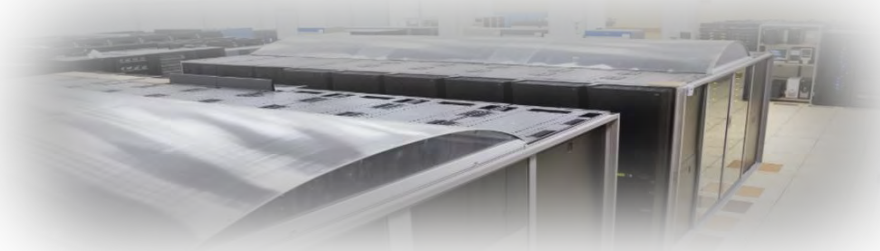
Distributed Computing at JINR: yesterday, today, tomorrow

Vladimir Korenkov

Meshcheryakov Laboratory of Information Technologies



The International Conference GRID-2025
Dubna, JINR, 7 July 2025

Meshcheryakov Laboratory of Information Technologies

M.G. Meshcheryakov
(17.09.1910 - 24.05.1994)

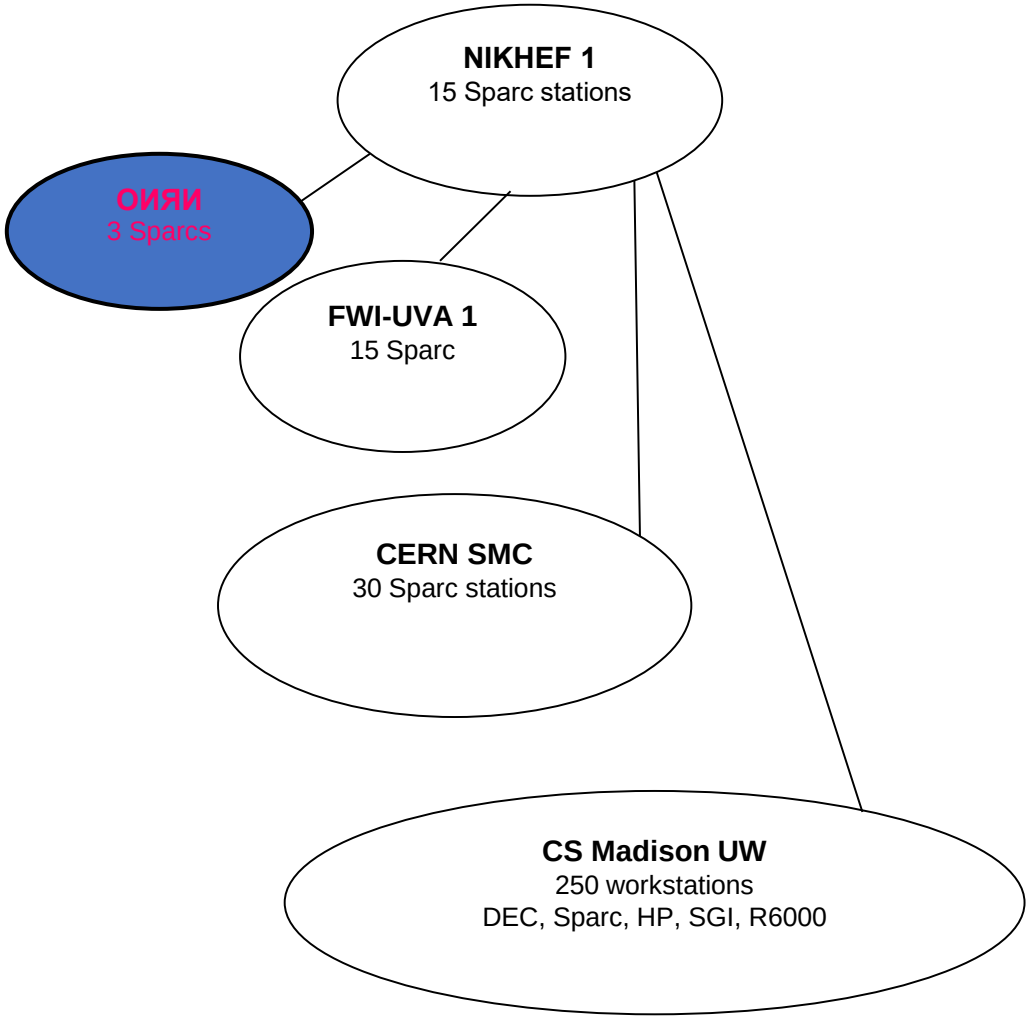
The Laboratory of Computing Techniques and Automation (now MLIT) was founded in August 1966.

The main directions of the 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** in high energy physics, nuclear physics, condensed matter physics, etc.

N.N. Govorun
(18.03.1930 - 21.07.1989)

Distributed Computing at JINR: first steps

Condor



PC-cluster

CCIC JINR

150 CPU

18TB RAID-5

39TB Certon100

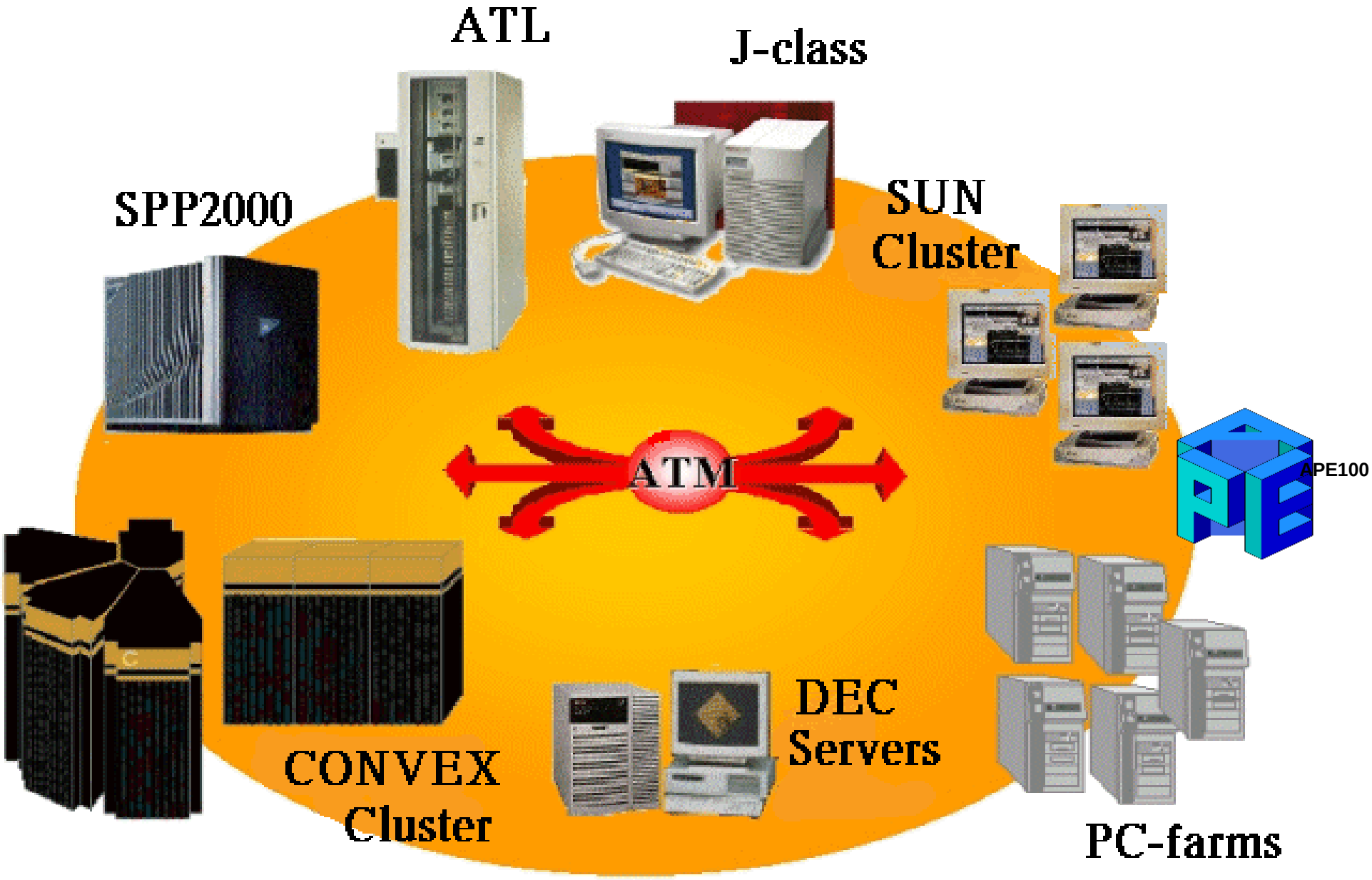
8 – Interactive & UI

32 – Common PC-farm

MYRINET (Parallel)

52 – LCG

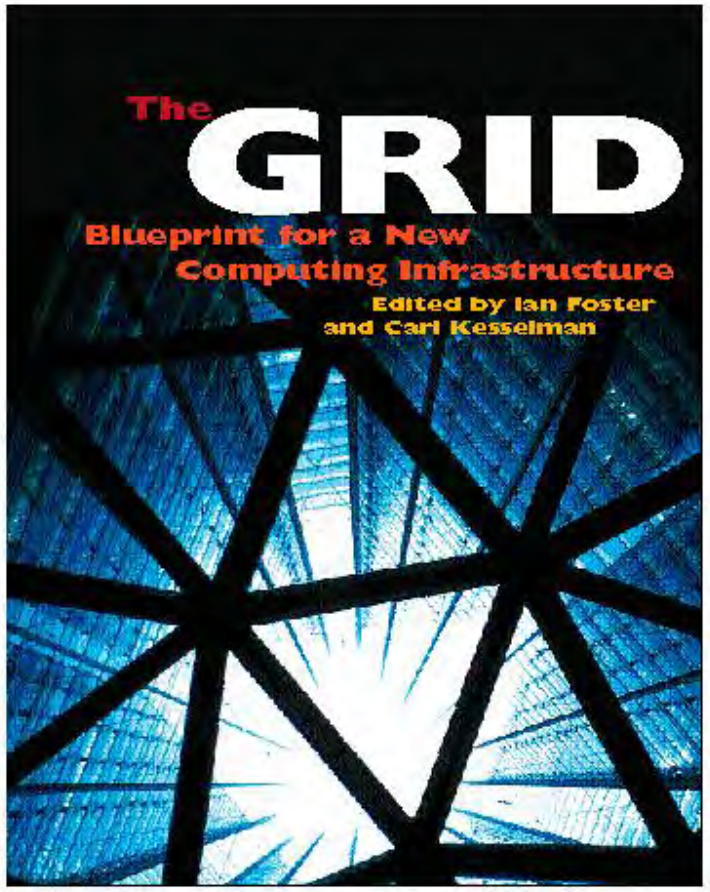
61 – servers


ATL
J-class
SPP2000
SUN
Cluster
ATM
APE100
CONVEX
Cluster
DEC
Servers
PC-farms

What is GRID

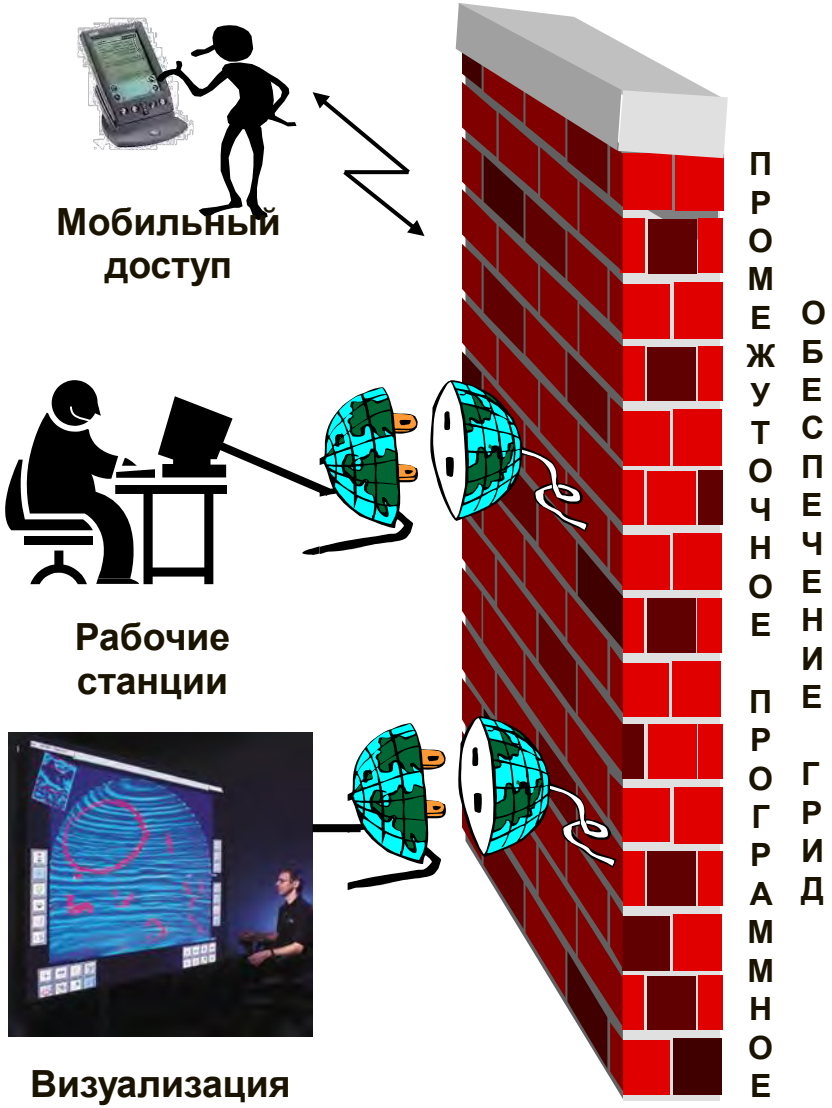
Five Emerging Models of Networked Computing From The Grid:

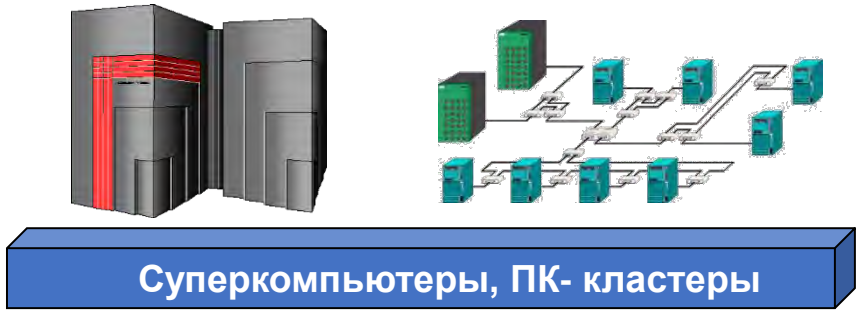
- **Distributed Computing**
- **High-Throughput Computing**
- **On-Demand Computing**
- **Data-Intensive Computing**
- **Collaborative Computing**

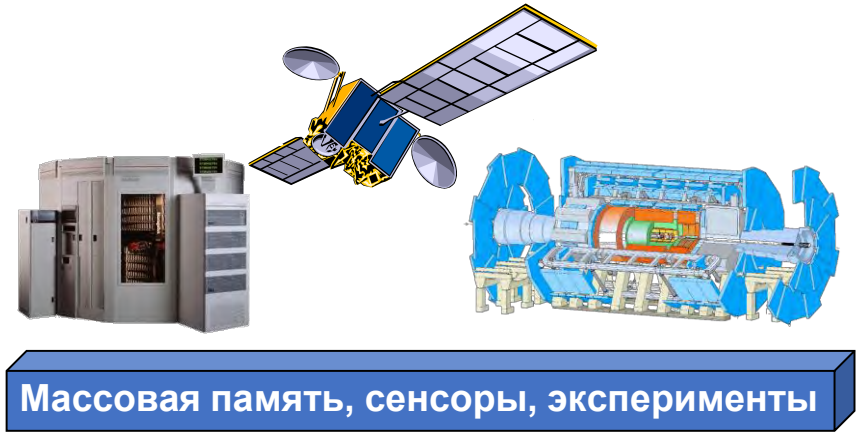


Ian Foster and Carl Kesselman, editors, "The Grid: Blueprint for a New Computing Infrastructure," Morgan Kaufmann, 1999, http://www.mkp.com/grids

GRID- is a means for sharing computing power and data storage via the Internet

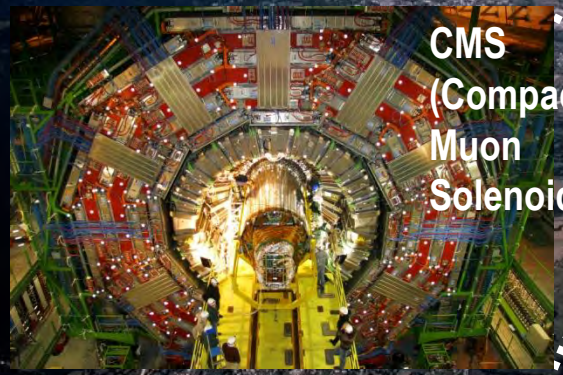






Large Hadron Collider

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)

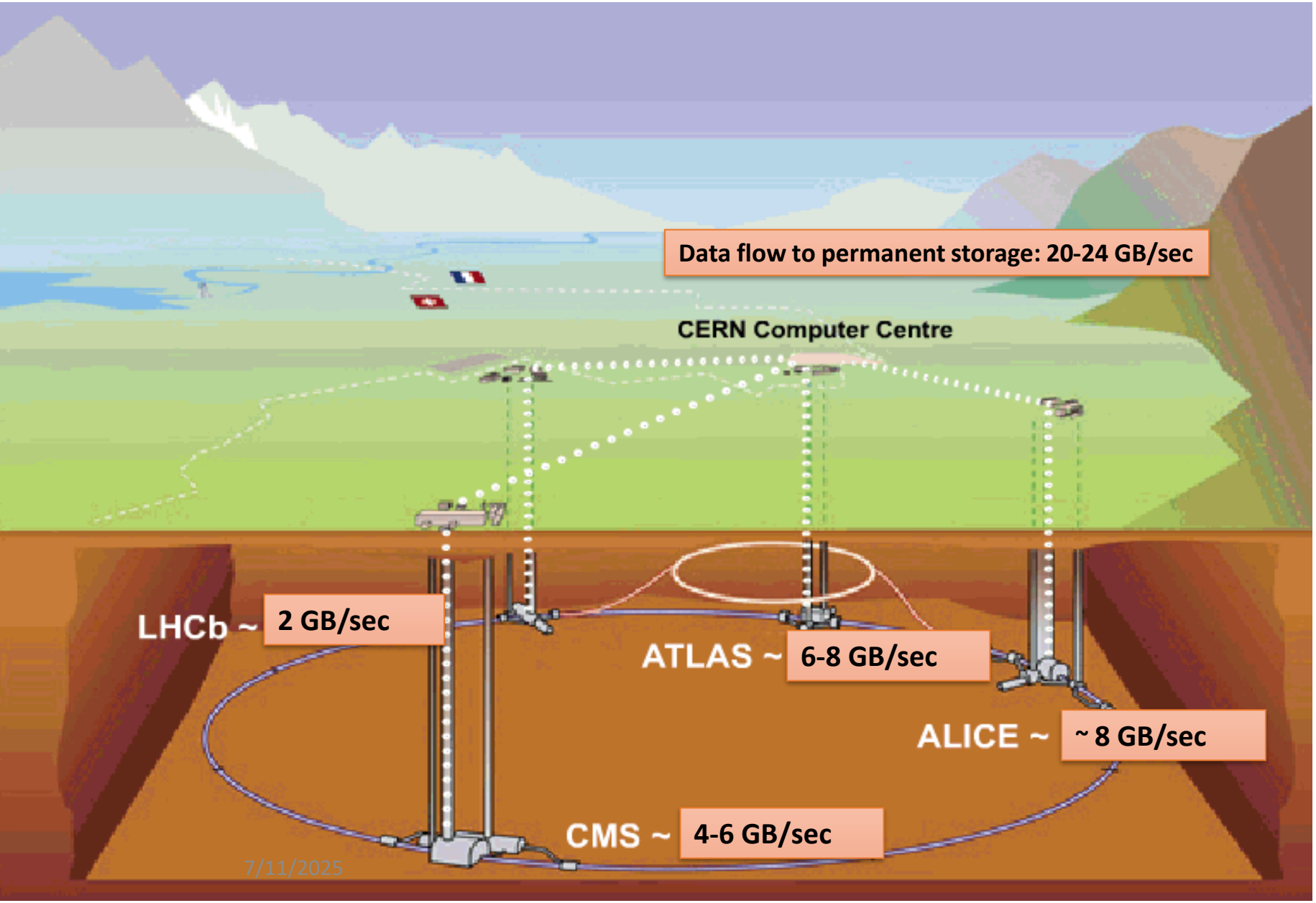
LHCb (Large Hadron Collider beauty experiment)

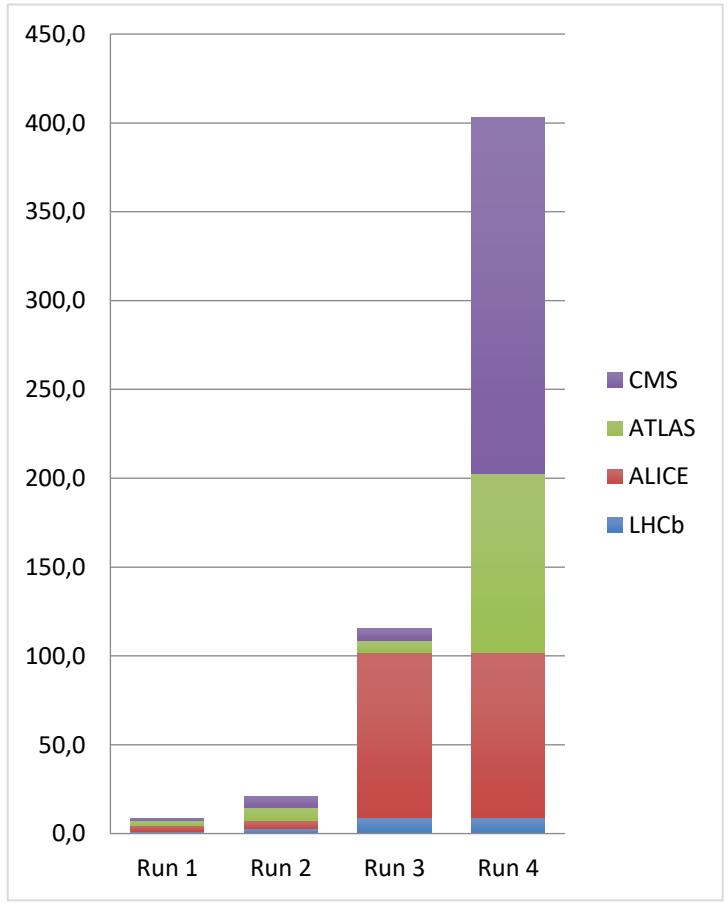
Data flow to permanent storage: 4-6 GB/sec

ALICE (A Large Ion Collider Experiment)

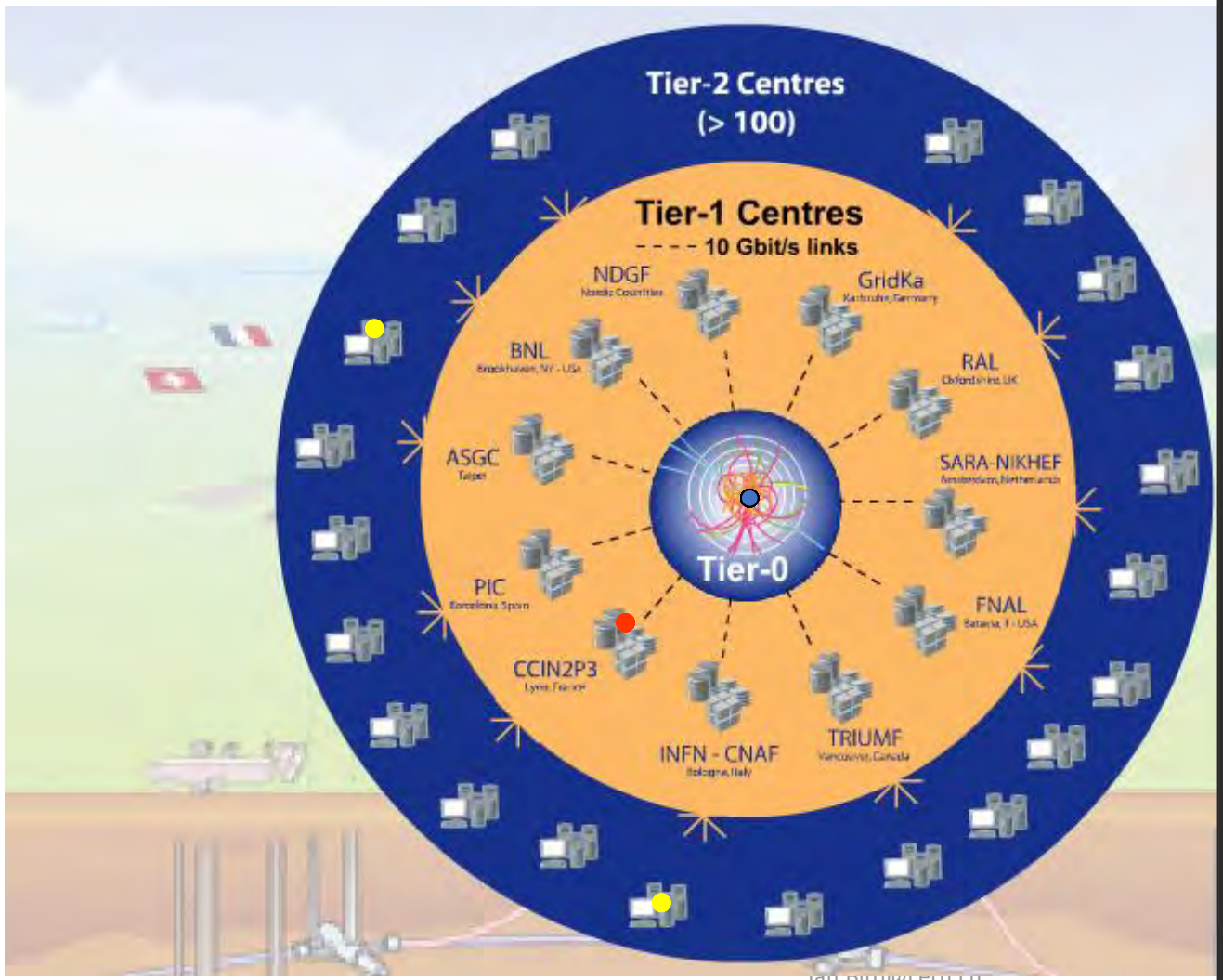
ATLAS (A Toroidal LHC ApparatuS)

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

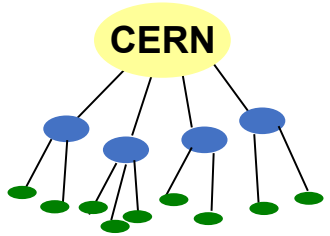
Tier-2 (>200 centers):

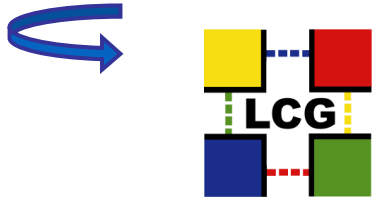
- simulation
- user physics analysis

Ian.Bird@cern.ch

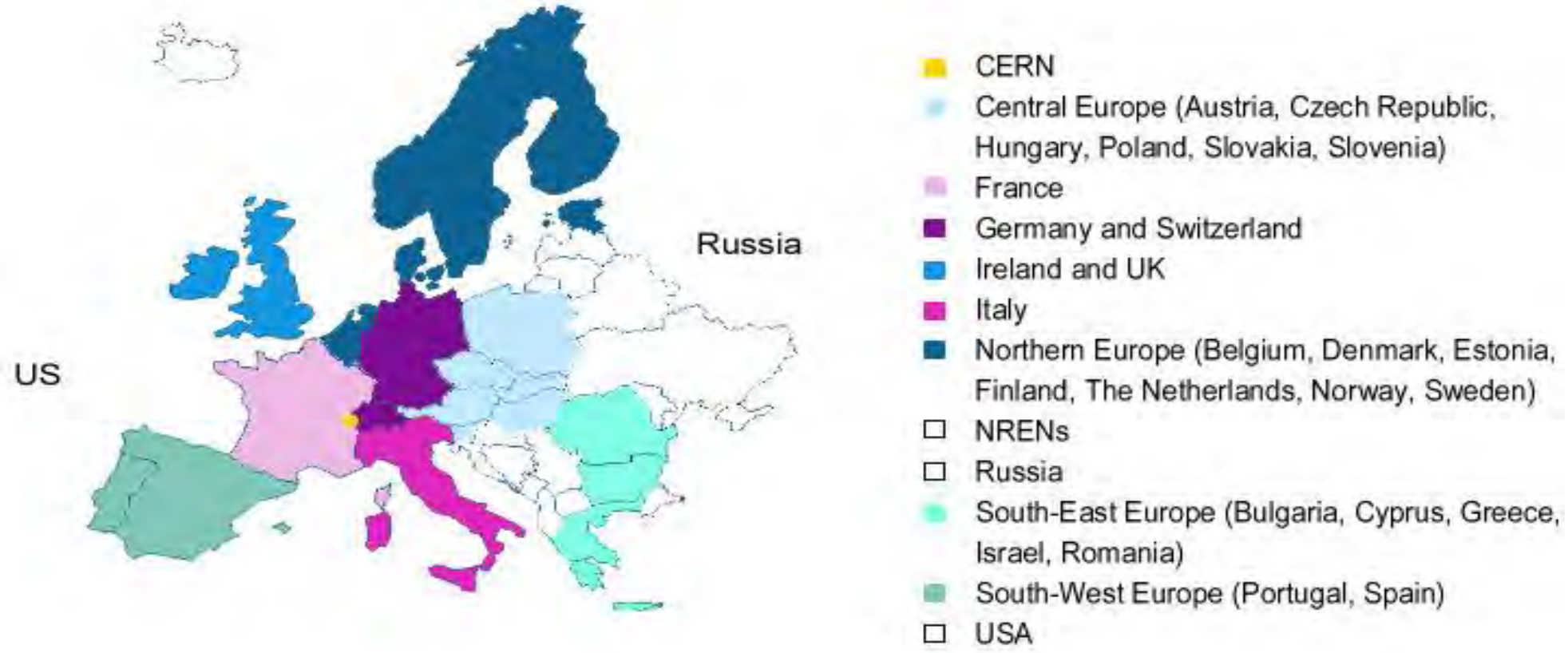
Some history

- 1999 – Monarc Project
  - Early discussions on how to organise distributed computing for LHC
- 2001-2003 - EU DataGrid project
  - middleware & testbed for an operational grid
- 2003 – RDIG in Russia (Tier2)
- 2002-2005 – LHC Computing Grid – LCG
- 2004-2006 – EU EGEE project phase 1
- 2005-2006 - PanDA and DIRAC
- 2006-2008 – EU EGEE-II
- 2008-2010 – EU EGEE-III
- 2010-2012 - EGI-InSPIRE
- 2010 – GRID-Cloud
- 2012 – discovery of the Higgs Boson
- 2013 – Tier1 in Russia (JINR and KI)
- 2013 – GRID-Supercomputer TITAN





EGEE - Enabling Grids for E-sciencE

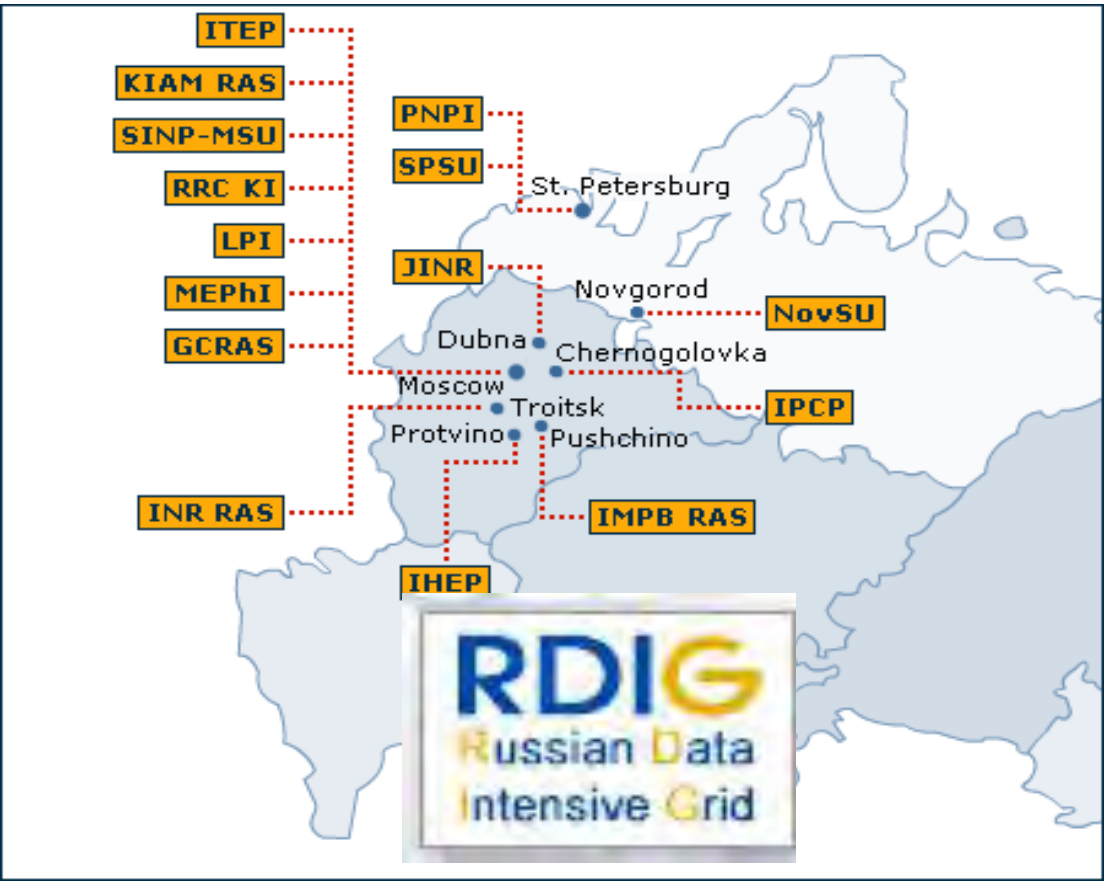


The EGEE project - Enabling Grids for E-sciencE aims to create international Grid-based workforces. The project is being implemented by a consortium of **70 institutes in 27 countries**, organized into regional grids.

JINR in the 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.

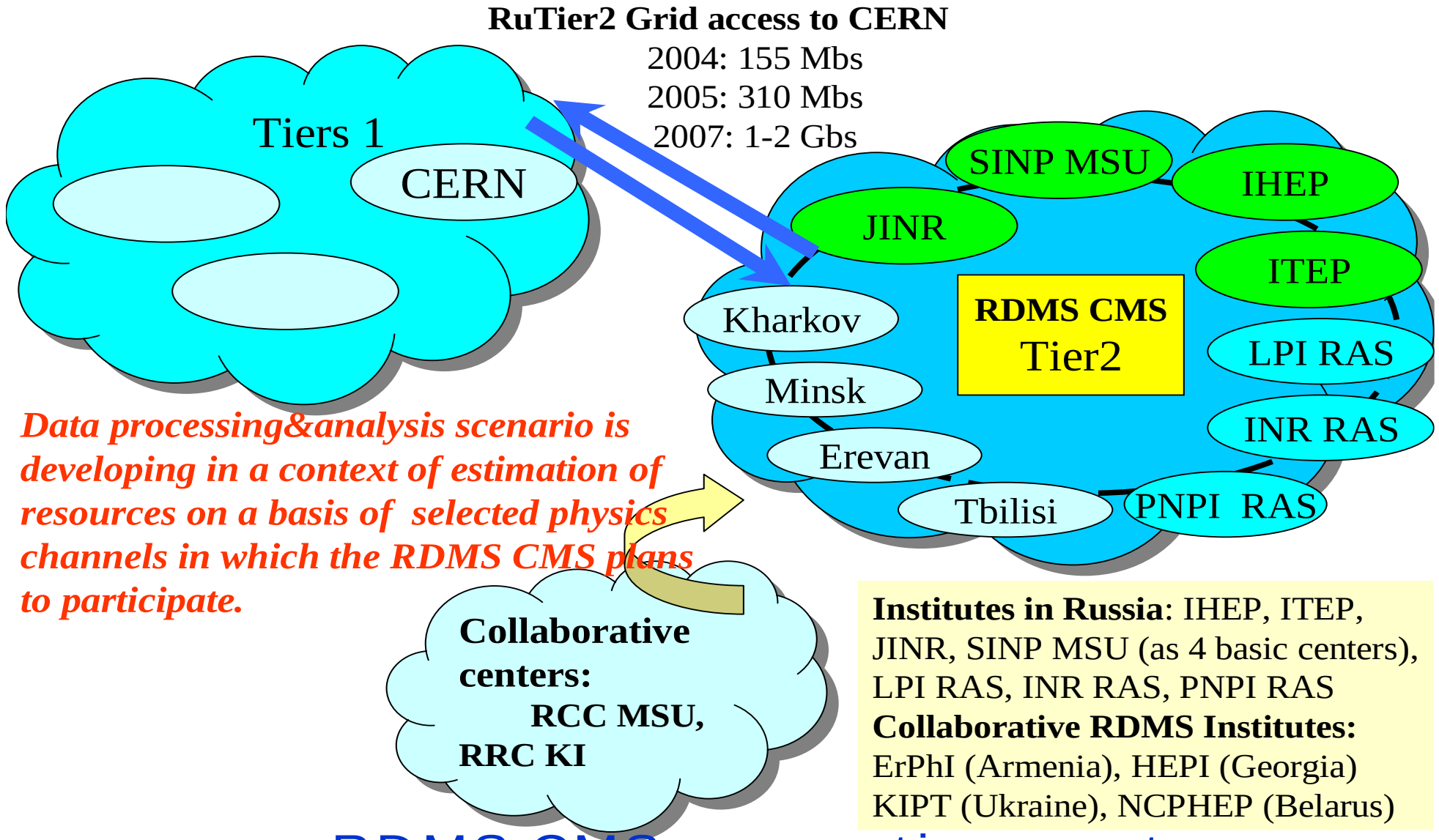
Now the RDIG infrastructure comprises 17 Resource Centers with > 5000 CPU (12000 kSI2K) and > 3200 TB of disc storage.



RDIG Resource Centres:

- ITEP
- JINR-LCG2
- Kharkov-KIPT
- RRC-KI
- RU-Moscow-KIAM
- RU-Phys-SPbSU
- RU-Protvino-IHEP
- RU-SPbSU
- Ru-Troitsk-INR
- ru-IMPB-LCG2
- ru-Moscow-FIAN
- ru-Moscow-GCRAS
- ru-Moscow-MEPHI
- ru-PNPI-LCG2
- ru-Moscow-SINP
- BY-NCPHEP

Development of RDMS CMS computing model



Data processing&analysis scenario is developing in a context of estimation of resources on a basis of selected physics channels in which the RDMS CMS plans to participate.

Institutes in Russia: IHEP, ITEP, JINR, SINP MSU (as 4 basic centers), LPI RAS, INR RAS, PNPI RAS
Collaborative RDMS Institutes:
ErPhI (Armenia), HEPI (Georgia)
KIPT (Ukraine), NCPHEP (Belarus)

RDMS CMS computing centers

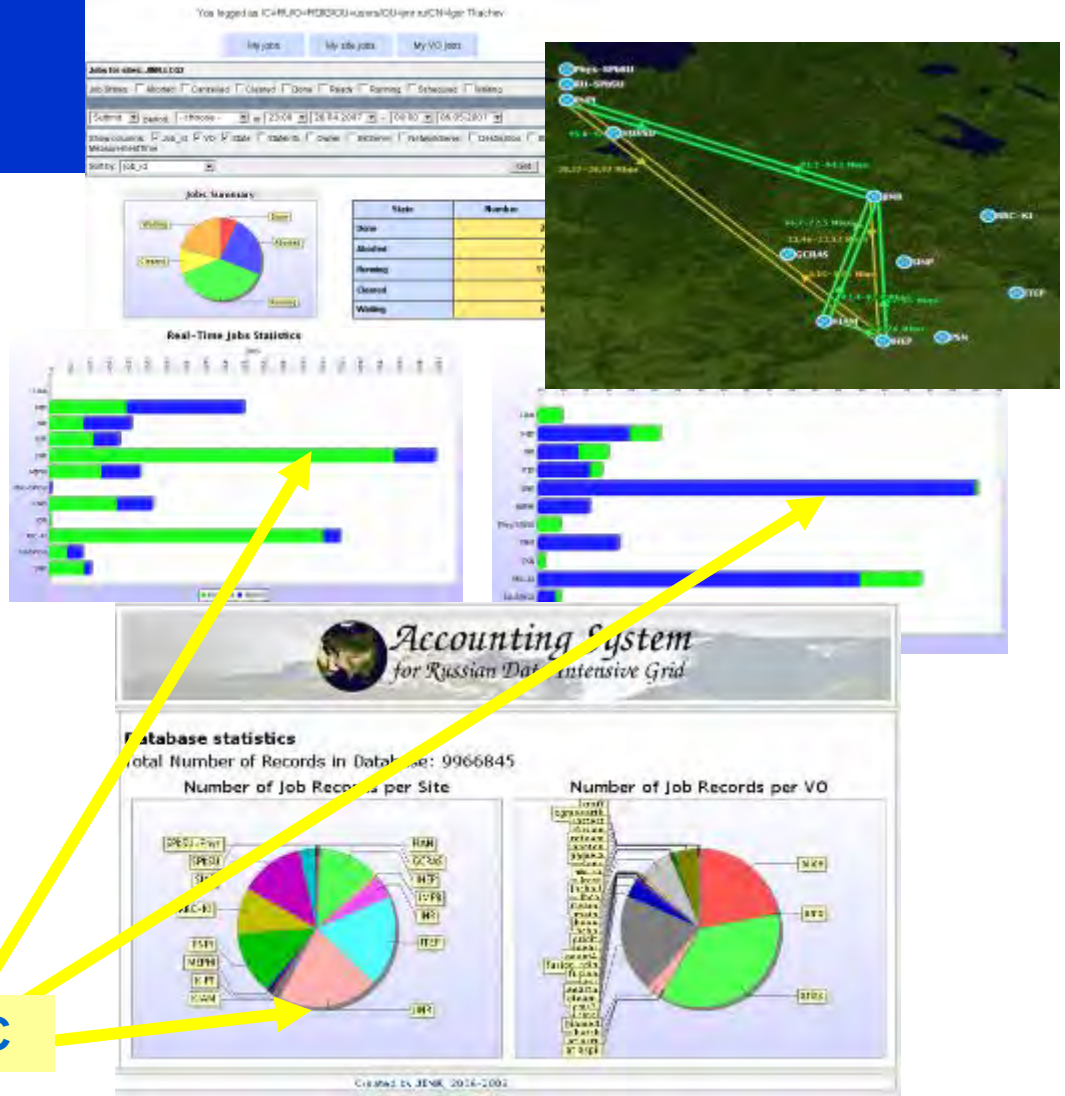
RDIG monitoring&accounting http://rocmon.jinr.ru:8080

- **Monitoring – allows to keep an eye on parameters of Grid sites' operation in real time**
- **Accounting - resources utilization on Grid sites by virtual organizations and single users**

Monitored values
CPUs - total /working / down/ free / busy
Jobs - running / waiting
Storage space - used / available
Network - Available bandwidth
Accounting values
Number of submitted jobs
Used CPU time
- Totally sum in seconds
- Normalized (with WNs productivity)
- Average time per job

Waiting time
- Totally sum in seconds
- Average ratio waiting/used CPU time per job

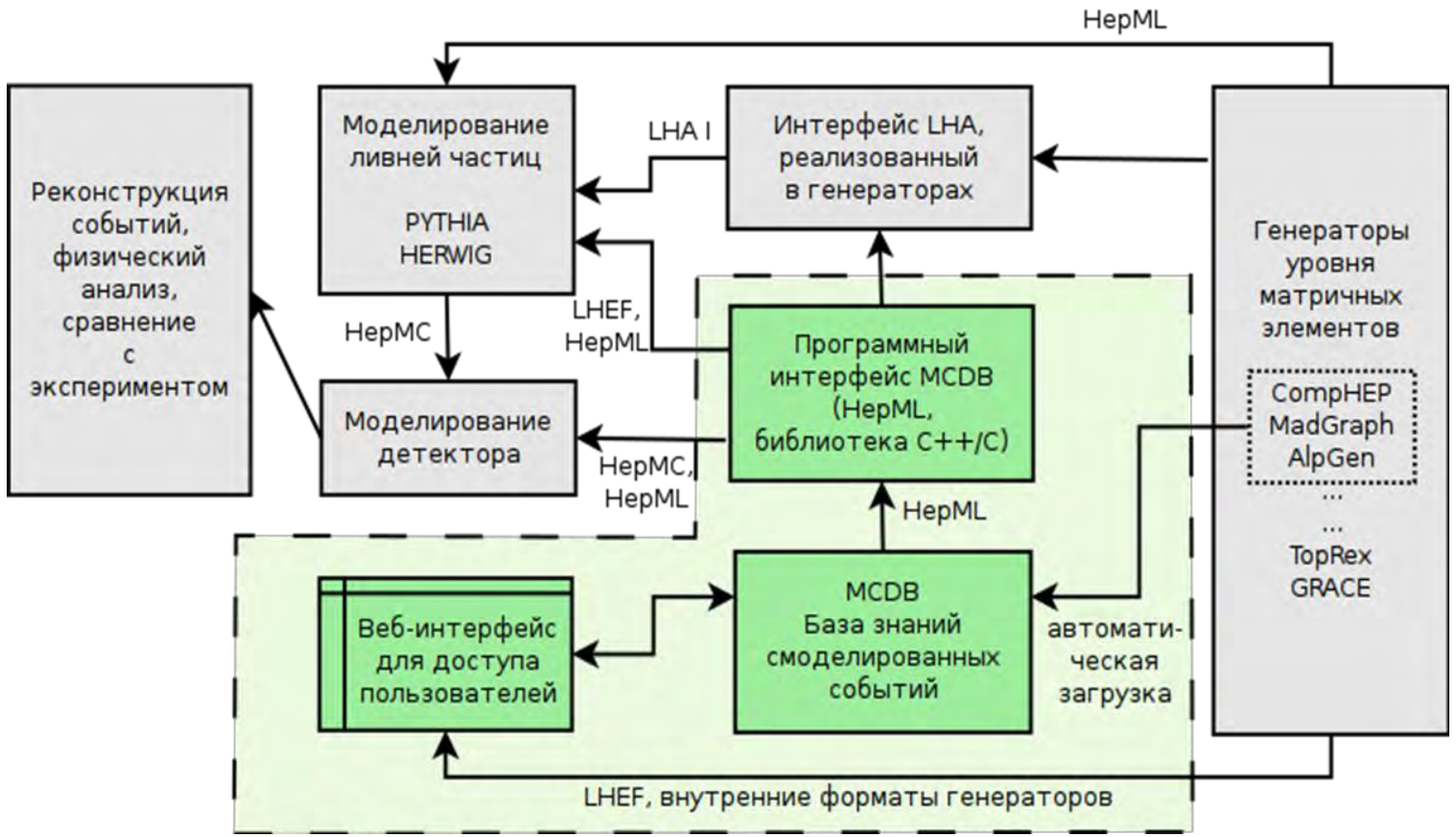
Physical memory
- Average per job



JINR CICC

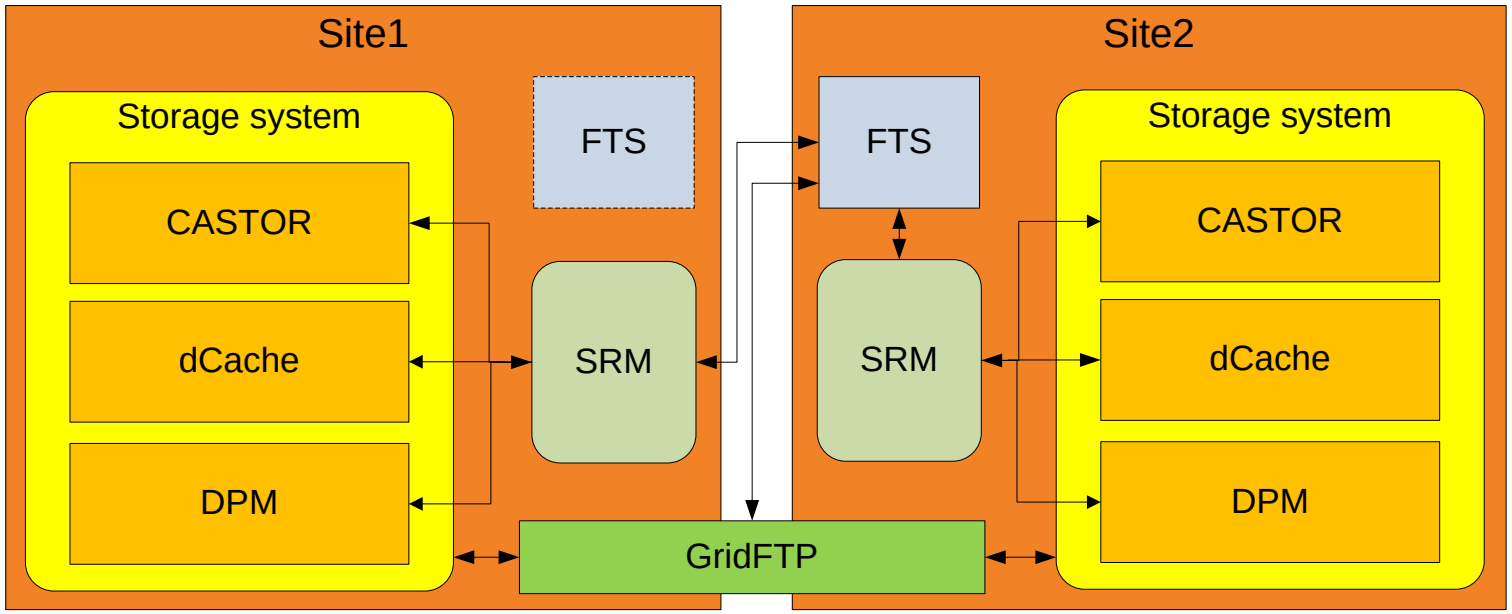
WLCG MCDB - project

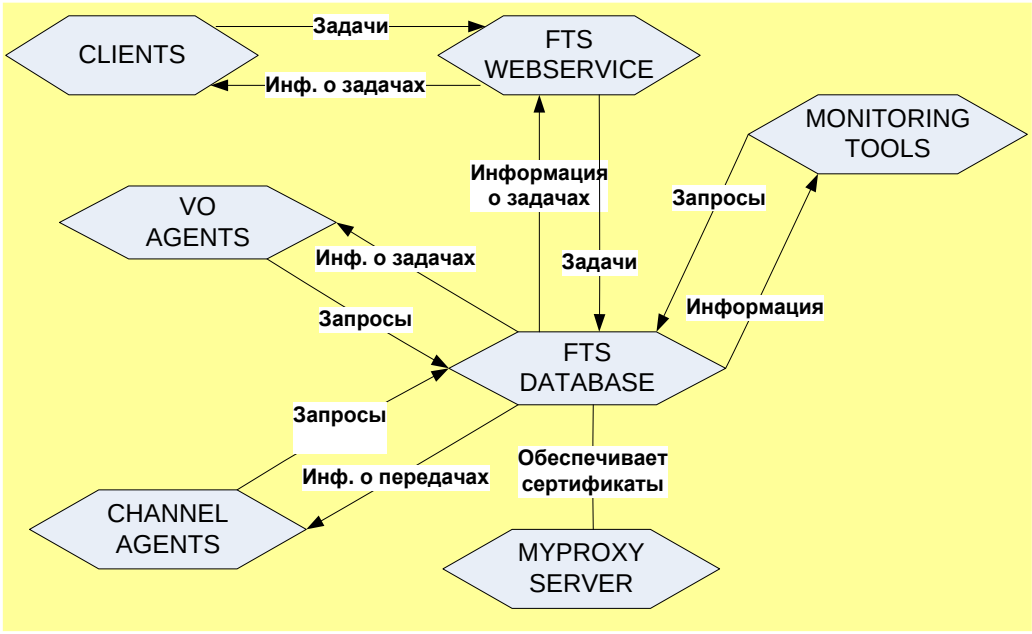
- MCDB access libraries have been integrated to CMSSW software
- Several improvements have been made in MCDB software
- New improved XML schema has been developed for High Energy Physics Markup Language (HepML)
- The program libraries have been developed to work with new HepML schema



FTS (FILE TRANSFER SERVICE) MONITORING FOR WORLDWIDE LHC COMPUTING GRID PROJECT

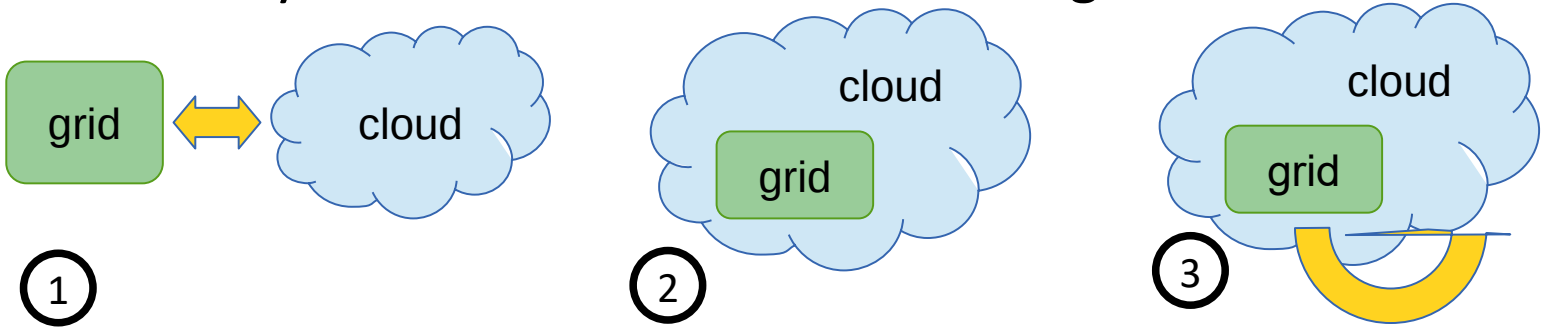
A monitoring system is developed which provides a convenient and reliable tool for receiving detailed information about the FTS current state and the analysis of errors on data transfer channels, maintaining FTS functionality and optimization of the technical support process. The system could seriously improve the FTS reliability and performance.





Clouds and grids

- Both ones **share** two main attributes:
  - they provide access to remote computing resources; and
  - they provide a service.
- But they are based on different paradigms:
  - clouds are being based on **virtualization of resources**,
  - grids being based on the **sharing of resources across boundaries**.
- Modern trend is a synthesis of these two technologies:



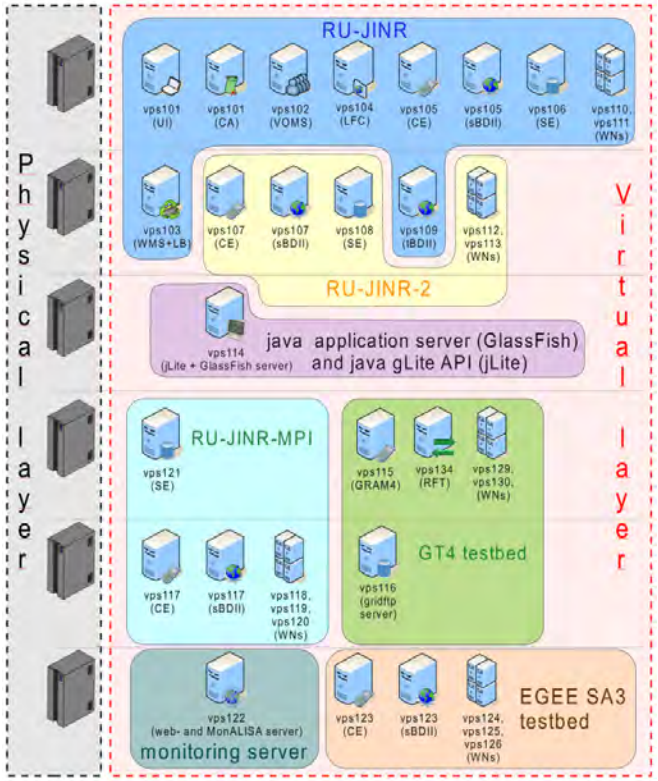
Cloud resources suppliments grid ones (e.g. during peak load to provide required QoS)

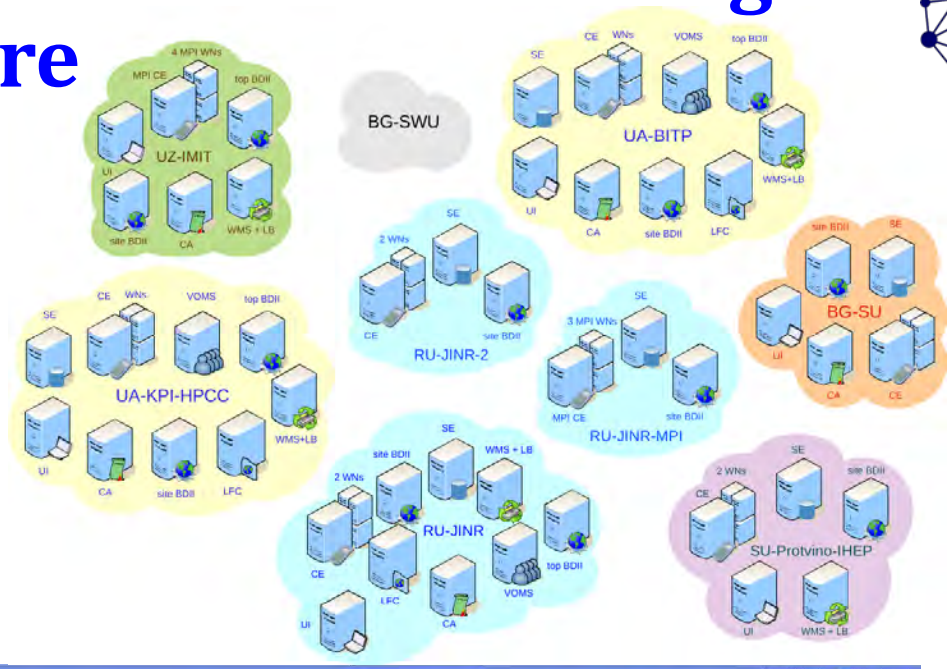
Services of grid site are deployed on cloud VMs (to increase hardware utilization efficiency and simplify admins' work)

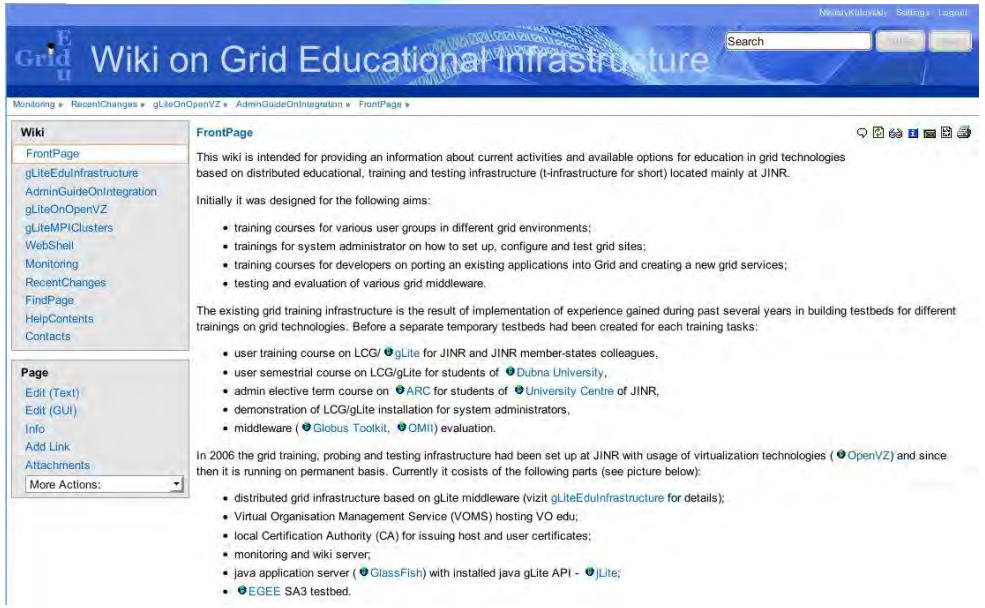
Synergy of 1st and 2nd approach

Grid training and education – distributed training infrastructure

gLite user trainings for students of Dubna University and University Centre of JINR,
grid site administrators trainings for JINR member-states,
testbed for grid developers,
testbed for middleware evaluation,
GILDA cooperation





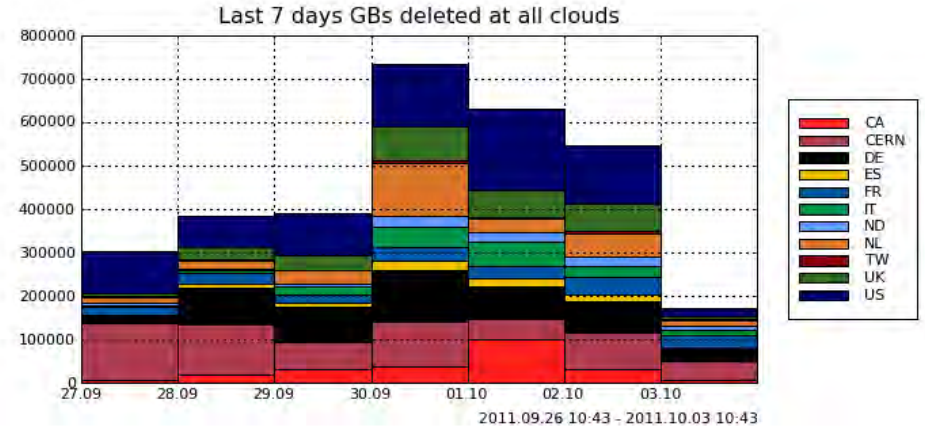


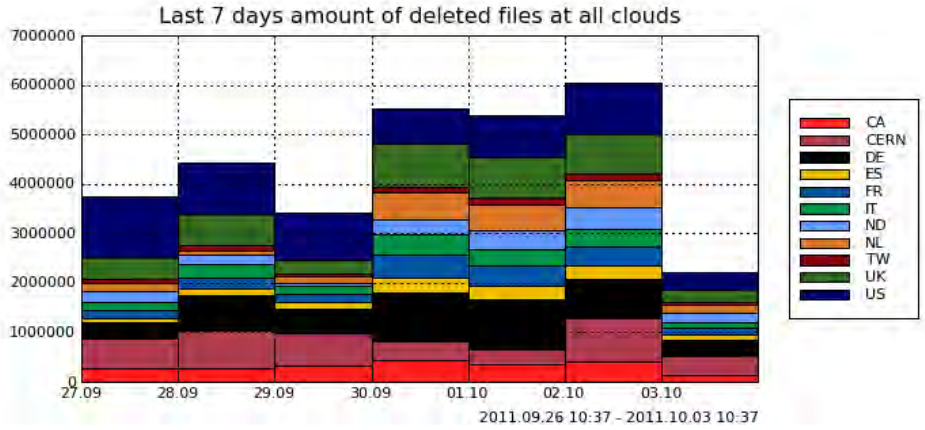
DDM DQ2 Deletion service

- The ATLAS Distributed Data Management project DQ2 is responsible for the replication, access and bookkeeping of ATLAS data across more than 120 distributed grid sites. It also enforces data management policies decided on by the collaboration and defined in the ATLAS computing model.

- The DQ2 Deletion Service is one of the most important DDM services. This distributed service interacts with 3rd party grid middleware and the DQ2 catalogues to serve data deletion requests on the grid. Furthermore, it also takes care of retry strategies, check-pointing transactions, load management and fault tolerance.

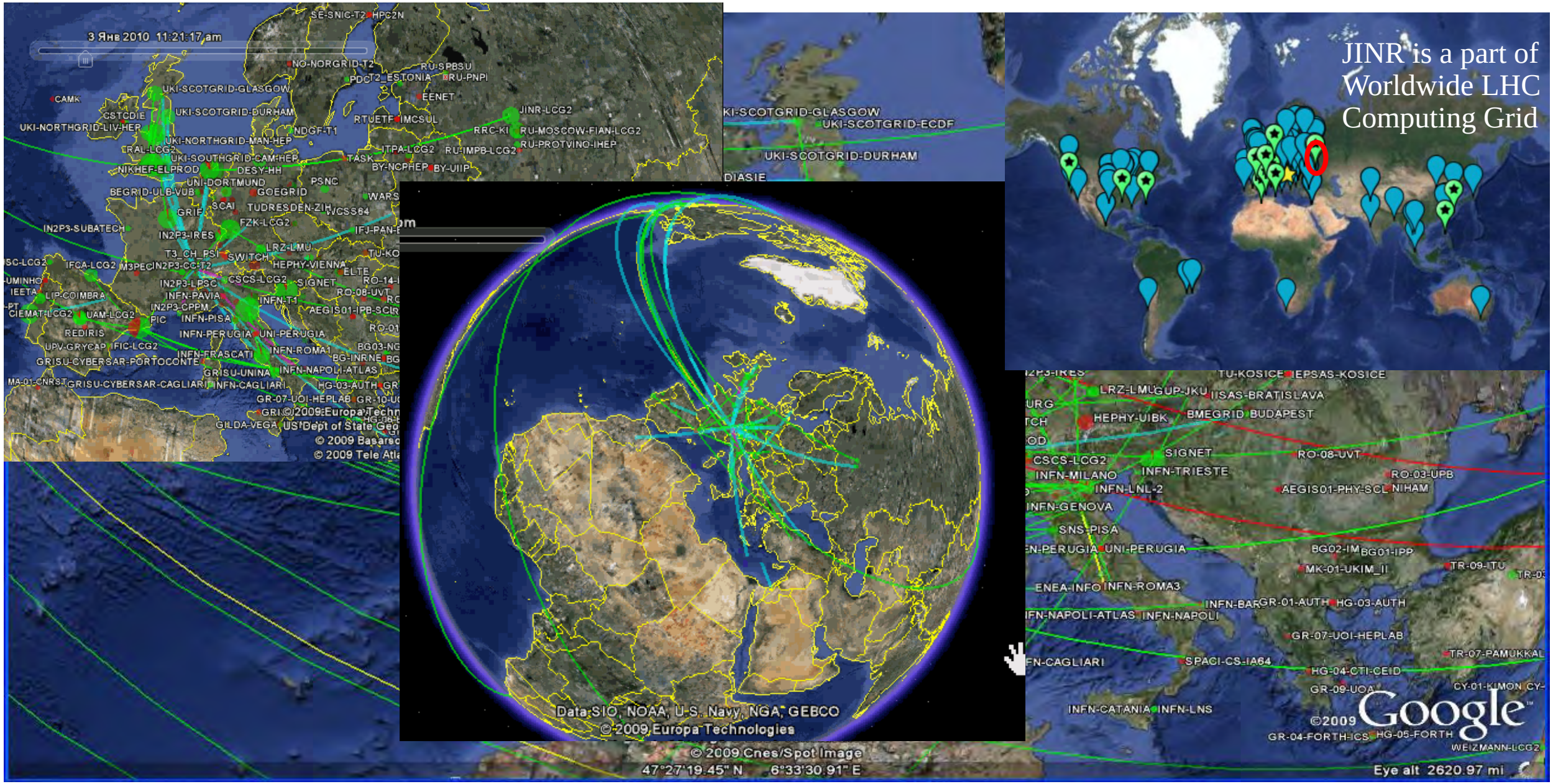
- Current version of Deletion Service was developed (and maintained) by JINR LIT specialists and is used by ATLAS Distributed Computing





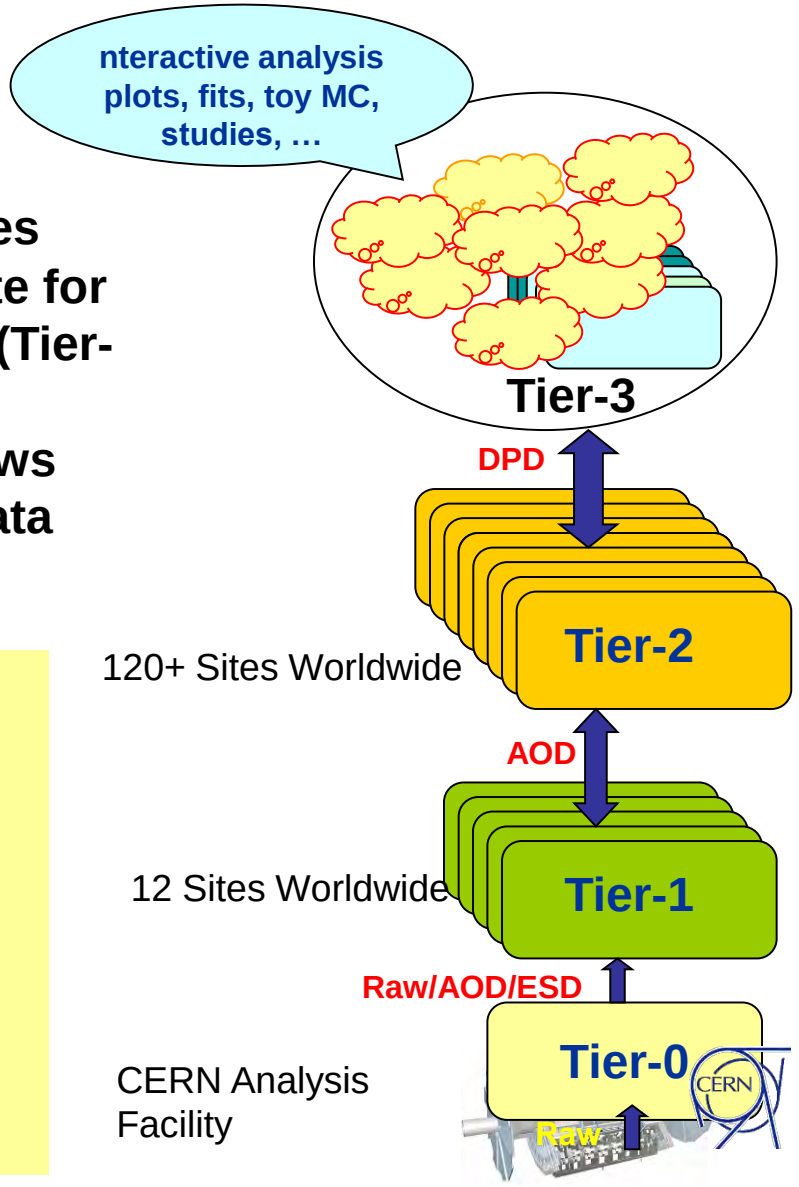
Deletion Service serves more than 120 sites. In usual operation it deletes 2-2,5M of files per day, which correspond to 400 - 500 TB per day. During the deletion campaigns when deletion was carried out on most sites, deletion rate achieved is more than 6M of files per day, reaching up to 300k files per hour.

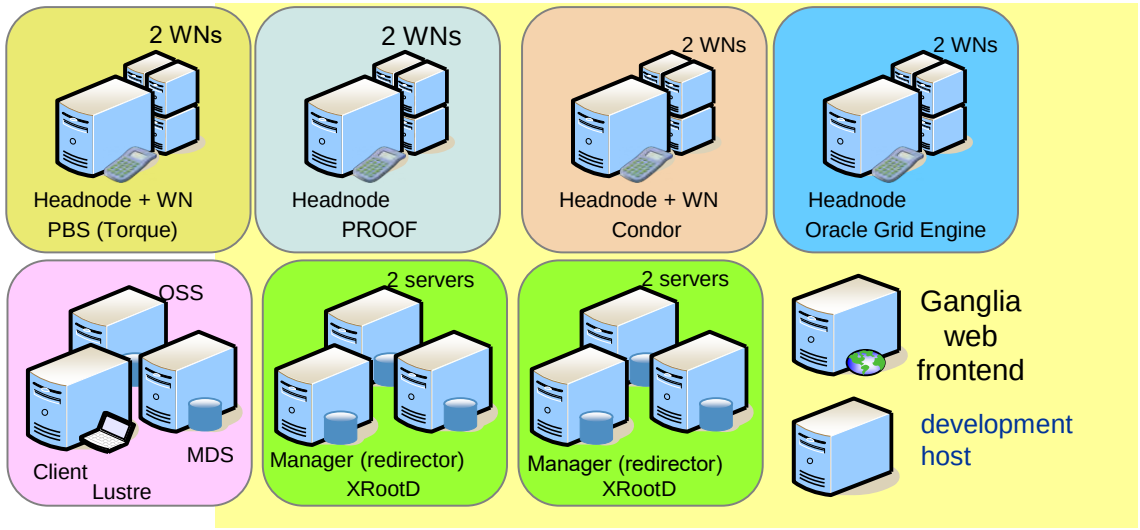
The Worldwide LHC Computing Grid (WLCG)



Tier3 sites monitoring project

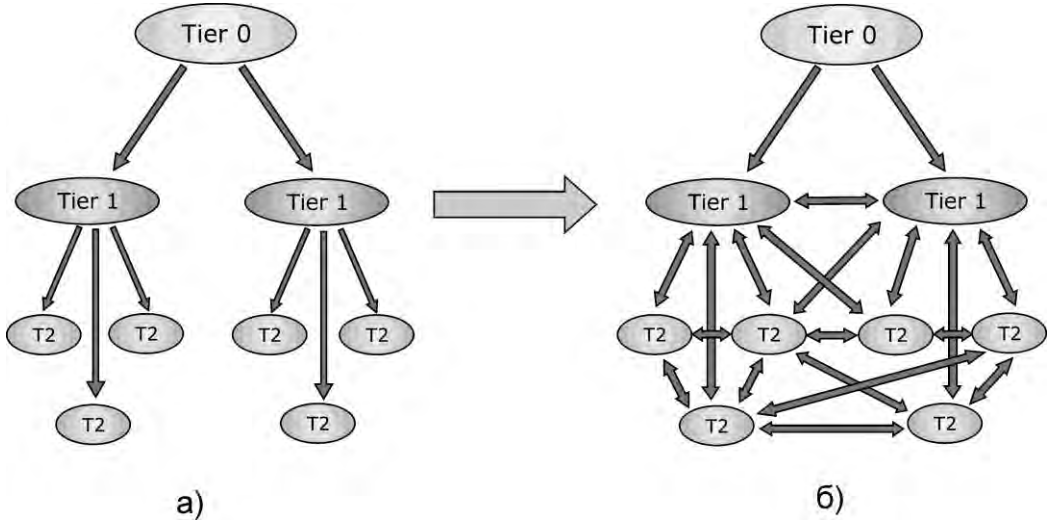
- **Traditional LHC Distributed Computing**
  Tier-0 (CERN) → Tier-1 → Tier-2
- **Additional → Tier-3**
- **Needs → a global view of the LHC computing activities**
- **LIT participates in the development of a software suite for Tier-3 sites global monitoring and ATLAS off-Grid sites (Tier-3) monitoring**
- **A virtual testbed has been created at JINR which allows simulation of various Tier3 clusters and solutions for data storage**

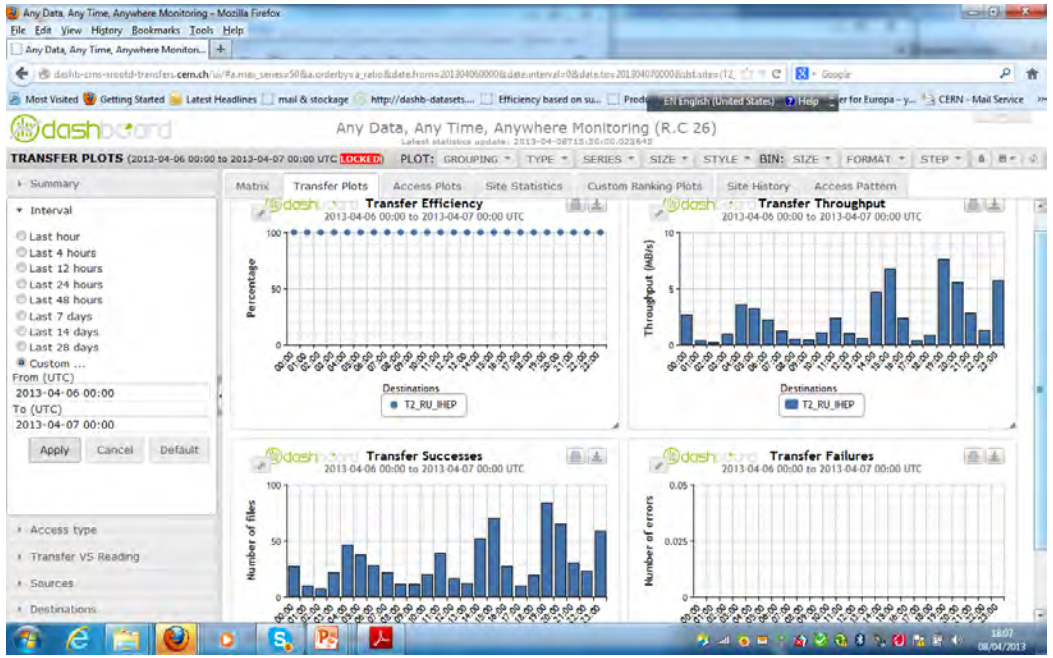




Poster reports at the Conference “Computing in High Energy and Nuclear Physics” (CHEP) 2012
21-25 May 2012 New York City, NY, USA

Monitoring of the XRootD federations





Data traffic to IHEP monitored by AAA Dashboard

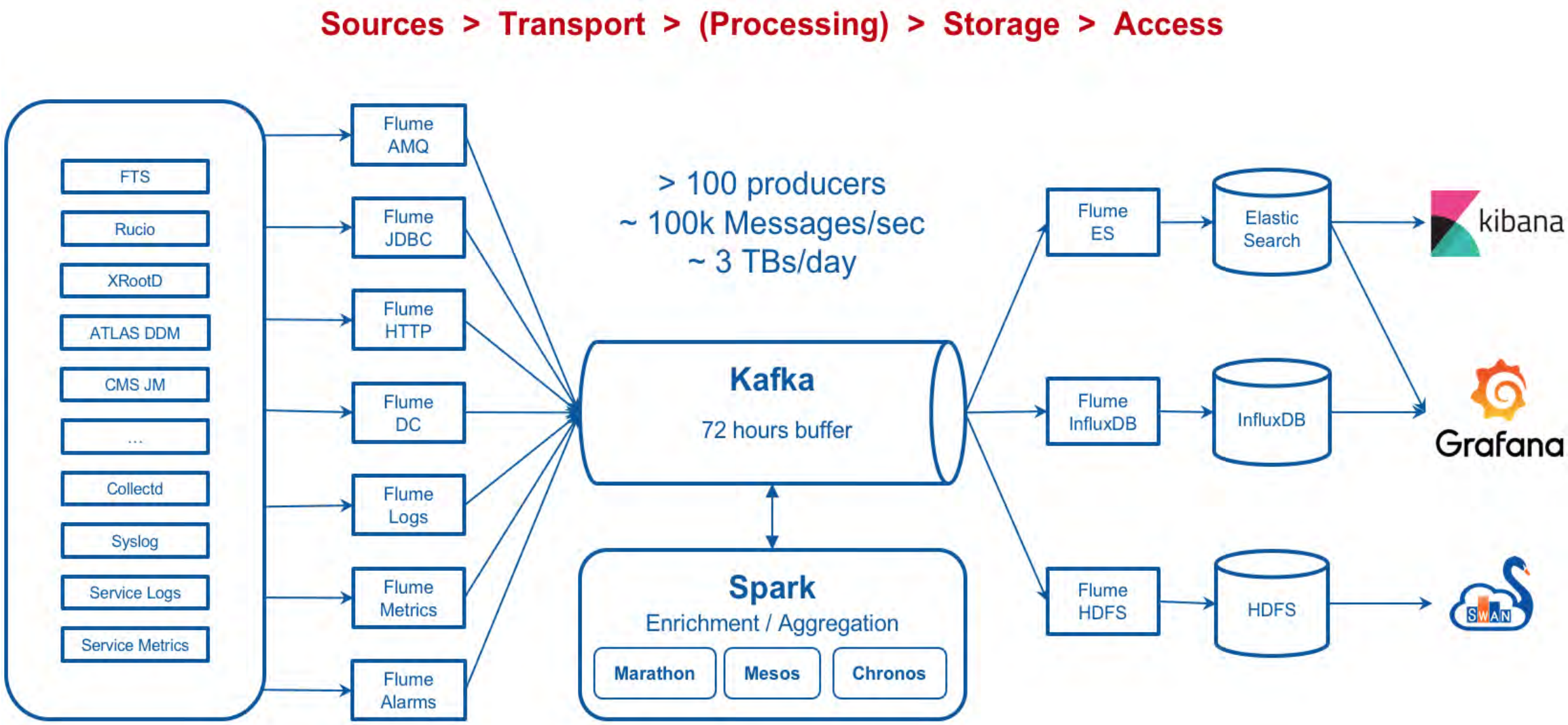
- The computing models of the LHC experiments are gradually moving from hierarchical data models with centrally managed data pre-placement towards federated storage which provides seamless access to data files independently of their location and dramatically improved recovery due to fail-over mechanisms.
- Construction of the data federations and understanding the impact of the new approach to data management on user analysis requires complete and detailed monitoring.
- In the WLCG context, there are several federations currently based on the XRootD technology. Monitoring applications for ATLAS XRootD federation (FAX Dashboard) and CMS XRootD federation (AAA Dashboard) were developed in collaboration of CERN IT and JINR LIT

WLCG Transfer Dashboard

- Along with data processing, data distribution is the key computing activity on the WLCG infrastructure.
- Monitoring of the data distribution is a challenging task because of the high scale of the activity and the heterogeneity of the infrastructure (various storage implementations and transport protocols used)
- The WLCG Transfer Dashboard developed during last two years, provides cross-experiment and cross-technology view of data transfers performed by the LHC experiments on the WLCG infrastructure
- JINR LIT actively participated in the development,
- Namely
  - development of the File Transfer Service (FTS) publisher to ActiveMQ,
  - monitoring of the state of the FTS queues,
  - integration of the traffic of the ALICE experiment which in difference with other LHC experiments does not use File Transfer Service (FTS)

WLCG home page contains the plot of the WLCG Transfer Dashboard

Organization of monitoring using Big Data technologies

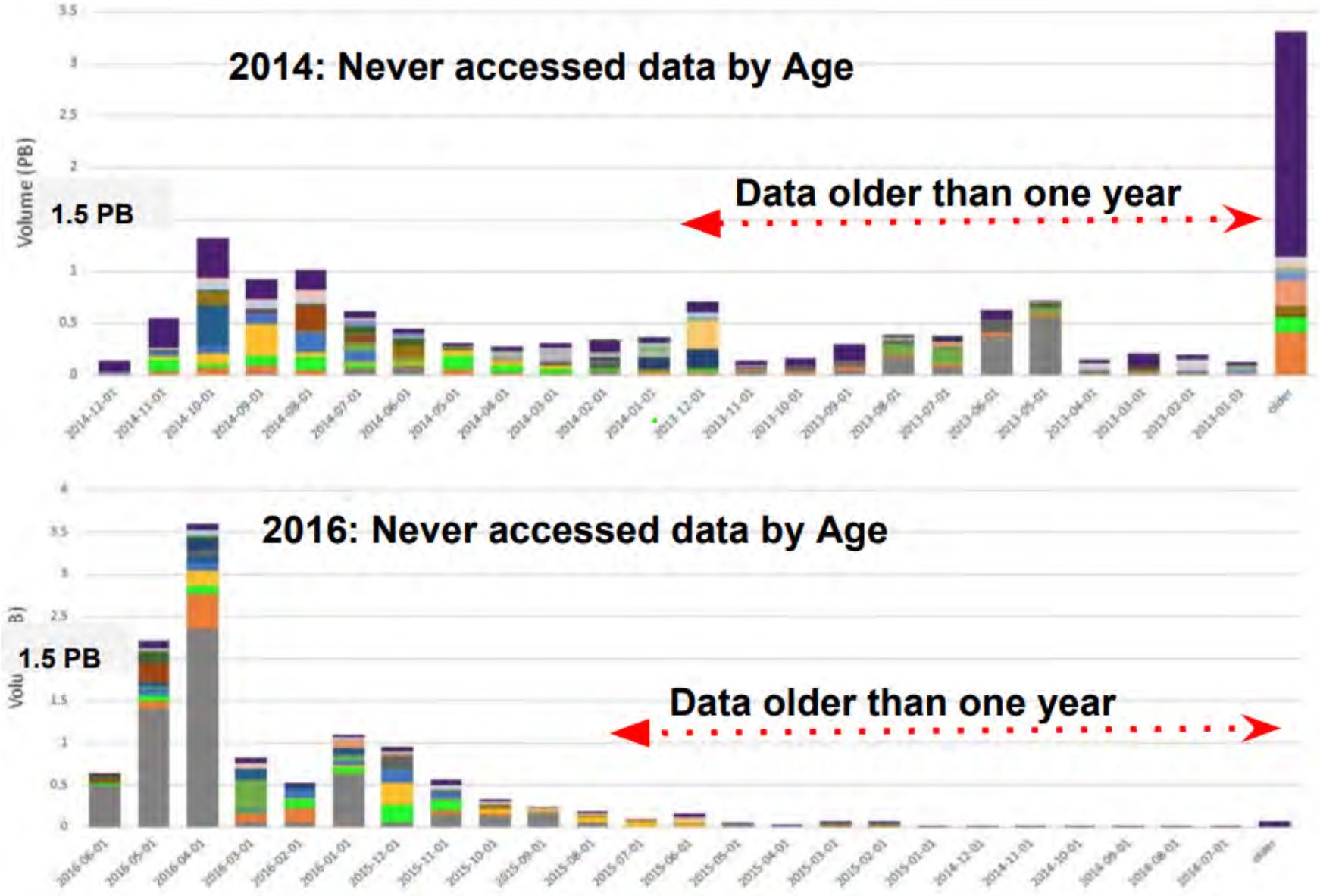


Implementation of file transfer monitoring in ATLAS

- Scaling: millions of transmissions per day
- Monitoring of both individual transmissions and global processes – close to real time
- Statistical slices by various parameters

Statistic of data transfer monitoring in ATLAS (project MONIT). Sept-Okt 2024

Analysis of data demand and change of data replication and storage strategy

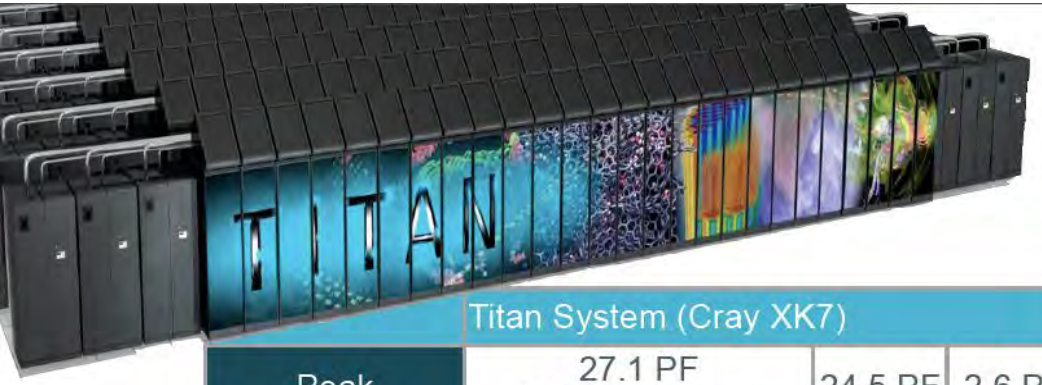


Remote access to ATLAS and CMS

- **System of remote access in real time (SRART) for monitoring and quality assessment of data from the ATLAS at JINR**
  - **One of the most significant results of the team TDAQ ATLAS at LIT during the last few years was the participation in the development of the project TDAQ ATLAS at CERN.**

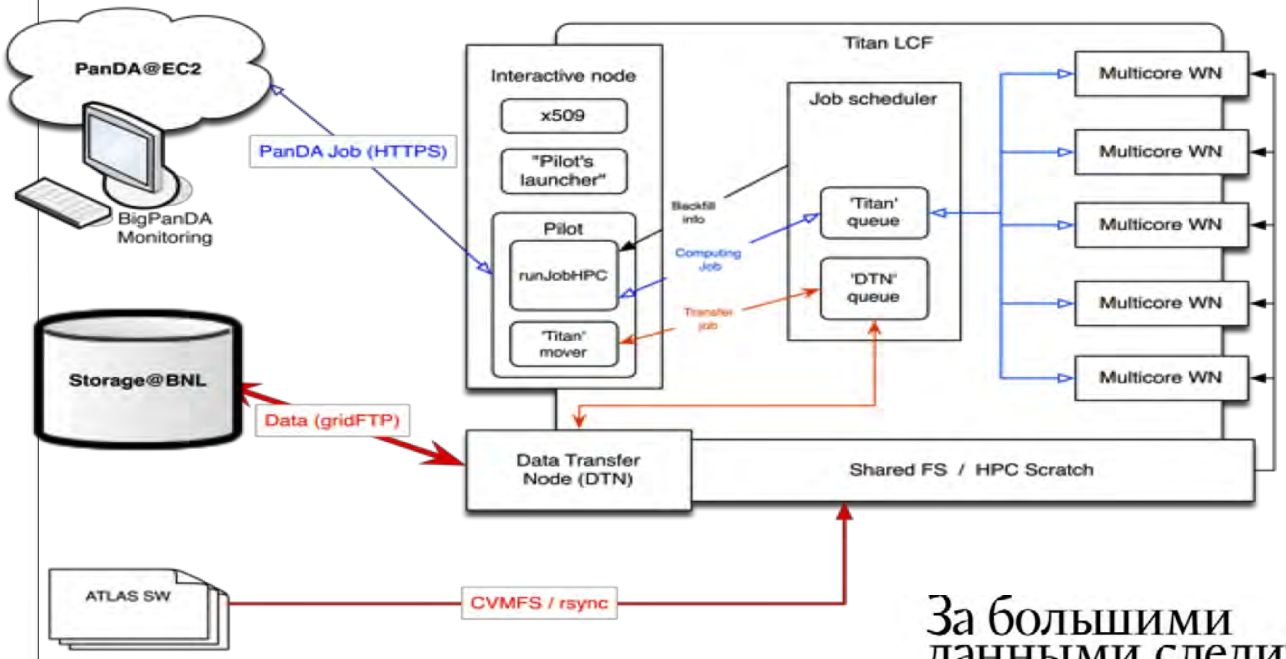
- **JINR CMS Remote Operation Centre**
  - **Monitoring of detector systems**
  - **Data Monitoring / Express Analysis**
  - **Shift Operations (except for run control)**
  - **Communications of JINR shifter with personal at CMS Control Room (SX5) and CMS Meyrin centre**
  - **Communications between JINR experts and CMS shifters**
  - **Coordination of data processing and data management**
  - **Training and Information**

Extending PanDA to Oak Ridge Leadership Computing Facilities



	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



За большими данными следит ПАНДА

PanDA development in the direction of integration of various distributed and parallel computing systems (grid, cloud, clusters, data centers, supercomputers) with the aim of creating a universal platform for large-scale big data management projects.

New COMPASS Production System

COMPASS Grid Production System was developed and provides automated task processing from definition till archiving

Key features:

Production management via Web UI, allows one to define a task, send, follow and manage it during lifecycle.

Via **PanDA** job execution layer jobs are being sent to any available type of computing resource: **Condor, LSF, PBS, etc.**

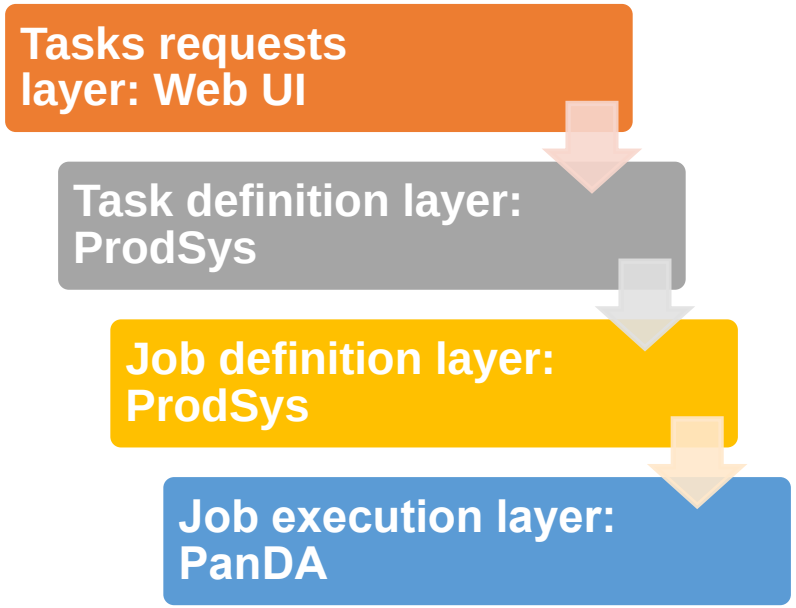
Computing sites: CERN Tier-1, JINR Tier-2

Storage: EOS and CASTOR at CERN

All management services deployed at JINR Cloud Service

In production since August, statistics:

- ~1 000 000 chunks of raw data processed,
- ~30 billions of events,
- ~200 TB of data produced,
- ~3 000 000 jobs processed:
  - reconstruction, ddd filtering,
  - merging of mDST, histograms
  - and event dumps.



ГРИД ННС

GridNNN infrastructure

- Grid support for Russian national nanotechnology network
  - To provide for science and industry an effective access to the distributed computational, informational and networking facilities
  - Expecting breakthrough in nanotechnologies
  - Supported by the special federal program

- Main points
  - based on a network of supercomputers (about 15-30)
  - has two grid operations centers (main and backup)
  - is a set of grid services with unified interface
  - partially based on Globus Toolkit 4

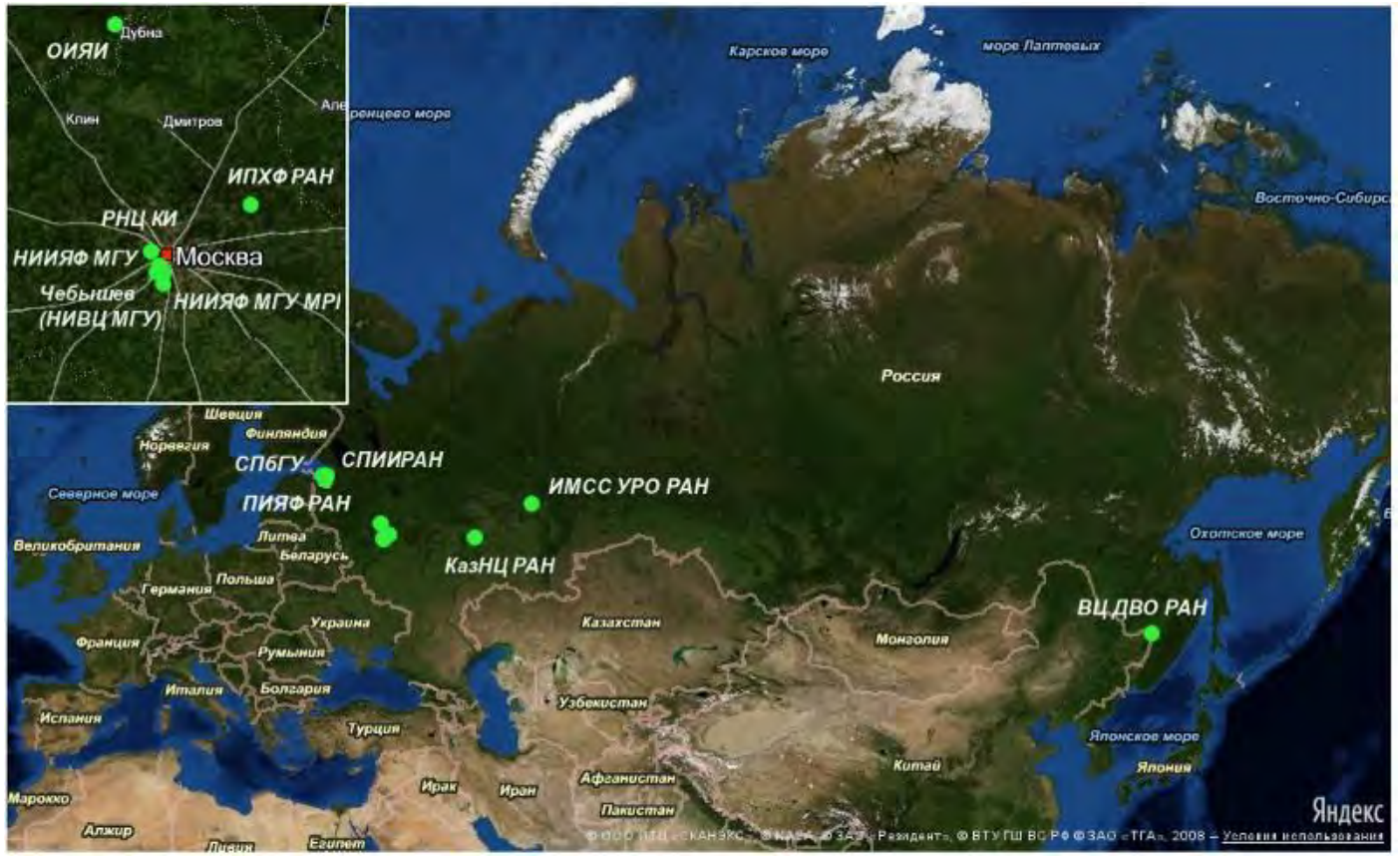
10 resource centers in different regions of Russia

- RRC KI, «Chebyshev» (MSU), IPCP RAS, CC FEB RAS, ICMM RAS, JINR, SINP MSU, PNPI, KNC RAS, SPbSU

Saint-Petersburg State University

Russian Grid Network

- Goal — to make a computational base for hi-tech industry and science
- Using the network of supercomputers and original software created within recently finished GridNNN project
- Some statistics
  - 19 resource centers
  - 10 virtual organizations
  - 70 users
  - more than 500’000 tasks processed



Tier1 center

March 2011 - Proposal to create the LCG Tier1 center in Russia (official letter by Minister of Science and Education of Russia A. Fursenko has been sent to CERN DG R. Heuer):

NRC KI for ALICE, ATLAS, and LHC-B
LIT JINR (Dubna) for the CMS experiment

***The Federal Target Programme Project*: «Creation of the automated system of data processing for experiments at the LHC of Tier-1 level and maintenance of Grid services for a distributed analysis of these data»**

***Duration:* 2011 – 2013**

September 2012 – Proposal was reviewed by WLCG OB and JINR and NRC KI Tier1 sites were accepted as a new "Associate Tier1"

Full resources - in 2014 to meet the start of next working LHC session.

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

GENEVE, SUISSE
GENEVA, SWITZERLAND

Mail address:
Dr. Ian Bird
CERN, IT Department
CH-1211 GENEVE 23
Switzerland
Tel: +41 22 767 5888

E-mail : Ian.Bird@cern.ch

Prof. Mikhail Kovalchuk
Director of National Research Centre
"Kurchatov Institute"
1, Akademia Kurchatova pl.
Moscow 123182, Russia

Prof. Victor Matveev
Director of Joint Institute for Nuclear Research
Joliot-Curie 6
141980 Dubna, Moscow Region, Russia

Votre référence/Your reference:
Notre référence/Our reference:

Subject: Acceptance of the proposal to build Tier 1 centres in Russia

Geneva, October 12, 2012

Dear Directors,

As you know, the proposals from the National Research Centre – "Kurchatov Institute" and the Joint Institute for Nuclear Research, Dubna, to build Tier 1 centres for LHC data analysis were discussed in the recent WLCG Overview Board held on September 28. I am very happy to report that the proposals were well received by the members of the board, and that the decision was made to accept the Russian sites as a new "Associate Tier 1". This decision will be noted in the formal minutes of the meeting.

The next step is now to proceed to signing the WLCG Memorandum of Understanding. The WLCG project office will assist in drafting this MoU, which should be signed by the relevant funding agencies for the two Russian Institutes, or their designated agents.

I am at your disposal for any assistance or to provide further details of the process.

Yours Sincerely,

Dr. Ian Bird
LHC Computing Grid Project Leader
IT Department
CERN

Cc: Prof. Sergio Bertolucci, Dr. Viacheslav Ilyin

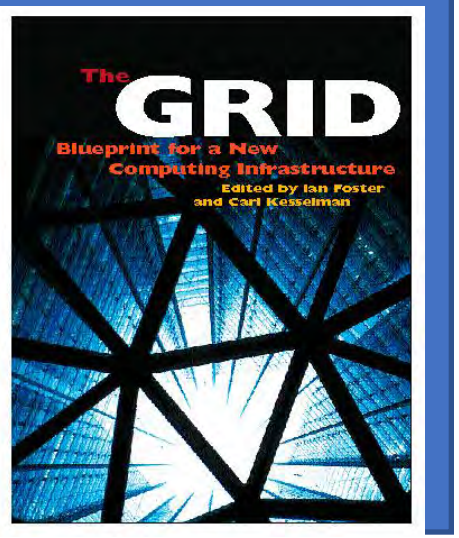
CMS Tier-1 at JINR

	2012	2013	2014
CPU (HEPSpec06) Number of core	14400 1200	28800 2400	57600 4800
Disk (Terabytes)	720	3500	4500
Tape (Terabytes)	72	5700	8000
Link CERN-JINR	4	10	40

Grids, clouds, fog, edge, supercomputers…

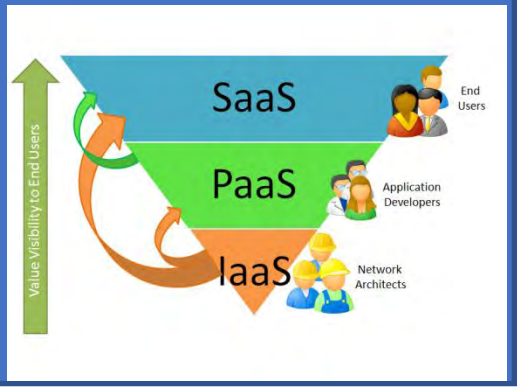
Grids

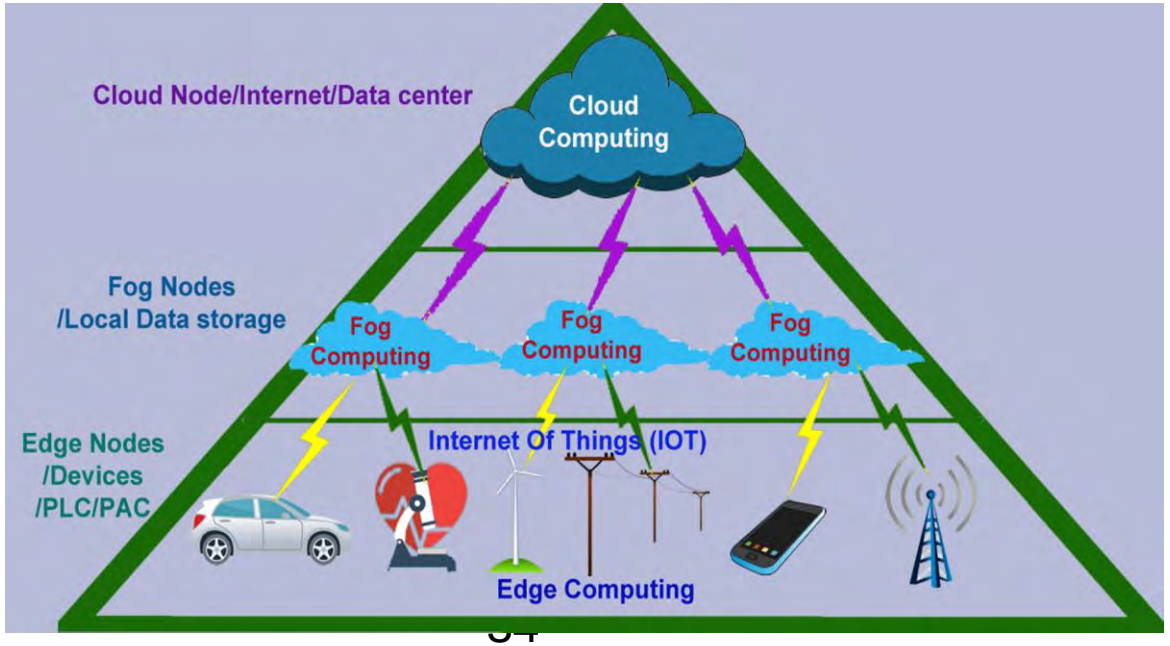
- Collaborative environment
- Distributed resources



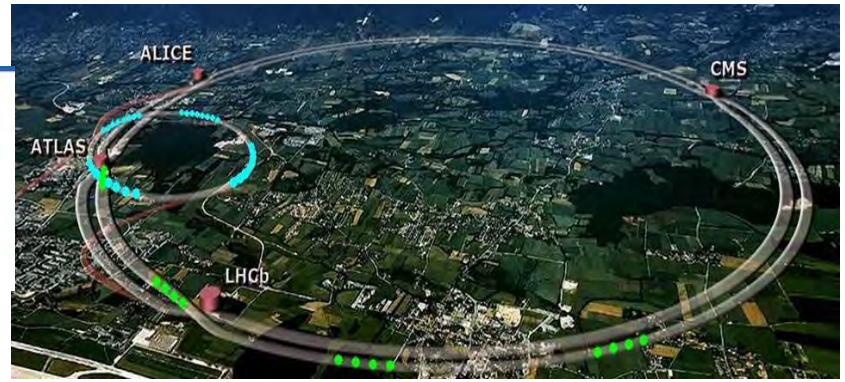
Supercomputers

Clouds

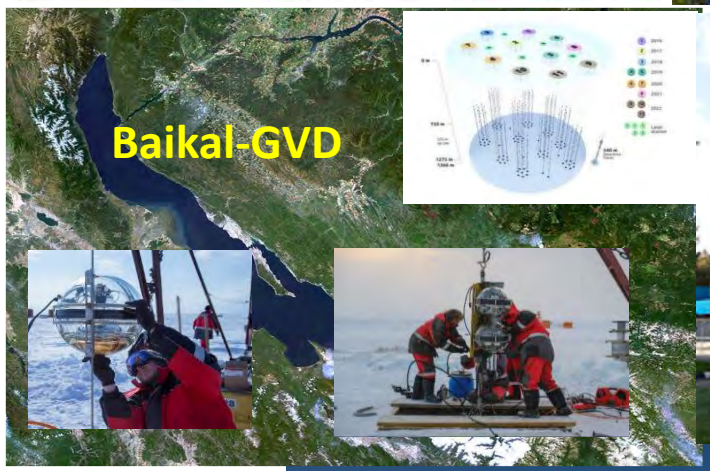


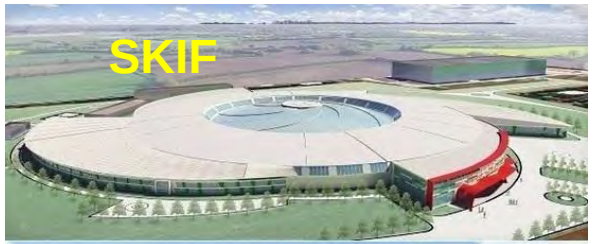


HPC+Big Data+AI

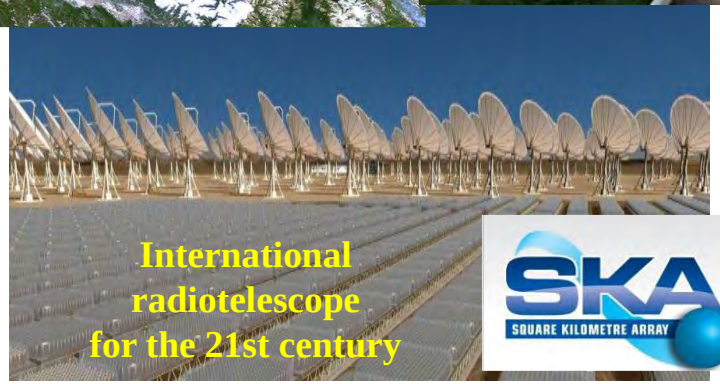


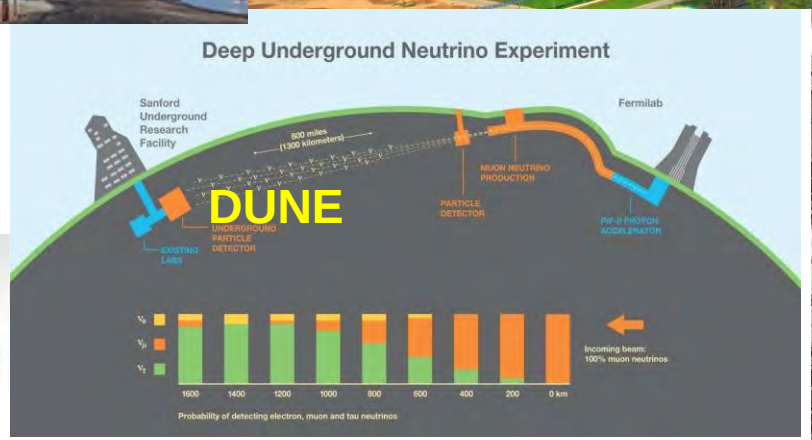
CERN Large Hadron Collider > 400 PB/Year





Square Kilometer Array radio telescope > 1 Eb/Year raw data (estimation)





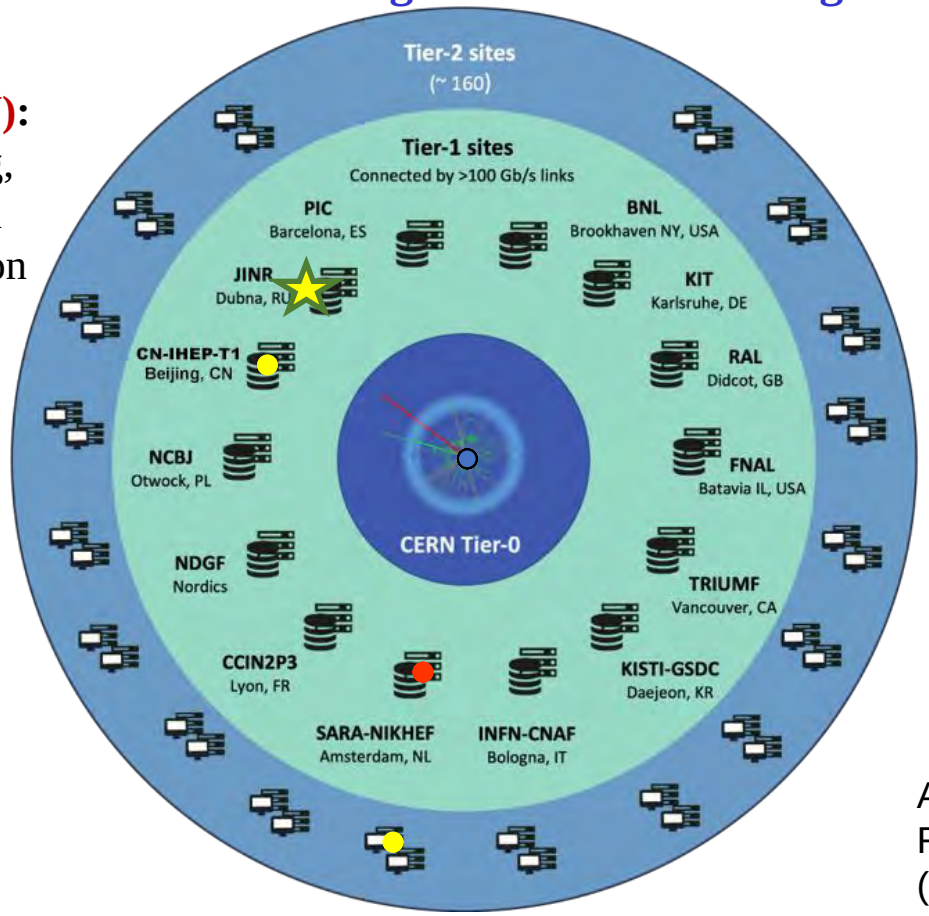
Worldwide LHC Computing Grid (WLCG)

The mission of the **WLCG** is to provide global computing resources for the storage, distribution and analysis ~50-70 Petabytes of data expected every year of operations from the LHC. **Integrates computer centres worldwide that provide computing and storage resource into a single infrastructure accessible by all LHC physicists**

Tier0 (CERN): data recording, reconstruction and distribution

Tier1: permanent storage, re-processing, analysis

Tier2: Simulation, end-user analysis



WLCG computing enabled physicists to announce the discovery of the Higgs Boson on 4 July 2012.

42 countries

170 sites

~2 M CPU cores

2 EB of storage

> 2 M jobs/day

100-250 Gb/s links

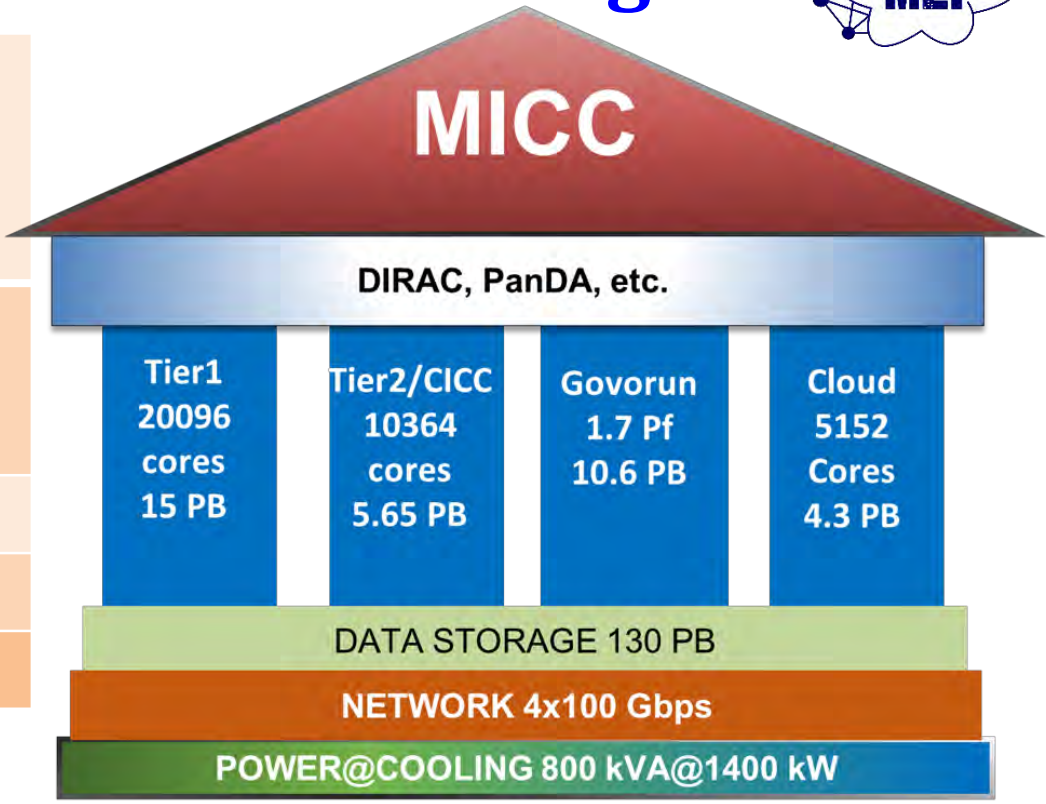
The mission of the WLCG project is to provide global computing resources to store, distribute and analyze the ~400 PB of data expected every year of operations from the Large Hadron Collider.

At the Nobel Prize ceremony for the discovery of the Higgs boson, CERN Director Rolf Heuer directly named grid technologies as one of the three pillars of success (along with the LHC accelerator and physics facilities). Without the organization of the grid infrastructure at the LHC, it would be impossible to process and store the colossal volume of data coming from the collider, and therefore, to make scientific discoveries. Today, not a single large project can be implemented without the use of a distributed infrastructure for data processing.

Meshcheryakov Laboratory of Information Technologies

Scientific IT ecosystem:
coordinated development of interconnected IT technologies and computational methods

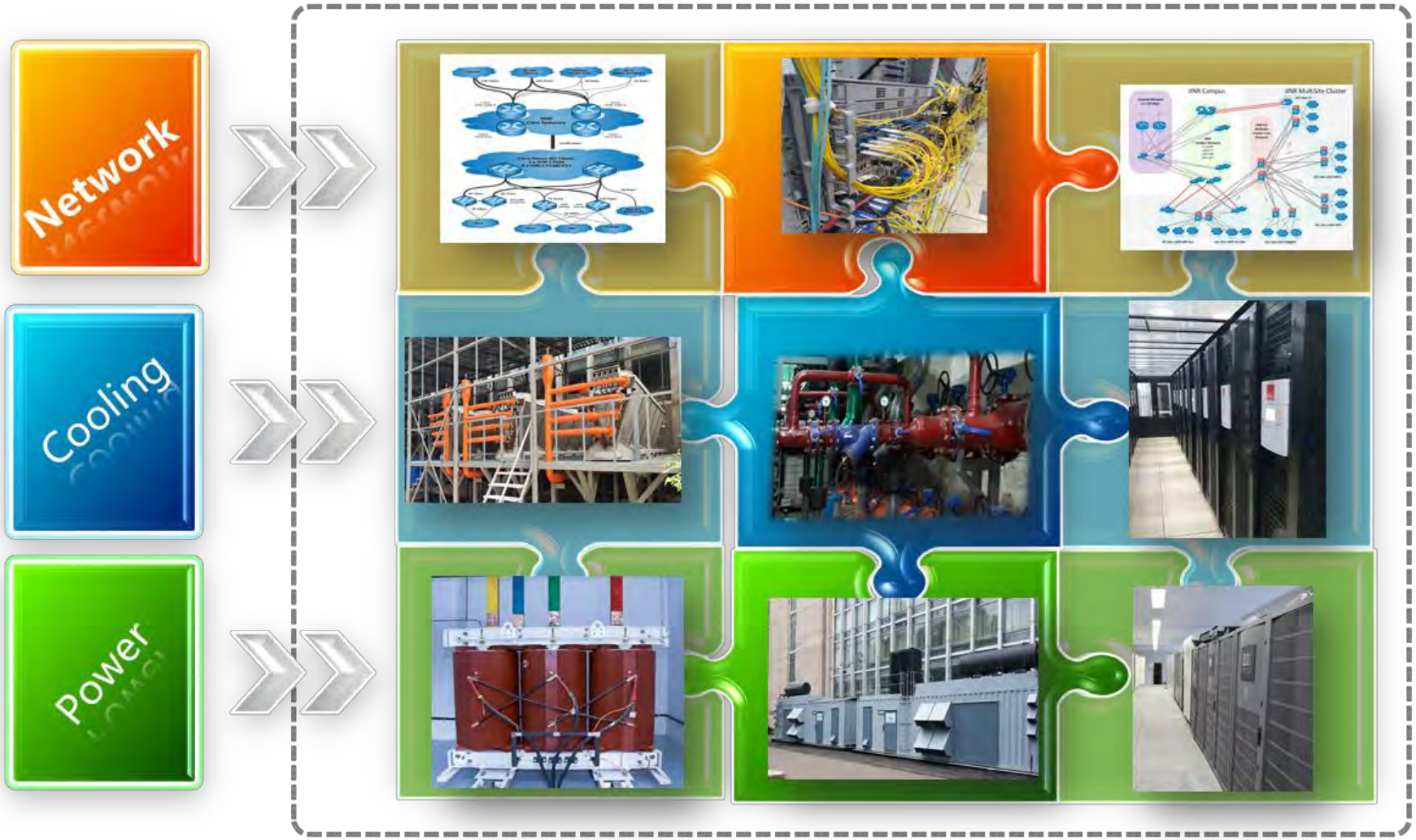
Scientists Doctors of Science Candidates of Science	**115** 21 62
Specialists (engineers, programmers)	**136**
Management	**18**
Workers	47
Total	316



Multifunctional Information and Computing Complex

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

MICC Power @ Cooling @ Network

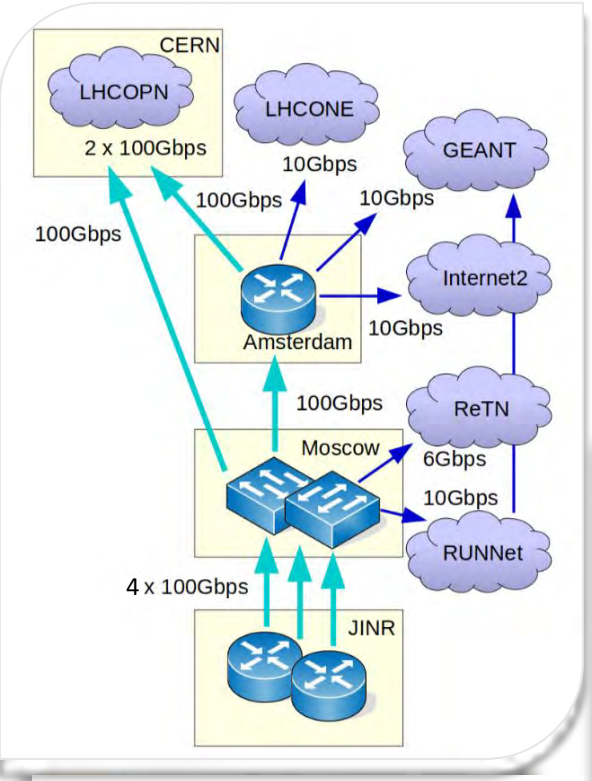


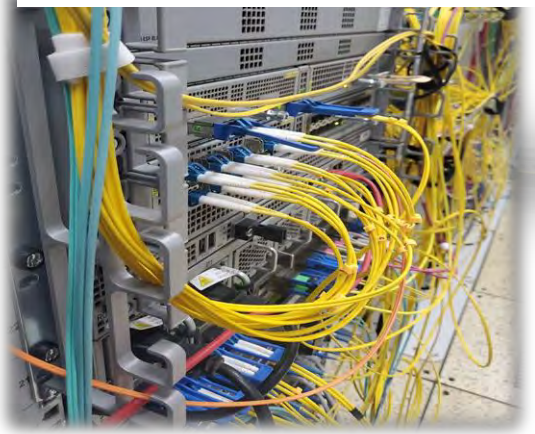
Wide Area Network 4x100 Gbps
Cluster Backbone 4x100 Gbps
Campus Backbone 2x100 Gbps

Dry chillers
In-Row systems
Total cooling 1400 kW

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

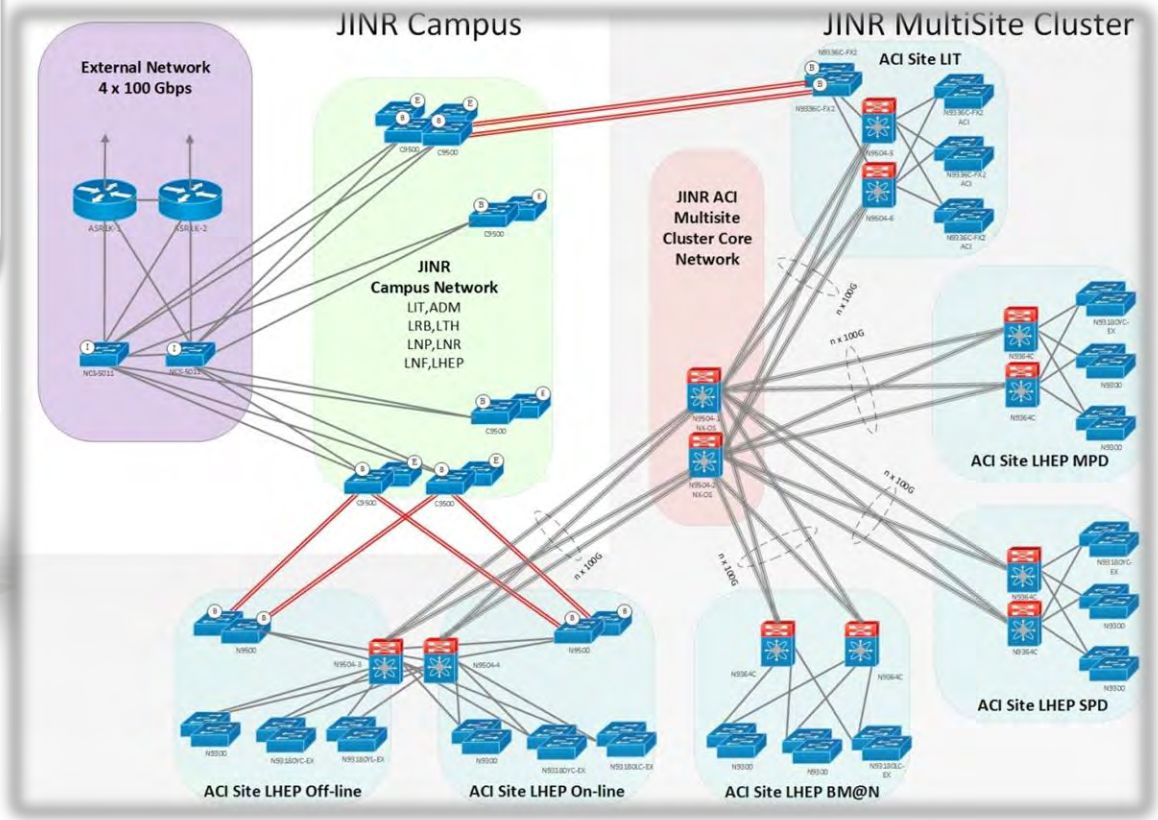
Network Infrastructure





MLIT ensures the reliable and fault-tolerant operation of all components of the network infrastructure:

- JINR-Moscow 4x100 Gbit/s
- JINR-CERN 100 Gbit/s and JINR-Amsterdam 100 Gbit/s
- multi-site cluster network with a bandwidth of 4x100 Gbit/s for the NICA megaproject
- local area network with a bandwidth of 2x100 Gb/s



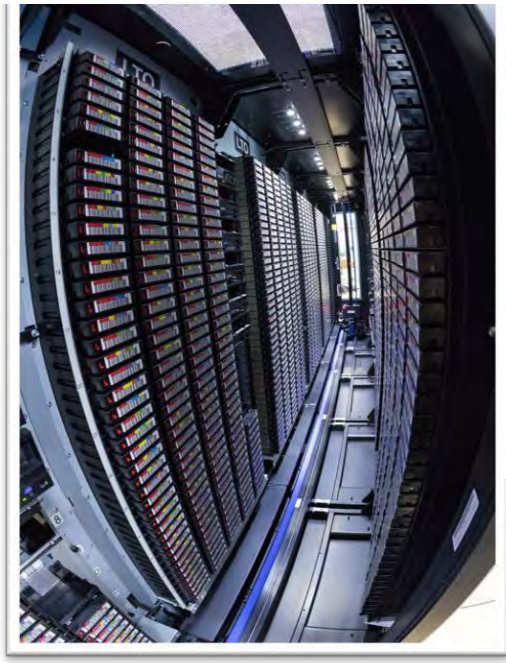
The JINR LAN comprises:

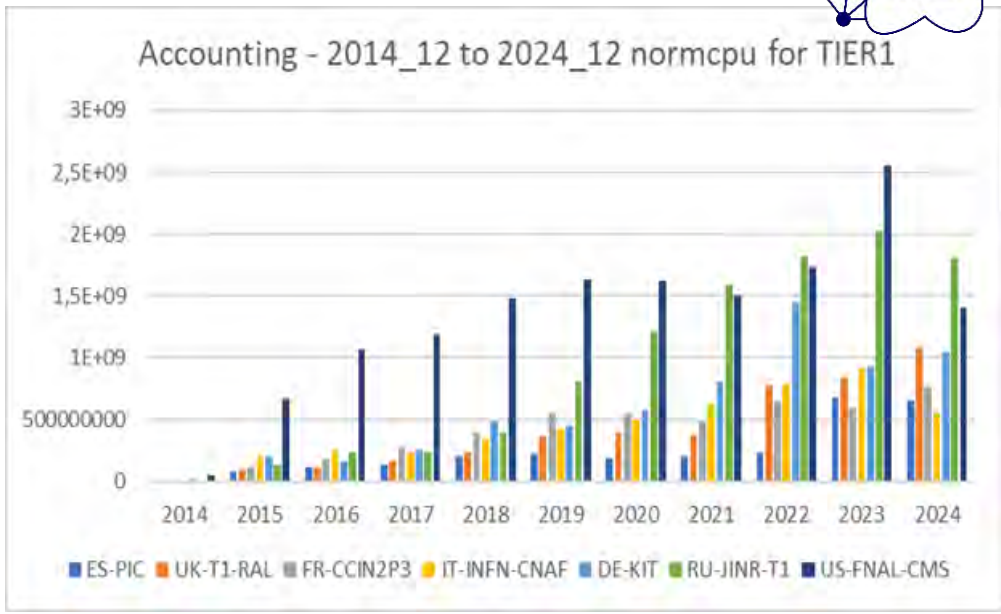
14017 network elements
23276 IP-addresses ipv4
1491 IP-addresses ipv6
5934 users registered within the network
4937 *.jinr.ru service users
1153 digital library users
967 remote VPN
157 EDUROAM users

Network traffic in 2024

42.53 PB - input
20.62 PB - output

Tier1 for CMS at JINR





- 20096 cores
- 360 kHS23
- 15.5 PB disks
- 100 PB tape
- 100% reliability and availability

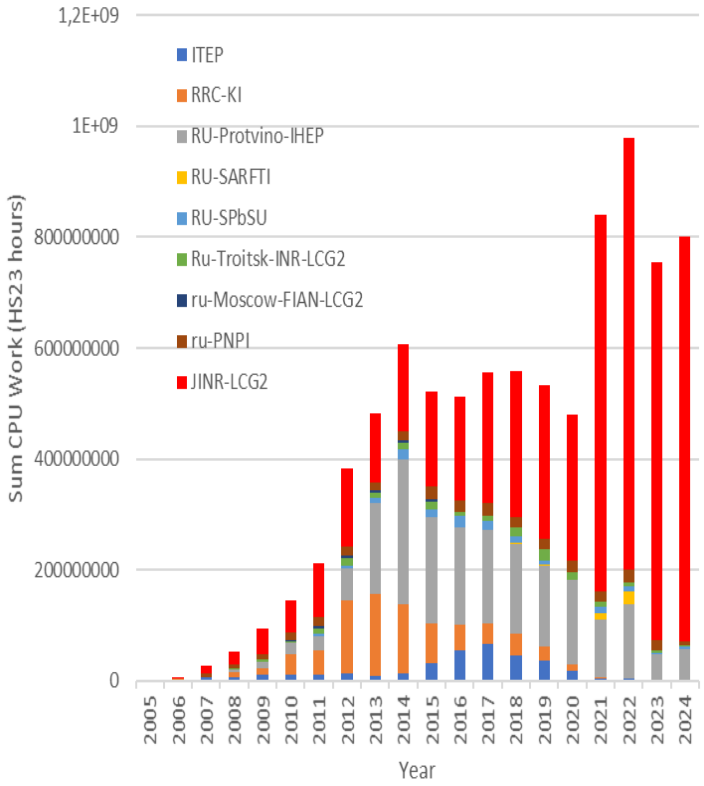
Tier1 CMS 2024

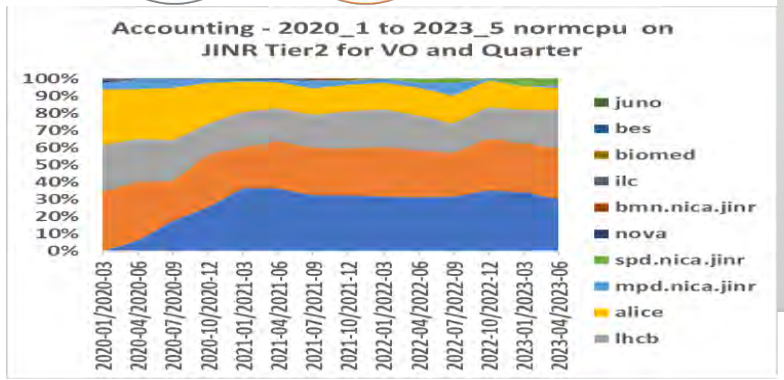
RU-JINR-T1	1,888,913,532	24 %
US-FNAL-CMS	1,665,321,019	21 %
UK-T1-RAL	1,132,299,978	14 %
DE-KIT	1,097,134,332	13 %
FR-CCIN2P3	807,778,212	10 %
ES-PIC	671,291,604	8 %
IT-INFN-CNAF	618,136,609	7 %

Tier2 at JINR

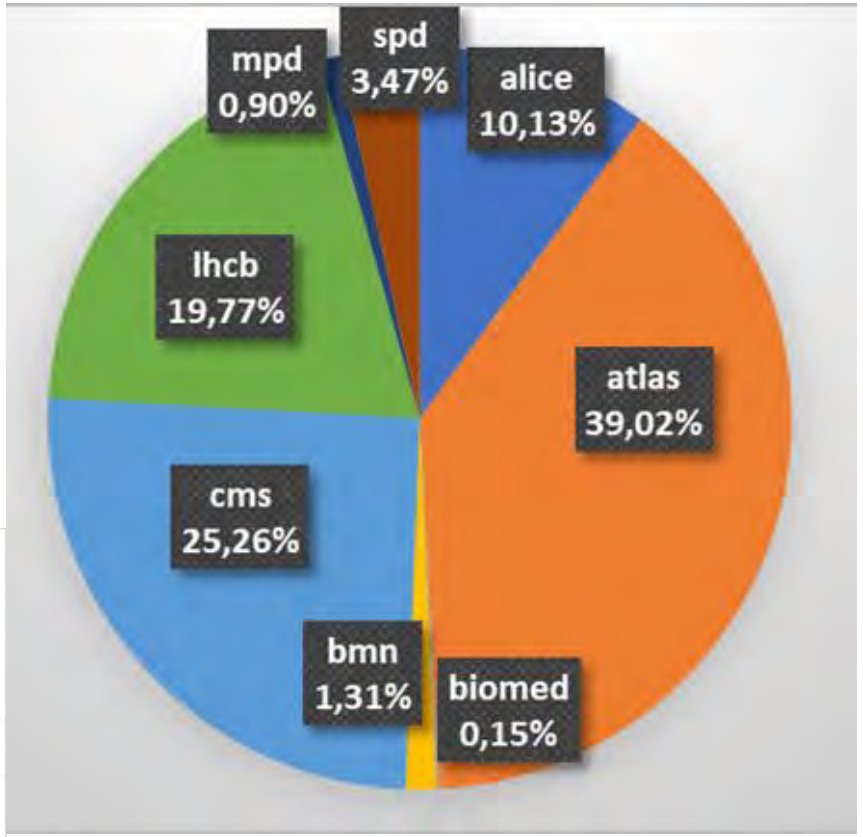
Tier2 at JINR provides computing power and data storage and access systems for the majority of JINR users and user groups, as well as for users of virtual organizations (VOs) of the grid environment (LHC, NICA, FAIR, etc.).

Accounting of RDIG Tier2's and years 2005-2024





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



Cloud Infrastructure

- Cloud Platform– OpenNebula,
- Visualization – KVM

- Storage (Local disks, Ceph)
- Resources: ~ 5,152 CPU core; 6.3 PB ceph-storage

➢ Computational resources for neutrino experiments

Neutrino experiments (JUNO, Baikal-GVD, NOvA) are the major users of the cloud infrastructure.

➢ VMs for JINR users

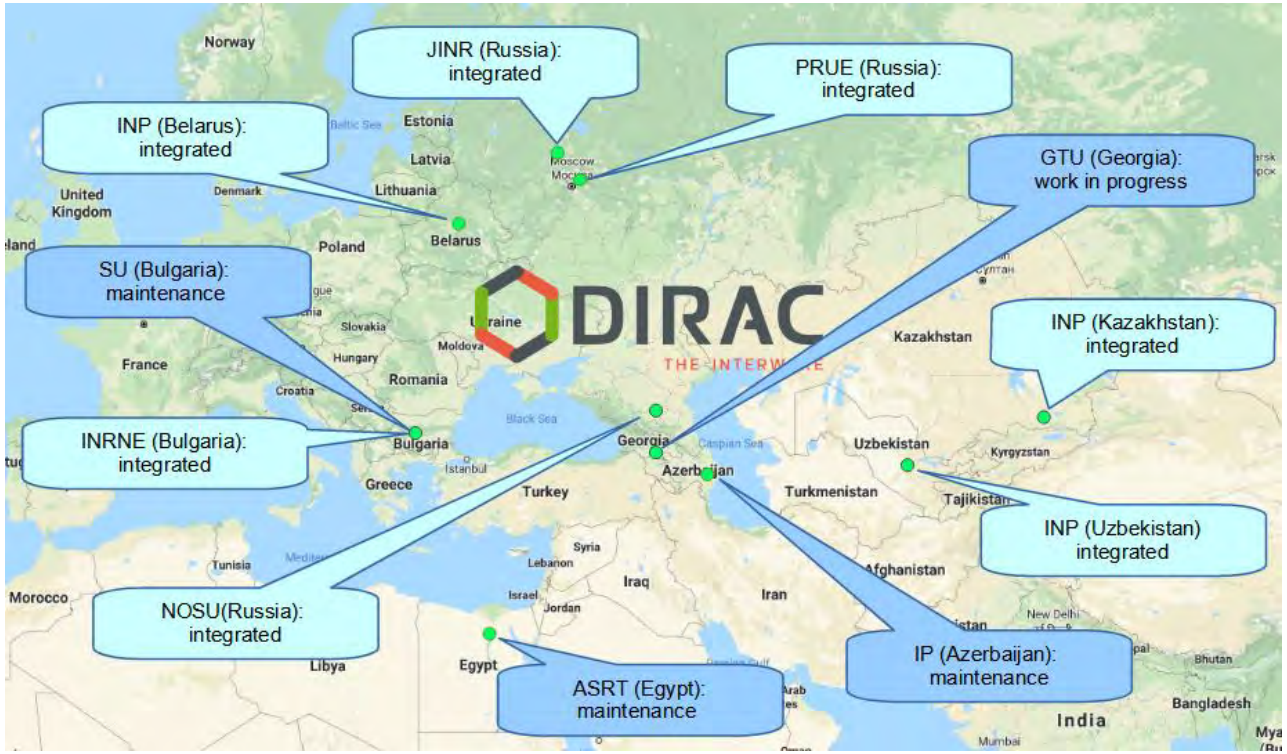
➢ Testbeds for research and development in IT

➢ COMPASS production system services

➢ Data Management System of the European Air Pollution Programme (UNECE ICP Vegetation)

➢ A system for diagnosing diseases of agricultural crops using modern machine learning methods

➢ Service for data visualization, Gitlab and some others



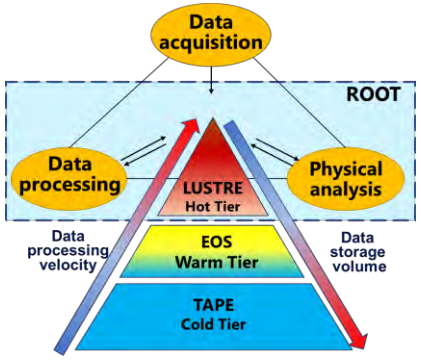
DIRAC-based distributed information and computing environment (DICE) that integrates the JINR Member State organizations' clouds

“Govorun” Supercomputer

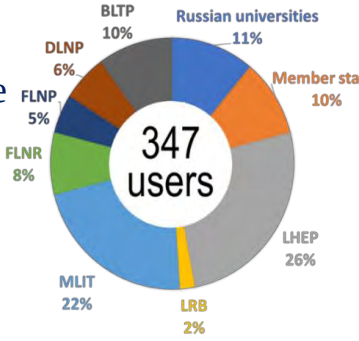
- Hyper-converged software-defined system
- Hierarchical data processing and storage system (1,6-10-30-100 PB)
- Scalable solution Storage-on-demand
- Total peak performance: 2.2 PFlops DP and 26 Pflops for AI tasks
- GPU component based on NVIDIA Tesla V100&A100 (H100)
- CPU component based on RSC “Tornado” liquid cooling solutions
- The most energy-efficient center in Russia (PUE = 1.06)
- Storage performance >300 GB/s

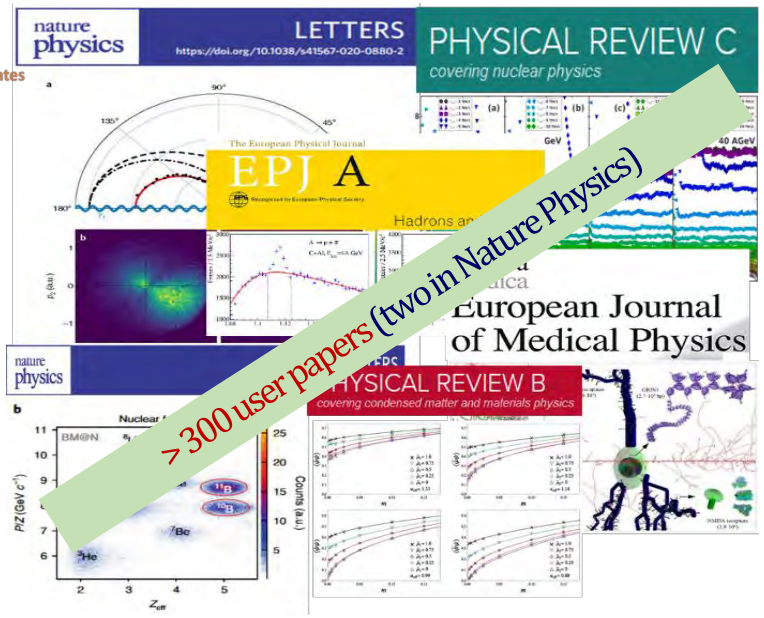
Key projects that use the resources of the SC “Govorun”:

- 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 : 347 including from the Member States (Armenia, Belarus, Vietnam, Egypt, South Africa)

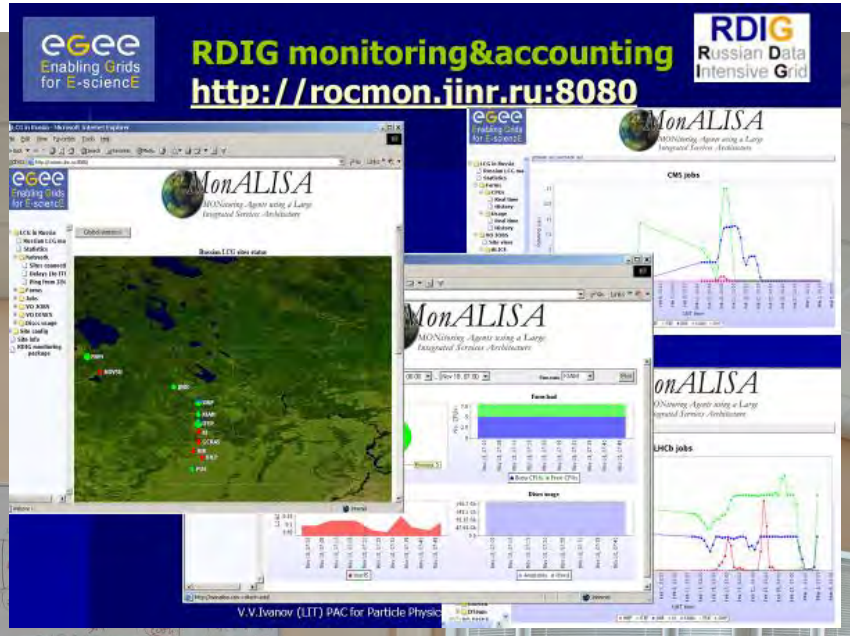


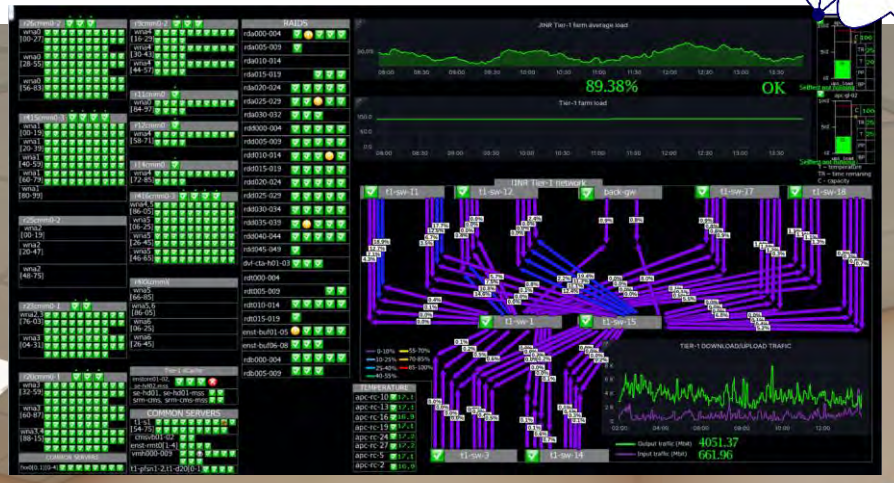


Russian DC Awards 2020 in “The Best IT Solution for Data Centers”

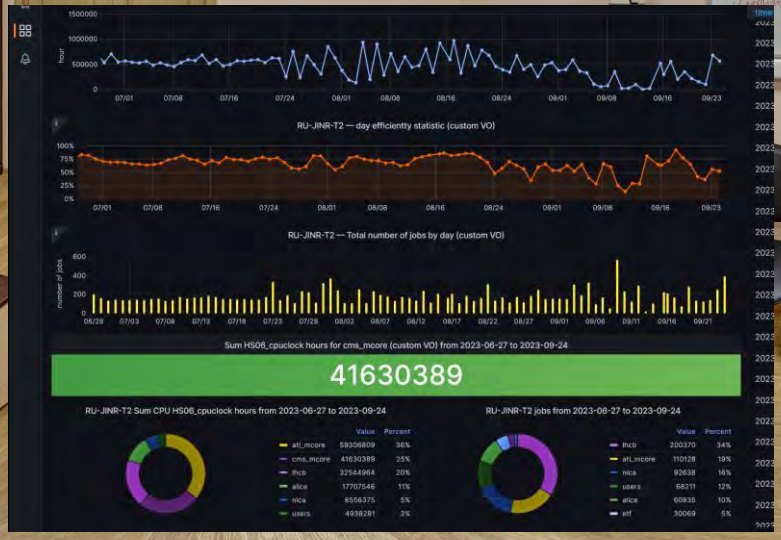
SC "Govorun" is included into a single supercomputer infrastructure based on the National Research Computer Network of Russia (NIKS).

Monitoring

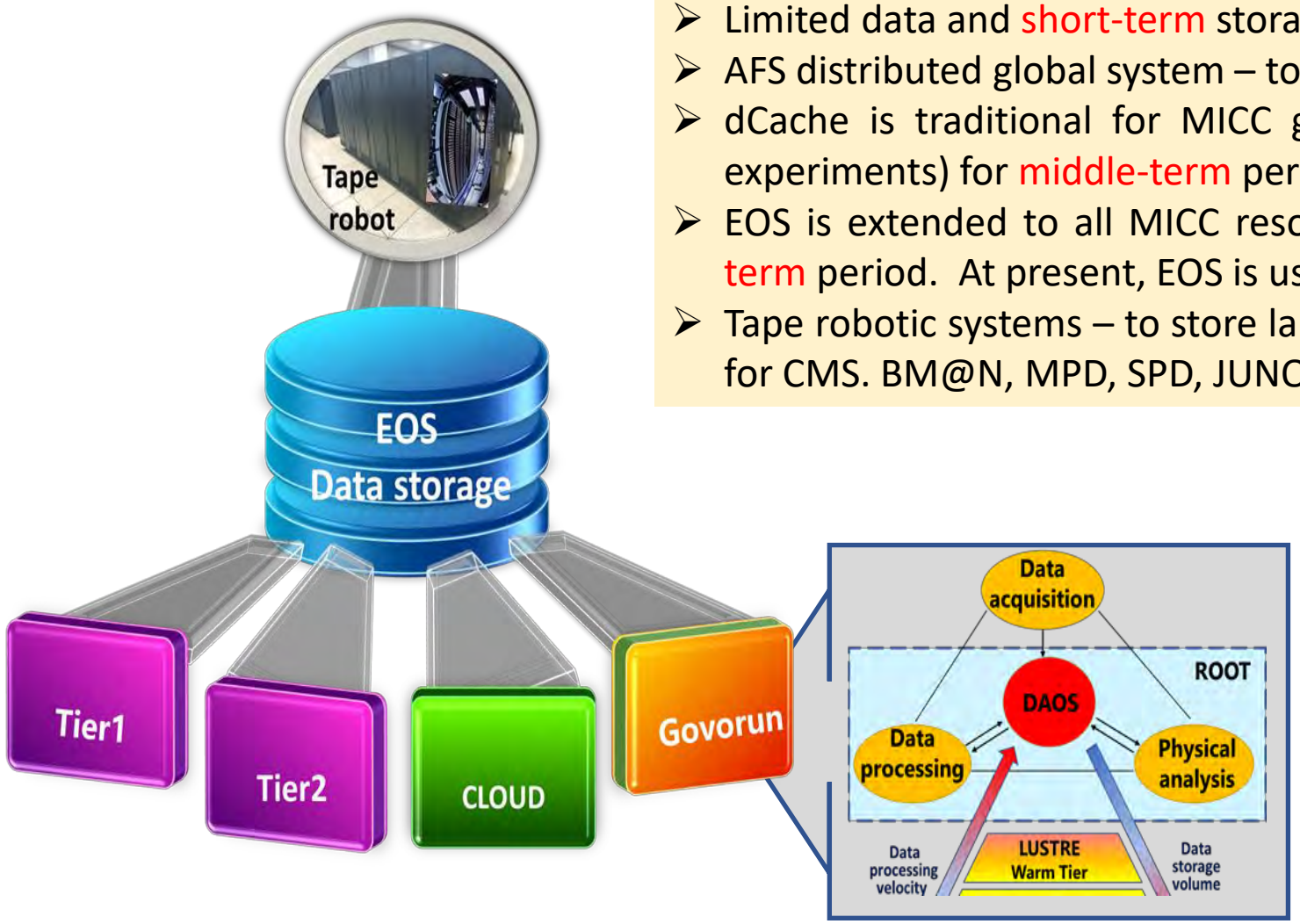

eGee
Enabling Grids for E-sciencE
RDIG monitoring&accounting
http://rocmon.jinr.ru:8080
RDIG
Russian Data Intensive Grid
MonALISA
V.V.Ivanov (LIT) PAC for Particle Physic


89.38%
OK
4051.37
661.96


50.6 PB
2.65 PB
11.7 PB
20000
1.99 PB
1.69 PB
1.94 PB
10364
7.51 PB
15680
22.4 PB
4320
5152
60.6 TB
3.84 PB
1.44 PB


RU-JINR-T2 — day efficientty statistic (custom VO)
RU-JINR-T2 — Total number of jobs by day (custom VO)
Sum HS06_cpuclock hours for cms_mcore (custom VO) from 2023-06-27 to 2023-09-24
41630389
RU-JINR-T2 Sum CPU HS06_cpuclock hours from 2023-06-27 to 2023-09-24
RU-JINR-T2 jobs from 2023-06-27 to 2023-09-24

Distributed Multilayered Data Storage System



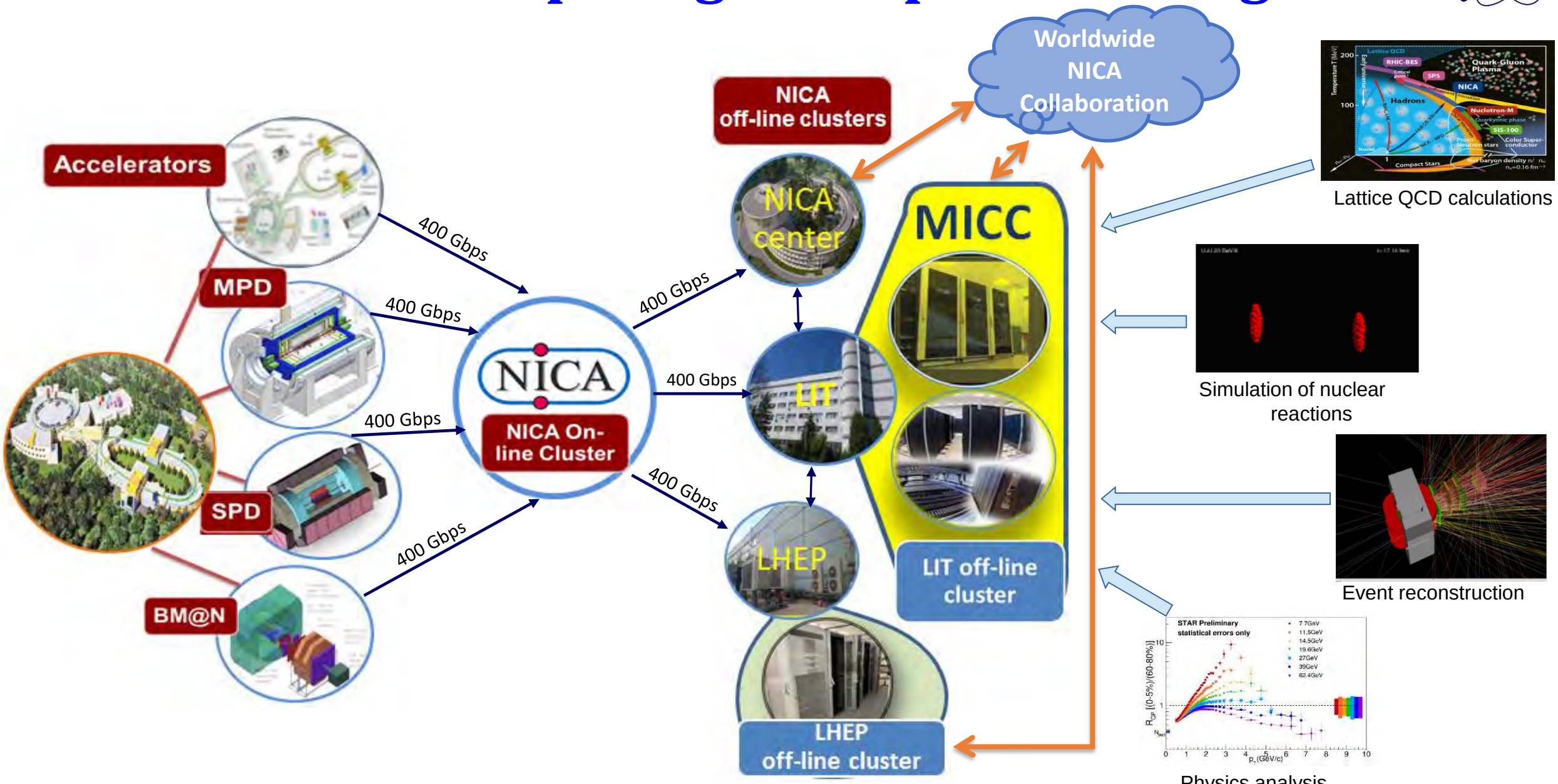
- Limited data and short-term storage – to store OS itself, temporary user files
- AFS distributed global system – to store user home directories and software
- dCache is traditional for MICC grid sites – to large amounts of data (mainly LHC experiments) for middle-term period
- EOS is extended to all 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).

NICA Computing Concept & Challenges



DIRAC-based distributed heterogeneous environment

LHEP resources

VBLHEP ceph

VBLHEP EOS

DDC cluster

DAQ computing farm

NICA cluster

MICC MLIT

Cloud ceph

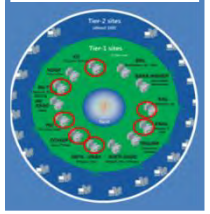
MLIT EOS

MLIT CTA

dCache

JINR Cloud

Tier-1



Tier-2

Govorun

SSD

Lustre

Ultra-fast storage

Облака

NOSU

IPANAS

INP

INRNE

INP

ASRT

PRUE

SU

INP

MSC

Polytech

ПОЛИТЕХ

Санкт-Петербургский политехнический университет Петра Великого

НИКС

Others/Collaboration resources

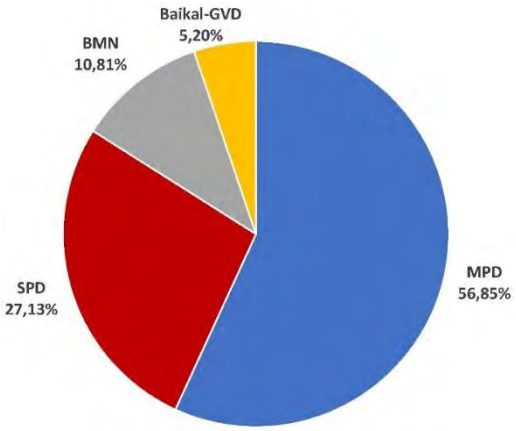
IMDT

MEPHI

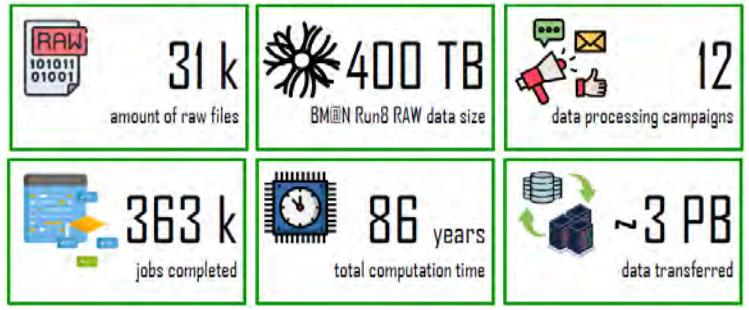
UNAM

To perform calculations related to the mass generation and processing of data from the NICA mega-science project experiments, a distributed environment based on the DIRAC Interware platform was created.

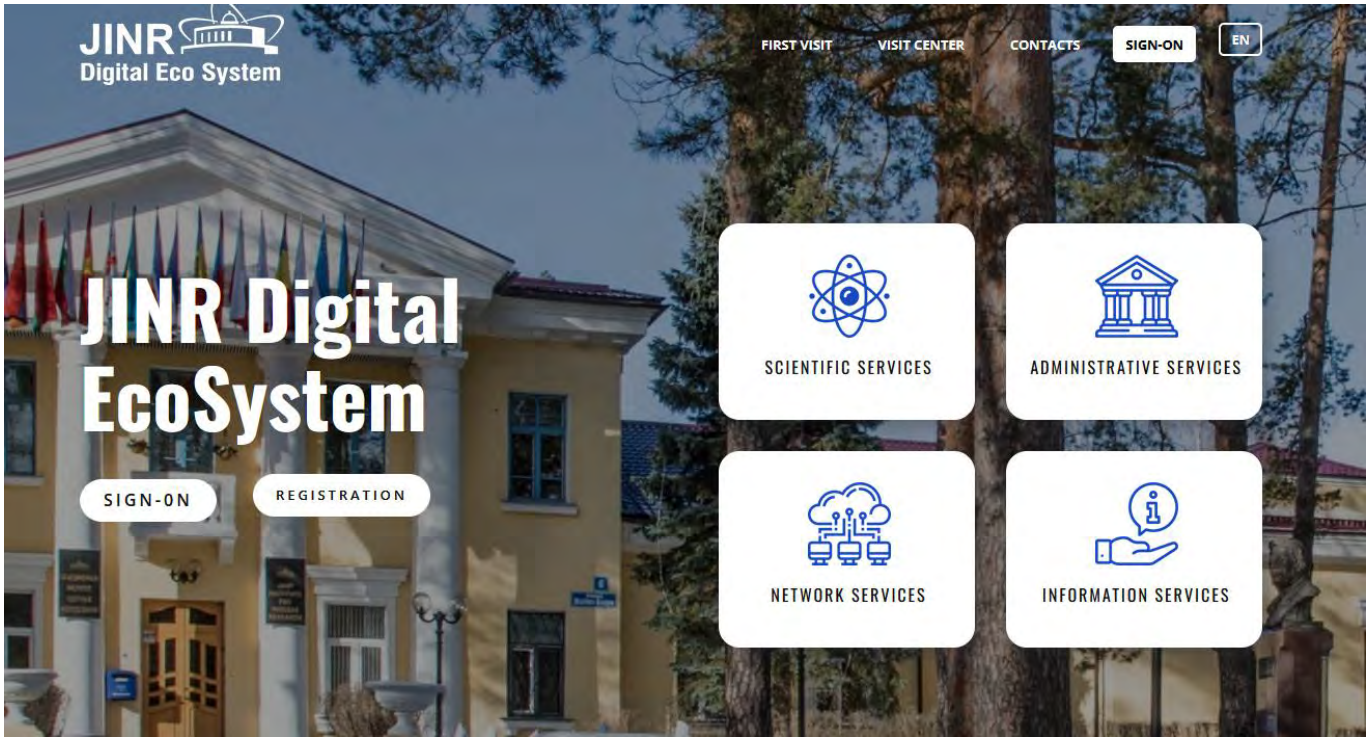
DIRAC is employed to solve the tasks of collaborations of all three experiments at the NICA accelerator complex, as well as of the Baikal-GVD neutrino telescope.

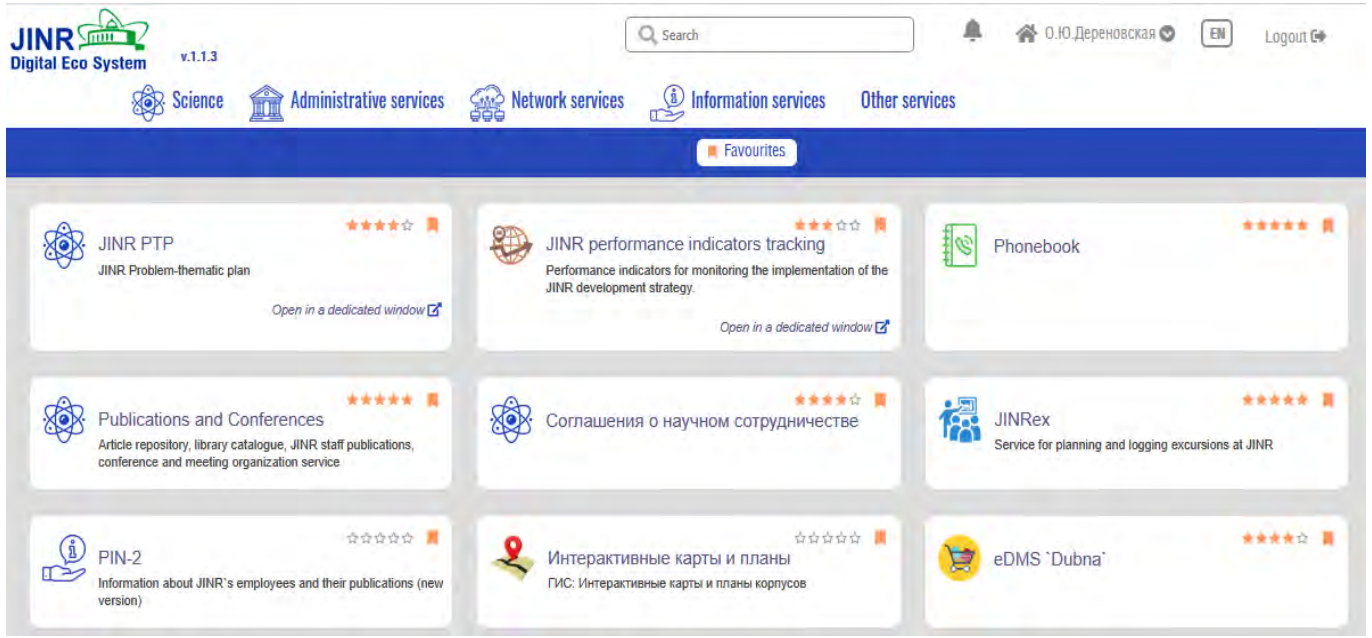


In 2023, for the first time at JINR, the complete processing of raw data from the 8th run of the BM@N experiment was performed on the distributed heterogeneous computing infrastructure integrated using the DIRAC platform.



Summary statistics of using the DIRAC platform for BM@N Run 8 data processing





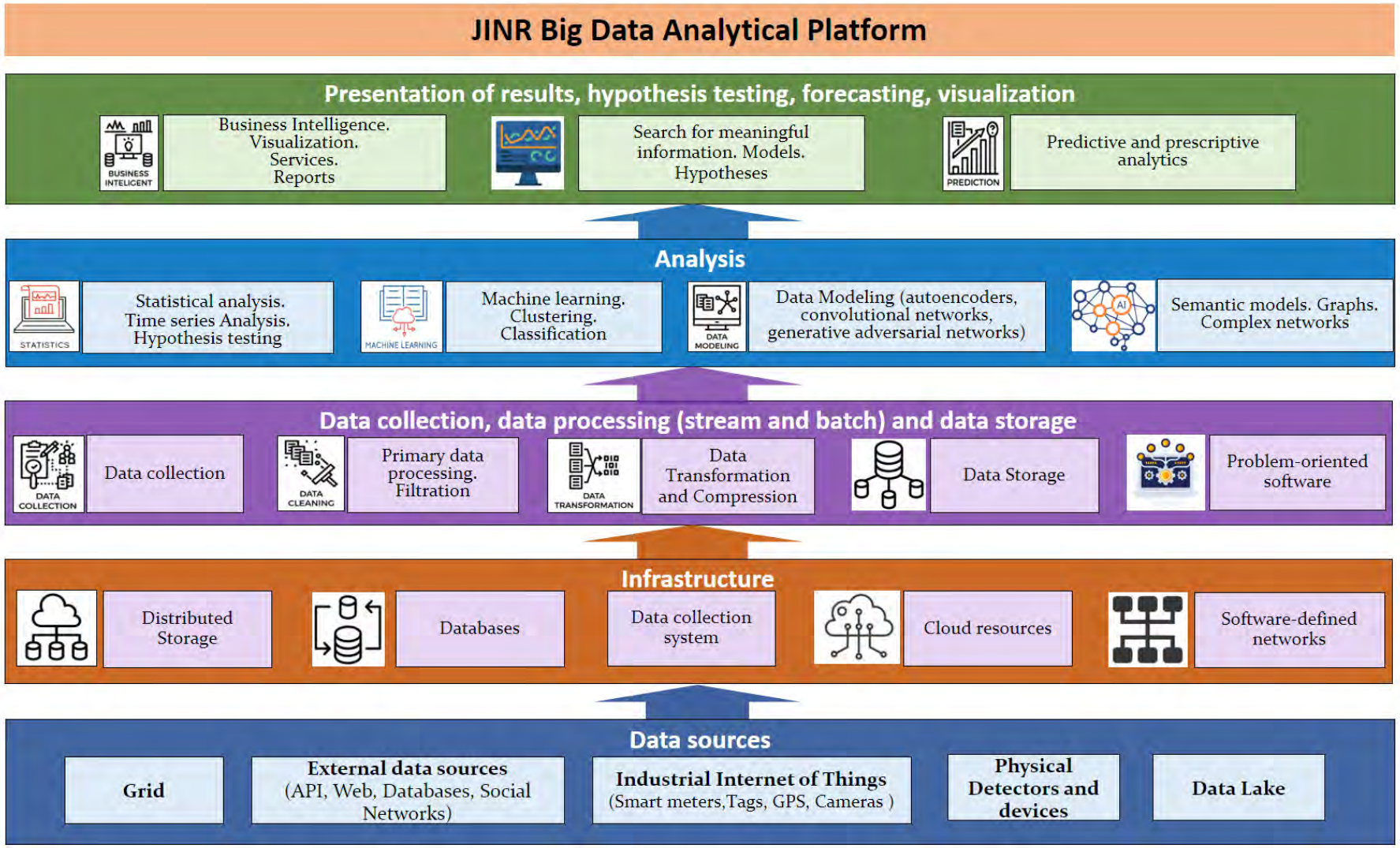
JINR Digital Ecosystem

a single window into the JINR digital environment

- integration of existing and prospective services for **supporting scientific, administrative and social activities**, as well as maintenance of the Institute's engineering and IT infrastructure.
- Integrated Personal Account of a JINR Employee
- Notifications in the Personal Account
- Some resources are available to unregistered users
- Relevance. Information is updated promptly and regularly by service owners
- Convenient interface for service administrators
- Supports bilingualism: Russian and English
- Mobile version of the system

Methods of Artificial Intelligence and Big Data Analytics

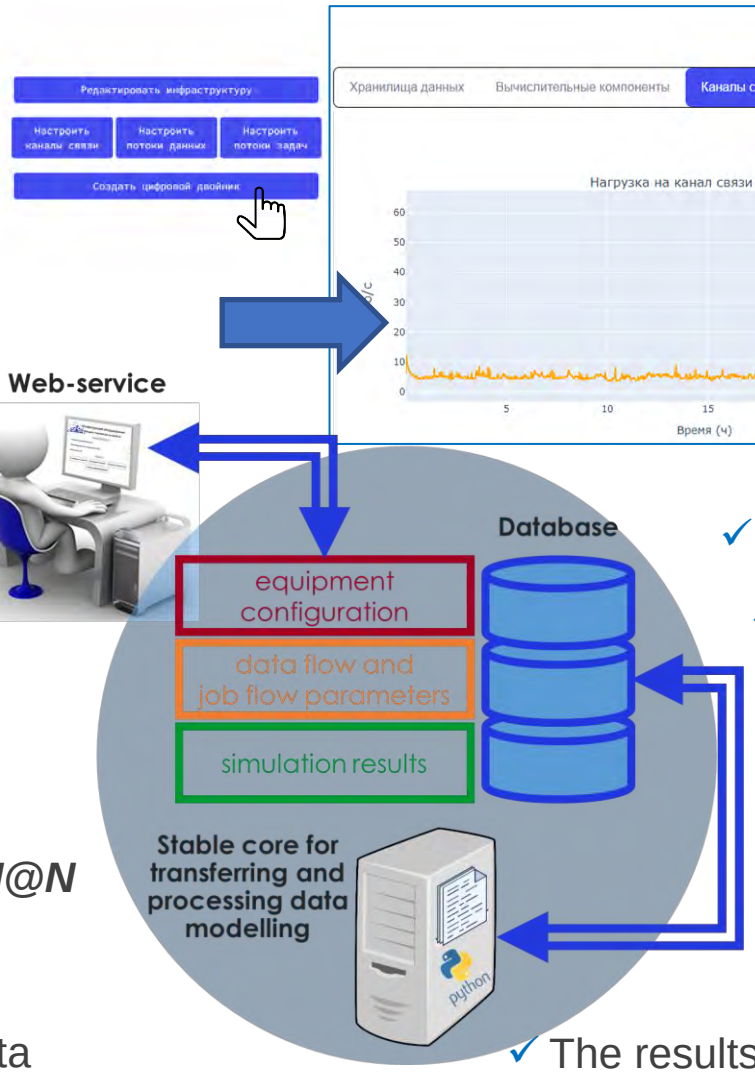
- Bringing best of Big Data approaches to JINR practices
- Providing the Big Data infrastructure for users



Software Complex for Creating Digital Twins of Distributed Data Acquisition, Storage and Processing Centers

Application examples for the NICA complex

- Creating the digital twin of the computing infrastructure of the ***BM@N experiment***.
- Creating the digital twin of the computing system of the online data filter of the ***SPD experiment***.

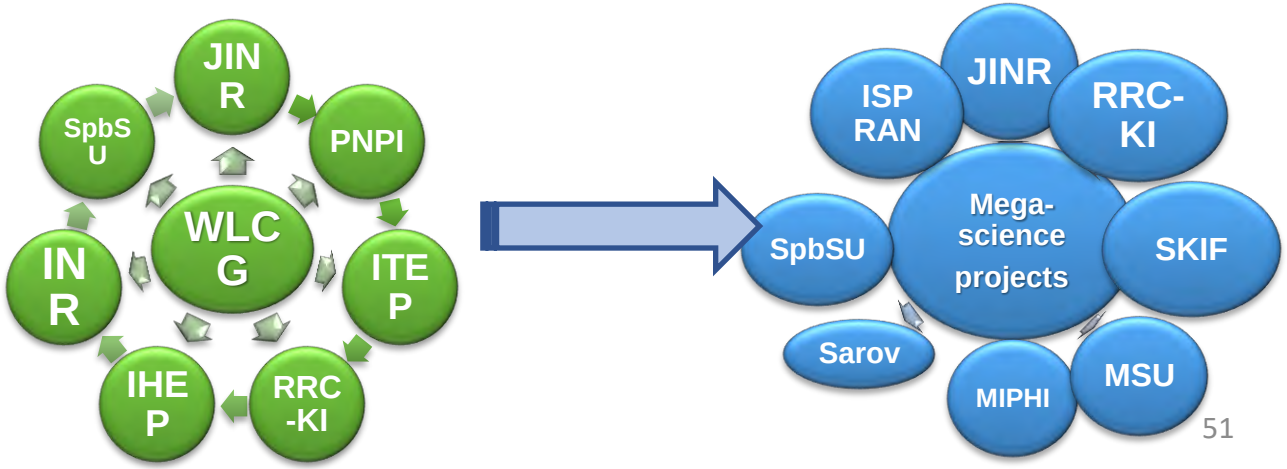


Specificities

- ✓ Flexibility.
- ✓ Important functional parameters of distributed centers are taken into account:
  - equipment characteristics;
  - the characteristics of data flows and jobs;
  - the probabilities of failures and changes in the equipment performance and other processes occurring in the system.
- ✓ The results of the digital twin's work differ from the results of the existing distributed center by no more than 20%.

Creation of a consortium for IT support of large-scale research infrastructure

- In Russia, a program of large-scale scientific projects is being implemented, the most important part of which is the development of distributed heterogeneous computer systems (including systems with parallelism) for processing, storing, analyzing experimental data, development and implementation of effective methods, algorithms and software for modeling physical systems, mathematical processing and analysis of experimental data, development of methods of machine learning, artificial intelligence, quantum computing.
- To solve this large-scale task, it is necessary to develop a distributed computer infrastructure that unites key scientific and educational institutes participating in mega-science projects - RDIG-M. The consortium created on the basis of JINR, NRC Kurchatov Institute, ISP RAS should become the core for IT support of the research infrastructure of the "mega-science" class.



JINR School of Information Technology

for Russian speaking students

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

Stage 1

Autumn School

acquaintance with the directions of JINR scientific research

Stage 2

Spring School

presentation the results of joint work with the Institute's specialists

MSU branch in Dubna

Training of specialists to work in the field of theoretical and experimental high energy physics, relativistic nuclear physics on the basis of the Joint Institute for Nuclear Research (JINR, Dubna), as well as for applied research and developments that are being carried out in medicine, biology and other fields using nuclear physical methods and information technologies.

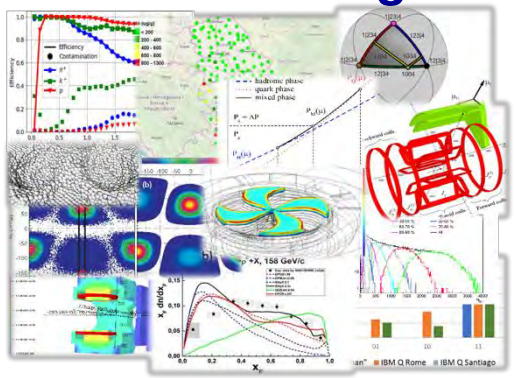
Fields of research in 2024

03.04.02 "Physics":
– Master's program "Physics of Elementary Particles"
– Master's program "Fundamental and Applied nuclear physics"

Master's program

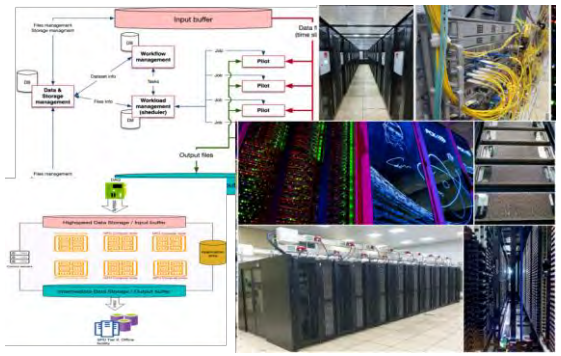
Methods and technologies for data processing in heterogeneous computing environments

Future:



Mathematical modeling, numerical methods and software packages

Deep machine learning and big data analytics



Computing (software and models) for megascience class projects

Trends in the development of distributed computing for large-scale scientific projects

Development of computer architectures and their integration:

- Peta-ExaFlop scale supercomputers, graphic, quantum, photonic processors as specialized computers around a universal system

- Peta-ExaByte scale distributed hierarchical information storage systems working with common metadata for secure efficient access and reliable storage of information

- cloud-based data centers that provide efficient services to users and support the operation of fog and edge computing systems

- intelligent task management systems in a distributed heterogeneous environment that includes various computer architectures (supercomputers, grid, clouds, clusters, servers, volunteer computing systems)

- development of methods, algorithms, platforms, systems of Big Data analytics, intelligent data analysis, ML/DL, artificial intelligence, digital services

- creation of digital twins of experimental setups, distributed computer systems and other complex objects

- training of highly qualified specialists in the field of distributed computing, storage, processing, and analysis of data for scientific projects

GRID'2004 – 204 participants from 8 countries;
GRID'2006 – 173 participants from 8 countries;
GRID'2008 – 211 participants from 20 countries;
GRID'2010 – 198 participants from 21 countries;
GRID'2012 – 243 participants from 22 countries
GRID'2014 – 190 participants from 12 countries;
GRID'2016 – 280 participants from 18 countries;
GRID'2018 – 260 participants from 16 countries;
GRID'2021 – 239 participants from 19 countries;
GRID'2023 – 280 participants from 17 countries;

GRID'2025 – 298 participants from 14 countries
37 plenary and over 135 sessional talks


JOINT INSTITUTE FOR NUCLEAR RESEARCH
LABORATORY OF INFORMATION TECHNOLOGIES

29 June - 2 July 2004
Dubna, Russia

Distributed Computing and Grid-technologies in Science and Education

Topics:

- creation and exploitation of Grid-infrastructures in various fields of science and education;
- methods and technologies of distributed computations; architecture and algorithms;
- distributed processing and data storage;
- network infrastructure for distributed data processing;
- algorithms and methods of solving applied tasks in distributed computing environments;
- theory, models and methods of distributed data processing;
- distributed computations in framework of the LHC projects;
- distributed information systems: design technologies and usage experience.

Advisory Committee:
Bogdanov A.V. (IHPC&DB, St.Petersburg)
Bubak M. (ICS/CYFRONET-AGH Cracow, CrossGrid, Poland)
Buzatu F. (IFIN-HH, Romania)
Cheremisina E.N. (University "Dubna")
Chetverushkin B.N. (IMM RAS, Moscow)
Dirner A. (P.J.Shafarik University, Slovakia)
Gavrilov V.B. (ITEP, Moscow)
Grigoryan A.A. (YerPhI, ArmeSFo, Armenia)
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Lokajicek M. (IP ASCR, Czech Republic)
Passage G. (INRNE BAS, Bulgaria)
Petukhov V.A. (IHEP, Protvino)
Ryabov Yu.F. (PNPI RAS, Gatchina)
Savin G.I. (JSC, Moscow)
Shabanov B.M. (JSC, Moscow)
Smirnova O.G. (JINR, NorduGrid)
Soldatov A.A. (SSC RRC KI, Moscow)
Tomilin A.N. (ISP RAS, Moscow)
Velikhov E.P. (SSC RRC KI, Moscow)
Voevodin Vl.V. (RCC MSU, Moscow)
Zabrodin A.V. (KIAM RAS, Moscow)
Zolotarev V.I. (SPbSU, St.Petersburg)
Zhuchkov A.V. (TC "Science&Society", Moscow)

Organizing Committee:
Sissakian A.N. chairman
Ivanov V.V. co-chairman
Korenkov V.V. co-chairman
Strizh T.A. scientific secretary
Zrelov P.V.
Kryukov Yu.A.
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Kalmykova L.A.
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Mitsyn V.V.
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Aristarkhova M.V
Fedorova E.A.
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Rudneva E.M.
Russakovich E.N.

JINR MLIT


JOINT INSTITUTE FOR NUCLEAR RESEARCH
LABORATORY OF INFORMATION TECHNOLOGIES
2nd International Conference
DISTRIBUTED COMPUTING AND GRID TECHNOLOGIES IN SCIENCE AND EDUCATION
June 26-30, 2006, Dubna, Russia
Dedicated to the 50th Anniversary of the Joint Institute for Nuclear Research
Subjects of the Conference:
- creation and operating experience of Grid-infrastructures in various areas of science and education;
- methods and technologies of distributed computing, questions of architecture, algorithms;
- distributed processing and data storage;
- network infrastructure for distributed data processing;
- algorithms and methods of solving applied tasks in distributed computing environments;
- theory, models and methods of distributed data processing;
- distributed computations within the LHC project;
- distributed information systems: technologies of construction and experience of use.
Organizing Committee: Ivanov V.V. - chairman
Korenkov V.V. - vice-chairman
Strizh T.A. - scientific secretary
Adam Gh., Arictotshova M.V., Bulyga N.I.,
Dokalenko N.M., Fedorova E.A., Kalmykova L.A.,
Katrasnas T.I., Prikhodko A.V.,
Rudinova E.M., Rumyantseva O.Yu.,
Tikhonenko E.A., Zrelov P.V.
Contacts: Strizh T.A.
Joint Institute for Nuclear Research
Laboratory of Information Technologies
J. Curie Street, 6
141980 Dubna, Moscow region
RUSSIA
Phone: (+7 496 21) 64019, 62308
fax: (+7 496 21) 65145
E-mail: strizh@jinr.ru
http://grid2006.jinr.ru/
RDIG
ПЛАТФОРМЫ


JOINT INSTITUTE FOR NUCLEAR RESEARCH
LABORATORY OF INFORMATION TECHNOLOGIES
GRID'2008
International Conference
3rd International Conference
Distributed computing and Grid technologies in
science and education
30 June - 4 July 2008, Dubna, Russia
Topics
questions of creation and experience of exploitation of Grid-infrastructures
methods and technologies of distributed computations; architecture and algorithms
network infrastructure for distributed data processing and storing
algorithms and methods of solving applied problems in distributed computing media
theory, models and methods of distributed data processing
distributed information systems: construction technologies and usage experience
Grid applications in science and education: high-energy physics, computing chemistry
biology, biomedicine, Earth sciences, etc.
Grid applications in business
Advisory committee
Organizing Committee
Contacts
http://grid2008.jinr.ru









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ПЛАТФОРМЫ


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GRID
2010
Joint Institute for Nuclear Research
Laboratory of Information Technologies
Topics:
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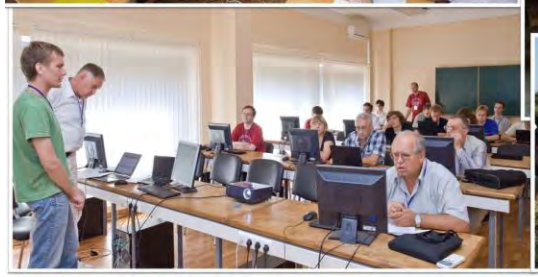
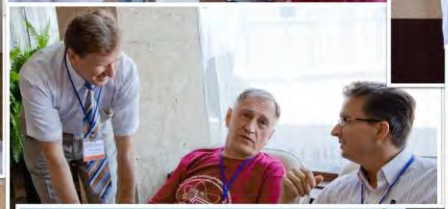
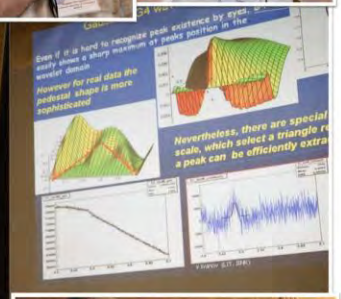
Organizing Committee (JINR):
Contacts:

Key element - middl
Many results in the world
DYNAMITE


High-Level Integration of
Computing Resources in
a Distributed Environment
A.P. Afanasiev






Even if it is hard to recognize peak existence by eyes, e
easily shows a sharp maximum at peaks position in the
wavelet domain
However for real data the
pedestal shape is more
sophisticated
Nevertheless, there are special
scale, which select a triangle re
a peak can be efficiently extra

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GRID'2012
5th International Conference
"Distributed Computing and Grid-technologies in Science and Education"
16-21 July, 2012, Dubna
Conference Topics
Advisory committee
Organizing Committee (JINR)
Contacts
NIAGARA
SUPERMICRO


GRID'2014
Joint Institute for Nuclear Research
Laboratory of Information Technologies
International Conference
"Distributed Computing and Grid-technologies in Science and Education"
30 June-5 July, 2014, Dubna, Russia
Topics:
The Worldwide LHC Computing Grid (WLCG)
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GRID
2016
July 4-9 2016
JINR
Dubna
7th International Conference
Distributed Computing and Grid-technologies in Science and Education
Laboratory of Information Technologies (LIT) of the Joint Institute for Nuclear Research (JINR)
Conference Topics:
Technologies, architectures, models of distributed computing systems
Operation, monitoring, optimization in distributed computing systems
Middleware and services for production-quality infrastructures
Scientific, industry and business applications in distributed computing systems
Distributed computing in education
Cloud computing, Virtualization
Desktop grid technologies and volunteer computing
High performance computing, CPU architectures, GPU, FPGA
Consolidation and integration of distributed resources
Databases, Distributed Storage systems, Big data Analytics
Advisory committee
Organizing Committee (JINR)
Contacts


GRID 2018
JINR
Dubna
September 10 - 14
8th International Conference
Distributed Computing and Grid-technologies in Science and Education
Laboratory of Information Technologies of the Joint Institute for Nuclear Research
Conference Topics:
1. Technologies, architectures, models of distributed computing systems
2. Operation, monitoring, optimization in distributed computing systems
3. Middleware and services for production-quality infrastructures
4. Scientific, industry and soft business applications in distributed computing systems
5. Distributed computing in education
6. Cloud computing, Virtualization
7. Desktop grid technologies and volunteer computing
8. High performance computing, CPU architectures, GPU, FPGA
9. Consolidation and integration of distributed resources
10. Databases, Distributed Storage systems, Datalakes
11. Big data Analytics, Machine learning
12. Bioinformatics
Advisory committee:
Co-located workshop
"Data Lakes"
and
International school
"Scientific computing"
Big data analytics
and machine learning technologies
for mega science projects
Organizing Committee (JINR):
Contacts
Address: Russia, Moscow region
Dubna, Joint Curie Street, 6
Phone: (7 496 21) 64019, 62308, 65736
Fax: (7 496 21) 65145
E-mail: grid2018@jinr.ru
URL: http://grid2018.jinr.ru/
HUAWEI
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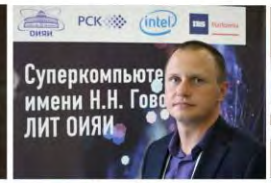
softline



ОИЯИ
PCK
intel
Суперкомпьюте
имени Н.Н. Гово
ЛИТ ОИЯИ














GRID 2018







GRID 2018














Slower lear
Catastrophi

GEANT General Overview


GRID
2021
July 5-9 Dubna
9th International Conference:
Distributed Computing and Grid-technologies
in Science and Education
Meshcheryakov Laboratory of Information Technologies
of the Joint Institute for Nuclear Research
Conference Topics
Advisory committee
Organizing Committee (JINR)
Contacts

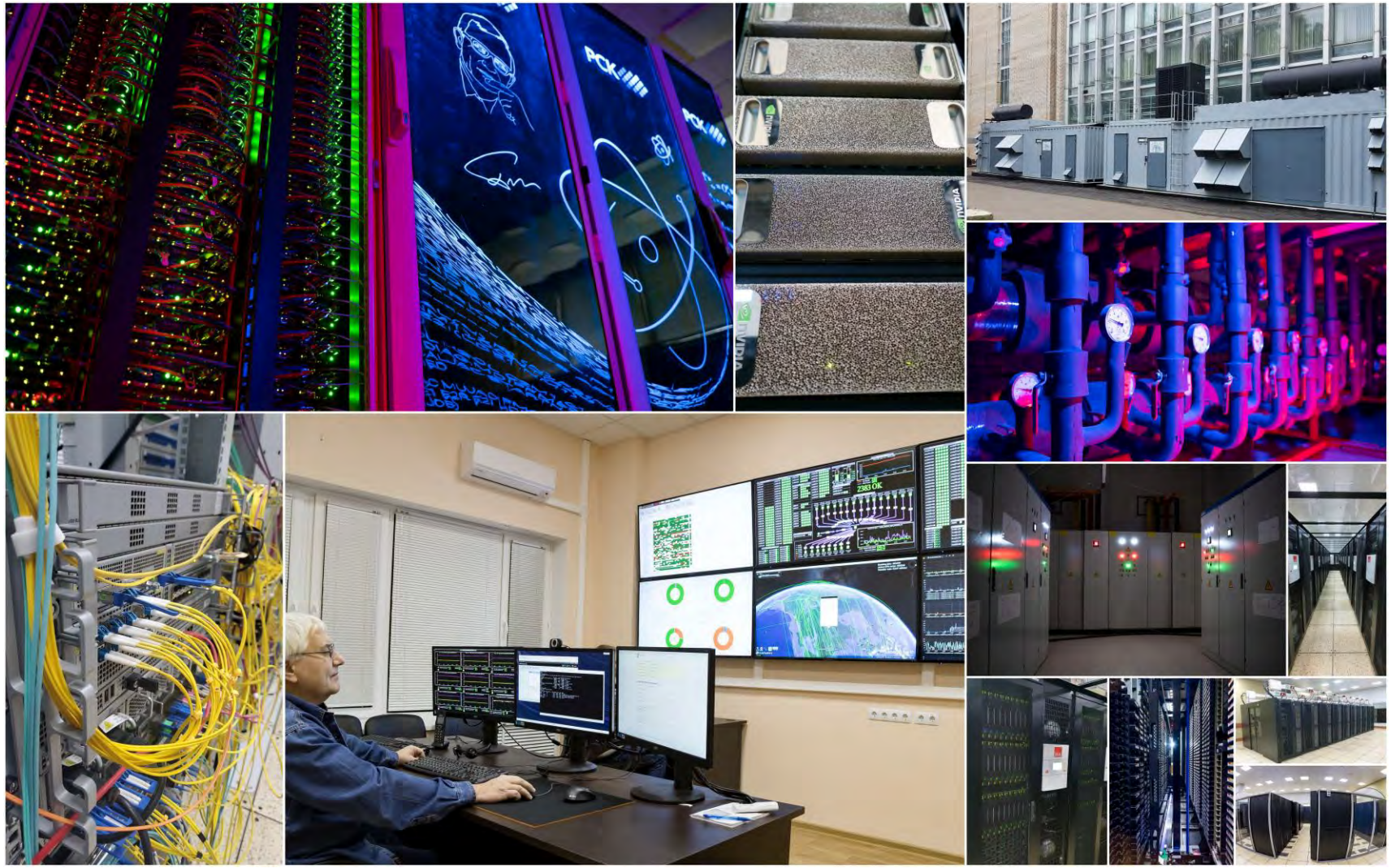
JINR MLIT


10
Joint Institute for Nuclear Research
Meshcheryakov Laboratory of Information Technologies
GRID2023
3-7 July 2023
10th International Conference
"Distributed Computing and Grid Technologies in Science and Education"
Advisory Committee
Organizing Committee:
Topics
Contacts
V.Sultanov
E.Sobole
PCK

Distributed Computing Team of MLIT

- Tikhonenko Elena, Uzhinskiy Aleksandr, Kutovskiy Nikolay, Oleynik Danila, Petrosyan Artem, Belov Sergey, Priakhina Daria, Pelevanyuk Igor
- Strizh Tatiana, Mitsyn Valery, Trofimov Vladimir, Dolbilov Andrey, Astakhov Nikolay, Baginyan Andrey, Balandin Anton, Gorbunov Iliya, Gromova Natalia, Poze Viktor, Dmitrienko Pavel, Tkachev Igor, Sidorova Irina, Mitsyn Sergey, Kadochnikov Ivan, Nechaevskiy Andrey, Semenov Roman, Balashov Nikita, Zhiltsov Viktor, Golunov Aleksei, Kashunin Ivan, Mazhitova Elena, Voytishin Nikolay, Gavrish Andrey, Vorontsov Aleksey
- Shmatov Sergey, Podgainy Dmitry, Streltsova Oksana, Moybenko Aleksandr, Belyakov Dmitry, Kokorev Aleksandr

Thank you for your attention!



https://lit.jinr.ru

t.me/MLIT_news