Laboratory of Information Technologies: Status and Future

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Director LIT JINR

Grid-2016, LIT JINR
04 July 2016

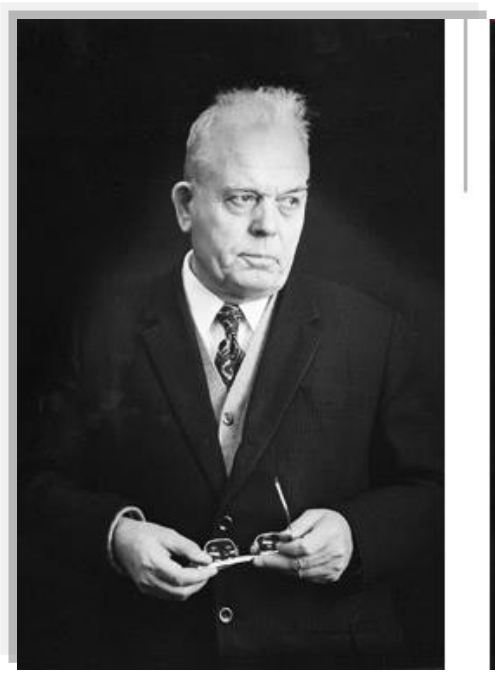
Grid technologies - a way to success

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).

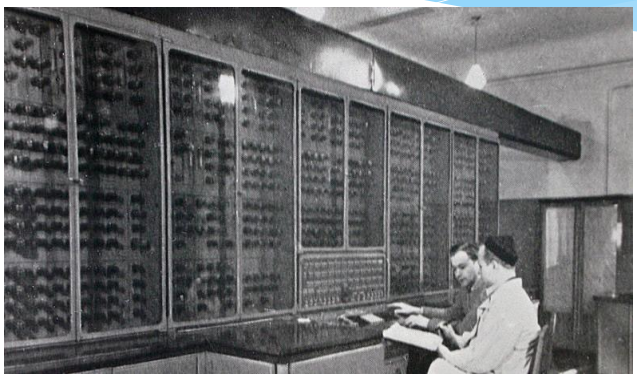
Without implementation of the grid-infrastructure on LHC it would be impossible to process and store enormous data coming from the collider and therefore to make discoveries.

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

In 1966 the Laboratory of Computing Techniques and Automation (Laboratory of Information Technologies) is formed in JINR



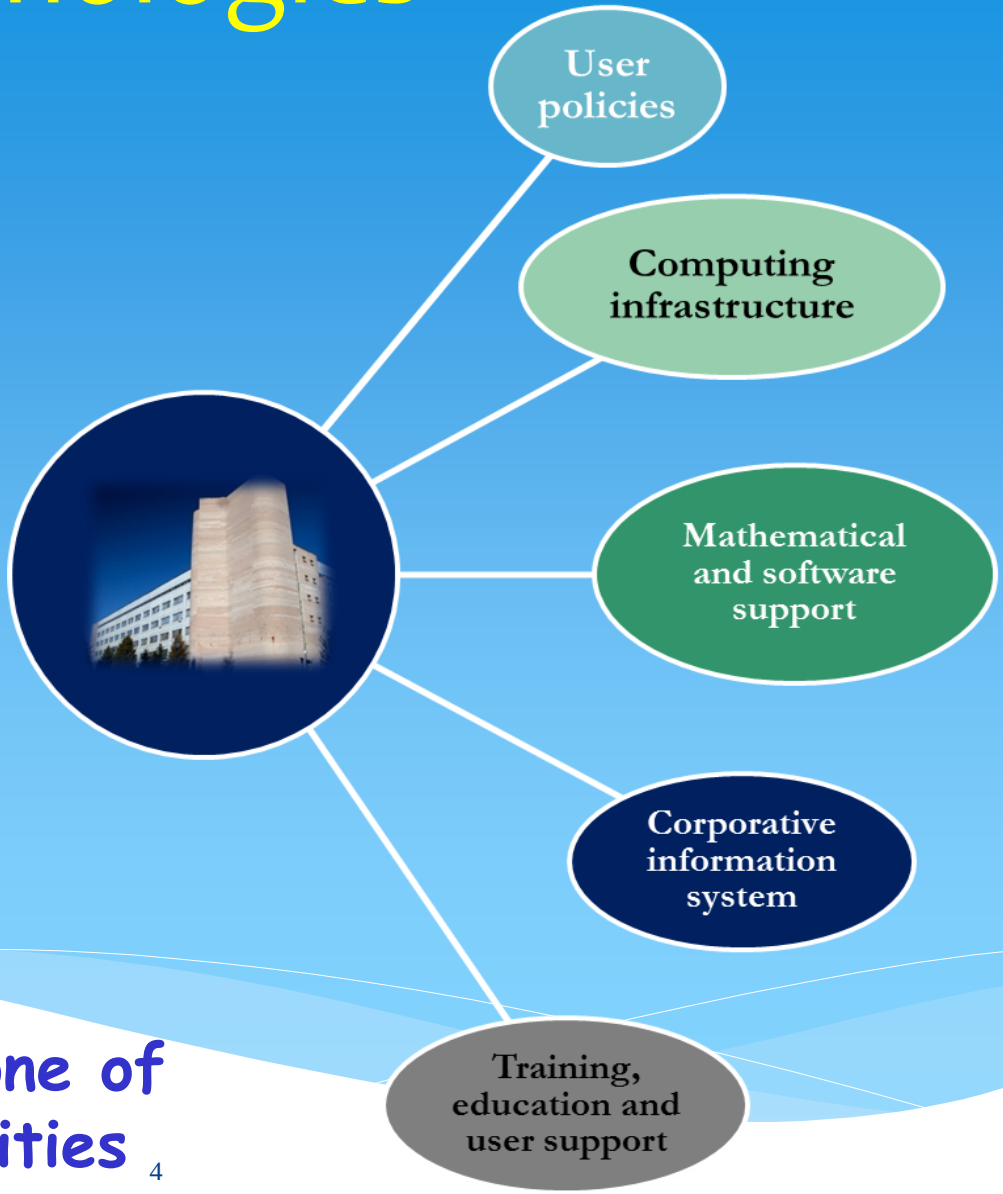
M. G. Meshcheryakov
(17.09.1910 - 24.05.1994)



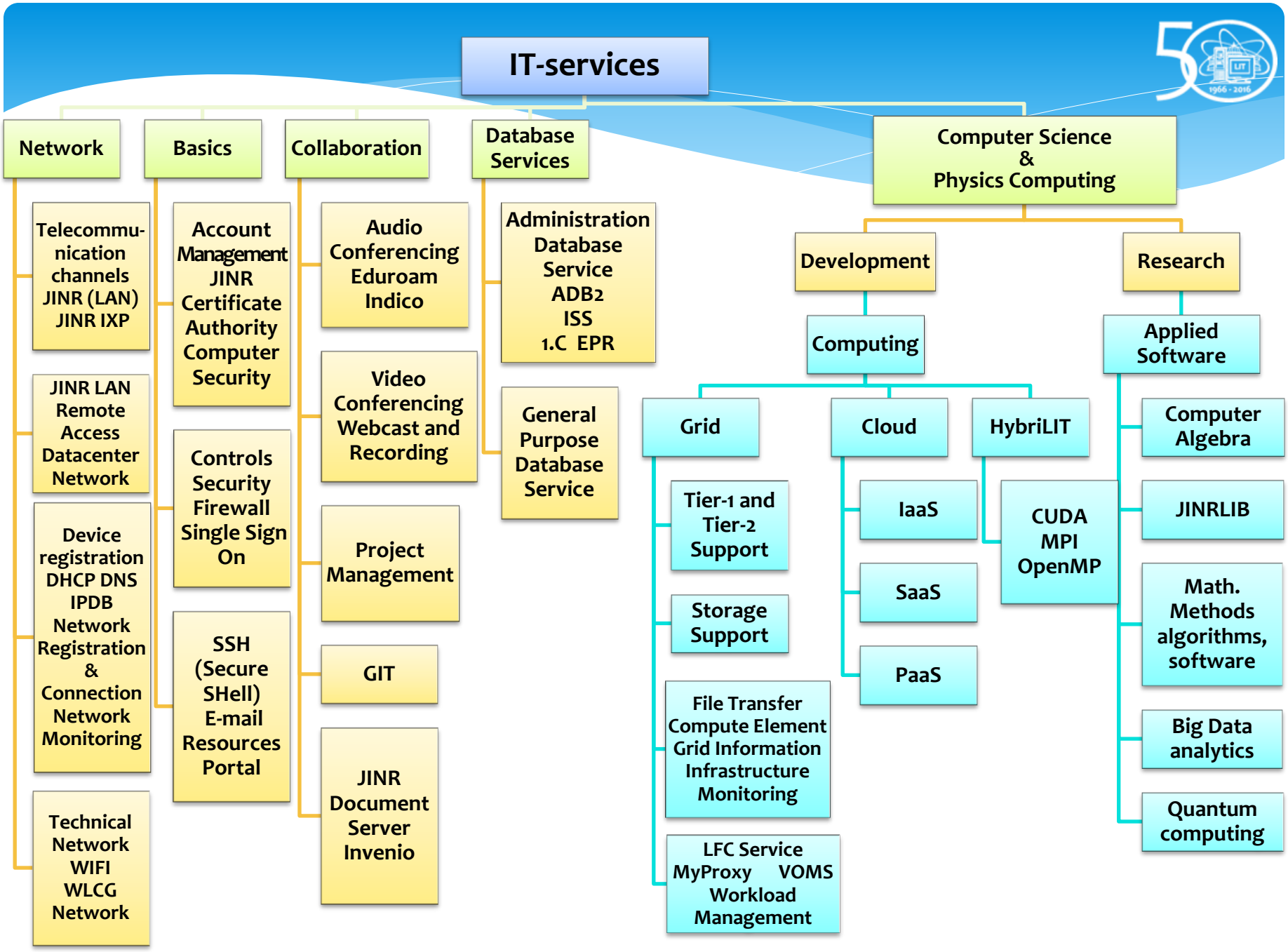
N. N. Govorun
(18.03.1930 - 21.07.1989)

IT technologies

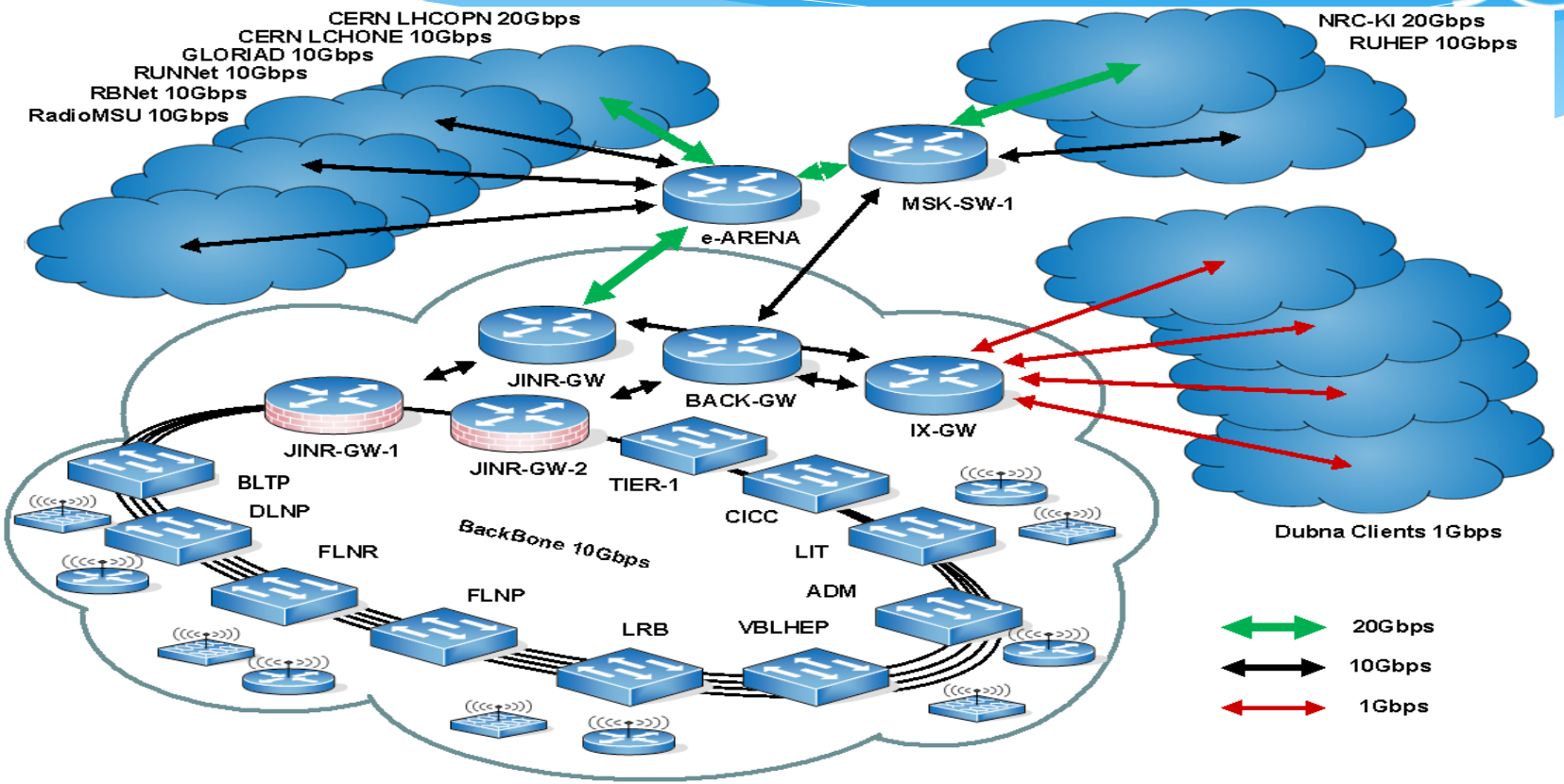
- The computer infrastructure development program.
- Mathematical support of studies conducted at JINR.
- Development of the multifunctional information and computing complex.



IT-infrastructure is one of the JINR basic facilities


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

Network and Telecommunication at JINR



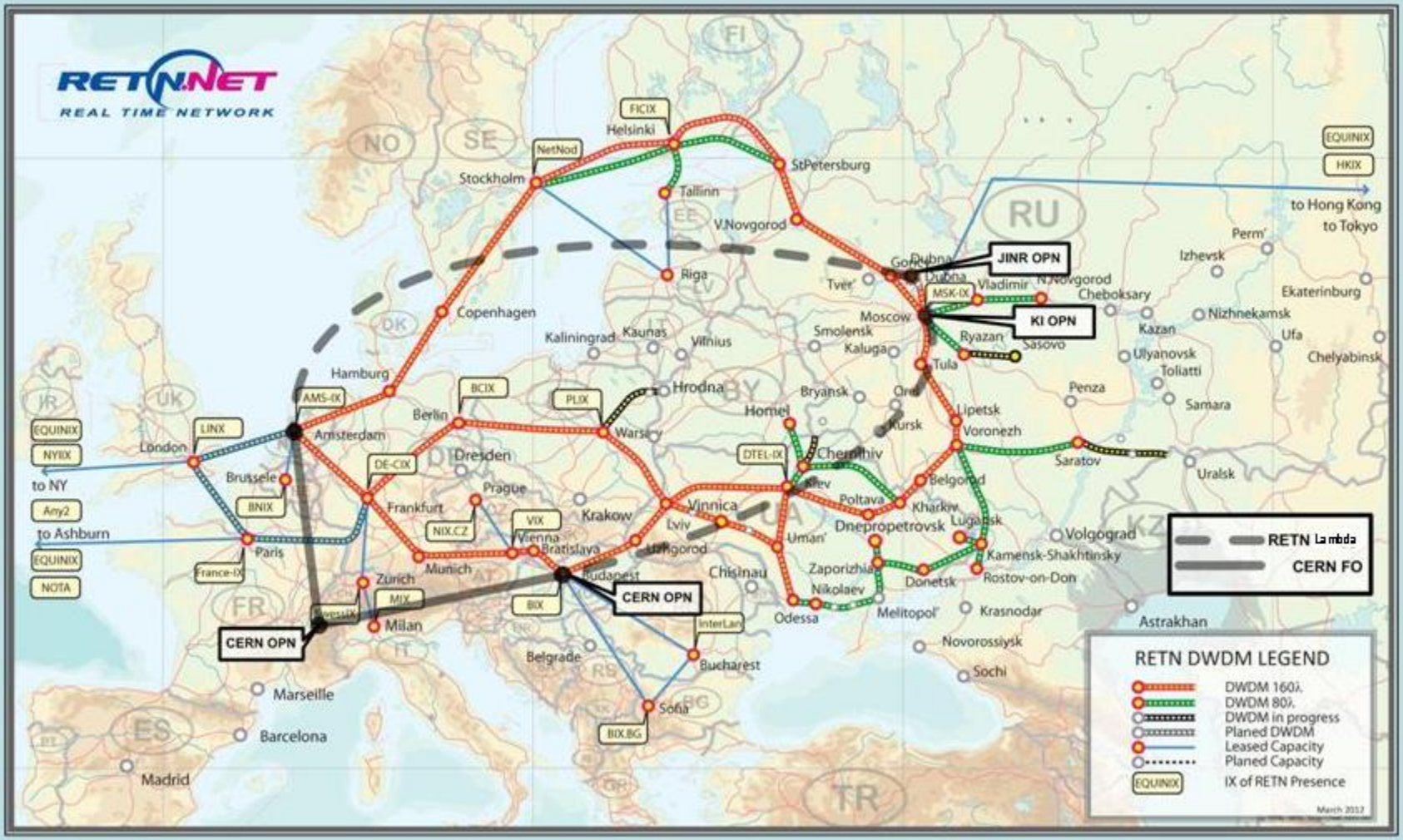
JINR Local Area Network

Comprises **8146** computers & nodes
Users – **4379**, IP – **13436**
Remote VPN users – **780**
E-library**- 1475,** mail.jinr.ru**-2400**

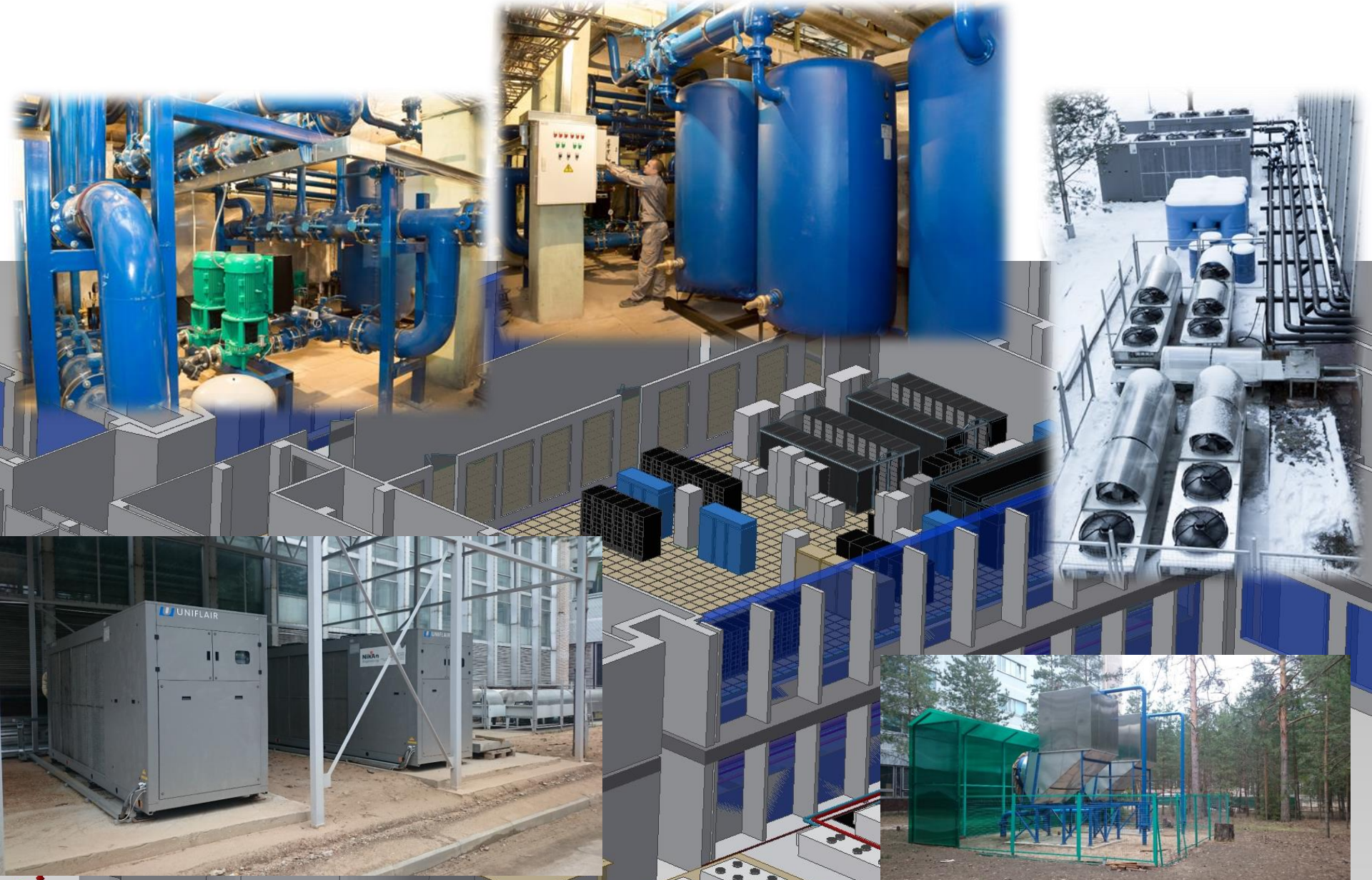
Controlled-access at network entrance.
General network authorization system involves basic services (Kerberos,AFS, batch systems, JINR LAN remote access, etc.)
IPDB database - registration and the authorization of the network elements and users, visualization of statistics of the network traffic flow,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

The upgrade of the JINR-Moscow telecommunication channel for data transfer up to 100 Gb/s speed has been approved

JINR Tier1 Connectivity Scheme



Engineering infrastructure

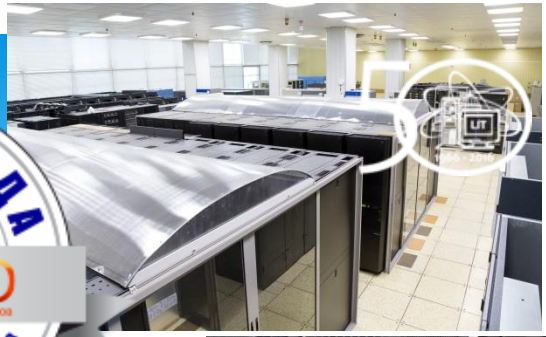


JINR Computing Centre for Data Storage, Processing and Analysis

- Increase of computational nodes by ~3 times: **to 6160**
- Increase of disk file system by ~3 times: **to 5000 TByte**
- Tape robot for **5000 TByte** was put into operation
- **100 Gps** telecommunication link to Moscow will be put into operation on the end of 2016

During three years more than **15 million** tasks have been carried out on the basis of the Computation center of JINR

JINR CMS Tier1 Center



LHCOPN – 10Gbps, 3400 cores (~ 50 kHS06),
5 PB tapes (IBM TS3500), 3.4 PB disk
Close-coupled, chilled water cooling InRow
Hot and cold air containment system
MGE Galaxy 7000 – 2x300 kW

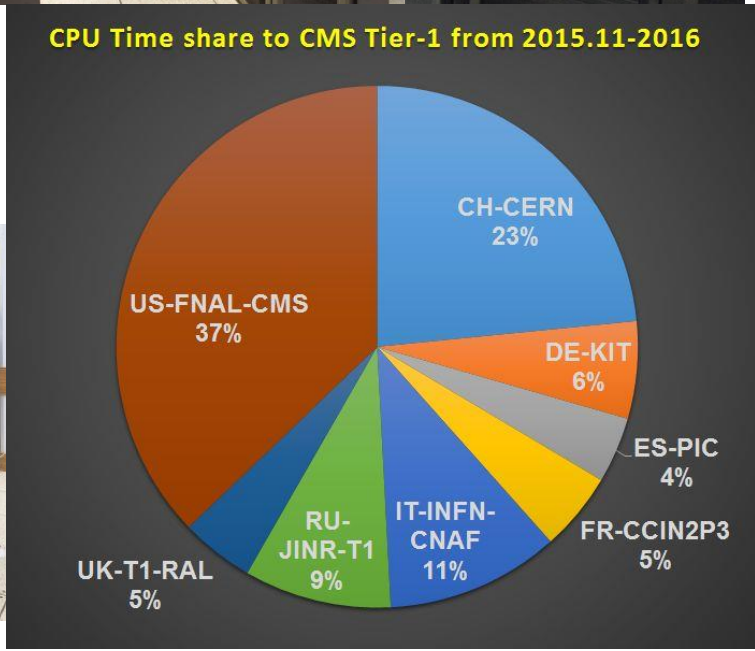
March 2015 – CMS Tier1 Inauguration

Computing elements

Uninterrupted power supply

NETWORK

Tape Robot



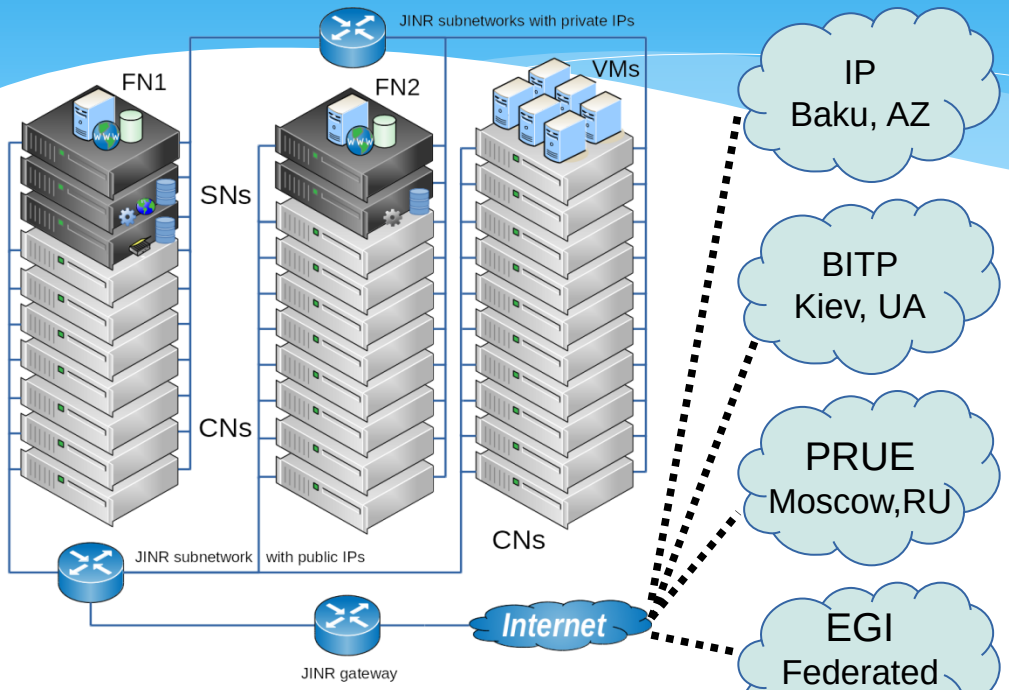
Monitoring system for the MICC

1. Monitor the state of all nodes and services- from the supply system to the robotized tape library.
2. Observe, in a real time mode, the whole computing complex state
3. Send the system alerts to users via e-mail, sms, etc.
4. ~690 elements are under observation
5. ~ 3500 checks in real time

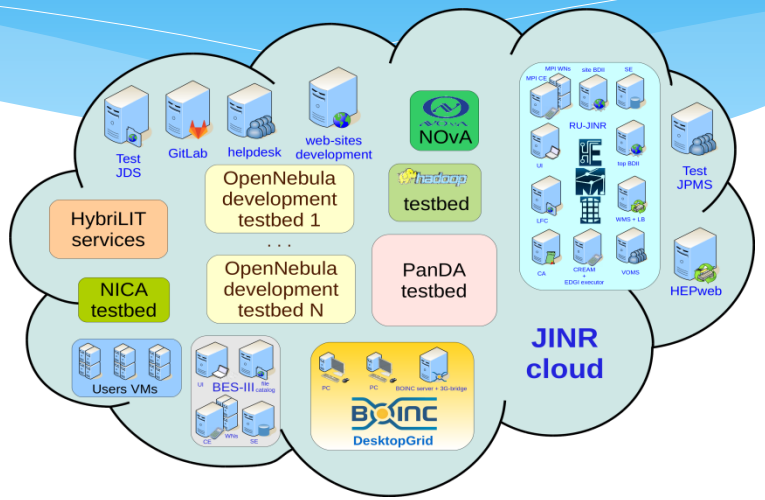
Further development of the monitoring system for the MICC architecture.
The development of a monitoring system that integrates the monitoring of all MICC components: engineering infrastructure, Tier-1, CICC/Tier-2, cloud environment, and heterogeneous cluster

JINR cloud infrastructure

JINR cloud architecture



JINR cloud utilization



JINR cloud characteristics:

Based on OpenNebula

CPU cores: 200

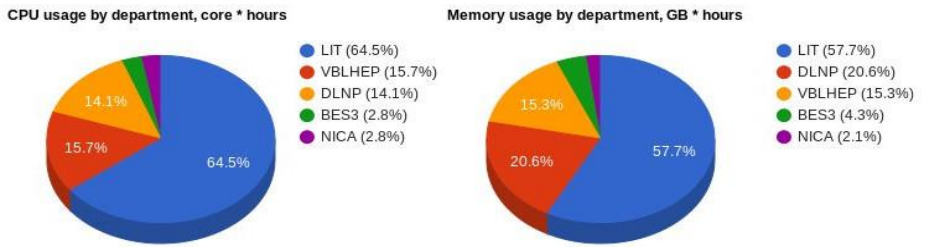
Total RAM: 400

Total disk capacity: 16 TB

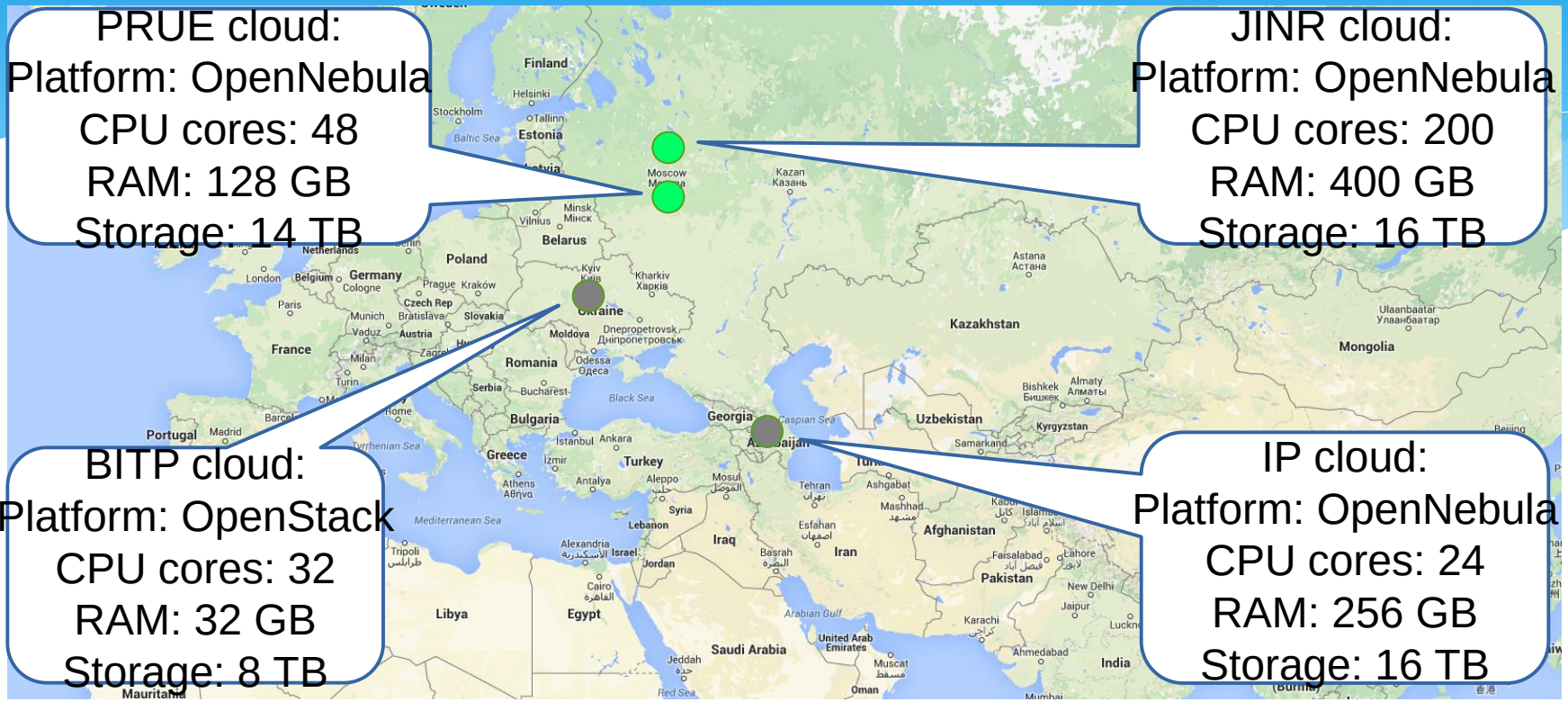
Registered users: 77

# of running VMs: 100

JINR cloud usage statistics



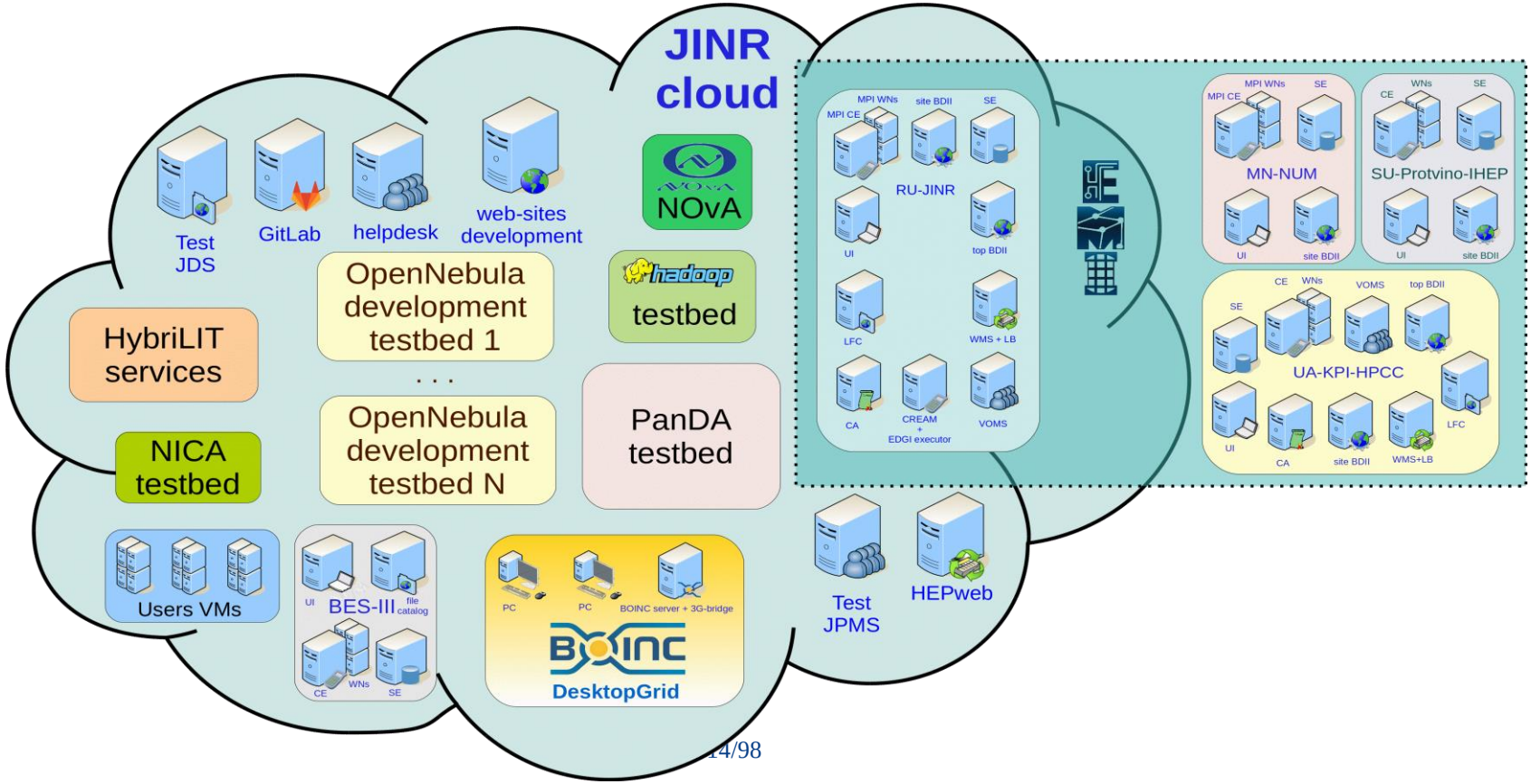
Clouds Integration



- To join resources for solving common tasks as well as to distribute a peak load across resources of partner organizations
- JINR cloud integration with clouds of partner organizations:
  - Institute of Physics of Azerbaijan National Academy of Sciences – IP (Baku, Azerbaijan)
  - Bogolyubov Institute for Theoretical Physics of the National Academy of Sciences of Ukraine – BITP (Kiev, Ukraine)
  - Plekhanov Russian University of Economics – PRUE (Moscow, Russia)
  - EGI Federated cloud

JINR distributed cloud grid-infrastructure for training and research

Educational, training, research and testing grid infrastructure (t-infrastructure for short) consists of a set of testbeds deployed on different grid middlewares. All grid services of each testbed are running on virtual machines (VMs) deployed in the JINR cloud service.

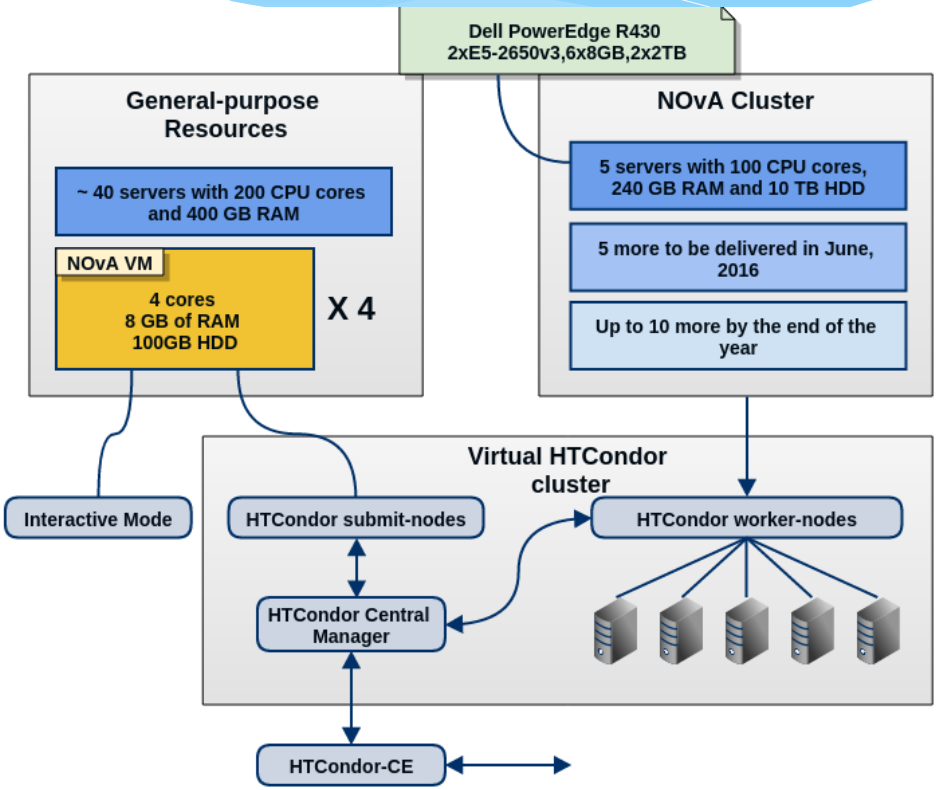


Computing Support for Neutrino Projects

NOvA (Fermilab, USA) is the first neutrino experiment actively using JINR Cloud:

- ✓ 4 VMs for interactive/batch processing used by local JINR NOvA team
- ✓ Virtual batch-cluster based on HTCondor and connected to OSG
- ✓ 100 CPU, 240 GB RAM and 10 TB HDD already available
- ✓ Up to 400 CPU, 1 TB RAM and 80 TB HDD by the end of the year
- ✓ Computing support team was formed including physicists and IT specialists

These resources may also be used by other future experiments at Fermilab, such as DUNE and mu2e.



Reactor neutrino experiments Daya Bay and JUNO also showed its interest in using JINR cloud resources. At the moment the experiments' tasks and required computing capacities are being discussed.

HybriLIT: heterogeneous computation cluster

Current Status 2016: 12 calculation nodes

Total performance: single precision 111 TFLOPS

double precision 40 TFLOPS

- **Computing resources:**

14x CPU Intel Xeon	224 cores
14x GPU K20, K40 & K80	47232 cores
3x Intel Xeon Phi 5110P & 7210P	182 cores

RAM 1920 GB

EOS storage 55.2 TB

Ethernet

InfiniBand 40 GB/s

- Power consumption 8.29 kW

Energy efficiency 4.56 GFlops/W

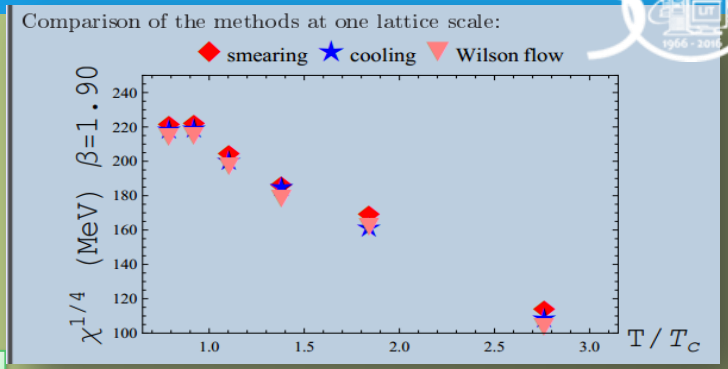
Peak power demand 10 kW

Currently the **total number** of users comprise **120** persons, including **26** from JINR Member States (*Armenia, Bulgaria, Mongolia, Romania, Slovakia, Ukraine*, etc.) and **19** – from Russia Universities : *MSU, SPSU, PFUR and "Dubna" University.*

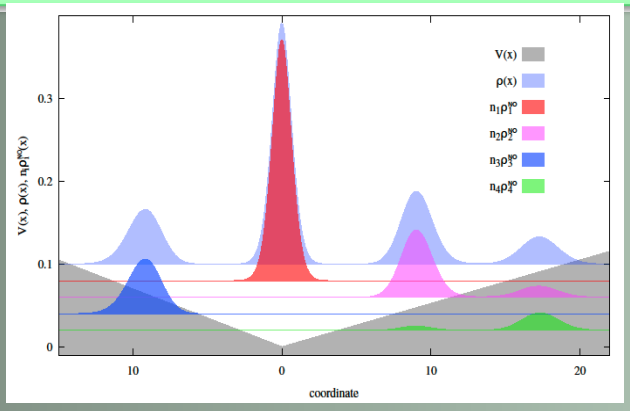
Parallel computing on HybriLIT

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:

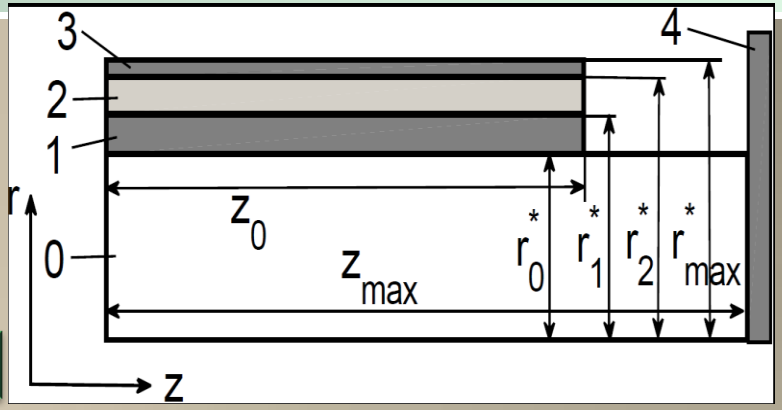
Alexej I. Streltsov ("Many-Body Theory of Bosons" group at CQD, Heidelberg University, Germany),
Oksana I. Streltsova (LIT JINR)

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

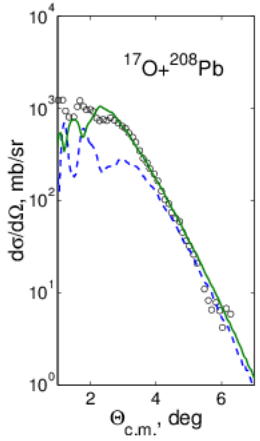


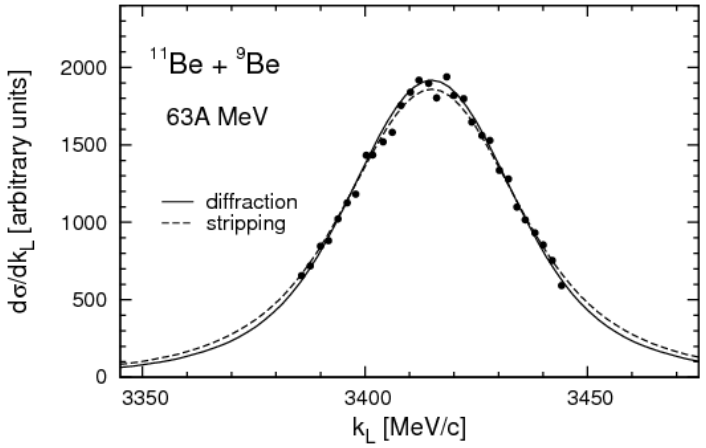
Hybrid Optical Potential Description of Elastic Scattering and Fragmentation Processes

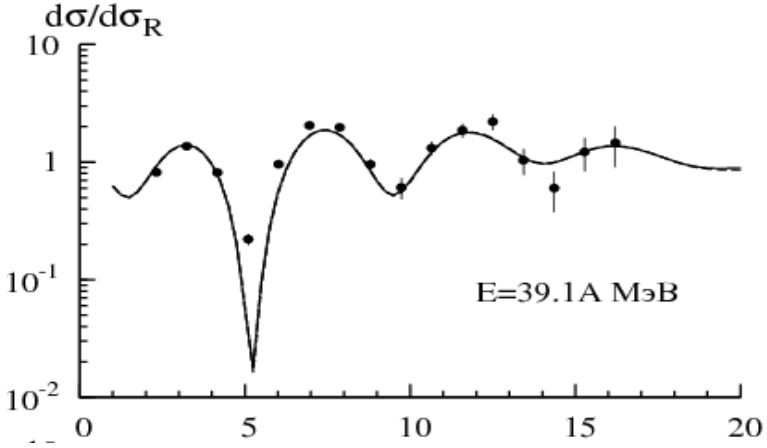
Computer time vs number of processes and discretization N. Calculations on the HybriLIT cluster of the microscopic OP for $^{6}He+^{28}Si$ at 50 Mev/Nucleon.

Number of processes	1	2	4	8	16	32
N=201	1156	399	153	75	66	76
N=401	15697	8106	4098	1745	834	968

Most recent results of analysis of elastic scattering and fragmentation processes of $^{10}Be+^{12}C$ from [Phys. Rev. **C 91** (2015) 034606]







V.K. Lukyanov, D.N. Kadrev, E.V. Zemlyanaya, K. Spasova, K.V. Lukyanov, A.N. Antonov, M.K. Gaidarov, PRC 91, 034606 (2015)

HybriLIT: tutorials

Parallel programming technologies on hybrid architectures

intel, Intel Xeon Phi, NVIDIA, MPI, OpenMP, Intel Cluster Studio, NVIDIA CUDA, OpenCL

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 **Dubna University**, **Sofia university**, **National University of Mongolia, Technical University of Moldova**. In particular within GRID'2014, MPAMCS'2014, The Helmholtz International Summer School 2014; ***MMCP'2015***, ***NEC'2015, AIS-GRID'2015, MCE'2016, May 2016, Master Class on Parallel Programming at University of Presov***. Planned: ***GRID-2016.***

All information (lectures, materials) of past and upcoming events can be found on http://indico-hybrilit.jinr.ru/

Worldwide LHC Computing Grid Project (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.

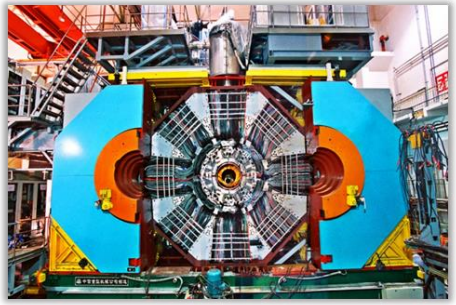
Tasks of the Russian centers and JINR within WLCG :

- 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
* Tier1 center for CMS

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

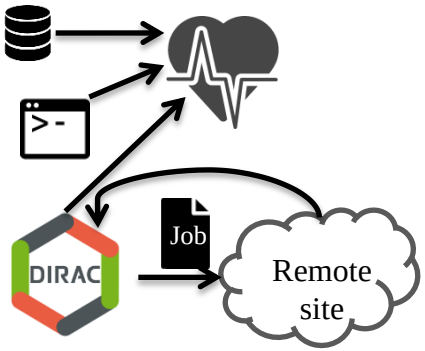
CLUSTER.USTC.c
200
24 TB

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

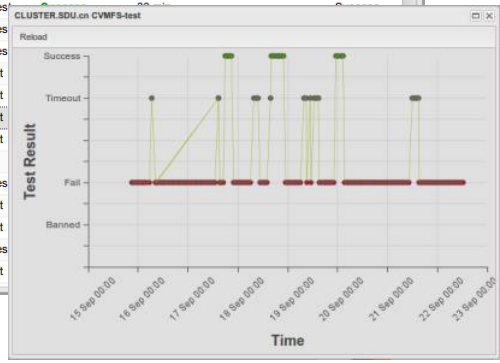
Planning to continue participate in BES-III experiment by:

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



CE availability monitoring

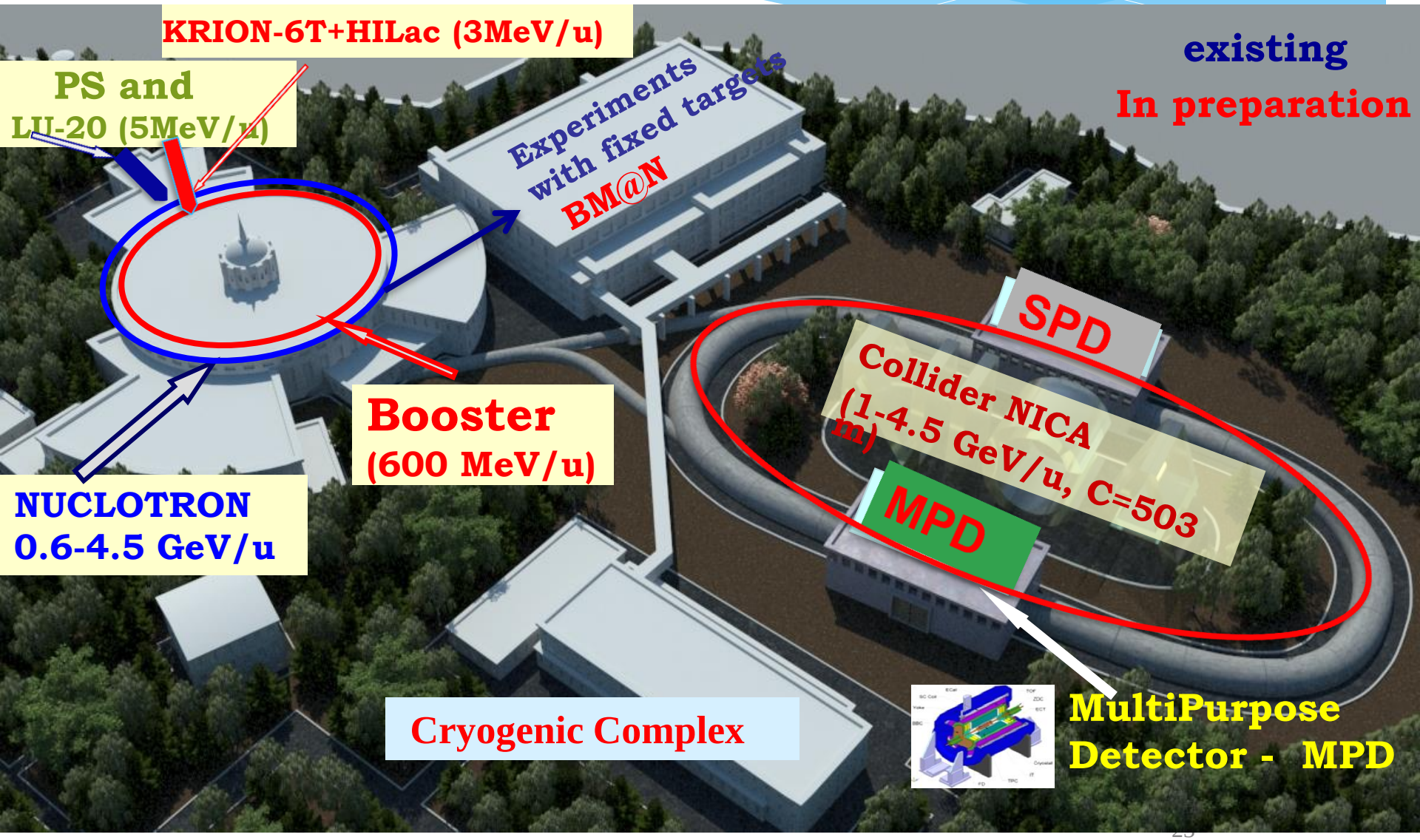
Site	Test	Result	Received ago	Description
CLUSTER.SDU.cn	WMS-test	Success	43 min	Remote call
GRID.INFN-Torino.it	WMS-test	Success	8 min	Remote call
CLOUD.IHEP-OPENSTACK.cn	WMS-test	Success	86 min	Remote call
GRID.INFN-ReCas.it	WMS-test	Success	40 min	Remote call
CLOUD.CNIC.cn	WMS-test	Success	44 min	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-tes			
GRID.INFN-ReCas.it	CVMFS-tes			
CLOUD.CNIC.cn	CVMFS-tes			
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			



NICA Complex: *New era in the hot dense matter science*

Collider basic parameters:

$\sqrt{S_{NN}}$ = 4-11 GeV; *beams: from* p to Au; L~10^{27} cm^{-2} c^{-1} (Au), ~10^{32} cm^{-2} c^{-1} (p)



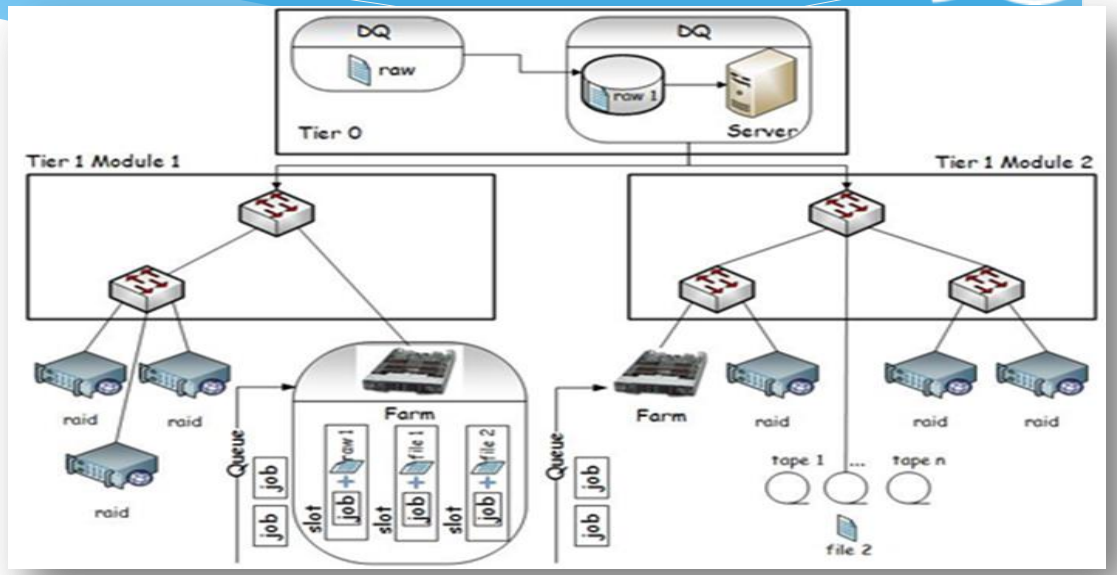
Simulation of NICA-MPD-SPD Tier0-Tier1 computing acilities

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

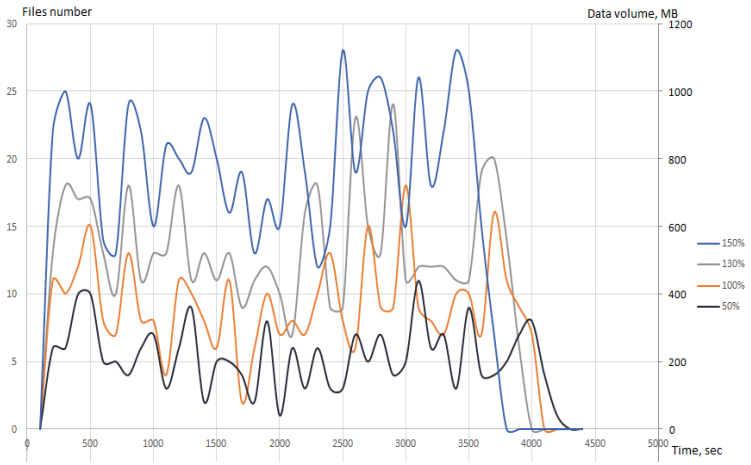
- large increase of CPU and network resources;
- combined grid and cloud access;
- Intelligent dynamic data placement
- distributed parallel computing;
- renewal most of simulation and analysis software codes.

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

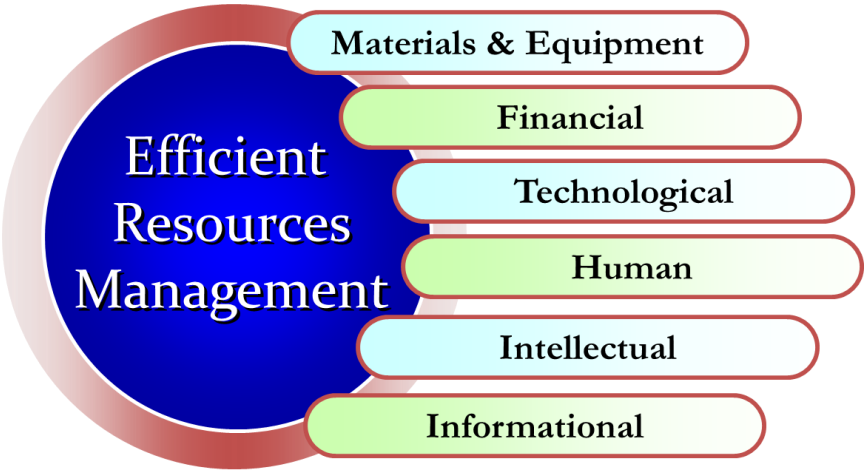


Number of DAQ data files stored on output disk buffer for growing data volumes

Estimated rate of NICA-MPD experimental data from Tier0 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

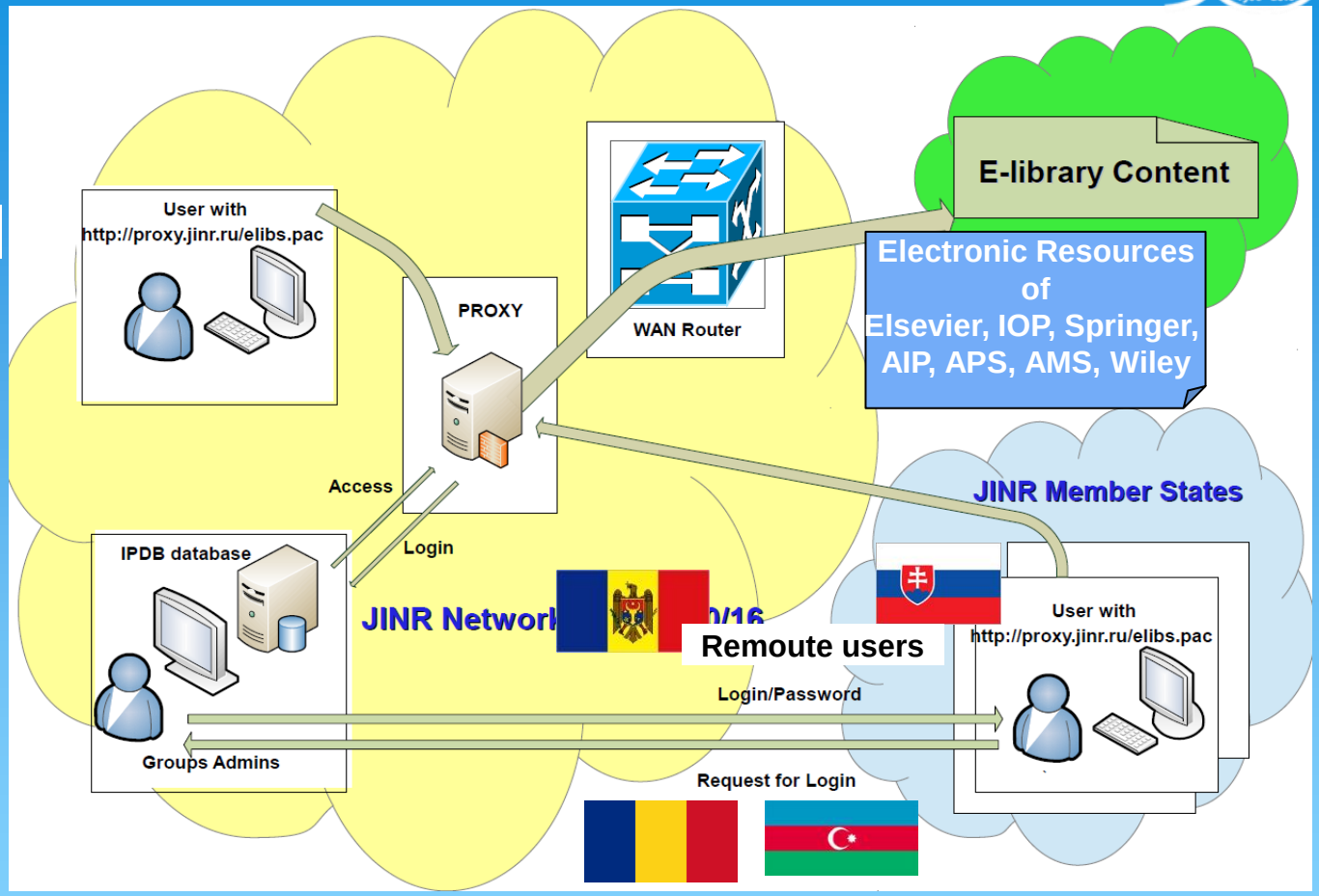
The JINR corporative information system (CIS)

- General 1C:Enterprise 8 platform intended for automation of everyday tasks of economic and management activity,
- APT EVM system (Activity Planning Tool Earned Value Management) for NICA and future projects management,
- Electronic document handling system EDH «Dubna»
- JINR Document Server – electronic open archive-repository of scientific publications and documents,
- JINR and JINR Member-states access to e-library,
- PIN – JINR staff personal information,
- JINR video portal



Access Service to Electronic Resources of World Publishers

Local users

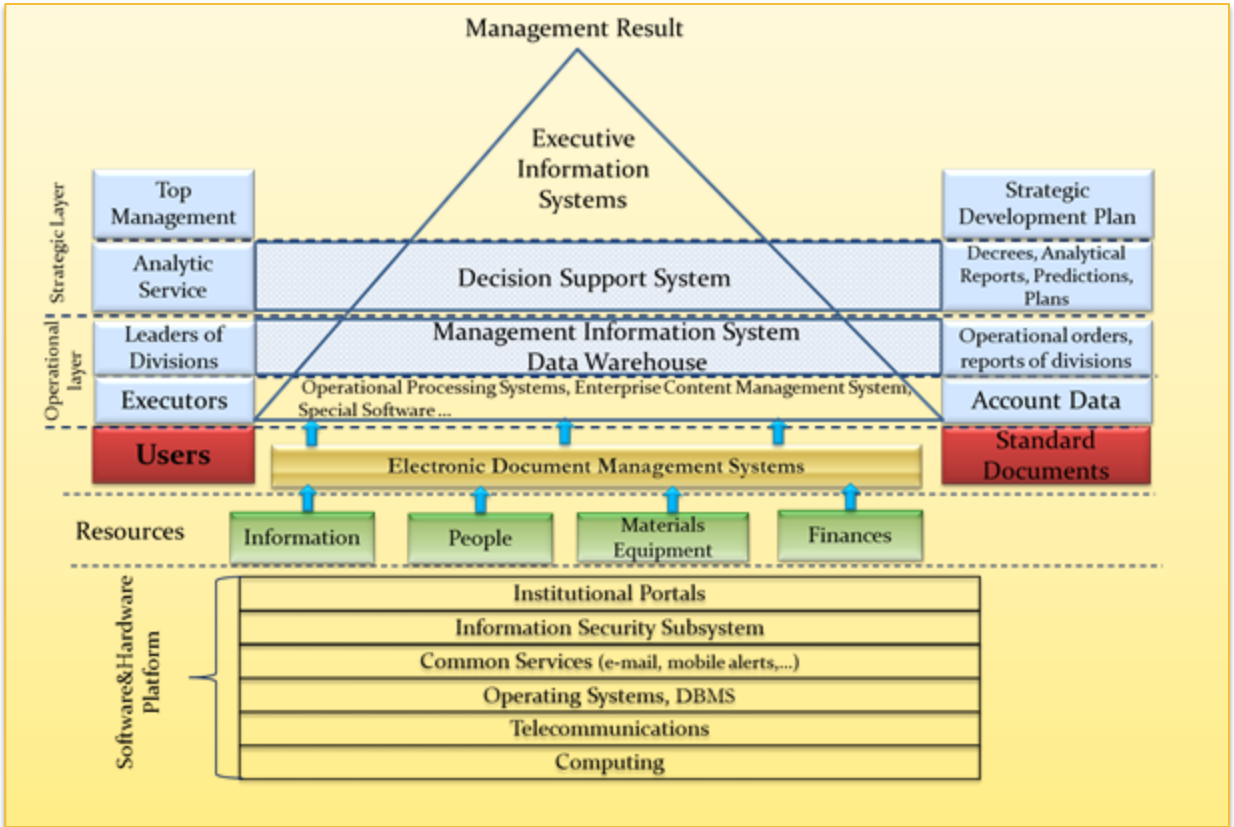


Total e-library users: 1475

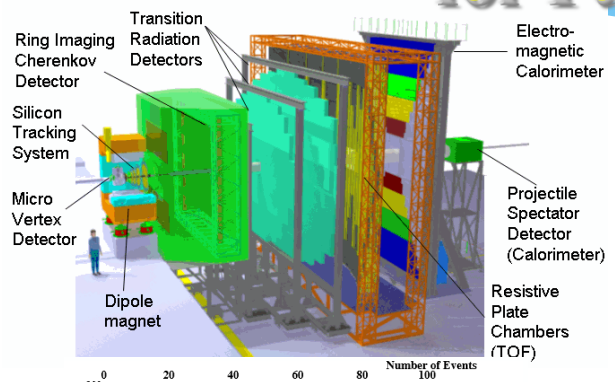
Remote JINR users from Member States :
Republic of Azerbaijan - 24, Georgia - 8
Slovak Republic - 39, Bulgaria - 10,
Republic of Moldova – 9, Romania – 37

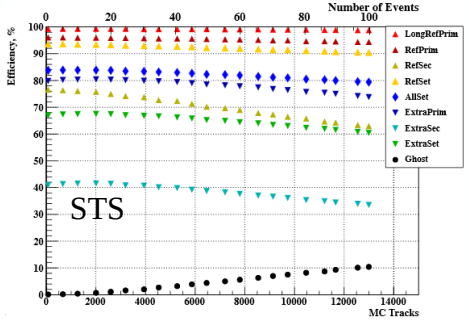
Development of CIS JINR

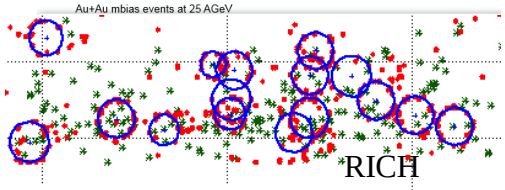
Implementation of fully integrated corporate information system (CIS) at JINR that comprises subsystems of accounting, financial and personnel records, electronic document circulation, interconnected through a universal gateway for data exchange and providing a rapid access to accurate management information. Development of the information management system for the NICA project. The PIN subsystem upgrade. Implementation of the system "My account" which provides the end user with access to personal information and simplifies access to the CIS JINR. Development of digital libraries and video portals.

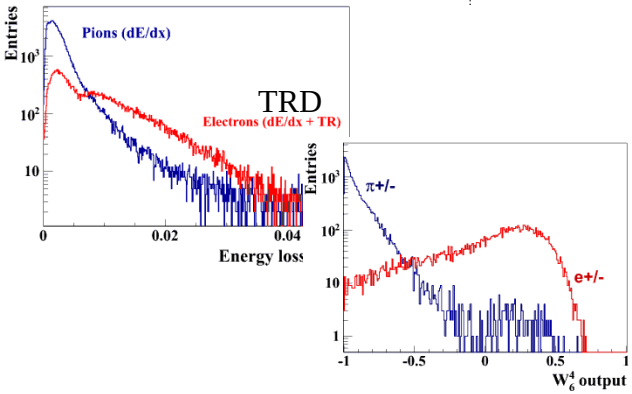


CBM@GSI – Methods, Algorithms & Software for Fast Event Reconstruction



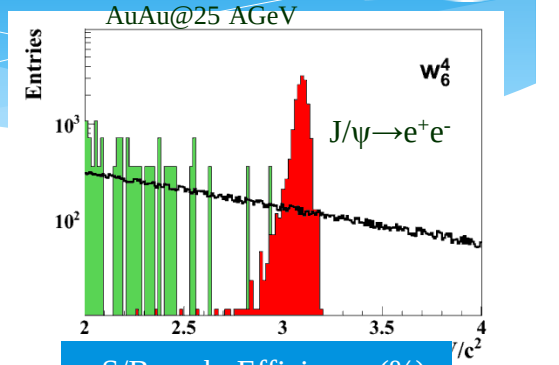






Tasks:

- global track reconstruction;
- event reconstruction in RICH;
- electron identification in TRD;
- clustering in MVD, STS and MUCH;
- participation in FLES (First Level Event Selection);
- development of the Concept of CBM Databases;
- magnetic field calculations;
- beam time data analysis of the RICH and TRD prototypes;
- contribution to the CBMROOT development;
- D0-, vector mesons, $J/\psi \rightarrow e^+e^-$ and $J/\psi \rightarrow \mu^+\mu^-$ reconstruction;

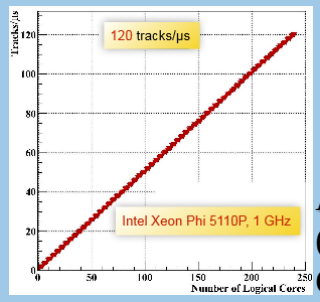


a: $S/Bg_{2\sigma}$, b: Efficiency (%), c: J/ψ per hour (10 Mhz)

	a	b	c
pC@30GeV	14	22	11
pAu@30GeV	18	22	27
AuAu@10AGeV	0.18	18	64
AuAu@25AGeV	7.5	13.5	5250

Modern parallelization involves multiplicative effects coming from:

1) Vectorization (SIMD - Single Instruction Multiple Data) factor 2 to 4;
2) Multithreading – factor 4/3 ; 3) υ -Many core processor – factor υ. Total ≈ 4 υ



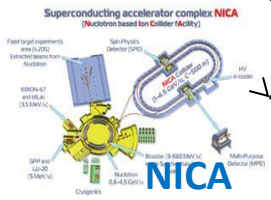
STS: CA	STS: Kalman Filter	RICH: ring reconstruct.	TRD: track reconstruct.	TRD: el. id. ω(k,n) criterion	KFPar - ticle
164.5	0.5	49.0	1390	0.5	2.5

Average time per core (μs/track or μs/ring) of SIMD-algorithms (besides track reconstruction in the TRD) for data processing. Global throughput increases linearly with the number of cores.

Improvement of QGSp in Geant4

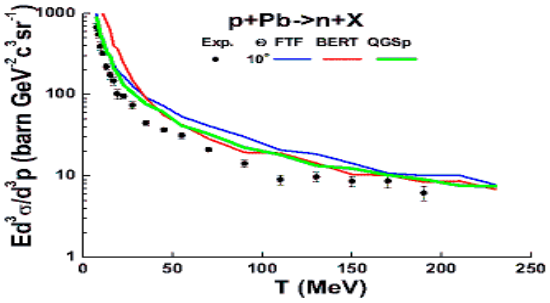
[Author of original code – N.S. Amelin (LIT, JINR)]
Developer – V.V. Uzhinsky (LIT, JINR)

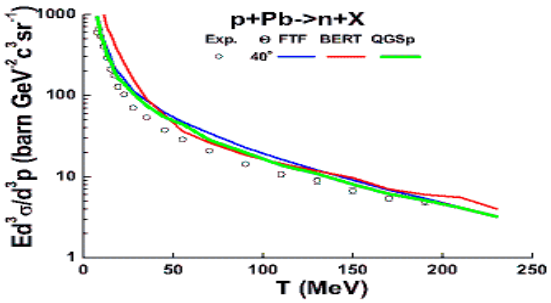
FAIR
Facility for Antiproton and Ion Research in Europe GmbH

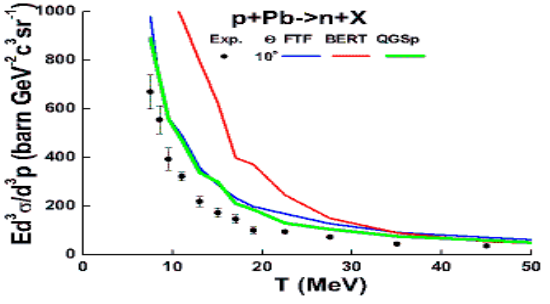


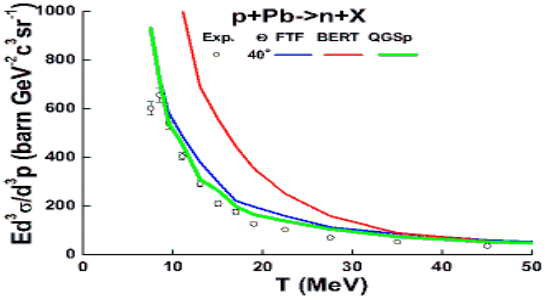
Geant 4

Physics List – QGSp_BERT used by ATLAS and CMS









Slow neutron production, ITEP experimental data (1983)

[It is expected this improves shower shape]

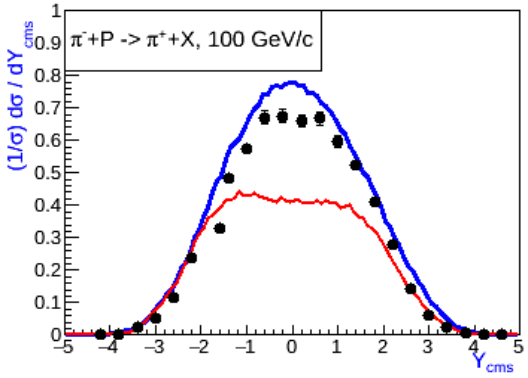
Tasks solved (2015):

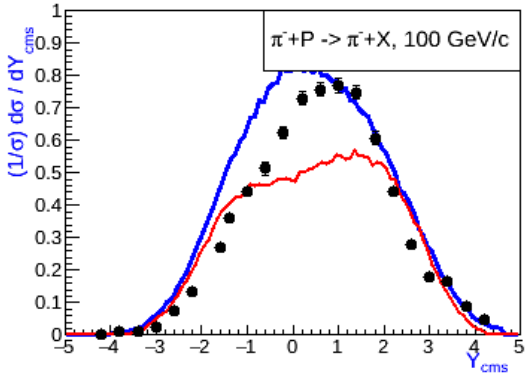
- **Improvement of string fragmentation**
- **Improvements of processes cross sections**
- **Inclusion of the Reggeon cascading for correct description of nucleus breakups**
- **Improvement of parton momenta sampling**

To do: fine tuning of the model parameters

Improved QGSp will be available in G4.10.2.beta (end June 2015)

It is expected that new QGSp will improve calorimeter responses!





πP interactions at 100 GeV/c

Red lines – old QGSp Blue lines – new QGSp

• Developments in Computer Algebra and Quantum Computing

– **New approaches to the derivation of involutive Groebner bases**

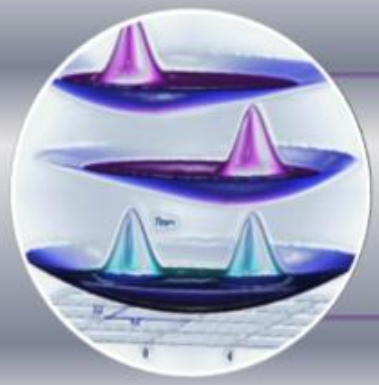
[Tasks: ●● Down-up approach to the derivation of compact bases;
●● Parallel algorithms for the construction of compact involutive bases;
●● Generation of finite difference schemes inheriting the algebraic properties of the ancestor partial differential equations;
●● Numerical algorithm applications to the analysis of low dimensional nanostructures and other composite quantum systems in molecular, atomic and nuclear physics]

– **Modelling and control of quantum information processes**

[Tasks: ●● Entanglement description in systems of qubits as the main resource in quantum information and communication;
●● Study of systems of charged particles under strong laser radiation;
●● Modelling quantum dynamics of elementary particles and nuclei interacting with strong laser radiation. Proposals for the European project “Extreme Light Infrastructure (ELI)”, Prague (Chezh Republic) and Măgurele (Romania)]

– **Design of algorithmic methods of discrete quantum mechanics**

[Tasks: ●● Description of quantum gates;
●● Applications to quantum information processes]



MCTDHB lab

The laboratory to study quantum many-body dynamics

Center for Quantum Dynamics

Many-body theory of bosons group
Heidelberg, Germany

PD Dr. Alexej I. Streltsov
UNIVERSITÄT HEIDELBERG

Dr. Oksana I. Streltsova
LIT JINR, DUBNA

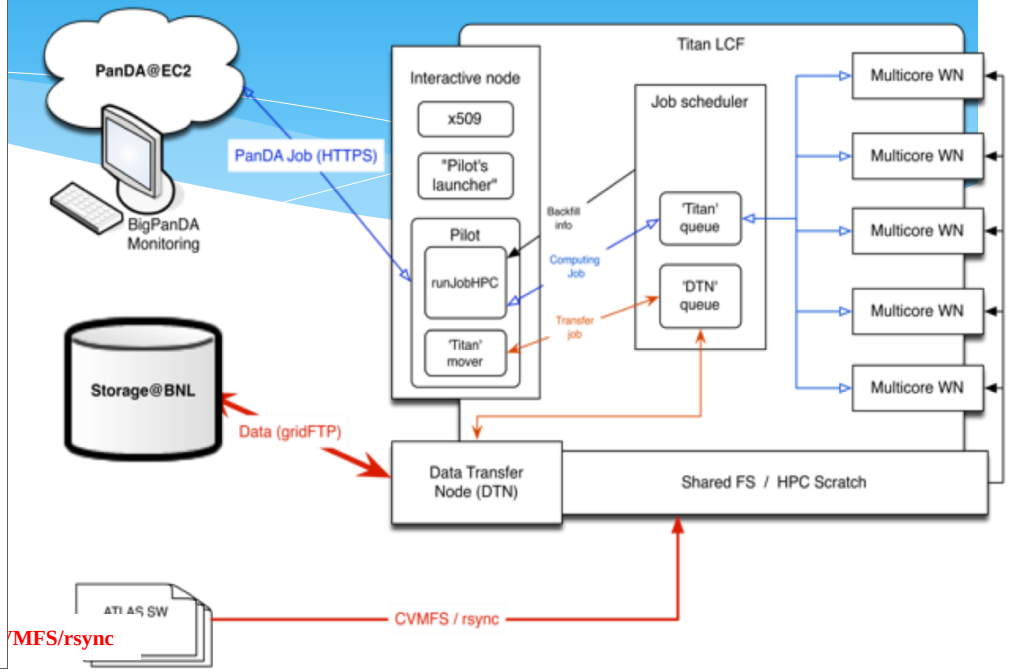
hYBRI

Heterogeneous Computations
HybriLIT - team

http://QDlab.org

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		



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. Generalizing PanDA. Beyond Grid and ATLAS

COMPASS

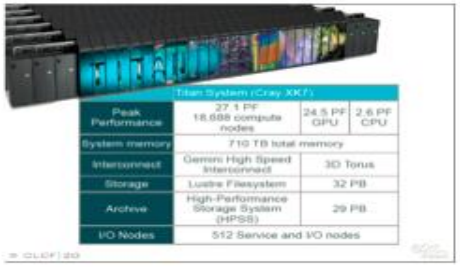
Google Cloud Platform

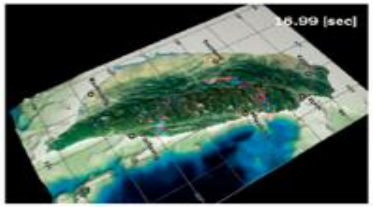
ALICE

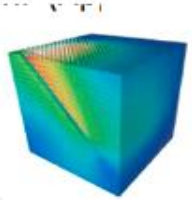
NICA

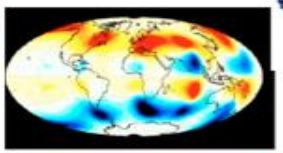
nectar

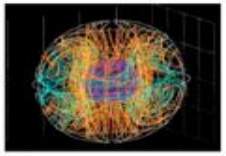
amazon web services | EC2

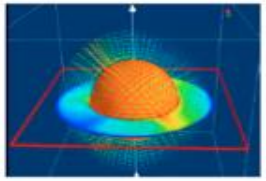












Main objective of the 7-year plan

Build up the Multifunctional Information and Computing Complex

CICC → MICC

Creation of a unified information environment integrating a number of various technologies and software in order to offer optimal approaches for solving various types of scientific and applied tasks on a global level

Requirements:

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

JINR grid sites of WLCG/EGI: Tier-1 for CMS Tier-2 for ALICE, ATLAS, CMS, STAR, LHCb, BES, biomed, fermilab

Cloud infrastructure

Heterogeneous(CPU + GPU) computing cluster HybriLIT

Off-line cluster and storage system for BM@N, MPD, SPD Storage and computing facilities for local users

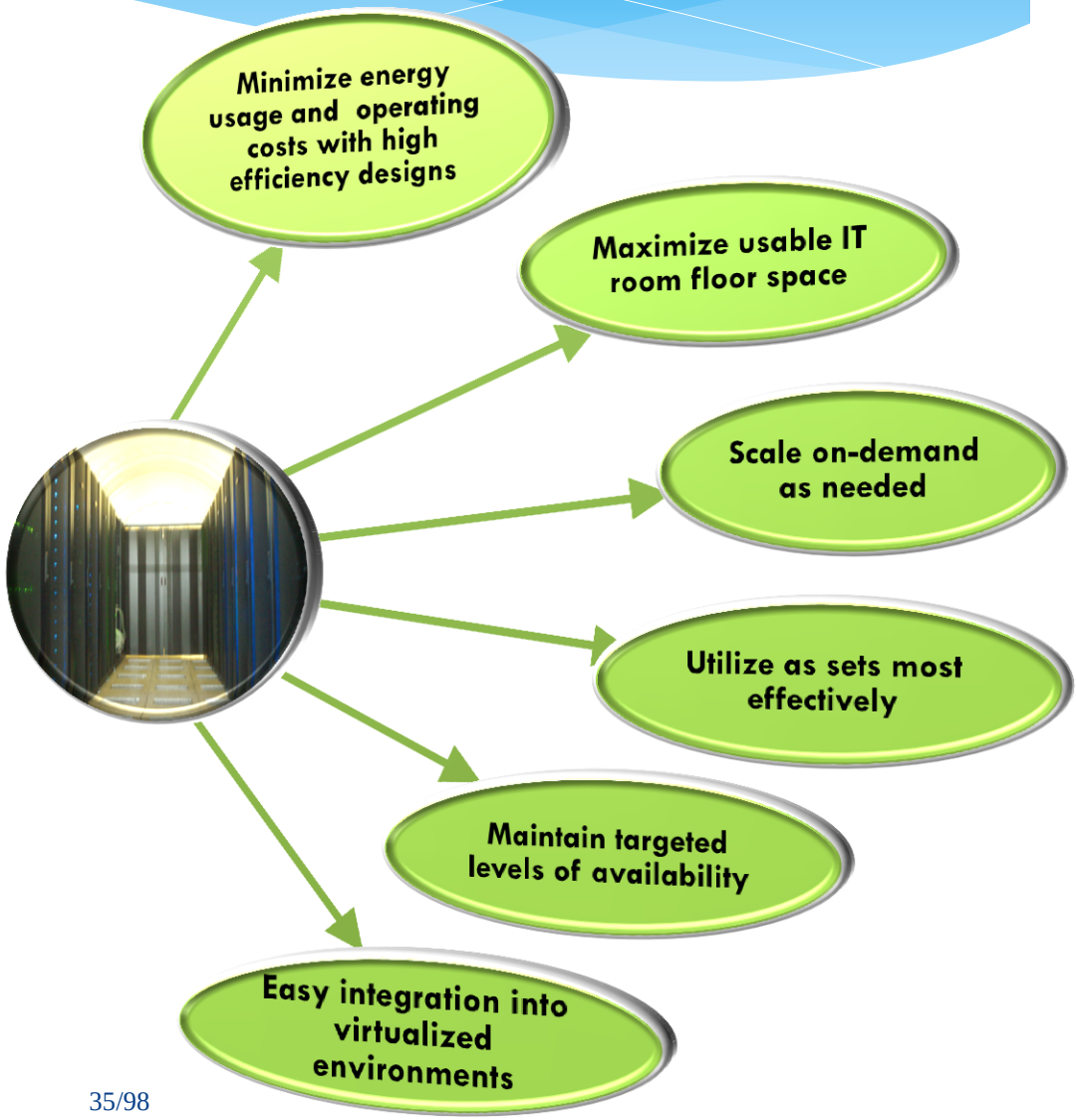
Network infrastructure

Engineering infrastructure

Project MICC (Multifunctional information and computing complex)

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, operating 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)



MICC components

JINR grid sites of WLCG/EGI: Tier-1 for CMS
Tier-2 for ALICE, ATLAS, CMS, STAR, LHCb,
BES, biomed, fermilab

Cloud infrastructure

Heterogeneous(CPU + GPU) computing cluster HybriLIT

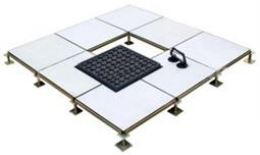
Off-line cluster and storage system for BM@N, MPD, SPD Storage and computing facilities for local users

Network infrastructure

Engineering infrastructure

MICC engineering infrastructure

Raised Flooring System

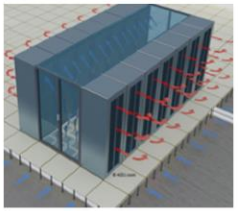


Fibre Optic & Data Structured Cabling System

Diesel generator set

Uninterruptible power supply

High Density Heat Containment System



Water Detection System

VESDA (Very Early Smoke Detection Apparatus)

Surveillance System

Fire Suppression System

Biometric Access System

MICC Monitoring System

Computer Room Air Conditioner

Development plans for the network infrastructure

Increasing the channel capacity of the external JINR data link: 2 x 100 Gbps

Modernization of optical backbone of the local area network of JINR: 100 Gbps

Development of network services:

- Implement IPv6
- The use of new data transfer protocols
- Improved email service
- Wi-Fi authorization service
- Project “Personal office”

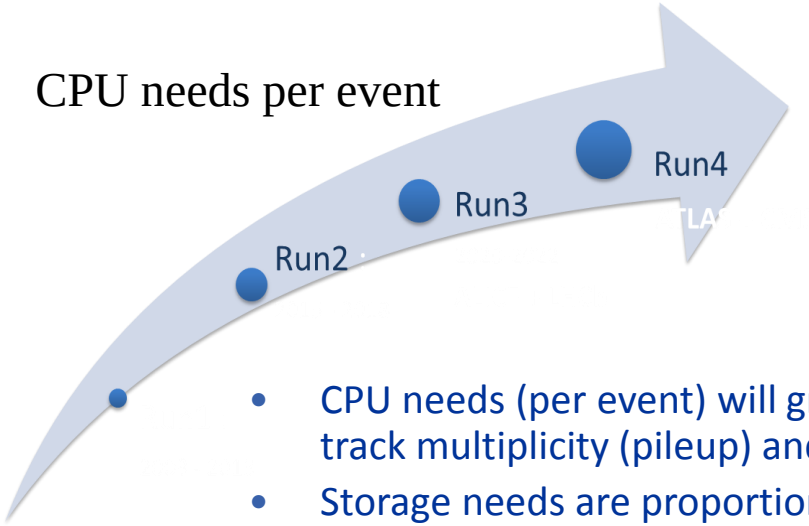
Local network of the NICA project: The projected capacity is stated as a data transmission channel with a throughput of100 GbE.

Development plans for the Tier-1 centre

Planned growth of Tier-1resources in years in absolute values with percentage growth over previous year.

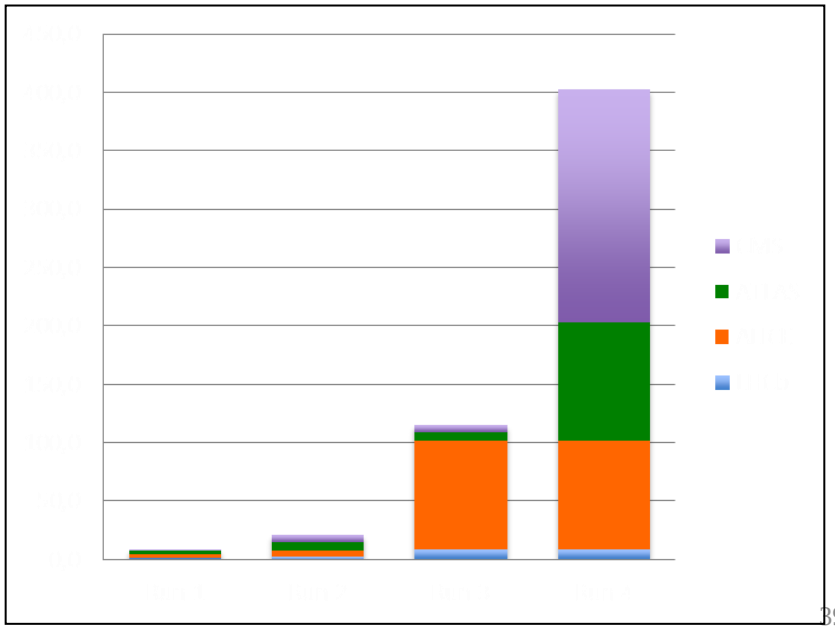
	2016	2017	2018	2019
Processor capacity of the core/kHS06	3400/54,4	4200/67,2 (24%)	5200/83,2 (23%)	10000/160 (52%)
Disc storage (TB)	3390	5070 (49%)	6100 (20%)	8000 (80%)
Tape storage (TB)	10000	20000 (100%)	20000 (0%)	20000 (0%)

CPU needs per event



- CPU needs (per event) will grow with track multiplicity (pileup) and energy
- Storage needs are proportional to accumulated luminosity
- Grid resources are limited by funding and fully utilized

LHC Upgrade 2019-2021. Computing Needs



The CICC/Tier-2 development plans

In the future we suppose to use and increase the CICC resources for

- Organization and support of the Tier-2 level sites for four LHC experiments;
- Provision of countable resources as well as data storage and data access for third-party collaborations , local user groups and individual JINR users.

One of the main directions is the creation of the infrastructure to support work of collaboration MPD NICA and the whole NICA project at all stages of its work. Within this work, it is planned to design a hardware-software installation DevLab for testing new hardware solutions and software systems for designing and creating a data processing complex for NICA.

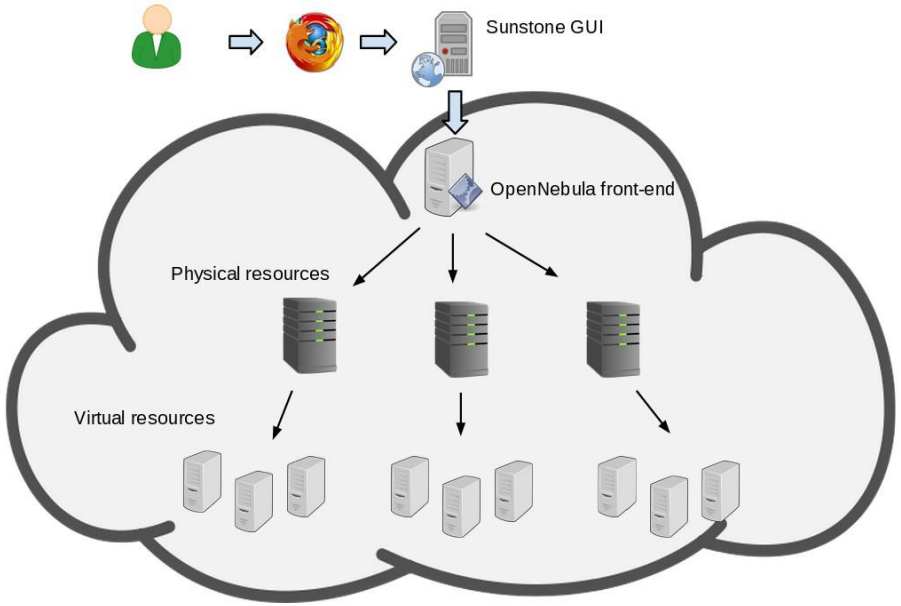
The planned growth of the CICC/Tier-2 resources over years

	2016	2017	2018	2019
Comp.cores / kHS06	2700/43,2	3700/59,2	4700/75,2	6000/96,0
Disk (TB)	2690	2970	3400	5000

Cloud and heterogeneous cluster

Advanced cloud infrastructures

- Dynamically reconfigurable computing services
- Large-scale open data repository and access services



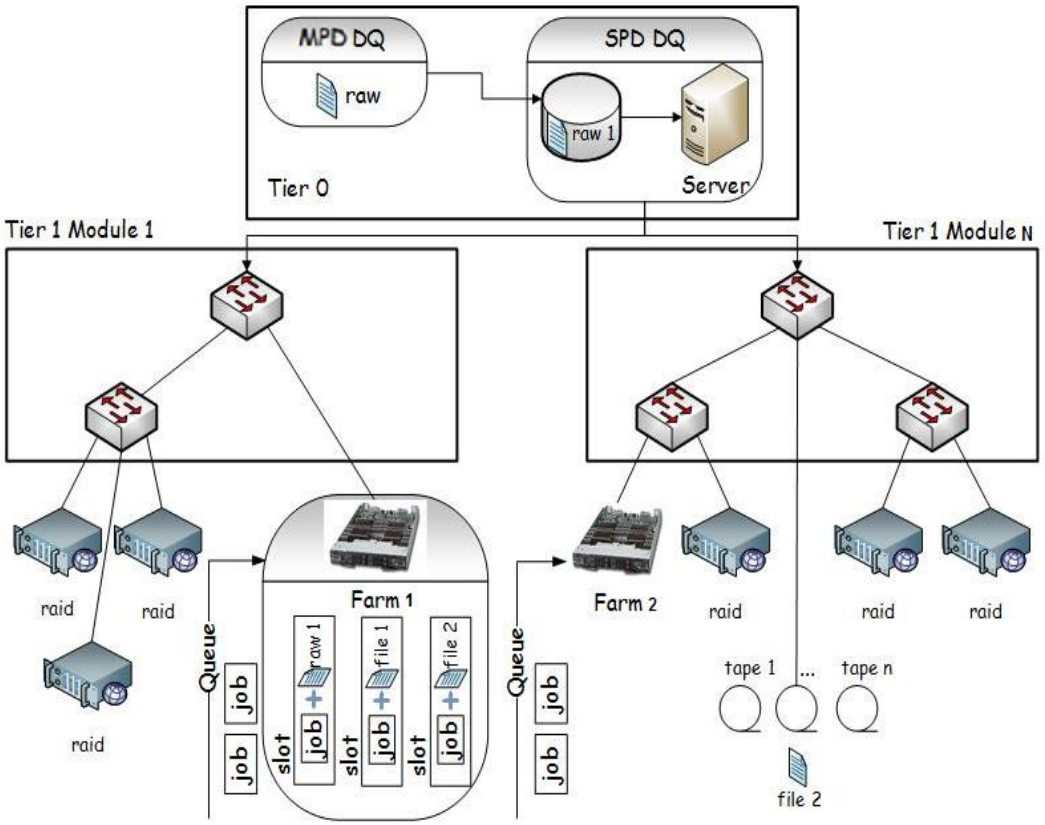
Advanced heterogeneous computing

- User friendly information-computing environment
- New methods and algorithms for parallel hybrid computations
- Infrastructure for tutorials on parallel programming techniques

	2016	2017	2018	2019
Cores	1000	1400	1800	**2200**
RAM/GB	4240	6160	8080	**10000**
Disk serves/TB	**384**	**576**	**768**	**960**

- **The annual increase in computing resources - 90 Tflops and in disk storages - 20TB**
- **Systematic research on the possibilities of new computing architectures appearing in the field of high-performance computing (HPC) include them into the cluster configuration in the future.**

Creation of the computing off-line complex for simulation, processing, analysis and storing data of the NICA project



SyMSim Simulation System > NICA > 3 models

1. A data model – description of the data generation processes, their volumes and storage conditions.
2. Data processing model - rules for the use of resources such as CPU, memory and I/O between concurrently running tasks .
3. Model of communications of data traffic for different protocols in local and global networks.

The goal of the planned work:

– creating a MICC component to store and process physical data taking specific parameters of the experiments into account. For this, it is necessary to properly describe and predict the performance and limitations of the developed system of processing and storing the NICA data.

In frames of the work conducted, an answer to the question should be received what kind of architecture of the system is preferable from a viewpoint of a reasonable balance of time, financial and technological costs.

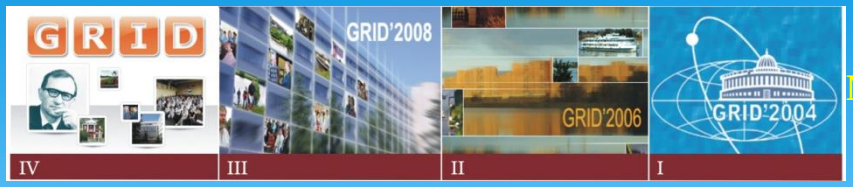
Expected results upon completion

creation of a uniform information environment of JINR resources: computation, information, and data storage on the basis of high speed telecommunication channels with reservation and modernization of JINR local network;
modernization of MICC engineering infrastructure including the power supply system, air conditioning and ventilation systems, the fire suppression system, development of automated system of dispatch and management; modernization of computer halls in LIT;
expansion of computer performance and data storage system of Tier-1 to provide priority access to CMS data for scientists from JINR Member-States;
expansion of computation resources and data storage systems of MICC to support of experiments at LHC (ATLAS, Alice, CMS), FAIR (CBM, PANDA) and other experiments that use grid-environment, and also for support the NICA project throughout all stages;
expansion of MICC cloud component in order to provide users with a wider range of services, and to create integrated cloud environment for experiments of JINR (NICA, ALICE, BESIII, NOvA, Daya Bay, JUNO, etc.) and of JINR Member-States;
expansion of computing resources of the heterogeneous cluster HybriLIT as a main source for high performance computations;
development of monitoring system and its expansion to information analysis system;
creation of MICC component – computer off-line complex for simulation of storage and processing of physical data with regard to particular parameters of the experiments at NICA; development of two-level system (disk-tape) for data storage for experiments at NICA;
implementation of developed information security system

Projects in framework Distributed computing

- Worldwide LHC Computing Grid (WLCG)
- EGI-InSPIRE
- RDIG Development
- Project BNL, ANL, UTA "Next Generation Workload Management 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" with South Africa;
- Development of grid segment at Cairo University and its integration to the JINR GridEdu
- 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 at LIT JINR and BITP for ALICE experiment"
- JINR-Romania cooperation Hulubei - Meshcheryakov programme
- JINR-China cooperation (BES-III)
- JINR- Mongolia cooperation (MongolGRID)
- Cooperation with Armenia, Azerbaijan, Belarus, Bulgaria, Georgia, Kazakhstan, Moldova, Poland, Slovakia, …

LIT traditional conferences



Distributed Computing and Grid-technologies in Science and Education

Mathematics. Computing. Education

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

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

Thank you for your attention!