JOINT INSTITUTE FOR NUCLEAR RESEARCH
ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

Многофункциональный информационно-вычислительный комплекс ОИЯИ

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Лаборатории информационных технологий
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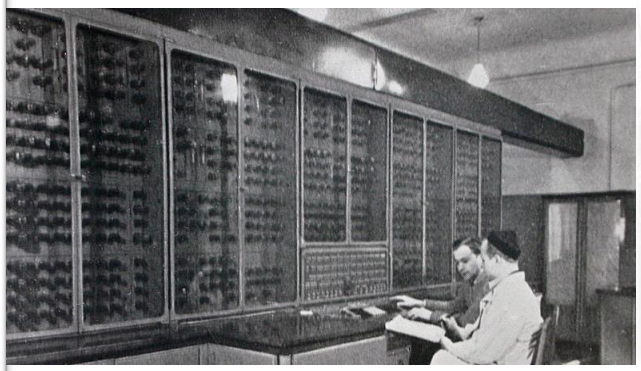
Рабочее совещание ОИЯИ-ВШЭ

14 июня 2024 года

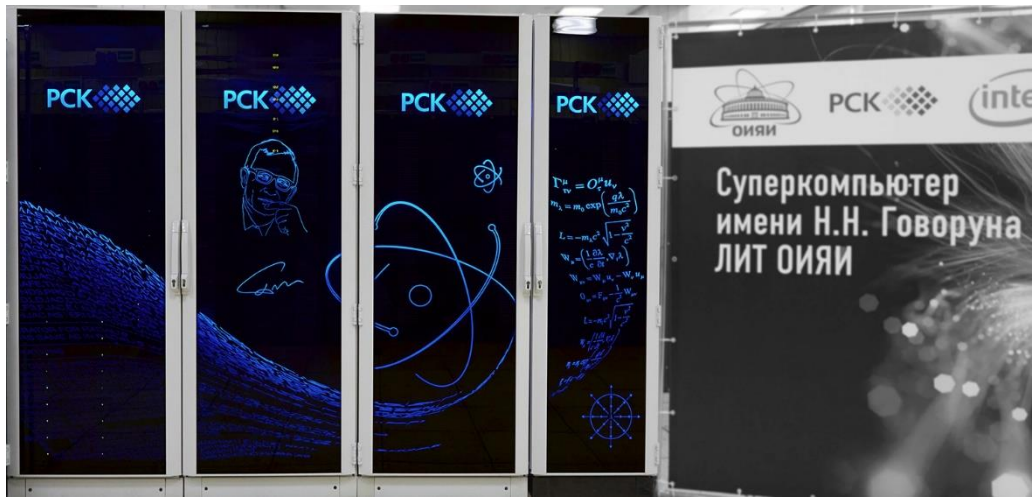
Meshcheryakov Laboratory of Information Technologies

M.G. Mesheryakov
(17.09.1910 - 24.05.1994)



N.N. Govorun
(18.03.1930 - 21.07.1989)

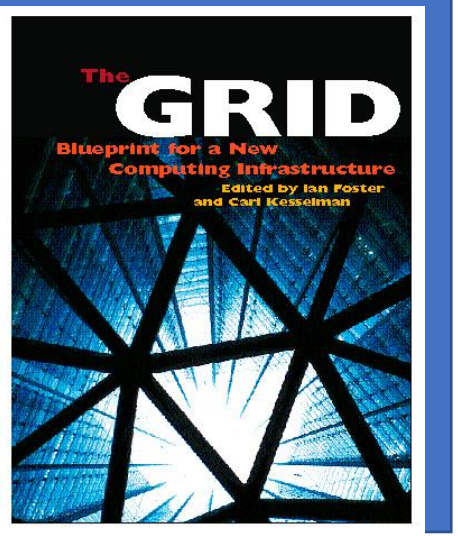
Meshcheryakov Laboratory of Information Technologies of the Joint Institute for Nuclear Research in Dubna was founded in August 1966. The main directions of the activities at the Laboratory are connected with the provision of networks, computer and information resources, as well as mathematical support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



Grids, clouds, fog, edge, supercomputers…

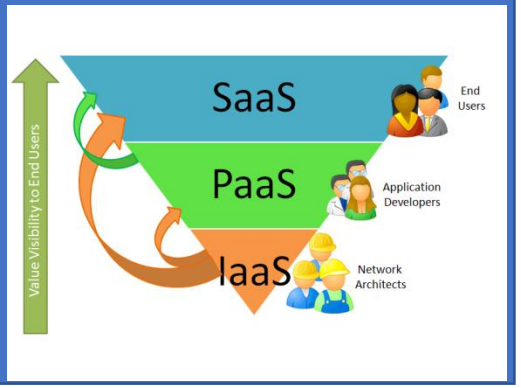
Grids

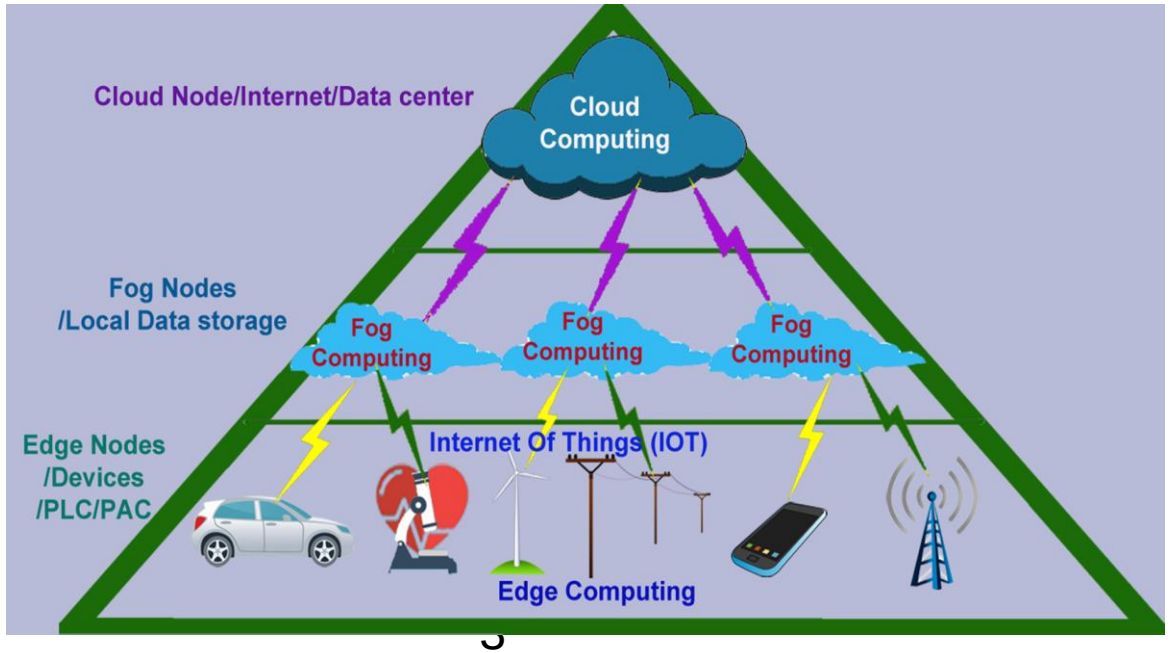
- Collaborative environment
- Distributed resources



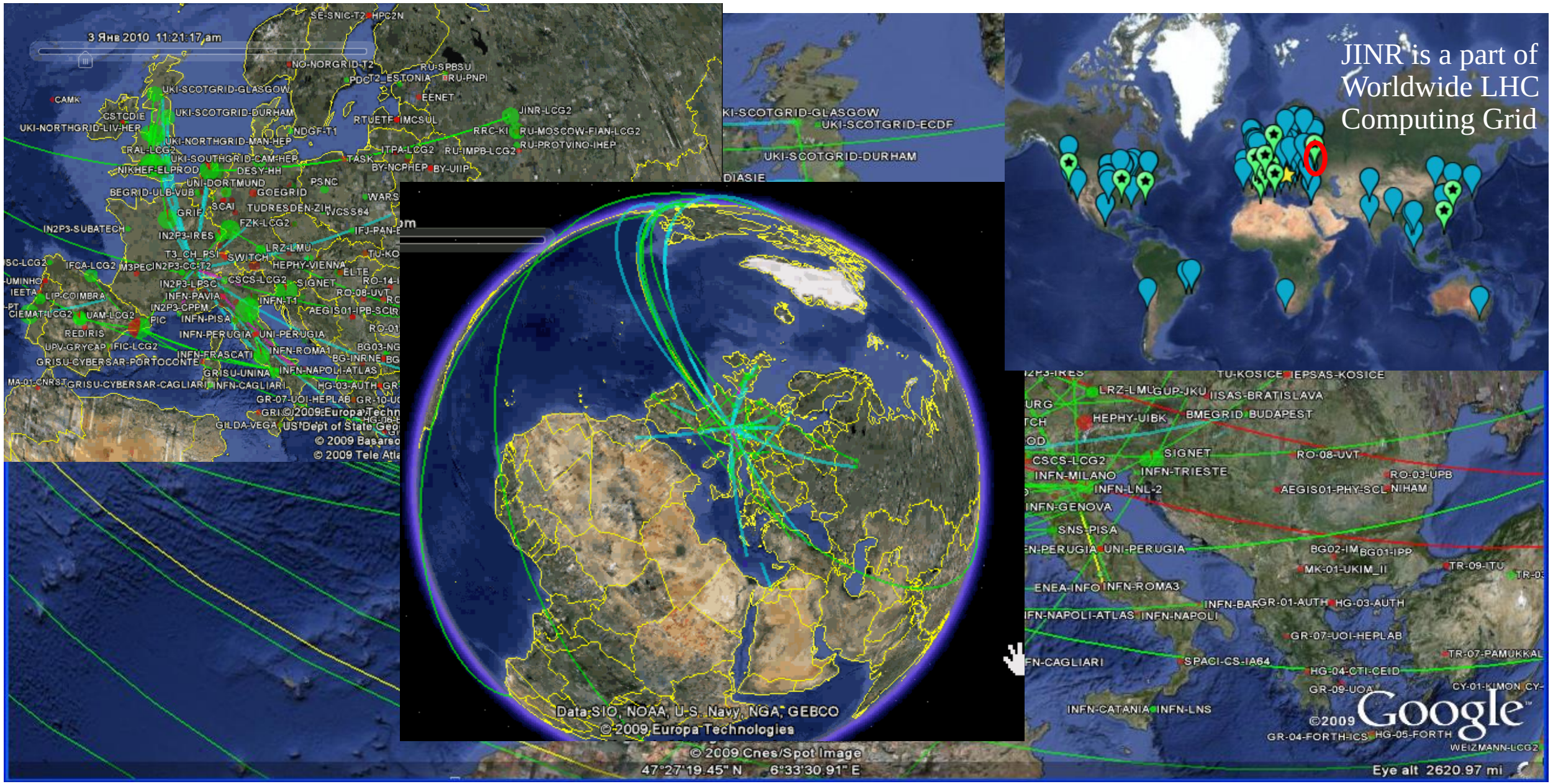
Supercomputers

Clouds



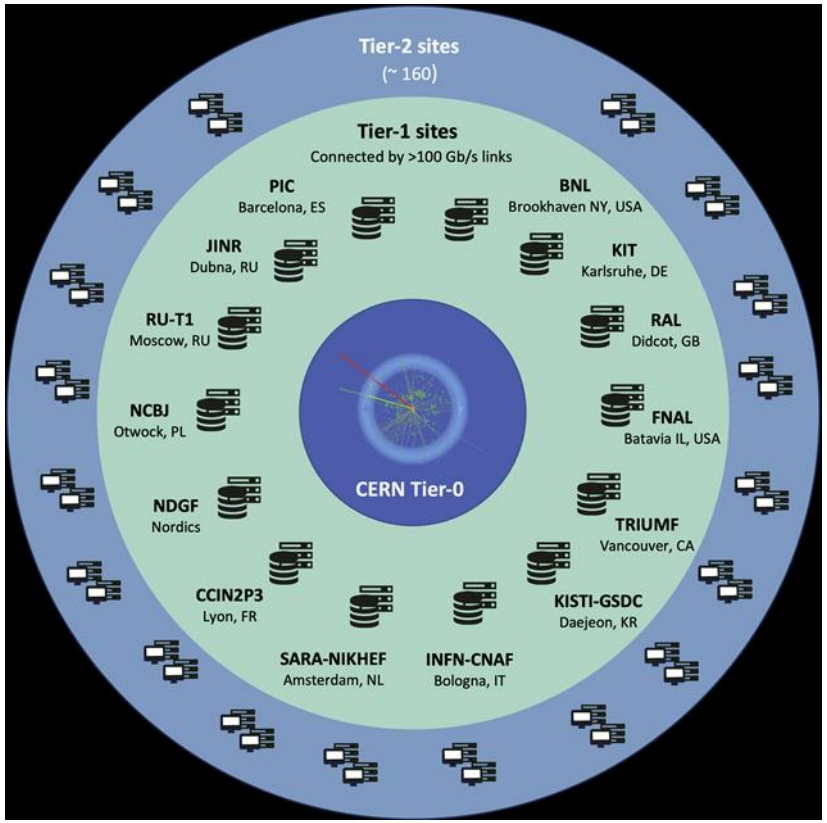


The Worldwide LHC Computing Grid (WLCG)



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 ~250-300 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

~1.6 M CPU cores

~2 EB of storage (1 EB - CERN)

> 2.5 million jobs/day

100-400 Gb/s links

Worldwide LHC Computing Grid - 2023

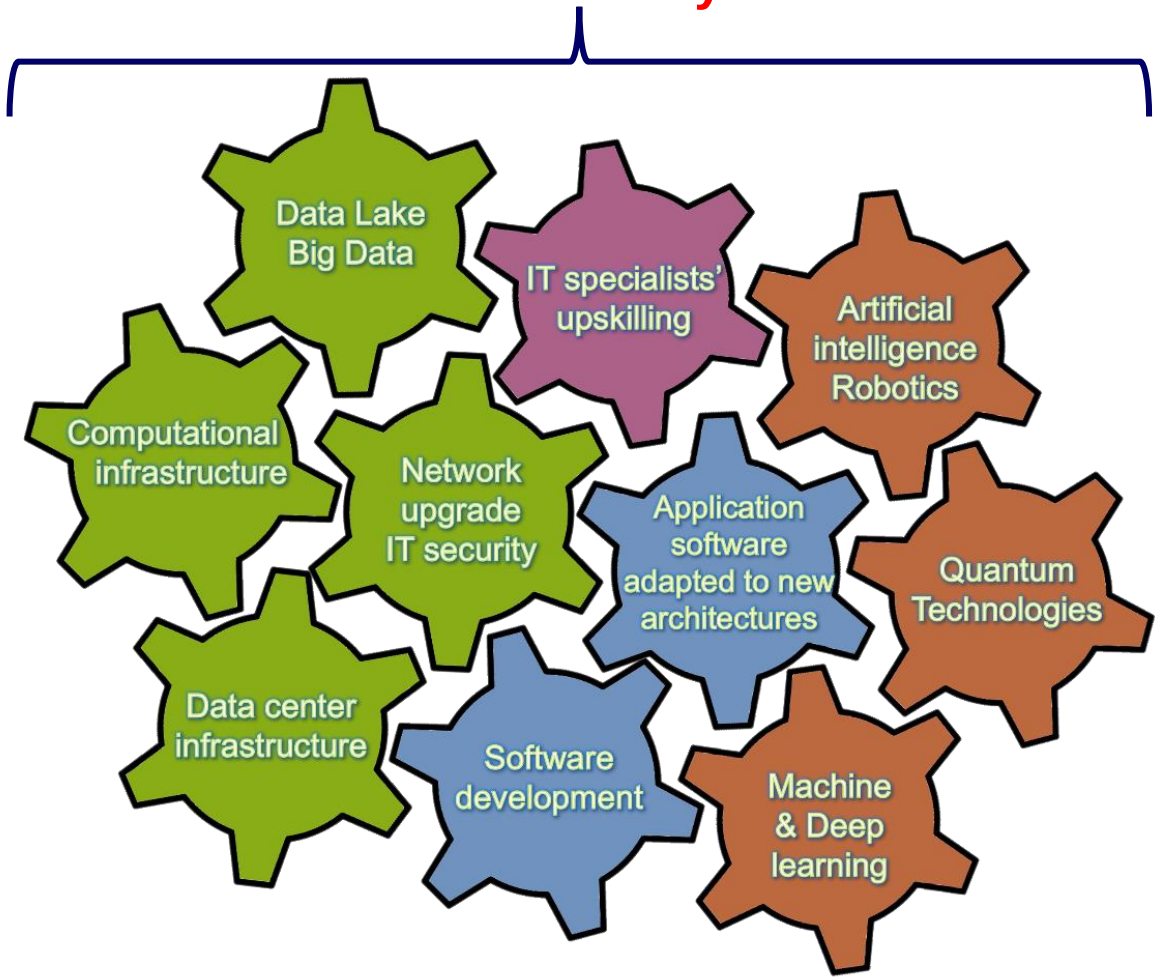
Tier0 (CERN): data recording, reconstruction and distribution

Tier1: permanent storage, re-processing, analysis

Tier2: Simulation, end-user analysis

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

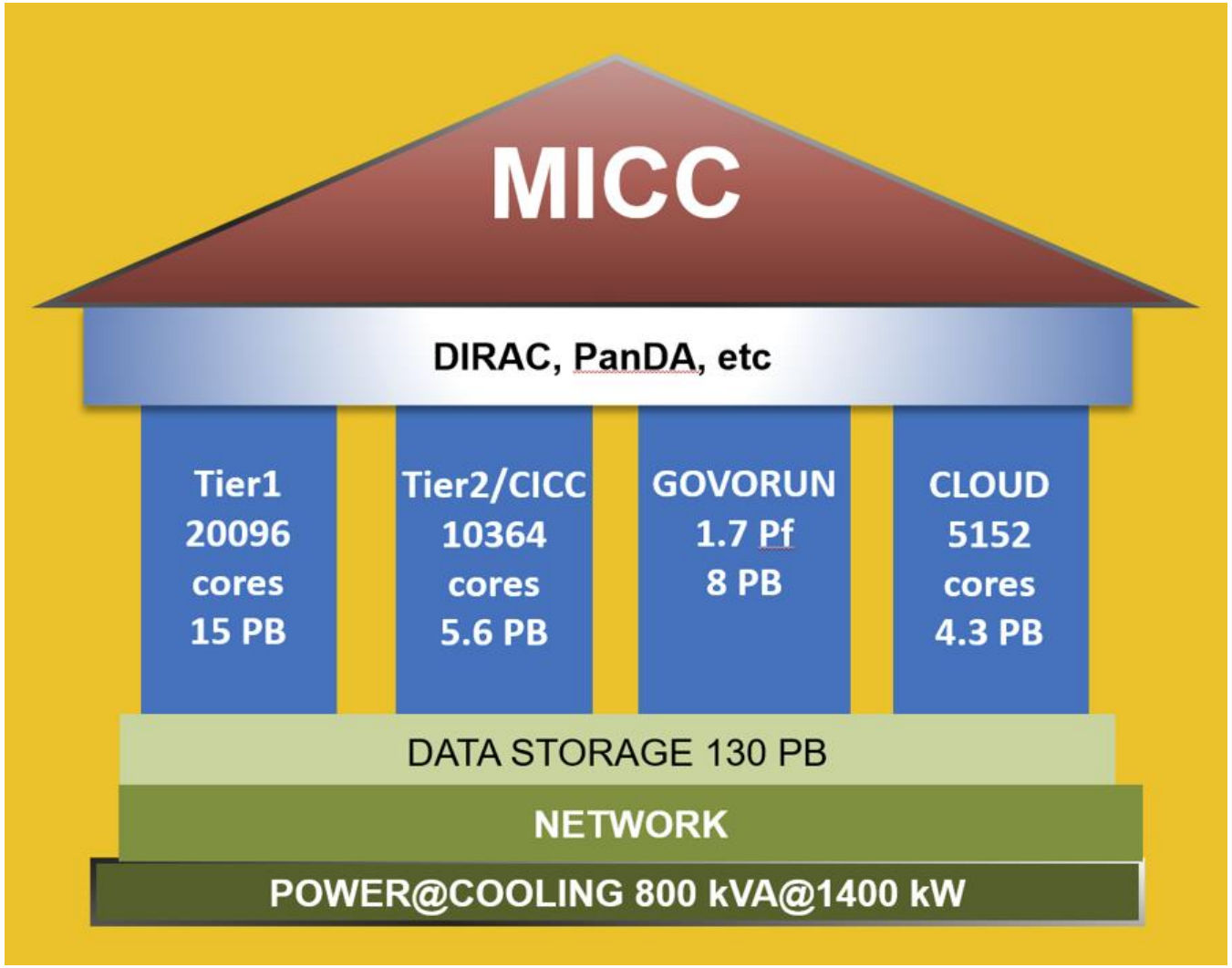
for all experiments.

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.

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

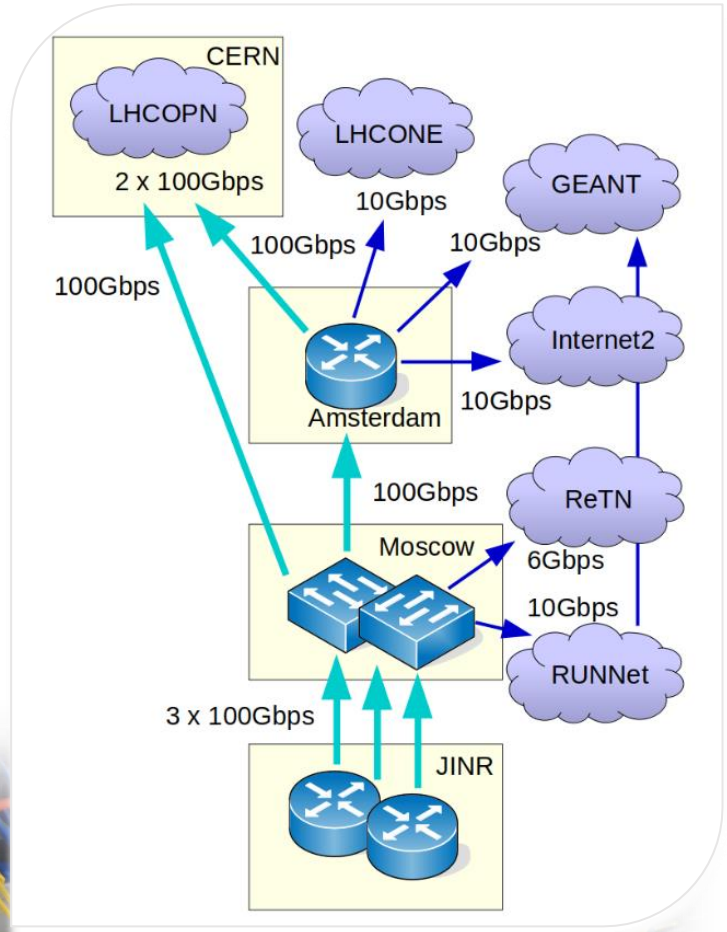
- Power
- Cooling

Network

- Wide Area Networkr
- Local Area Network

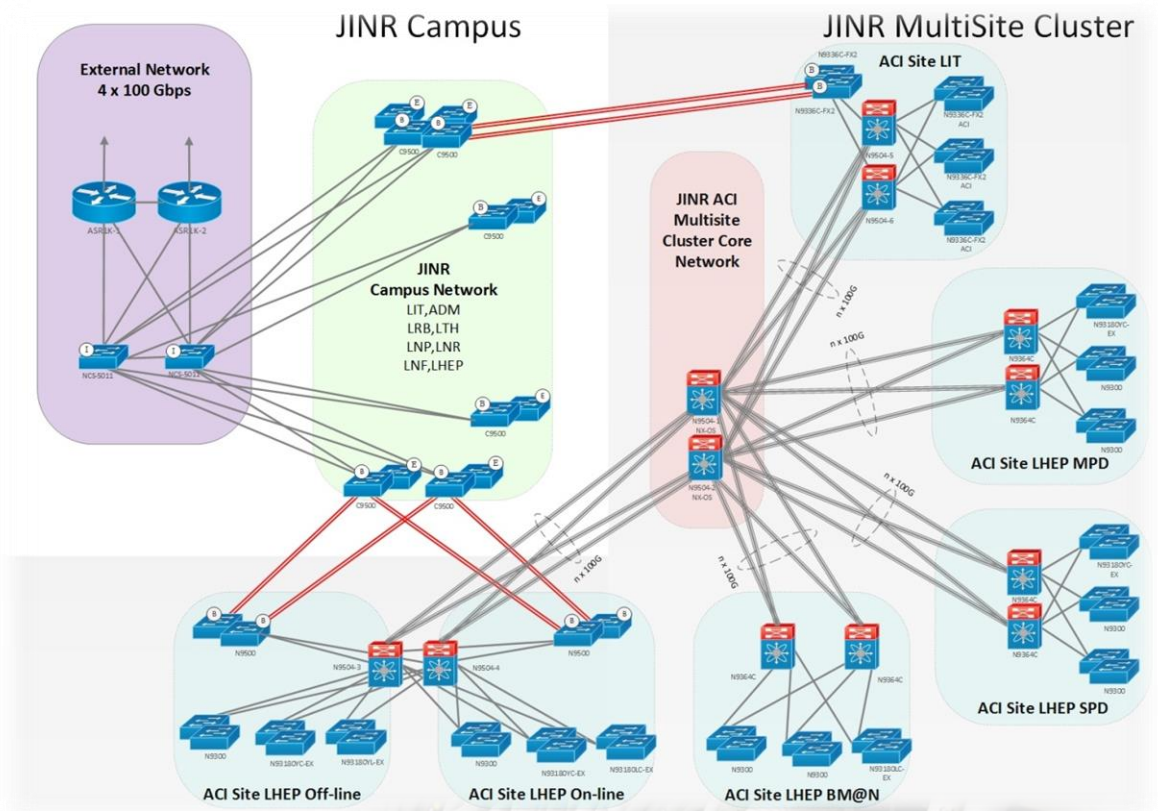
The main objective of the project is to ensure multifunctionality, scalability, high performance, reliability and availability in 24x7x365 mode for different user groups that carry out scientific studies within the JINR Topical Plan

Networking



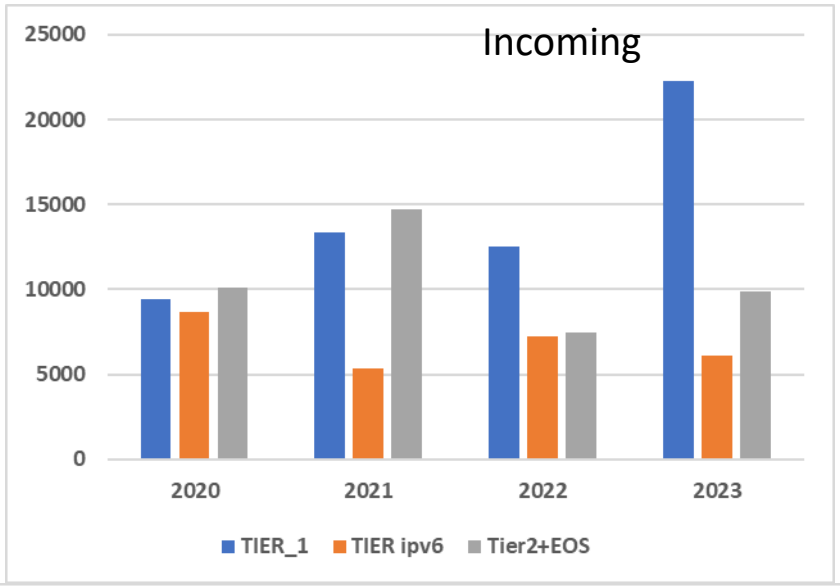
- JINR-Moscow 3x100 Gbit/s
- JINR-CERN - 100 Gbit/s and JINR-Amsterdam 100 Gbit/s for LHCOPN, LHCONE, GEANT networks
- Direct channels up to 100 Gbit/s for communication with NIKS networks
- The multi-site cluster network with a bandwidth 4x100 Gbit/s between VBLHEP and MLIT

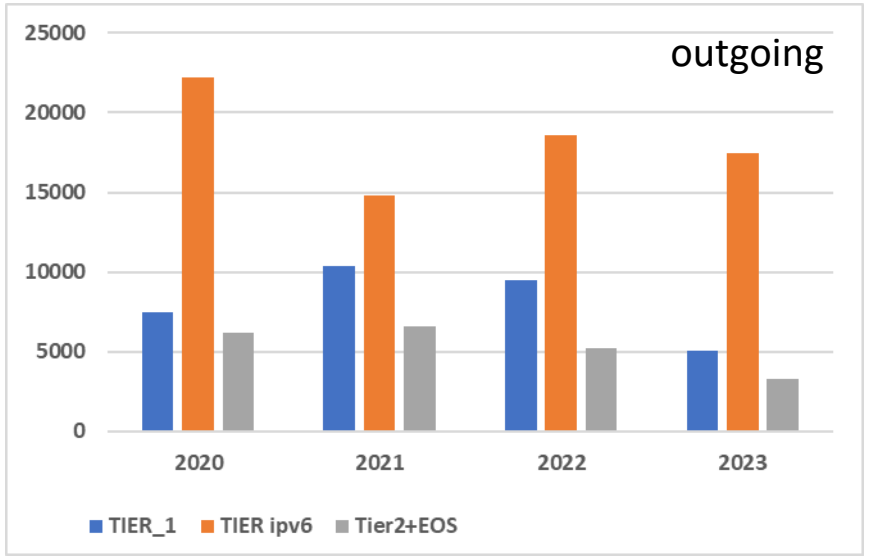
9327 network elements
18163 IP-addresses
6355 users
1464 E-library
911 remote VPN
121 VOIP
116 EDUROAM
4579 Email @jinr.ru

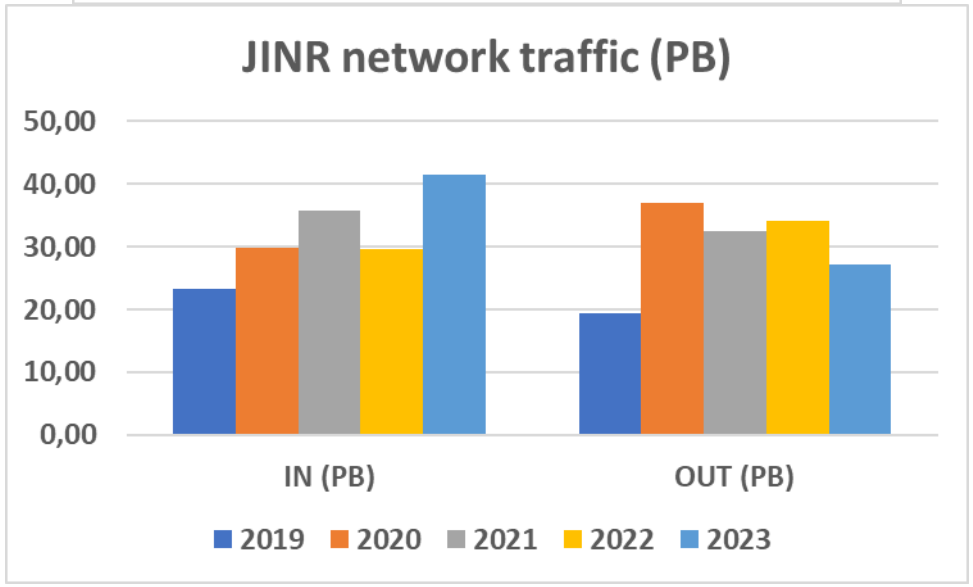


Networking @ Traffic

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



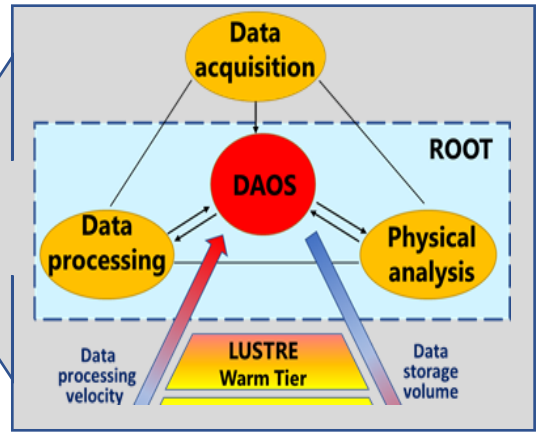




Общий входящий трафик ОИЯИ, включая сервера общего назначения, Tier1, Tier2, СК «Говорун» и облачные вычисления, составил в 2023 году 41,5 ПБ, общий исходящий – 27,5 ПБ.

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.

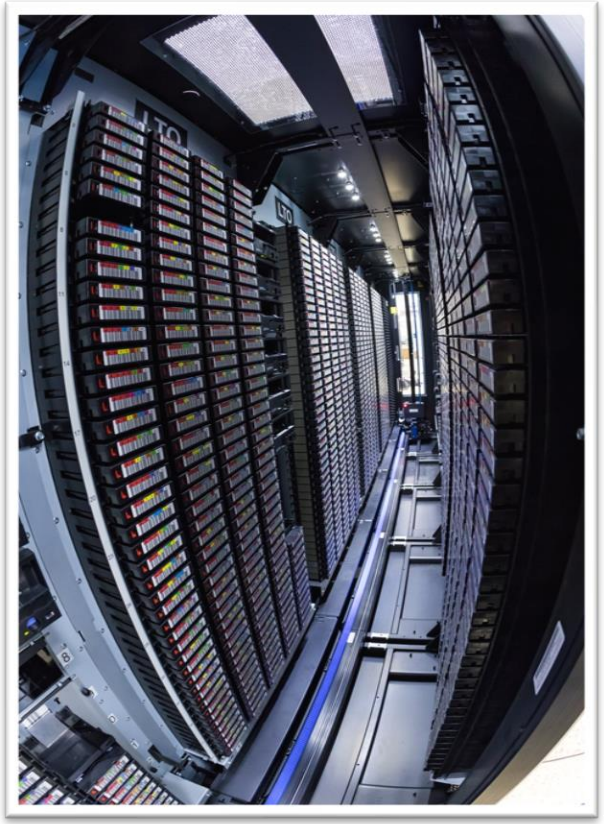


Special hierarchical data processing and storage system with a software-defined architecture was developed and implemented on the “Govorun” supercomputer.

According to the speed of accessing data there are next layers:

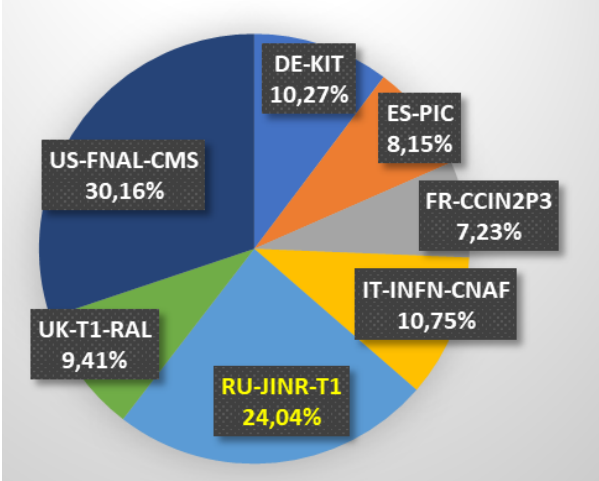
- ✓ very hot data (DAOS (Distributed Asynchronous Object Storage)) ,
- ✓ the most demanded data (fastest access),
- ✓ hot data
- ✓ warm data (LUSTRE).

JINR Tier1 for CMS (LHC) and NICA



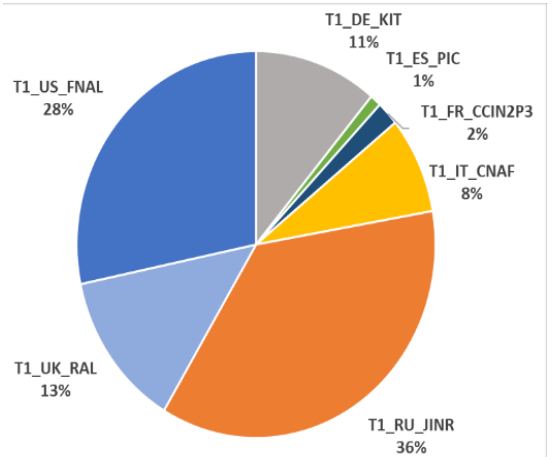
- 20064 cores
- 360 kHS06
- 14.5 PB disks
- 103 PB tapes
- 100% reliability and availability

Вклад мировых Tier1 центров в обработку экспериментальных данных CMS за 2023 год:

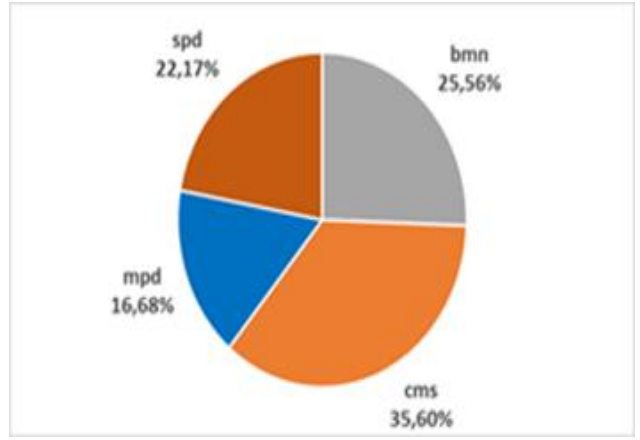


Tier1 CMS	2024	%
DE-KIT	484,792,812	16,23
ES-PIC	222,818,510	7,44
FR-CCIN2P3	73,462,505	2,44
IT-INFN-CNAF	198,473,663	6,64
RU-JINR-T1	**911,105,399**	**30,56**
UK-T1-RAL	391,091,629	13,11
US-FNAL-CMS	699,418,243	23,44

Количество обработанных событий эксперимента CMS за 2023 год

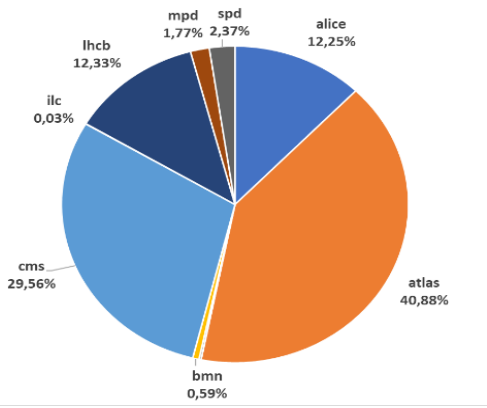


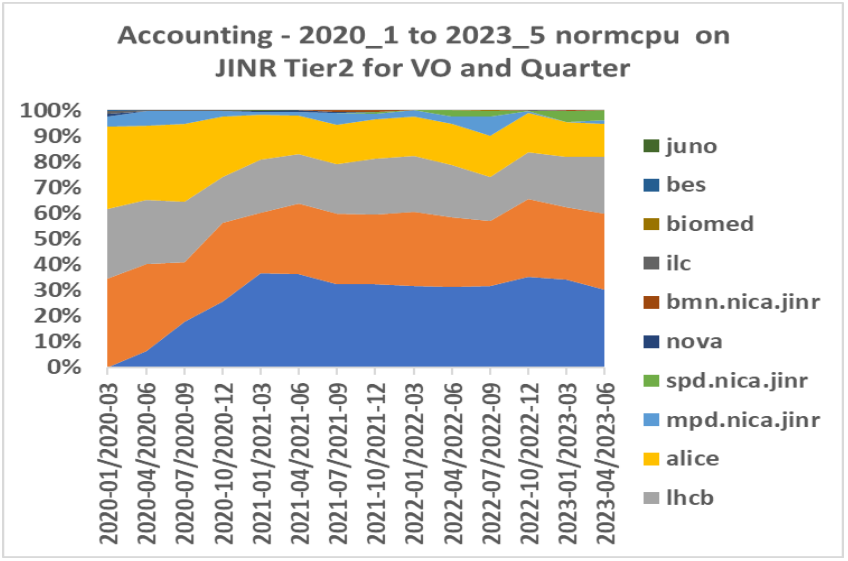
Распределение по числу задач выполненных на Tier1 экспериментами CMS, BM@N, MPD и SPD в 2023 году



Tier2 at JINR

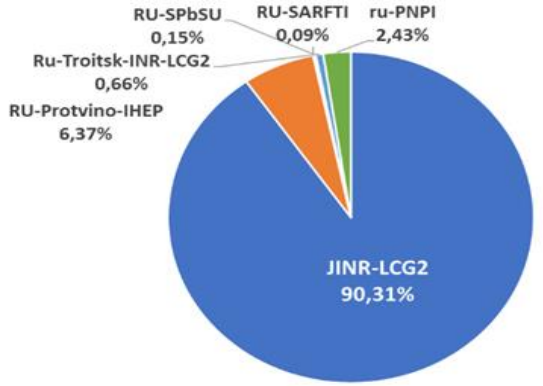
Использование Tier2 сайта ОИЯИ (JINR-LCG2) виртуальными организациями в рамках грид-проектов



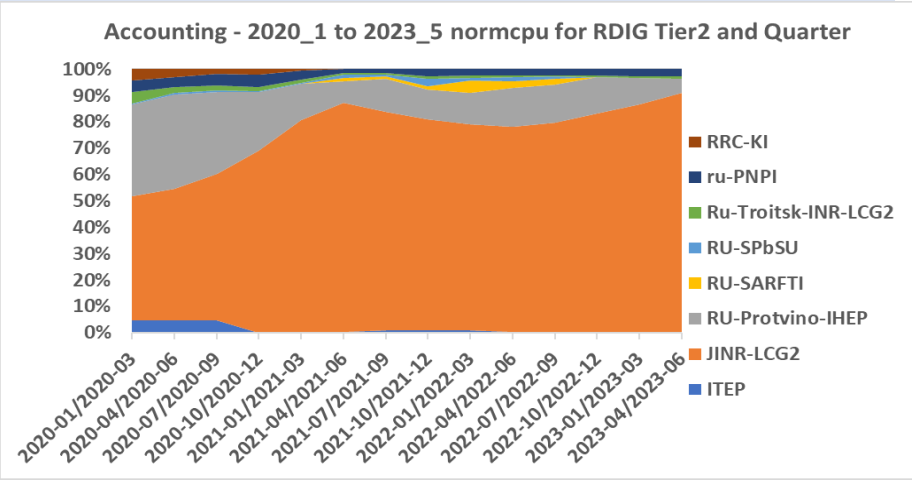


Tier2 at JINR provides computing power and data storage and access systems for the majority of JINR users and user groups, as well as for users of virtual organizations (VOs) of the grid environment (LHC, NICA, FAIR, etc.).

Распределение выполненных на грид-сайтах RDIG задач

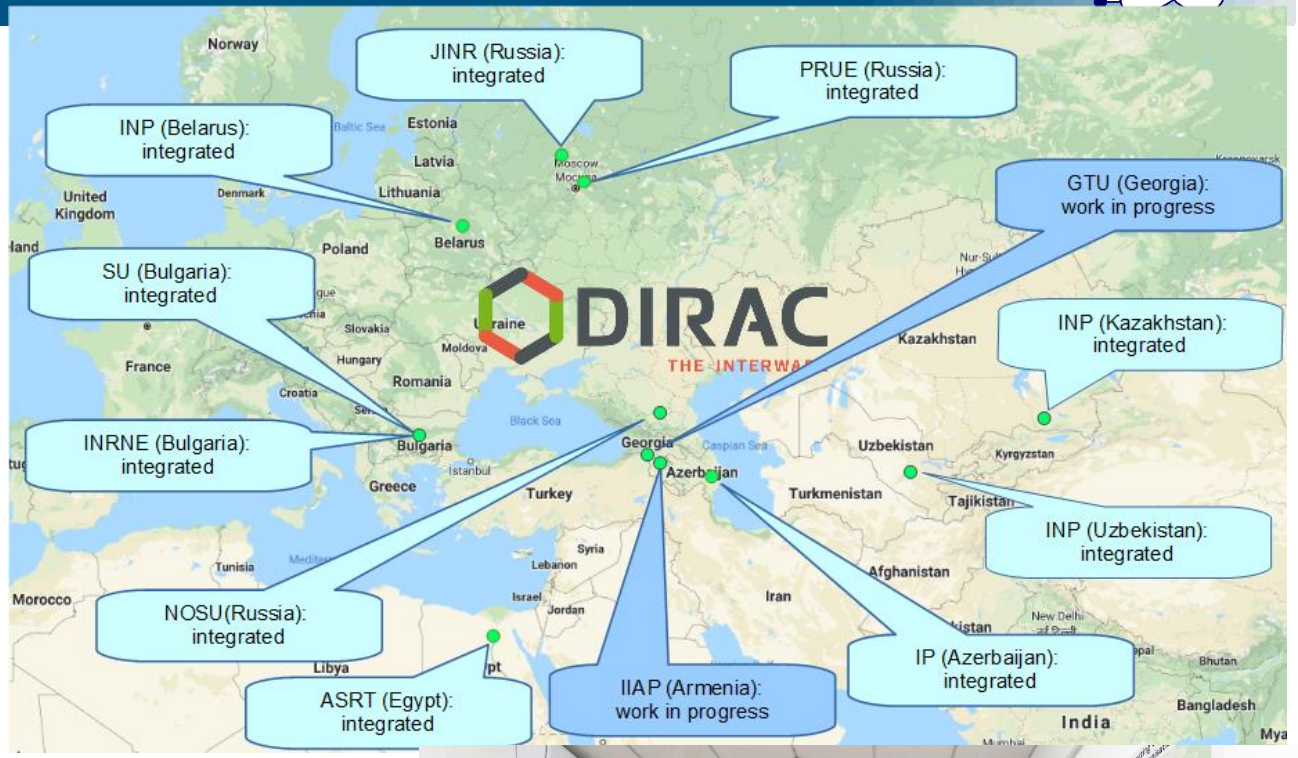


The JINR Tier2 output is the highest (90.31%) in the Russian Data Intensive Grid (RDIG) Federation.



Cloud Infrastructure

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

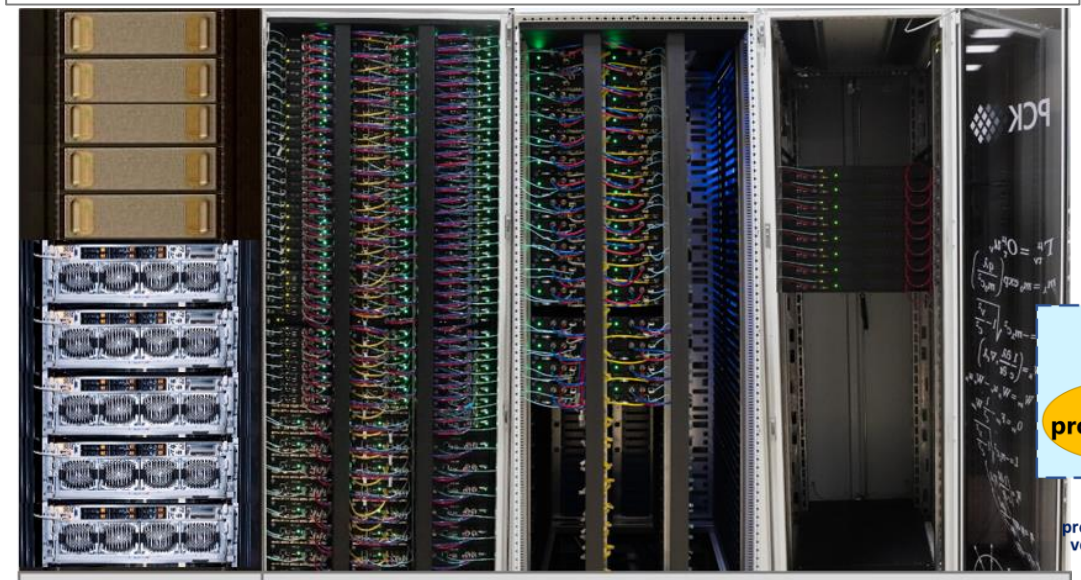


- Cloud Platform - OpenNebula
- Virtualization - KVM
- Storage (Local disks, Ceph)
- Total Resources
  ~ 5,152 CPU cores; 80 TB RAM;
  4.3 PB of raw ceph-based storage

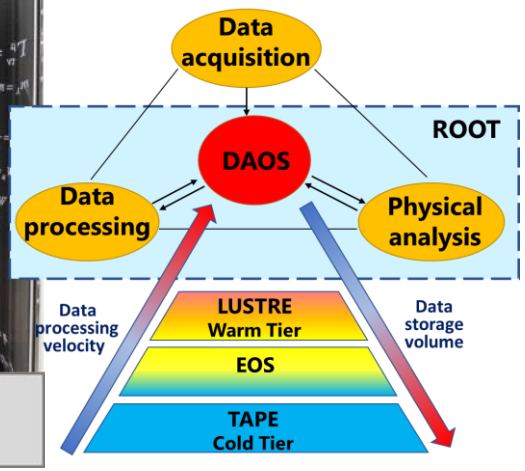
- Computational resources for neutrino experiments
- Testbeds for research and development in IT
- COMPASS production system services
- Data management system of the UNECE ICP Vegetation
- Scientific and engineering computing
- Service for data visualization
- VMs for JINR users

“Govorun” Supercomputer

- Hyper-converged software-defined system
- Hierarchical data processing and storage system
- Scalable solution Storage-on-demand
- Total peak performance: 1.7 PFlops DP
- GPU component based on NVIDIA Tesla 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

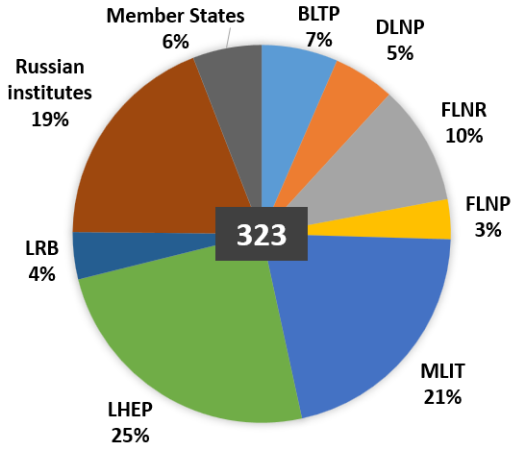


GPU-accelerator | Hyperconverged CPU and Distributed Storage Nodes



Key projects that use the resources of the SC “Govorun”:

- 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.

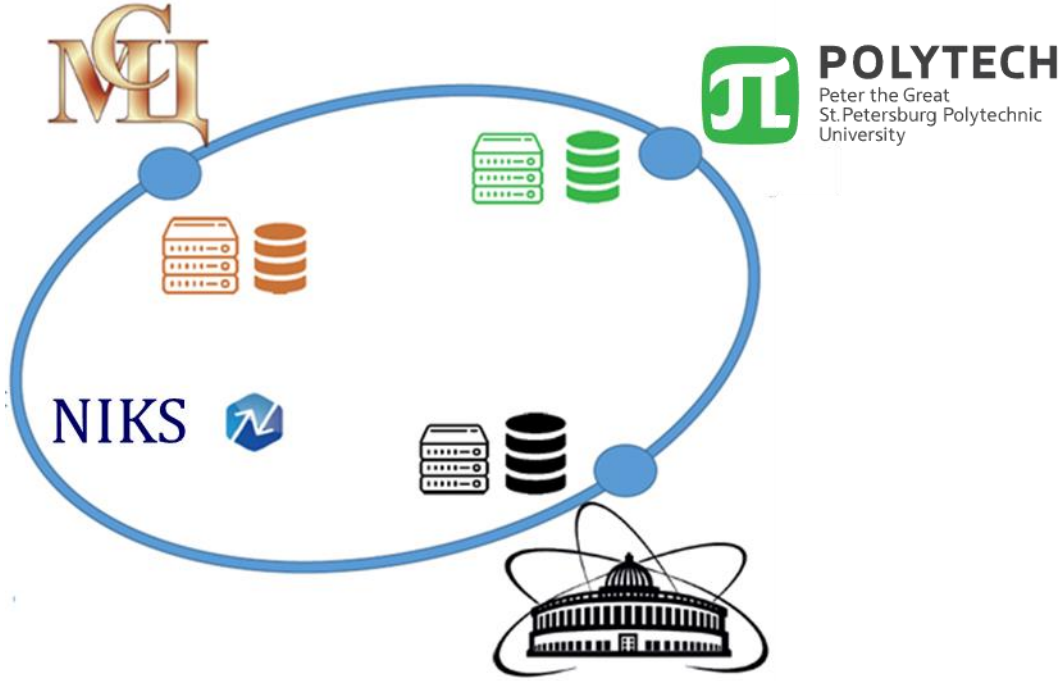


Total number of users : 323

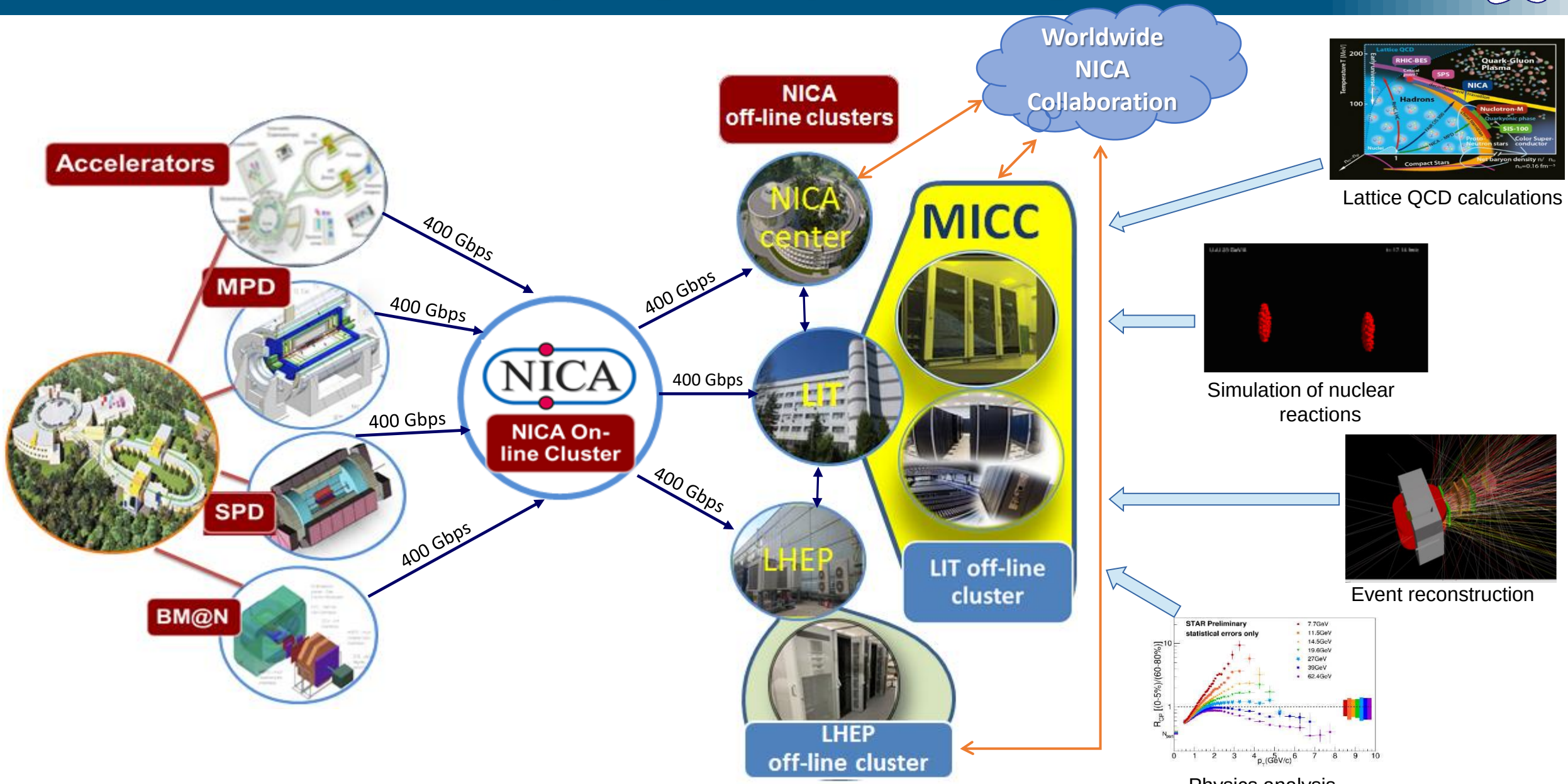
> 250 user papers (two in Nature Physics)

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.

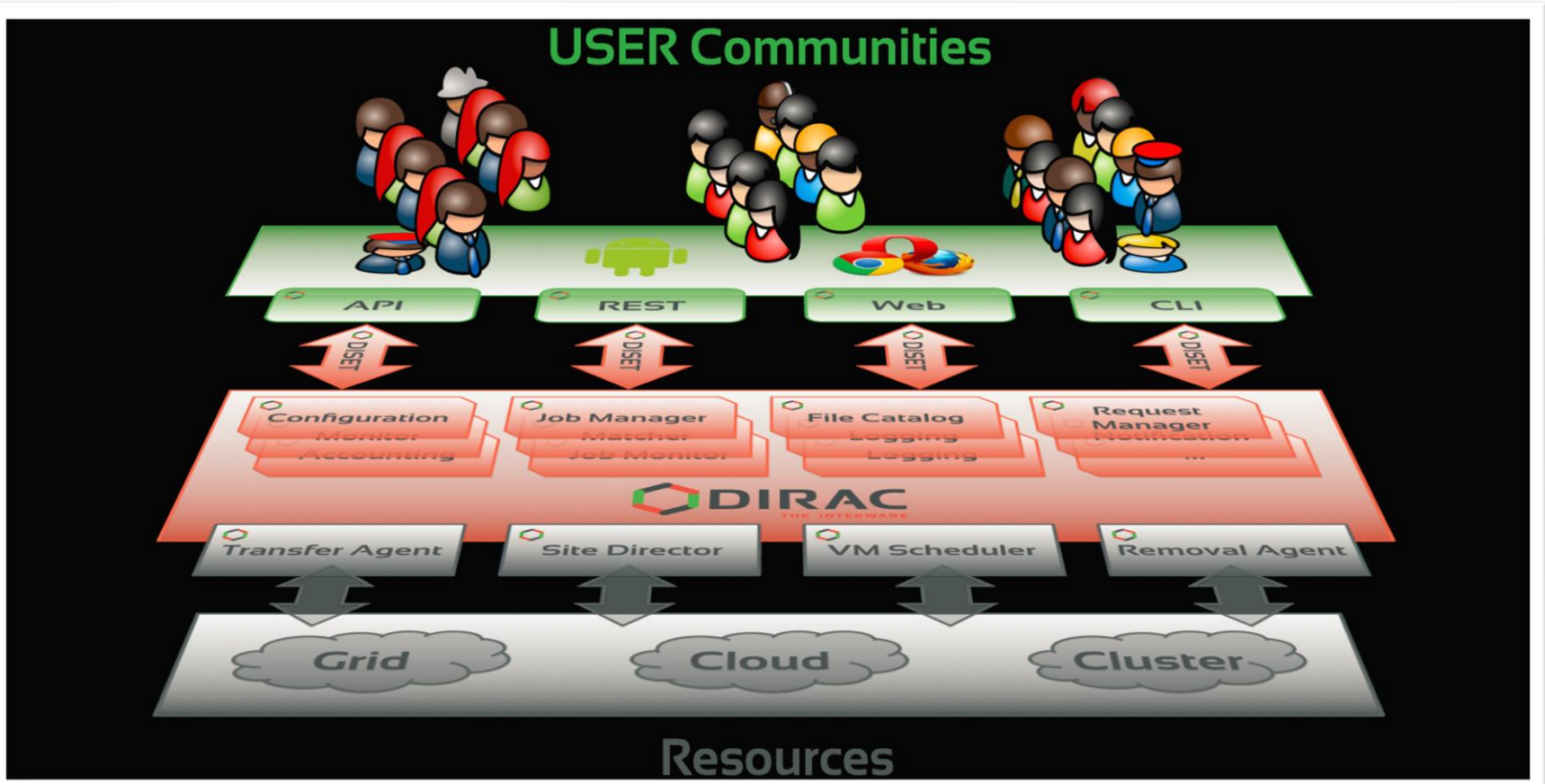


NICA Computing Concept & Challenges

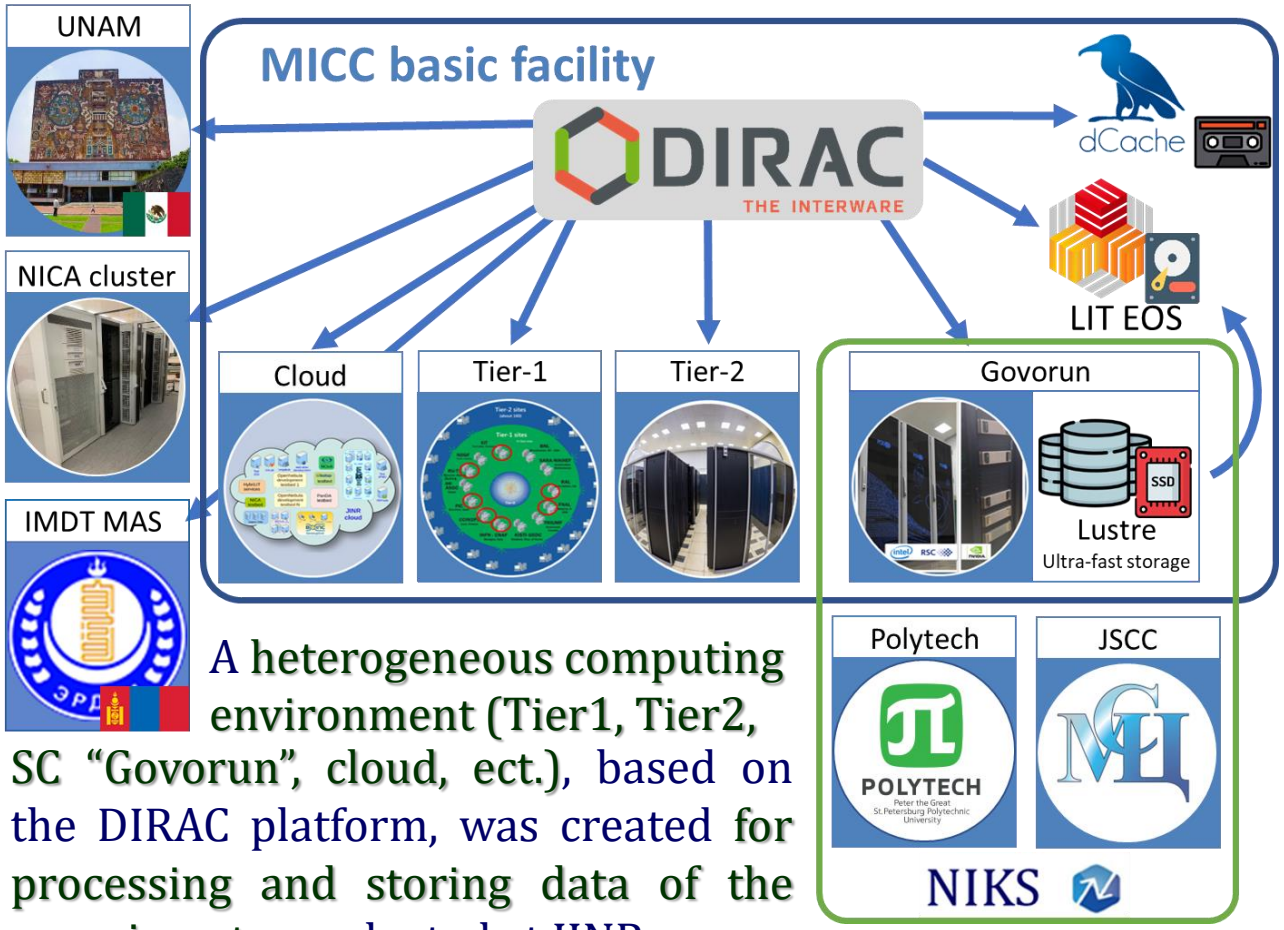


Платформа DIRAC

- DIRAC has all the necessary components to build ad-hoc grid infrastructures **interconnecting** computing resources of different types, allowing **interoperability** and simplifying **interfaces**.
- This allows to speak about the DIRAC ***interware***.



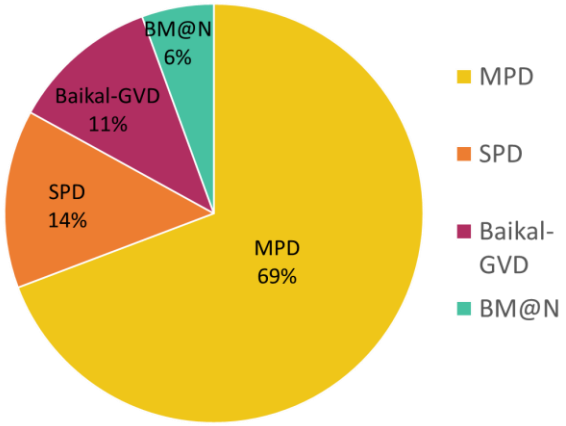
DIRAC-based distributed heterogeneous environment



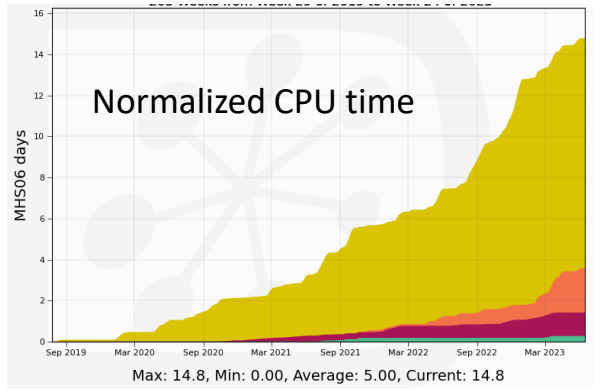
A heterogeneous computing environment (Tier1, Tier2, SC "Govorun", cloud, ect.), based on the DIRAC platform, was created for processing and storing data of the experiments conducted at JINR.

The distributed infrastructure is used by the MPD, Baikal-GVD, BM@N, SPD.

Use of DIRAC platform by experiments in 2019-2022

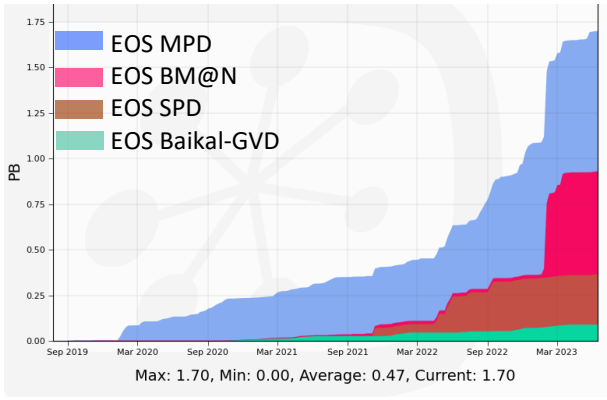


Total Number of executed jobs



The major user of the distributed platform is the MPD experiment

Data processed by experiments



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

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

Создание консорциума для IT-обеспечения исследовательской инфраструктуры класса «мегасайенс»

- Консорциум Российский ГРИД для интенсивных операций с данными (РДИГ) был создан в 2003 году для активного участия в распределенной обработке данных экспериментов на Большом адронной коллайдере LHC в рамках научной коллаборации LHC WLCG (Worldwide LHC Computing Grid). Созданная инфраструктура RDIG имеет огромное значение для эффективного участия ученых России в научной программе экспериментов на LHC.
- В России реализуется программа масштабных научных проектов, важнейшей частью которых является развитие распределенных гетерогенных компьютерных систем (включая системы с экстрамассивным параллелизмом) для обработки, хранения, анализа экспериментальных данных, разработка и внедрение эффективных методов, алгоритмов и программного обеспечения для моделирования физических систем, математической обработки и анализа экспериментальных данных, развитие методов машинного обучения, искусственного интеллекта, квантовых вычислений.
- Для решения этой масштабной задачи необходимо развивать распределенную компьютерную инфраструктуру, объединяющую ключевые научные и образовательные институты, участвующие в проектах мегасайенс - РДИГ-М. Созданный консорциум на базе ОИЯИ, НИЦ Курчатовский институт, ИСП РАН должен стать ядром для IT-обеспечения исследовательской инфраструктуры класса «мегасайенс».

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 Data Analysis Framework

MATLAB

GEANT4

Maple

Frameworks and tools for ML/DL tasks

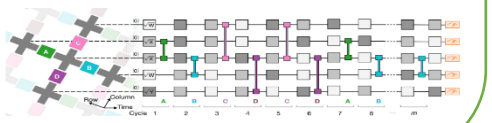
jupyterhub

TensorFlow

NumPy

scikit learn

Quantum algorithms, quantum programming and quantum control



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

The main focus is on mathematical aspects of diverse problems in fundamental and applied quantum technologies such as

- quantum information theory,
- quantum communications,
- quantum computation, simulation, and quantum algorithms.

More than **60** participants from

Armenia,	Georgia,	Moldova,
Belarus,	Egypt,	Romania,
Bulgaria,	India,	Serbia,
Great Britain,	Kazakhstan,	the Czech Republic

Russia was represented by specialists from Voronezh, Kazan, Moscow, St. Petersburg, Tver, Chelyabinsk and Dubna.

32 reports

JINR School of Information Technology 2023

50 students from 11 Russian universities

Осенняя ИТ-школа состоится в ЛИТ ОИЯИ с 7-11 октября

Preliminary Topics:

- Mathematical methods and tools for modeling complex physical systems;
- Mathematical methods in life sciences;
- Modern methods for data processing and analysis in Mega-science 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.

Participant registration and abstract submission: September 1st, 2024

All the necessary information about the requirements and submission guidelines is on the conference page: mmcp.jinr.int.