The development of distributed computing technologies and BigData in LIT

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Adam G., Podgainyi D.

RO-LCG 2015, Cluj-Napoca, 28 - 30 Oct. 2015

Grid technologies - a way to success

On a festivity dedicated to receiving the Nobel Prize for discovery of Higgs boson, CERN Director professor Rolf Dieter Heuer directly called the **grid-technologies one of three pillars of success** (alongside with the LHC accelerator and physical installations).

Without implementation of the grid-infrastructure on LHC it would be impossible to process and store enormous data coming from the collider and therefore to make discoveries.

Nowadays, every large-scale project will fail without using a distributed infrastructure for data processing.

LIT Fundamentals

- 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

IT-infrastructure is one of the JINR basic facilities

User policies

Computing infrastructure

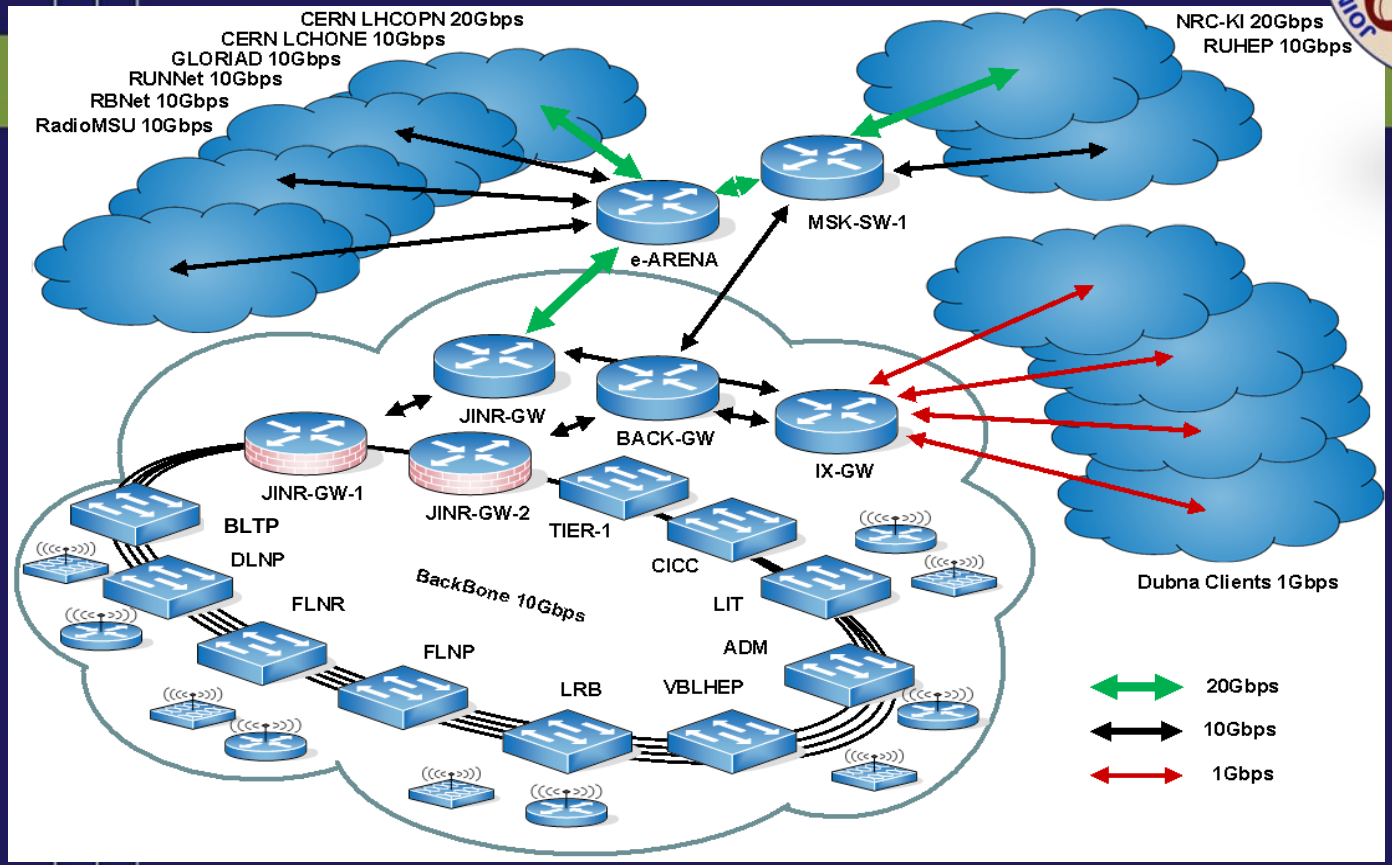
Mathematical and software support

Corporative information system

Training, education and user support

IT-services

- **Network**
  - Telecommu-nication channels JINR (LAN) JINR IXP
  - JINR LAN Remote Access Datacenter Network
  - Device registration DHCP DNS IPDB Network Registration & Connection Network Monitoring
  - Technical Network WIFI WLCG Network
- **Basics**
  - Account Management JINR Certificate Authority Computer Security
  - Controls Security Firewall Single Sign On
  - SSH (Secure SHell) E-mail Resources Portal
- **Collaboration**
  - Audio Conferencing Eduroam Indico
  - Video Conferencing Webcast and Recording
  - Project Management
  - GIT
  - JINR Document Server Invenio
- **Database Services**
  - Administration Database Service ADB2 ISS 1.C EPR
  - General Purpose Database Service
- **Computer Science & Physics Computing**
  - **Development**
    - **Computing**
      - **Grid**
        - Tier-1 and Tier-2 Support
        - Storage Support
        - File Transfer Compute Element Grid Information Infrastructure Monitoring
        - LFC Service MyProxy VOMS Workload Management
      - **Cloud**
        - IaaS
        - SaaS
        - PaaS
      - **HybriLIT**
        - CUDA MPI OpenMP
  - **Research**
    - **Applied Software**
      - Computer Algebra
      - JINRLIB
      - Math. Methods algorithms, software
      - Big Data analytics
      - Quantum computing

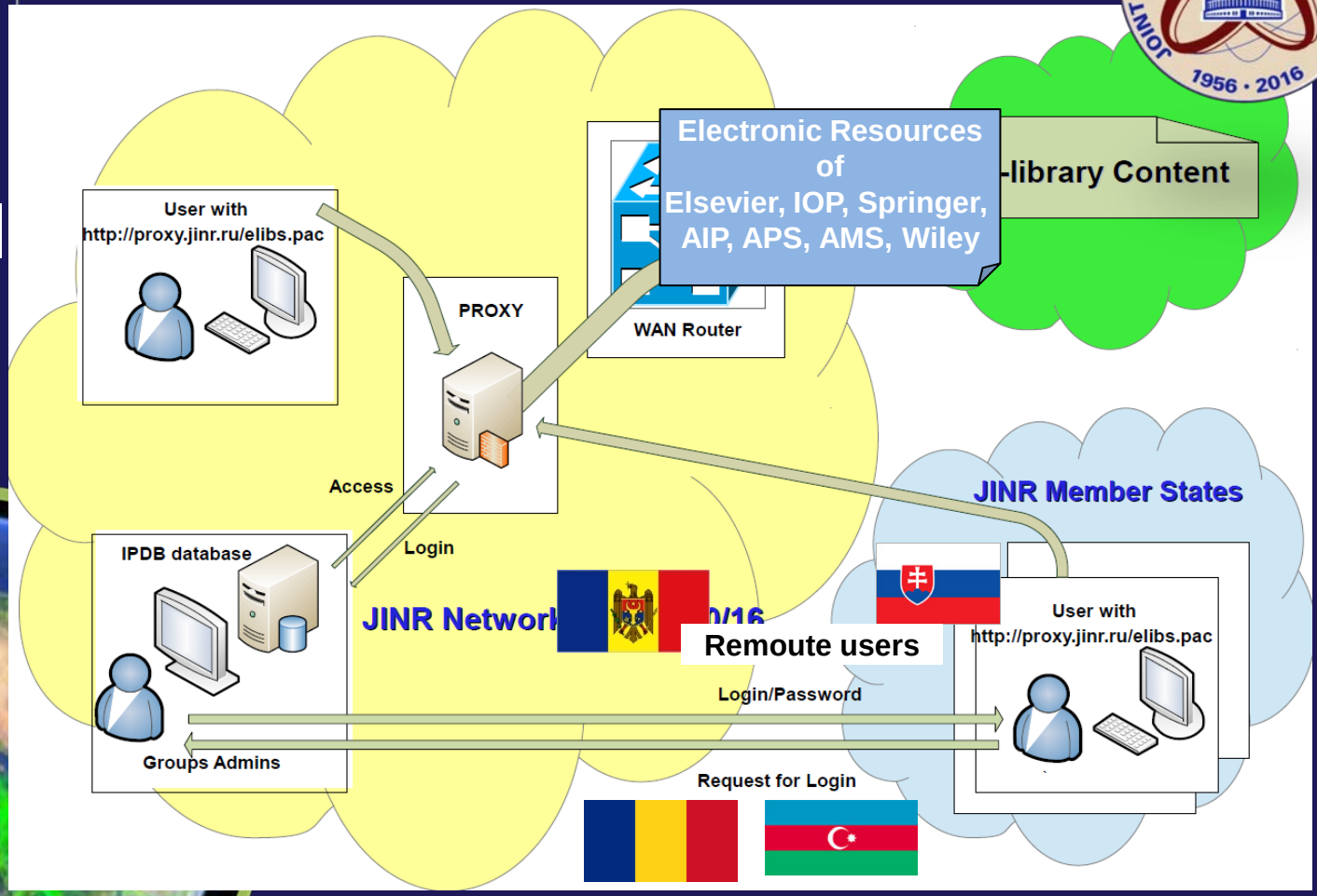


JINR Local Area Network

Comprises **7846** computers & nodes
Users – **4079**, IP – **12436**
Remote VPN users – **708**
E-library**- 1463, mail.jinr.ru-2000**
High-speed transport (10 Gb/s)

Controlled-access at network entrance.
General network authorization system involves basic services (Kerberos,AFS, batch systems, JINR LAN remote access, etc.)
IPDB database - registration and the authorization of the network elements and users, visualization of statistics of the network traffic flow, etc.

Access Service to Electronic Resources of World Publishers

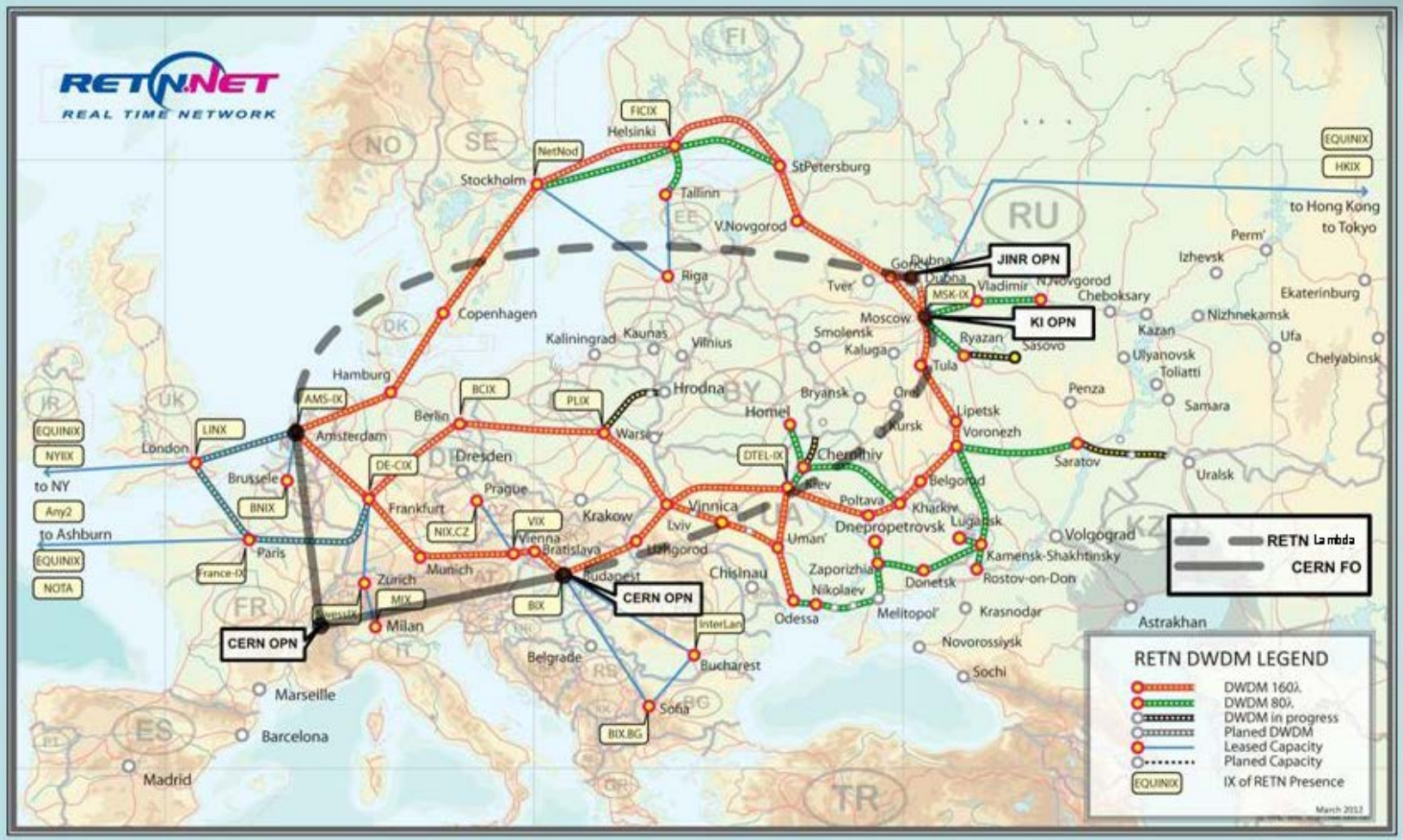


Total e-library users: 1375

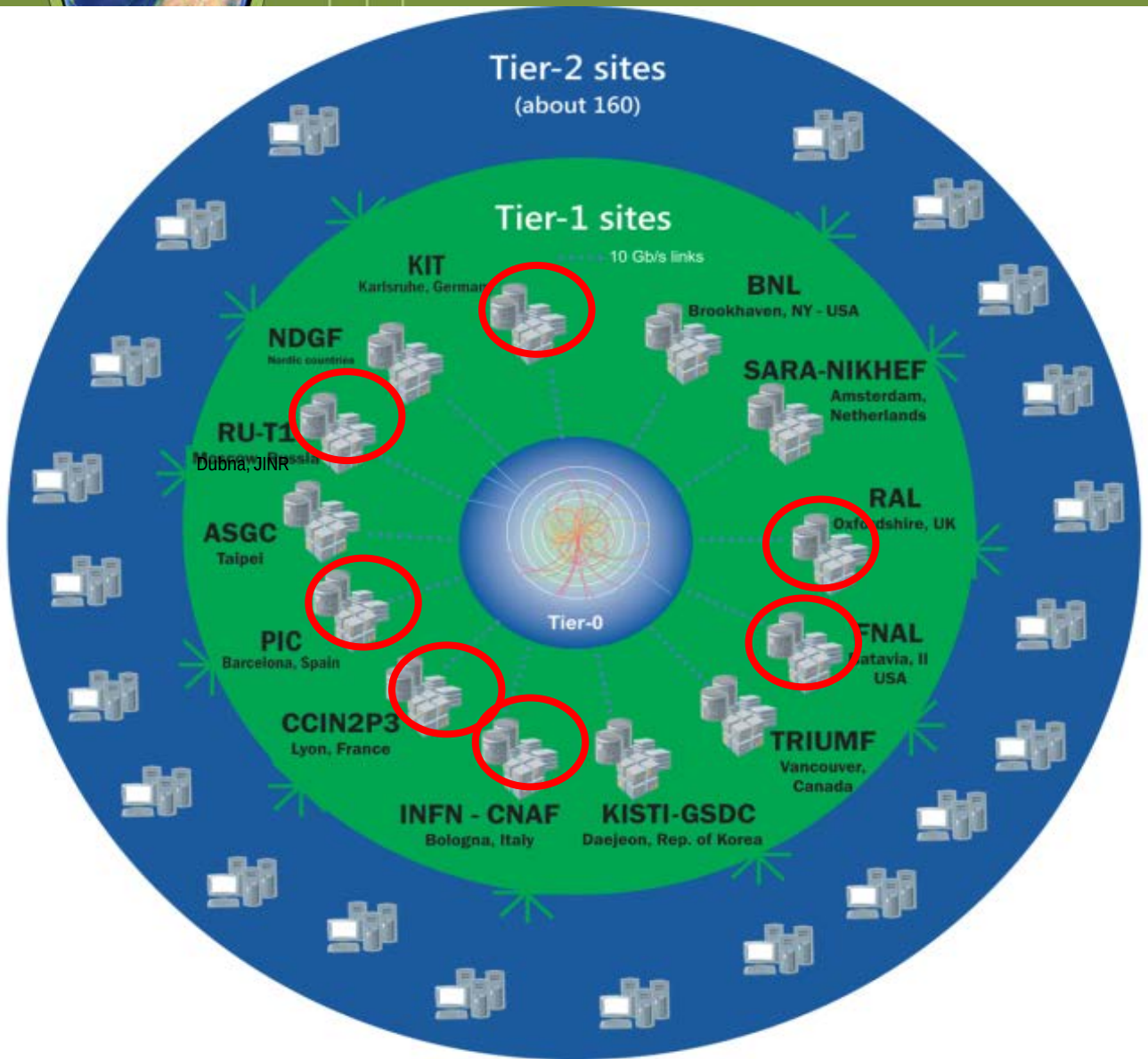
Remote JINR users from Member States :

Republic of Azerbaijan - 24
Slovak Republic - 39
Republic of Moldova – 6 (+3)
Romania – 37, Bulgaria -1 (+8), Georgia-1(+7)

JINR Tier1 Connectivity Scheme



LHC Computing Model



Tier-0 (CERN):
- Data recording
- Initial data reconstruction
- Data distribution

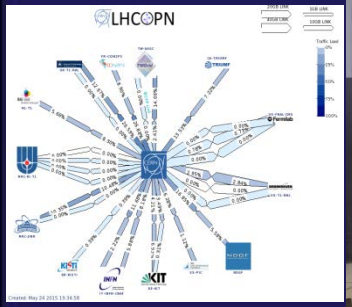
Tier-1 (>14 centres):
- Permanent storage
- Re-processing
- Analysis
- Simulation

Tier-2 (>200 centres):
- Simulation
- End-user analysis

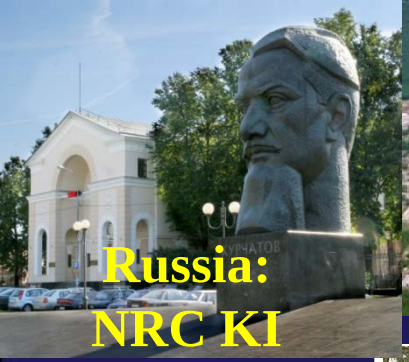
Tier-1 Components

March 2015

- LHCOPN
- 2400 cores (~ 30 kHS06)
- 5 PB tapes (IBM TS3500)
- 2,4 PB disk
- Close-coupled, chilled water cooling InRow
- Hot and cold air containment system
- MGE Galaxy 7000 – 2x300 kW energy efficient solutions 3Ph power protection with high adaptability



The inauguration of the Tier1 center for the CMS experiment at LIT (March 26, 2015)


Russia:
NRC KI


US-BNL


Amsterdam/NIKHEF-SARA


Taipei/ASGC


JOINT INSTITUTE FOR NUCLEAR RESEARCH
1956 · 2016
Bologna/CNAF


JINR


Ca-
TRIUMF


Traffic
More...
Map
Satellite
Terrain
Suomi
Finland
Sverige
Norge
Bergen
Oslo
Stockholm
Helsinki
Tallinn
Eesti
Latvija
Riga
Lietuva
Kaunas
Vilnius
Danmark
København
Göteborg
Sankt-Peterb
NDGF


CERN


US-FNAL

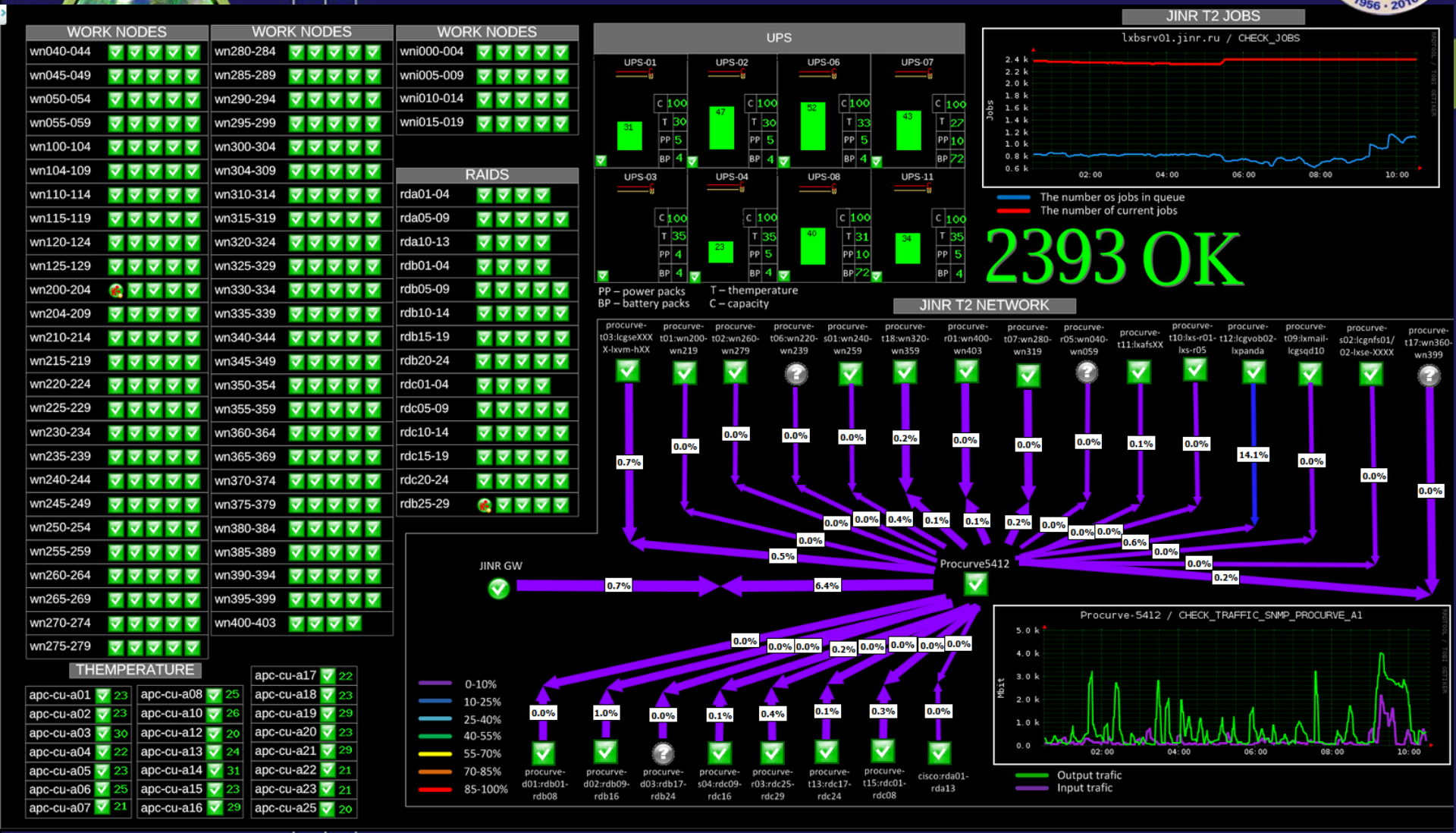

Barcelona/PIC


Lyon/CCIN2P3


UK-RAL


De-FZK

Monitoring

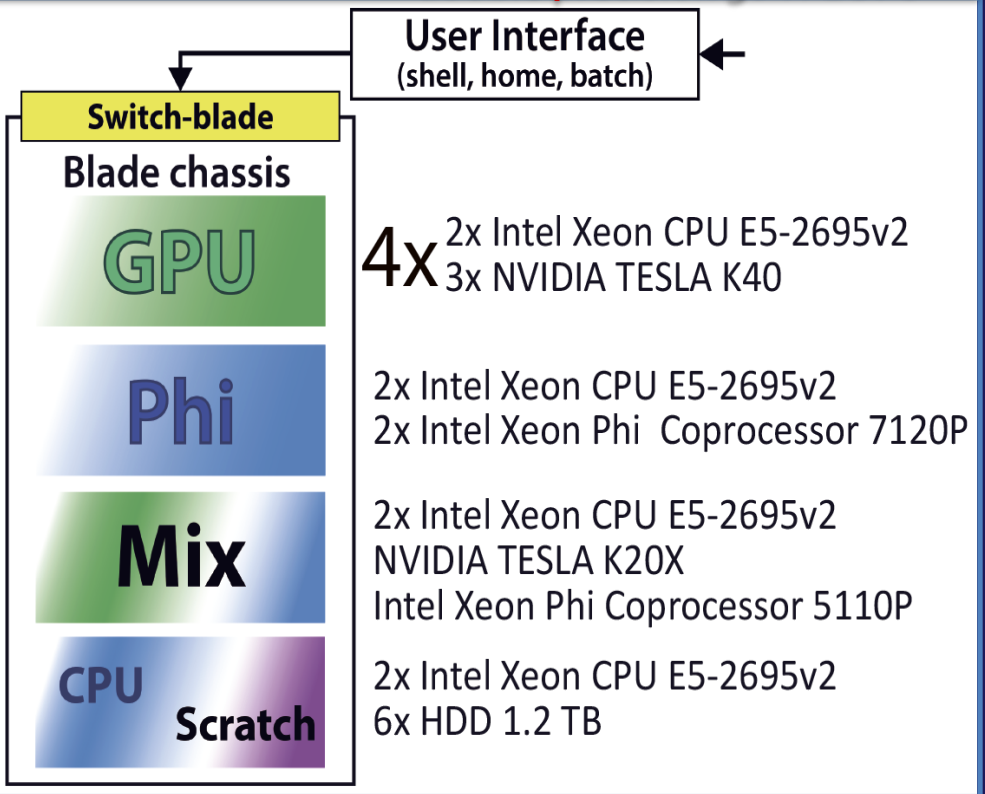


Network monitoring information system - more than 623 network nodes are in round-the-clock monitoring

HybriLIT: heterogeneous computation cluster

Current Status 2015:

Total performance: single precision 75 TFLOPS
double precision 30 TFLOPS



Nearest Plans 2015:

Total performance: +35 TFLOPS

- **Hardware upgrades:**

2 X GPU

Blades with 4 NVIDIA TESLA K80

- **Creating of polygon for training courses on Parallel Computing Technologies**

Operating system: Scientific Linux 6.5
File systems: EOS and NFS
Batch system: SLURM

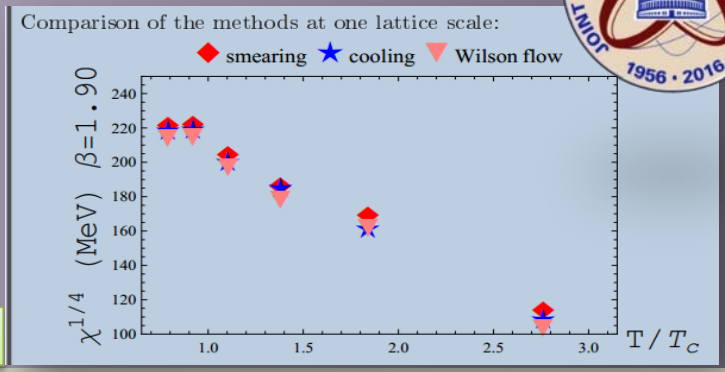
Currently the **total number** of users comprise **95** people:
26 are from JINR member-countries: *Armenia, Bulgaria, Mongolia, Romania, Slovakia, Ukraine*, etc.
19 people are from the following universities of Russia: *MSU, SPSU, PFUR and "Dubna" University.*

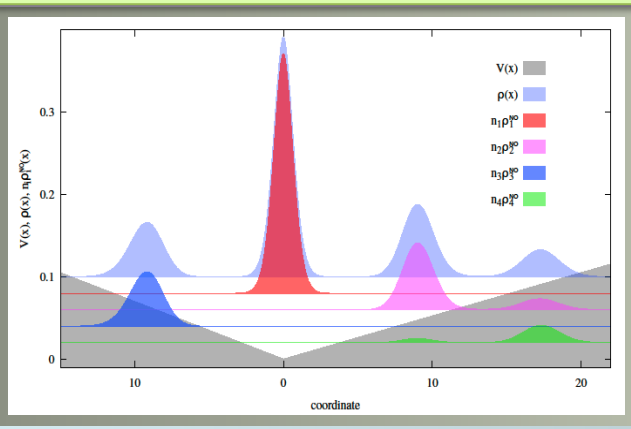
Parallel computing on HybriLIT

Parallel computing for QCD problems:

F. Burger(IP, HU, Berlin,),
M. Müller-Preussker (IP HU, Berlin, Germany),
E.-M. Ilgenfritz (BLTP& VBLHEP, JINR),
A. M. Trunin (BLTP JINR)

http://theor.jinr.ru/~diastp/summer14/program.html#posters





Parallel computing for investigation of Bose-systems:

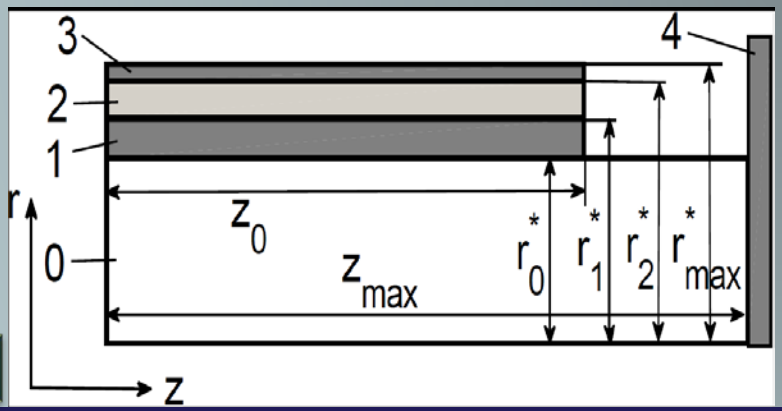
Alexej I. Streltsov ("Many-Body Theory of Bosons" group at CQD, Heidelberg University, Germany),
Oksana I. Streltsova (LIT JINR)

http://MCTDHB.org

Parallel computing for Technical problems:

A. Ayriyan (LIT JINR), J. Busa Jr. (TU of Kŏsice, Slovakia),
E.E. Donets (VBLHEP, JINR),
H. Grigorian (LIT JINR,;Yerevan State University, Armenia),
J. Pribis (LIT JINR; TU of Kŏsice, Slovakia)

arXiv:1408.5853



HybriLIT: tutorials

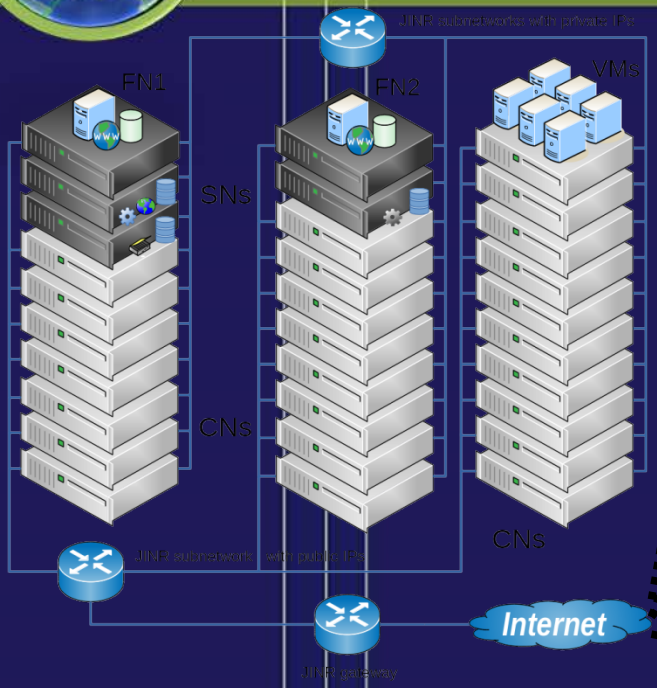
Tutorials on the basis of ***HybriLIT***:

- Regular tutorials on parallel programming technologies both for the institute staff and for students and young scientists from JINR member-states organized by the UC;
- Specialized courses from the leading software developers.

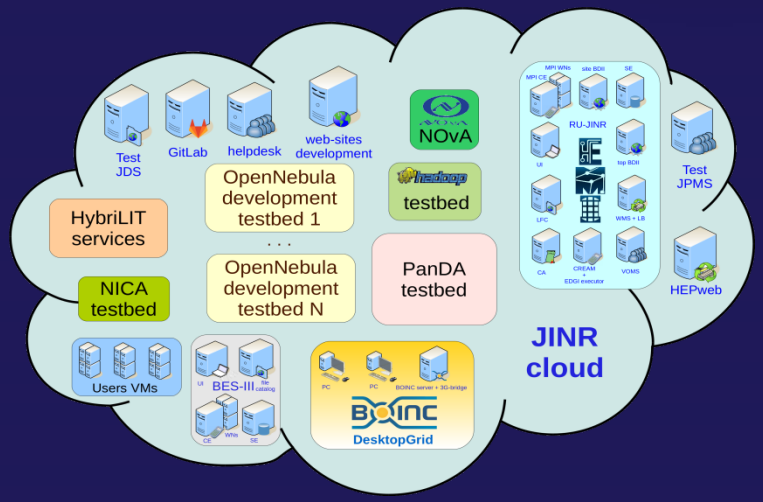
Specialized courses and **seminars** within conferences and schools organized by JINR. In particular within GRID'2014, International youth conference *MPAMCS'2014*, The Helmholtz International Summer School "Lattice QCD, Hadron Structure and Hadronic Matter" 2014; ***MMCP'2015***, ***NEC'2015, AIS-GRID'2015***.

JINR cloud infrastructure

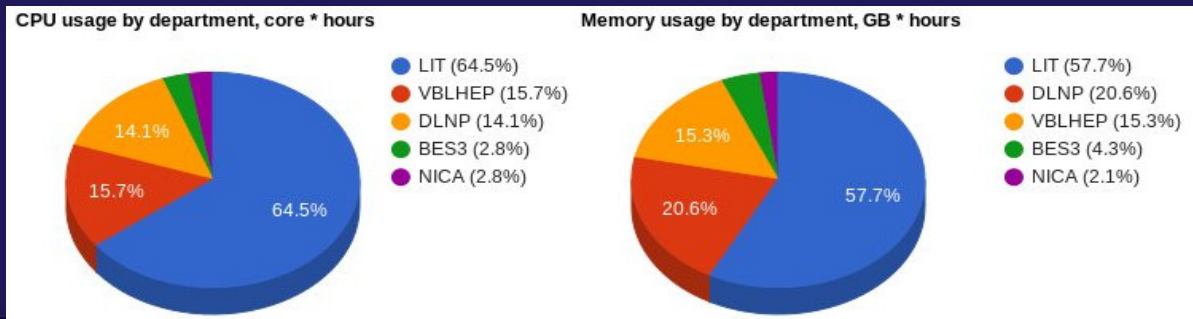
JINR cloud architecture



JINR cloud utilization



JINR cloud usage statistics



JINR cloud characteristics:

Based on OpenNebula

CPU cores: 200

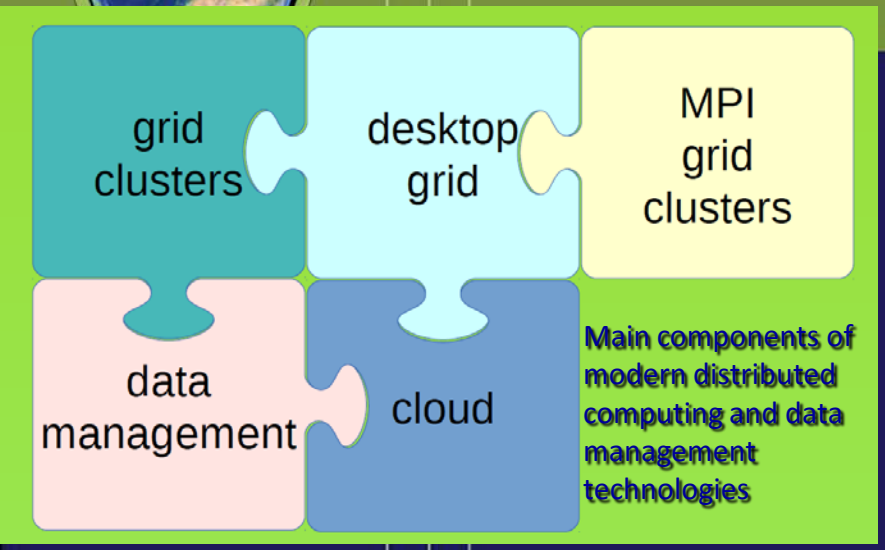
Total RAM: 400

Total disk capacity: 16 TB

Registered users: 77

# of running VMs: 100

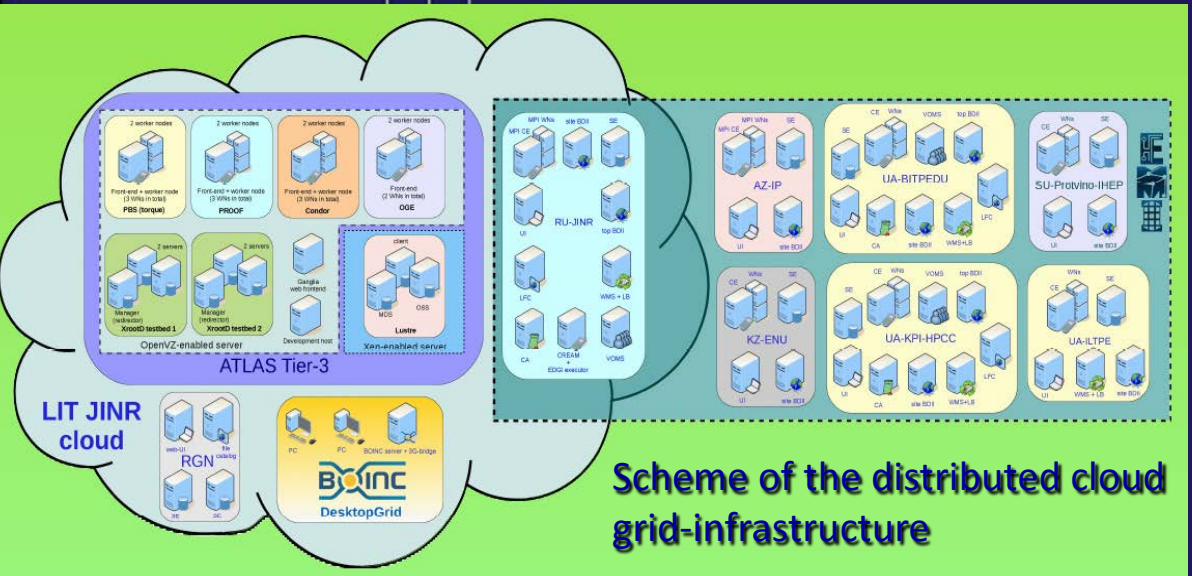
JINR distributed cloud grid-infrastructure for training and research



Main components of modern distributed computing and data management technologies

There is a demand in special infrastructure what could become a platform for training, research, development, tests and evaluation of modern technologies in distributed computing and data management.

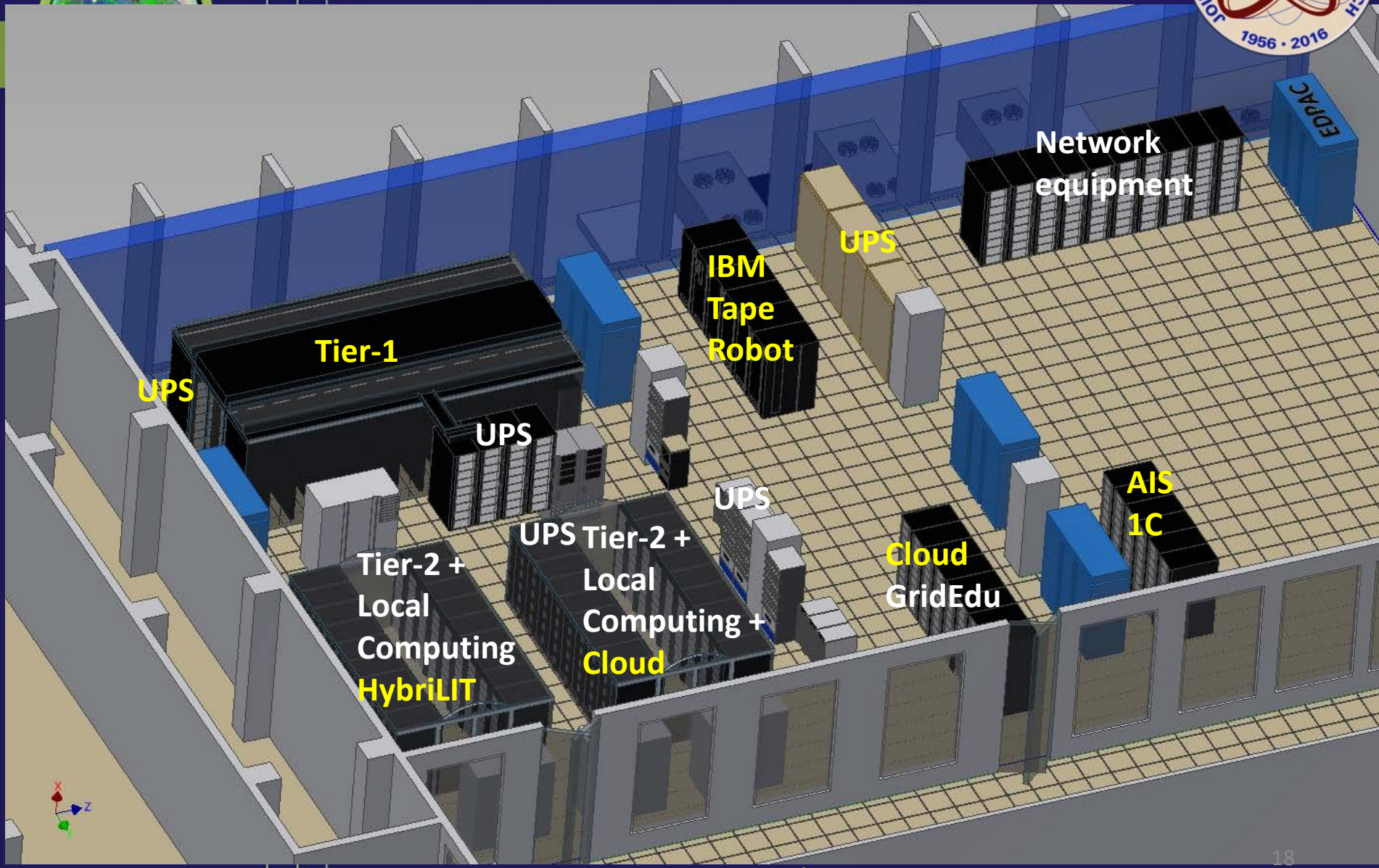
Such infrastructure was set up at LIT integrating the JINR cloud and educational grid infrastructure of the sites located at the following organizations:



Scheme of the distributed cloud grid-infrastructure

- Institute of High-Energy Physics (Protvino, Moscow region),
- Bogolyubov Institute for Theoretical Physics (Kiev, Ukraine),
- National Technical University of Ukraine "Kyiv Polytechnic Institute" (Kiev, Ukraine),
- L.N. Gumilyov Eurasian National University (Astana, Kazakhstan),
- B.Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine (Kharkov,Ukraine),
- Institute of Physics of Azerbaijan National Academy of Sciences (Baku, Azerbaijan)

JINR Computing Centre Status



JINR CICC Usage

Year 2015 numbers of jobs run:

Local users – 152,344

Tier2 total - 3,990,980

ATLAS - 2,570,666

CMS - 727,482

ALICE - 369,980

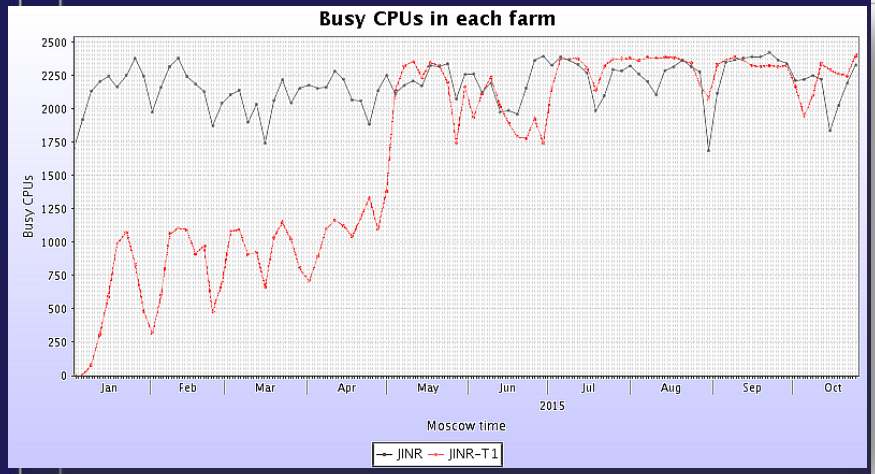
Tier1 CMS - 1,177,995

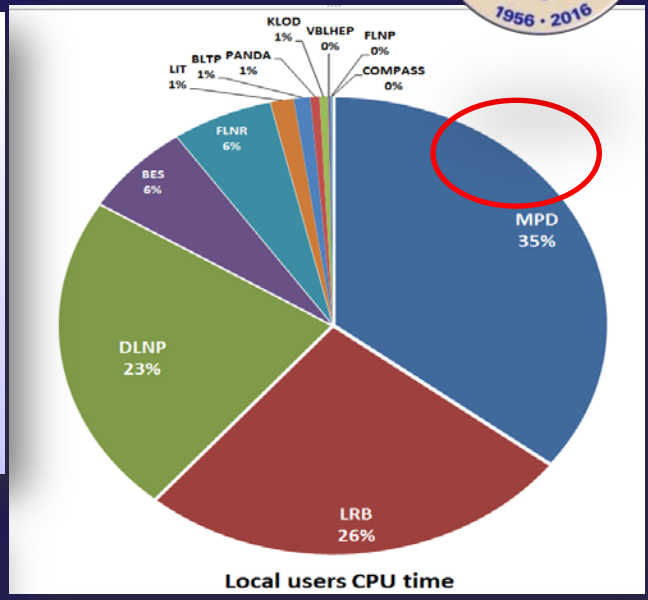
Users of:

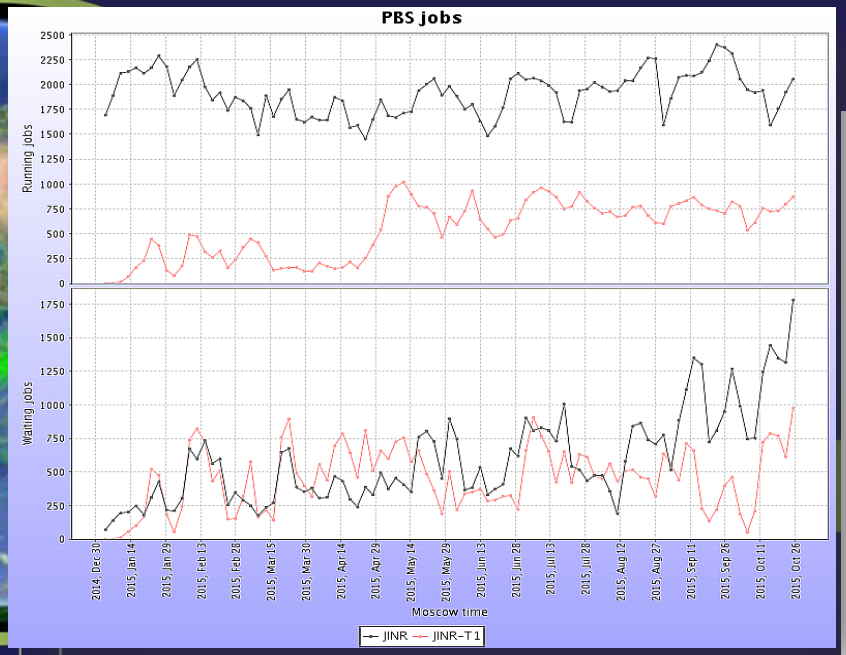
Local CICC - 903

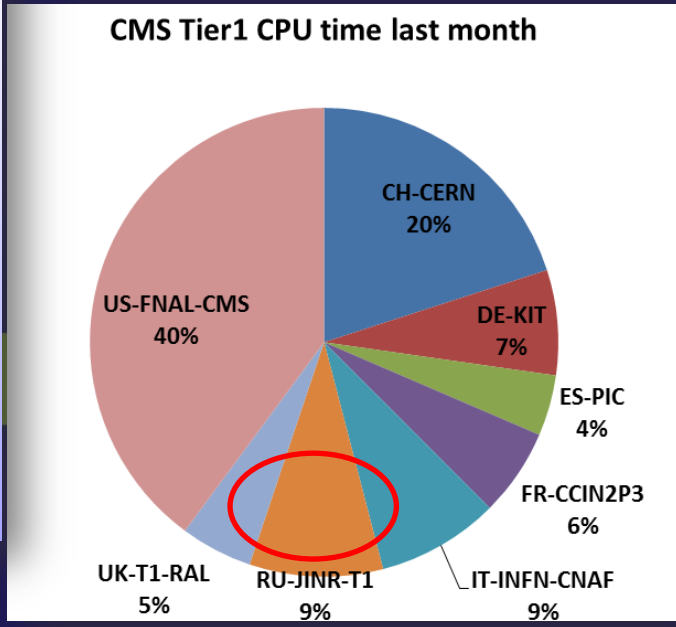
JINR Cloud - 77

HybriLit - 95



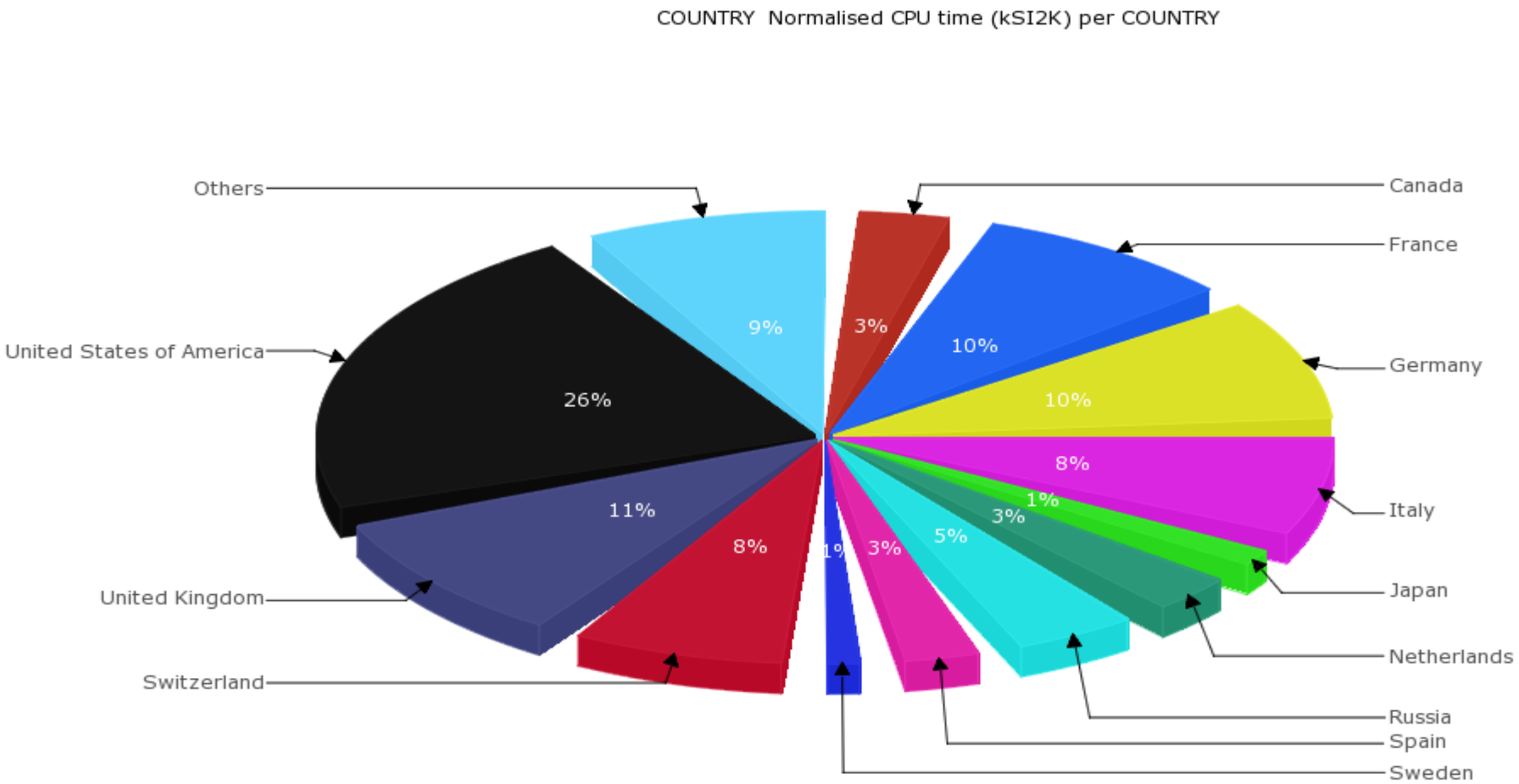






Country Normalized CPU time 2014-2015

A 'EGI View' : / normcpu / 2015:5-2015:10 / COUNTRY-VO / lhc (x) / GRBAR-LIN / l



All Country - 39,141,955,720 **Russia- 1,692,805,500**

Job 1,199,005,437 **40,529,530**

Worldwide LHC Computing Grid (WLCG)

The primary goal of the WLCG project is to create a global infrastructure of regional centers for processing, storage and analysis of data of the LHC physical experiments.

The grid-technologies are a basis for constructing this infrastructure.

A protocol between CERN, Russia and JINR on participation in the LCG project was signed in 2003. MoU about participation in the WLCG project was signed in 2007.

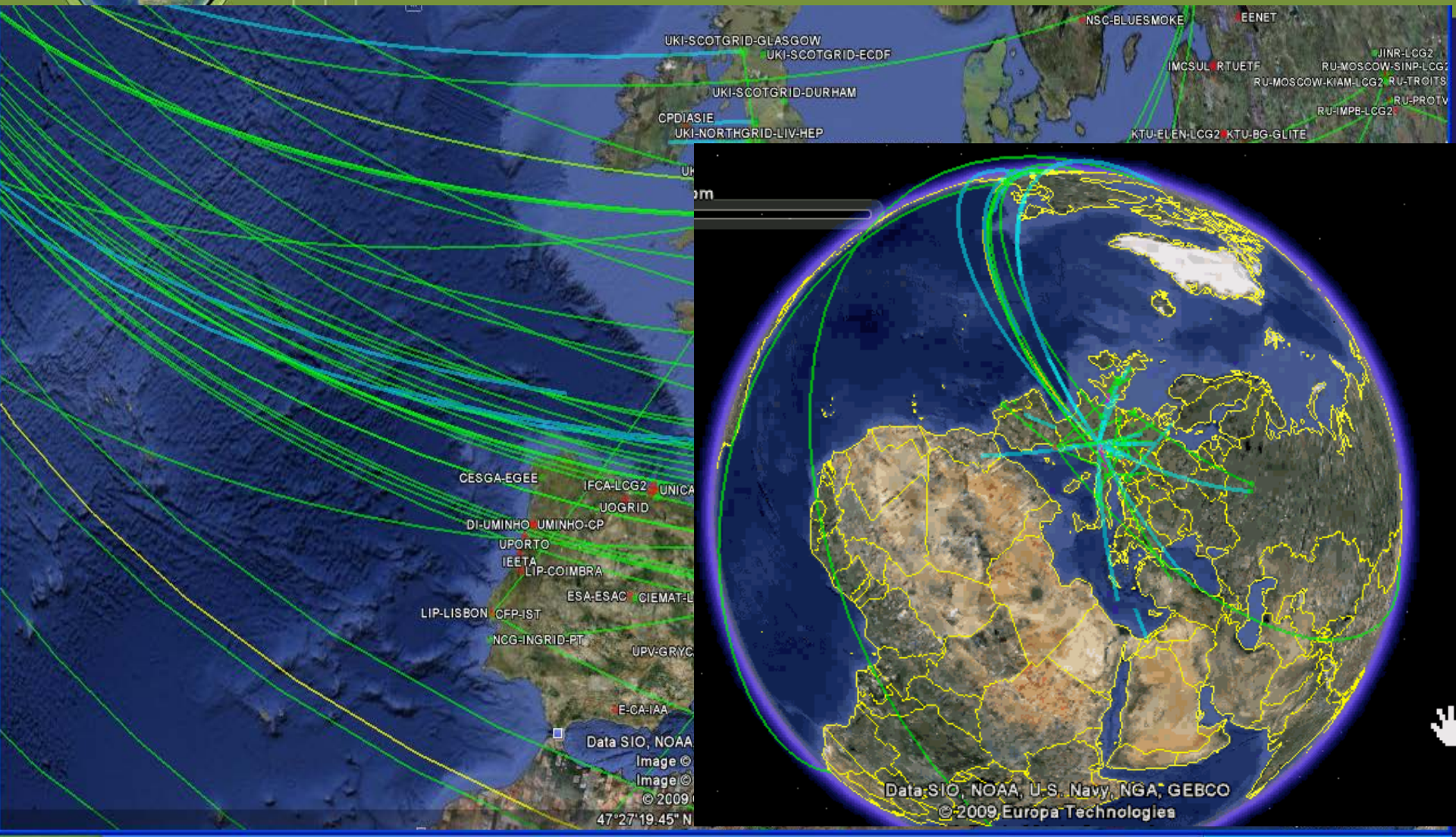
Tasks of the Russian centers and JINR within WLCG :

- Creation of a complex of tests for WLCG software
- Introduction of WLCG services for experiments
- Development of WLCG monitoring systems
- Development of simulation packages for experiments
- Creation of a Tier1 center in Russia

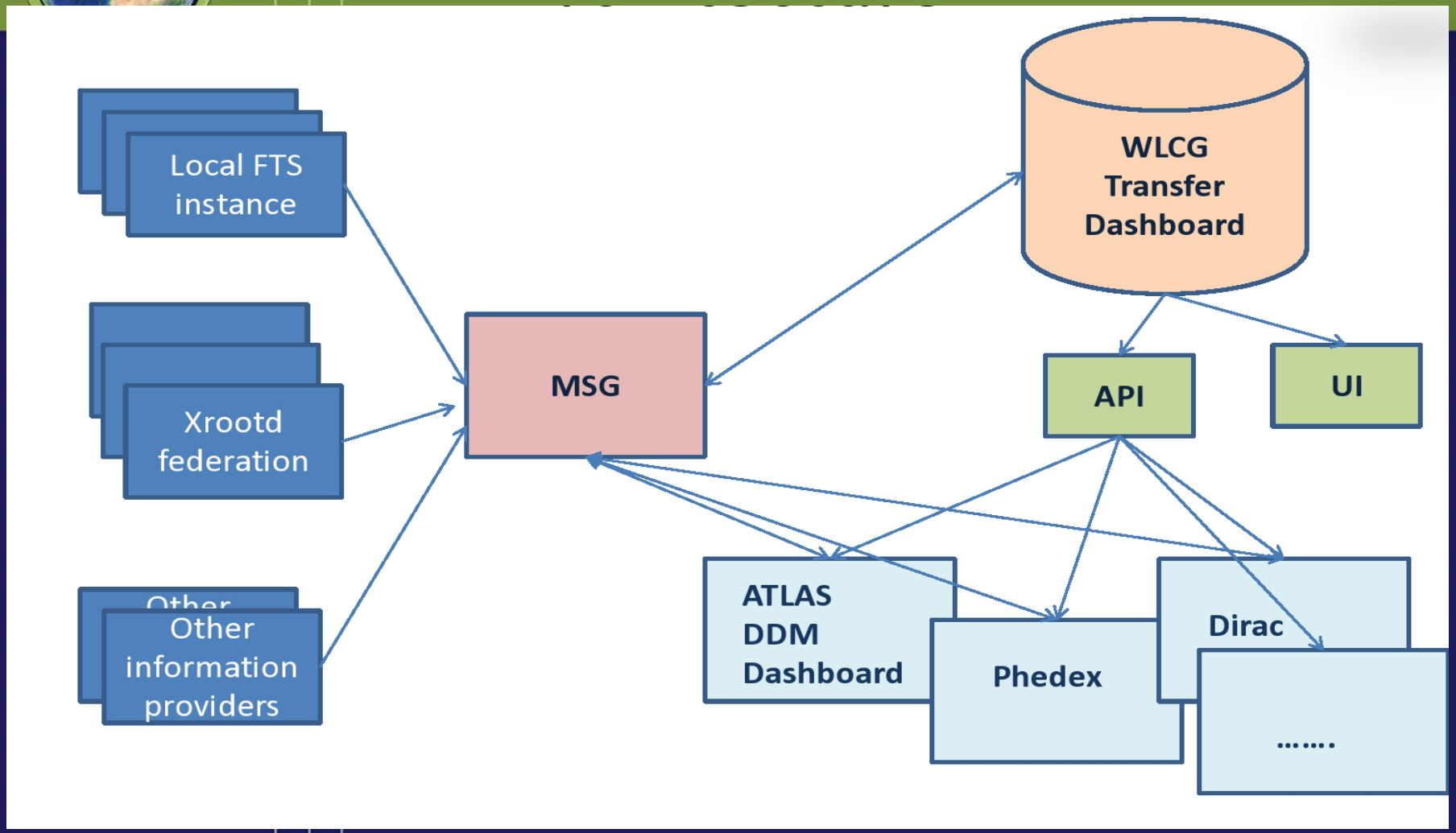
JINR activity at WLCG project

- Participation in development of software for ATLAS, ALICE, CMS
- Development WLCG Dashboard
- Global data transfer monitoring system for WLCG infrastructure
- NOSQL storage
- Integration GRID, Cloud, HPC
- Local and global Monitoring of Tier3 centers
- Development of DDM, AGIS for ATLAS
- GENSER & MCDB

WLCG Google Earth Dashboard



Global data transfer monitoring system for WLCG



Development of Dashboard WLCG

Module OCSP

Event

Nagios Core

Evidence from other Nagios servers

Command Pipe

Python-Metric

Parameters

Plugin mq2nagios

Passive check

Communication

simplevisor

Communication

DIRQ

Decision commands

stompclt

Element Python-Queue DQS

DIRQ

Element Python-Queue DQS

Контейнер Python-Message

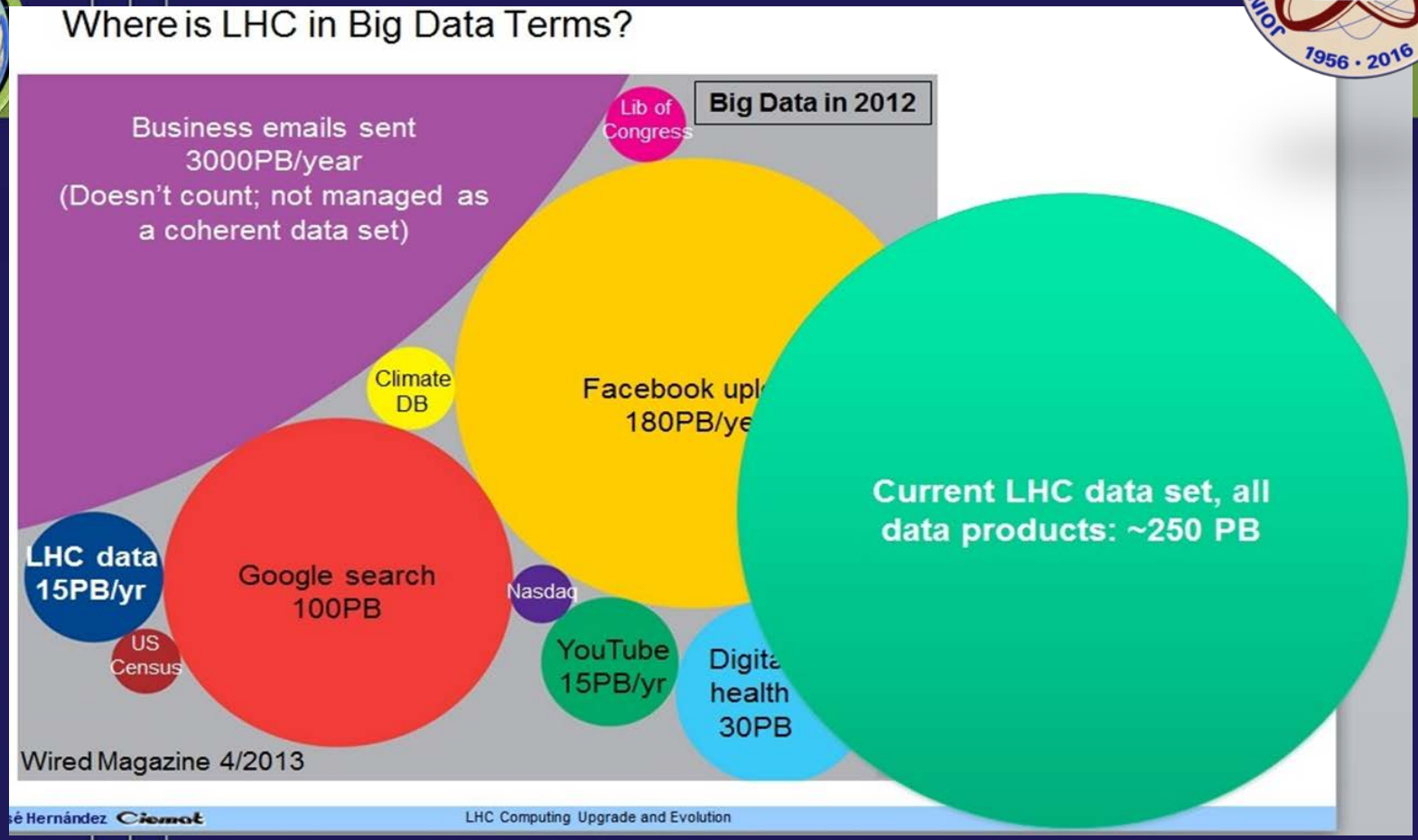
stompclt

Conteiner Python-Message

ActiveMQ

Exchanges with other Nagios servers

Entering into the era of Big Data



A comparative diagram of processed data evidently shows that the studies underway at CERN are performed under Big Data conditions.

After LHC modernization and start-up in 2015, the data stream will increase 2.5 times thus demanding increase in the resources and optimization of their use.

PanDA Workload Management

Production managers

define

task/job repository (Production DB)

End-user

PanDA server

submitter (bamboo)

production job

https

analysis job

https

submit

pull

https

job

Data Management System (DQ2)

https

Local Replica Catalog (LFC)

https

Logging System

https

https

https

EGEE/EGI

pilot

OSG

pilot

NDGF

pilot

arc

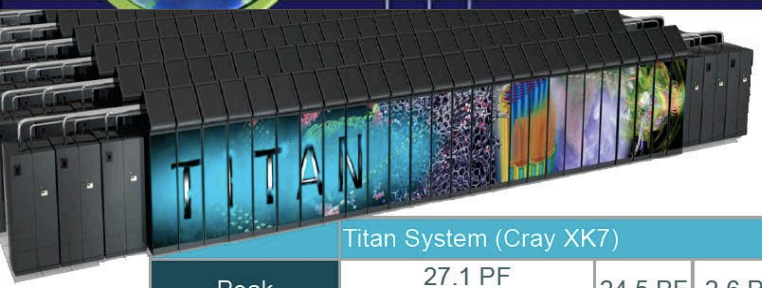
ARC Interface (aCT)

condor-g

pilot scheduler (autopyfactory)

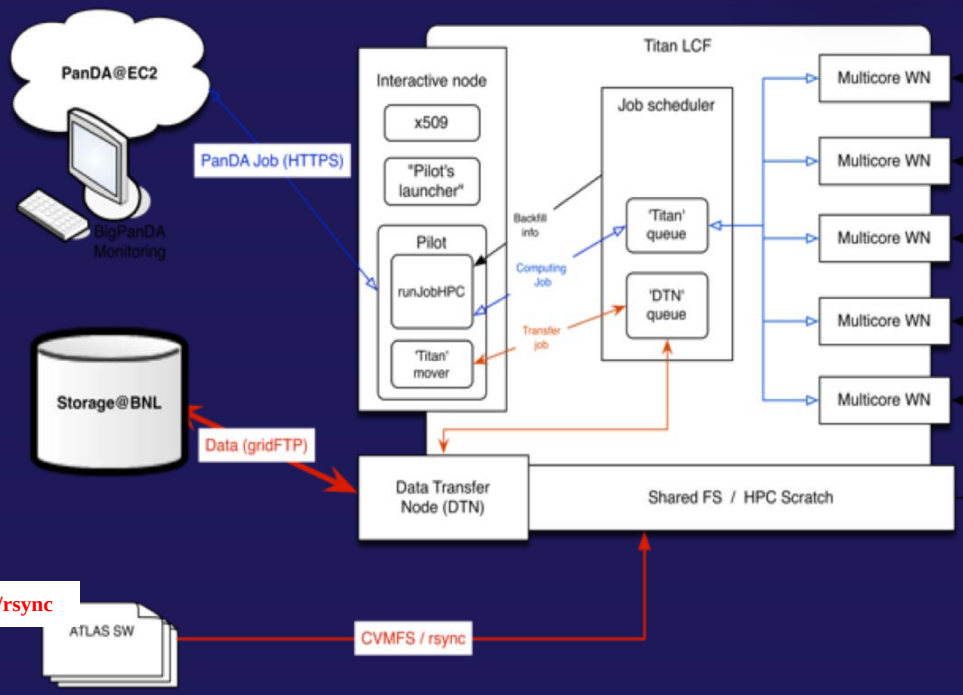
Worker Nodes

Evolving PanDA for Advanced Scientific Computing



	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



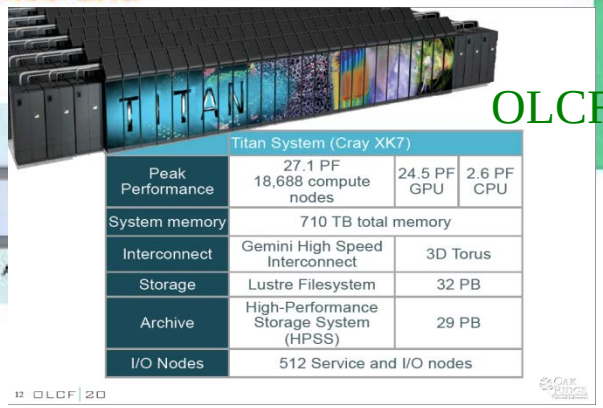
ATLAS (BNL, UTA), OLCF, ALICE (CERN,LBNL,UTK), LIT JINR:

- adapt PanDA for OLCF (Titan)
- reuse existing PanDA components and workflow as much as possible.
- PanDA connection layer runs on front-end nodes in user space. There is a predefined host to communicate with CERN from OLCF, connections are initiated from the front-end nodes
- SAGA (a Simple API for Grid Applications) framework as a local batch interface.
- Pilot (payload submission) is running on HPC interactive node and communicating with local batch scheduler to manage jobs on Titan.
- Outputs are transferred to BNL T1 or to local storage

BigPanDA

Many Others

Open Science Grid



OLCF

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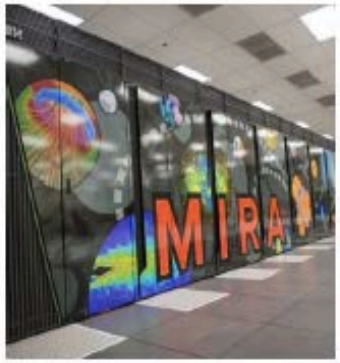
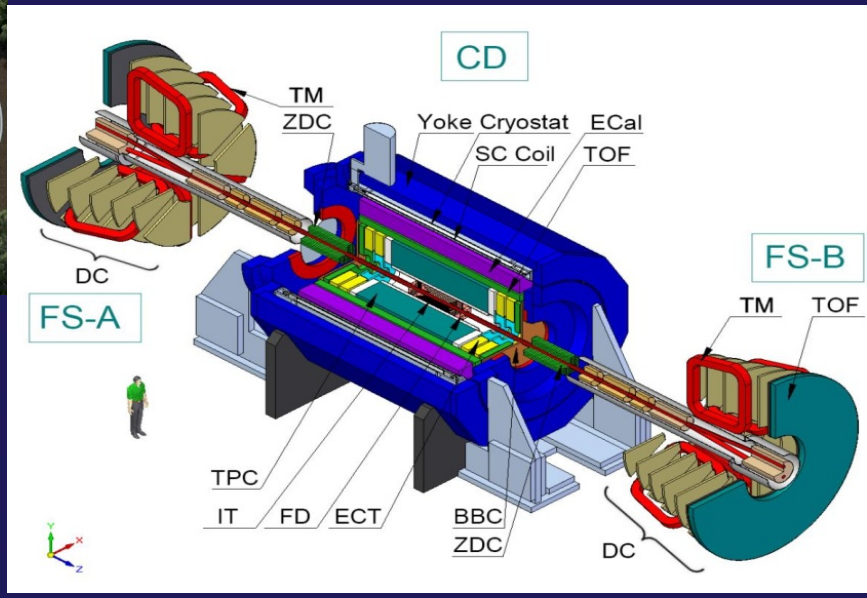


NICA Accelerator Complex



For the NICA project the data stream has the following parameters:

- high speed of the event set (up to 6 kHz),
- in central Au-Au collision at the NICA energies, about 1000 charged particles are generated,
- predicted event quantity - 19 billion;
- the total amount of initial data can be valued as 30 PB annually or 8.4 PB after processing.

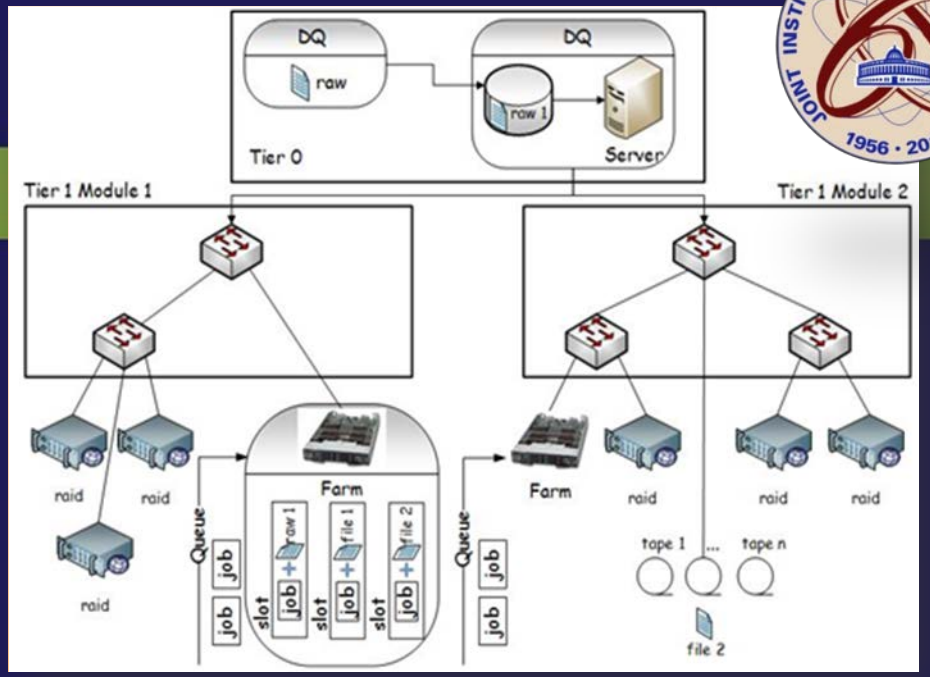
Simulation of NICA-MPD-SPD Tier0-Tier1 computing facilities

Working at TB scale the NICA MPD-SPD experiments will face with great challenges in distributed computing:

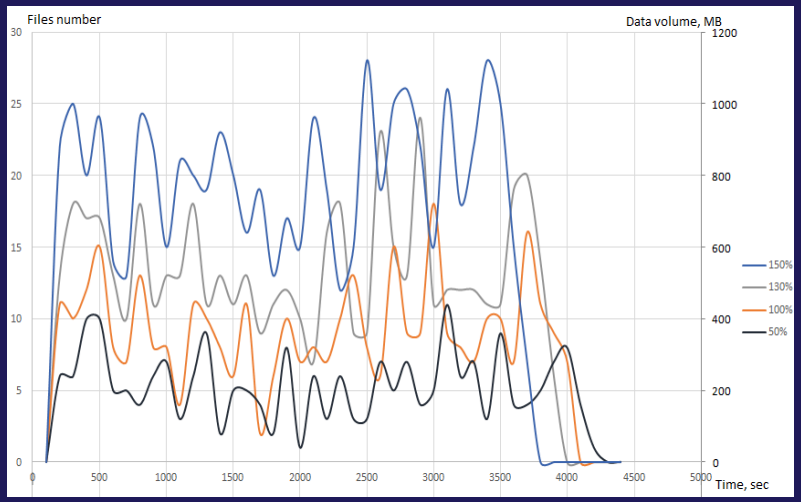
- large increase of CPU and network resources;
- combined grid and cloud access;
- Intelligent dynamic data placement
- distributed parallel computing;
- renewal most of simulation and analysis software codes.

The program SyMSim (Synthesis of Monitoring and SIMulation) for simulation of grid-cloud structures is developed.

The **originality** consists in **combining a simulation program with a real monitoring system** of the grid/cloud service in frame of the same program.



Data storage and processing scheme of Tier0-Tier1 level

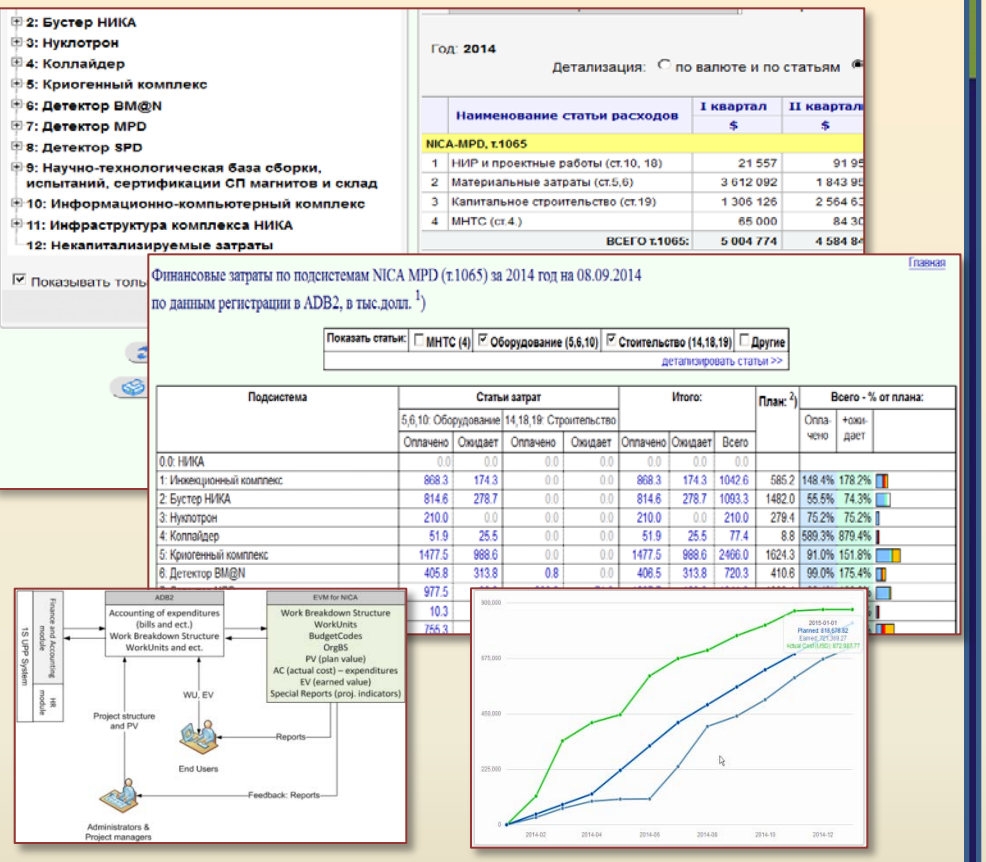


Number of DAQ data files stored on output disk buffer for growing data volumes

Estimated rate of NICA-MPD experimental data to be transferred to Tier 1 is about 24 PB by one month. Simulation result shows what happened in the grid/cloud system if the data volumes are grow up to 1,5 times for example. Simulation result allows one to understand how the intensity of the input stream determines the reserves of the system capacity

Computing for NICA

Development of management system for NICA project

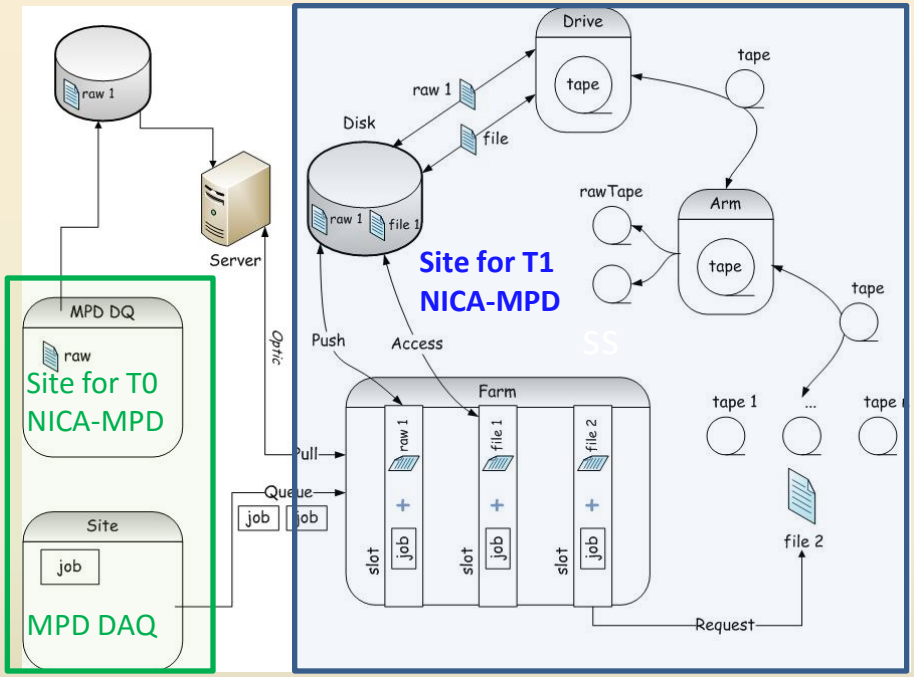


Current status:

- ❑Financial planning and cost control – in production;
- ❑Distributed collection of earned value data – in production;
- ❑Installation of CERN's EVM system at JINR and system integration – finished, in production;
- ❑Development of subsystem for versioning of plans – in progress.

Solution of tasks on processing, storage and security of petabyte data [illegible] experiments on NICA complex

Aim: get optimal configuration of processors, tape drives, and changers for data processing



Job & data flow scheme of T0-T1 NICA-MPD

Under study structure composition:

- ✓Tape robot,
- ✓Disk array,
- ✓CPU Cluster.

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***.

LIT JINR - China collaboration

LIT team is a key developer of the BES-III distributed computing system

A prototype of BES-III Grid has been built (9 sites including IHEP CAS and JINR). Main developments have been done at IHEP and JINR. The Grid is based on DIRAC interware.

Monitoring

- BES-III grid monitoring system is operational since February 2014.
- Implementation of the new monitoring system based on DIRAC RSS service are in progress

Job management

- Advising on the CE's installation and management
- BES-III jobs can be submitted on JINR cloud service now

Data management

- Installation package for Storage Element was adopted for BES-III Grid
- Solution on dCache-Lustre integration was provided for main data storage in IHEP
- Research on the alternative DB and data management service optimization is in progress

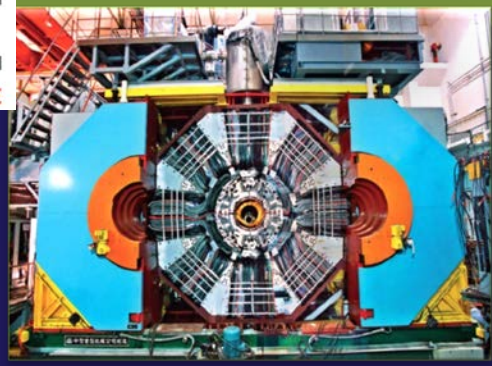
Infrastructure

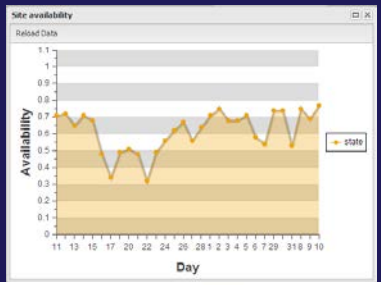
- Creation of the back-up DIRAC services for BES-III grid at JINR is in progress

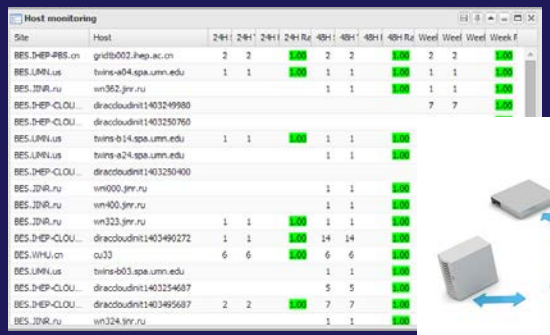
DIRAC
THE INTERWARE

SE latency monitoring

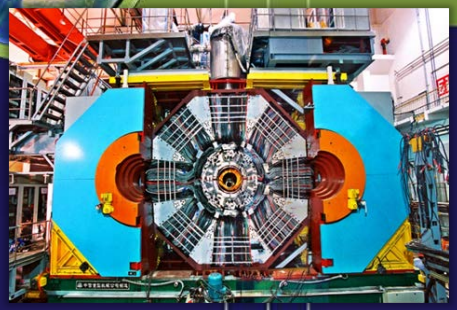
Source	Destination	Latency(sec)
IHEPD-USER	IHEPD-USER	2.678
IHEPD-USER	JINR-USER	16.316
IHEPD-USER	USTC-USER	15.932
IHEPD-USER	WHU-USER	6.728
JINR-USER	IHEPD-USER	14.322
JINR-USER	JINR-USER	14.24
JINR-USER	USTC-USER	14.827
JINR-USER	WHU-USER	8.516
USTC-USER	IHEPD-USER	3.677
USTC-USER	JINR-USER	17.855
USTC-USER	USTC-USER	2.746
USTC-USER	WHU-USER	624.375
WHU-USER	IHEPD-USER	5.727
WHU-USER	JINR-USER	20.227
WHU-USER	USTC-USER	9.199
WHU-USER	WHU-USER	3.092







BES-III Distributed Computing



GRID.JINR.ru
100
30 TB

CLOUD.JINR.ru
5

GRID.INFN-Torino.it
200
30 TB

CLOUD.TORINO.it
101

GRID.INFN-ReCas.it
50
30 TB

CLOUD.IHEP-OPENSTACK.cn
96
66 TB

CLOUD.IHEP-OPENNEBULA.cn
178
126 TB

CLUSTER.WHU.c
120
39 TB

CLUSTER.UMN.u
768
50 TB

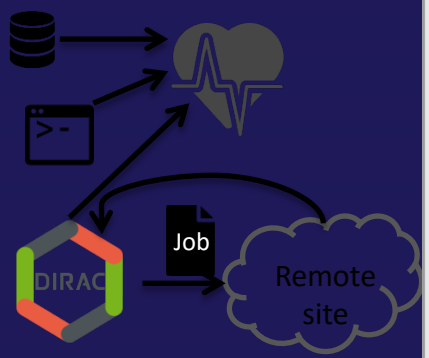
CLUSTER.USTC.c
200
24 TB

What have been done in computing:

- Grid monitoring system developed from scratch
- JINR cloud was integrated in BES-III infrastructure
- 6 % of all jobs was done in JINR during the past year

Planning to continue participate in BES-III experiment by:

- Improving monitoring
- Research on clouds in grid
- Providing storage and CPU cores



CE availability monitoring

Site	Test	Result	Received ago	Description
CLUSTER.SDU.cn	WMS-test	Success	43 min	Remote call
GRID.INFN-Torino.it	WMS-test	Success	8 min	Remote call
CLOUD.IHEP-OPENSTACK.cn	WMS-test	Success	86 min	Remote call
GRID.INFN-ReCas.it	WMS-test	Success	40 min	Remote call
CLOUD.CNIC.cn	WMS-test	Success	44 min	Remote call
CLUSTER.UMN.us	CVMFS-test	Success	37 min	Success
GRID.INFN-Torino.it	CVMFS-test	Success	8 min	Success
CLOUD.IHEP-OPENSTACK.cn	CVMFS-test	Success	30 min	Success
CLOUD.IHEP-OPENNEBULA.cn	CVMFS-test	Success	33 min	Success
GRID.INFN-ReCas.it	CVMFS-test	Success	36 min	Success
CLOUD.CNIC.cn	CVMFS-test	Success	42 min	Success
CLUSTER.UMN.us	BOSS-test			
GRID.INFN-Torino.it	BOSS-test			
GRID.INFN-ReCas.it	BOSS-test			
CLOUD.CNIC.cn	BOSS-test			
CLOUD.AWS.cn	WMS-test			
CLOUD.AWS.cn	CVMFS-tes			
BOINC.IHEP.cn	BOSS-test			
CLOUD.AWS.cn	BOSS-test			
CLUSTER.SDU.cn	CVMFS-tes			
CLUSTER.SDU.cn	BOSS-test			

Main objective of the 7-year plan

Creation of a **unified information environment** integrating a number of various technological solutions, concepts, techniques, and software in order to offer **optimal approaches** for solving various types of **scientific and applied** tasks on a global level of the development of advanced information and computation technologies

Unified environment

- Grid
- Supercomputer (heterogeneous)
- Cloud
- Local computing cluster
- ….

Requirements:

- scalability
- interoperability
- adaptability to new technical solutions.
- operates 12 months a year in a 24x7 mode

CICC to MICC

Build up the Multifunctional Information and Computing Complex (MICC)

- fault-tolerant infrastructure with electrical power storage and distribution facilities with expected availability of 99.995%,
- supports and uses a large variety of architectures, platforms, operational systems, network protocols and software products
- provides means for organization of collective development
- supports solution of problems of various complexity and subject matter
- enables management and processing of data of very large volumes and structures (Big Data)
- provides means to organize scientific research processes
- enables training IT infrastructure users

Multifunctional Information&Computing Complex

- Engineering infrastructure
- Local network infrastructure and telecommu-nication data links
- Tier1 level grid automated system of data processing of the CMS experiment on the Large Hadron Collider (LHC) , including that as a prototype of the system of data storage and processing of the NICA experiments in a role of the center of Tier0 and Tier1 levels
- Tier-2 level grid-system to support LHC experiments (ATLAS, ALICE, CMS, LHCB), FAIR (PANDA) and other large-scale experiments and projects within the global grid-infrastructure
- High-performance computing system (including parallel computations) beyond the range of heterogeneous and grid systems
- Heterogeneous computer complex for high-efficiency calculations
- Cloud environment

Research and Development

- development of a distributed research environment ;
  - research in the field of integration of heterogeneous computing resources and data sources;
  - research on the questions of optimizing usage of the existing capacities, in particular supercomputers, for data processing in a distributed environment;
  - scientific studies in the field of integrating hybrid (HPC), cloud and grid technologies with the purpose of their optimal use;
  - research in the field of the local and global monitoring of distributed computing systems;
  - research and development of intellectual methods of new generation computing infrastructure management;
  - introduction and development of the methodology of a short-term/medium term/long-term forecast of the development of the multifunctional computer center;
- research in the field of intensive operations with massive data in distributed systems (Big Data), development of corresponding tools and methods of visualization, including 3D;
- development of new parallel applications, cross-platform and multi-algorithm software complexes in a heterogeneous computing environment that allows one to expand the spectrum of solvable computationally intensive fundamental scientific problems.

SOFTWARE

Parallel software will be the mainstream:

- development and support of the program libraries of general and special purpose;
- creation and support of program libraries and software complexes realized on the parallel programming technologies CUDA, OpenCL, MPI+CUDA, etc.;
- support and development of a specialized service-oriented environment for modeling experimental installations and processes and experimental data processing;
- tools and methods for software development:
  - flexible, platform-independent simulation tools
  - self-adaptive (data-driven) simulation development software

The JINR corporative information system

- General Information platform 1C,
- APT EVM system (Activity Planning Tool Earned Value Management) for NICA and future projects management,
- JINR Document Server – electronic archive-repository of scientific publications and documents,
- JINR and JINR Member-states access to e-library,
- PIN – JINR staff personal information,
- JINR Events at Indico,
- JINR video portal,
- geographic information system (GIS) - a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data of the JINR infrastructure

Cognitive system

- Collaborative work support
- Advanced knowledge management tools

Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data

New computing technologies need new mathematical support and adaptation of the earlier developed software to the functioning on heterogeneous architectures and creation of new applications on the basis up-to-date paralleling technologies

- software development and realization of mathematical support of experiments conducted on the JINR basic facilities and in the frameworks of international collaboration;
- development of numerical methods, algorithms and software packages for modelling complex physical systems:
  - interactions inside hot and dense nuclear matter,
  - physicochemical processes in materials exposed to heavy ions,
  - evolution of localized nanostructures in the open dissipative systems,
  - properties of atoms in magnetic optical traps,
  - electromagnetic response of nanoparticles and optical properties of nanomaterials,
  - evolution of quantum systems in external fields,
  - astrophysical studies;
- development of methods and algorithms of computer algebra for simulation and research of quantum computations and information processes;
- development of symbolic-numerical methods, algorithms and software packages for the analysis of low-dimensional compound quantum systems in molecular, atomic and nuclear physics.

Projects of LIT in distributed computing

- Worldwide LHC Computing Grid (WLCG)
- EGI-InSPIRE
- RDIG Development
- Project BNL, ANL, UTA "Next Generation Workload Management and Analysis System for BigData"
- Tier1 Center in Russia (NRC KI, LIT JINR)
- 6 Projects at CERN
- CERN-RFBR project "Global data transfer monitoring system for WLCG infrastructure"
- BMBF grant "Development of the grid-infrastructure and tools to provide joint investigations performed with participation of JINR and German research centers"
- "Development of grid segment for the LHC experiments" was supported in frames of JINR-South Africa cooperation agreement;
- Development of grid segment at Cairo University and its integration to the JINR GridEdu infrastructure
- JINR - FZU AS Czech Republic Project "The grid for the physics experiments"
- NASU-RFBR project "Development and implementation of cloud computing technologies on grid-sites of Tier-2 level at LIT JINR and Bogolyubov Institute for Theoretical Physics for data processing from ALICE experiment"
- JINR-Romania cooperation Hulubei - Meshcheryakov programme
- JINR-Moldova cooperation (MD-GRID, RENAM)
- JINR-Mongolia cooperation (Mongol-Grid)
- JINR-China cooperation (BES-III)
- Cooperation with Belarus, Slovakia, Poland, Bulgaria, Kazakhstan, Armenia, Georgia, Azerbaijan…

Cooperation with Romania (1)

- **JINR-Romania cooperation Hulubei - Meshcheryakov programme**
- **Main directions of cooperation:**
- **- development of dedicated Grid infrastructure within WLCG**
- **- research in computer mathematics and computer physics**
- **Directional financing (grants and projects of the Romanian Plenipotentiary Representative to JINR)** cca. 60 k$/year
- **Main use of these money:**
- **- upgrade of the heterogeneous hybrid computing cluster HybriLIT** (by acquisition of basic hardware modules, basic license software)
- **- organization of conferences** (8 k$ for MMCP 2015)
- **- mobility**
- **Tutorials on parallel computing using HybriLIT**

Cooperation with Romania (2)

- **Future cooperation will continue within Hulubei - Meshcheryakov programme.**
- **The most perspective topics:**
- **- development of cloud computing infrastructure**
- **- parallel programming** (training and research) **based on the heterogeneous hybrid computing cluster HybriLIT**
- **- research in mathematical modeling of physical phenomena** (including entanglement) **in strong laser fields expected to be created at the new ELI-NP facility**

LIT traditional conferences and schools in 2015

MATHEMATICAL MODELING AND COMPUTATIONAL PHYSICS 2015

Stará Lesná, High Tatra Mountains, Slovakia

July 13 — 17, 2015

XXV INTERNATIONAL SYMPOSIUM ON NUCLEAR ELECTRONICS & COMPUTING

Montenegro, Budva, 28 september - 02 october

and

SCHOOL ON NUCLEAR ELECTRONICS & COMPUTING

JINR/CERN/MEPHI

GRID AND ADVANCED INFORMATION SYSTEMS

SCHOOL ON JINR/CERN GRID AND ADVANCED INFORMATION SYSTEMS

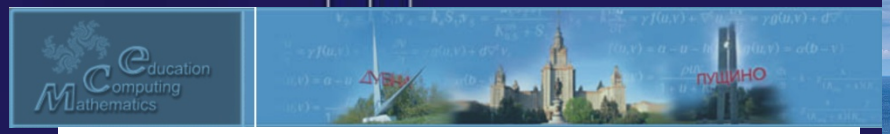
November 02-06, 2015

In LIT holds regular tutorial courses and traineeship of young scientists and students from the JINR Member States

RO-LCG 2015, Cluj-Napoca, 28 - 30 Oct. 2015

LIT traditional conferences

Distributed Computing and Grid-technologies in Science and Education



Mathematics. Computing. Education

DIGITAL LIBRARIES: ADVANCED METHODS AND TECHNOLOGIES, DIGITAL COLLECTIONS

The International Conference Mathematical Modeling and Computational Physics, 2015

LIT schools

JINR / CERN

GRID AND ADVANCED INFORMATION SYSTEMS

IT – Student's SCHOOL BASED ON XXV INTERNATIONAL SYMPOSIUM ON NUCLEAR ELECTRONICS & COMPUTING

AIS-GRID-2015

2-6 November

In LIT holds regular tutorial courses and traineeship of young scientists and students from the JINR Member States

RO-LCG 2015, Cluj-Napoca, 28 - 30 Oct. 2015

In 2016 JINR will celebrate its 60th anniversary.
You all are welcome to take part in this remarkable event !

Thank you for your attention!