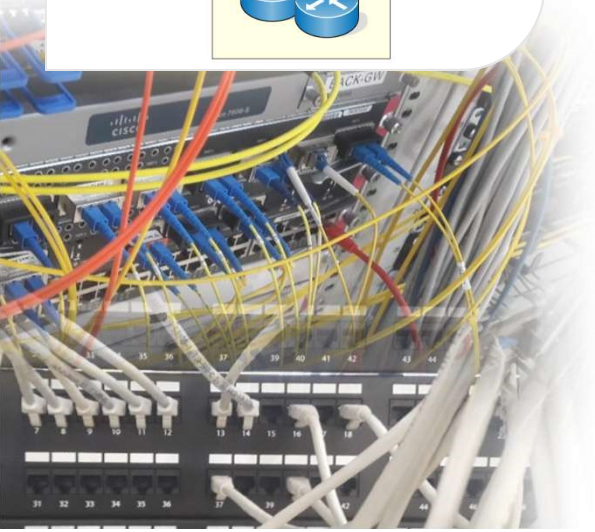
Uninterruptible power supplies
8 x 300 kVA
Diesel-generator units (DGU)
2x1500 kVA
Transformers2x2500 kVA

Engineering Infrastructure

- ✓ Power supply expansion
- ✓ New cooling system for the MICC machine hall
- ✓ 100% “hot water” cooling system of the “Govorun” supercomputer
- ✓ Guaranteed power supply using diesel generators and uninterruptible power supplies

Networking





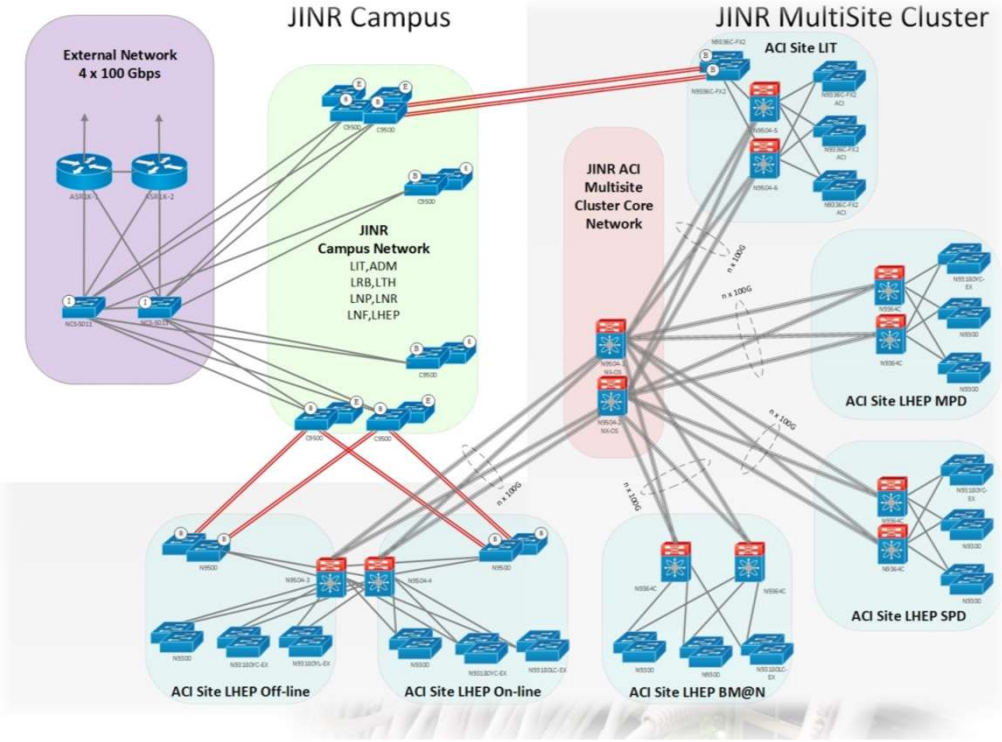
- JINR-Moscow 3x100 Gbit/s
- JINR-CERN - 100 Gbit/s and JINR-Amsterdam 100 Gbit/s for LHCOPN, LHCONE, GEANT networks
- Direct channels up to 100 Gbit/s for communication using RU-VRF technology with the collaboration of RUHEP research centers and with Runnet, ReTN networks
- The multi-site cluster network with a bandwidth 4x100 Gbit/s between VBLHEP and MLIT

The JINR LAN comprises:

9291 network elements
18044 IP-addresses
6355 users registered within the network
4477 *.jinr.ru service users
1455 digital library users
837 remote VPN
111 EDUROAM users

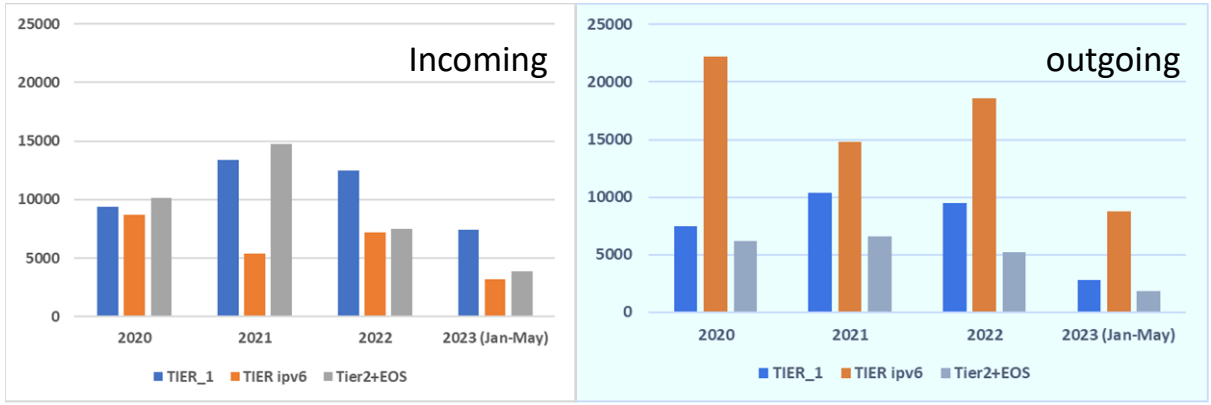
network traffic in 2022

- 29.56 PB - input
- 34.19 PB - output

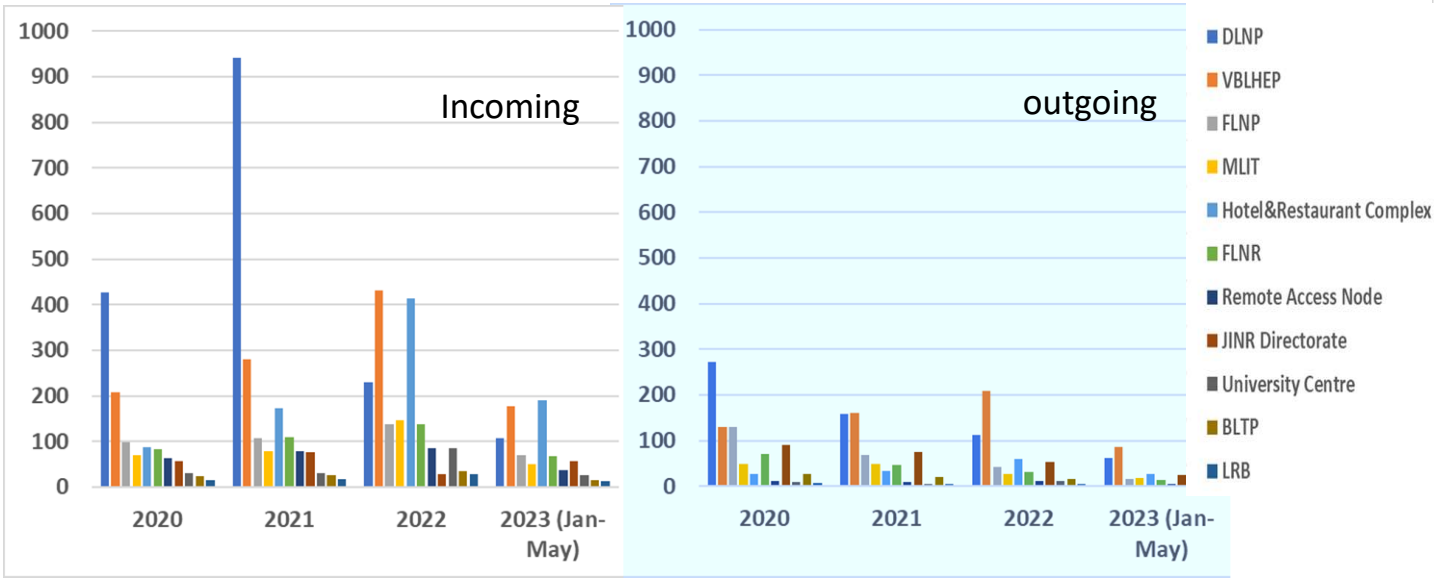


Networking @ Traffic

Distribution of the incoming and outgoing traffics by the JINR MICC in 2020-2023 (TB)

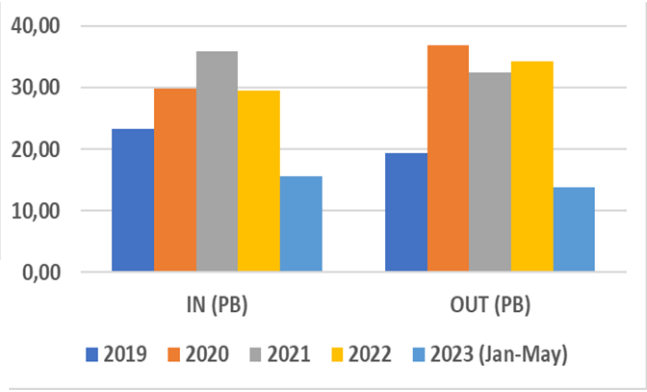


Distribution of the incoming and outgoing traffics by the JINR Subdivisions in 2020-2023 (TB)



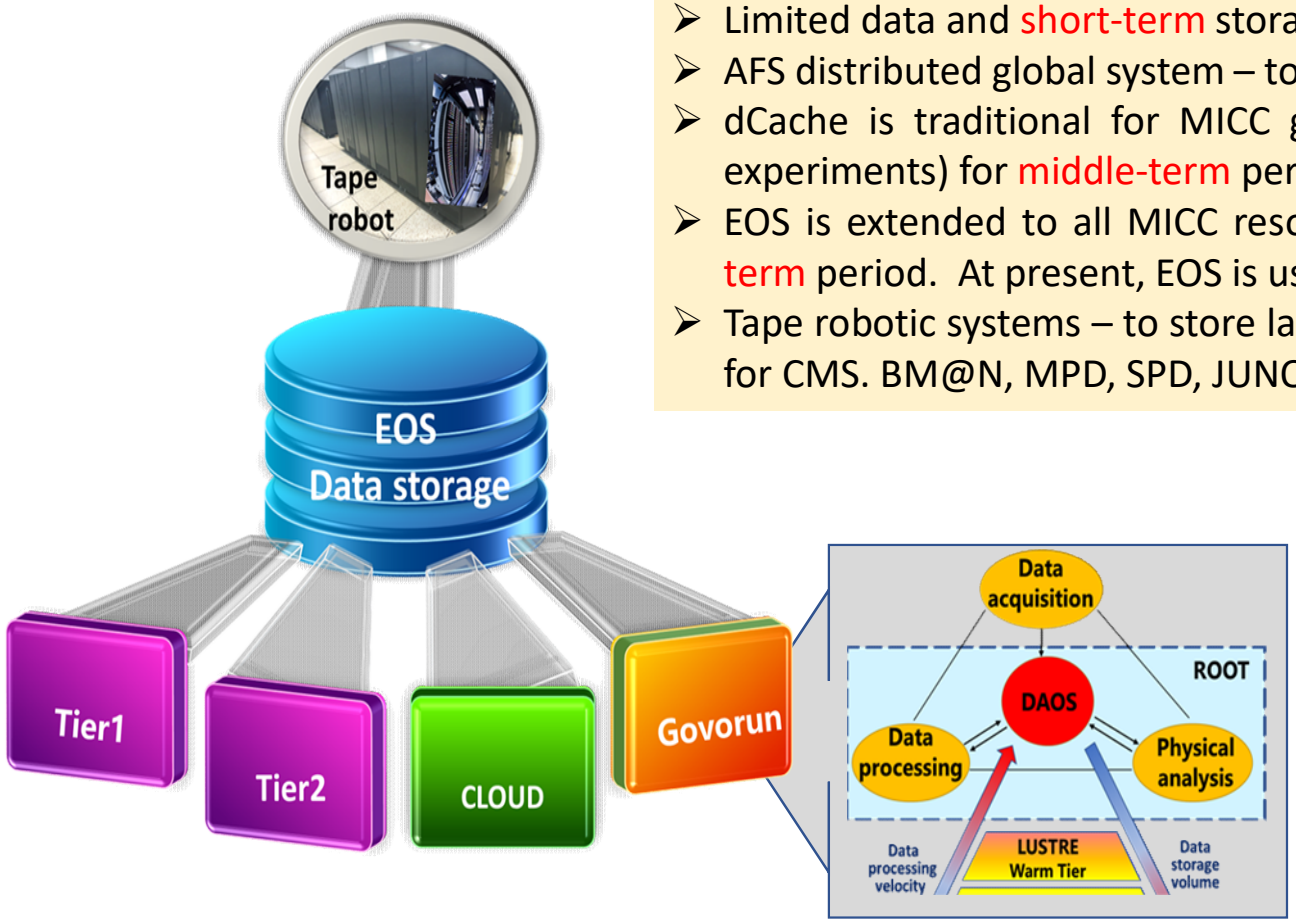
Wide Area Network 3x100 Gbps
Cluster Backbone 4x100 Gbps
Campus Backbone 2x100 Gbps

JINR Traffic in PB



Users - 6353
Network elements - 9327
IP addresses - 18163
Remote access - 911
E-library- 1464
VOIP - 121
EDUROAM - 116
Email @jinr.ru - 4579

Distributed Multilayered Data Storage System



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

Special 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 there are next layers:

- ✓ very hot data (DAOS (Distributed Asynchronous Object Storage)) ,
- ✓ the most demanded data (fastest access),
- ✓ hot data
- ✓ warm data (LUSTRE).

JINR Tier1 for CMS (LHC) and NICA

- 20096 cores
- 360 kHS06
- 14 PB disks
- 50.6 PB tapes
- 100% reliability and availability

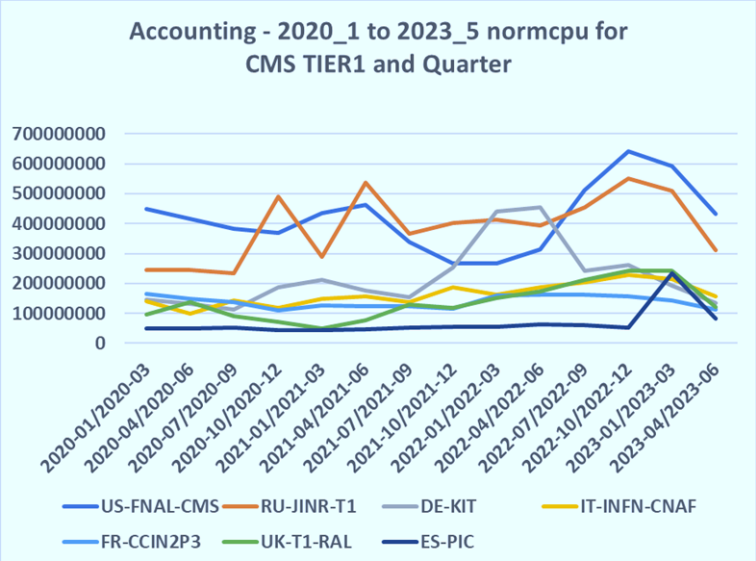
Since the beginning of 2015, a full-scale WLCG Tier1 site for the CMS experiment has been operating at MLIT JINR.

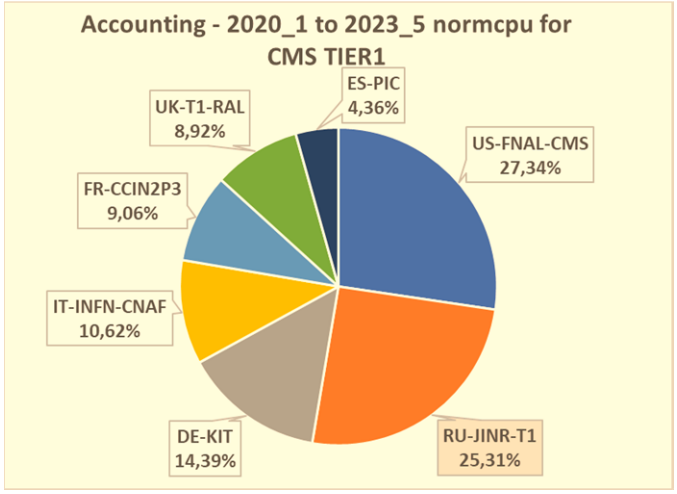
The importance of developing, modernizing and expanding the computing performance and data storage systems of this center is dictated by the research program of the CMS experiment, in which JINR physicists take an active part within the RDMS CMS collaboration.

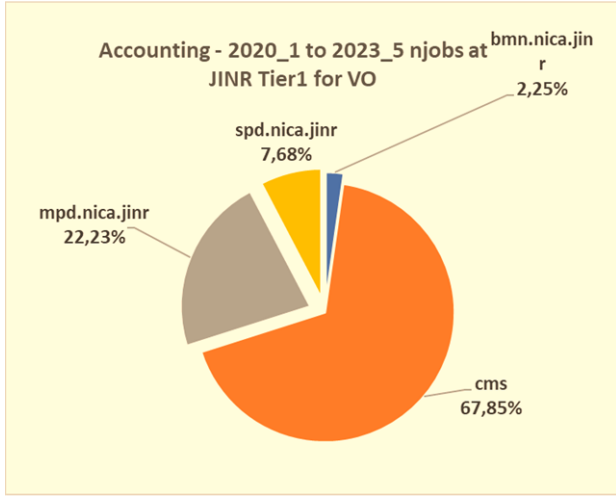
The JINR Tier1 is regularly ranked on top among world Tier1 sites that process data from the CMS experiment at the LHC.

Since 2021 the JINR Tier1 center has demonstrated stable work not only for CMS (LHC), but also for NICA experiments.

2020-2023

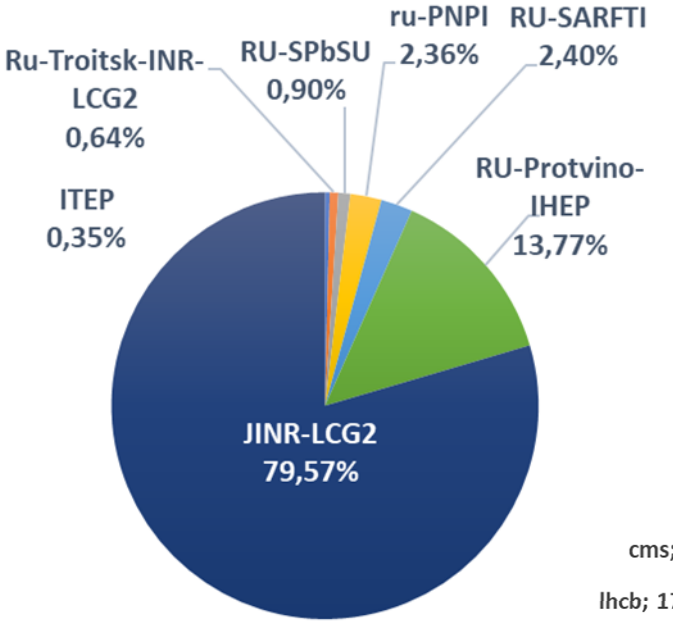






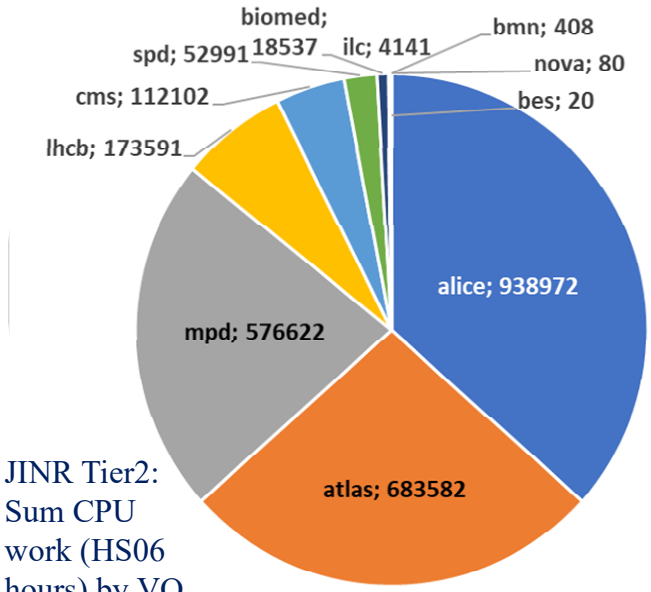
Tier2 at JINR

Tier2 at JINR provides computing power and data storage and access systems for the majority of JINR users and user groups, as well as for users of virtual organizations (VOs) of the grid environment (LHC, NICA, FAIR, etc.).



RDIG: distribution by the number of jobs by websites of organizations (year 2022)

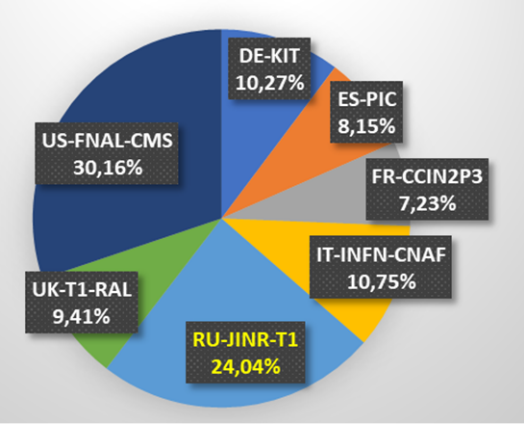
JINR Tier2 is the most productive in the Russian Data Intensive Grid (RDIG) Federation.



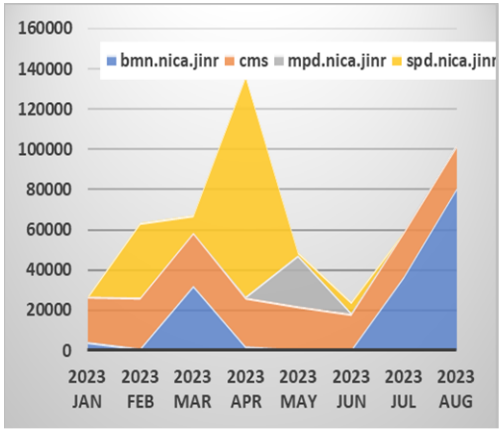
JINR Tier2: Sum CPU work (HS06 hours) by VO (year 2022)

MICC – Grid Infrastructure and DIRAC

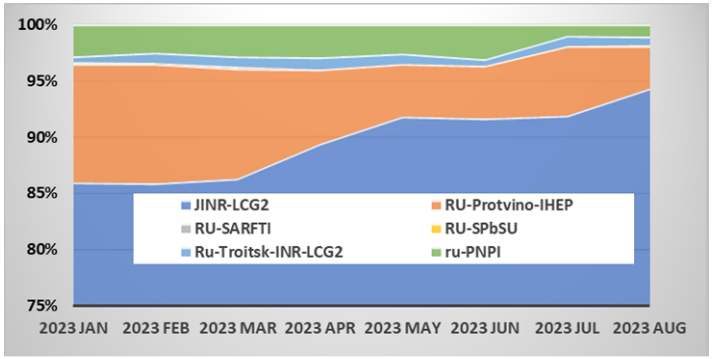
In 2023, the JINR Tier1 site for CMS is ranked second (24%) among Tier1 world centers for CMS. JINR Tier1 is also used for the MPD, BM@N and SPD experiments.



Distribution by CPU Work (HS23 hours) among CMS Tier1 worldwide



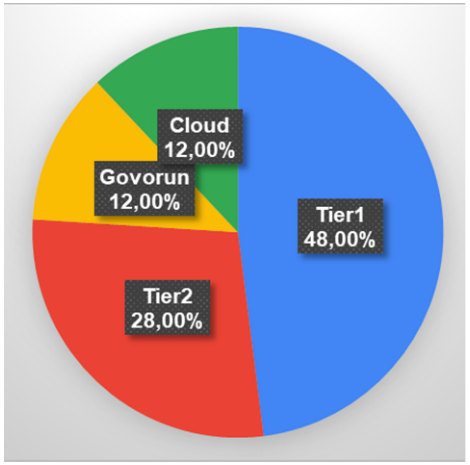
Distribution by the number of jobs completed on Tier1 by CMS, BM@N, MPD and SPD



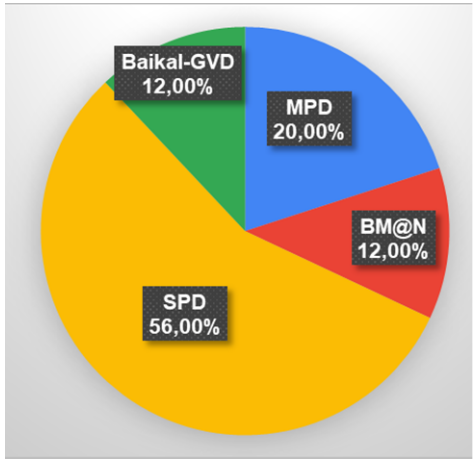
The JINR Tier2 output is the highest (89.3%) in the Russian Data Intensive Grid.

In 2023, DIRAC is the only system that includes all key MICC components. DIRAC serves as an intermediate layer between users and various computing resources, ensuring their efficient, transparent and reliable use, providing a common interface to heterogeneous resources.

At the moment, DIRAC is used to support the collaborations of the NICA experiments: MPD, BM@N and SPD, as well as the Baikal-GVD neutrino telescope.



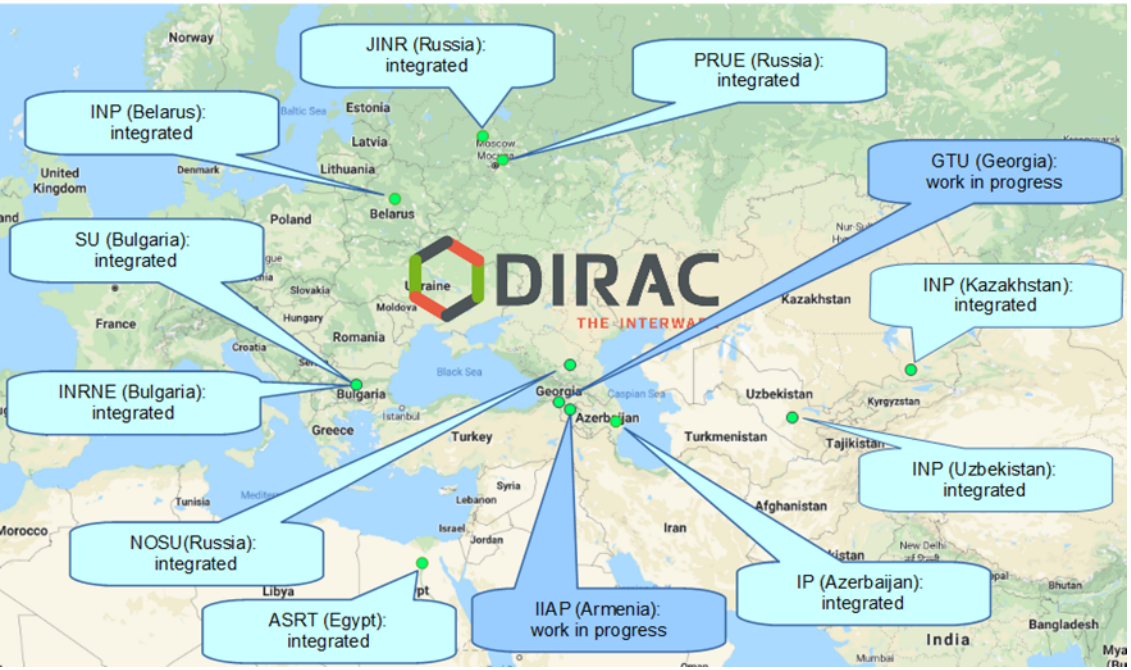
Distribution by the normalized CPU time among the MICC components: Tier1, Tier2, Cloud and Govorun for jobs sent via DIRAC in 2023



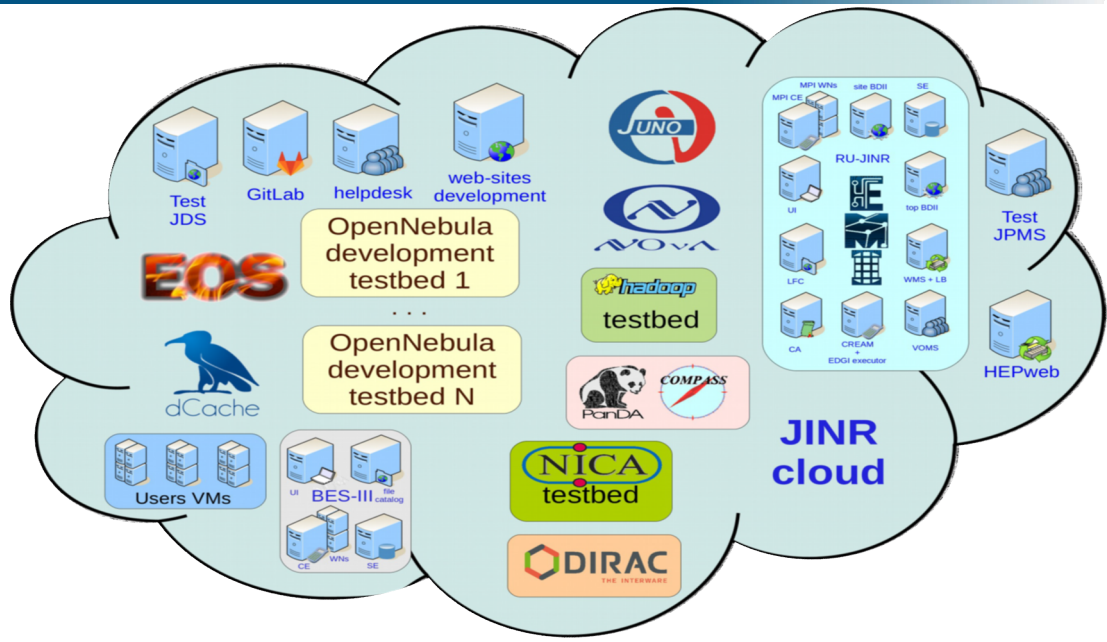
Distribution by the normalized CPU time among MPD, BM@N, SPD and Baikal-GVD for jobs sent via DIRAC in 2023

Cloud Infrastructure

- Cloud Platform - OpenNebula
- Virtualization - KVM
- Storage (Local disks, Ceph)
- Total Resources
  ~ 5,000 CPU cores; 60 TB RAM;
  3.5 PB of raw ceph-based storage



DIRAC-based distributed information and computing environment (DICE) that integrates the JINR Member State organizations' clouds



- VMs for JINR users
- Computational resources for neutrino experiments
- Testbeds for research and development in IT
- COMPASS production system services
- Data management system of the UNECE ICP Vegetation
- Scientific and engineering computing
- Service for data visualization
- Gitlab and some others

Development of the heterogeneous HybriLIT platform

Cluster HybriLIT 2014:
Full peak performance:
50 TFlops for double precision

#18 в Top50
"Govorun" supercomputer
First stage 2018:
Full peak performance :
500 TFlops for double precision
9th in the current edition of the IO500 list (July 2018)

#10 в Top50
"Govorun" supercomputer
Second stage 2019:
Full peak performance :
860 TFlops for double precision
288 ТВ ССХД with I/O speed >300 Gb/s
17th in the current edition of the IO500 list (July 2020)

Russian DC Awards 2020 in "The Best IT Solution for Data Centers"

"Govorun" supercomputer modernization in 2022 - 2023

GPU-accelerator | Hyperconverged CPU and Distributed Storage Nodes

\+ 40 NVIDIA A100 GPU accelerators
Performance: + 600 Tflops DP

+32 hyperconverged compute nodes
+2 432 new computational cores
Performance: +239 Tflops DP
Performance “new cores”/”old cores” increase more than 1,5 times

+8 distributed storage nodes
Lustre, EOS increase: +8 PB
DAOS increase: +1.6 PB
+0,4 PB for the MPD mass production storages integrated into the DIRAC File Catalog
+1 PB for the MPD EOS storage

\+

5 servers with 8 NVidia A100 GPUs in each

\+

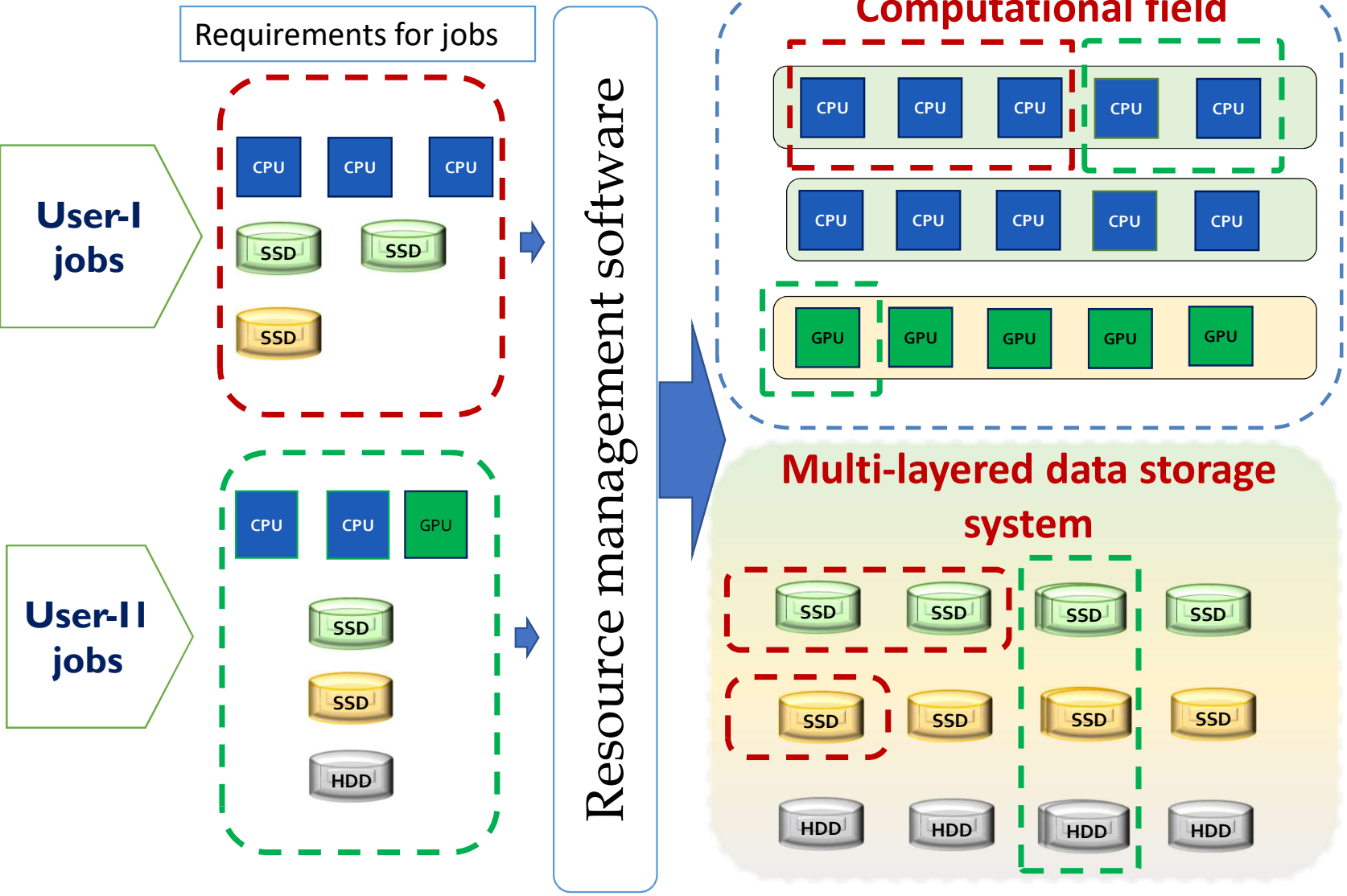
Computation field:
+32 hyperconverged compute nodes

\+

Hierarchical Storage:
+8 distributed storage nodes

SC “Govorun” total peak performance: 1.7 PFlops DP
Total capacity of Hierarchical Storage: 8.6 PB
Data IO rate: 300 Gb/s

Orchestration and hyperconvergence on the “Govorun” supercomputer



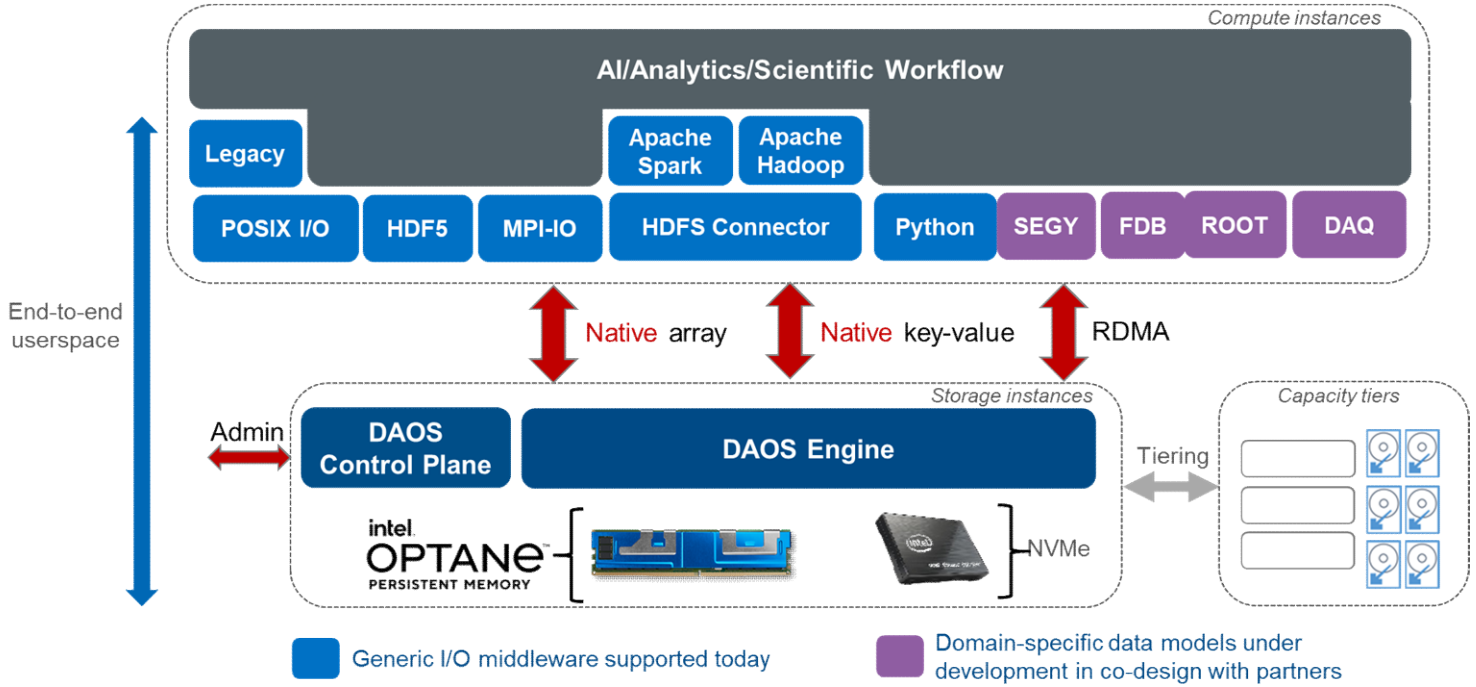
The “Govorun” supercomputer has unique properties for the flexibility of customizing the user’s job.

For his job the user can allocate the required number and type of computing nodes and the required volume and type of data storage systems.

This property enables the effective solution of different tasks, which makes the “Govorun” supercomputer a unique tool for research underway at JINR.

DAOS: Promising technology for HPC, Big Data, AI

DAOS (Distributed Asynchronous Object Storage) Software Ecosystem

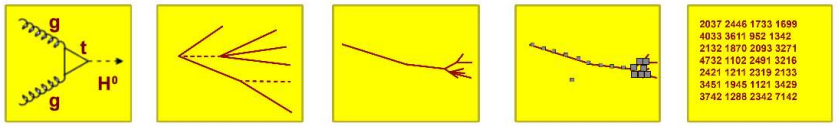


- Complex approach to build a hierarchical storage system
- DAOS is significant part of data acquisition and processing
- Different types of containers are used for different data processing stages
- No need of POSIX file system for most data operations
- Great system performance even for a few DAOS clients
- RSC Storage on-Demand software offers unique flexibility, speed, and convenience for DAOS users

The DAOS polygon on the supercomputer “Govorun” take the 1st place among Russian supercomputers in the current IO500 list

HEP experiments data flow

From Physics to raw data



Basic physics

Fragmentation, Decay

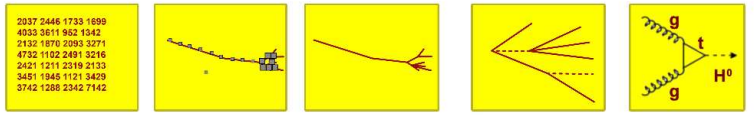
Interaction with detector material
Multiple scattering, interactions

Detector response
Noise, pile-up, cross-talk, inefficiency, ambiguity, resolution, response function, alignment

Raw data

Read-out addresses, ADC, TDC values, Bit patterns

From raw data to Physics



Raw data

Convert to physics quantities

Detector response
Apply calibration, alignment

Interaction with detector material
Pattern, recognition, Particle identification

Fragmentation, Decay
Physics analysis

Basic physics

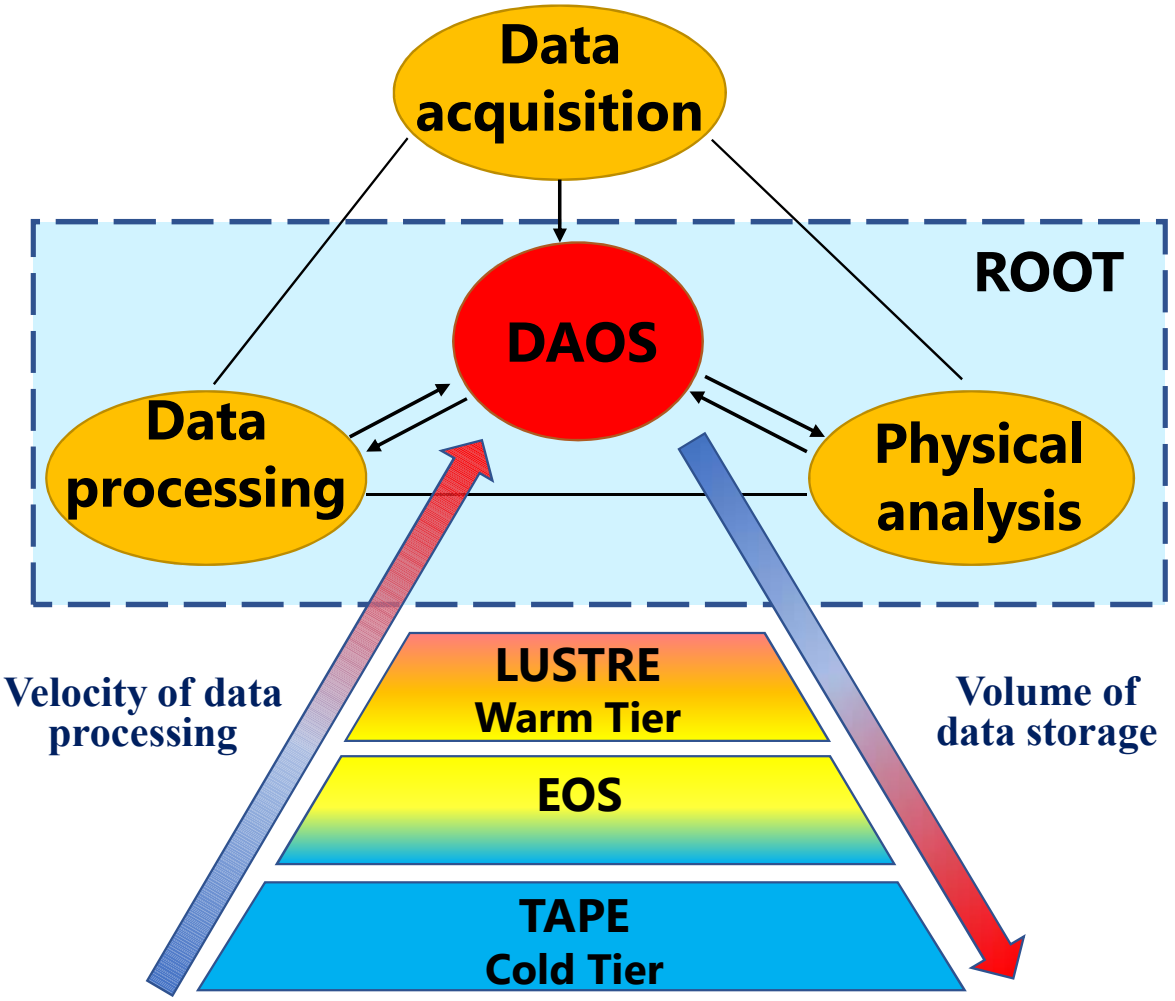
Results

Reconstruction

Analysis

Simulation (Monte-Carlo)

We need to go from raw data back to physics reconstruction + analysis of the event(s)



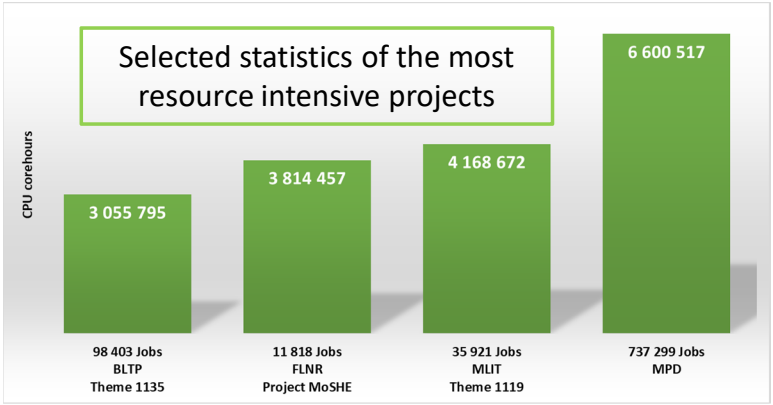
Using of the “Govorun” Supercomputer for JINR task in 2022

The projects that mostly intensive use the CPU resources of the “Govorun” supercomputer:

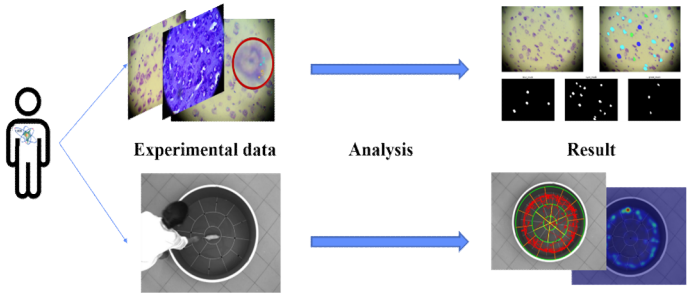
- NICA megaproject,
- simulation of complex physical systems,
- computations of the properties of atoms of superheavy elements,
- calculations of lattice quantum chromodynamics.

The GPU-component is activle used for solving applied problems by neural network approach:

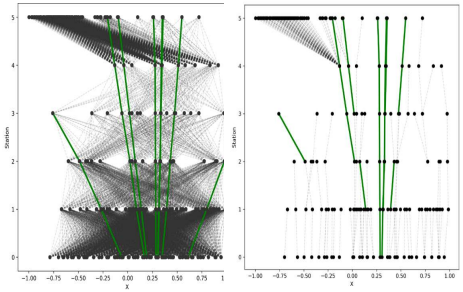
- process data from experiments at LRB,
- data processing and analysis at the NICA accelerator complex and ect.



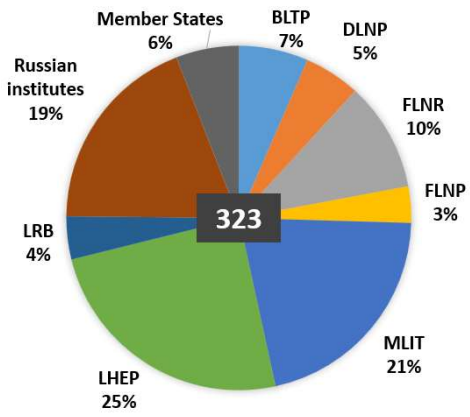
During 2022, **890 911** jobs were performed on the **CPU** component of the “Govorun” supercomputer, which corresponds to **18 543 076** core hours.



Information System for Radiation Biology Tasks



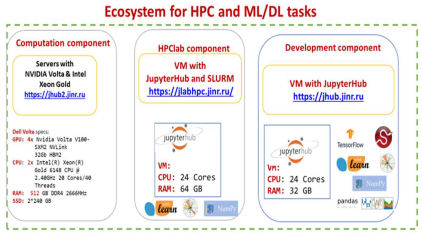
Neural network for data analysis



The resources of the “Govorun” spercomputer are used by scientific groups from all the Laboratories of the Institute within **25 themes** of the JINR Topical Plan.

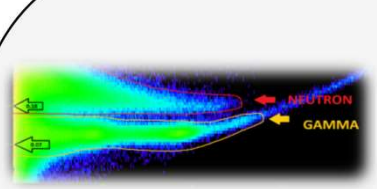
Development of tools and services for users of the “Govorun” supercomputer

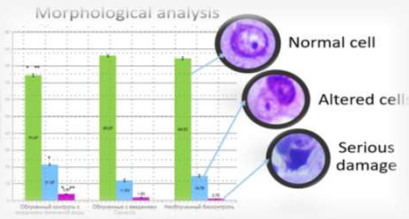
Ecosystem for Supercomputer Modeling

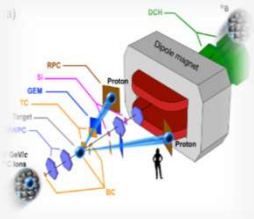


Ecosystem for Machine/Deep Learning

Ecosystem for Applied Computations





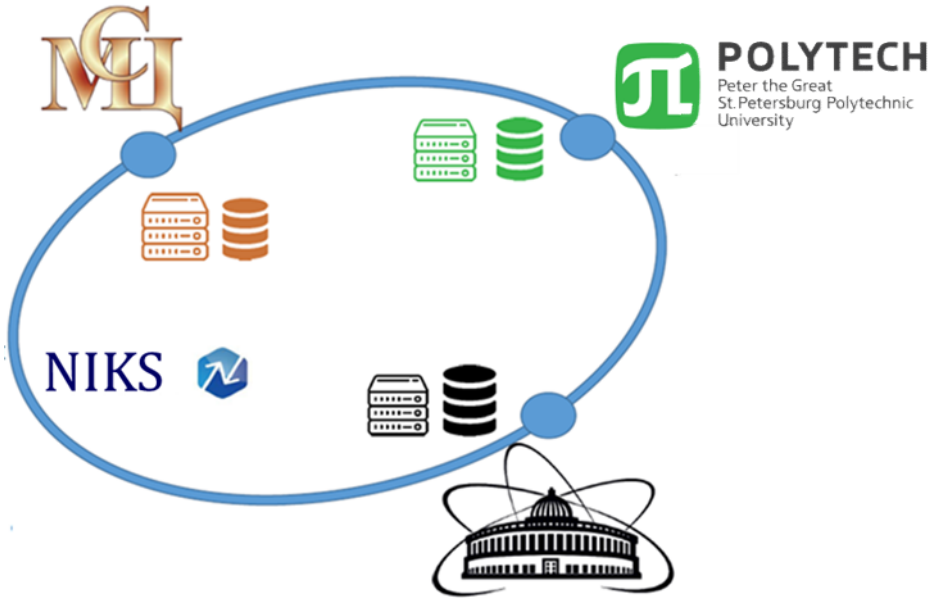


RESEARCH ENVIRONMENT FOR SOLVING RESOURCE-INTENSIVE TASKS OF JINR:

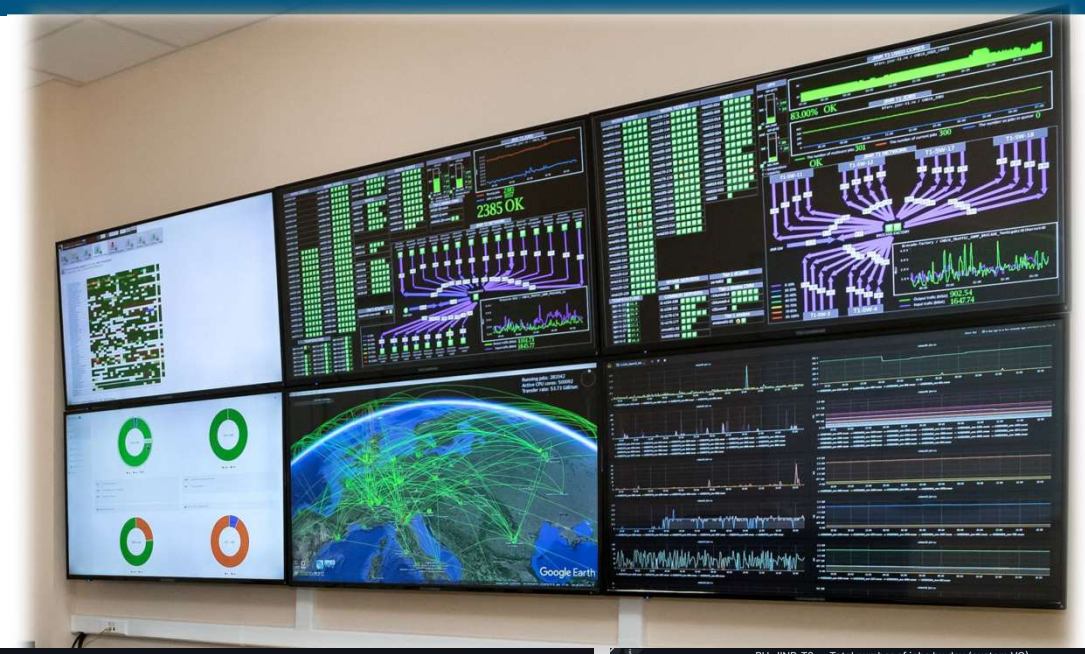
- Parallel computing
- ML/DL/AI tasks
- Quantum computing
- Tools for data analysis and visualization
- Calculations on application packages
- Web services for application programs
- Training courses

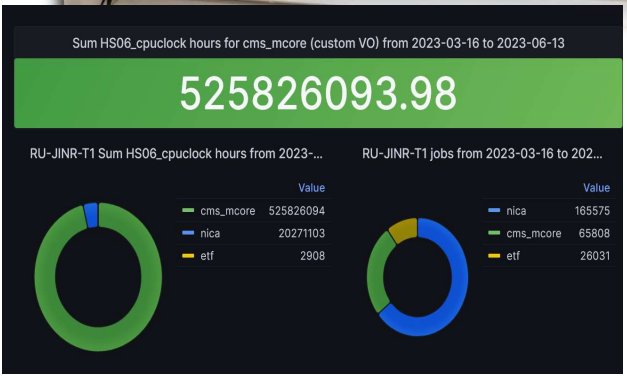
Unified Scalable Supercomputer Research Infrastructure

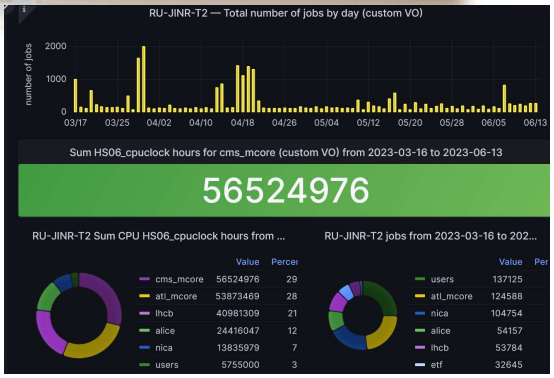
Based on the integration of the supercomputers of JINR, of the Interdepartmental Supercomputer Center of the Russian Academy of Sciences and of Peter the Great St. Petersburg Polytechnic University, a unified scalable supercomputer research infrastructure based on the National Research Computer Network of Russia (NIKS) was created. Such an infrastructure is in demand for the tasks of the NICA megaproject.



MICC Monitoring @Accounting







❖ **3 monitoring servers**

❖ **About 1800 nodes**

❖ **About 16000 service checks**

The successful functioning of the computing complex is ensured by the monitoring system of all MICC components/ We must

- 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),
- to account every user job at every MICC component? account

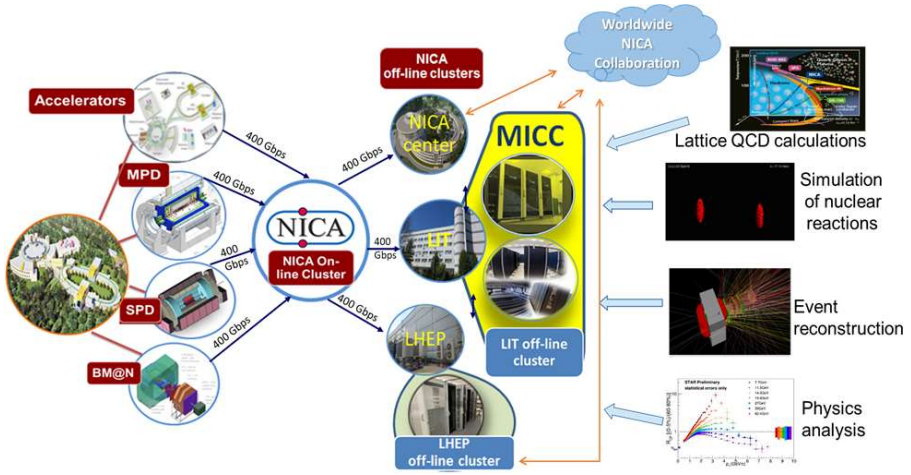
We must to develop intelligent systems that will enable to detect anomalies in time series on the basis of training samples, which will result in the need to create a special analytical system within the monitoring system to automate the process.

Development of the NICA Information and Computer Complex

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.

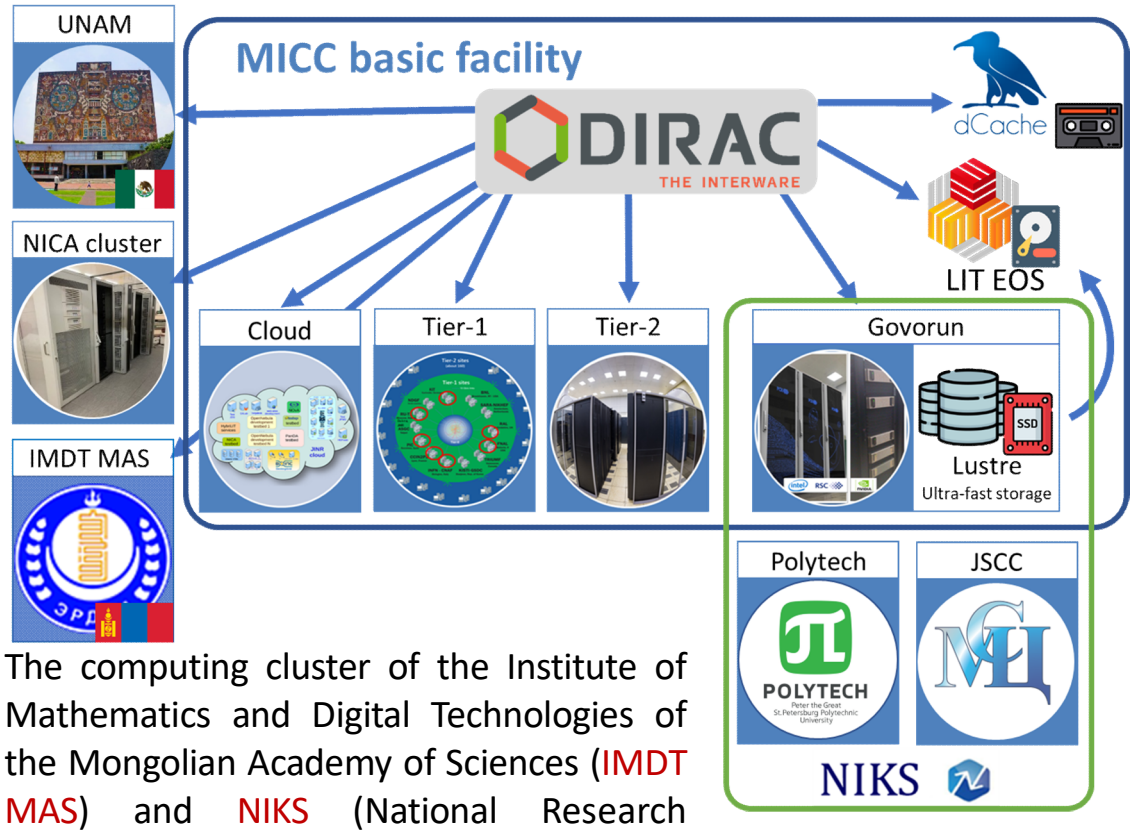
The information and computer unit of the NICA complex embraces:

1. **online NICA cluster**,;
2. **offline NICA cluster at VBLHEP**,
3. **all MICC components** (Tier0, Tier1, Tier2, “Govorun” supercomputer, cloud computing);
4. multi-layer **data storage system**
5. **distributed computing network**

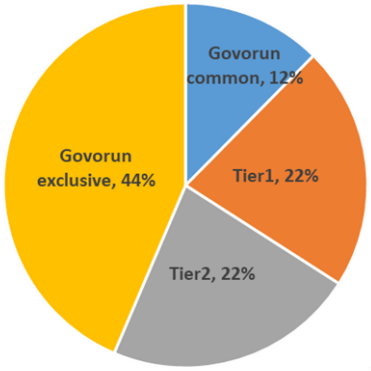


NICA Tier 0,1,2	2024	2025	2026	2027	2028	2029	2030
CPU (PFlops)	2.2	2.6	8.6	8.6	15.6	15.6	15.6
DISK (PB)	17	24	47	75	96	119	142
TAPE (PB)	45	88	170	226	352	444	536
NETWORK (Gbps)	400	400	800	800	800	1000	1000

Heterogeneous distributed computing environment

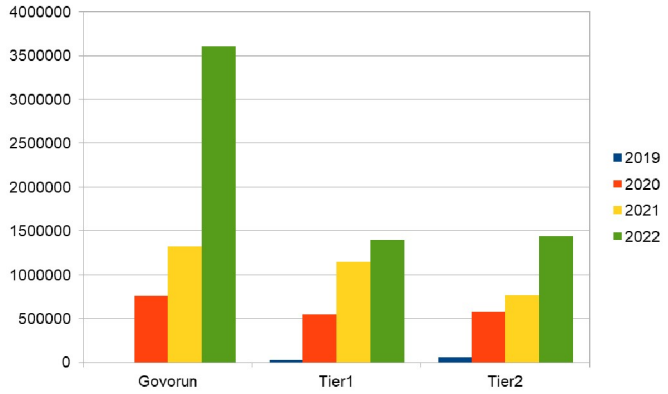


The computing cluster of the Institute of Mathematics and Digital Technologies of the Mongolian Academy of Sciences (IMDT MAS) and NIKS (National Research Computer Network, the Russia's largest research and education network) were integrated into the heterogeneous distributed environment based on the DIRAC platform.



Share of the use of different MICC components for MPD tasks in 2022: the SC "Govorun" resources are the most efficient for MPD tasks.

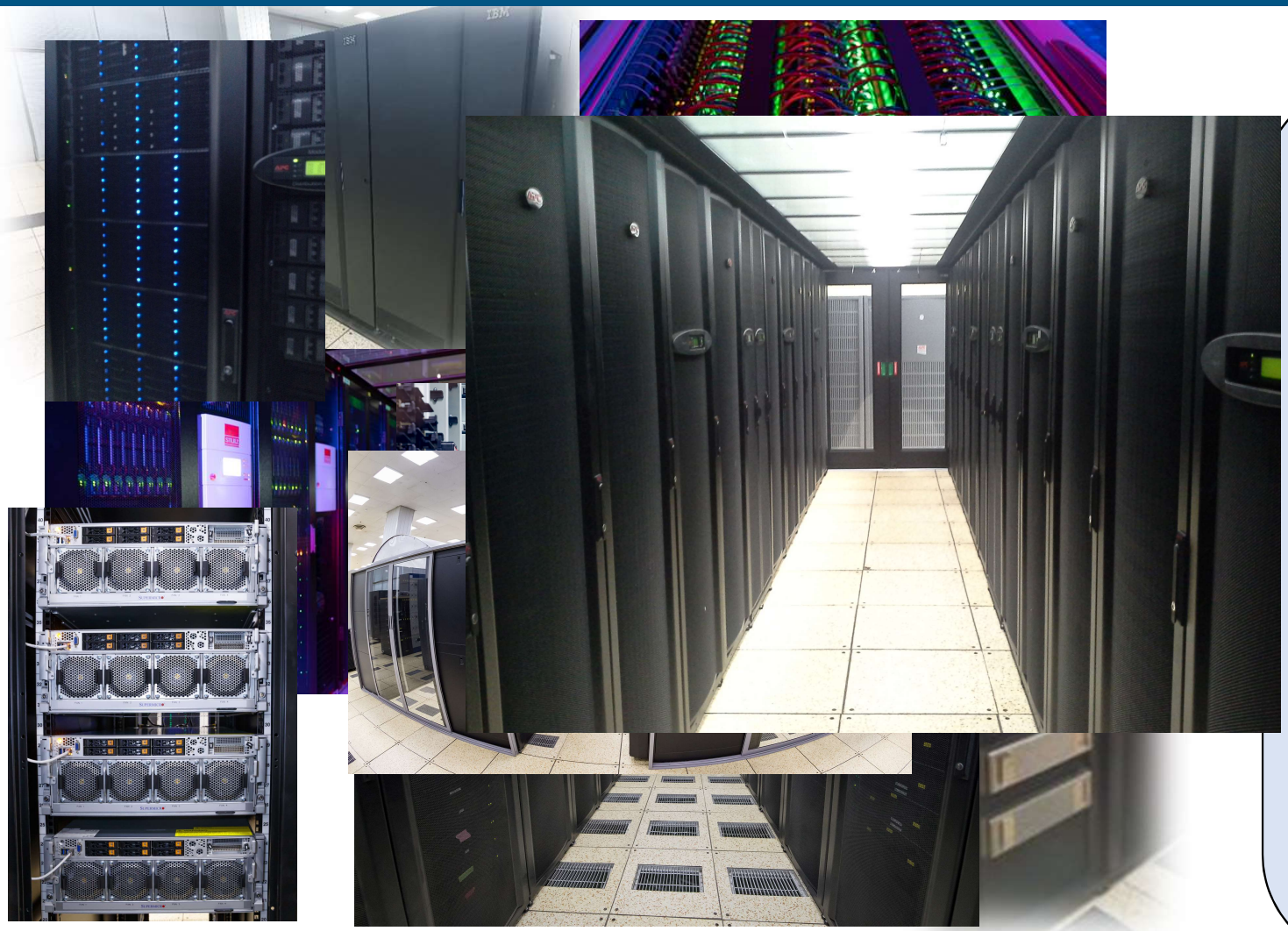
Increase in the share of the MICC computing resources on the DIRAC platform in normalized CPU HEP-SPEC06 days



Summary statistics of using the DIRAC platform for MPD tasks in 2019-2022

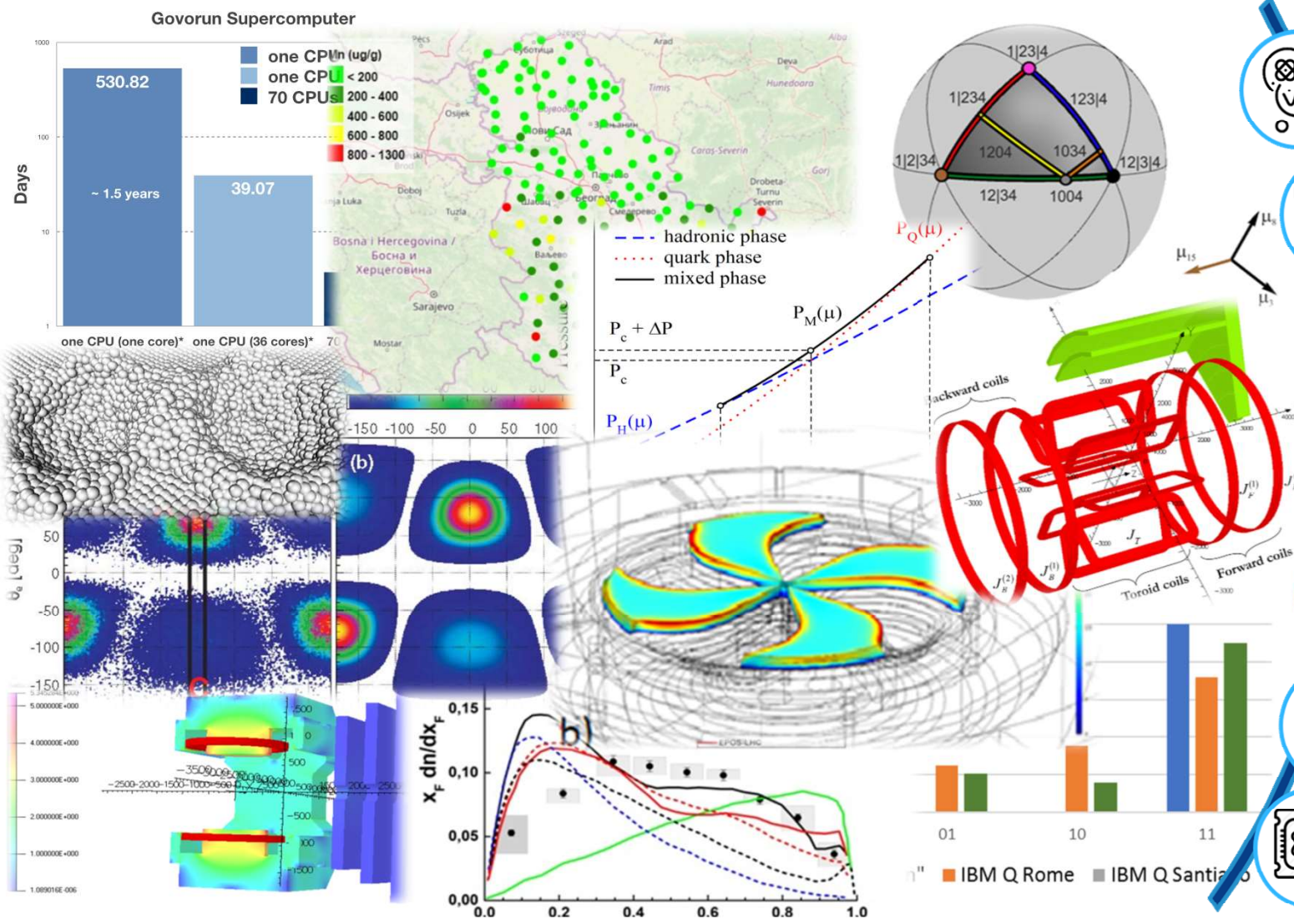
31	1.283 B	440M	1.5M	1557 years	1.3 PB
data generation campaigns	events generated	events reconstructed	jobs completed	total computation time	MPD data produced

MICC Resources Development



- ✓ Increase in computing resources of Tier1 up to **50 000 cores**
- ✓ Increase in computing resources of Tier2 up to **170 kHS06**
- ✓ Expansion of the storage system of Tier1 on disks up to **16 PB**
- ✓ Expansion of the MICC storage system on EOS up to **60 PB**
- ✓ Increase in CLOUD total recourses up to **11000** cores, ~**7PB** storage, ~7 TB **RAM**
- ✓ Year by year increase “Govorun” performance

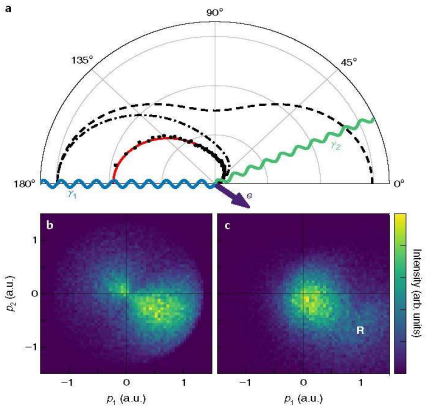
Methods, Algorithms and Software

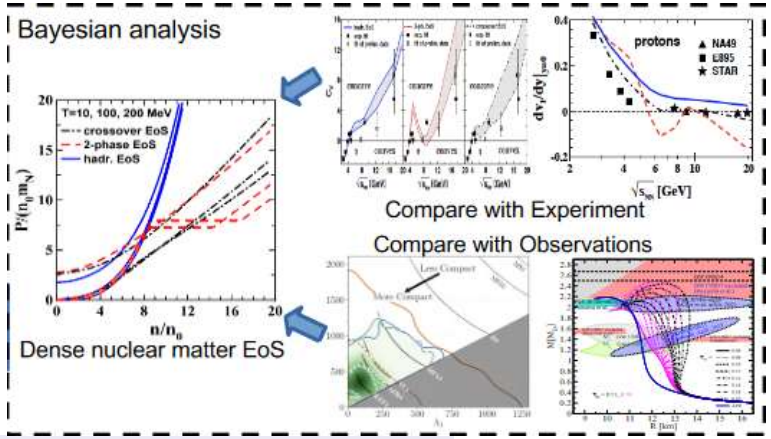


- Numerical modeling of complex physical systems
- Experimental data processing and analysis
- Big Data
- Machine and Deep learning
- AI and robotics
- Computer algebra
- Quantum computing

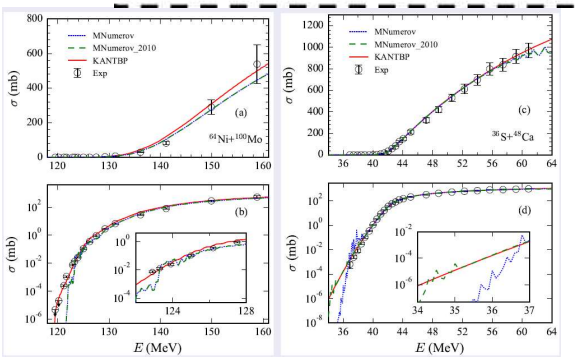
Methods of Mathematical Modeling, Computational Physics, and High-Performance Computing for Complex System Studies at JINR

- **Simulating interactions of various types in nuclear-physical systems**, including calculations of cross sections for sub-barrier fusion/fission reactions of heavy nuclei within the channel coupling method.
- **Studying multifactorial processes in models of complex systems with external influences**, including the modeling of structural changes in materials under irradiation with charged particles and the superconducting processes study in Josephson structures.
- **Solving problems arising in the design and optimization of the operation of large experimental facilities**, including problems related to the simulation of magnetic fields.
- **Modeling physical phenomena based on the state equation of dense nuclear matter**, including complex astrophysical systems and heavy ion collision processes in the NICA energy range.





Scheme of ionization by Compton scattering at hv=2.1 keV



Sub-barrier fusion and fission reactions of heavy nuclei

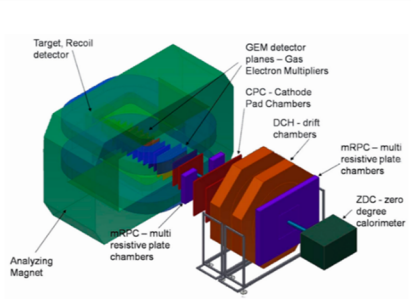
In 2020-2022, more than 150 publications in peer-reviewed scientific publications have been prepared in cooperation with colleagues from the other Laboratories and the JINR Member States; 4 problem-oriented software packages in the JINRLIB electronic program library; 2 computer programs are designed for the international library of computer programs CPC.

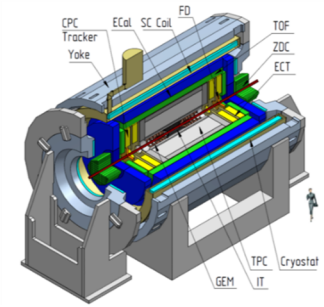
Implementation of ML/DL Methods in Data Processing and Analysis at the NICA Experiments: BM@N, MPD and SPD

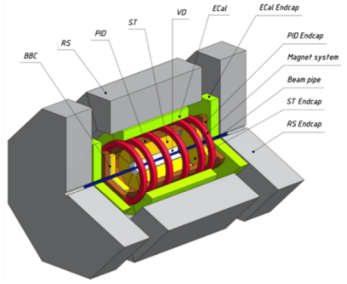
Scientific and practical significance: **expanding the scope of machine learning methods**, in particular, in high energy physics; **software for** experimental data **processing and analysis** at the NICA accelerator complex; corresponding development of root-frameworks.

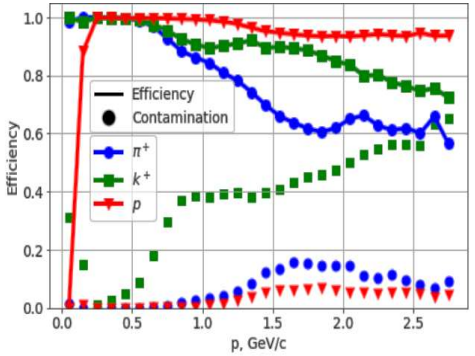
Possible areas for ML/DL application: hit finding, tracking, particle identification, decay reconstruction, global tracking.

The main ML/DL methods: Recurrent Neural Networks, Graph Neural Networks, Convolutional Neural Networks, Decision Trees, Gradient Boosting, etc.

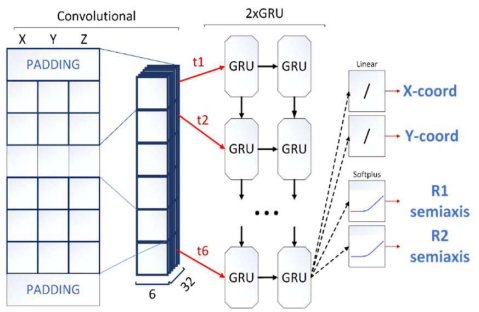




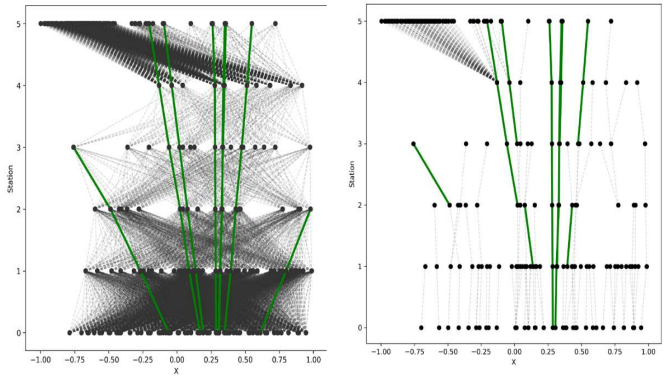




Gradient-boosted decision trees for PID in MPD



Deep GNNs for solving tracking problems in BM@N, BESIII, SPD

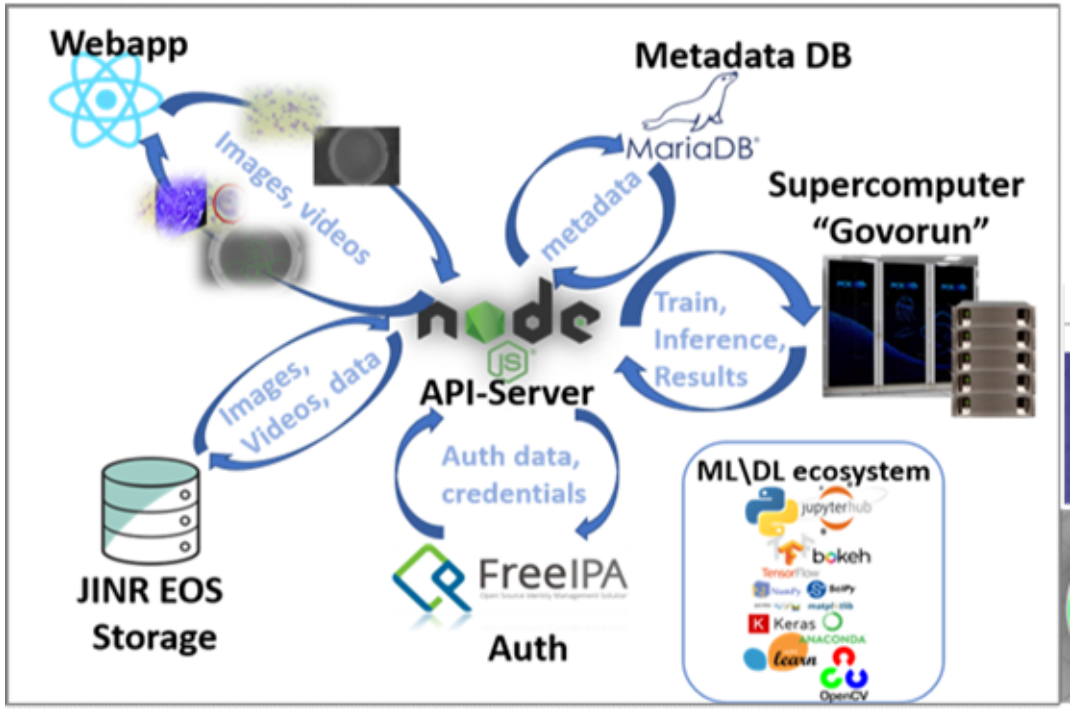


Graph Neural Networks for Tracking

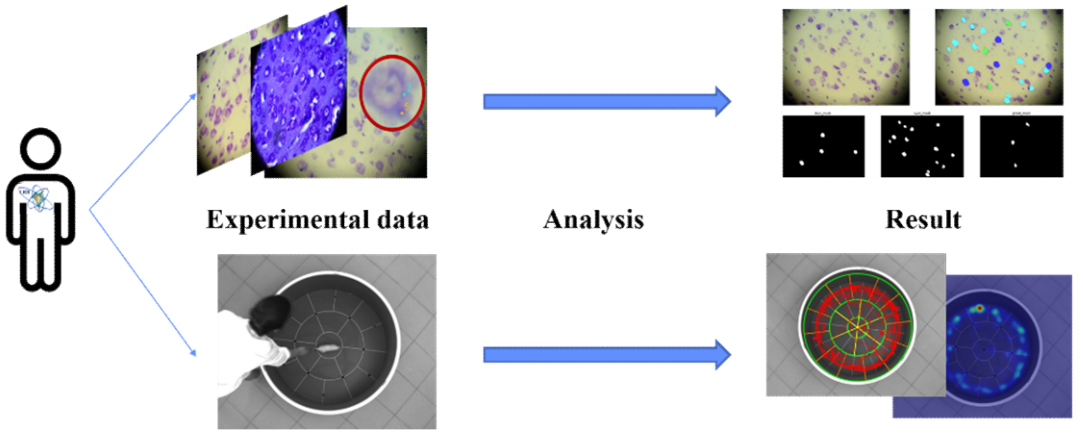
The participants are presented by members of all targeted international collaborations: BM@N, MPD, SPD.

Information System for Radiation Biology Tasks

The joint project of MLIT and LRB is focused on creating an Information System (IS) as a set of IT solutions.

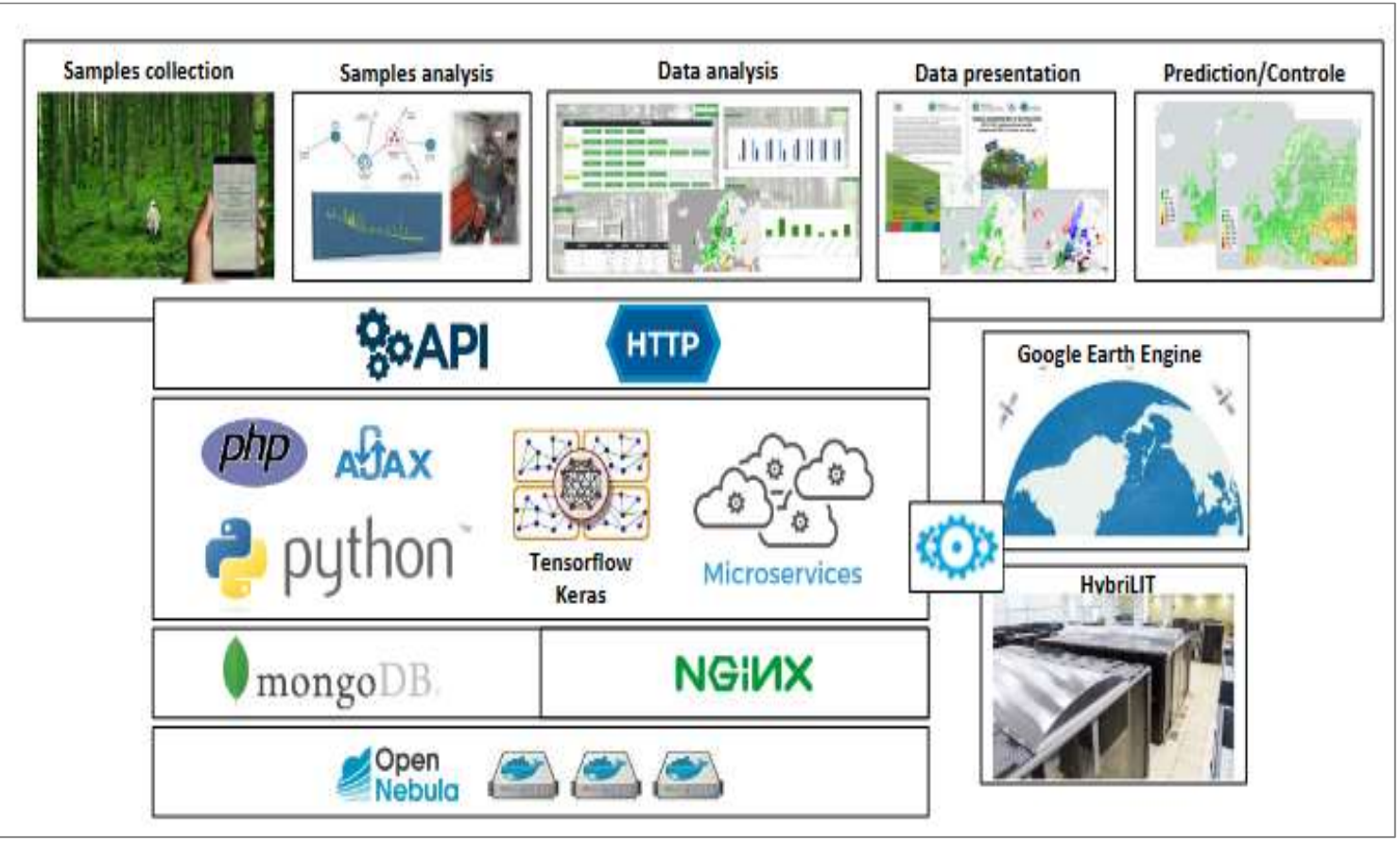


The information system allows one to store, quickly access and process data from experiments at LRB using a stack of neural network and classical algorithms of computer vision, providing a wide range of possibilities for automating routine tasks. It gives an increase in productivity, quality and speed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



Conceptual scheme of the service

Intelligent Environmental Monitoring Platform



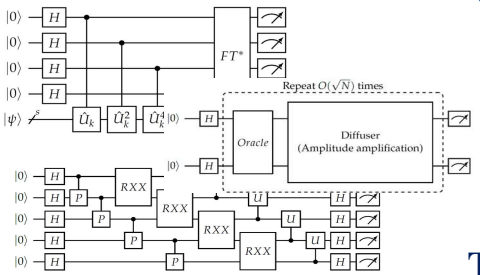
Within the framework of cooperation between MLIT and FLNP, the work on the prediction of air pollution by heavy metals using biomonitoring data, satellite imagery and different technologies of machine and deep learning is in progress. On the MLIT cloud platform, the Data Management System (DMS) of the UNECE ICP Vegetation was created to provide its participants with a modern unified system of collecting, analyzing and processing biological monitoring data.

hYBRI LIT/JINR *The studies are carried out using the HybriLIT platform.*

Quantum computing and quantum algorithms

Objective: development of quantum algorithms (QAs) to calculate complex atomic and molecular systems, taking into account the limiting capabilities of available computing resources.

Quantum algorithms



Quantum simulators

Qiskit
QuEST
qsim
CUQUANTUM

SC "Govorun"

T A S K S

- Form a list of QAs required to solve tasks within the studied physical models
- Select the type of quantum simulator to simulate a classical architecture on computers
- Define resources for the selected quantum-limiting capabilities of available computing simulators (number of qubits and computation time)
- Search for exact solutions to urgent problems of quantum chemistry and study the chemical properties of heavy elements

Current result

The limiting computing capacities of the "Govorun" supercomputer are revealed on the example of simulating quantum algorithms (quantum Fourier transform, quantum phase estimation, Grover's algorithm, test synthetic algorithm) using a different class of quantum circuits for the following simulators: QuEST, Qiskit, CuQuantum.

CPU	GPU
• 38 qubits	• 34 qubits

According to modern concepts, from 30 to 50 qubits are sufficient for the exact solution of most practically significant problems of quantum chemistry

ИНТЕЛЛЕКТУАЛЬНАЯ СИСТЕМА УПРАВЛЕНИЯ ДАВЛЕНИЕМ АЗОТА В КРИОГЕННОЙ УСТАНОВКЕ

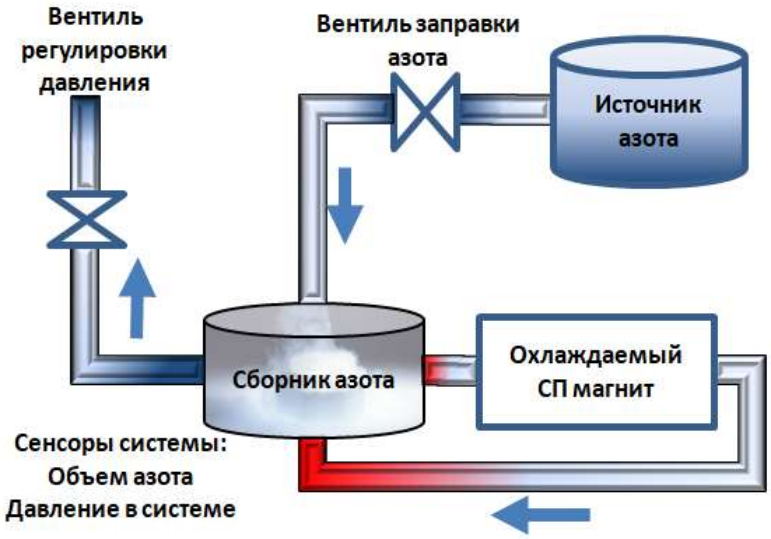
Внедрение встраиваемых интеллектуальных систем управления на основе нечёткой логики, нейронных сетей, генетических и квантовых алгоритмов в задаче стабилизации давления азота в криогенной системе испытательного стенда фабрики магнитов ЛФВЭ ОИЯИ позволили:

1) осуществить проектирование системы управления с максимальным уровнем надежности и управляемости сложным объектом в условиях неопределенности исходной информации;

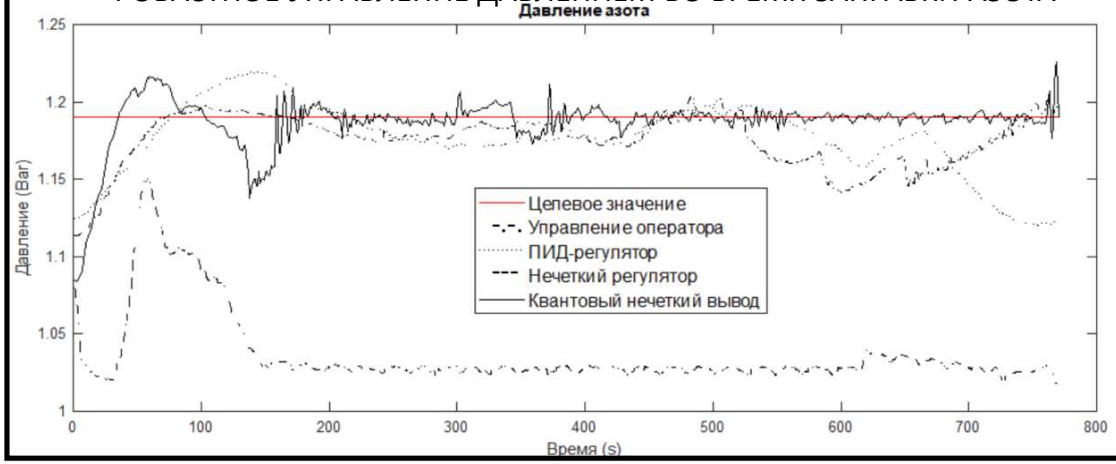
2) в отсутствии модели системы, использовать реальные физически измеряемые данные с реальной установки.

3) не изменяя нижний уровень системы управления повысить её надежность и эффективность.

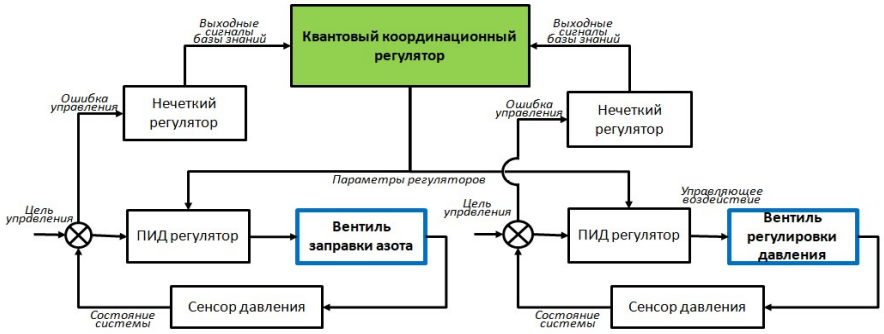
Структурная схема объекта управления



РОБАСТНОЕ УПРАВЛЕНИЕ ДАВЛЕНИЕМ ВО ВРЕМЯ ЗАПРАВКИ АЗОТА

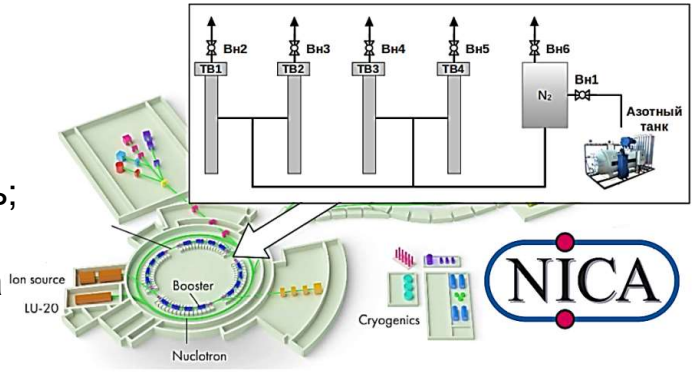


КВАНТОВЫЙ КООРДИНАЦИОННЫЙ РЕГУЛЯТОР НА ОСНОВЕ НЕСКОЛЬКИХ НЕЙРОННЫХ СЕТЕЙ

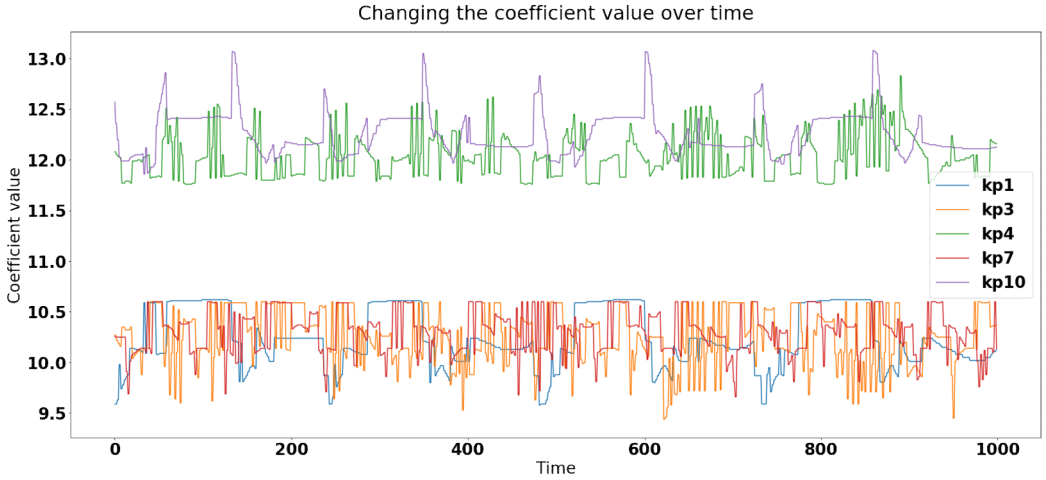


Моделирование **квантового нечёткого вывода** для скоординированного управления криогенной системой бустера

- 5 управляемых вентилей;
- По 2 нечётких регулятора на вентиль;
- 3 выходных значения из каждого регулятора (коэффициенты ПИД).

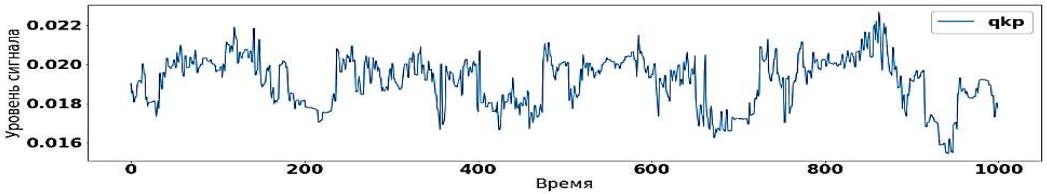


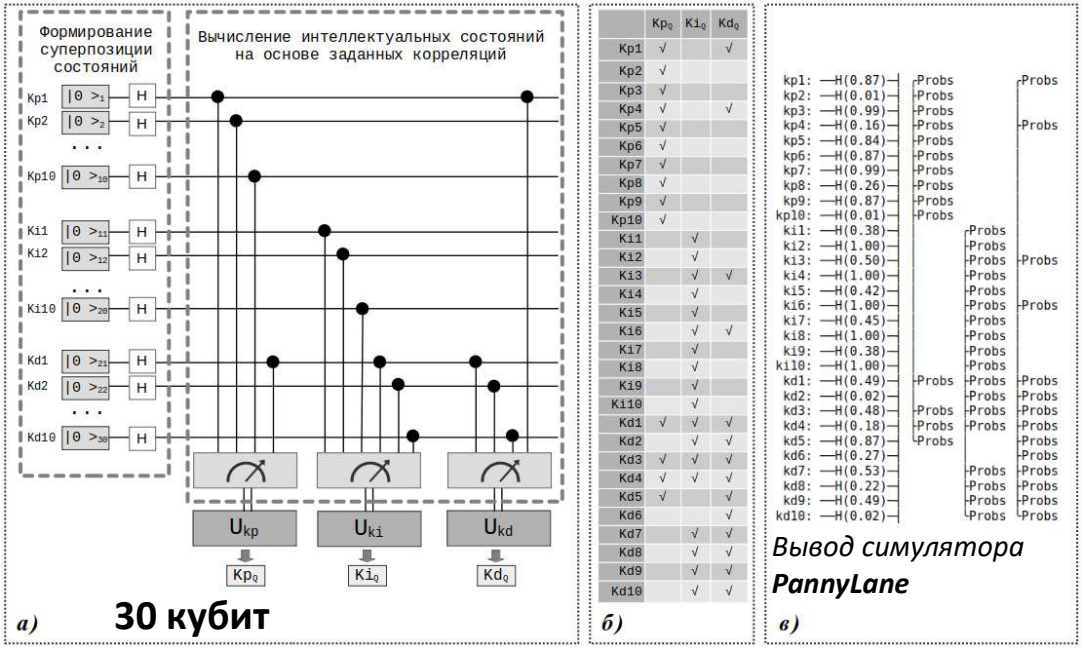
Моделирование работы квантового алгоритма проводилась с помощью симулятора PannyLane на СК “Говорун”.



Изменение значения пропорционального коэффициента нечётких регуляторов

Получение результирующего сигнала





Квантовая схема алгоритма управления

JINR Digital EcoSystem

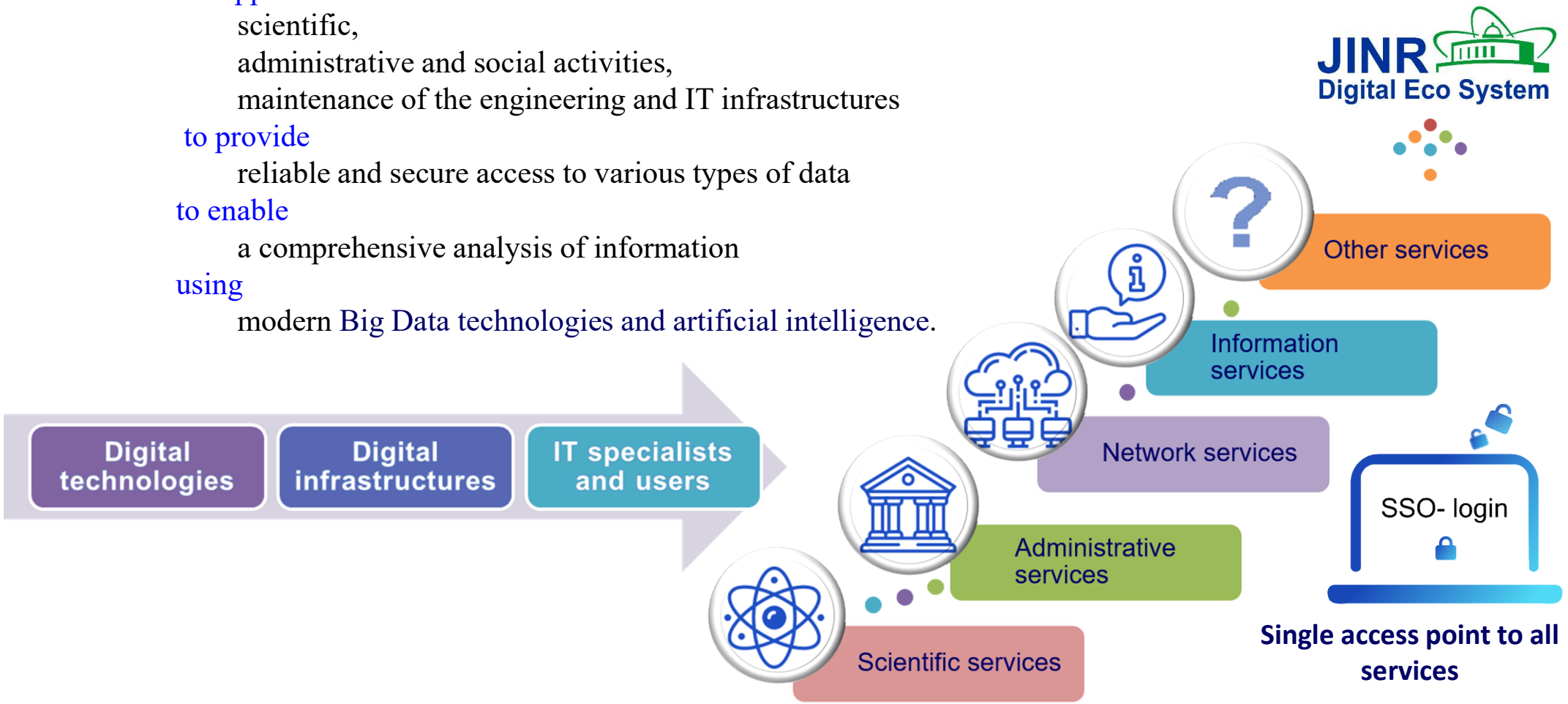
The digital platform "JINR Digital EcoSystem " integrates existing and future services

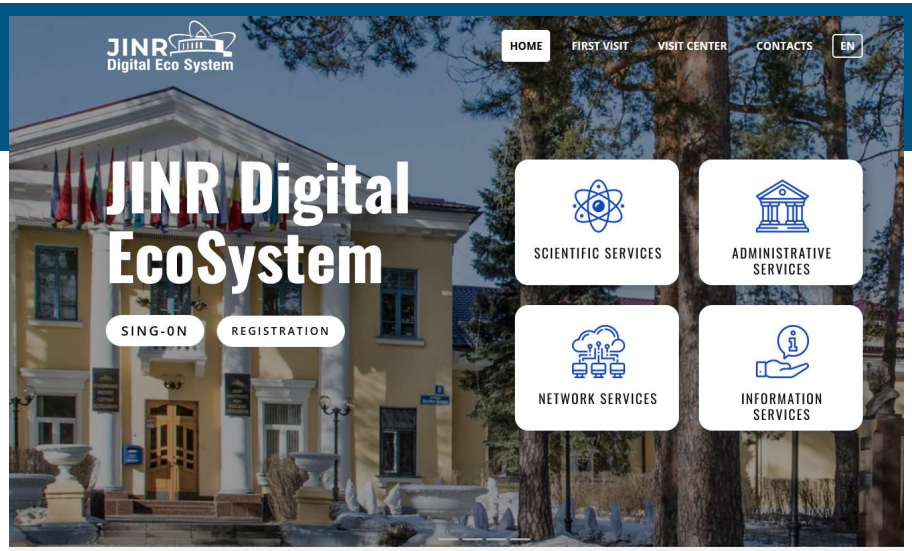
to support
scientific,
administrative and social activities,
maintenance of the engineering and IT infrastructures

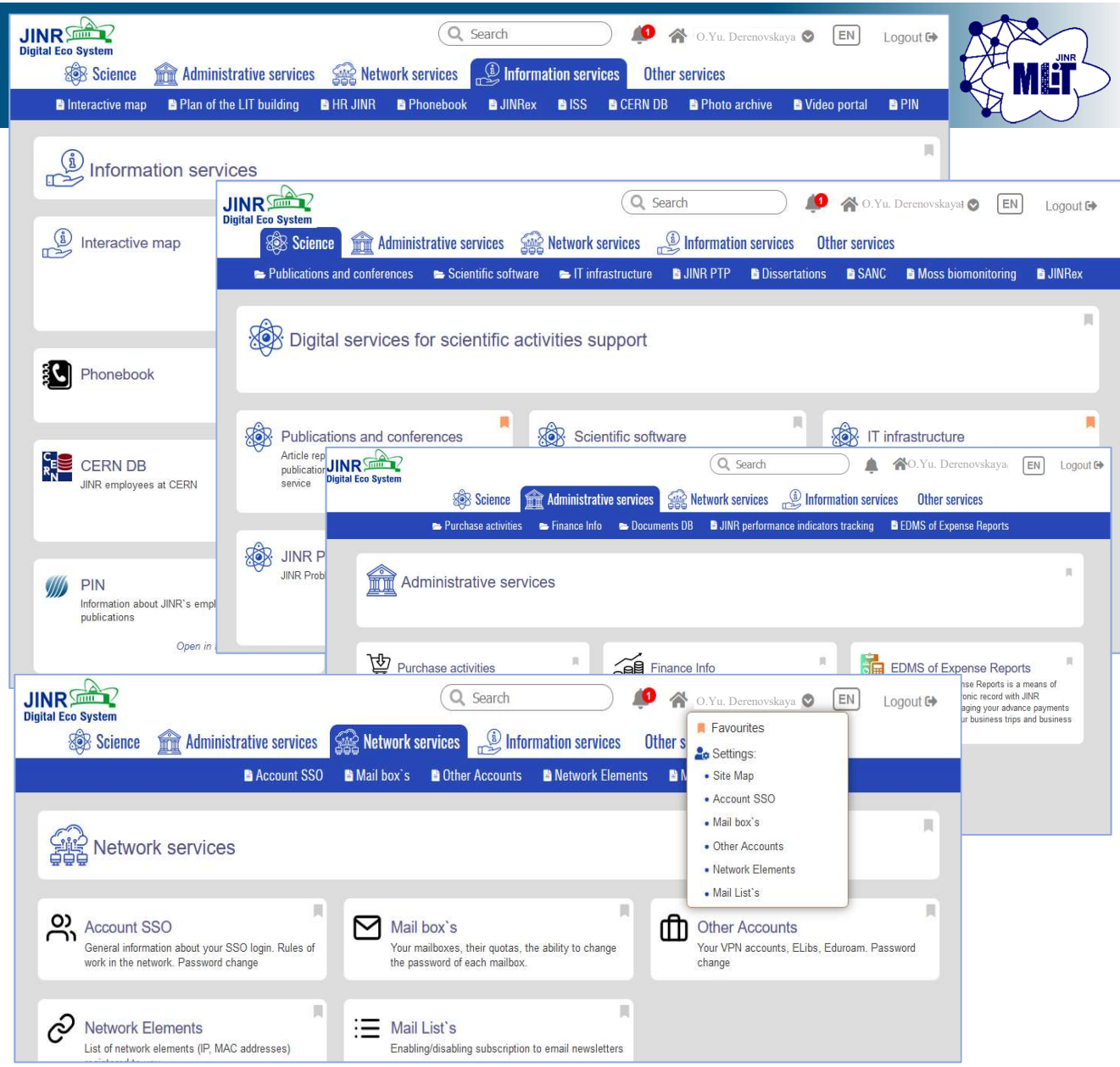
to provide
reliable and secure access to various types of data

to enable
a comprehensive analysis of information

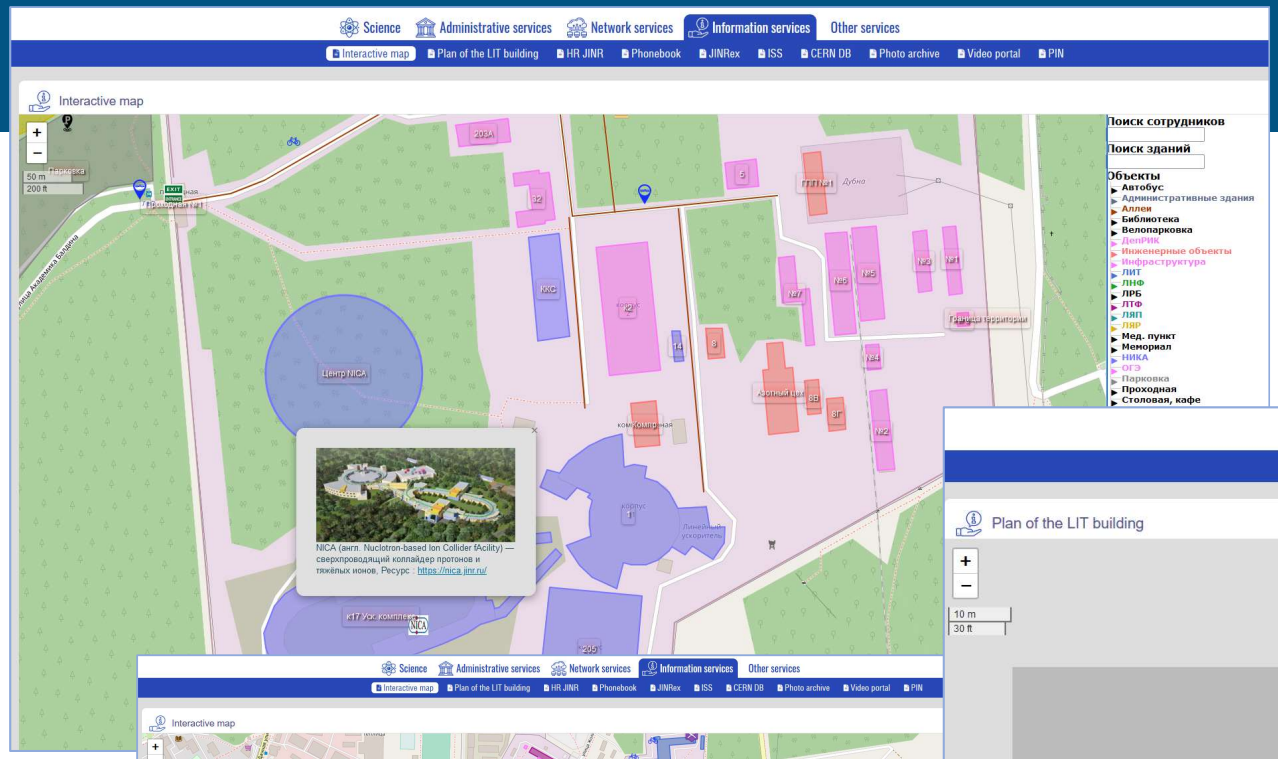
using
modern Big Data technologies and artificial intelligence.

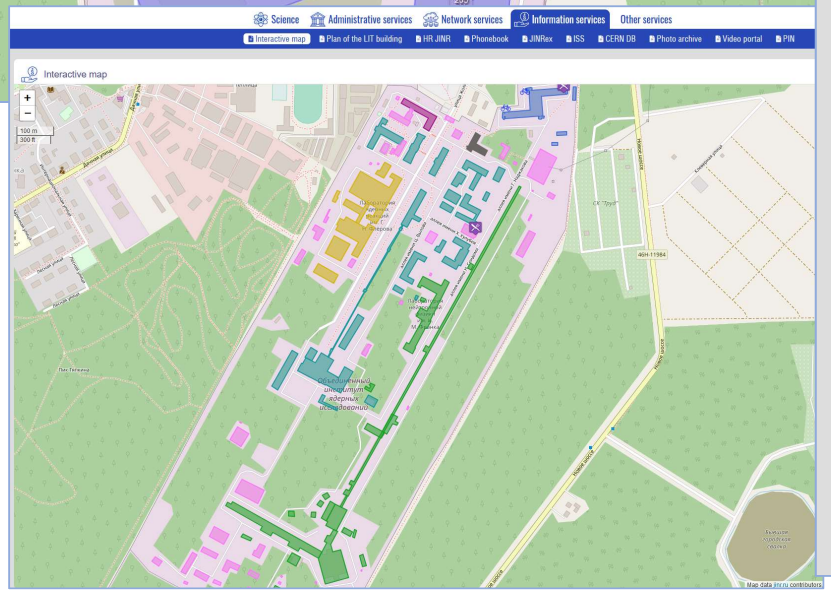


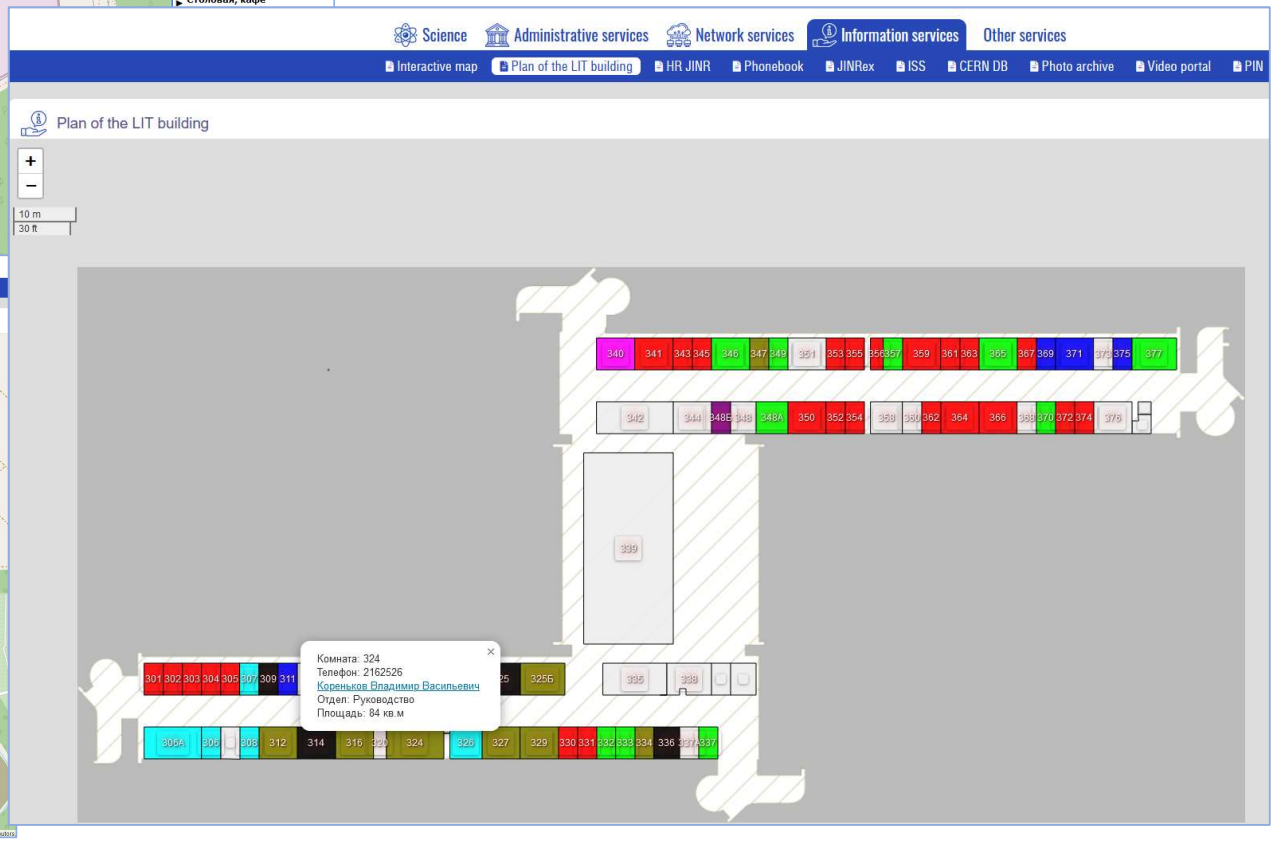




- ✓ Personal account of a JINR employee
- ✓ Notifications in a personal account
- ✓ Responsive interface, customizable by the user
- ✓ Easy access, convenient navigation and search for information on a large-scale network of a wide variety of JINR services



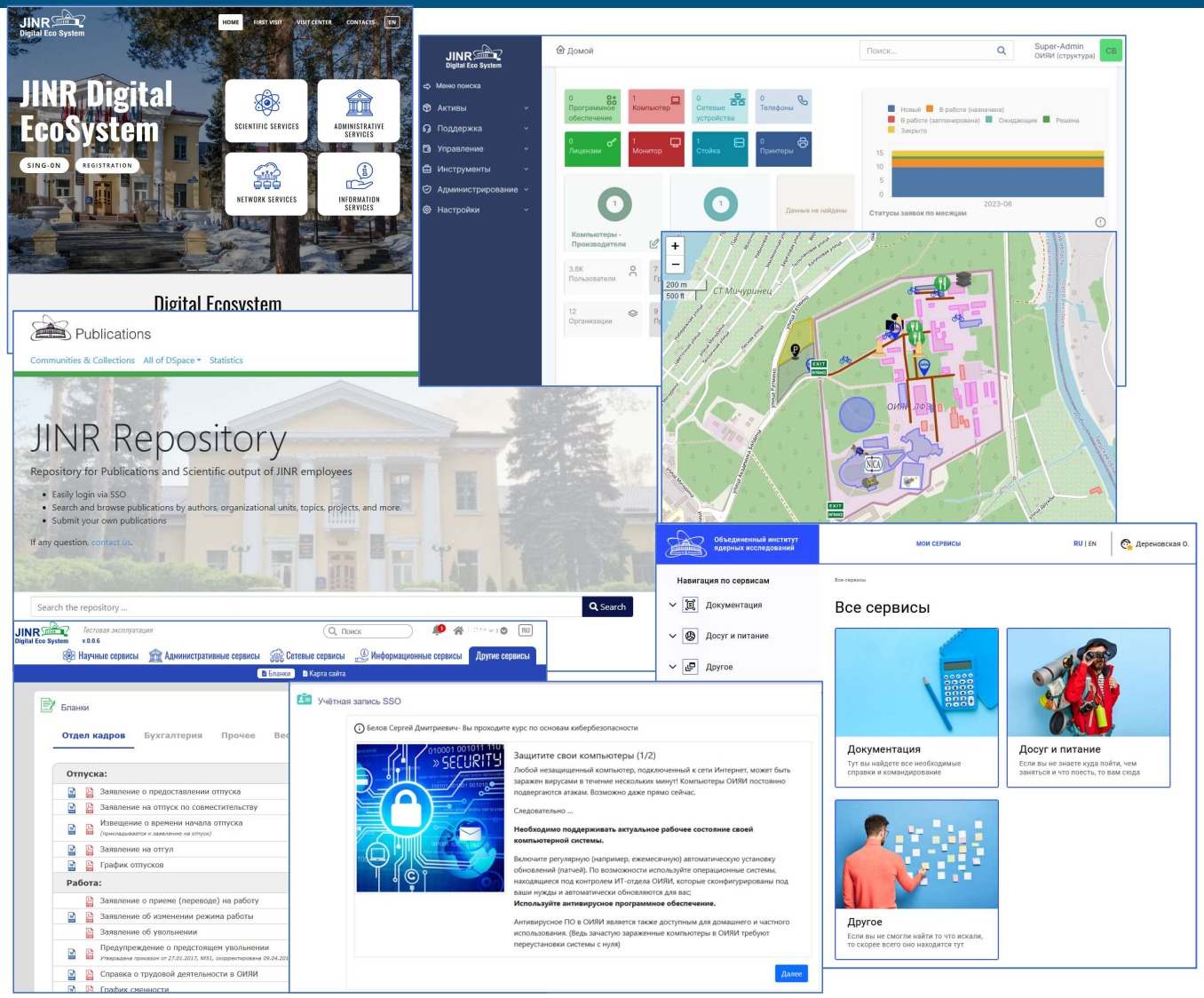




- ✓ Quick and easy search for information, both by services and by employees and buildings on an interactive JINR map

Progress in the JINR Digital EcoSystem Development

(MLIT jointly with DDSD)



Implemented in the DES:

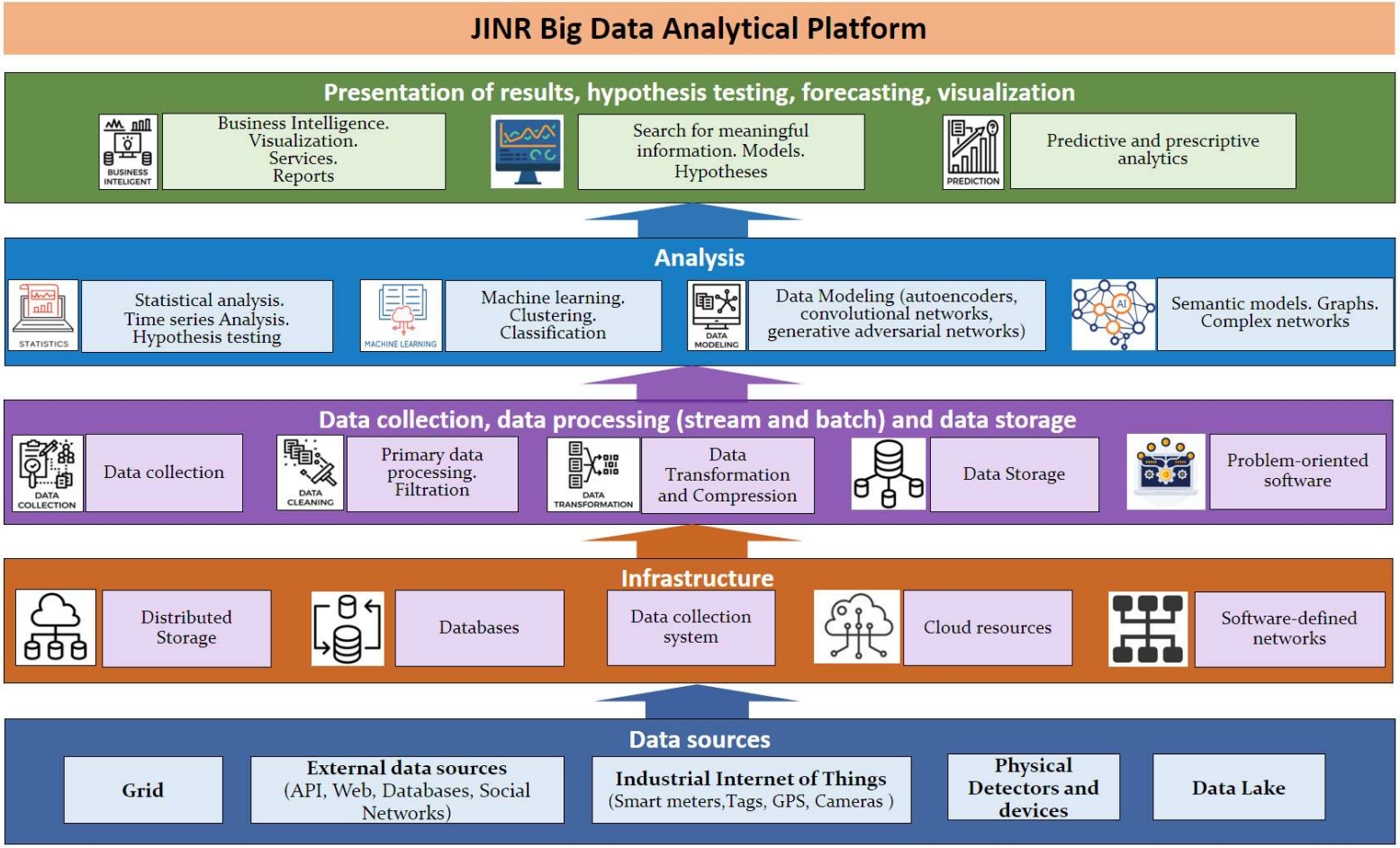
- Network services: computer security course and exam
- Interactive maps: possibility to add engineering networks; the plans of buildings are being linked
- Collection of forms of documents (during the transition to digital workflow)
- Administrative services: a service for ordering certificates has been launched

In the process of implementation:

- Network services: service for issuing digital certificates of electronic signature
- User support and feedback: digital Service Desk
- Scientific and technical documentation base: the prototype has been developed
- Work with publications: the institutional repository service has been deployed; work to fill it is underway
- Administrative services: services for business trips, tickets, repairs

Methods of Artificial Intelligence and Big Data Analytics

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



Development of the system for training and retraining IT specialists

Training courses, master classes and lectures

MLIT staff and leading scientists from JINR and its Member States

Leading manufacturers of modern computing architectures and software

Parallel programming technologies

OpenMP

MPI

OpenCL

NVIDIA CUDA

Tools for debugging and profiling parallel applications

Intel Cluster Studio

Work with applied software packages

COMSOL MULTIPHYSICS

Wolfram Mathematica

ROOT

MATLAB

GEANT4

Maple

Frameworks and tools for ML/DL tasks

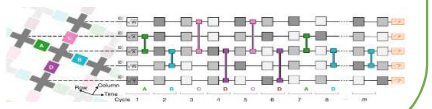
jupyterhub

TensorFlow

NumPy

scikit learn

Quantum algorithms, quantum programming and quantum control



The International Conference "Distributed Computing and Grid Technologies in Science and Education"

- Distributed computing systems
- Computing for MegaScience Projects
- Distributed computing applications
- Data Management, Organisation and Access
- HPC
- Virtualization
- Big data Analytics and Machine learning
- Research infrastructure

The International Symposium Nuclear Electronics and Computing

- Detector & Nuclear Electronics
- Triggering, Data Acquisition, Control Systems
- Distributed Computing, GRID and Cloud Computing
- Machine Learning Algorithms and Big Data Analytics new!
- Research Data Infrastructures
- Computations with Hybrid Systems (CPU, GPU, coprocessors)
- Computing for Large Scale Facilities (LHC, FAIR, NICA, SKA, PIC, XFEL, ELI, etc.)
- Innovative IT Education

MATHEMATICAL MODELING AND COMPUTATIONAL PHYSICS

- ❑methods, software and program packages for data processing and analysis;
- ❑mathematical methods and tools for modeling complex physical and technical systems, computational biochemistry and bioinformatics;
- ❑methods of computer algebra, quantum computing and quantum information processing;
- ❑ machine learning and big data analytics;
- ❑ algorithms for parallel and hybrid calculations.

MLIT Schools

Joint Institute for Nuclear Research
Meshcheryakov Laboratory of Information Technologies

10 GRID2023

3-7 July 2023

10th International Conference
"Distributed Computing and Grid Technologies in Science and Education"

More than **275** participants
In person - 216
Remotely - 60

30 Plenary reports
135 Sessional reports

17 Countries: Azerbaijan, Armenia, Belarus, Bulgaria, the Czech Republic, Egypt, Germany, Georgia, Iran, Kazakhstan, Mexico, Moldova, Mongolia, Serbia, CERN and Uzbekistan. **Russia** was represented by participants **from 41 universities and research centers**.

Conference Topics:

1. Distributed Computing Systems
2. HPC
3. Distributed Computing and HPC Application
4. Cloud Technologies
5. Computing for MegaScience Projects
6. Quantum Informatics and Computing
7. Big Data, M/D Learning, Artificial Intelligence
8. Student session

Workshop "Computing for radiobiology and medicine"

Workshop "Modern approaches to the modeling of research reactors, creation of the "digital twins" of complex systems"

Round table "RDIG-M - Russian distributed infrastructure for large-scale scientific projects in Russia"

Round table on IT technologies in education

Joint Institute for Nuclear Research
Meshcheryakov Laboratory of Information Technologies

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GRID2023

3-7 July 2023

10th International Conference
"Distributed Computing and Grid Technologies in Science and Education"

Social events

500 shashlik skewers

Thank you for your attention

http://lit.jinr.ru