Information Technologies in JINR Physics Research

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LIT-JINR Dubna

Overview

1. **Two Sides of Information Technologies at JINR**
2. The JINR-LCG2 Site
    - *A. The network level*
    - *B. The resource level*
    - *C. The applications level*
3. Other Grid Developments at JINR
    - *A. WLCG Tier-1 in Russia*
    - *B. Grid training and education*
    - *C. Grid NNN*
    - *D. Tier-3 sites monitoring project*
    - *E. Distributed data processing for NICA/MPD project*

1. Two Sides of Information Technologies at JINR

1.1. Development of **telecommunication, network,** and **informational & computing facilities.**

1.2. **Mathematical support** of the experimental and theoretical research conducted by JINR.

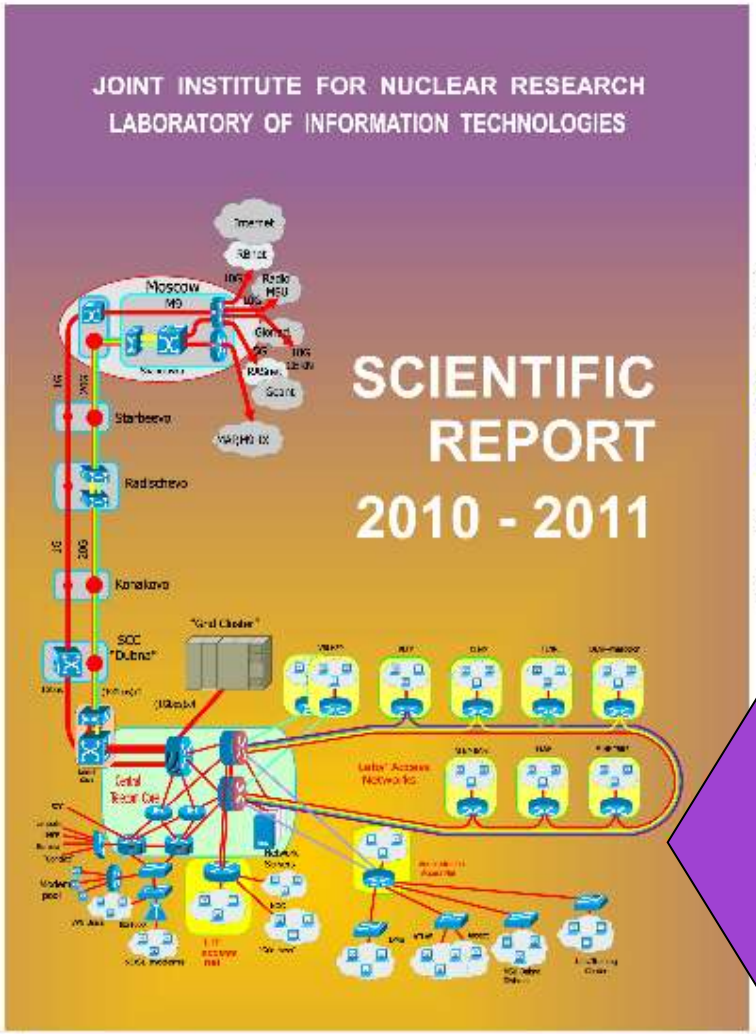
- Valuable **information on LIT activity in JINR** can be found at the web pages **http://www.jinr.ru** and **http://lit.jinr.ru**

JOINT INSTITUTE FOR NUCLEAR RESE - Mozilla Firefox

File Edit View History Bookmarks Yahoo! Tools Help

Annual reports | JOINT INSTITUTE FOR NUCLEA...

http://lit.jinr.ru/Reports/SC_report_10-11/LIT-Rep-2010-2011SC.htm



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Foreword

Contents

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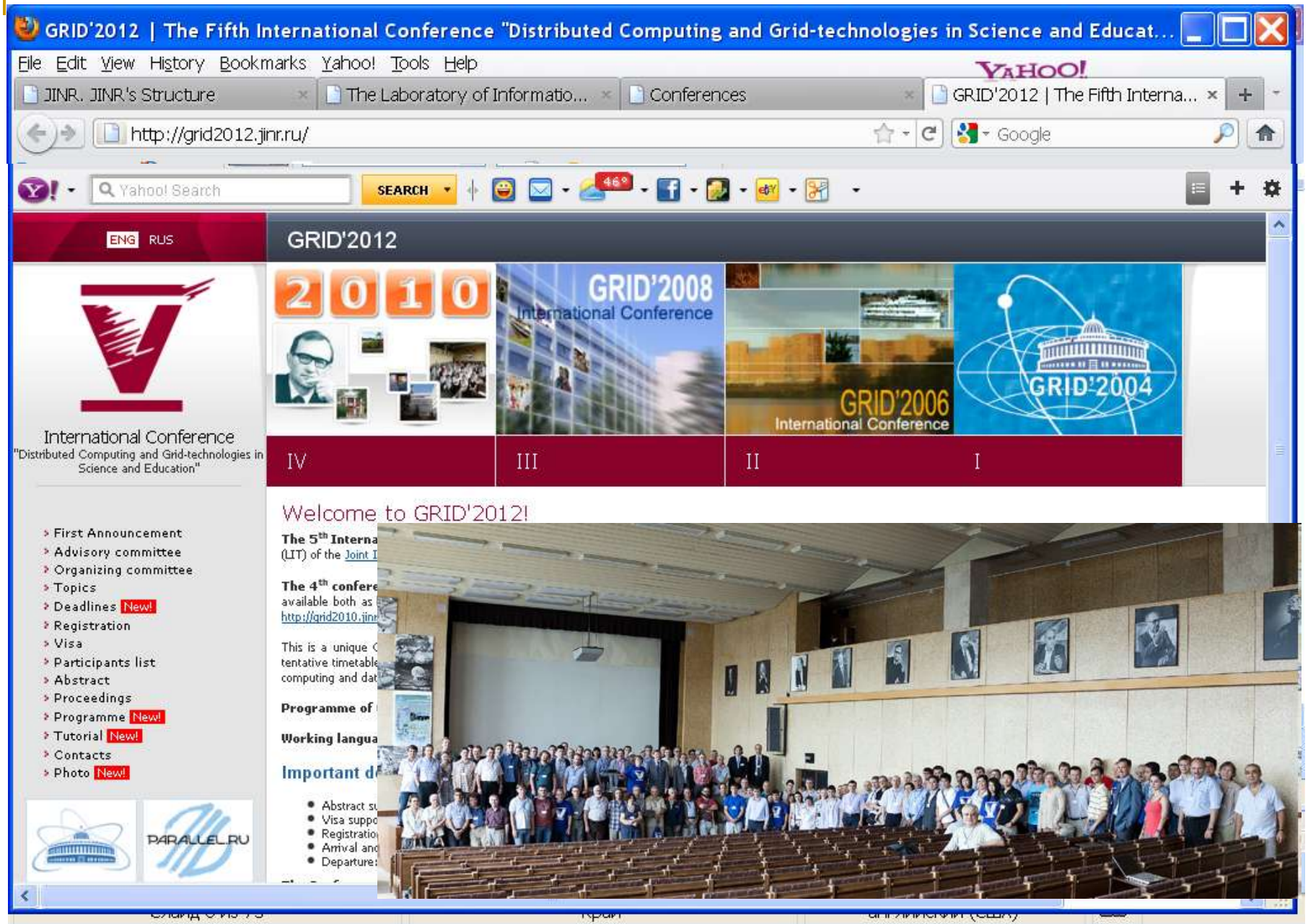
Comprehensive presentation of LIT scientific results obtained during 2010-2011 can be found in the **LIT Scientific Report** (cover on left)

1.1. Development of telecommunication, network, and informational & computing facilities

- Development of **telecommunication channels** connecting JINR with institutions in the JINR Member States and other partner institutions on the basis of national and regional telecommunication networks.
- Development of a fault-tolerant, protected, and reliable JINR **local area network (LAN)** and its state-of-the-art upgrade.
- Development and maintenance of a **high throughput distributed computer infrastructure** with **large scale mass storage** resources.
- **Information, algorithmic and software support** of the **research-and-production** activity of JINR.
- Reliable operation and development of the **JINR Grid segment** as part of the global Grid infrastructure.

JINR-Dubna, 16-21 July 2012 http://grid2012.jinr.ru



uclear Electronics & Computing - Mozilla Firefox

Справка

ru/topics.php

XXIII International Symposium on Nuclear Electronics & Computing

Bulgaria, Varna,
12-19 September, 2011.

NEC'2011

- First Announcement
- Organizing Committee
- Topics
- Registration Form
- Participants list
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I S T C
М Н Т Ц

The main topics of the symposium are:

- Detector & Nuclear Electronics;
- Accelerator and Experiment Automation Control Systems. Triggering and Data Acquisition.
- Computer Applications for Measurement and Control in Scientific Research;
- Methods of Experimental Data Analysis;
- Data & Storage Management. Information & Data Base Systems;
- GRID & Cloud computing. Computer Networks for Scientific Research;
- LHC Computing;
- Innovative IT Education: Experience and Trends.

http://
nec2011.jinr.ru

1.2. Mathematical support of experimental & theoretical research conducted by JINR (1)

- Assumes performance of top research in discrete mathematics and computational physics concerning **simulation** of physical processes in experimental installations, **mathematical modeling**, derivation of **algorithms** and their implementation into **efficient** and **reliable hardware adapted programs**.
- The common mathematical basis of some of these undertakings allows **application** of the developed methods and algorithms **to other science and technology topics** (nanotechnology, biology, medicine, economy, industry, etc.).

1.2. Mathematical support of experimental & theoretical research conducted by JINR (2)

- Development of new mathematical **methods** and **approaches** to **physical processes modeling** and **experimental data analysis**.
- Derivation of new **methods** and numerical **algorithms** for modeling **magnetic systems**.
- Elaboration of **software** and **computer complexes** for **experimental data processing**.
- Mathematical **modeling** and elaboration of numerical **algorithms** and **software** for the simulation of **complex physical systems**.
- Development of **methods**, **algorithms** and **software** of **computer algebra**.
- Contributions to **new generation computing tools** development.

Mathematical Modeling and Computational Physics (MMCP'2011)

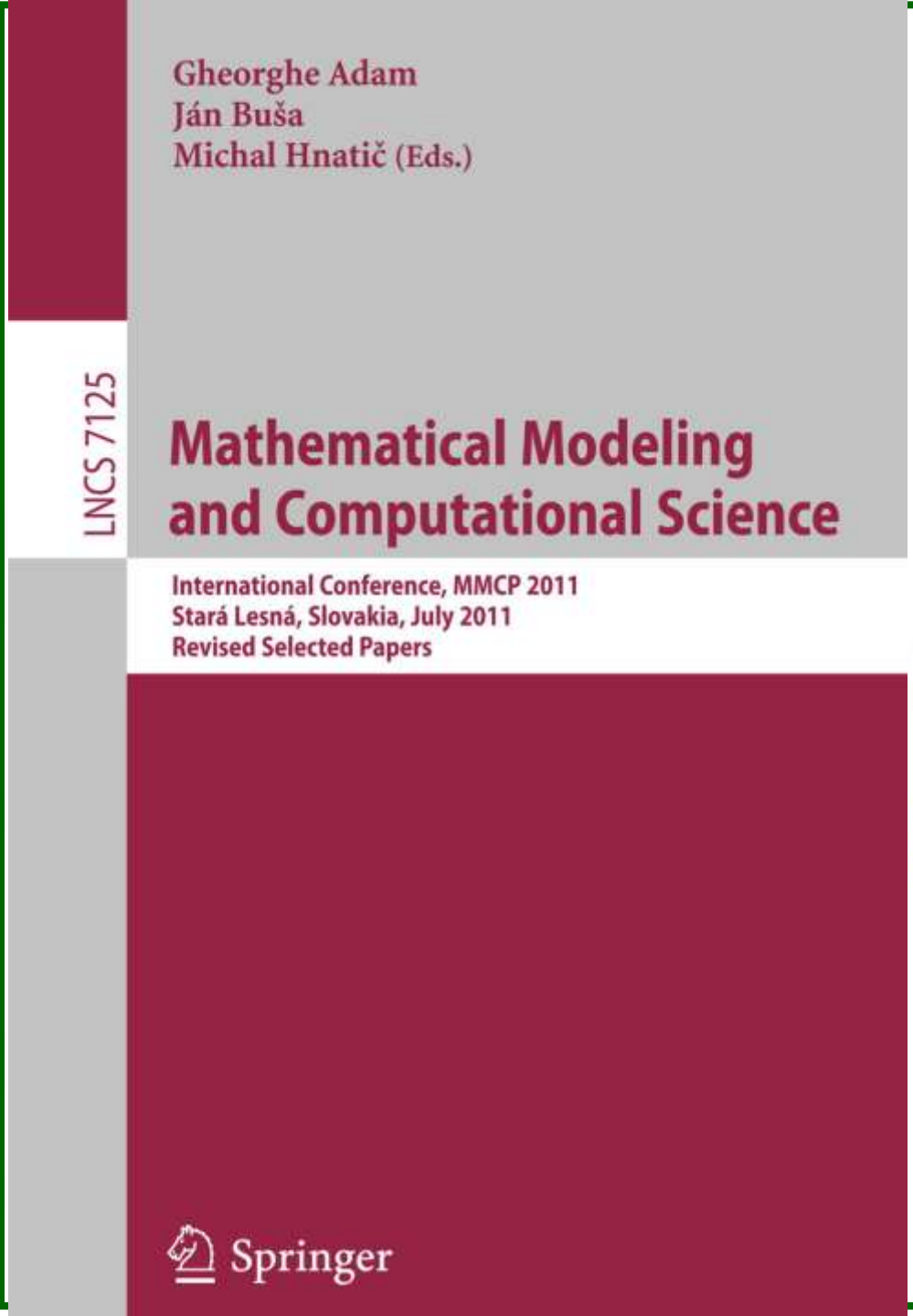
July 4 - July 8, 2011 Stará Lesná, Slovakia

Organizers:

Laboratory of Information Technologies, Inst. Exp. Physics, SAS, Košice, Technical University, Košice, Pavol Jozef Šafárik University, Košice, Union of Slovak Mathematicians and Physicists, Košice, Slovakia

Topics:

-mathematical methods and tools for modeling complex physical and technical systems;
- methods, software and computer complexes for experimental data processing;
- methods, algorithms and software of computer algebra;
- computational chemistry, biology, and biophysics;
- distributed scientific computing;
- computing tools of a new generation.



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2. The JINR-LCG2 Site (1)

• **Evolving model** the **design** and **implementation** of which attempts to **accommodate** the various **requests** directed to LIT by the **whole JINR user community**.
Due to this fundamental constraint, the **JINR Grid site** constitutes only the **most prominent part** of a **flexible multifunctional informational infrastructure**.
• Role of the **participation** in **large scale international projects** (EU Data Grid, WLCG, EGEE, EGI) for the **extensive** and **intensive** developments of the **JINR Grid site**.
Since 2004, **full integration** into WLCG/EGEE environments under Grid site domain name "**JINR-LCG2**".
• Within WLCG infrastructure, serves as a **Tier-2 level** center for **LHC experiments**.

WEB-PORTAL “GRID AT JINR” – “ГРИД В ОИЯИ”: http://grid.jinr.ru

- Pages
- Grid at JINR
- Conception of Grid
  - Grid-technologies
  - Grid-projects
  - RDIG Consortium
- JINR grid-site
  - Infrastructure and services
  - Scheme
  - Statistics
  - Support of VOs and experiments

    ATLAS, ATLAS DQ2 Deletion Service,

    CMS, CBM and PANDA, HONE
  - How to become a grid user
- JINR in grid-projects

  WLCG, GridNNN, EGEE, RFBR Projects,

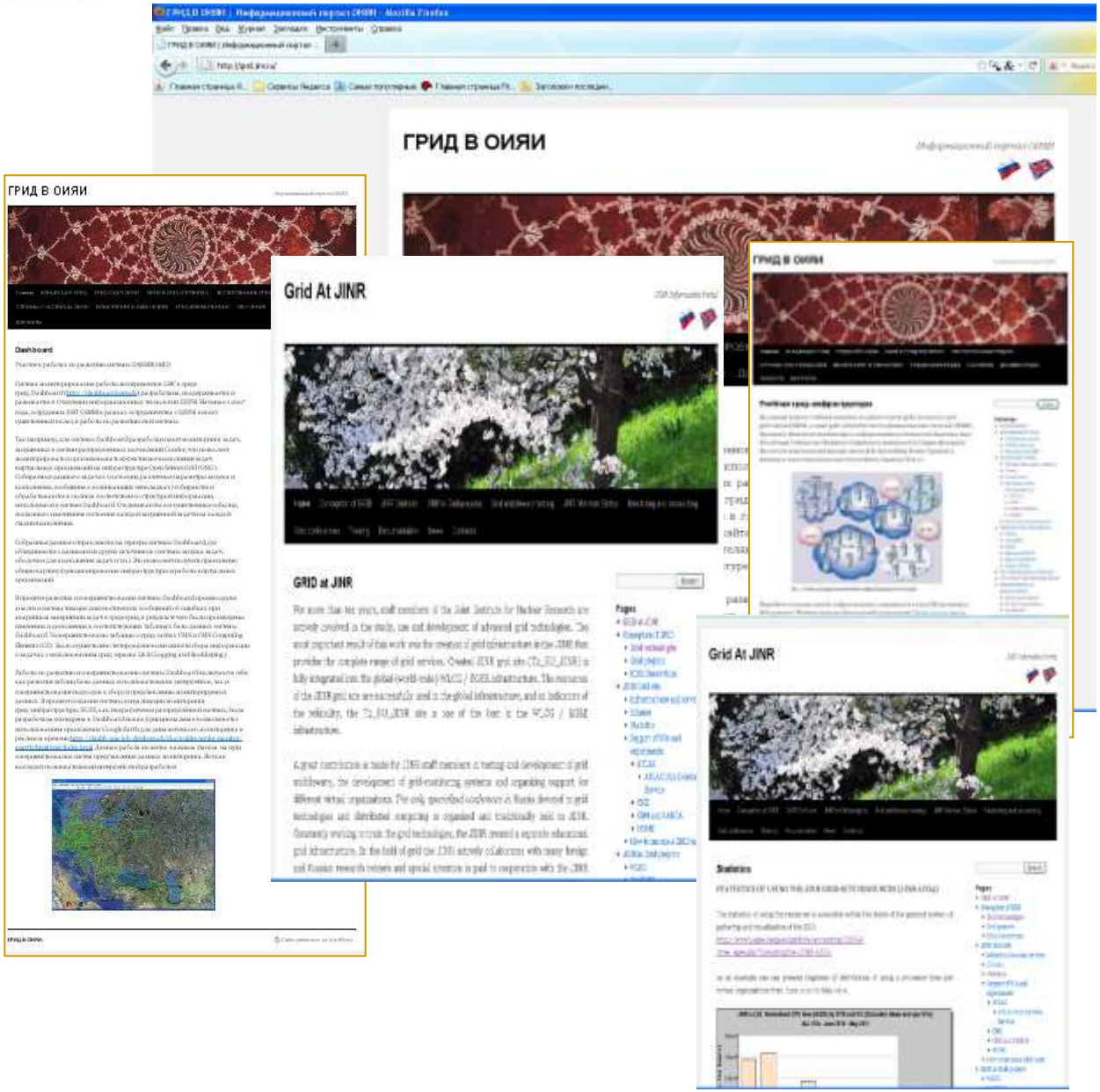
  INTAS Projects, SKIF-GRID
- Grid middleware testing
- JINR Member States
- Monitoring and accounting

  Local monitoring, RDIG monitoring, dCache monitoring, Dashboard, FTS monitoring, H1 MC monitoring, Tier3 Monitoring
- Grid conferences
- Training

  Educational grid-infrastructure, Courses and lectures, Training materials
- Documentation
  - Presentations
  - Publications

    Journals and preprints, Proceedings,

    NEC Proceedings, LIT Reports, LIT Inf Bulletin
  - JDS-server at JINR
- News
- Contacts

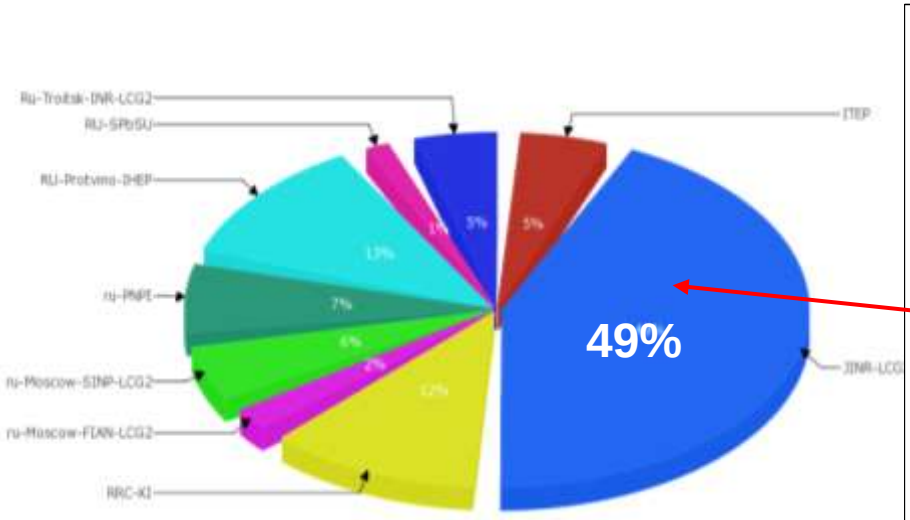


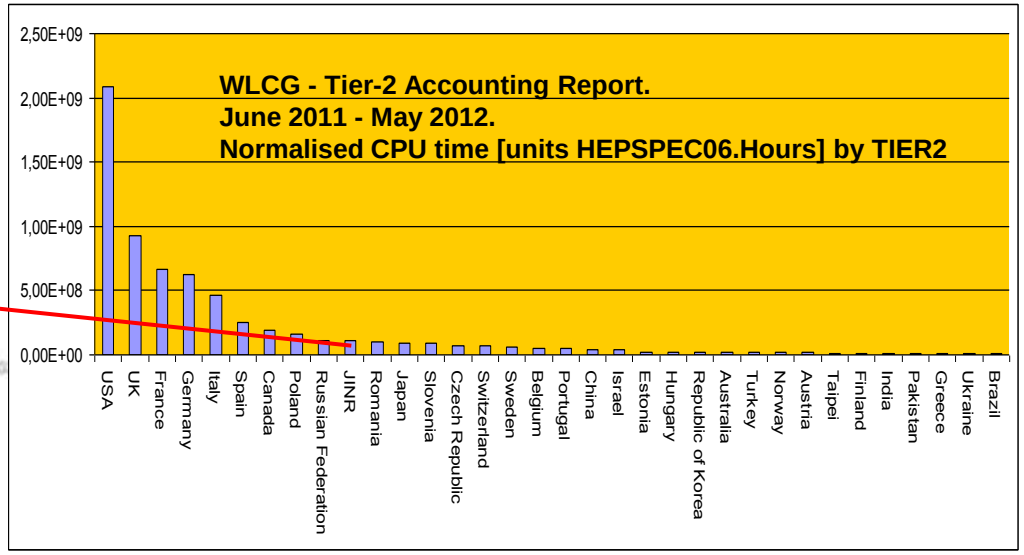
2. The JINR-LCG2 Site (2)

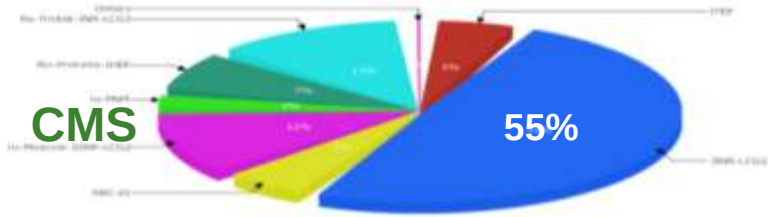
- A noticeable feature of JINR-LCG2 site is its **close involvement** into the Russian grid segment within the **Russian Data Intensive Grid** (**RDIG**) frame. Within RDIG, JINR grid site provides important **services** and **support** to the Russian grid segment.
- The **current shares** of the **JINR Grid** site within **RDIG** are about **40-50 percent** as it concerns the **computing output**.
- **Multi-year statistics** accumulated **at the EGI accounting portal** on the **Normalized CPU time** points to a **prominent place** of JINR-LCG2 site **within the WLCG community**:
among the first ten worldwide and the **among the first three in Europe**.

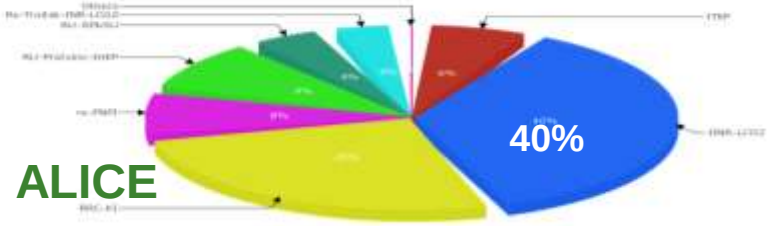
EGI portal statistics on Normalized CPU times

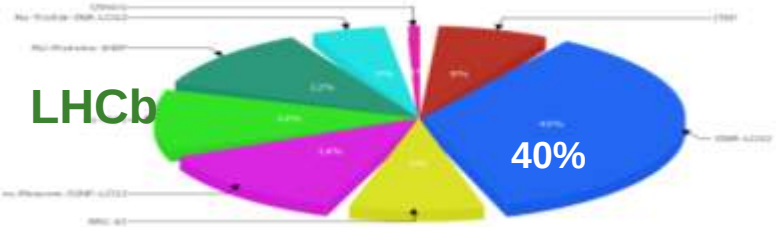
The **JINR-LCG2** is in the **top 10** of the Country Tier2 sites worldwide.
It covered about **49%** of the **RDIG** share to the **LHC in 2011-2012**



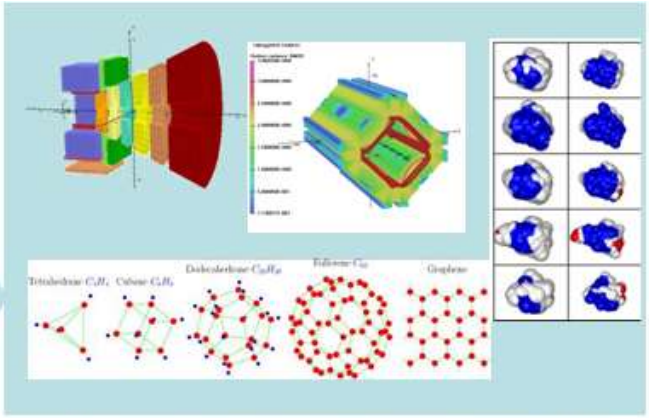


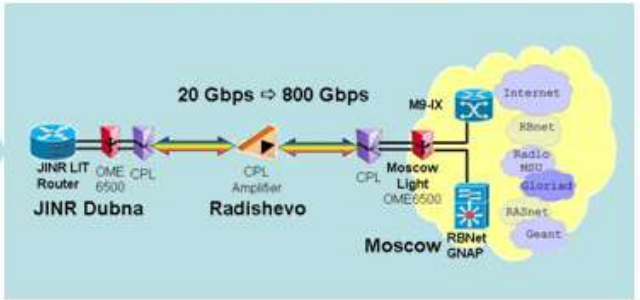




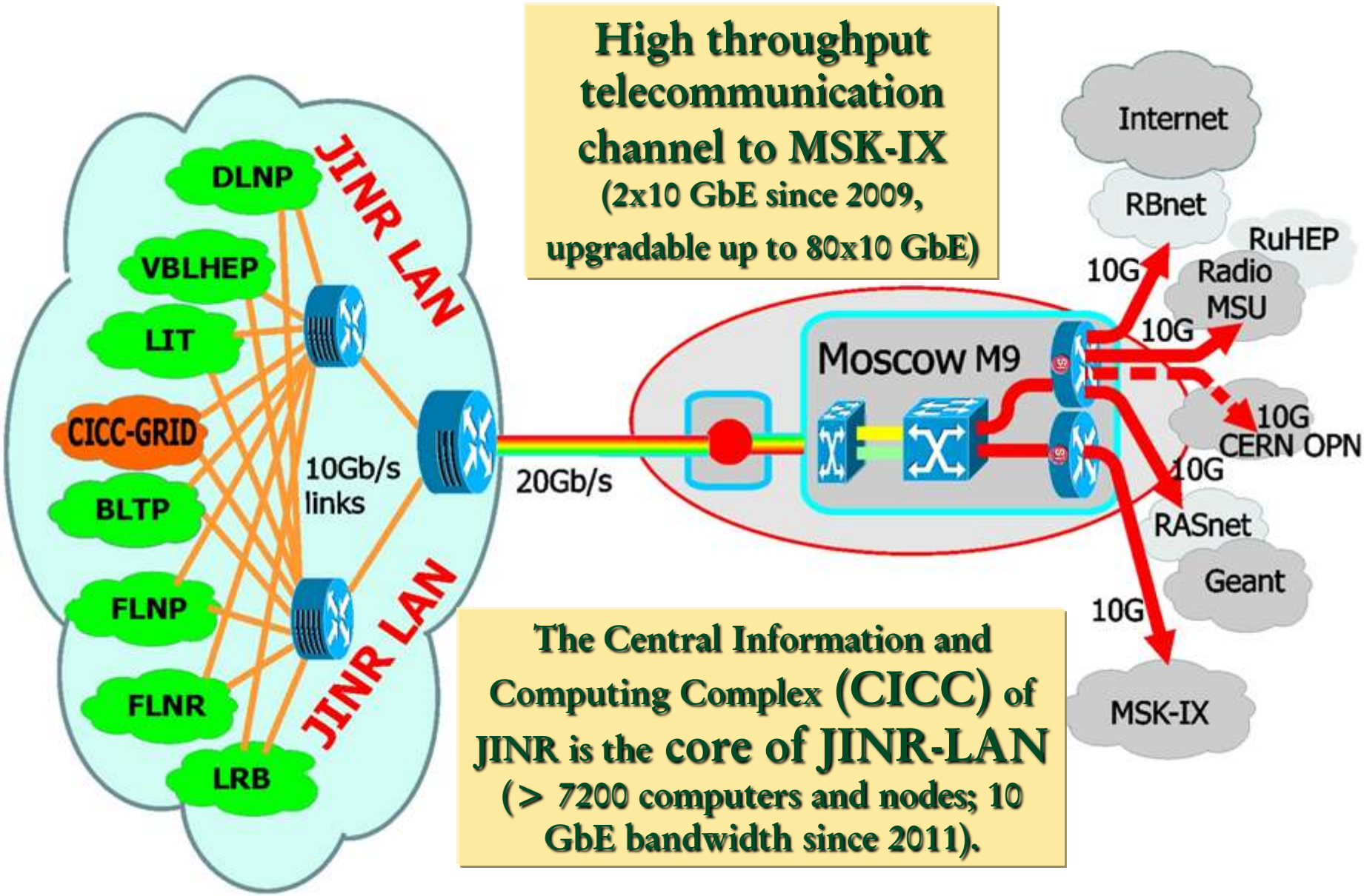


2. Three levels of grid infrastructure (left) with illustration for LIT-JINR (right)





2A. *The Network Level*



2B. *The Resource Level*

There are **three kinds of resources** which make the JINR Grid site functional:
-the **CICC computing cluster and mass storage unit**,
-the **center of primary services**,
-**basic software support**.

The **CICC** is logically organized as a **unified informational computational resource**, grounded on the **distributed model** of **data storage** and **processing**. It provides support to **all directions of** the **research** activities underway at JINR. Its **hardware** comprises **computing clusters** (**2012** figures: **2582 cores** corresponding to 26000 HEPSpec06) and efficient **data storage** systems (**2012** figures: **2 disk** data storage systems on **dCache** basis and **3 disk** data storage systems on **XROOTD** basis, providing nearly 1800 terabyte total volume) , together with a doubly functional **CPU/GPU-based hybrid High Performance Computing (HPC)** unit which can be loaded as both distributed computing & parallel computing facility, depending on user demands.

The **computing performance** of the implemented architecture **was measured**, **analyzed**, and **improved via** home-made **parallelization** of the information flow among the different **main modules**.

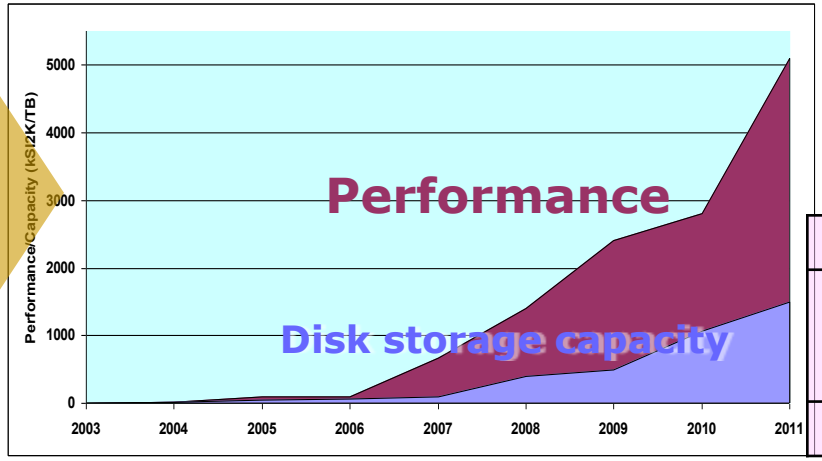
JINR Central Information and Computing Complex (CICC)

CICC comprises 2582 Cores
Performance 26000 HEPSpec06
Disk storage capacity 1800 TB

Availability and Reliability = 99%

More than **5,3 million tasks** were executed during 2011

Growth of JINR CICC resources in 2003 - 2011



Foreseen future JINR CICC resources increase

	2011	2012-2013
CPU (kSI2k)	Plan-3500 Realized - 5000	Plan-5000 Corrected - 7000
Disk systems (TB)	1500	2500

2B. *The center of primary services*

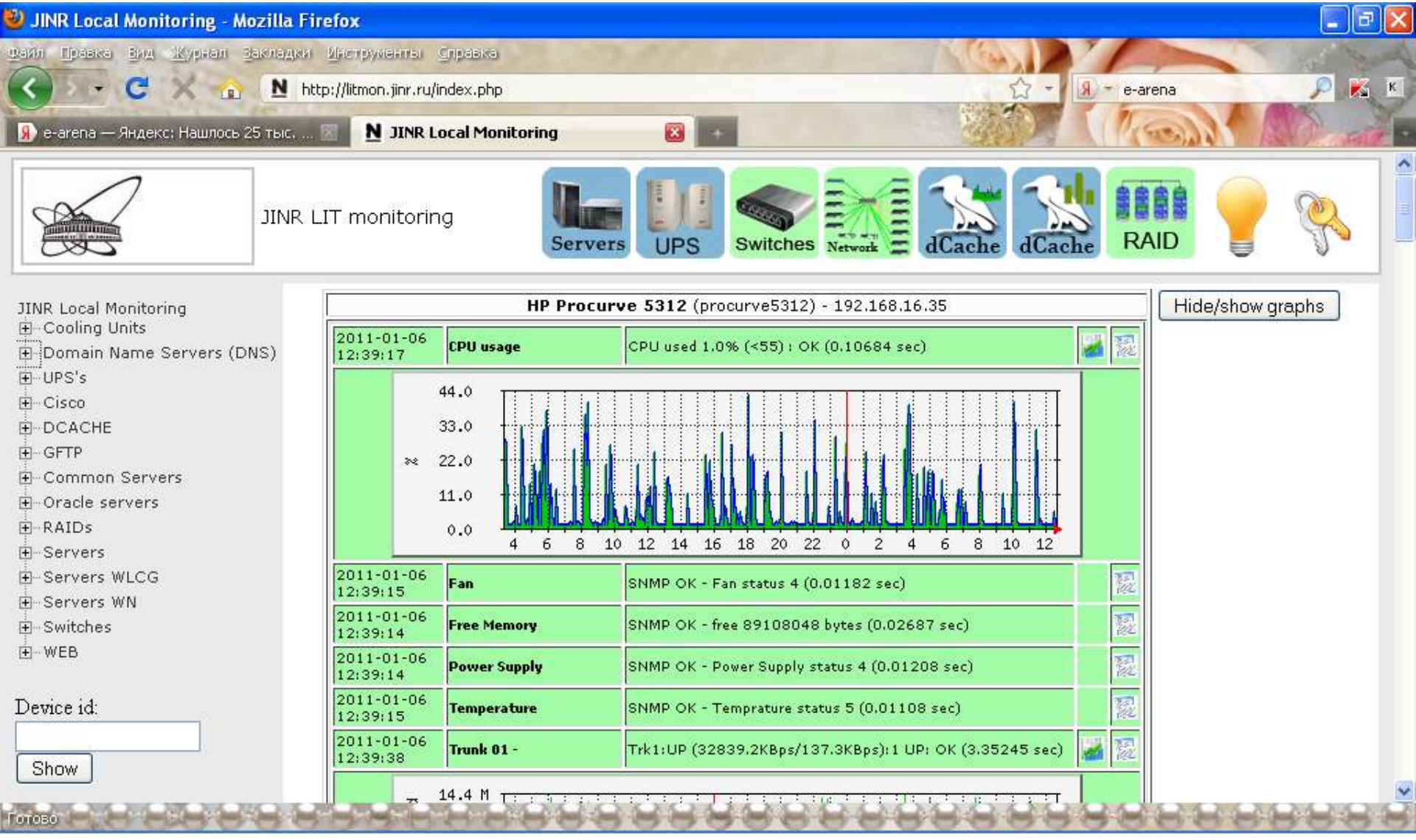
• The **primary software services** enable the use of the CICC resources both by **international projects** for **distributed** computations (WLCG, FUSION, BIOMED, HONE, PANDA, CBM, etc.) and by **local JINR users**.
• The **computing cluster** is operated by means of **gLite 3.2 middleware**.
• More than **50 specialized servers** assist the cluster functioning.
• **OS Linux** (release Sci. Linux - **SL5, x86_64 architecture**) is the main CICC OS.
• **Basic grid service interfaces** comprise: Berkeley Data Information Index (BDII) (top level and site BDII), Computing Element (CREAMCE), Proxy Server (PX), Workload Management System (WMS), Logging & Book keeping service (LB), Accounting Processor for Event Logs (APEL publisher), LCG File Catalog (LFC), Storage Element (SE), User Interface (UI).
• **Specialized grid services** – to be detailed within discussion at application level.
• **Compilers:** g77/gcc/g++ - GNU Fortran 77, C and C++ version 3.4.6;
gfortran/gcc4/g++ 4 - GNU Fortran 95, C and C++ version 4.1.2;
ifort/icc/icpc - Intel Fortran, C, C++ compilers version 11.1.
GCC (GNU Compiler Collection) - (for C/C++/Fortran, etc.).
The Intel compilers were supplied with OpenMP standard compliant codes.
To design codes using MPI (Message Parsing Interface) package, the MPI libraries have been installed for C, C++ and Fortran.

2B. *The local monitoring system*

• **Based on** open-source software product **Nagios** and **enhanced** with a number of **pluggable software modules written in-house** for the CICC needs.
• Secures **round-the clock monitoring** of more than **350 network nodes**.
• **Provides profiling** of their parameters and **does prospective analysis** of their expected behavior in near future. In case of **expected failure** prognostic, either:
(i) **warnings to the subsystem experts** are issued, or
(ii) **automatic measures** designed to the system safeguard are taken.
• **Levels of local monitoring data collection and display**
(i) The **hardware level** (individual network nodes, their hardware and software, their network accessibility check, processor and memory levels, power supply status, temperature control, etc.).
(ii) The **network level** (devices & services to support local networks operation, availability of the external networks needed for the operation of the complex).
(iii) The **top service level** controls the services provided to end users:
- ***basic services*** (SMTP, POP, DNS, e-mail, etc.) – use standard Nagios plugins;
- ***dCache filesystem*** (use scripts running through NRPE to collect necessary metrics);
- ***gFTP service***; ***RAID disk arrays*** (3 Ware, Adaptec) ***supplying dCache work*** (with help of monitoring tools from RAID manufacturers, integrated into a single plugin).

2B. *JINR monitoring main page*

http://litmon.jinr.ru



2B. *Other CICC resource level facilities*

- **Program libraries** (CERNLIB, CPC Program Library, JINRLIB).
- **Supplementary resources** such as the ***HEPWEB***, all carefully described and updated on specialized web pages.
- The **open access JINR Document Server (JDS) electronic archive-repository** (**http://jds.jinr.ru/**) was developed at JINR in the frame of international programme Open Access Initiative (OAI). **Its aim** is the ***acquisition, storage and analysis*** of ***JINR intellectual output***. The JDS functionality is provided by software CDS Invenio that covers all the aspects of modern digital library management.

2B. *HepWeb Overview*

http://hepweb.jinr.ru/

Provides: **WEB access to** computing resources of LIT for **Monte Carlo simulations** of **hadron-hadron**, **hadron-nucleus**, and **nucleus-nucleus** interactions, by means of the **most popular generators**.

Realization: service - oriented architecture.

Goals:

- **Monte Carlo simulations** at the server
- Provide physicists with **new calculation/simulation tools**
- **Mirror site of GENSER** of LHC Computing GRID project
- **Informational & mathematical support** to physicists
- Introduce **young physicists** into HEP world

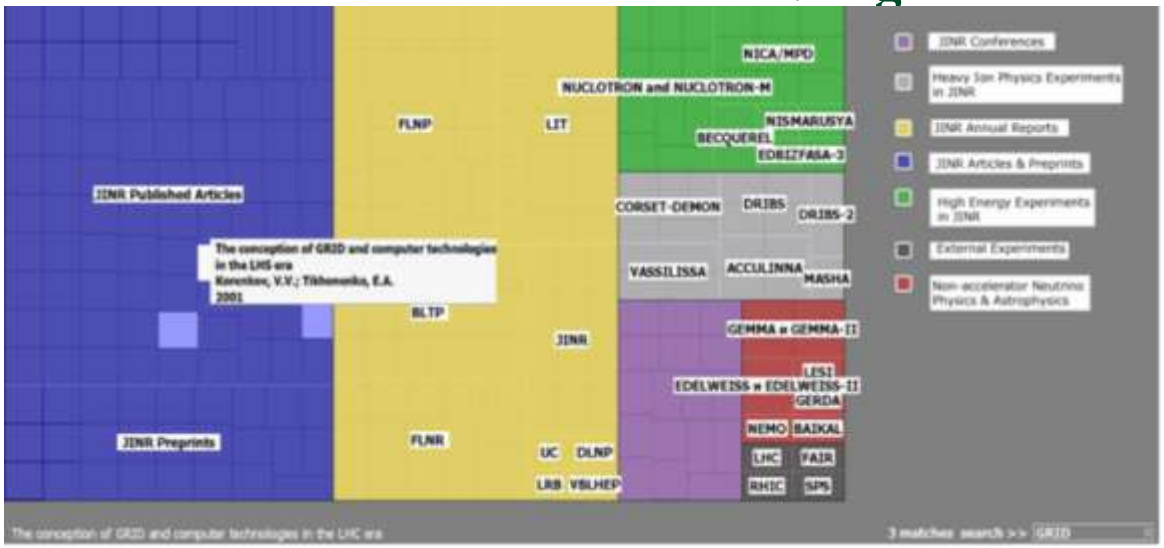
*Project HepWeb team:**E. Alexandrov, V. Kotov, V. Uzhinsky, and P. Zrelov***

JINR DOCUMENT SERVER – Open Access repository of JINR

http://jds.jinr.ru/

Makes available, on-the-fly, to the worldwide physical community the results of scientific research performed at JINR. JINR scientists get open access to a vast amount of documents in the field of nuclear, particle physics and related areas.

Visualization of Search and Navigation



2C. *The Applications Level* (1)

- **Covers user applications** working in a **virtual organization (VO)** environment comprising both users and owners of computing resources.
- The **JINR Grid site** provides **VO access** through the global life system via **specialized grid services**: ROCMON; VO boxes for ALICE, CMS, CBM, and PANDA; Storage Element of XROOTD type for ALICE;

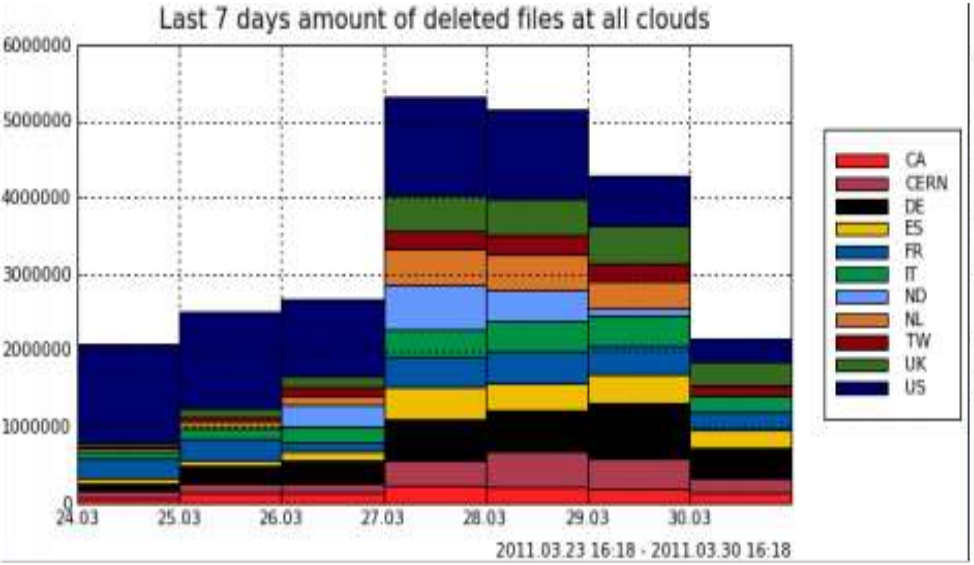
Frontier-caching service for access to CMS and ATLAS databases.
The **interfaces to** the LHC virtual organizations provide **support** to the **actual specialized software versions**: AliROOT, ROOT, and GEANT for ALICE, atlas-offline and atlas-production for ATLAS, CMSSW for CMS, and DaVinchi and Gauss for LHCb.

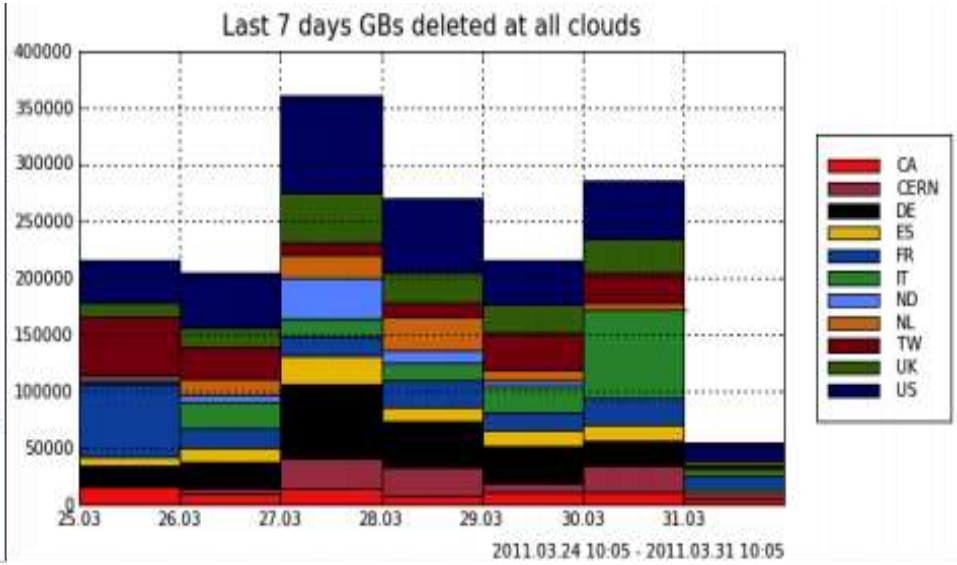
2C. *The Applications Level* (2)

• **Chief users** of **JINR grid resources** are the VOs **alice**, **atlas**, **cms**, and **lhcb** of the corresponding LHC experiments at CERN.
The **principal efforts:** mass Monte-Carlo event production, physics analysis and storage of data replicas of large volumes.
• **Other seven active organizations** (bes, biomed, dteam, fusion, hone, rgstest, and aps) use JINR grid resources, access defined for use of grid resources by the future CBM and PANDA experiments.
• For the **CMS** and **ATLAS** experiments, special **LIT done developments** secured to the two Institute teams **direct access** to these experiments through:
(i) the CMS JINR Monitoring and Analysis Remote Centre,
(ii) the System of remote access in real time (SRART) for monitoring and quality assessment of data from ATLAS at JINR.

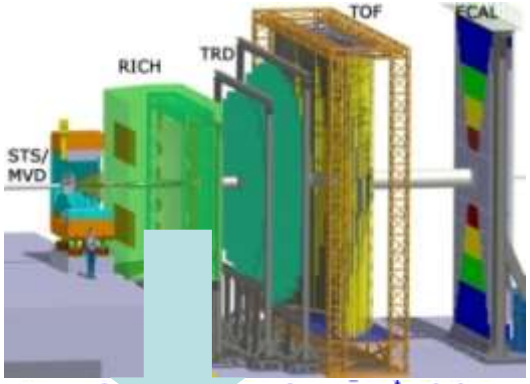
2C. ATLAS DQ2 Deletion service

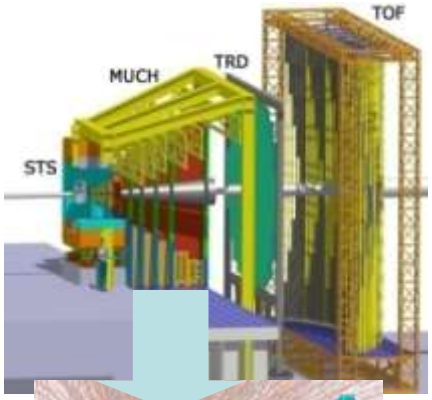
- The **ATLAS DQ2 deletion service for the ATLAS Distributed Data Management system is nowadays** ***maintained by LIT specialists***.
- Works started by mid-April 2010. At the end August, a new version of DQ2 was tested for a set of sites and since November 2010 for all sites managed by DQ2.
- **New interfaces** between parts of the deletion service have been **built** (based on the web service technology), a **new database schema** was created, the **deletion service core** part was rebuilt, **interfaces to the mass storage systems** were developed, and the **deletion monitoring system** was enhanced.

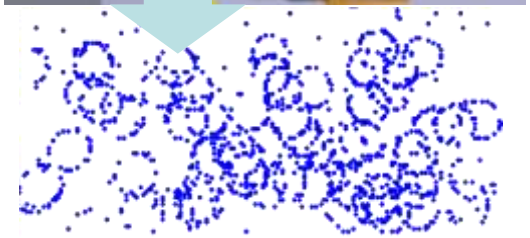


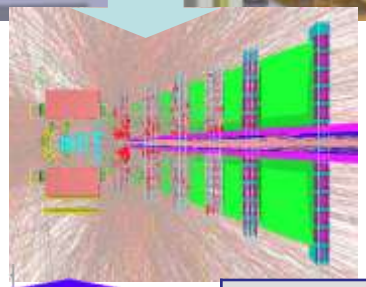


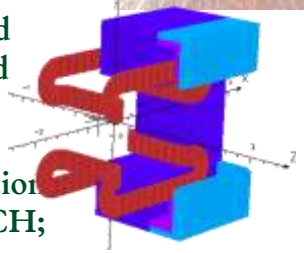
CBM (GSI) - Methods and Algorithms for Global Tracking

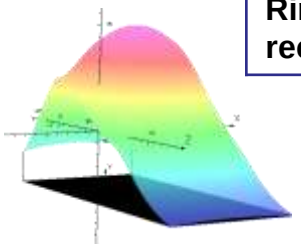












Fast parallel algorithms for event reconstruction in CBM detector

Modern technologies for parallelization:
1) Vectorization (SIMD - Single Instruction Multiple Data)
2) Multithreading (many core CPU)

Event reconstruction algorithms:
1) Tracking: Kalman filter and track following
2) Ring reconstruction: Hough Transform

Results:
1) High track and ring reconstruction efficiency (93-95%)
2) Fast algorithms

TASKS:

- Development of methods, algorithms and codes for global tracking in STS, RICH and TRD - track matching; Kalman filter for track fitting;
- Further development of pattern recognition and ring reconstruction algorithms for RICH;
- Development and comparative study of different algorithms for accurate momenta reconstruction;
- Development of algorithms for accurate reconstruction and selection of primary and secondary vertexes;
- Magnetic field calculations;
- GEANT simulations.

	Initial Time [ms/event]	Parallel Time [ms/event]	Speedup X
Tracking	730	1.5	487
Ring reconstruct.	375	2.5	143

Data production on **CBMGRID**, at **LIT** and **GSI** sites. Produced 5,000,000 UrQMD events

Two PhD theses were defended on the basis of these studies

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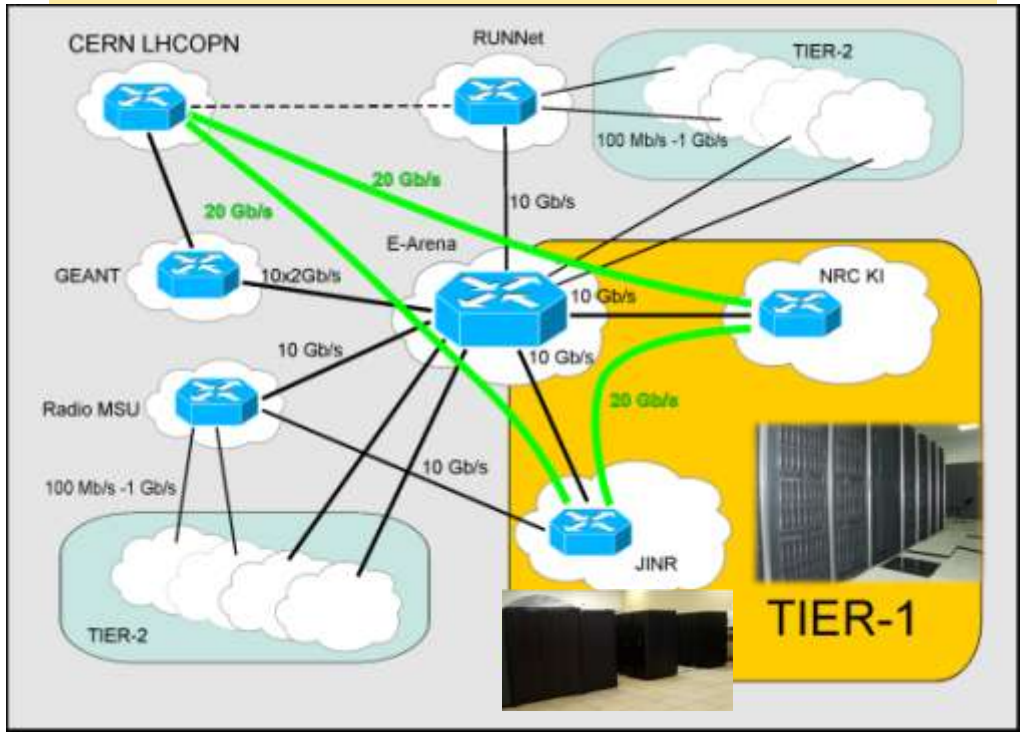
3A. *WLCG Tier-1 in Russia*

Project: **«Creation of the automated system of data processing for experiments at the Large Hadron Collider (LHC) of Tier-1 level and maintenance of Grid-services for a distributed analysis of these data»** (launched March 2011)



Terms: 2011-2013

Type of project: R&D

Cost: federal budget - 280 million roubles, extrabudgetary sources - 50% of total cost

Leading executor: NRC KI «Kurchatov institute»

Co-executor: **LIT JINR (for the CMS experiment)**

Core of the proposal:

Working prototype of the first-level center for data processing within the LHC experiments

Technical polygon for designing systems of distributed processing and analysis of data obtained at future scientific megainstallations:

FAIR (Darmstadt, Germany),

NICA (JINR, Dubna),

XFEL (Hamburg, Germany)

2012:

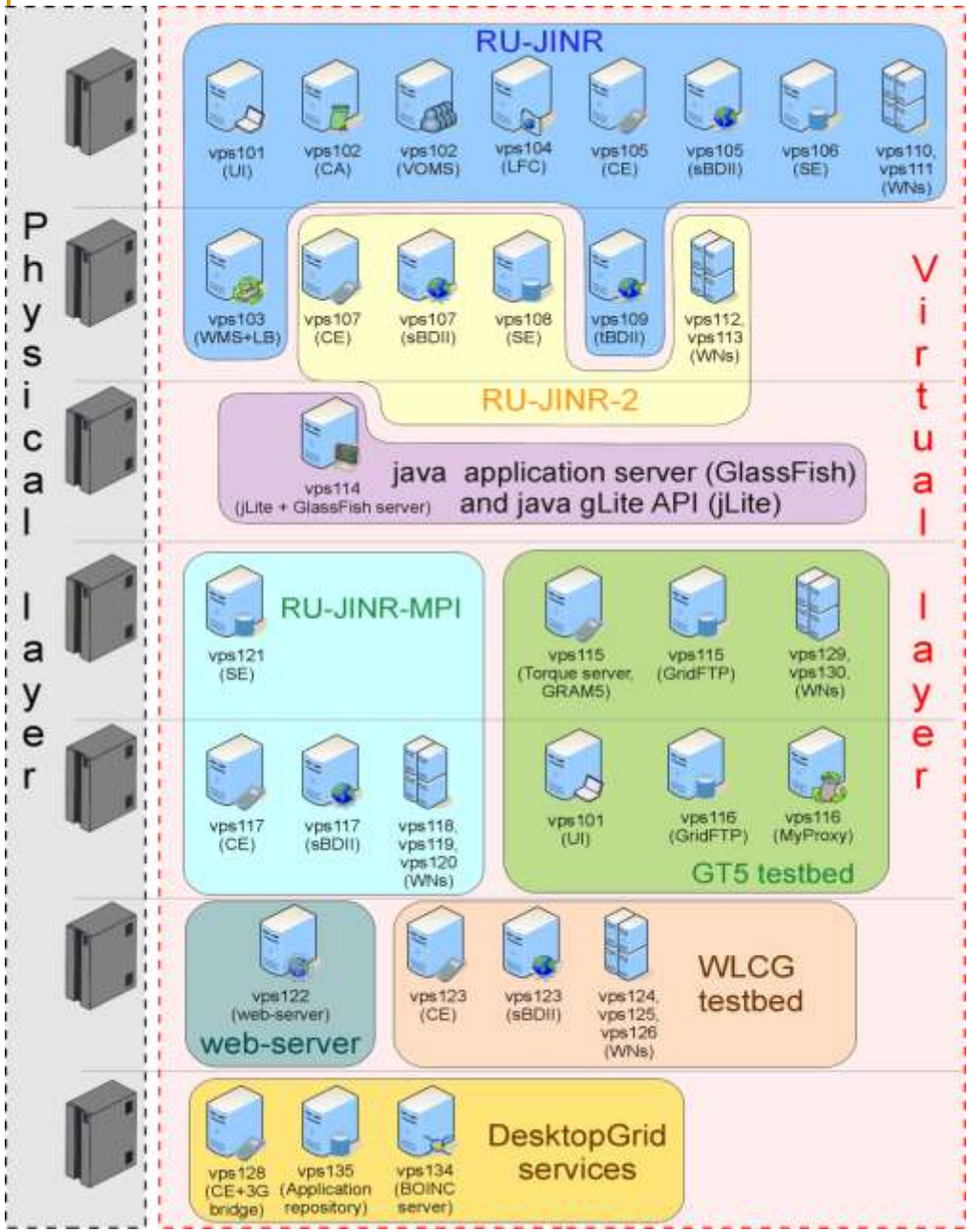
1. **Direct 10Gbps telecommunication channel to CERN**
2. **Tier-1-CMS Prototype**

   CPU (kSI2k) – 1000

   Disk(Tbytes) – 500

3B. *Grid Training and Education (T-infrastructure)*

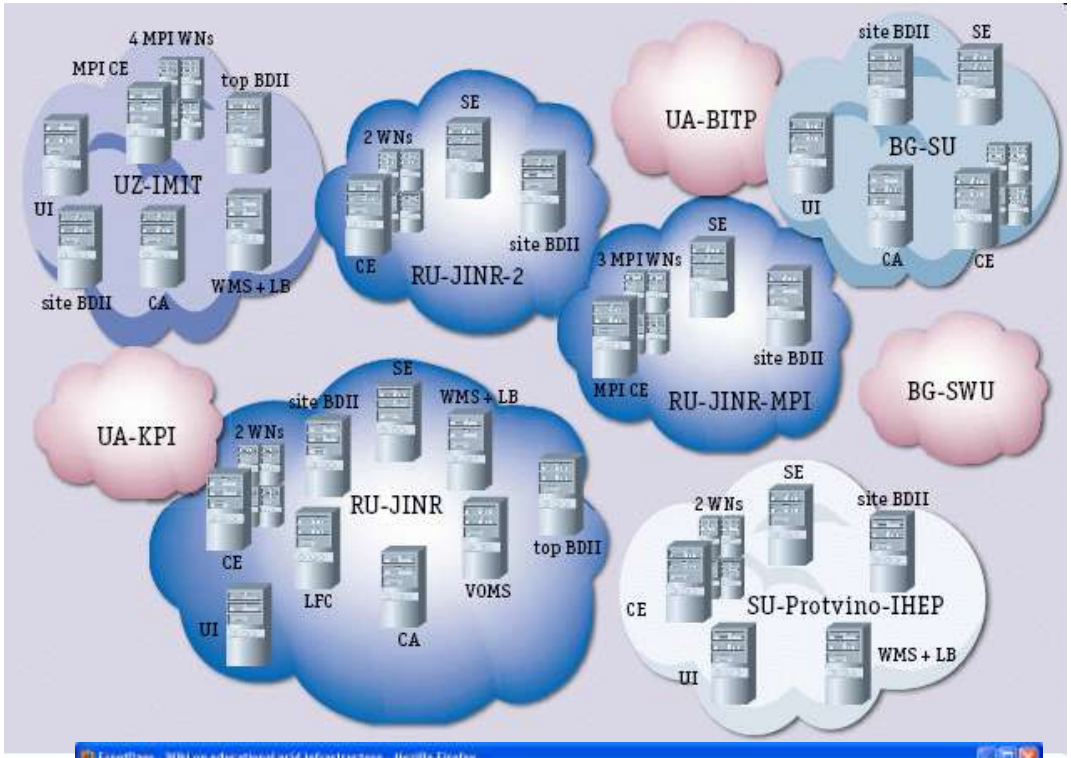
- **Project purpose:** solving the workforce problems raised by the use of grid technologies.
- **Means of realization**: training courses at three levels:
  - *users* (basic ideas and skills),
  - *system administrators* (grid sites deployment),
  - *developers* of grid applications and services.
- **Central issues**: comparative evaluation of different implementations of grid middleware, testing particular grid services, grid services development, porting existing applications into grid environment.



T-infrastructure implementation

- All services are deployed on VMs (OpenVZ)
- Main parts:
  - three grid sites on gLite middleware,
  - GT5 testbed,
  - desktop grid testbed based on BOINC,
  - testbed for WLCG activities.
- Running since 2006

JINR based distributed Grid-infrastructure for training and education



site name	hosting organization
RU-JINR	JINR (Dubna, Russia)
RU-JINR-2	– // –
RU-JINR-MPI	– // –
BG-SU	Sofia University "St. Kliment Ohridski" (Sofia, Bulgaria)
SU-Protvino-IHEP	Institute of High-Energy Physics (Protvino, Russia)
UZ-IMIT	Institute of Mathematics and Information technologies (Tashkhent, Uzbekistan)
UA-BITP	Bogolyubov Institute for Theoretical Physics (Kiev, Ukraine)
UA-KPI-HPCC	National Technical University of Ukraine "Kyiv Polytechnic Institute" (Kiev, Ukraine)
KZ-ENU	L.N. Gumilyov Eurasian National University (Astana, Kazakhstan)
UA-ILTPE	B.Verkin Institute for Low Temperature Physics and Engineering (Kharkov,Ukraine)

Letters of Intent with
Moldova "MD-GRID",
Mongolia "Mongol-Grid"
Project with Cairo University

3C. *Grid NNN* http://ngrid.ru ГРИД ННС

- **Purpose:**
- *Grid support* for National Nanotechnology Network (NNN) in Russia
  - To provide *effective access* for science and industry to distributed computational, informational and networking facilities
  - To help get *expected breakthroughs* in nanotechnology
  - *Supported* by a special federal program of RF
- **Characterization**
  - based on a network of supercomputers (about 15-30)
  - two grid operations centers (main and backup)
  - set of grid services with unified interface
  - partially based on Globus Toolkit 4
- **JINR participation** (http://grid-eng.jinr.ru/?page_id=243):

  - development of the service of registration of resources and grid services,
  - the monitoring system,
  - the accounting system on resources usage,
  - adaptation of application software packages for use in grid,
  - GridNNN support service

the globus toolkit

Grid NNN Infrastructure

ГРИД ННС

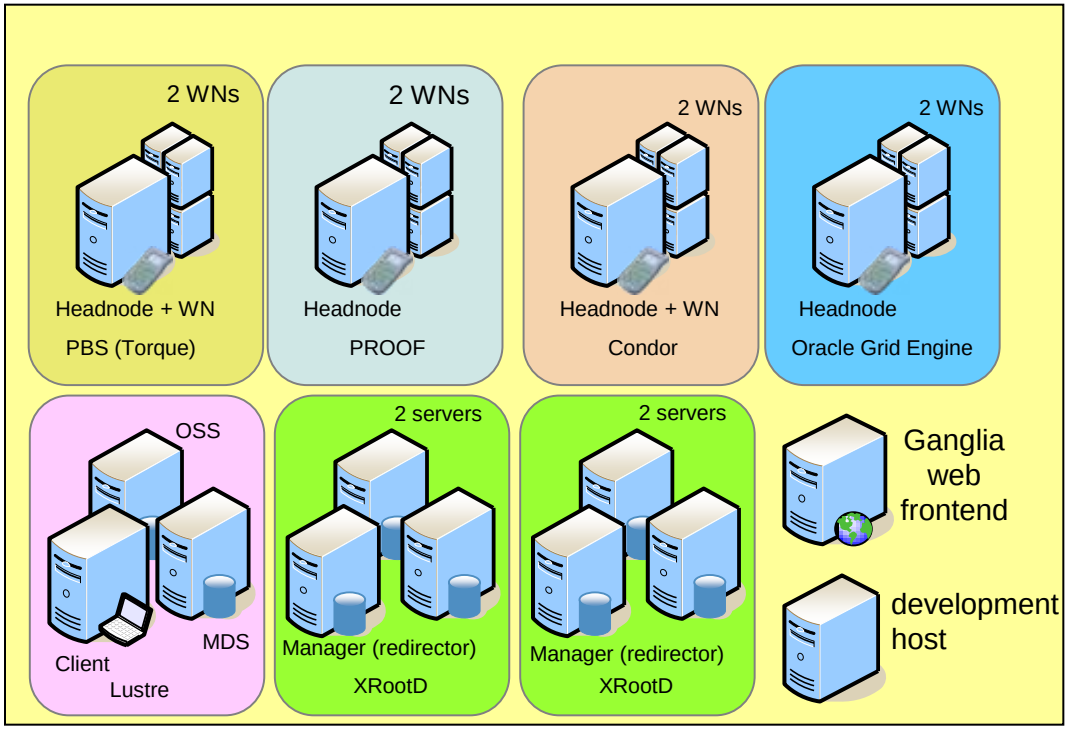
- 10 resource centers in different regions of Russia: RRC KI, «Chebyshev» (MSU), IPCP RAS, CC FEB RAS, ICMM RAS, JINR, SINP MSU, PNPI, KNC RAS, SPbSU
- 10 virtual organizations
- 70 users
- more than 500'000 tasks processed

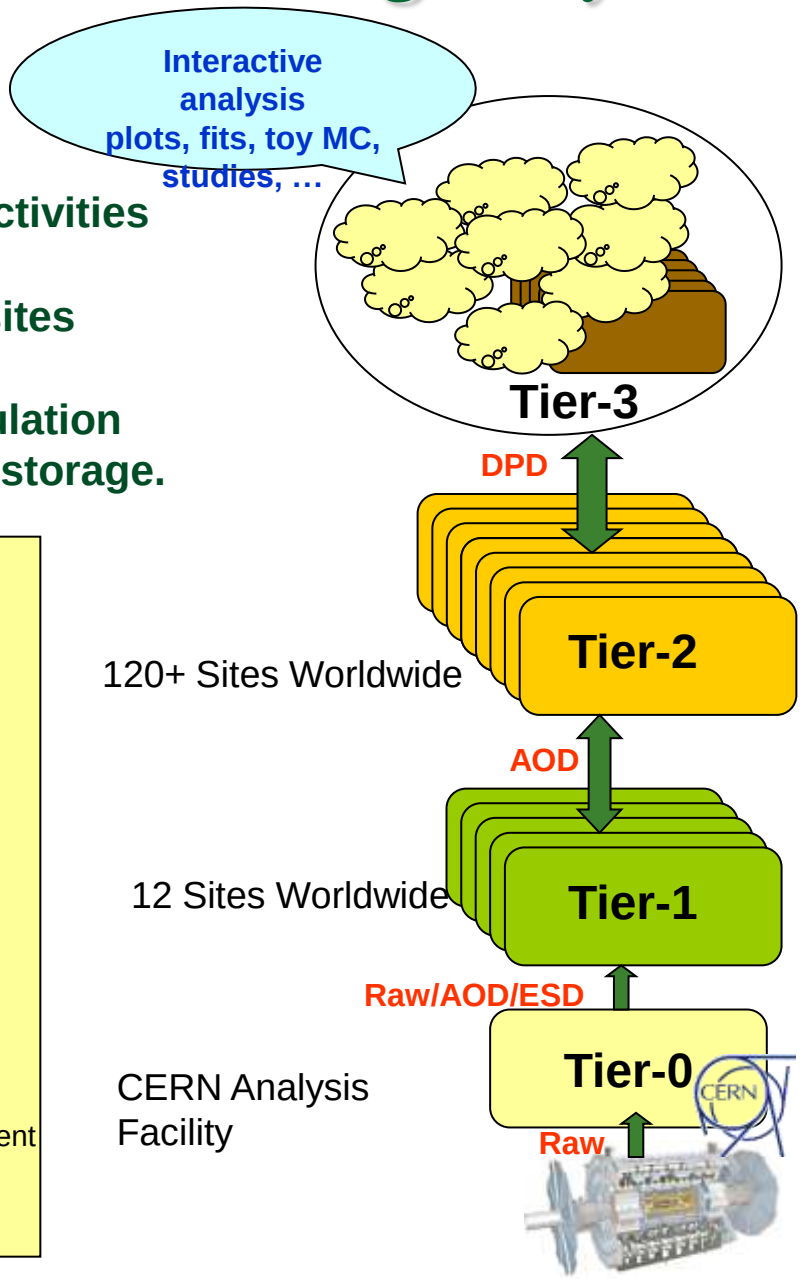
НИИЯФ МГУ

Saint-Petersburg State University

3D. *Tier-3 off-grid Sites Monitoring Project*

- **Promoted by the ATLAS team, participation of BNL (USA), JINR, and CERN IT (ES group)**
- **Purpose → get global view on LHC computing activities**
- **LIT contributes to the definition of project tasks**
- **LIT develops a software suite for Tier-3 off-grid sites monitoring (both locally and globally)**
- **A virtual testbed created at LIT-JINR allows simulation of various Tier3 clusters and of solutions for data storage.**

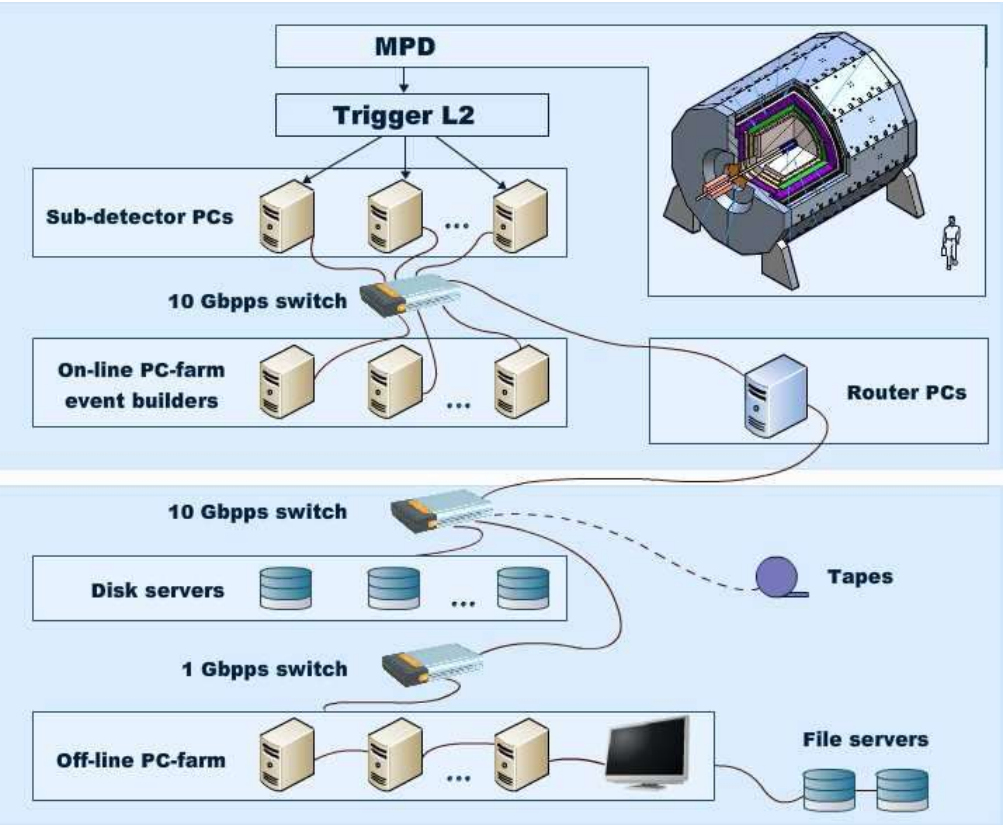




3D. *Tier-3 off-grid Sites Monitoring Project*

- Tier-3 off-grid sites provide resources mostly dedicated to data analysis by geographically close or local scientific groups. Can be organized in a federation.
- Many institutes and national communities have built (or have plans to build) Tier-3 facilities. Tier-3 sites comprise different architectures, many do not possess Grid middleware, whence the need of specific Grid monitoring systems.
- **Tier3 monitoring objectives**:
  - Monitoring individual Tier 3 sites (local monitoring).
  - Monitoring Tier 3 sites federation (global monitoring).
- **Monitoring individual Tier 3 sites** (**tasks**):
  - Detailed monitoring of the local fabric (overall cluster or clusters monitoring, monitoring each individual node in the cluster, network utilization)
  - Monitoring the batch system.
  - Monitoring the mass storage system (total and available space, number of connections, I/O performance)
  - Monitoring VO computing activities at a site
- **Monitoring Tier 3 sites federation** (**tasks**):
  - Monitoring the VO usage of the Tier3 resources in terms of data transfer and job processing and the quality of the provided service based on the job processing and data transfer monitoring metrics.

3E. *Distributed Data Processing for NICA/MPD Project*



MPD data processing model

(from "The MultiPurpose Detector – **MPD Conceptual Design Report v. 1.4** ")

Project: Development of a shared distributed system for acquisition, transfer and processing of very large-scale data volumes, based on grid technologies, for the future NICA accelerator complex

Terms: 2011-2012

Cost: federal budget

- 10 million rubles;

extra budgetary sources

- 25% of the total cost

Leading executor: LIT JINR

Co-executor: VBLHEP JINR

Thank you for your attention !