JOINT INSTITUTE FOR NUCLEAR RESEARCH
ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

Распределенные и гибридные вычисления для масштабных научных проектов

Кореньков Владимир Васильевич

Директор Лаборатории информационных технологий имени М.Г. Мещерякова ОИЯИ

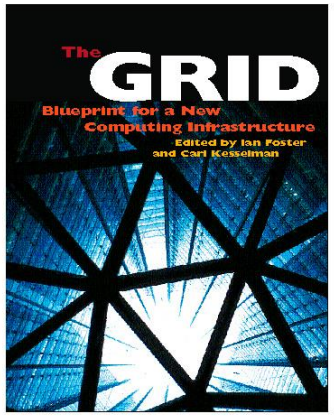
ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ УЧРЕЖДЕНИЕ
«ПЕТЕРБУРГСКИЙ ИНСТИТУТ ЯДЕРНОЙ ФИЗИКИ ИМ. Б.П. КОНСТАНТИНОВА
НАЦИОНАЛЬНОГО ИССЛЕДОВАТЕЛЬСКОГО ЦЕНТРА «КУРЧАТОВСКИЙ ИНСТИТУТ»

ПИЯФ, 14 февраля 2023 года

Grids, clouds, supercomputers, Big data

Grids

- Collaborative environment
- Distributed resources

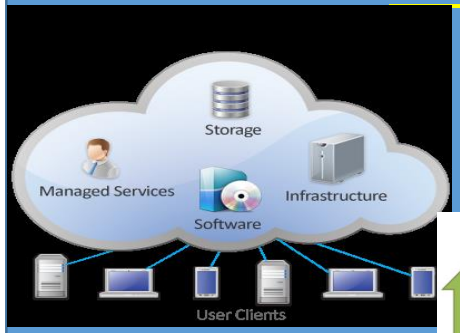


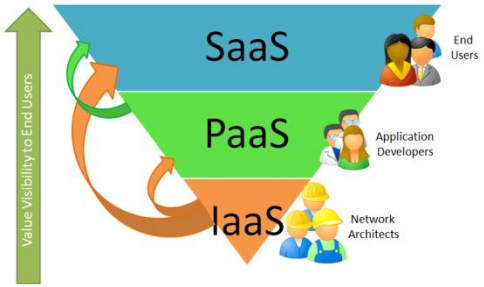
Supercomputers

	Titan System (Cray XK7)		
Peak Performance	27.1 PF 18,688 compute nodes	24.5 PF GPU	2.6 PF CPU
System memory	710 TB total memory		
Interconnect	Gemini High Speed Interconnect	3D Torus	
Storage	Lustre Filesystem	32 PB	
Archive	High-Performance Storage System (HPSS)	29 PB	
I/O Nodes	512 Service and I/O nodes		

12 OLCF | 20

Clouds



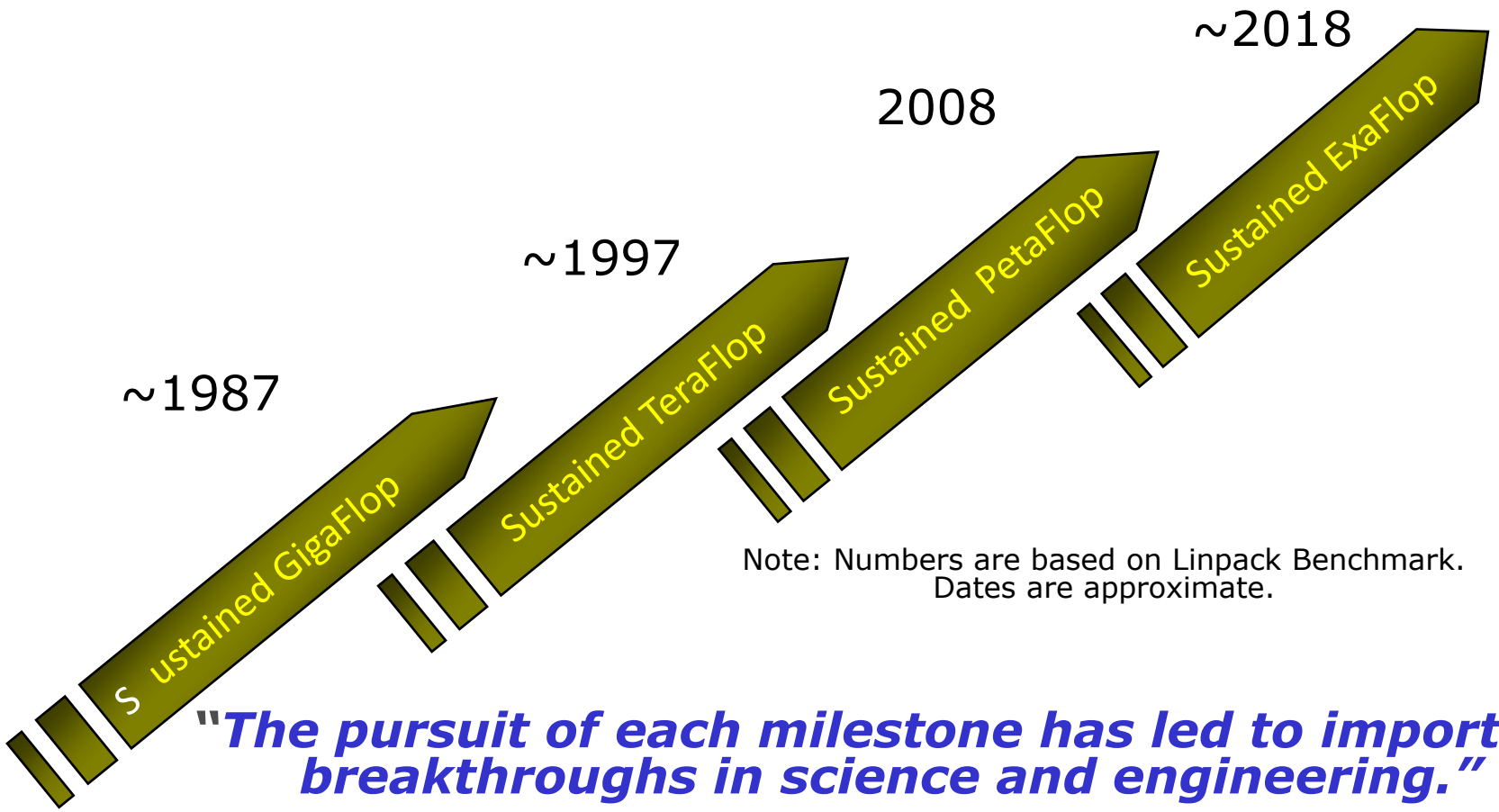


Big Data

- *Volume*
- *Velocity*
- *Variety*

Reach Exascale by 2018

From GigFlops to ExaFlops



Note: Numbers are based on Linpack Benchmark.
Dates are approximate.

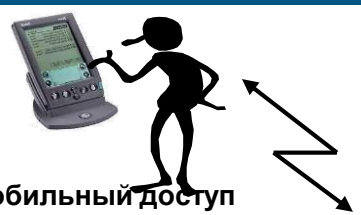
"The pursuit of each milestone has led to important breakthroughs in science and engineering."

Source: IDC "In Pursuit of Petascale Computing: Initiatives Around the World," 2007

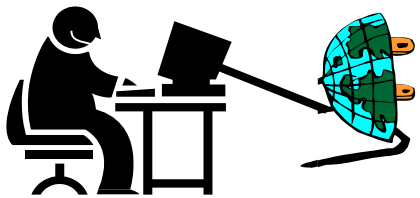
TOP500 List – November 2022

Rank	System	Cores	Rmax (PFlop/s)	Rpeak (PFlop/s)	Power (kW)
1	**Frontier** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory US	8,730,112	**1,102.00**	1,685.65	21,100
2	**Supercomputer Fugaku** - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	**442.01**	537.21	29,899
3	**LUMI** - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	2,220,288	**309.10**	428.70	6,016
4	**Leonardo** - BullSequana XH2000, Xeon Platinum 8358 32C 2.6GHz, NVIDIA A100 SXM4 64 GB, Quad-rail NVIDIA HDR100 Infiniband, Atos EuroHPC/CINECA Italy	1,463,616	**174.70**	255.75	5,610
5	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM DOE/SC/Oak Ridge National Laboratory US	2,414,592	**148.60**	200.79	10,096
6	**Sierra** - IBM Power System AC922, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM / NVIDIA / Mellanox DOE/NNSA/LLNL US	1,572,480	**94.64**	125.71	7,438
7	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway, NRCPC National Supercomputing Center in Wuxi China	10,649,600	**93.01**	125.44	15,371
8	**Perlmutter** - HPE Cray EX235n, AMD EPYC 7763 64C 2.45GHz, NVIDIA A100 SXM4 40 GB, Slingshot-10, HPE DOE/SC/LBNL/NERSC US	761,856	**70.87**	93.75	2,589
9	**Selene** - NVIDIA DGX A100, AMD EPYC 7742 64C 2.25GHz, NVIDIA A100, Mellanox HDR Infiniband, Nvidia NVIDIA Corporation US	555,520	**63.46**	79.22	2,646
10	**Tianhe-2A** - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000, NUDT National Super Computer Center in Guangzhou China	4,981,760	**61.44**	100.68	18,482
25	**Chervonenkis** - YANDEX Y4N-GA1-TY25-ZB0, AMD EPYC 7702 64C 2GHz, NVIDIA A100 80GB, Infiniband, YANDEX, NVIDIA Yandex Russia	193,440	21.53	29.42	

Грид - это средство для совместного использования вычислительных мощностей и хранилищ данных посредством интернета



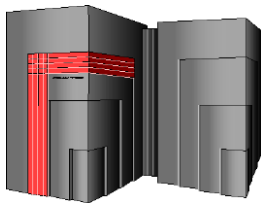
Мобильный доступ

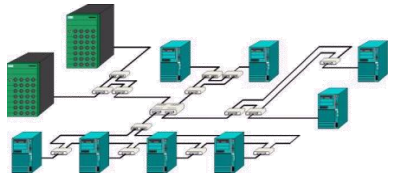


Рабочие станции

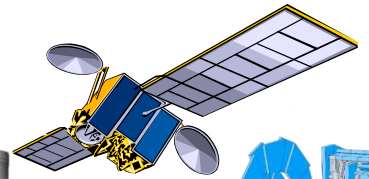
Визуализация

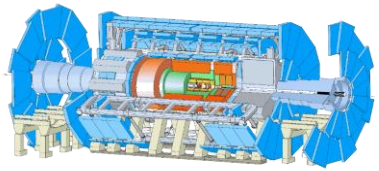
ПРОМЕЖУТОЧНОЕ ПРОГРАММНОЕ ОБЕСПЕЧЕНИЕ ГРИД



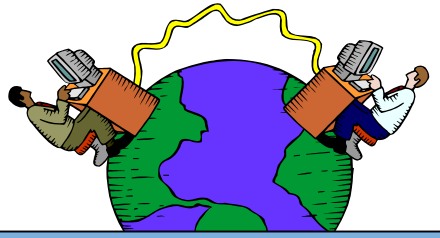


Суперкомпьютеры, ПК- кластеры

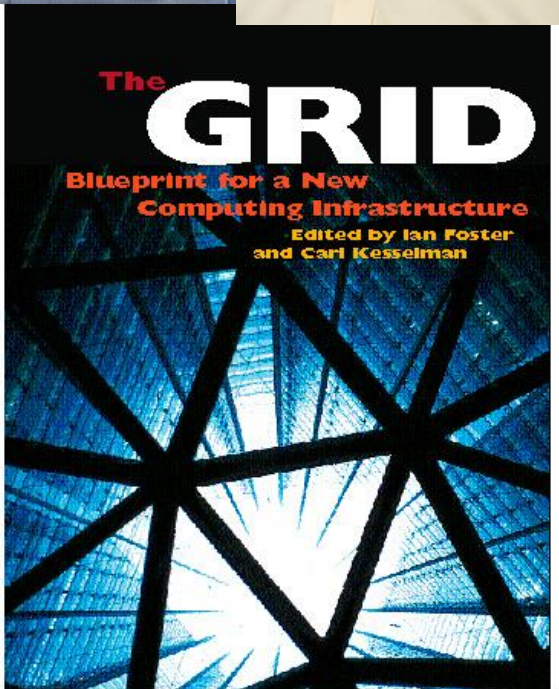




Массовая память, сенсоры, эксперименты



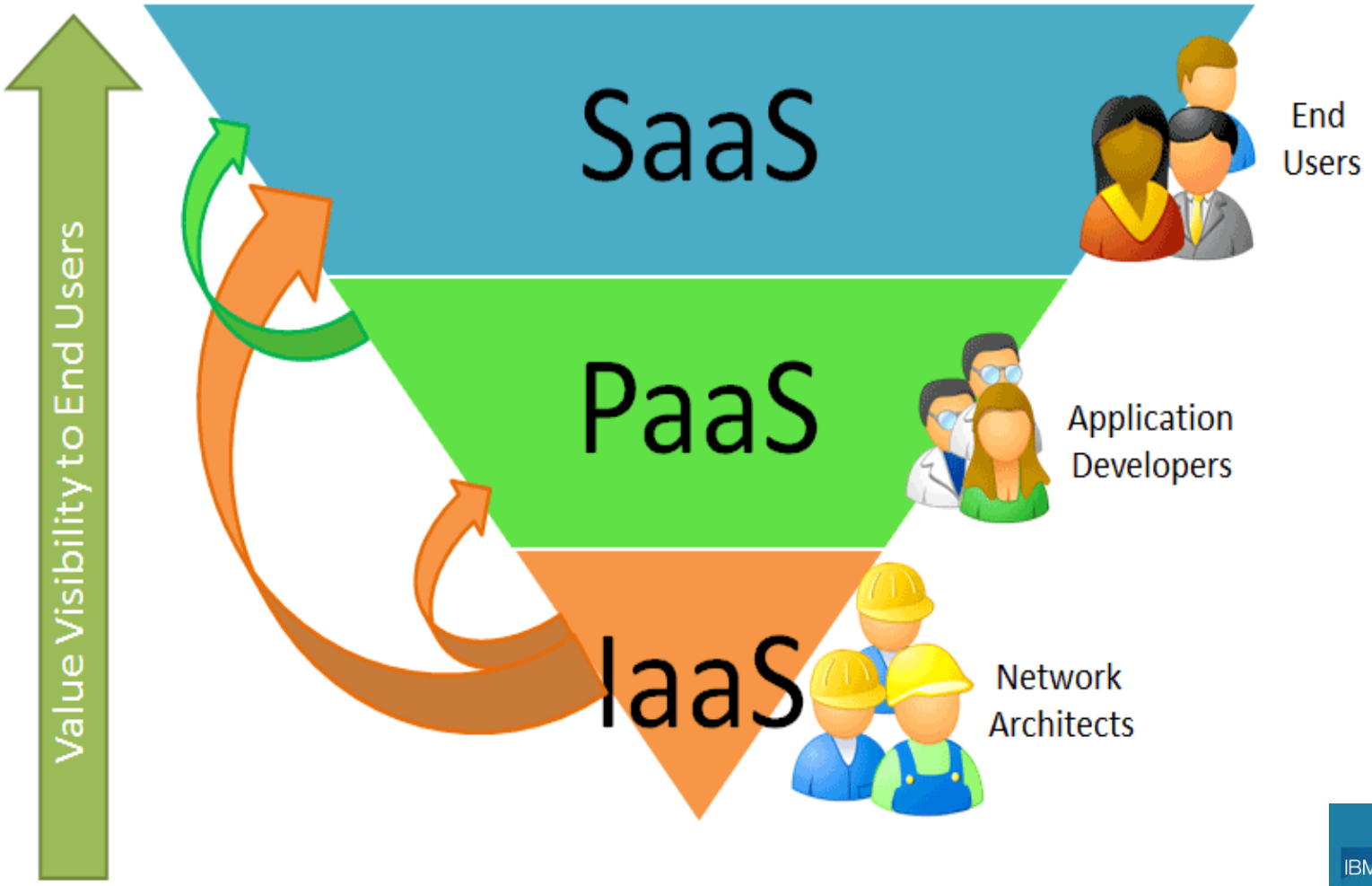
Интернет, сети



Облачные технологии

Облачные вычисления (англ. cloud computing) — модель обеспечения удобного сетевого доступа по требованию к некоторому общему фонду конфигурируемых вычислительных ресурсов (например, сетям передачи данных, серверам, устройствам хранения данных, приложениям и сервисам — как вместе, так и по отдельности), которые могут быть оперативно предоставлены и освобождены с минимальными эксплуатационными затратами или обращениями к провайдеру.

Cloud computing



Gmail by Google

Dropbox

YouTube

Google App Engine

Microsoft Azure

Google Compute Engine

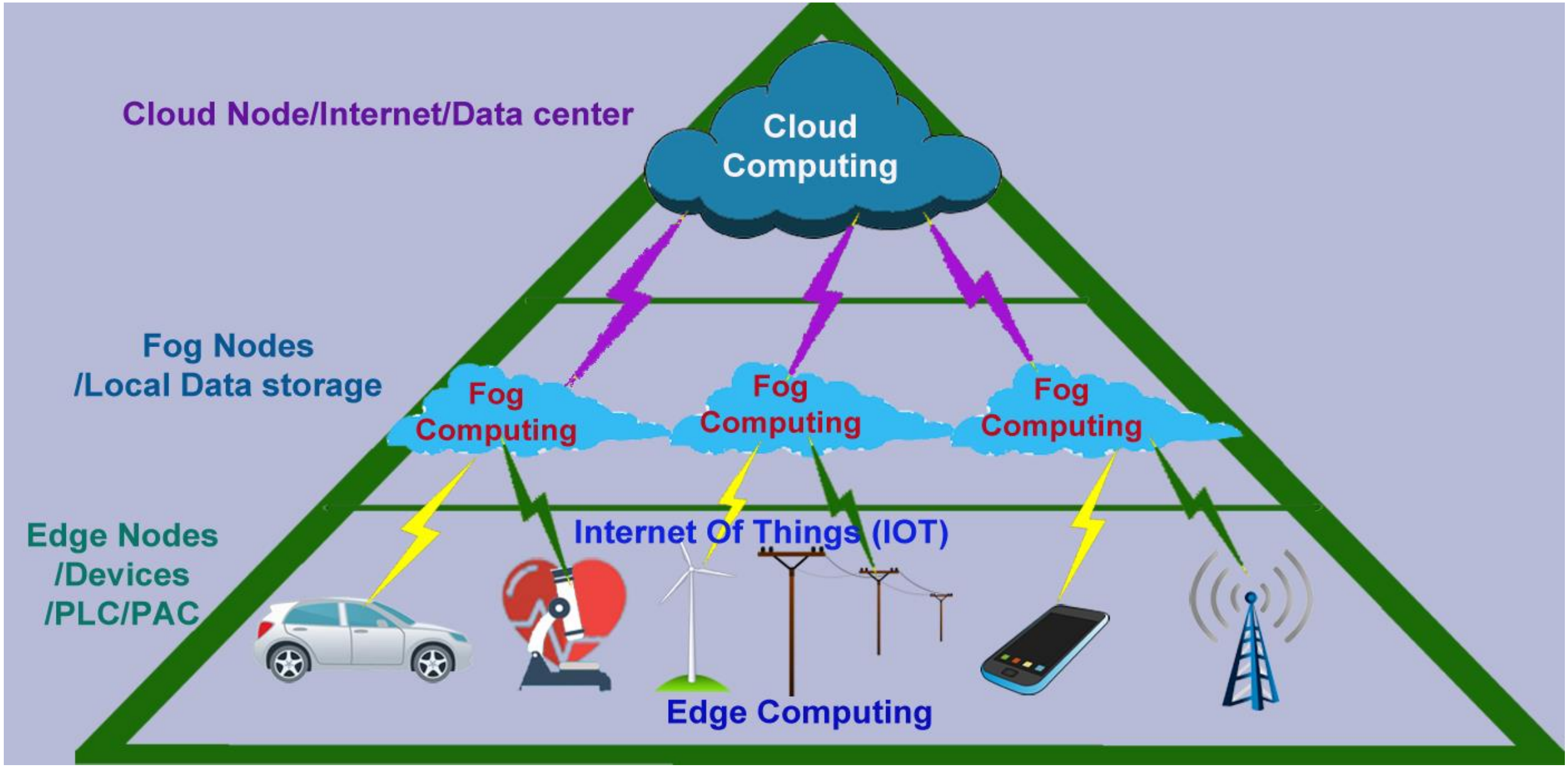
amazon

openstack

IBM SmartCloud Enterprise

OpenNebula.org

Cloud – Fog – Edge Computing



Грид технологии – путь к успеху

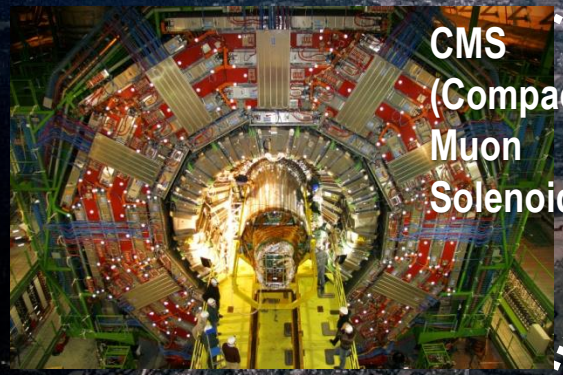
На торжестве по поводу получения Нобелевской премии за открытие бозона Хиггса директор ЦЕРНа Рольф Хойер прямо назвал **грид-технологии одним из трех столпов успеха** (наряду с ускорителем LHC и физическими установками).

Без организации грид-инфраструктуры на LHC было бы невозможно обрабатывать и хранить колоссальный объем данных, поступающих с коллайдера, а значит, совершать научные открытия.

Сегодня уже ни один крупный проект не осуществим без использования распределенной инфраструктуры для обработки данных.

Large Hadron Collider

The Large Hadron Collider (LHC), one of the largest and truly global scientific projects ever, is the most exciting turning point in particle physics.

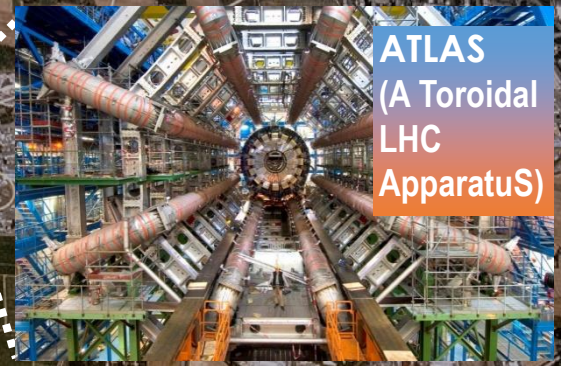


CMS (Compact Muon Solenoid)

LHCb (Large Hadron Collider beauty experiment)

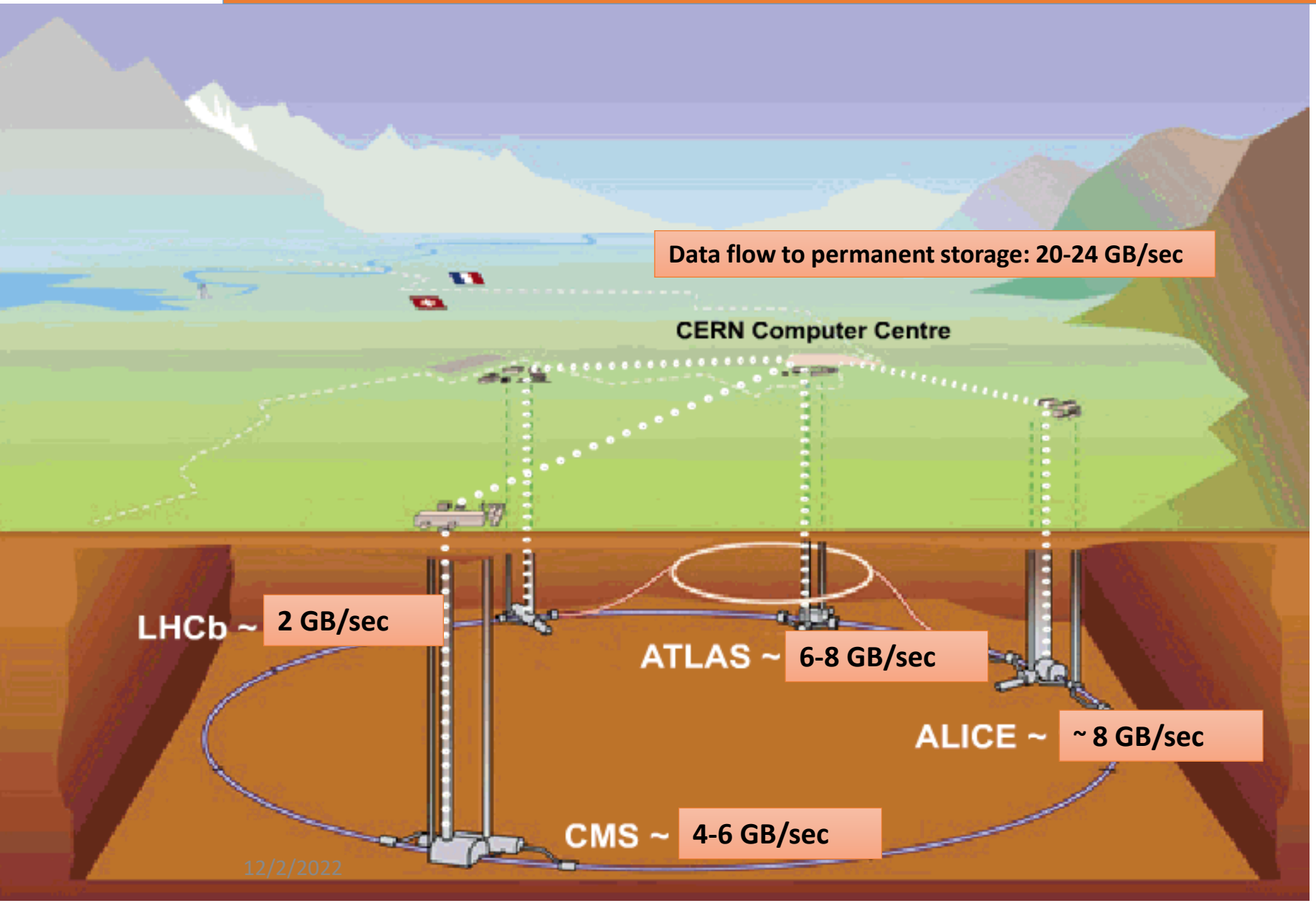
Data flow to permanent storage: 4-6 GB/sec

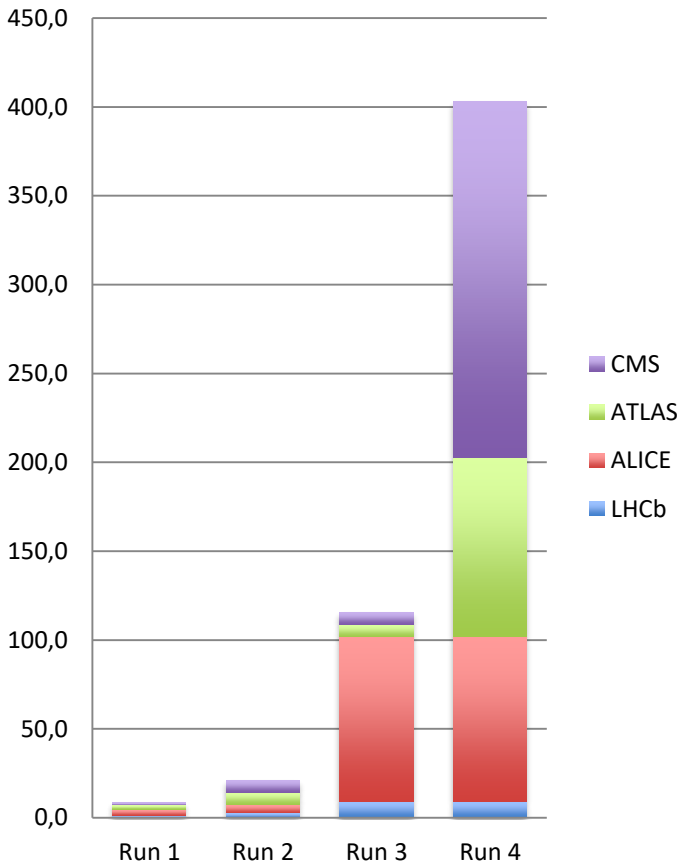
ALICE (A Large Ion Collider Experiment)



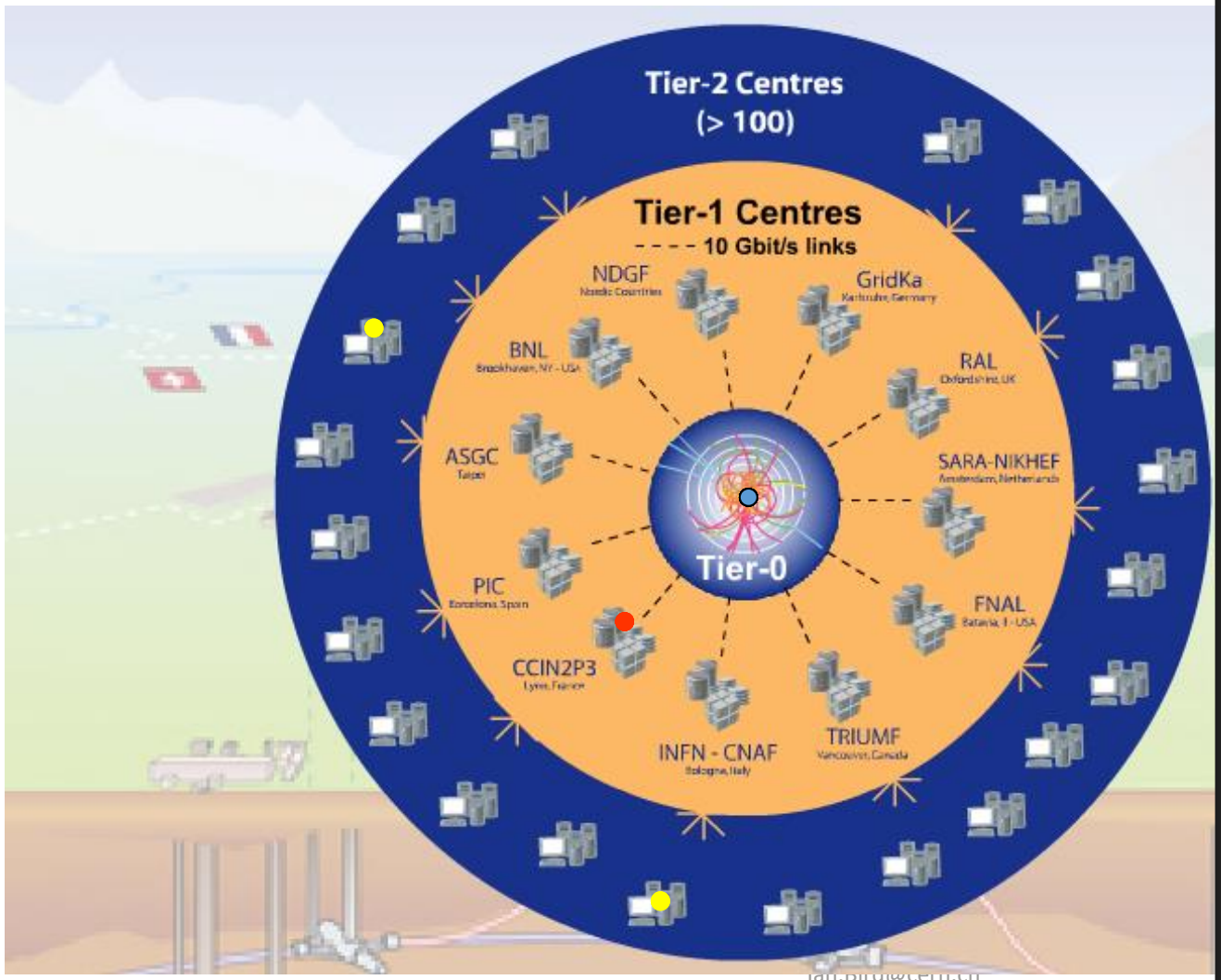
ATLAS (A Toroidal LHC ApparatuS)

Data Collection and Archiving at CERN





Tier Structure of GRID Distributed Computing: Tier-0/Tier-1/Tier-2



Tier-0 (CERN):

- accepts data from the CMS Online Data Acquisition and Trigger System
- archives RAW data
- the first pass of reconstruction and performs Prompt Calibration
- data distribution to Tier-1

Tier-1 (11 centers):

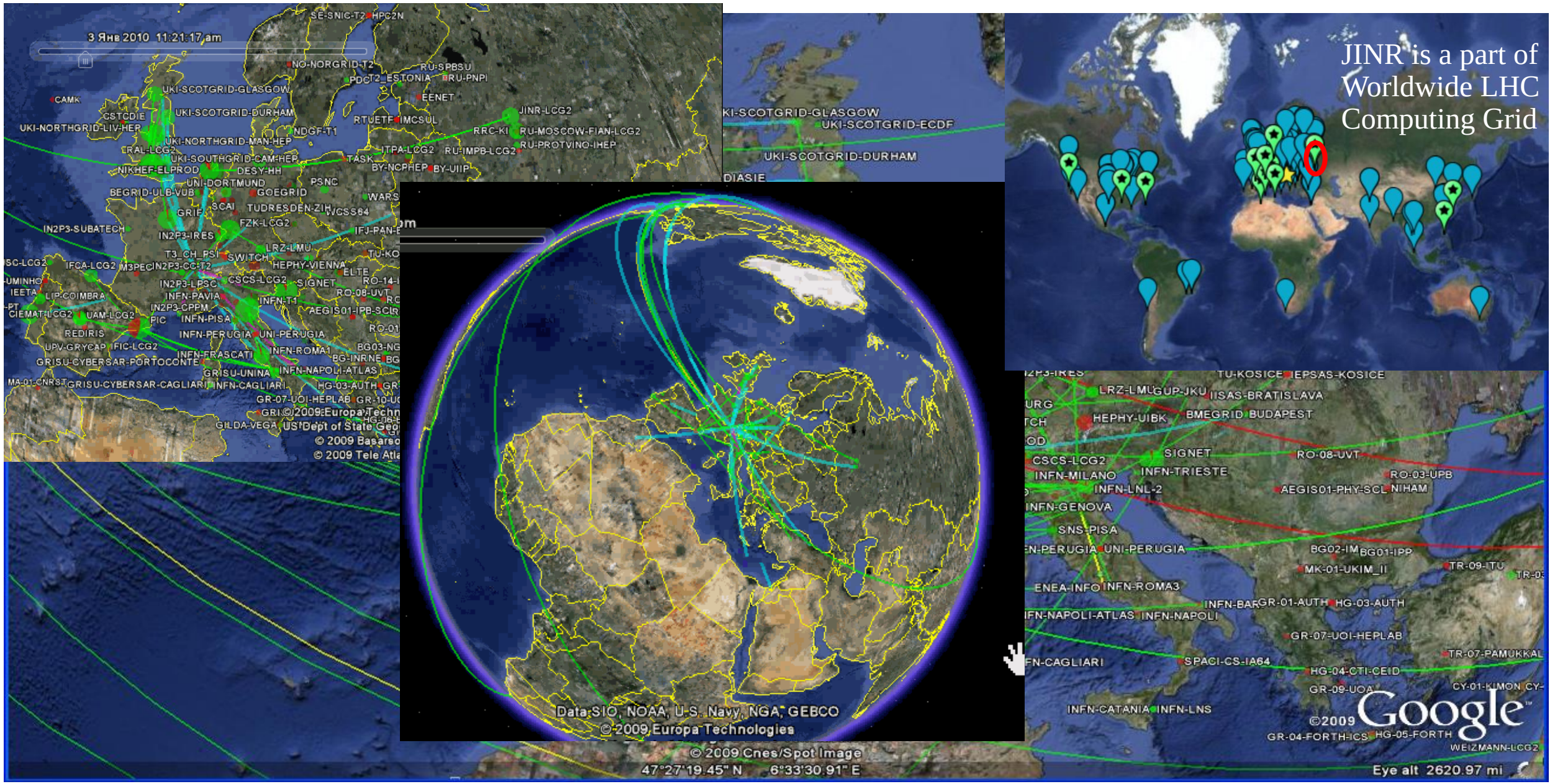
- receives a data from the Tier-0
- data processing (re-reconstruction, skimming , calibration etc)
- distributes data and MC to the other Tier-1 and Tier-2
- secure storage and redistribution for data and MC

Tier-2 (>200 centers):

- simulation
- user physics analysis

Ian.Bird@cern.ch

The Worldwide LHC Computing Grid (WLCG)

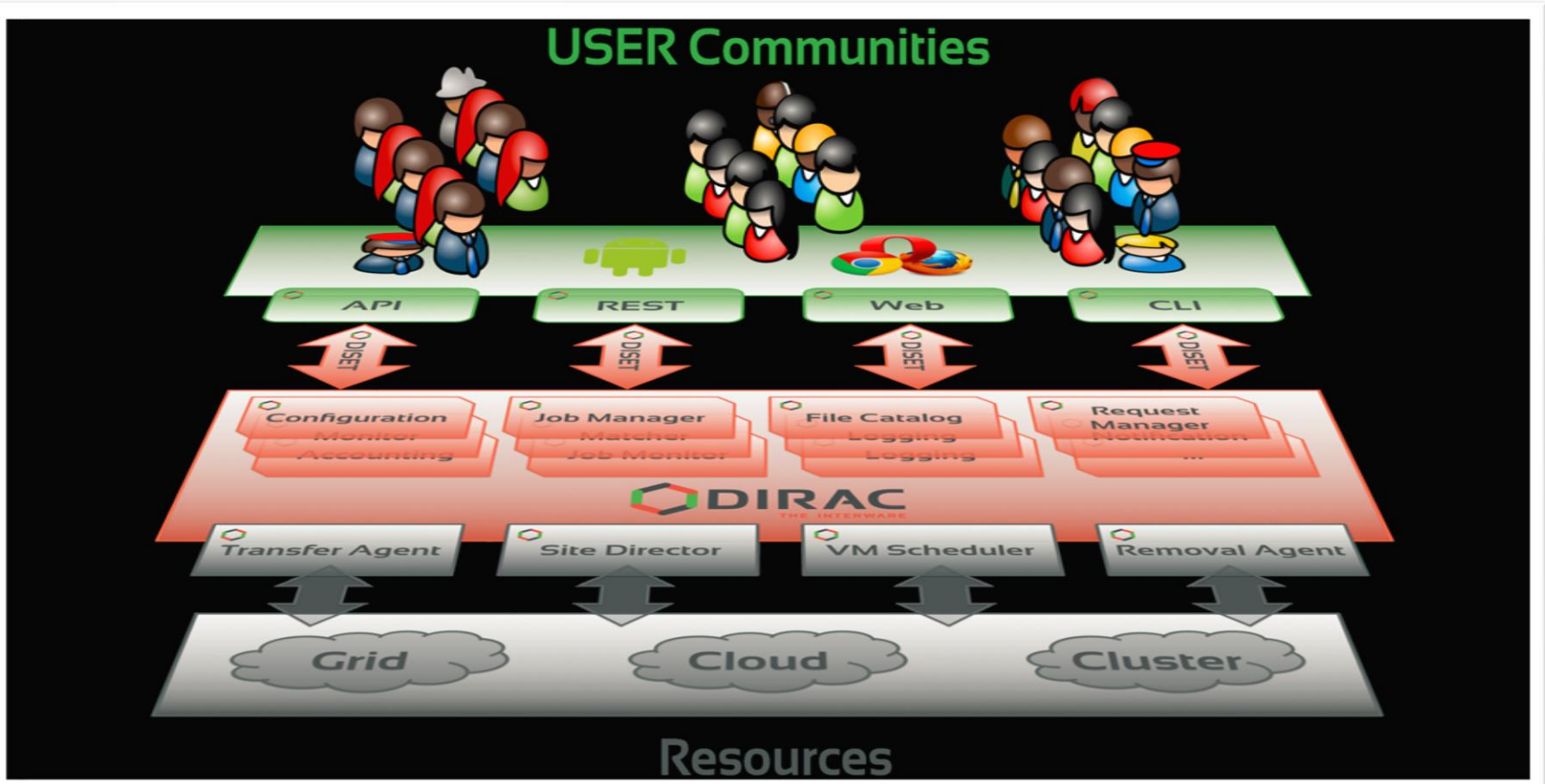


Эволюция модели компьютинга

- Расширение компьютерных ресурсов за счет использования внешних невыделенных ресурсов (HLT, Clouds, HPC…)
- Изменения модели компьютинга в каждом эксперименте, с целью оптимизации использования ресурсов
- Значительные усилия вкладываются в развитие программного обеспечения, чтобы улучшить общую производительность при использовании современных архитектур (многоядерность, GPU…)
- Оптимизации процессов обработки, количество хранящихся реплик данных и др.

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***.



* PanDa в эксперименте ATLAS

В эксперименте ATLAS на Большом адронном коллайдере разработана платформа для управления вычислительными ресурсами PanDA Workload Management System (WMS), которая обладает следующими возможностями:

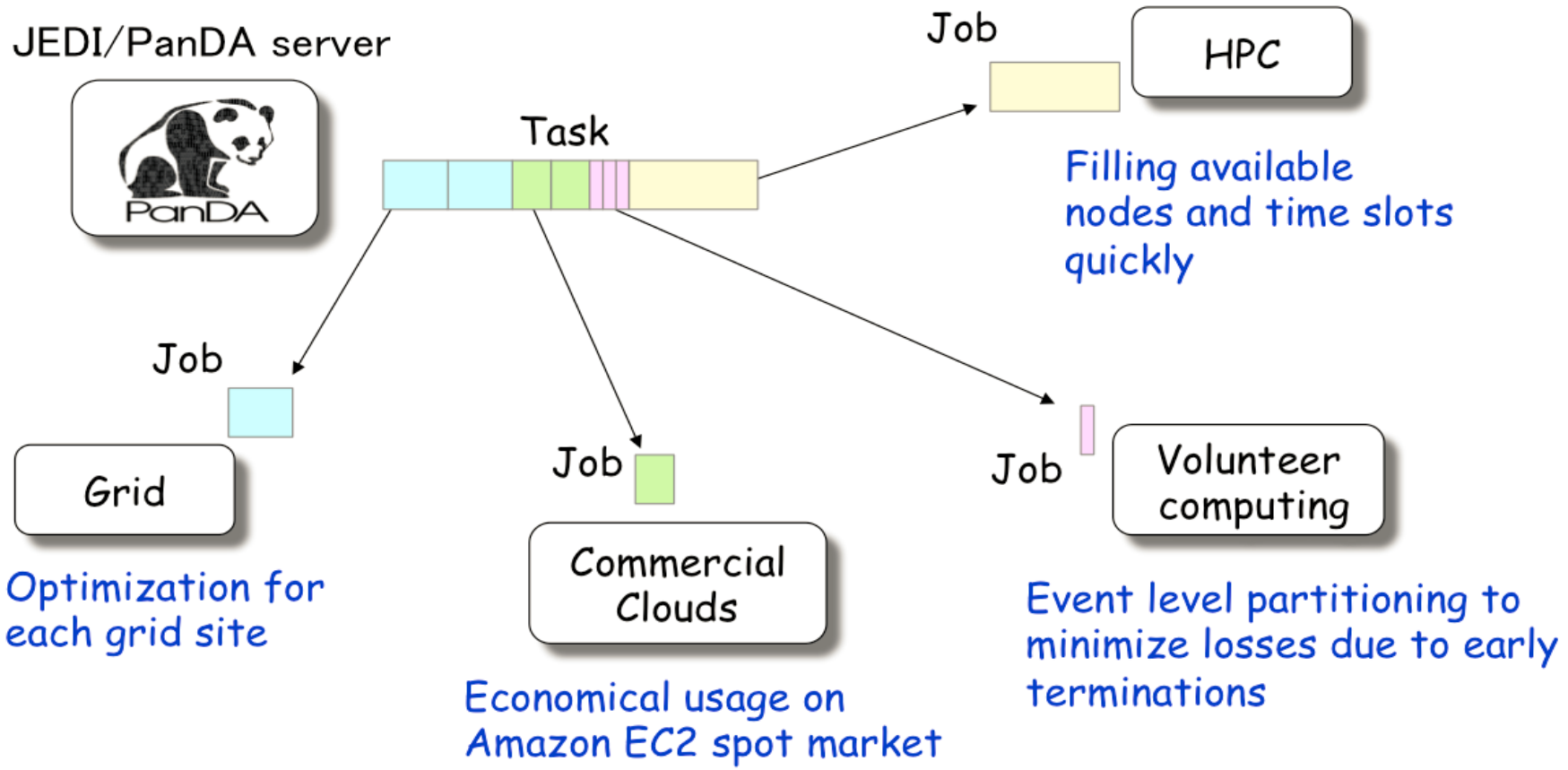
- Проект PanDA начался в 2005 году группами BNL и UTA - **P**roduction **an**d **D**ata **A**nalysis system.
- Автоматизированная и гибкая система управления заданиями, которая может оптимально сделать распределенные ресурсы доступными пользователю.
- С помощью PanDA, физики видят единый вычислительный ресурс, который предназначен для обработки данных эксперимента, даже если дата-центры разбросаны по всему миру
- PanDa изолирует физиков от аппаратного обеспечения, системного и промежуточного программного обеспечения и других технологических сложностей, связанных с конфигурированием сети и оборудования.
- Вычислительные задачи автоматически отслеживаются и выполняются. Могут выполняться групповые задачи физиков

В настоящее время PanDa контролирует:

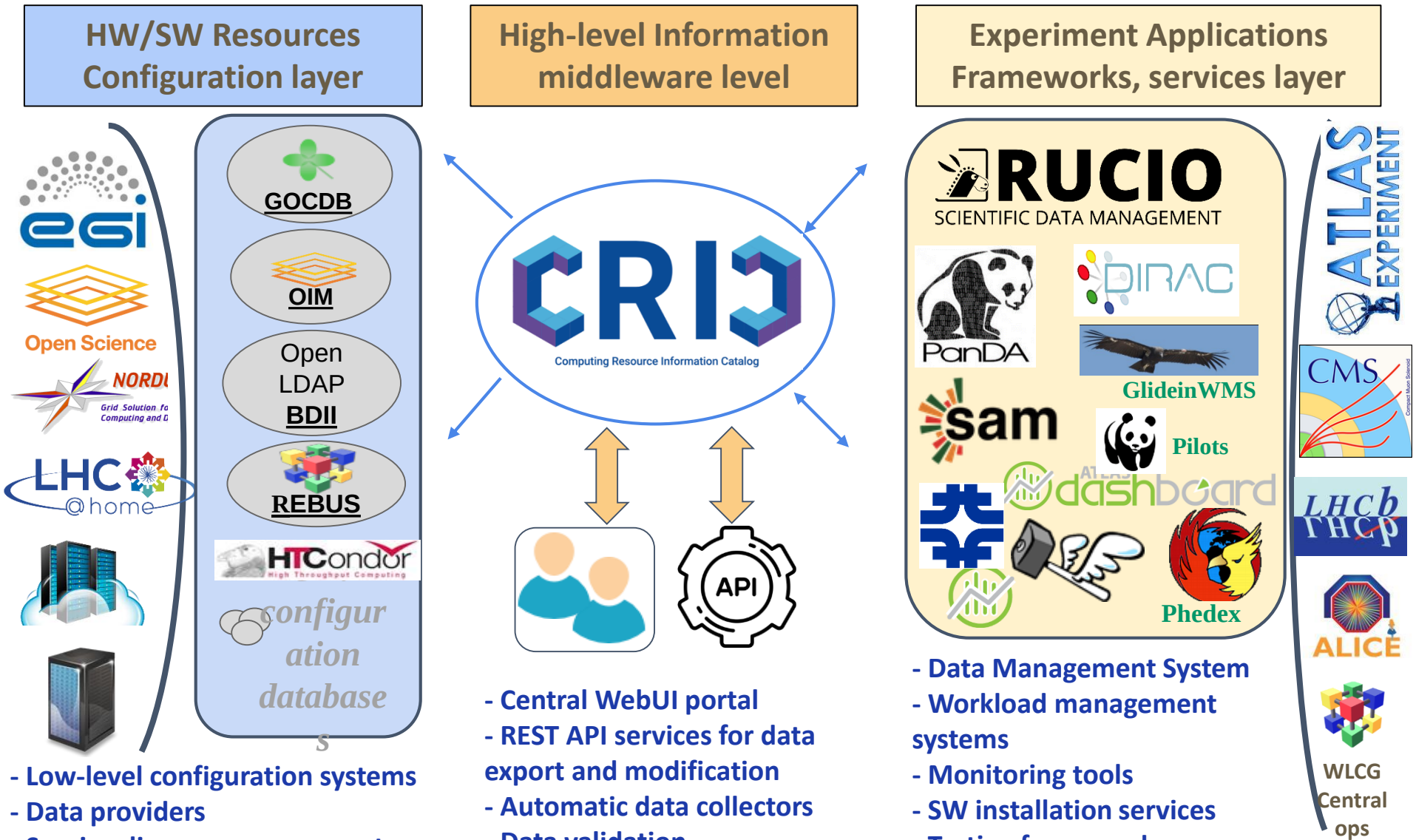
- **сотни дата - центров в 50 странах мира**
- **сотни тысяч вычислительных узлов**
- **сотни миллионов заданий в год**
- **тысячи пользователей**

Dynamic Job Definition in PanDA

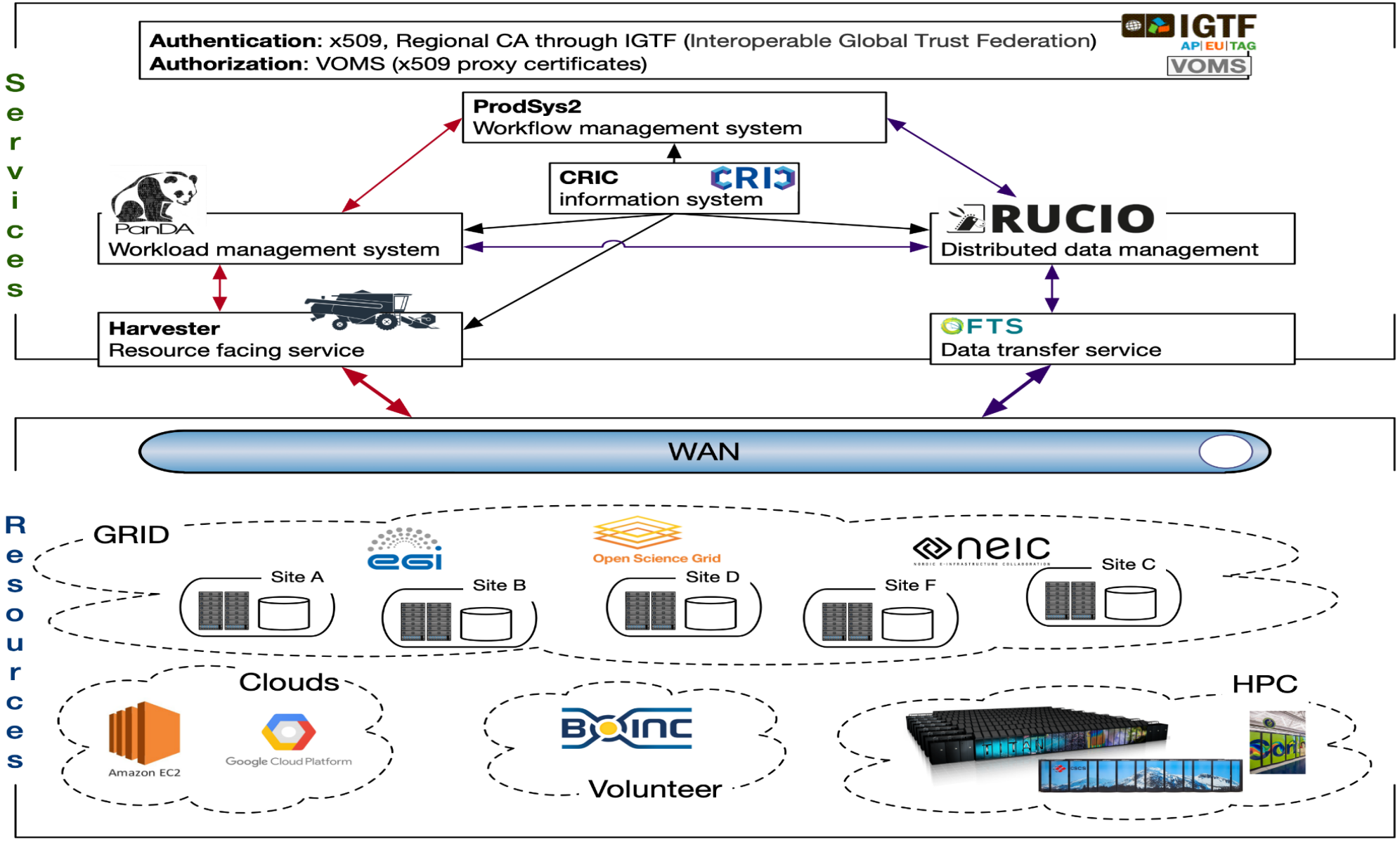
- Workload partitioning for traditional and opportunistic resources



CRIC: a unified topology system for a large scale, heterogeneous and dynamic computing infrastructure

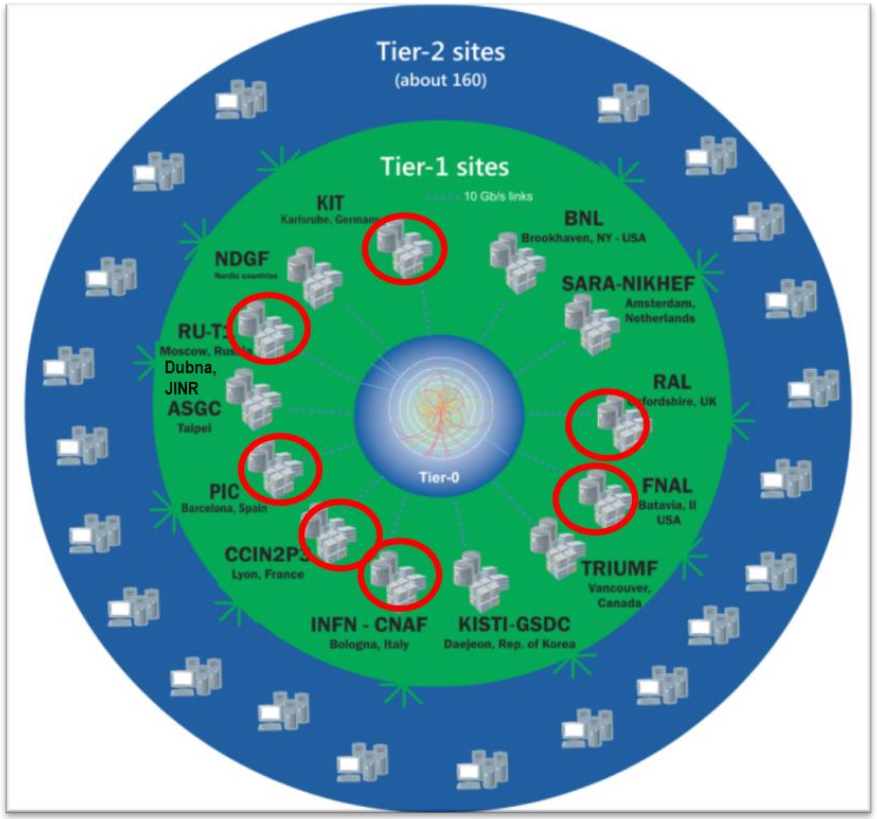


ATLAS computing



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.

161 sites

42 countries

~1M CPU cores

1 EB of storage

> 3 million jobs/day

10-100 Gb links

Worldwide LHC Computing Grid - 2019

Tier0 (CERN): data recording, reconstruction and distribution

Tier1: permanent storage, re-processing, analysis

Tier2: Simulation, end-user analysis

International Large-scale projects

Russian research institutes and universities actively participate in international large-scale projects:

- LHC, CERN (experiments: ATLAS, ALICE, LHCb, CMS)
- XFEL, DESY (European free electron laser)
- ESRF, France (European synchrotron center)
- FAIR, GSI, Germany (CBM, PANDA experiments)
- ITER, France …

International large-scale projects are being prepared in Russia:

- **NICA**, JINR, Dubna (proton and heavy ion collider)
- **PIK**, PNPI, Gatchina (high-flow reactor complex)
- **SKIF**, INP SB RAS Novosibirsk (Siberian ring photon source)
- **Super S-Tau Fabric**, Sarov (electron-positron collider)
- **Нейтринная программа (Байкал, JUNO, NOVA, DUNE …)**
- **синхротронно-нейтронная программа, науки о жизни**

Joint Institute for Nuclear Research
SCIENCE BRINGING NATIONS TOGETHER

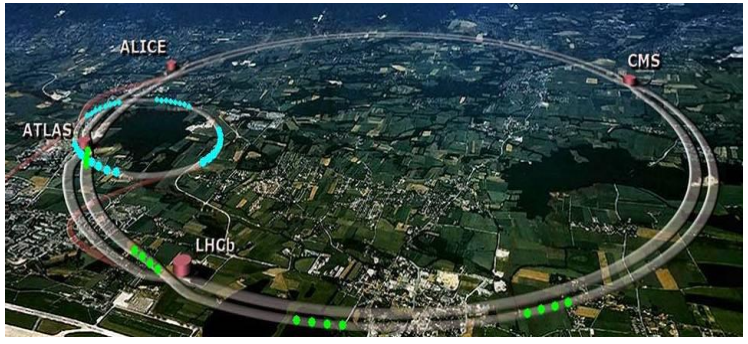
NICA

СКИФ
СИБИРСКИЙ КОЛЬЦЕВОЙ ИСТОЧНИК ФОТОНОВ

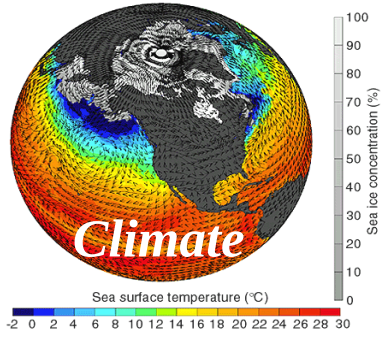
Институт ядерной физики имени Г. И. Будкера СО РАН

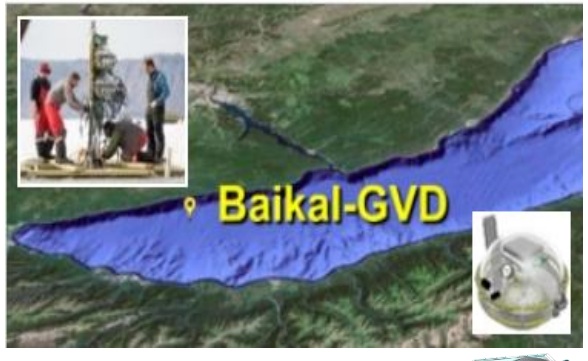
HPC+Big Data+Artificial intelligence

High Energy Physics

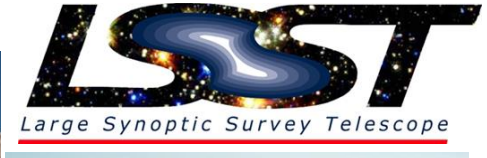


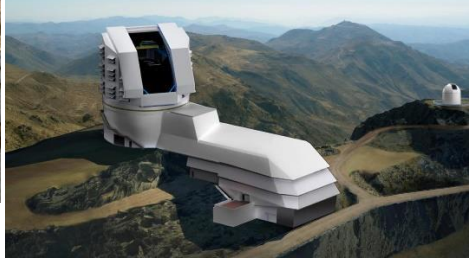
CERN Large Hadron Collider > 600 Pb/Year





Square Kilometer Array radio telescope
> 1 Eb/Year ra
data (estimatic



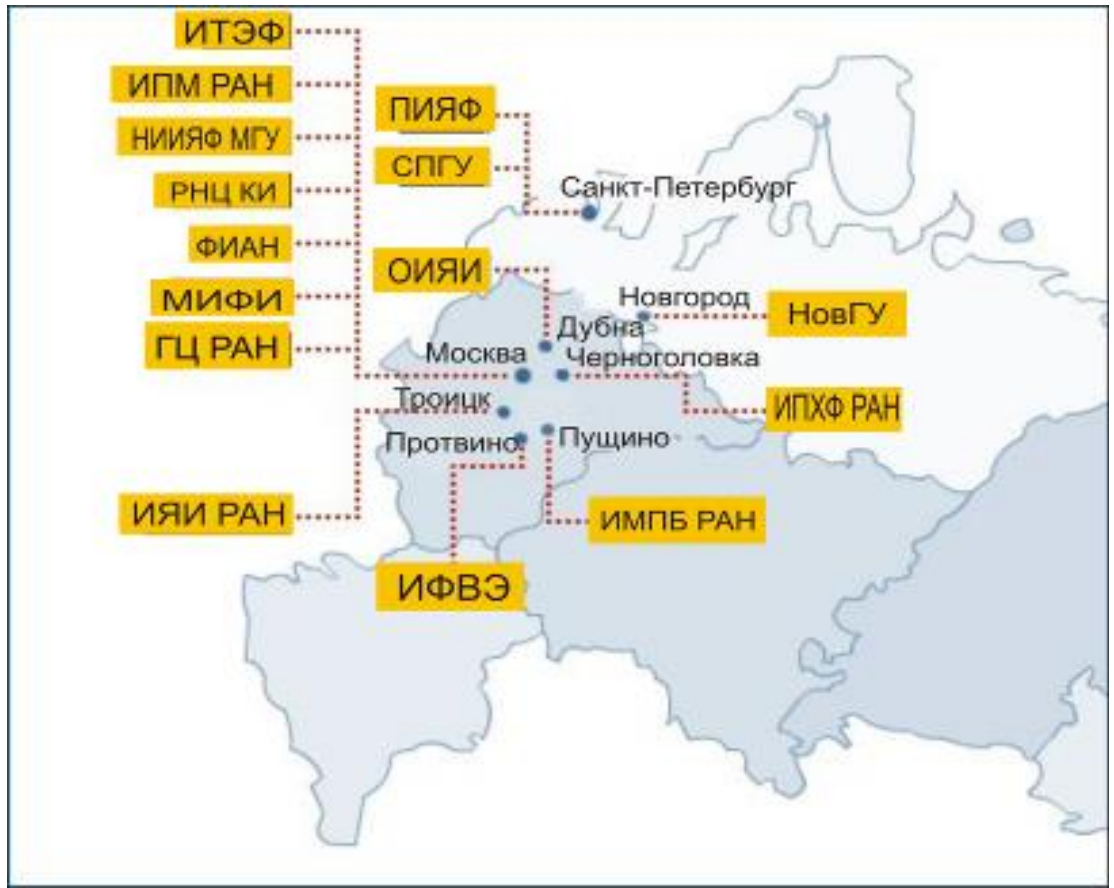


Large Synoptic Survey Telescope > 10 Pb/Year (estimation)

... et cetera

Russian Data Intensive Grid infrastructure (RDIG)

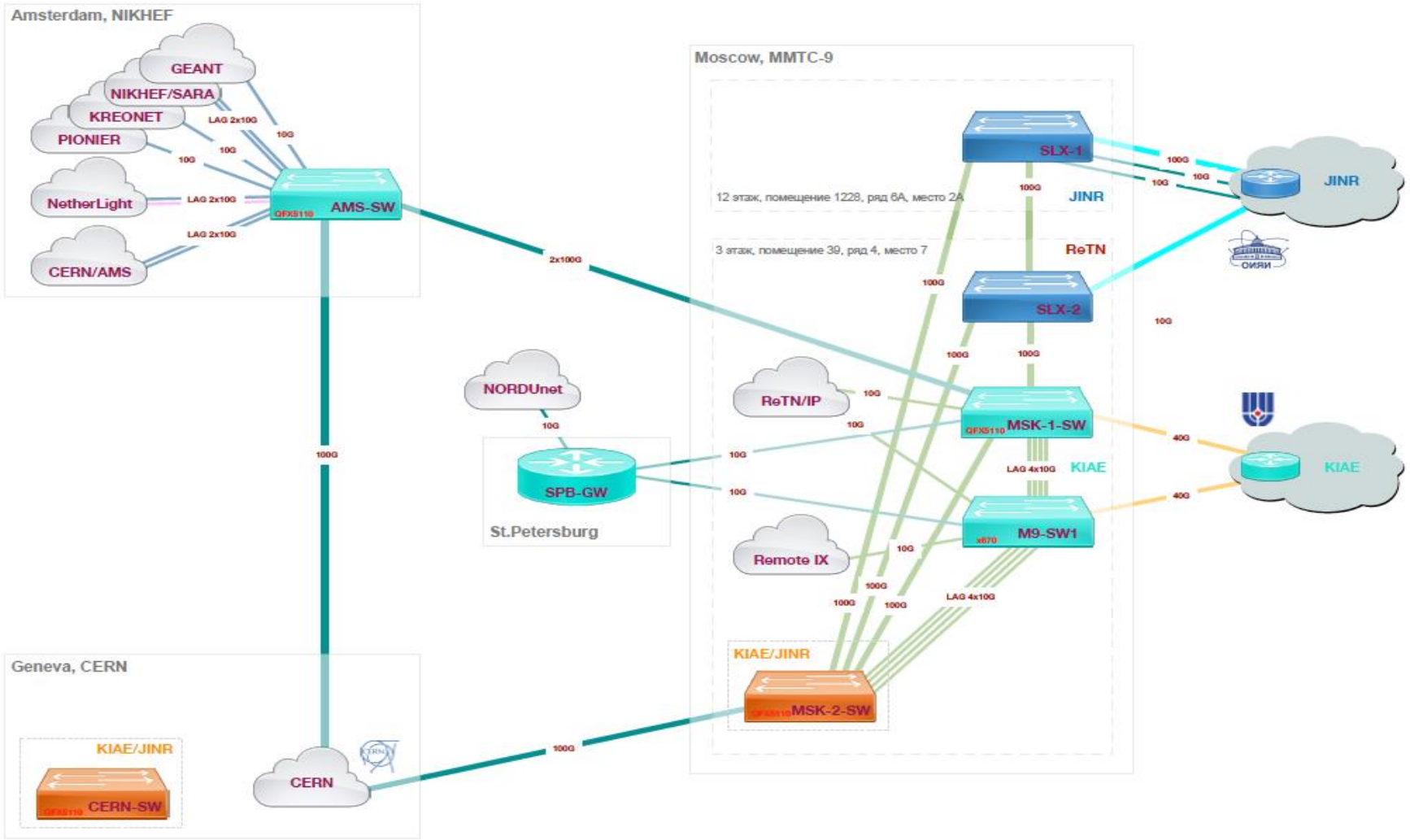
The Russian consortium RDIG (Russian Data Intensive Grid), was set up in September 2003 as a national federation in the EGEE project. A protocol between CERN, Russia and JINR on participation in the LCG project was signed in 2003.
MoU on participation in the WLCG project was signed in 2007.



RDIG Resource Centres:

– ITEP
– JINR-LCG2 (Dubna)
– RRC-KI
– RU-Moscow-KIAM
– RU-Phys-SPbSU
– RU-Protvino-IHEP
– RU-SPbSU
– Ru-Troitsk-INR
– ru-IMPB-LCG2
– ru-Moscow-FIAN
– ru-Moscow-MEPHI
– ru-PNPI-LCG2 (Gatchina)
– ru-Moscow-SINP

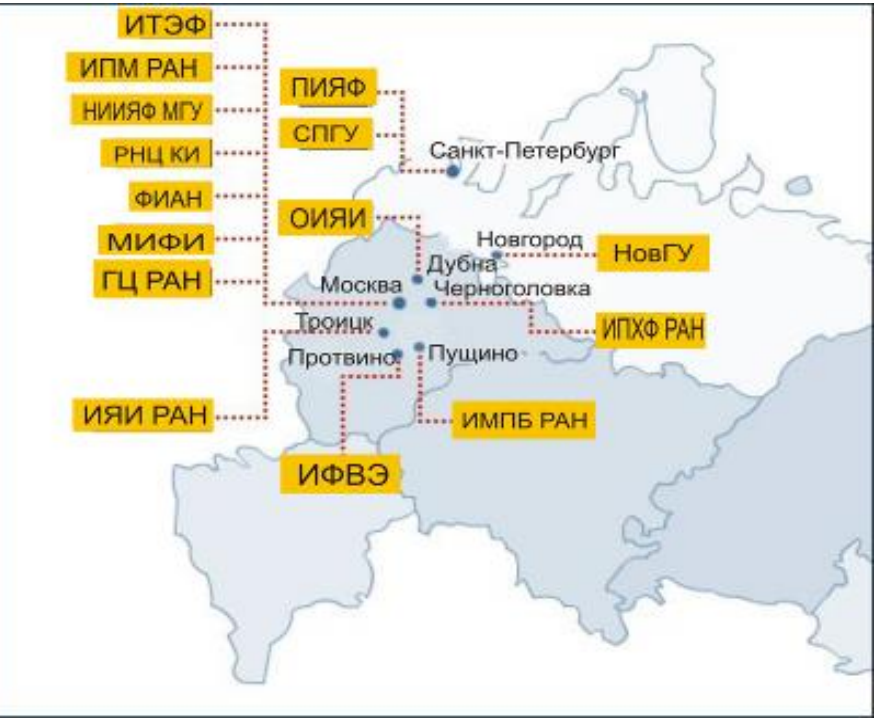
Сеть RDIG-M для мегасайенс проектов



Tier1 – Tier2 in Russia 2022-2023 (Sum CPU in HS06 hours)

• **JINR-T1**	**2,055,790,087**	**48.77%**
• **RRC-KI-T1**	**1,119,123,700**	**26.55%**
• JINR-LCG2	827,242,243	19.62%
• RU-Protvino-IHEP	145,047,775	3.44%
• ru-PNPI	25,692,598	0.61%
• ITEP	3,474,591	0.08%
• RU-SARFTI	23,660,539	0.56%
• RU-SPbSU	8,862,169	0.21%
• Ru-Troitsk-INR-LCG2	6,807,206	0.16%

From RDIG to RDIG-M



The Russian consortium RDIG (Russian Data Intensive GRID) was set up in September 2003 as a national federation in the EGEE project.

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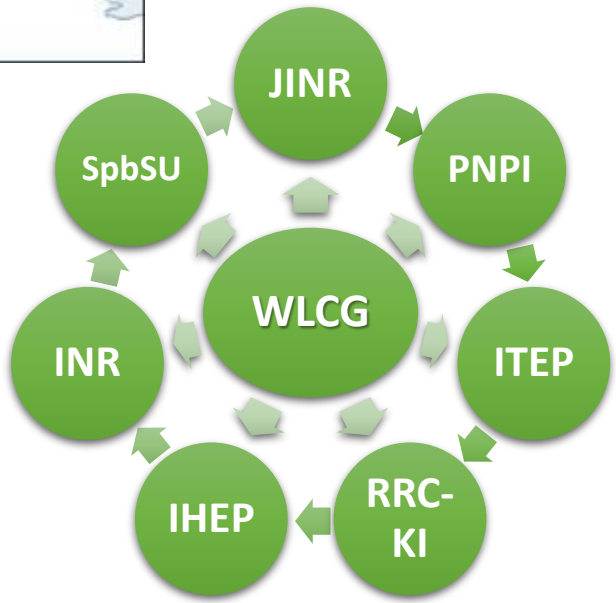
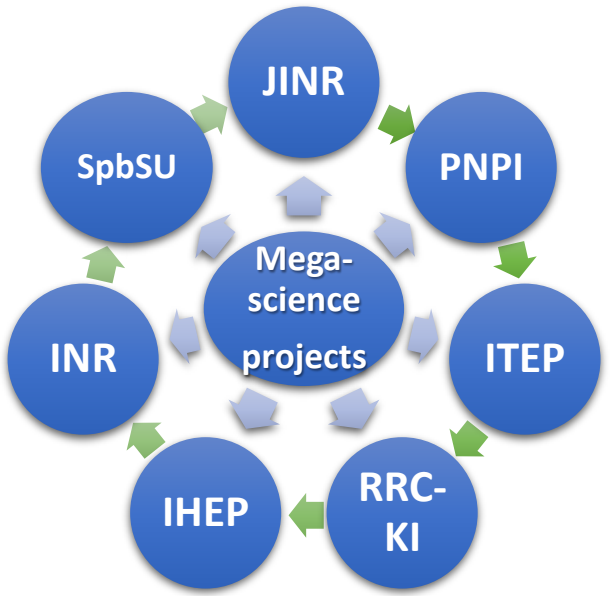
Consortium RDIG-M – Russian Data Intensive GRID for Megascience projects

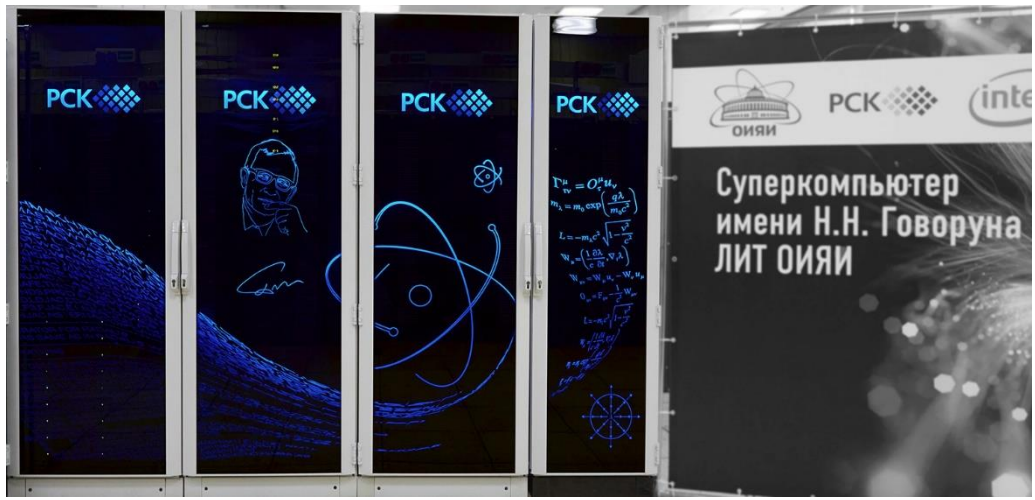




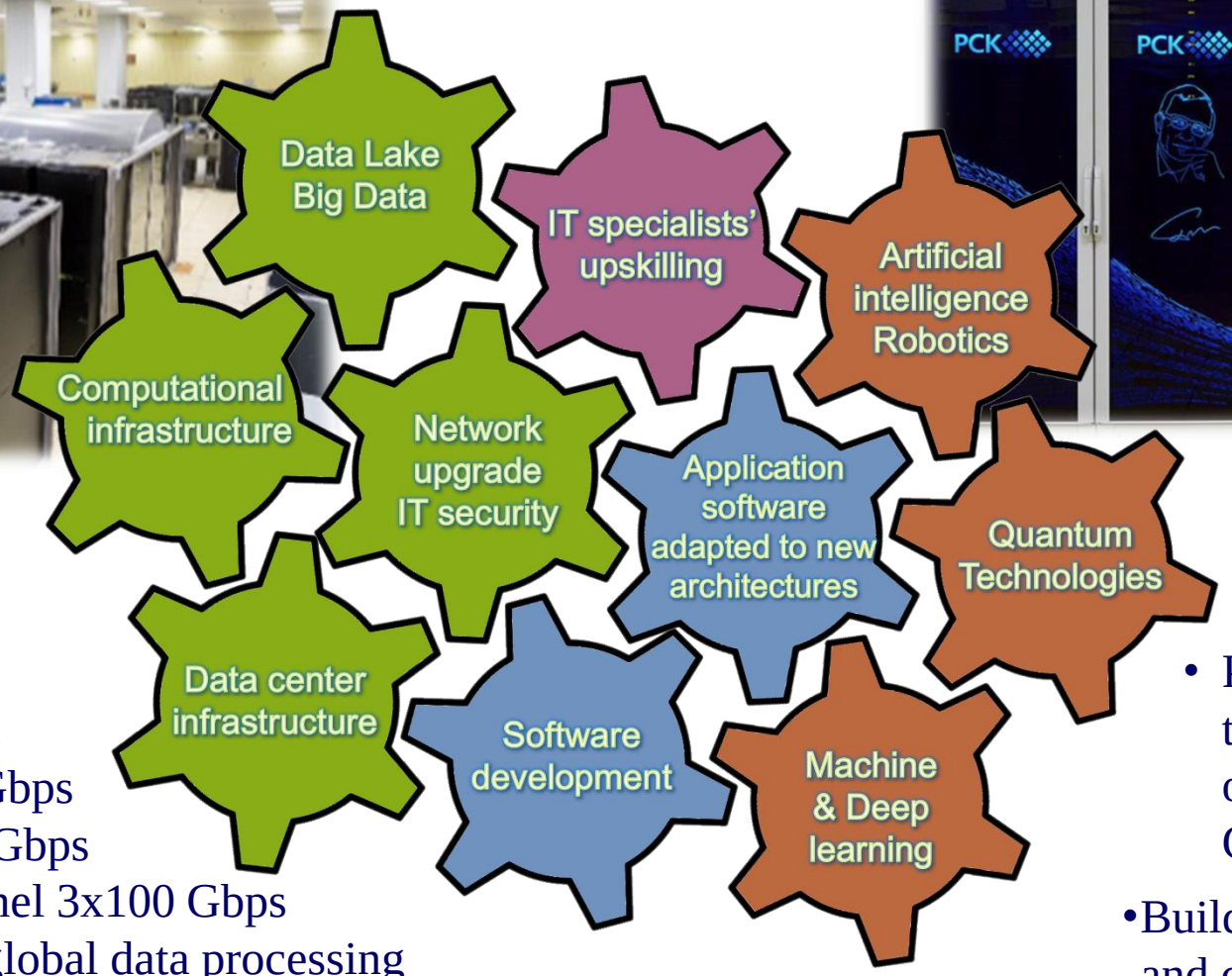
Meshcheryakov Laboratory of Information Technologies

M.G. Mesheryakov
(17.09.1910 - 24.05.1994)

N.N. Govorun
(18.03.1930 - 21.07.1989)



MLIT today: Scientific IT-ecosystem



Staff: 315
Scientists: 100
Doctors of Science: 25
Candidates of Science: 62
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

- The coordinated development of interconnected IT technologies and computational methods
- Providing the IT services necessary for the fulfillment of the JINR Topical Plan on Research and International Cooperation in an efficient manner.
- Building world-class competence in IT and computational physics.
- 24x7 support of the computing infrastructure and services.

Engineering Infrastructure



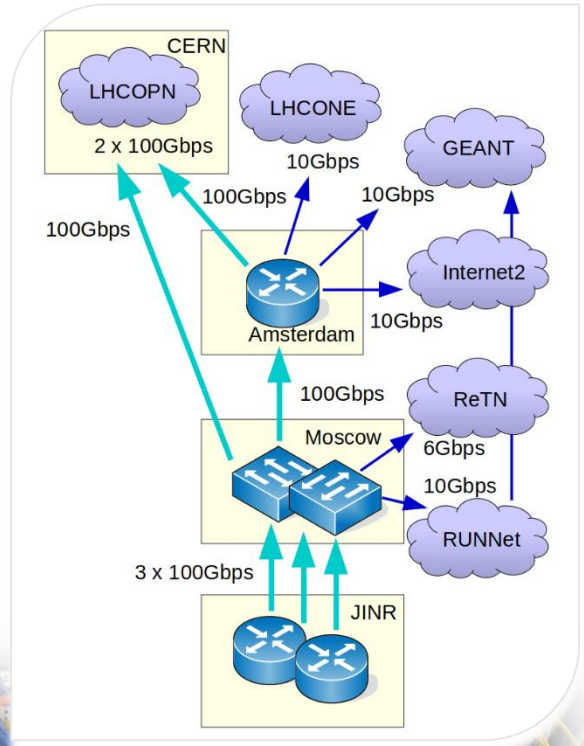






- ✓ Power supply expansion
- ✓ New cooling system for the MICC machine hall
- ✓ 100% “hot water” cooling system of the “Govorun” supercomputer
- ✓ Guaranteed power supply using diesel generators and uninterruptible power supplies

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:

8768 network elements

17602 IP-addresses

6377 users registered within the network

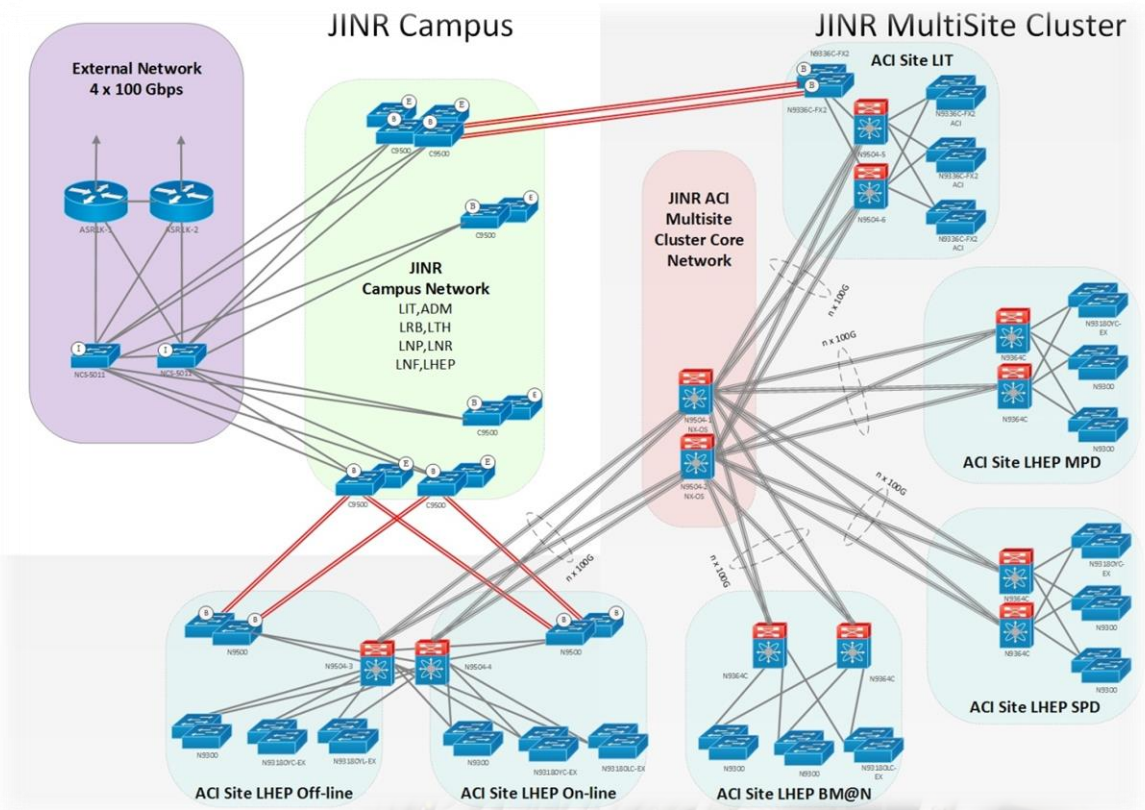
4203 *.jinr.ru service users

1419 digital library users

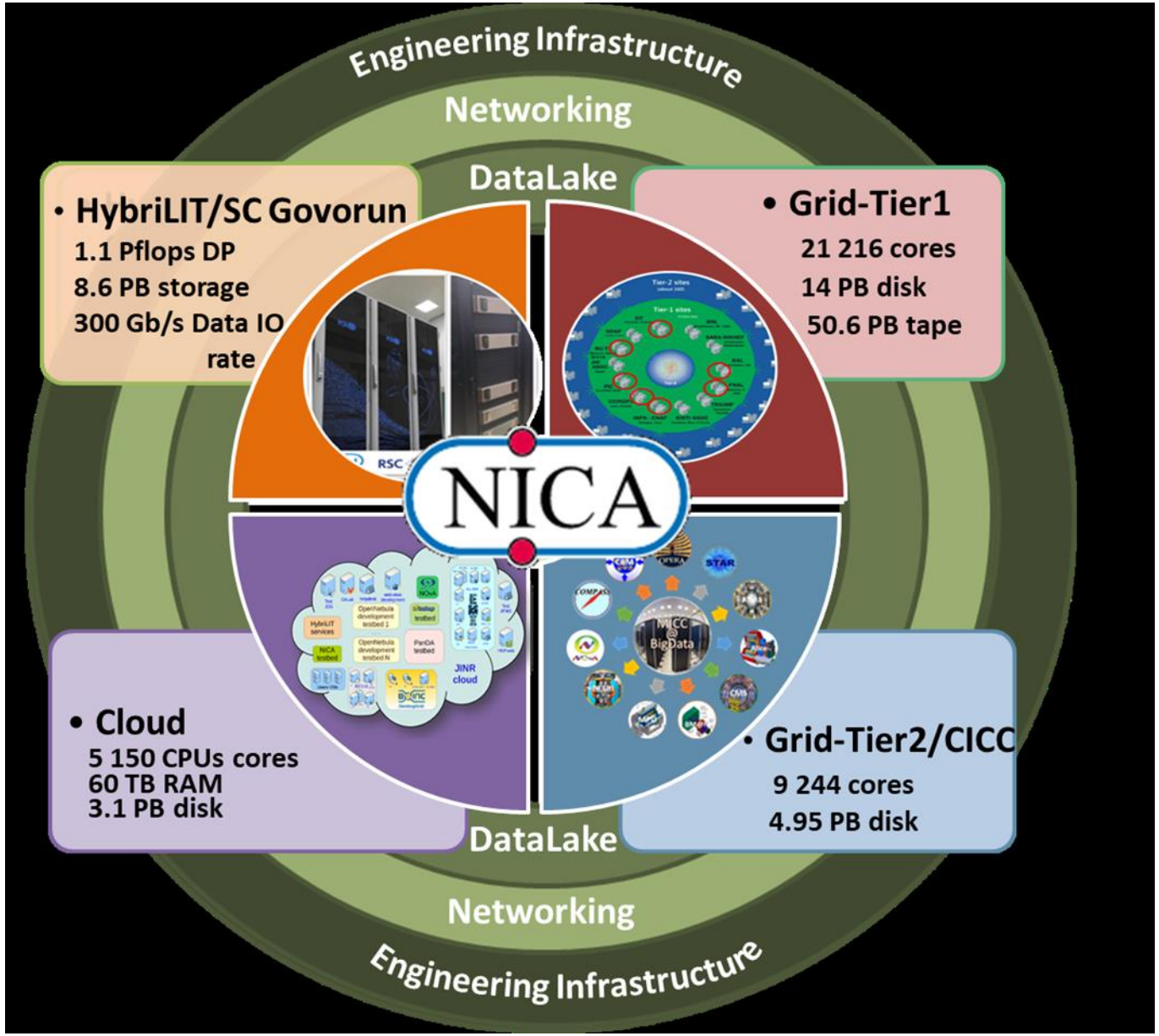
504 remote VPN and EDUROAM users

network traffic in 2021

- **33.23 PB - input**
- **35.86 PB - output**



Multifunctional Information and Computing Complex at JINR

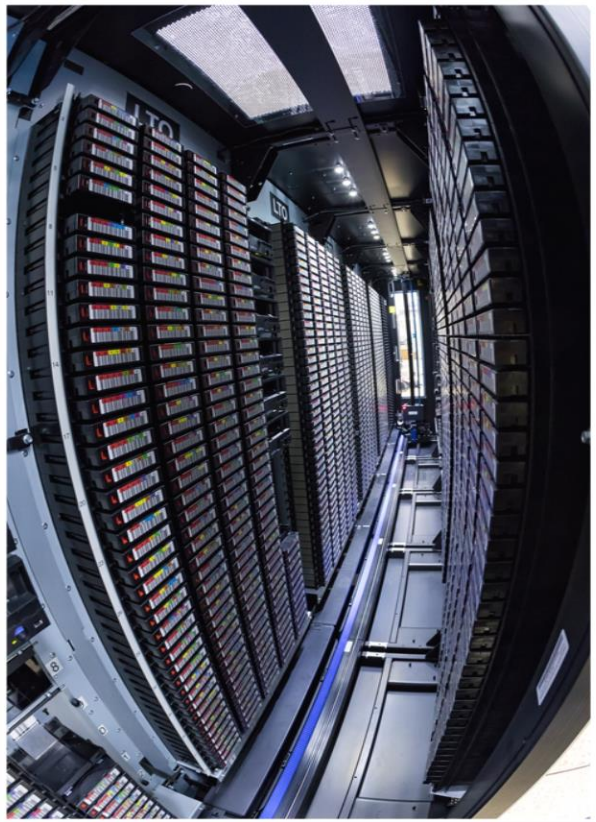


The **MICC** meets the requirements for a modern highly performant scientific computing complex:

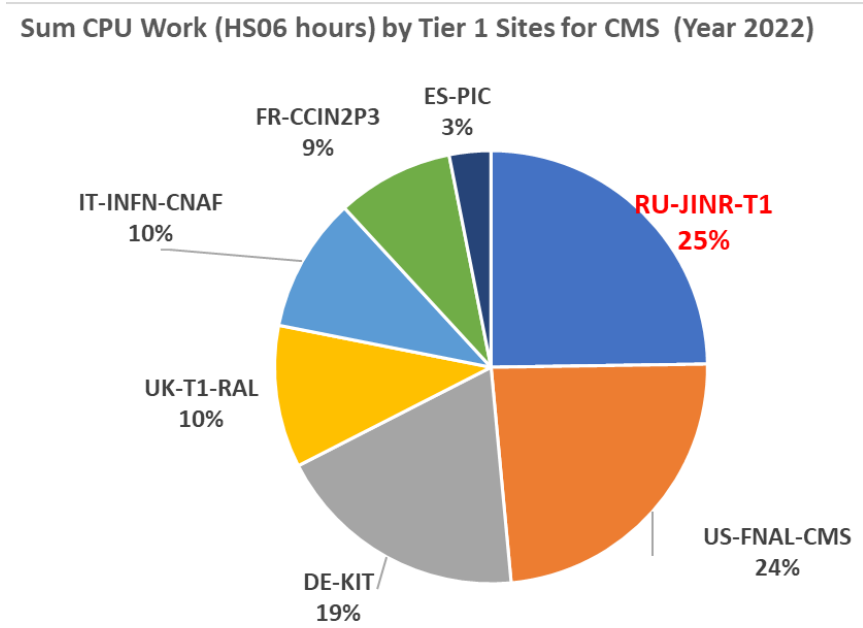
- multi-functionality,
- high performance,
- task-adapted data storage system,
- high reliability and availability,
- information security,
- scalability,
- customized software environment for different user groups,
- high-performance telecommunications and modern local network.

The MICC should be considered as a basic scientific infrastructure project.

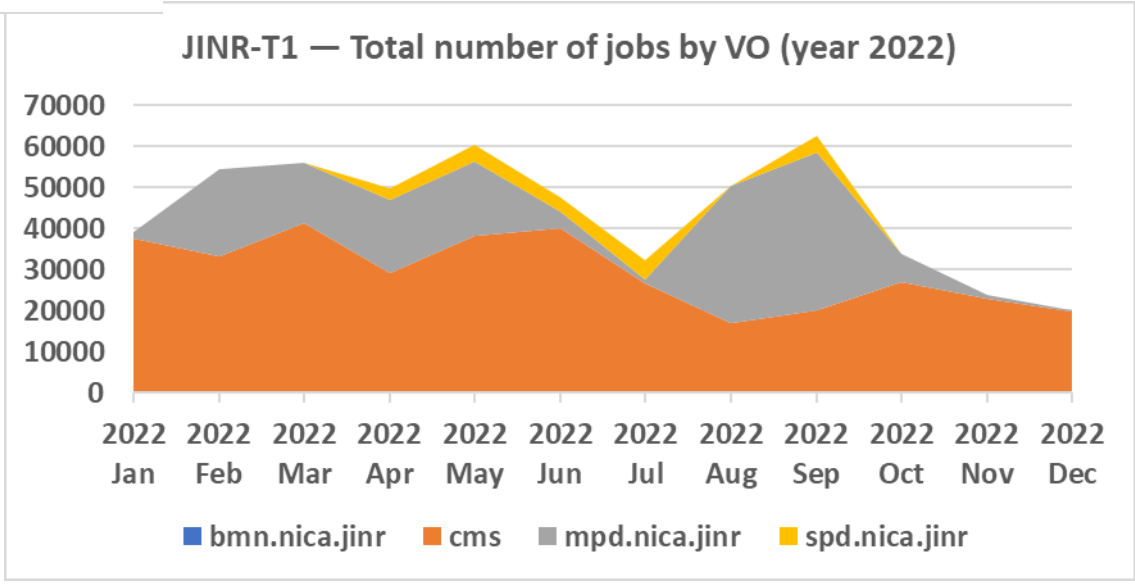
Tier1 at JINR



- 216216 cores
- 360 kHS06
- 16 PB disks
- 52.6 PB tapes
- 100% reliability and availability

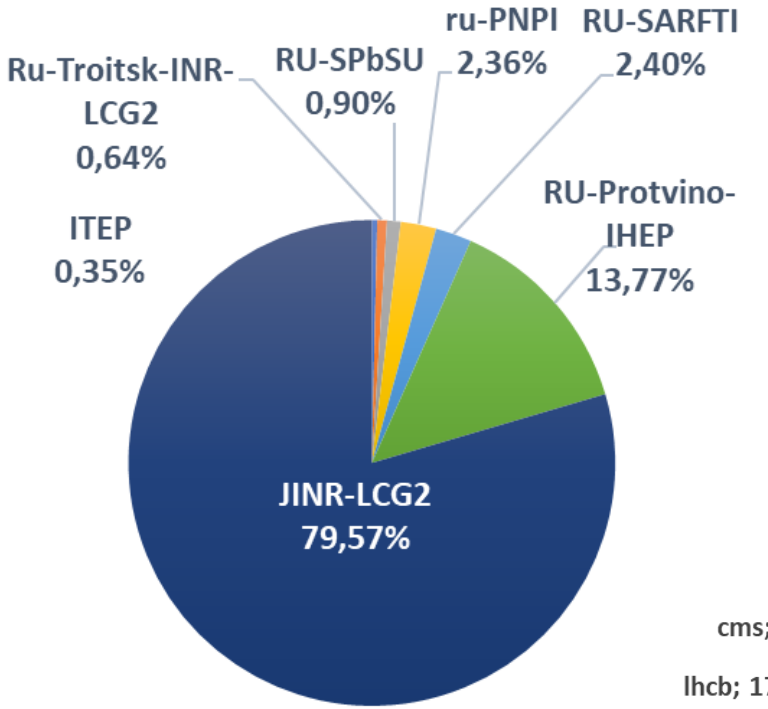


- The JINR Tier1 center has demonstrated stable work not only for CMS (LHC), but also for MPD (NICA).
- The Tier1 site for CMS is ranked first among world centers for CMS.
- 30% of all jobs executed at Tier1 JINR are NICA jobs



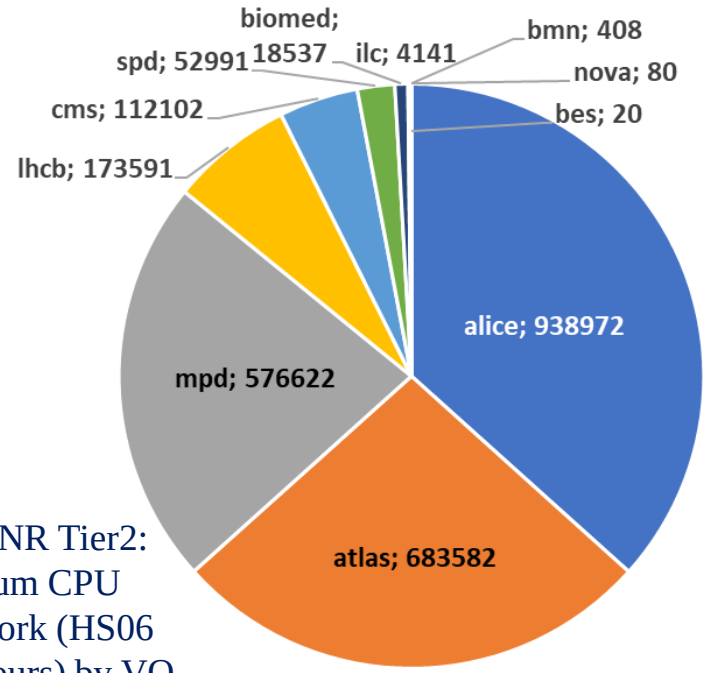
Tier2 at JINR

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)

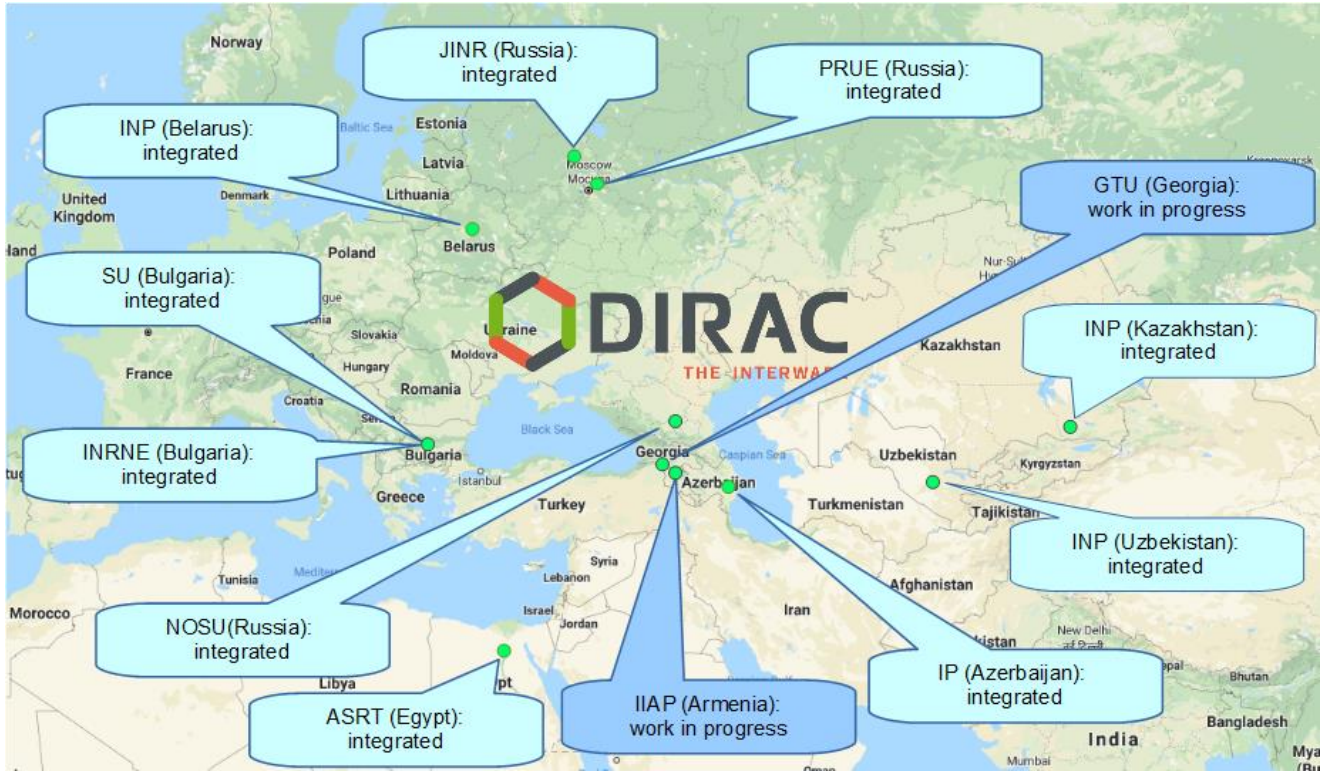
JINR Tier2 is the most productive in the Russian Data Intensive Grid (RDIG) Federation.



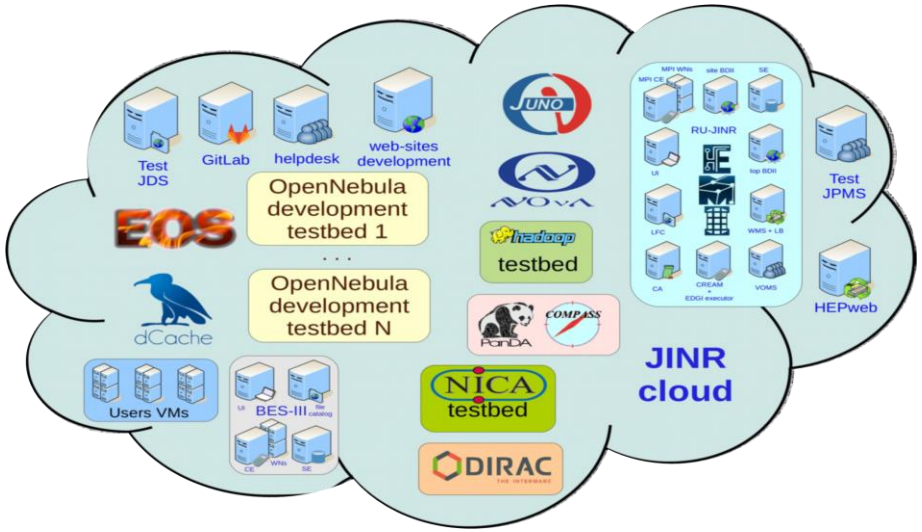
JINR Tier2: Sum CPU work (HS06 hours) by VO (year 2022)

Cloud Infrastructure

- Cloud Platform - OpenNebula
- Virtualization - KVM
- Storage (Local disks, Ceph)
- Total Resources
  ~ 5,000 CPU cores; 60 TB RAM; 4.1 PB of raw ceph-based storage



DIRAC-based distributed information and computing environment 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

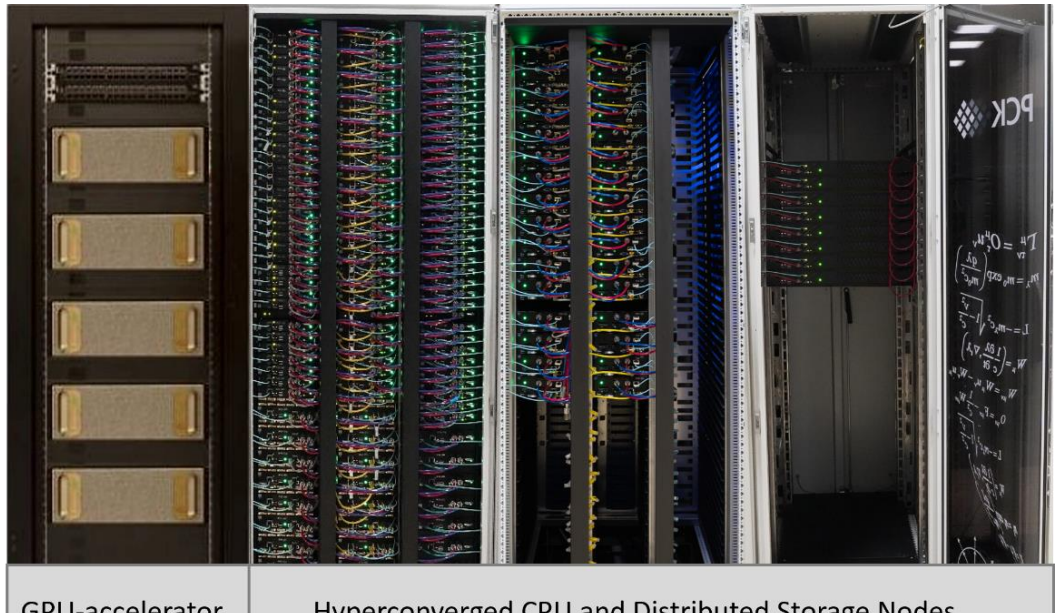
- Hyper-converged software-defined system
- Hierarchical data processing and storage system
- Scalable solution Storage-on-demand
- Total peak performance: 1.1 PFlops DP
- GPU component based on NVIDIA
- CPU component based on liquid cooling solutions
- The most energy-efficient center (PUE = 1.06)
- Storage performance >300 GB/s

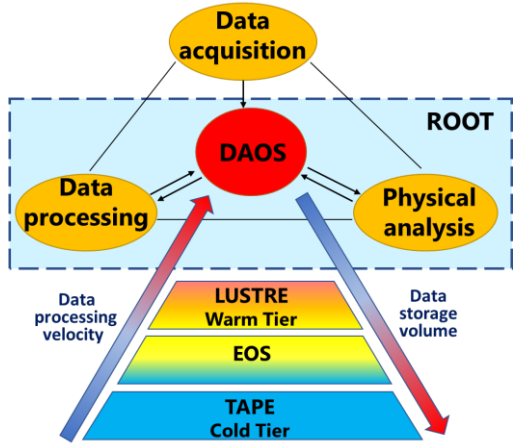
The expansion of the “Govorun” supercomputer by 32 hyperconverged compute nodes and 8 distributed storage nodes made it possible to:

- enhance its performance by 239 Tflops (Total peak performance: 1.1 PFlops DP);
- increase the DAOS data processing and storage subsystem to 1.6 PB;
- enlarge the volume of the "warm data" storage subsystem by 8 PB with support for the creation of dynamic storage systems such as Luster, DAOS, EOS, dCache, NFS.

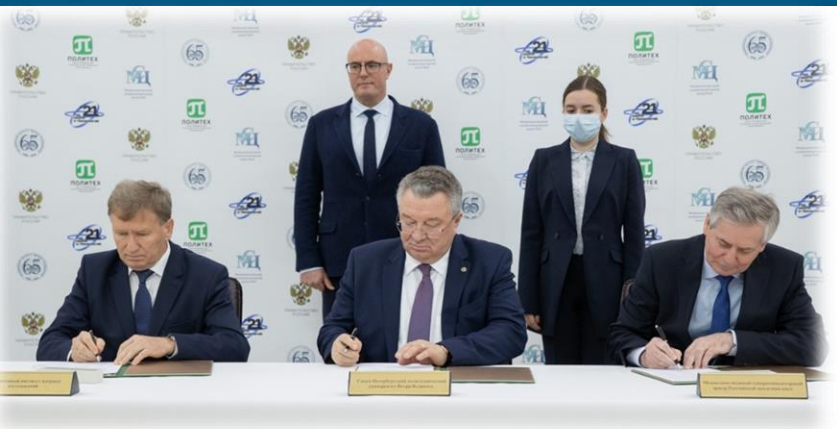
Key projects that use the resources of the SC “Govorun”:

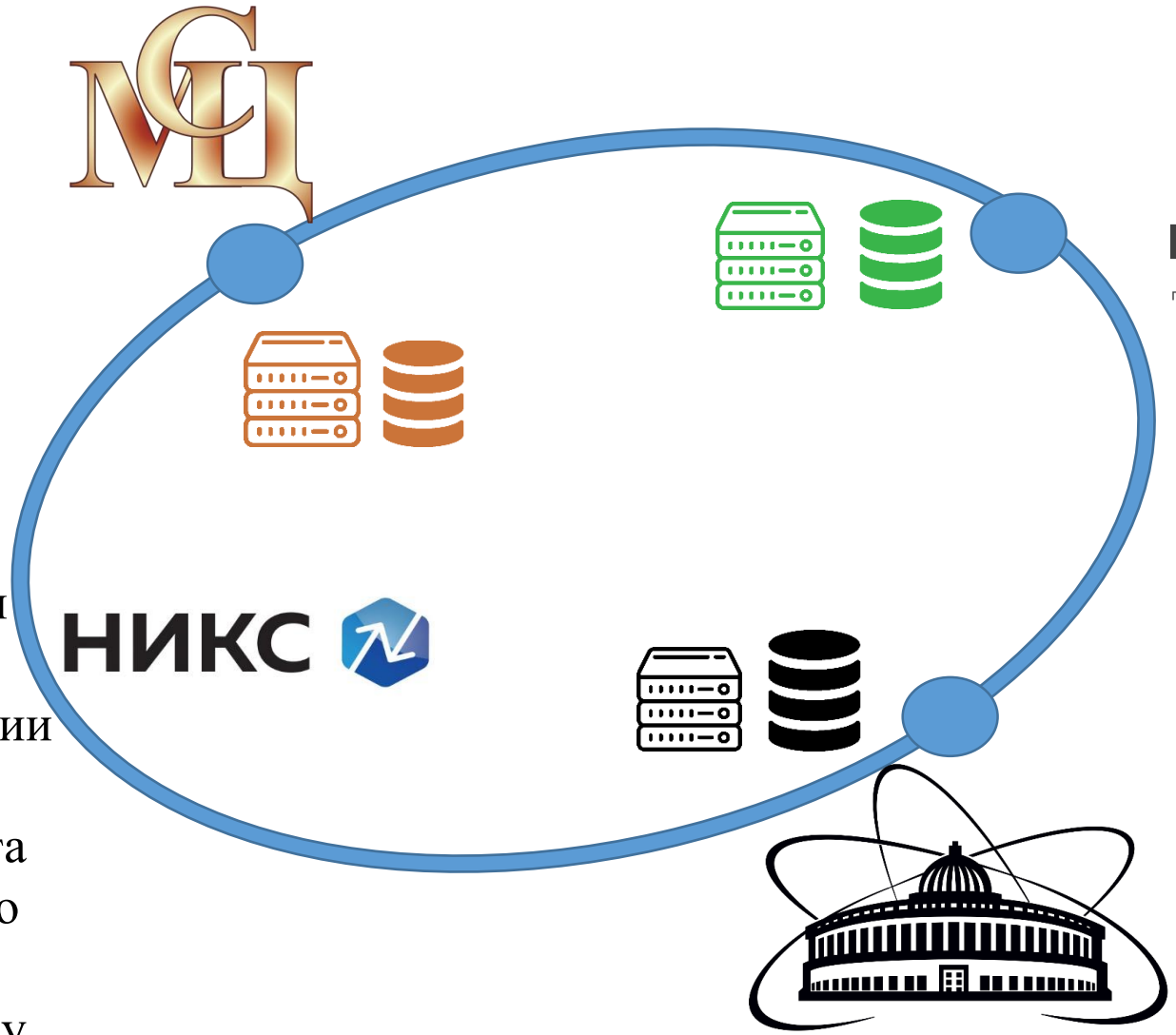
- NICA megaproject,
- calculations of lattice quantum chromodynamics,
- computations of the properties of atoms of superheavy elements,
- studies in the field of radiation biology,
- calculations of the radiation safety of JINR’s facilities.





Объединенная географически распределенная суперкомпьютерная инфраструктура





ПОЛИТЕХ
Санкт-Петербургский политехнический университет Петра Великого

В январе 2022 года успешно завершен первый совместный эксперимент по использованию объединенной суперкомпьютерной инфраструктуры для задач проекта NICA.
Всего было запущено 3000 задач генерации данных методом Монте-Карло и реконструкции событий для эксперимента MPD. Сгенерировано и реконструировано порядка 3 миллионов событий.
Полученные данные перемещены в Дубну для дальнейшей обработки и физического анализа

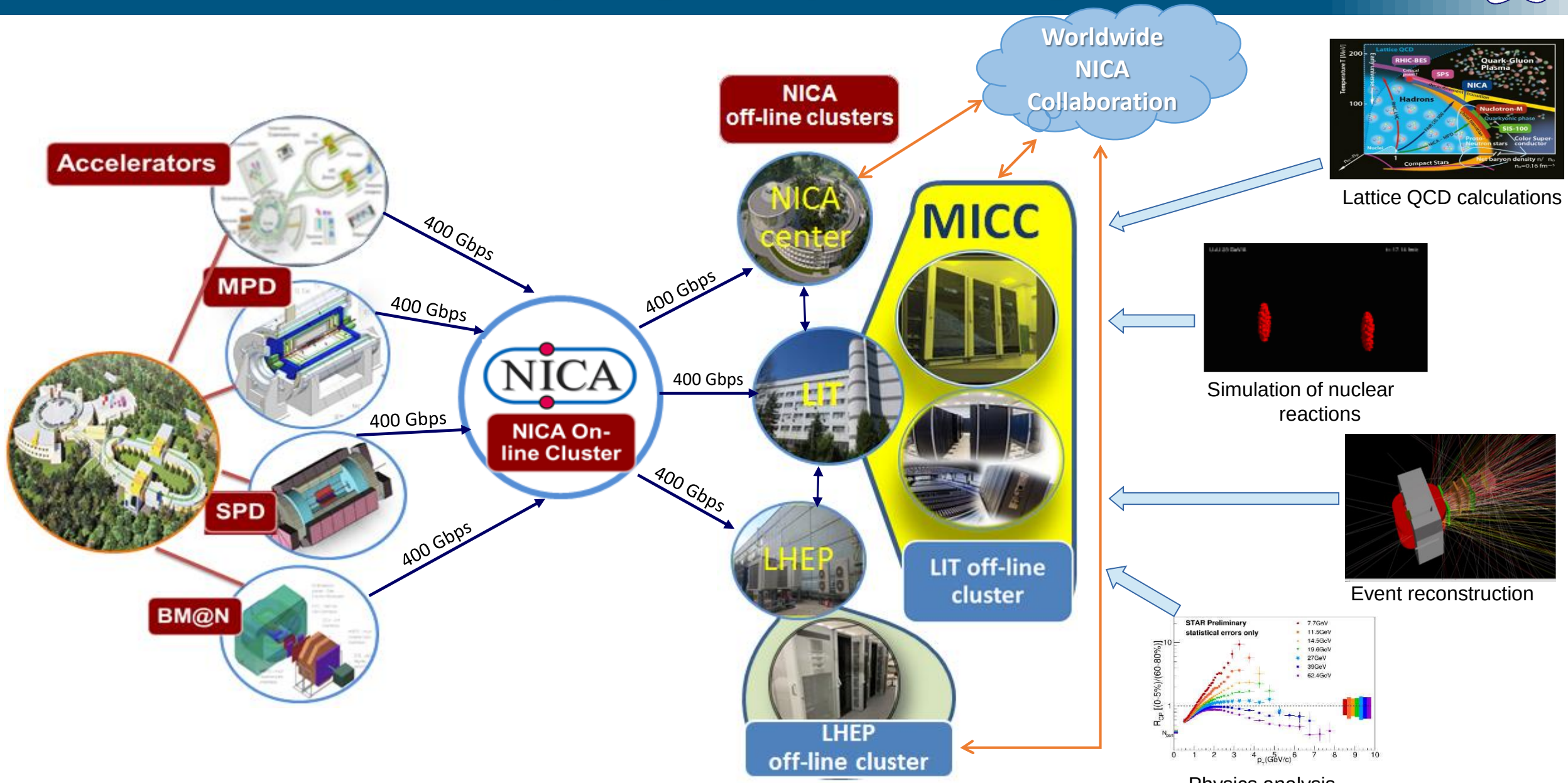
MICC Monitoring

For a robust performance of the complex it is necessary to monitor the state of all nodes and services - from the supply system to the robotized tape library.

- Global real time 24x7 survey of the state of the whole computing complex
- In case of emergency, alerts are sent to users via e-mail, SMS, etc.
- ~ 850 elements are under observation

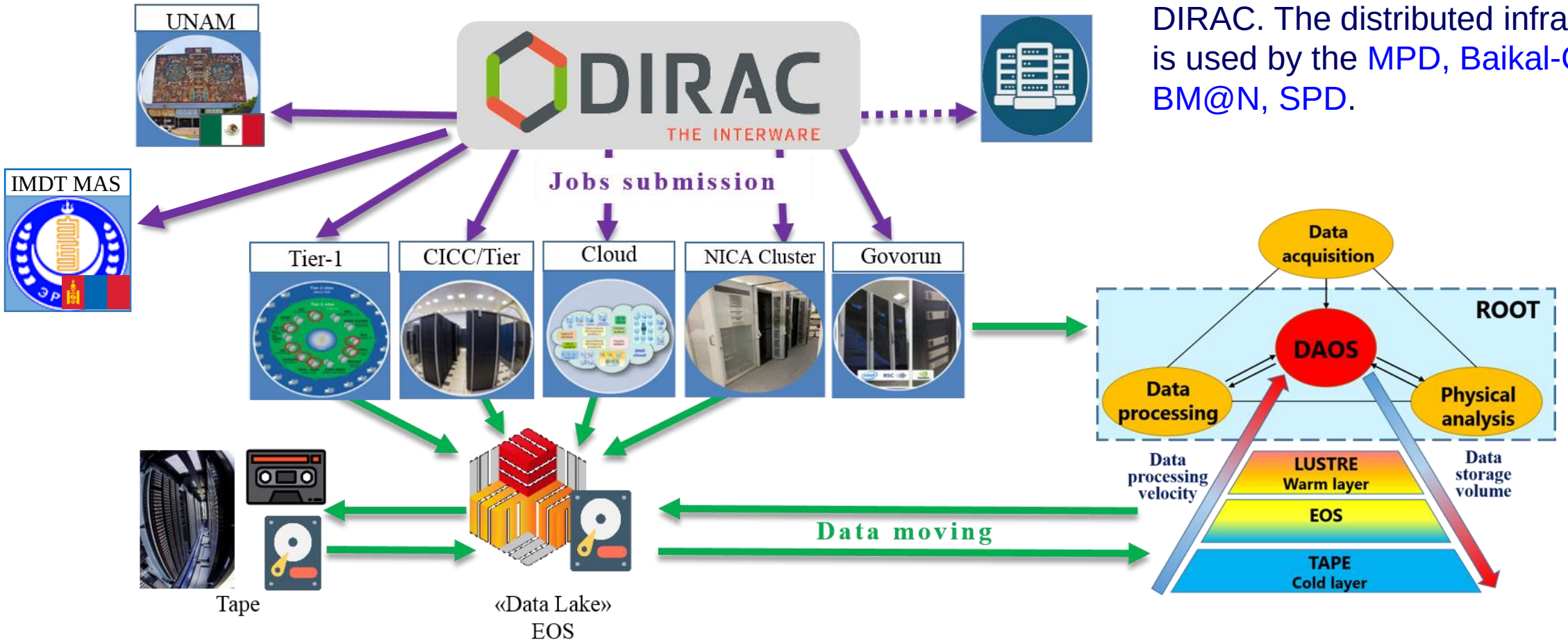

MICC Operational Center

NICA Computing Concept & Challenges

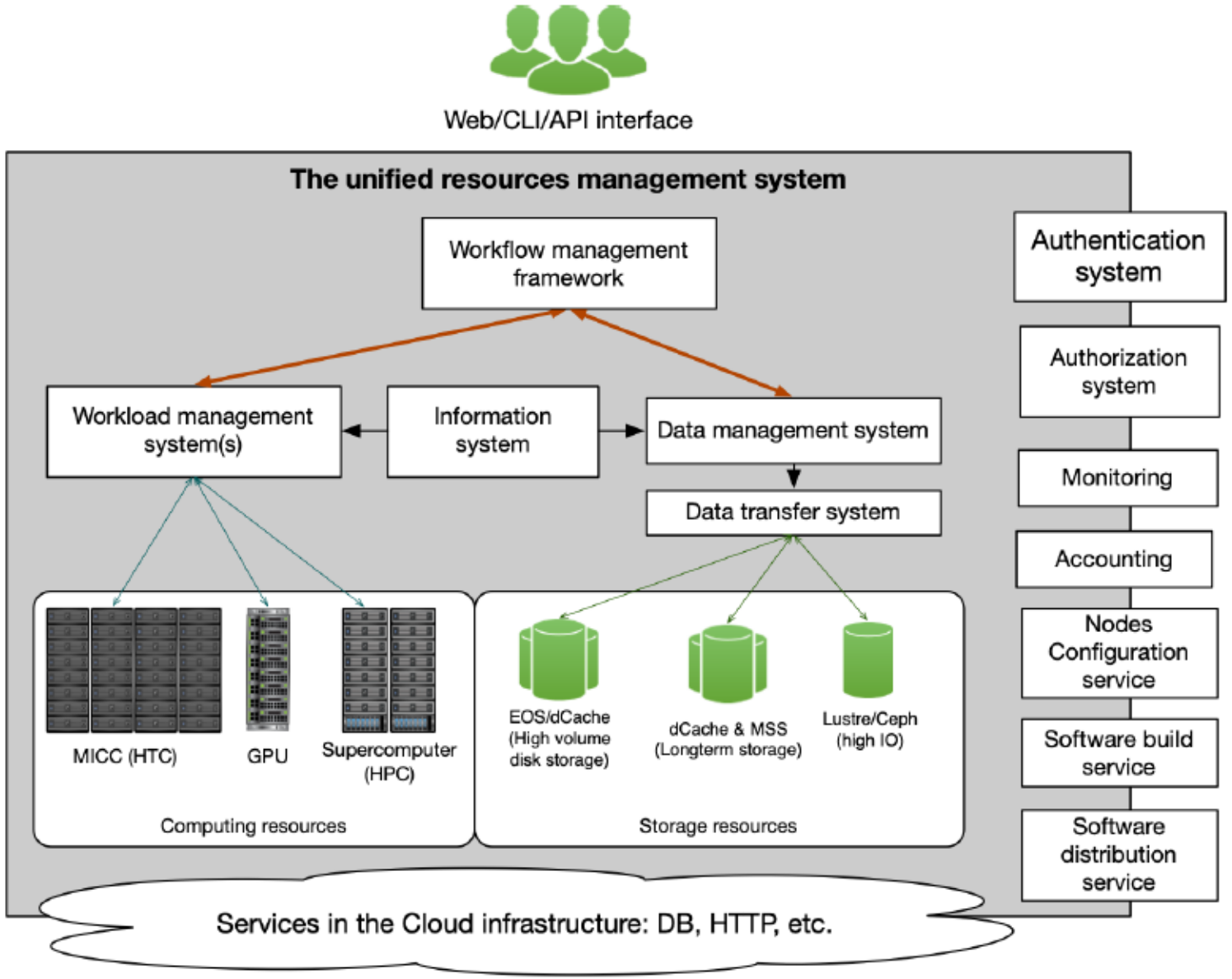


Heterogeneous Distributed Computing Environment

A heterogeneous computing environment, based on the DIRAC platform, was created for processing and storing data of experiments conducted at JINR. Tier1, Tier2, the “Govorun” supercomputer, the clouds of the JINR Member States, the NICA cluster, as well as the resources of the National Research Computer Network of Russia, the cluster of the National Autonomous University of Mexico (UNAM, within cooperation on the MPD project) and the cluster of Institute of Mathematics and Digital Technology (Mongolian Academy of Science), were integrated into DIRAC. The distributed infrastructure is used by the MPD, Baikal-GVD, BM@N, SPD.



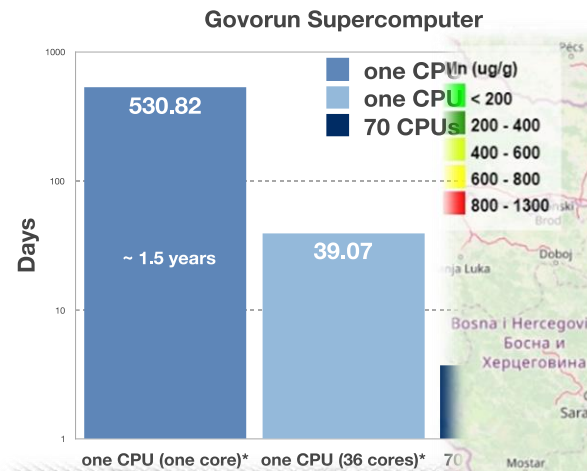
MICC Unified Resource Management System

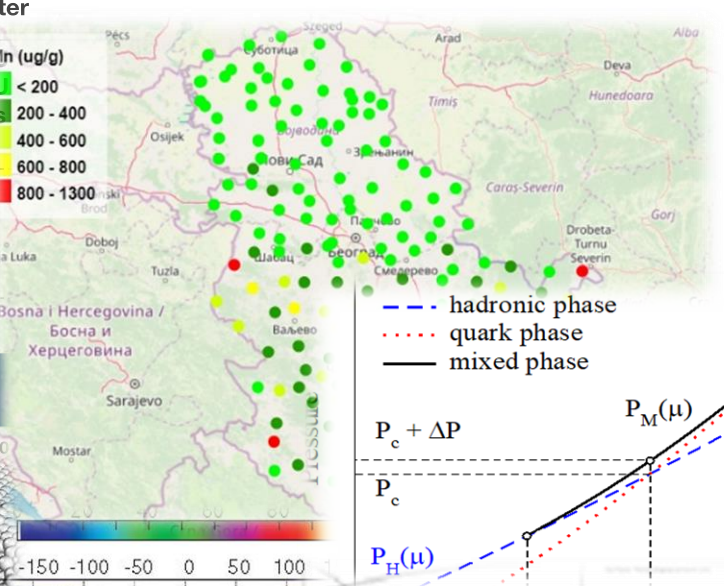


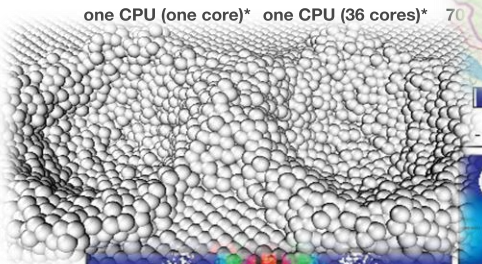
The main objectives of the unified resource management system are:

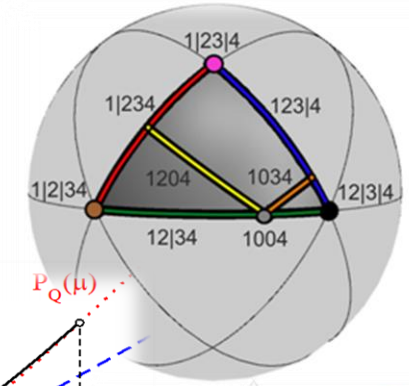
- to provide the ability to process large amounts of data
- to enable the organization of massive computing tasks
- to optimize the efficiency of using computing and storage resources
- to effectively monitor resource loading
- to consolidate resource accounting
- to provide a unified interface for accessing resources

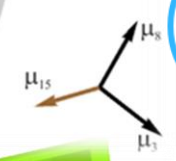
Methods, Algorithms and Software

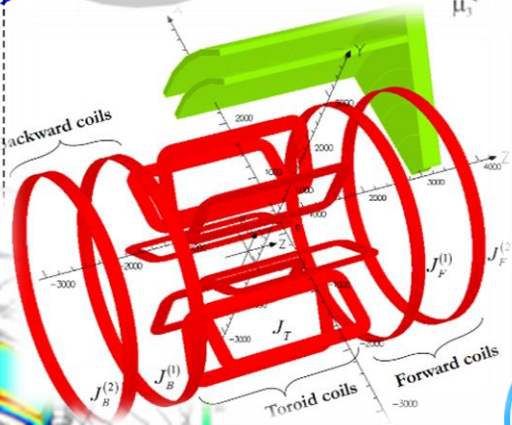


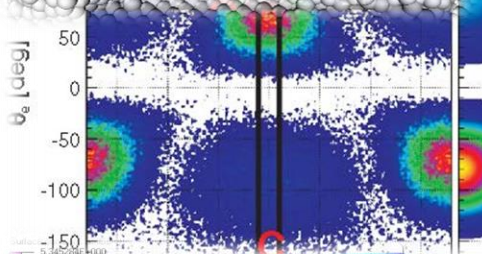


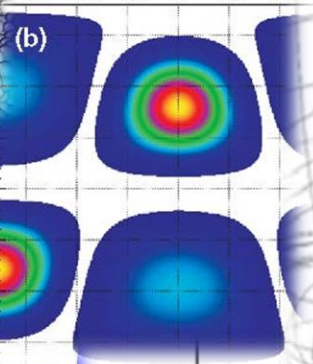


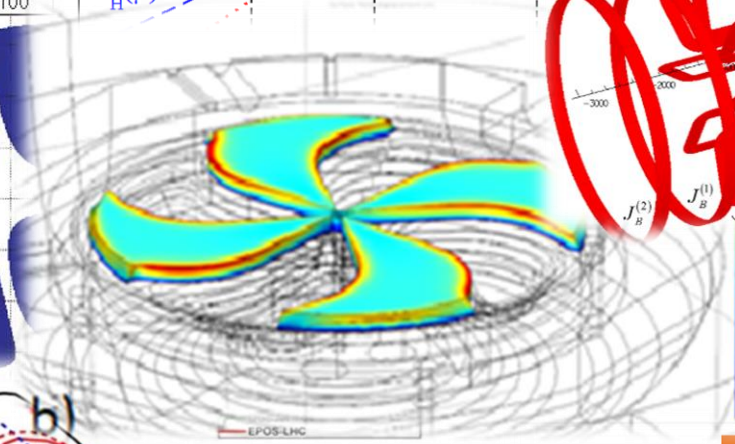


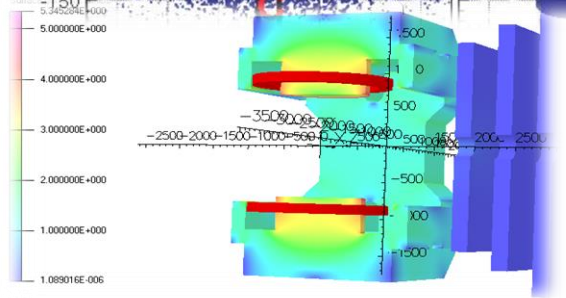


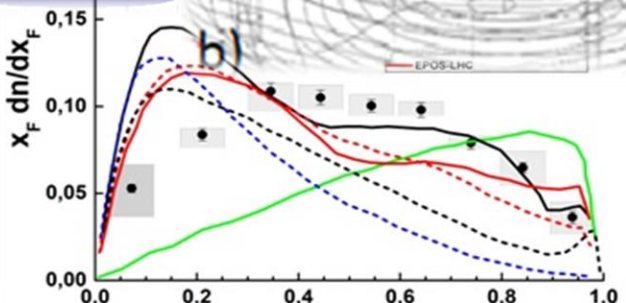


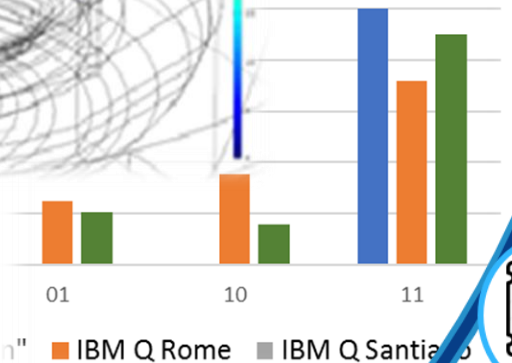










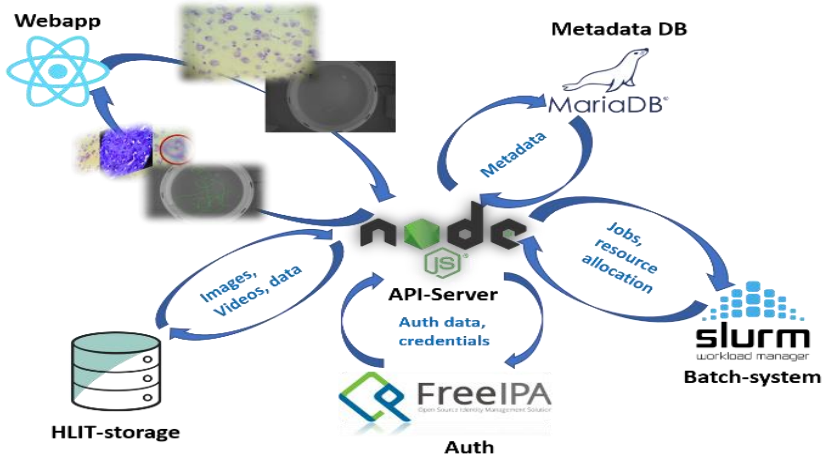


- Numerical modeling of complex physical systems
- Experimental data processing and analysis
- Big Data
- Machine and Deep learning
- AI and robotics
- Computer algebra
- Quantum computing

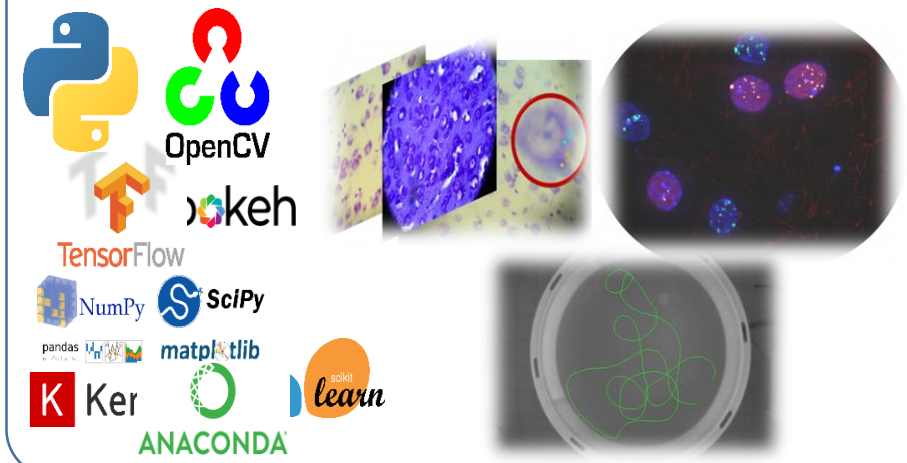
Information System for the tasks of Radiation Biology
https://bio.jinr.ru

The joint project of LIT and LRB is focused on creating an Information System (IS). The IS allows one to store, quickly access and process data 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.

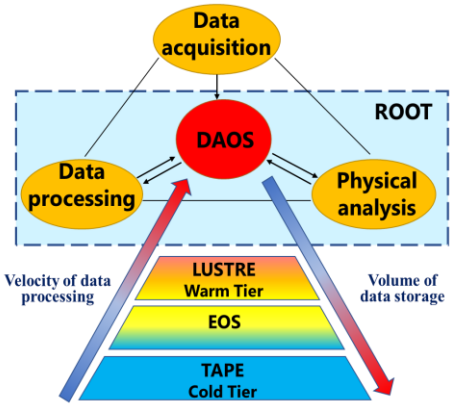
Web services for morphofunctional changes in the CNS and DNA damage analysis



Machine and deep learning methods, computer vision and neural network approaches



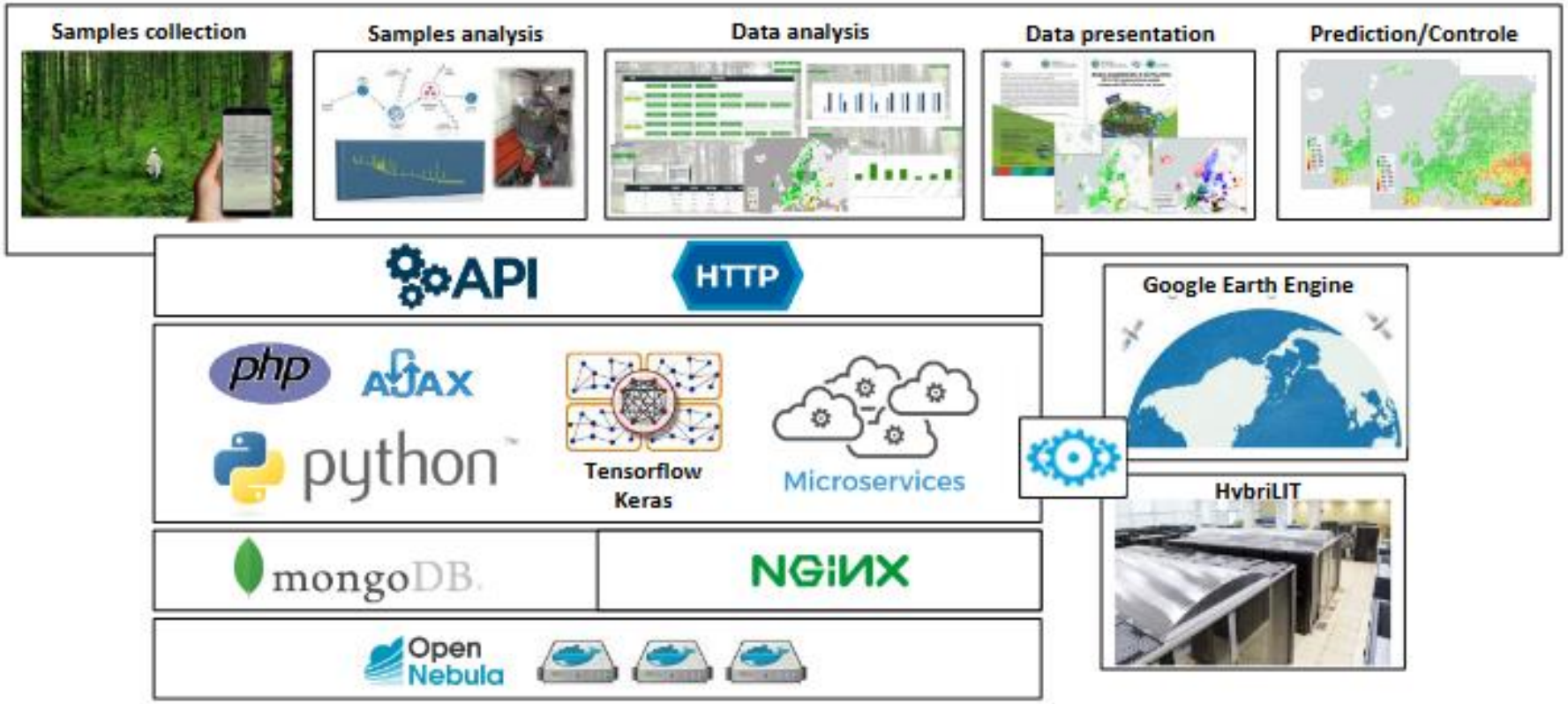
Computing resources and hierarchical storage system based on the “Govorun” SC

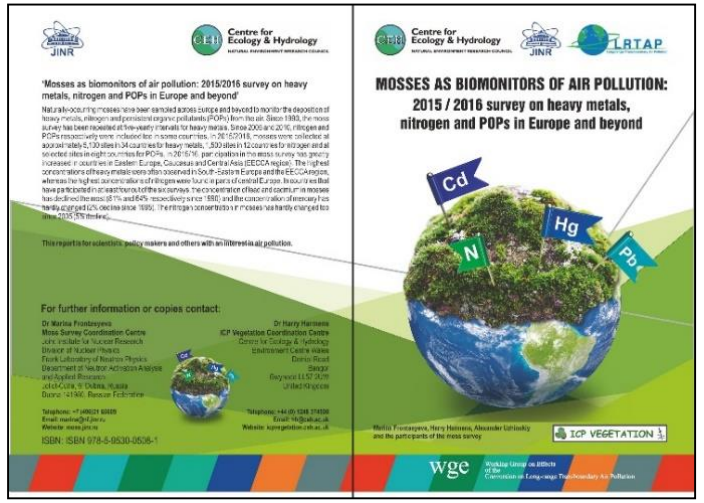


Intelligent Environmental Monitoring Platform

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 IT technologies is in progress.

On the MLIT cloud platform, a Data Management System (DMS) of the UNECE ICP Vegetation was created. DMS is intended to provide its participants with a modern unified system of collecting, analyzing and processing biological monitoring data**.** A combination of satellite data, biomonitoring measurements, and different machine and deep learning technologies was used to predict potentially toxic elements.



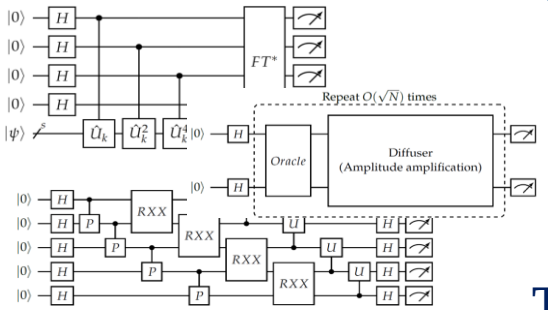


A. Uzhinskiy, M. Aničić Urošević, M. Frontasyeva. Prediction of air pollution by potentially toxic elements over urban area by combining satellite imagery, Moss Biomonitoring Data and Machine Learning. Ciencia e Tecnica Vitivinicola Journal

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

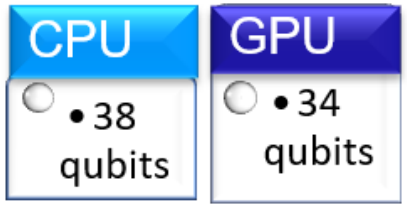
SC "Govorun"

TASKS

- 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

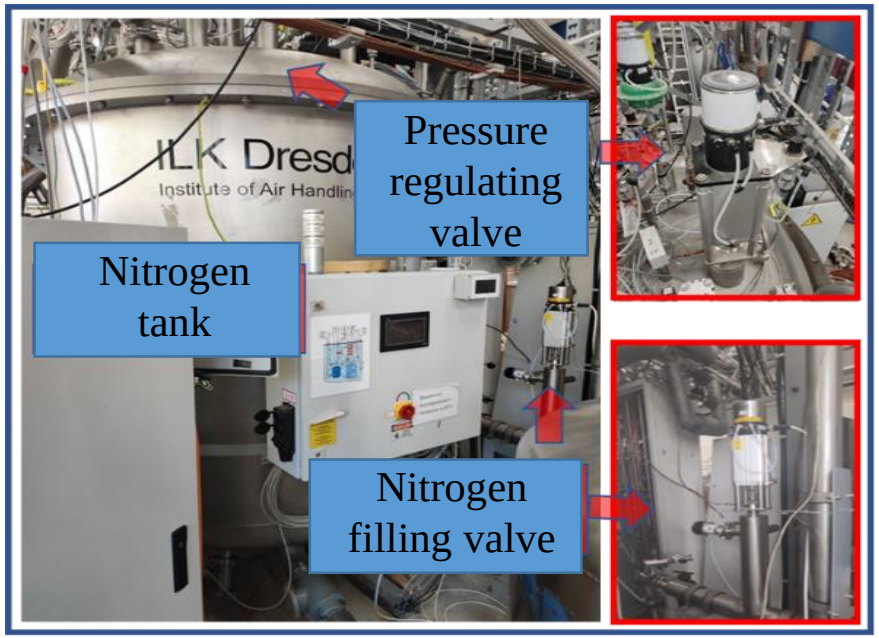
The limiting computing capacities of the "Govorun" supercomputer are revealed on the example of simulating quantum algorithms (quantum Fourier transform, quantum phase estimation, Grover's algorithm, test synthetic algorithm) using a different class of quantum circuits for the following simulators: QuEST,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

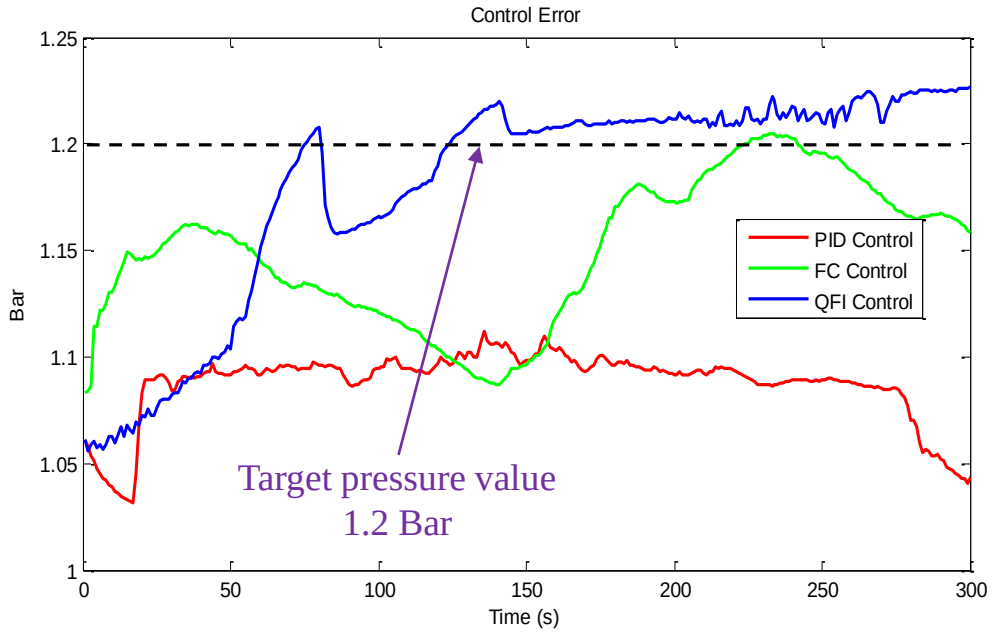


According to modern concepts, from 30 to 50 qubits are sufficient for the exact solution of most practically significant problems of quantum chemistry

Quantum intelligent control

Tests of an **intelligent automatic control system for the nitrogen collector** of the satellite helium refrigerator #1 at the site of the cryogenic testing of superconducting magnets at VBLHEP **on the basis of quantum algorithms** (QFI) are successfully completed.





Control of the process of reaching a predetermined pressure level in cooling mode

- The quantum controller (blue curve) is almost 5 times faster in reaching the target value than the closest controller on soft computing (green curve), while the PID-controller (red curve) does not reach the target value.
- The quantum controller demonstrates low overshoot and accuracy in achieving the control goal compared to other types of controllers.
- Automatic control based on the quantum controller reduces nitrogen consumption by 53%.

In the future, the system will be put into operation, and its regular operation will start.

JINR Digital EcoSystem

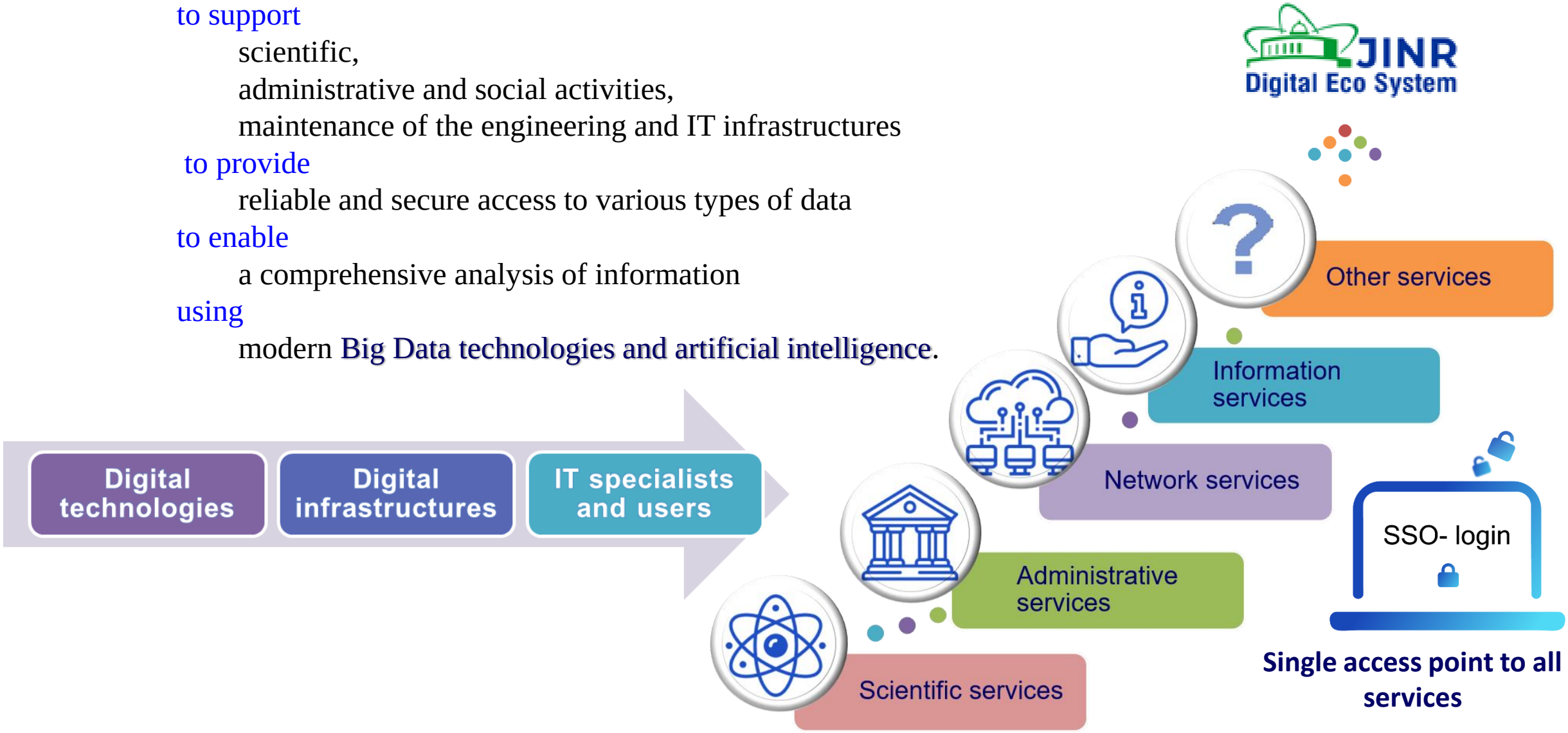
The digital platform “JINR Digital EcoSystem ” integrates existing and future services

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

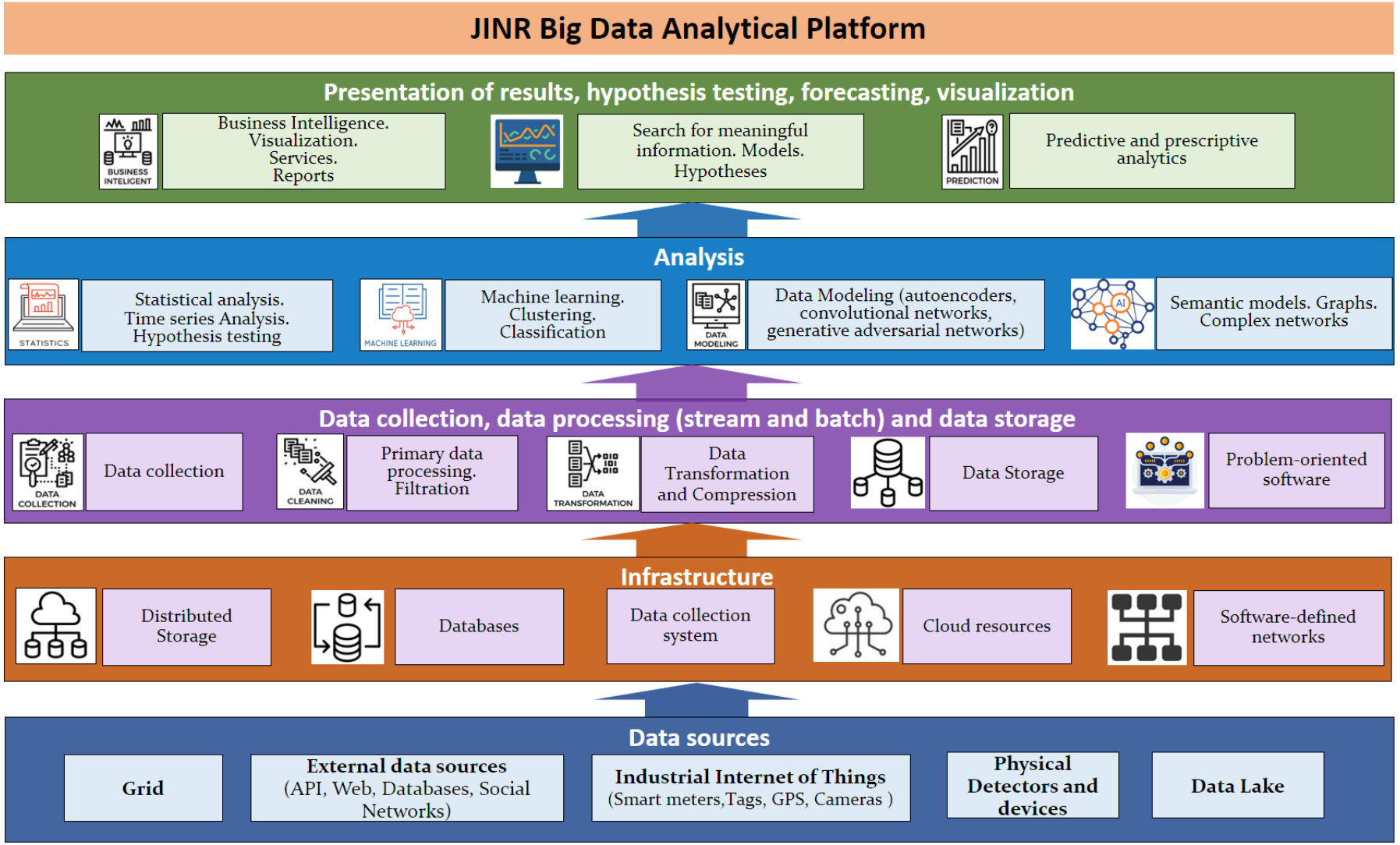
to enable
a comprehensive analysis of information

using
modern Big Data technologies and artificial intelligence.



JINR Big Data Analytical Platform

- 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 Data Analysis Framework

MATLAB

GEANT4

Maple

Frameworks and tools for ML/DL tasks

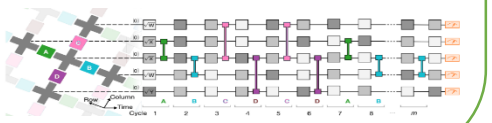
jupyterhub

TensorFlow

NumPy

scikit learn

Quantum algorithms, quantum programming and quantum control



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

NEC'2019

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

MMCP

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

JINR School of Information Technology 2022

60 students from 13 Russian universities