Laboratory of Information Technologies

Presented by :
Igor Pelevanyuk
engineer-developer

July 03, 2017

LIT

Here works:

~ 300 staff

It helps:

~ 4500 users

Provide:

- Services
- 10 Gb/s network
- Storage resources
- Computing resources

And wide range of scientific research are conducting here.

History

It is the performance of experimental information processing facilities that will eventually determine the "performance" of physical research

August 6, 1966

History

Laboratory of Information Technologies of the Joint Institute for Nuclear Research in Dubna was founded in August 1966.

The main directions of the activities at the Laboratory are connected with the provision of networks, computer and information resources, as well as mathematical support of a wide range of research at JINR in high energy physics, nuclear physics, condensed matter physics, etc.

M.G. Mescheryakov

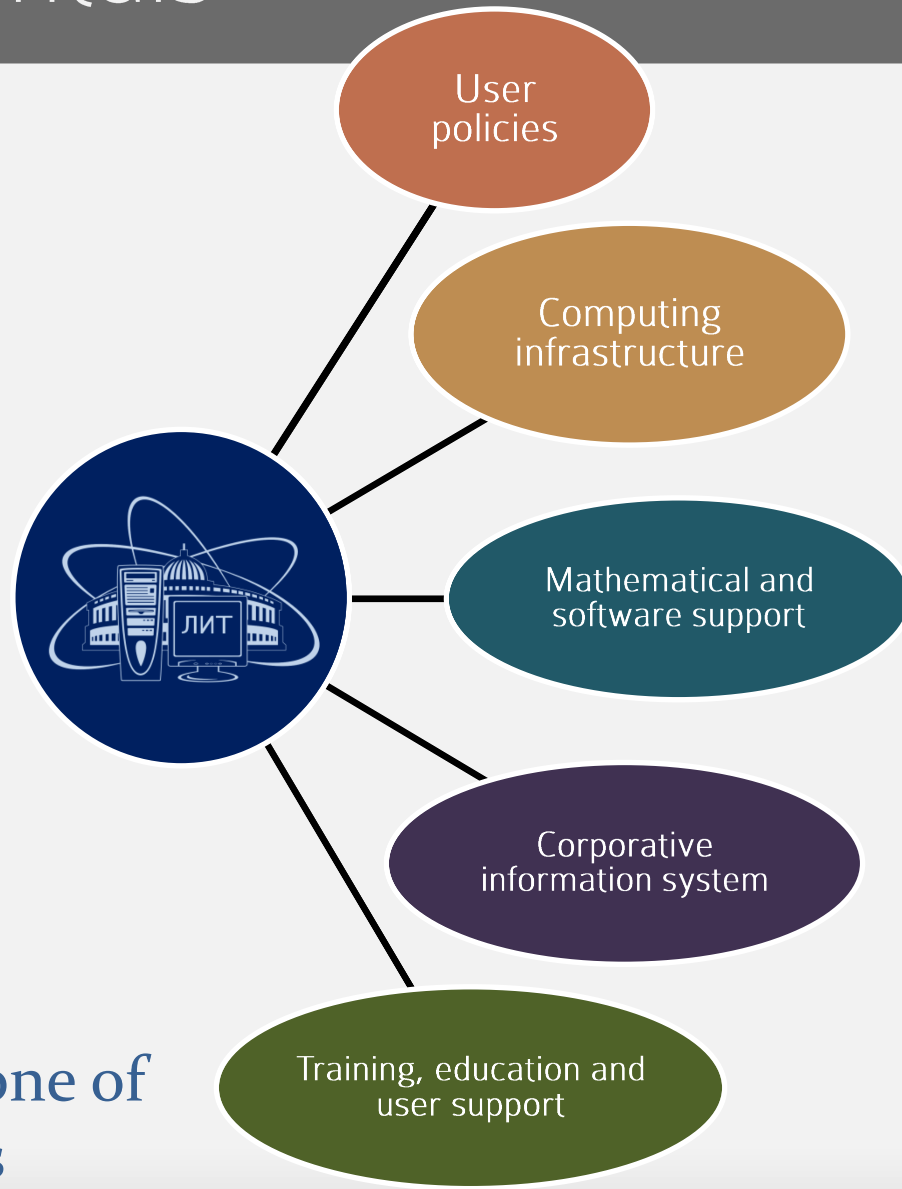
N.N. Govorun

Computing is an integral part of theory, experiment, and technology development

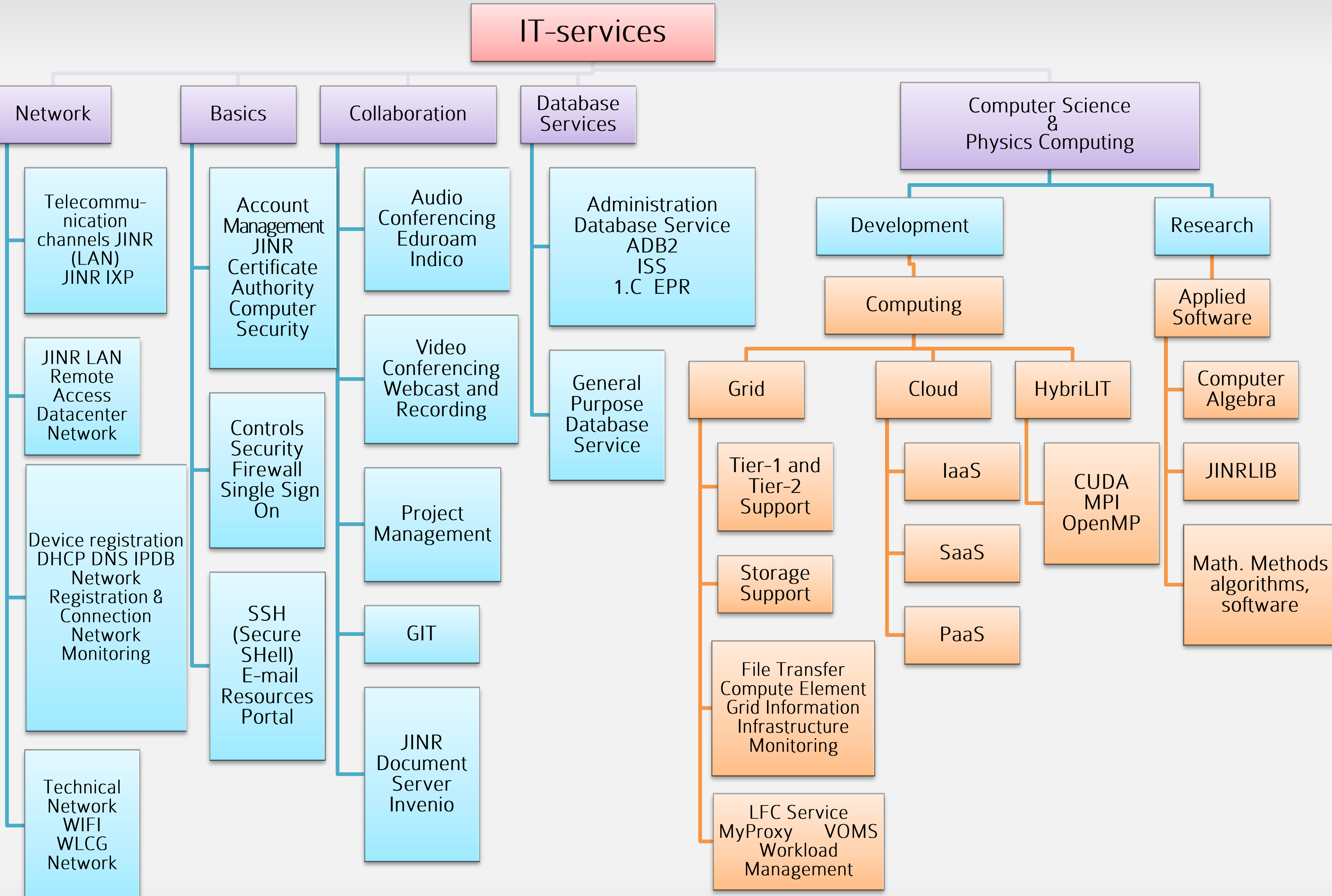
Many recent successes only possible because of significant community effort to develop and advance the necessary computing tools!

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 <u>nonstop service</u>



IT-infrastructure is the one of 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

Multifunctional Information and Computing Complex

- **LAN**: 10 Gbps
- **WAN**: 100 Gbps + 2x10 Gbps
- **Tier-1**: 3600 core, 56 kHS06, 4,5 PB disk, 8 PB tape
- **CICC/Tier-2**: 3500 core, 48 kHS06, 2PB disk
- **HybriLIT**: 252 CPU, 77184 GPU cores, 182 PHI-cores, 2.4 TB RAM, 57.6 TB HDD, 142 Tflops
- **Cloud**: 330 CPU, 840GB RAM

LIT IT-infrastructure is the one of JINR basic facilities

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

Cloud infrastructure

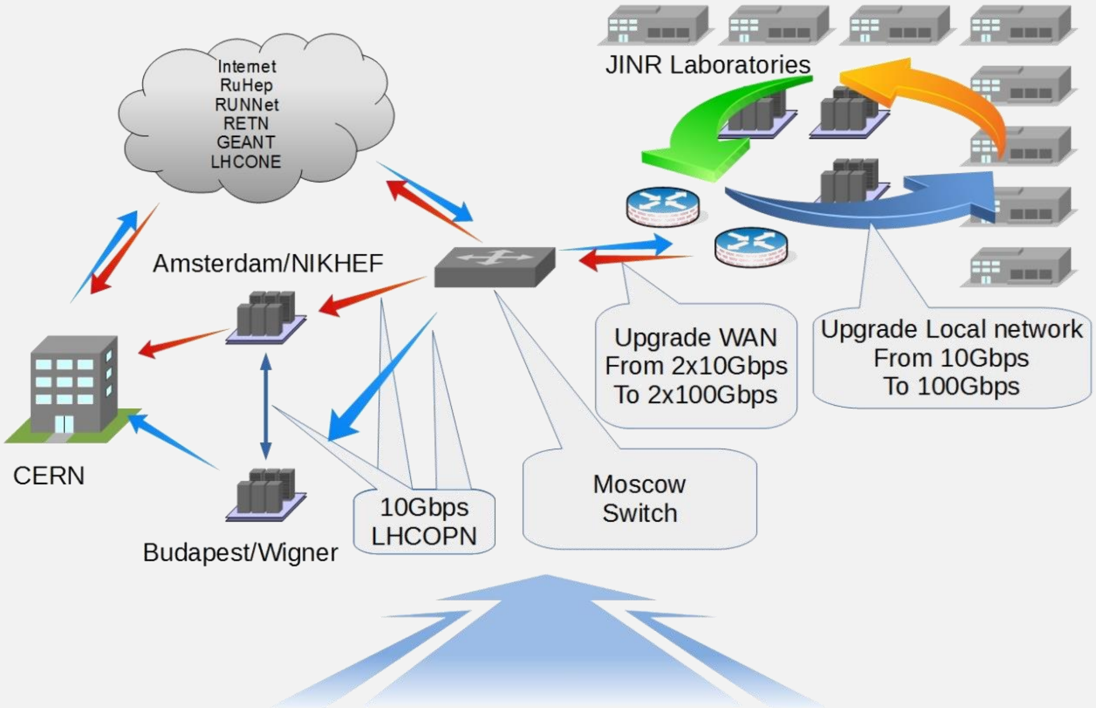
Heterogeneous(CPU + GPU) computing cluster HybriLIT

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

Network infrastructure

Engineering infrastructure

Network



Users – 4298

Network nodes – 7945

IP addresses – 13055

Remote access – 370

E-library – 1501

AFS – 367

VOIP – 127

E-mail – 2356

Local Area Network – 10Gbps, planned upgrade to 100Gbps
Wide Area Network – 2x10Gbp, 100Gbps – test mode
Upgrade WAN to 2x100Gbps planned

Grid technologies - 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.

Grid technologies - success

At the initiative of CERN, a project EU-dataGrid started up in January 2001 with the purpose of testing and developing advanced grid-technologies. JINR was involved with this project.

The LCG (LHC Computing Grid) project was a continuation of the project EU-dataGrid. The main task of the new project was to build a global infrastructure of regional centres for processing, storing and analysis of data of physical experiments on the Large Hadron Collider (LHC).

2003 – Russian Consortium RDIG – Russian Data Intensive Grid – was established to provide a full-scale participation of JINR and Russia in the implementation of the LCG/EGEE project.

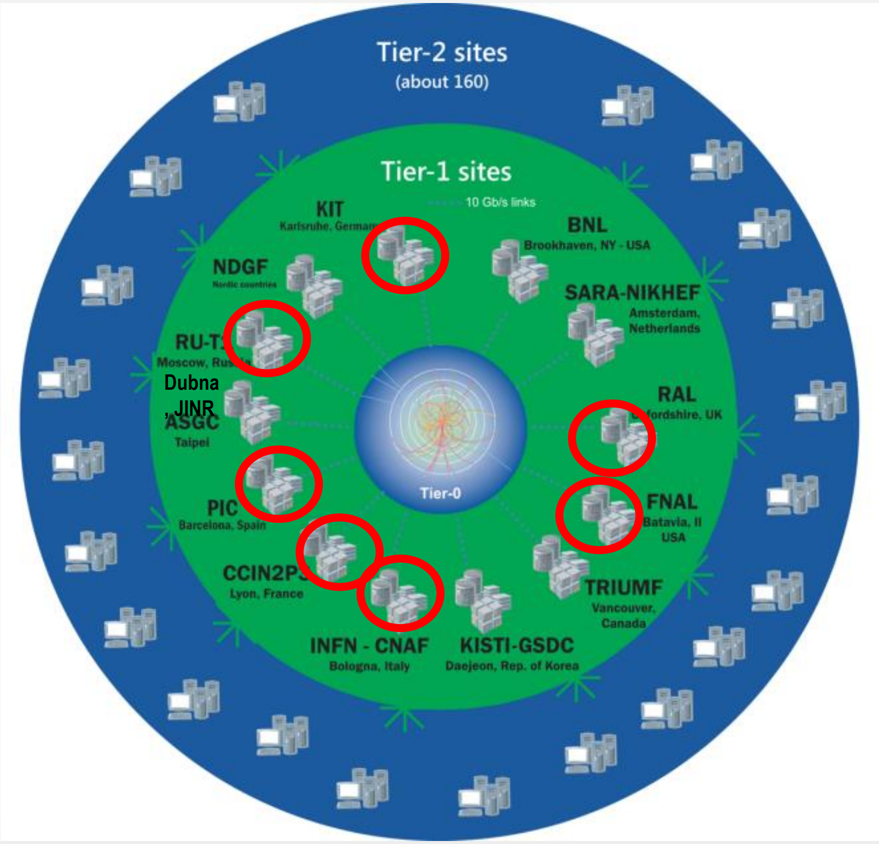
2004 – The EGEE (Enabling Grid for E-Science) projects was started up. CERN is its head organization, and JINR is one of its executors.

2010 – The EGI-InSPIRE project (Integrated Sustainable Pan-European Infrastructure for Researchers in Europe)

LHC computing model

The Worldwide LHC Computing Grid (WLCG):
Integrates computer centers globally to provide computing and storage resources into a single infrastructure accessible by all LHC physicists for data analysis

42 countries
~300,000 cores
Average
173 PB of storage
> 2 million
jobs/day
>10 Gb links



Tier-0 (CERN & Wigner, Budapest):
- Data recording
- Initial data reconstruction
- Data distribution

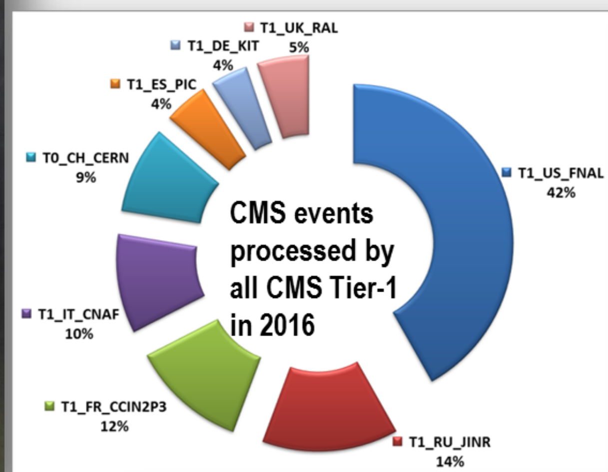
Tier-1 (11→14 centres):
- Permanent storage
- Re-processing
- Analysis
- Simulation

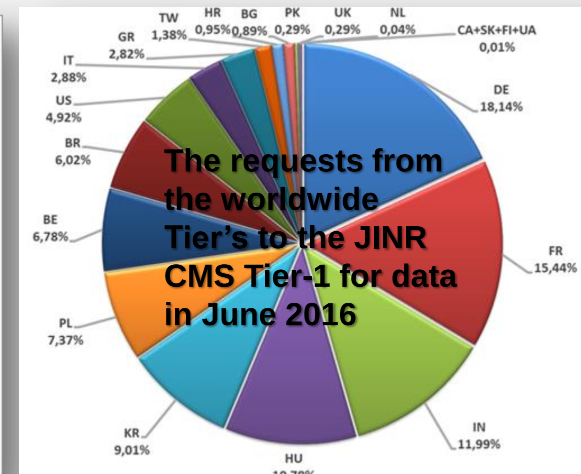
Tier-2 (>200 centres):
- Simulation
- End-user analysis

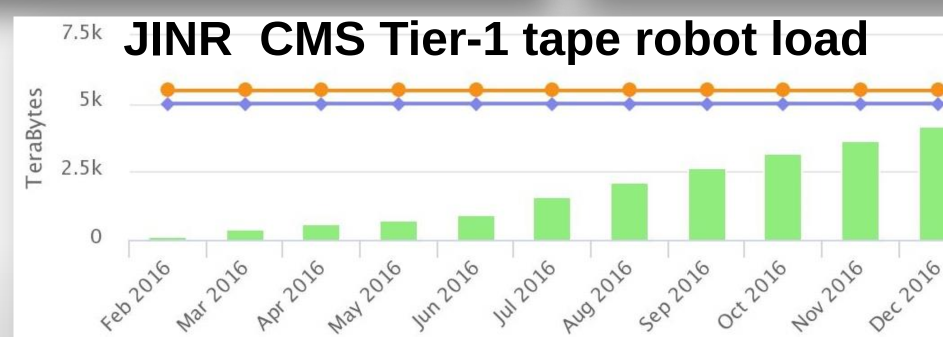
JINR Tier-1 center for CMS

Current configuration

- 3600 cores
- 8 PB tapes
- 4.5 PB disks
- 100% R/A
- 70 TB per day



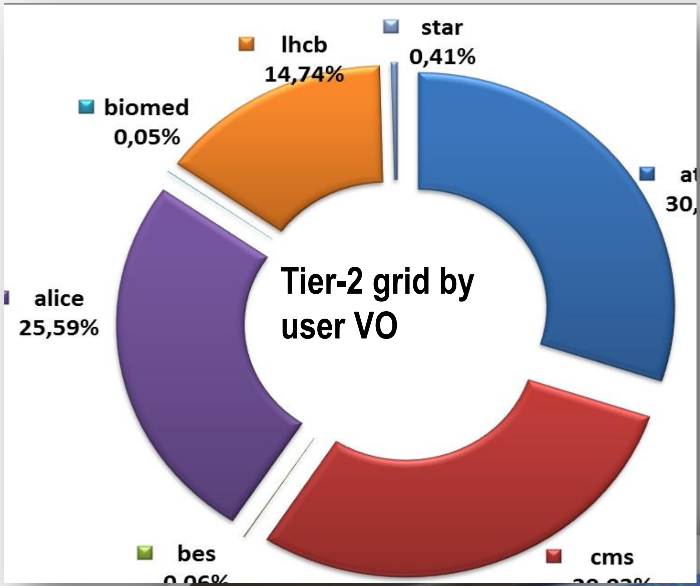


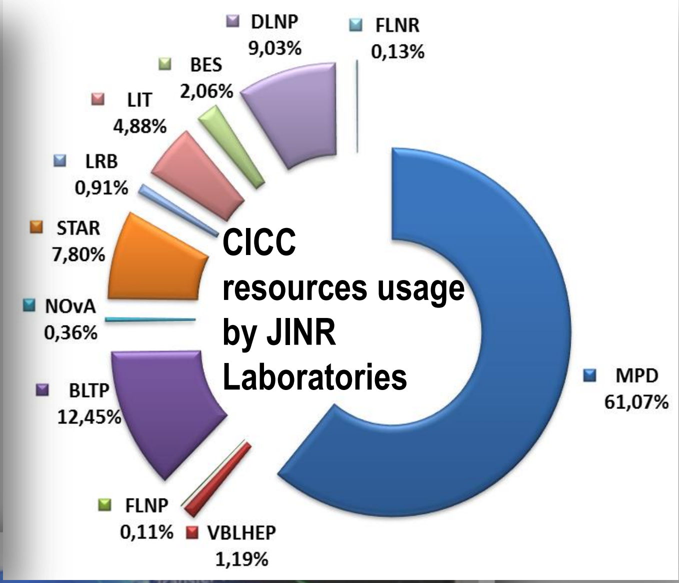


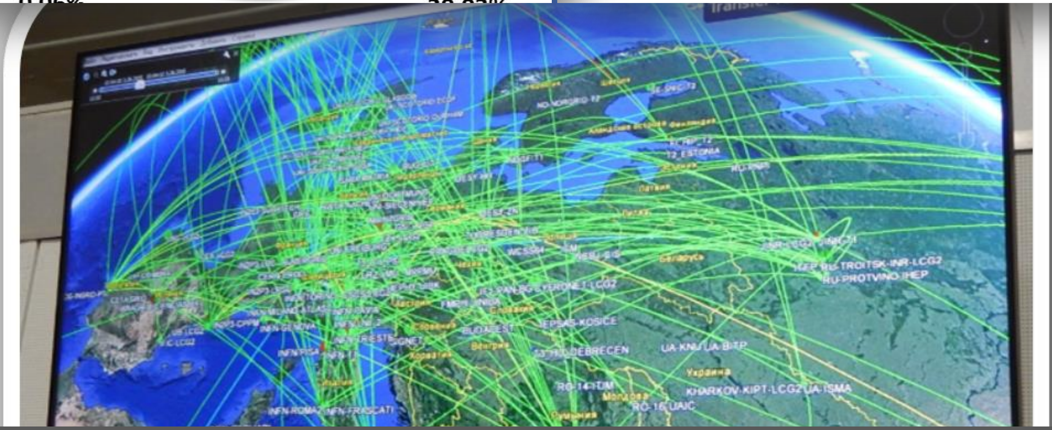
Tier-2 and CICC

Experiments

BM@N,
MPD,
CMS,
ATLAS,
ALICE,
LHCb,
COMPASS,
PANDA,
CBM,
STAR,
NOvA,
BESIII,
DIRAC,
OPERA
NEMO
Mu2e,
NUCLON,
HONE,
BIOMED







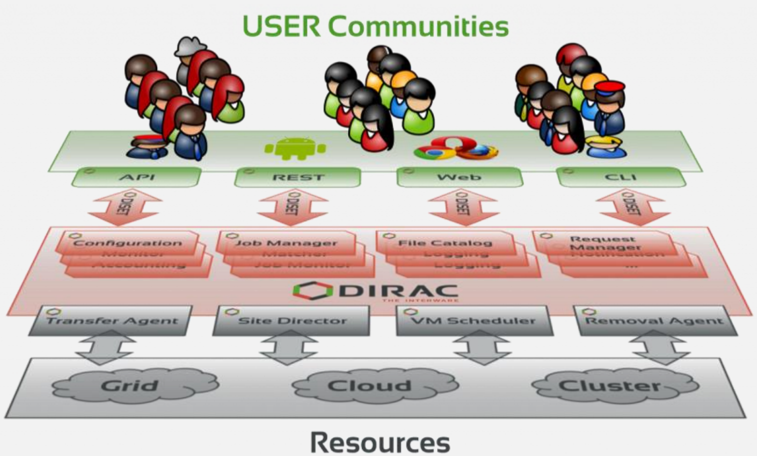
Tier-1 and Tier-2:
JINR in Worldwide LHC Computing Grid

BigPanDA - Beyond ATLAS

DIRAC THE INTERWARE @JINR

(just for tests)

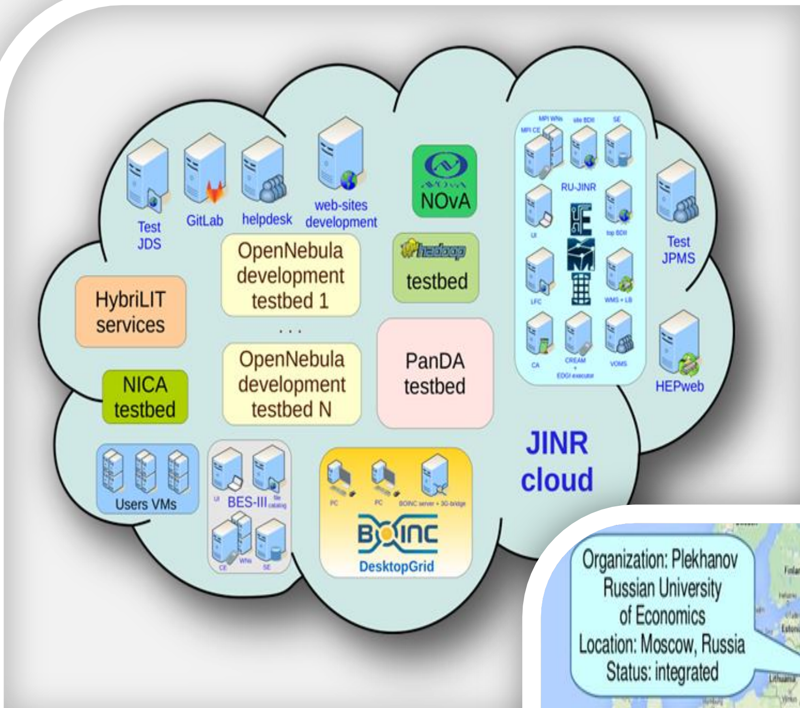
DIRAC (Distributed Infrastructure with Remote Agent Control) INTERWARE is a software framework for distributed computing providing a complete solution to one (or more) user community requiring access to distributed resources.



NICA

Tests for NICA were performed. MPD events were generated using MPD root and then saved storage. All done with DIRAC.

JINR Cloud



One of the most important trends in the cloud technologies is the development of method of integrating various cloud infrastructures.

In order to join the cloud resources of partner organizations from JINR Member State for solving common tasks as well as to distribute a peak load across them, a cloud bursting driver has been designed by the JINR cloud team. It allows one to integrate the JINR cloud with the partner clouds either OpenNebula-based one or any other cloud platform which supports Open Cloud Computing Interface (OCCI).

The geographical location of the partner's organizations from JINR Member States whose cloud resources are integrated into the JINR cloud following the so-called "cloud bursting" model.

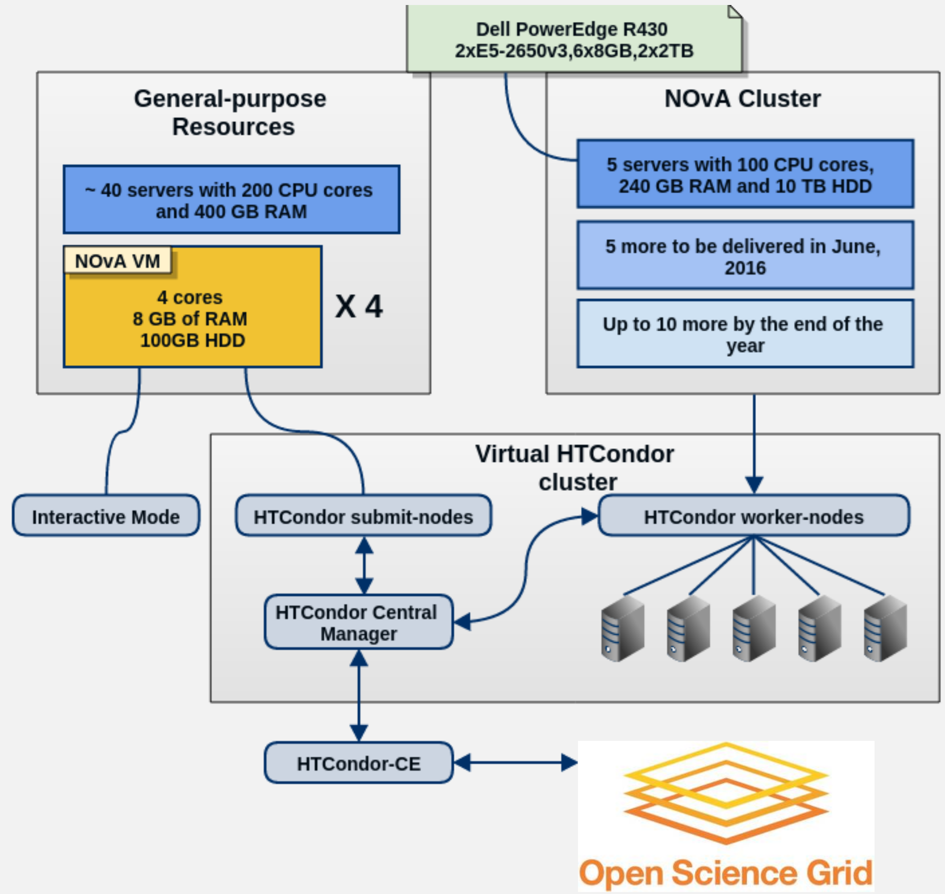
Besides, the JINR cloud is integrated into EGI Federated cloud thus enabling a possibility to use part of the JINR computing resources by EGI FedCloud Virtual Organizations.

Neutrino computing support

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.

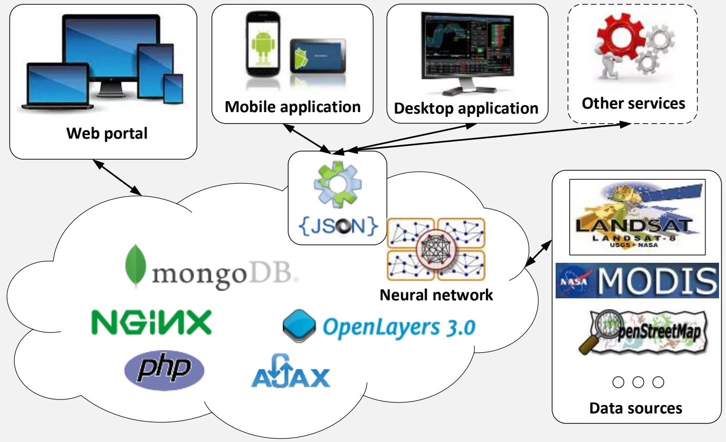
Environmental Monitoring

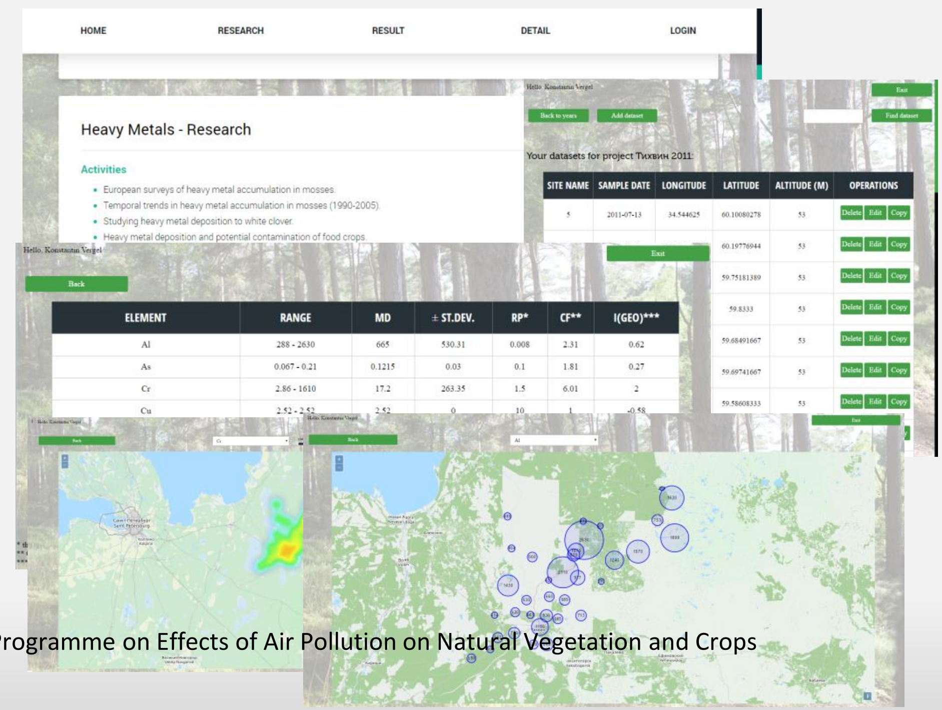
UNECE ICP Vegetation programme[1] is realized in 36 countries of Europe and Asia. Mosses are collected at thousands of sites across Europe and Asia.

The goal of this programm is to identify the main polluted areas, produce regional maps and further develop the understanding of long-range transboundary pollution.

Since 2014 FLNP (Frank Laboratory of Neutron Physics) at the Joint Institute for Nuclear Research has been in charge of that part of the project which is related to the moss biomonitoring.

We propose a cloud platform for data management to facilitate IT-aspects of all biological monitoring stages starting from a choice of collection places and parameters of samples description and finishing with generation of pollution maps of a particular area or state-of-environment forecast in the long term.



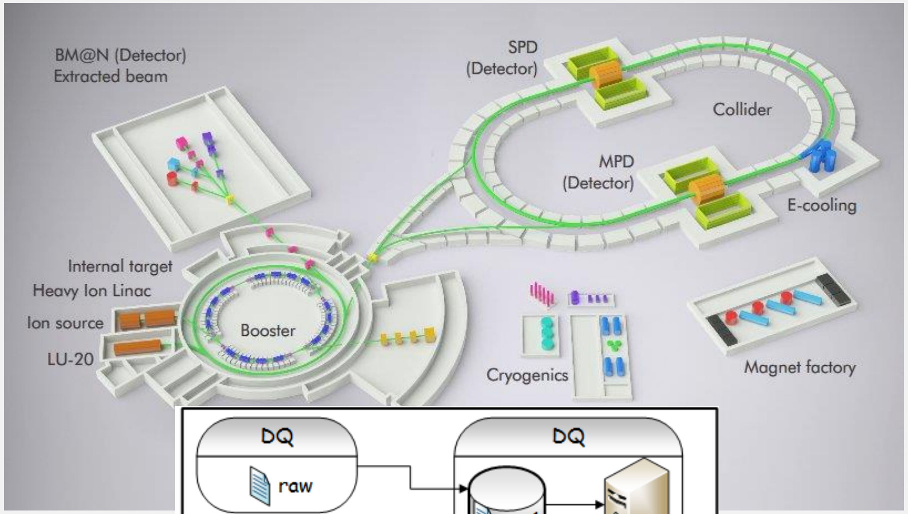


1. United Nations Economic Commission for Europe International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (http://icpvegetation.ceh.ac.uk)

Optimisation of Distributed Data Processing system for NICA BM@N Experiment by Using Simulation

2017 – second run of Baryonic Matter at Nuclotron (BM@N) experiment.

The run requires developing distributed computing system for BM@N data storing and processing.

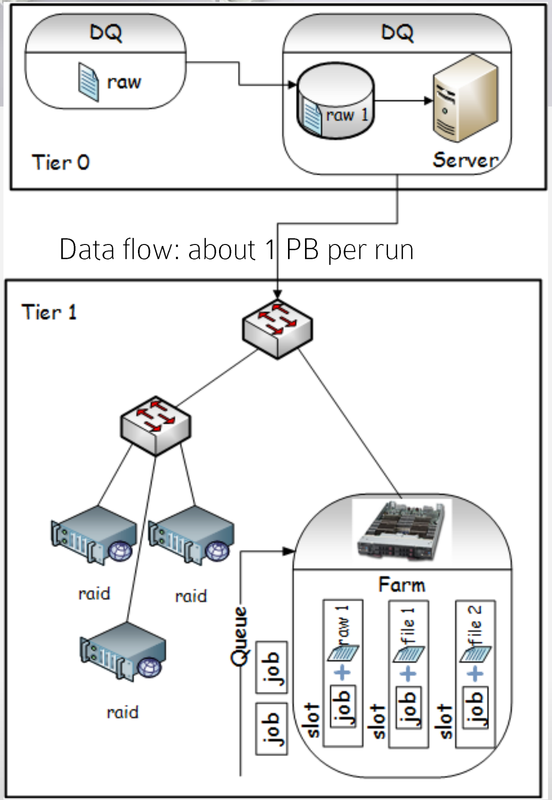


A simulation is needed to: 1. optimize architecture and equipment. 2. define main parameters and structures of data processing system.

The simulation program SyMSim (Synthesis of Monitoring and Simulation) was developed at LIT-JINR.

SyMSim was used to model and optimize the infrastructure of the CMS JINR Tier1 center and NICA project computing system infrastructure

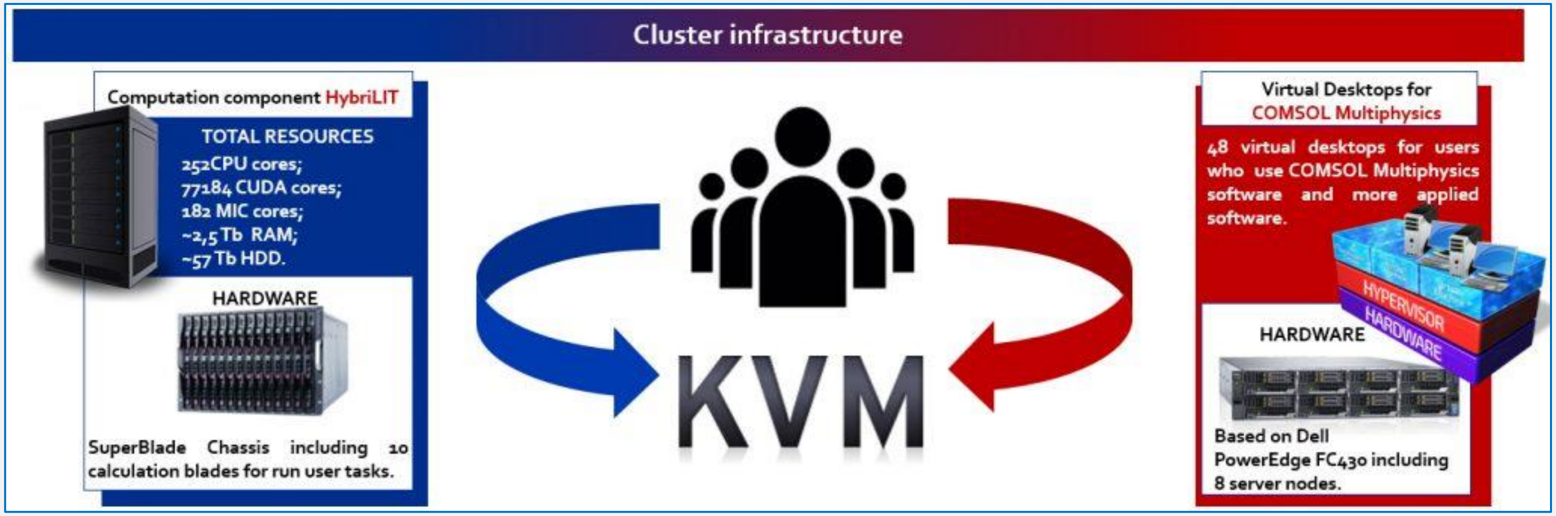
Now SyMSim is used to choose a proper architecture of the BM@N computing system infrastructure.



Scheme of the Data Processing System

HYBRILIT IN 2016: NEW POSSIBILITIES AND SERVICES

New possibilities for carrying out computations: component for using COMSOL Multiphysics



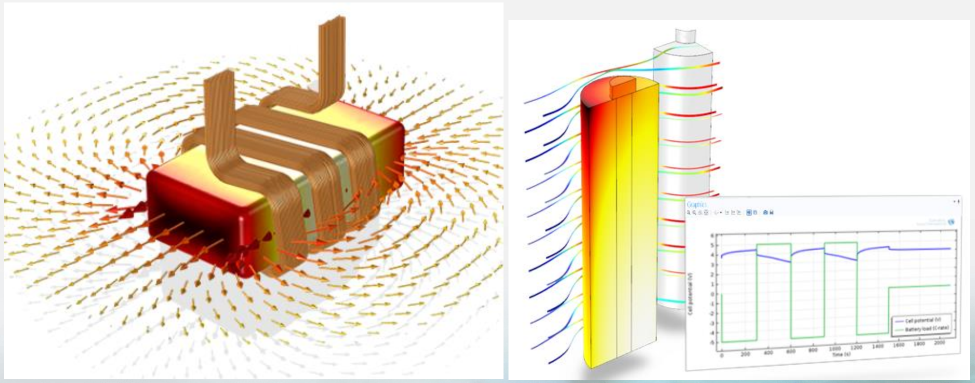
New services providing a more convenient workspace computations: ***http://hybrilit.jinr.ru***

MobiLiT – is a native Android mobile application for users of the HybriLiT HPC cluster.

Author: Alexej I. Streltsov (Heidelberg, Germany), developed with support from HybriLIT team.

We are on Google Play Store with the name "MobiLIT@HPC" available.

Computations with COMSOL Multiphysics – new possibilities for physics and engineering applications

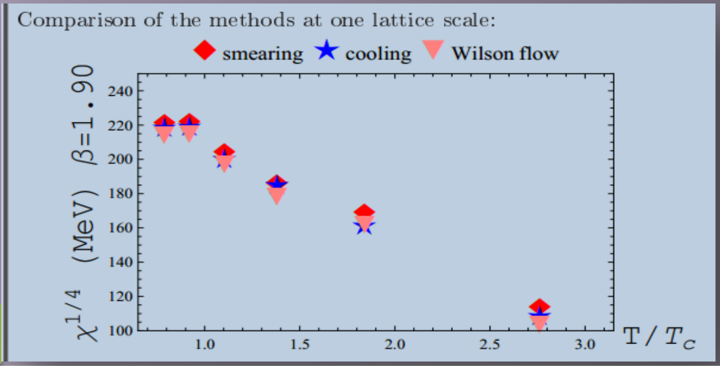


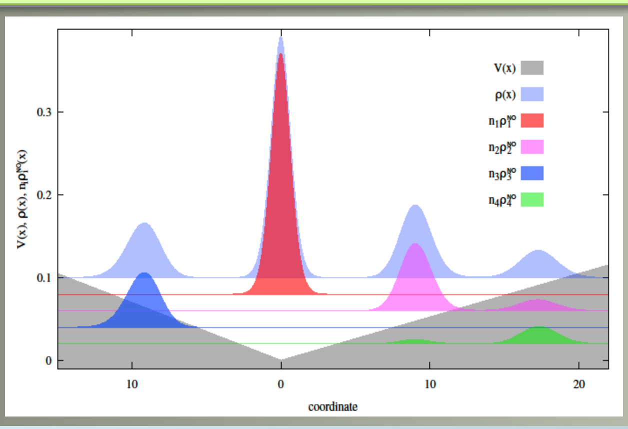
Parallel computing on HybriLIT

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:

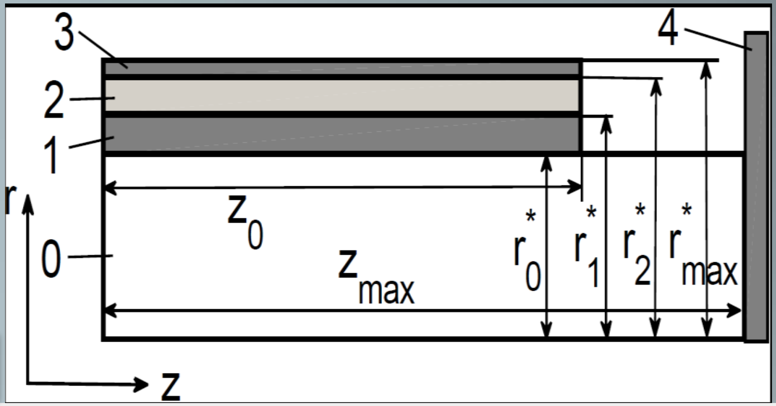
Alexej I. Streltsov ("Many-Body Theory of Bosons" group at CQD, Heidelberg University, Germany),
Oksana I. Streltsova (LIT JINR)

http://MCTDHB.org

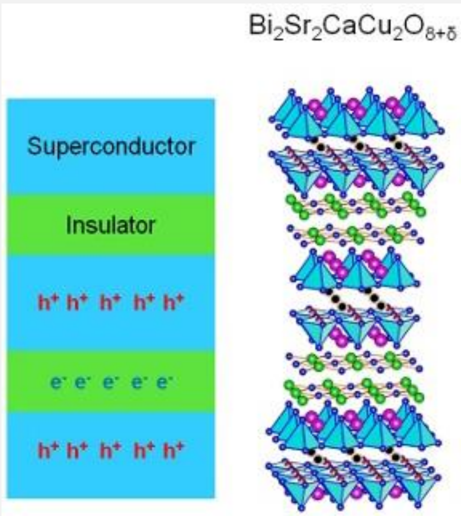
Parallel computing for Technical problems:

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



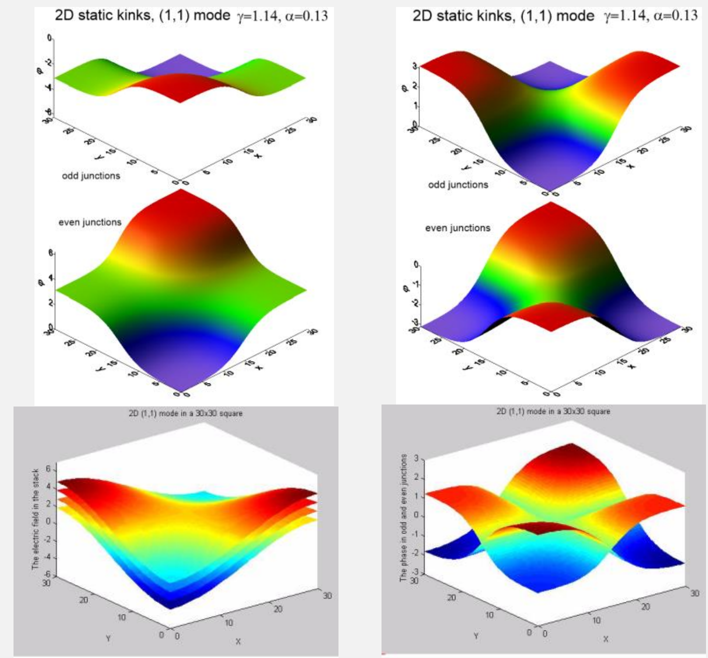
Standing Wave Solutions Corresponding to the Cavity Resonances in BSCCO Intrinsic Josephson Junctions



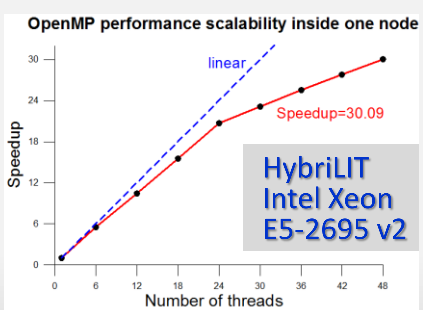
The Intrinsic Josephson Junctions in BSCCO crystals (IJJ-BSCO) are a strong source of THz radiation.

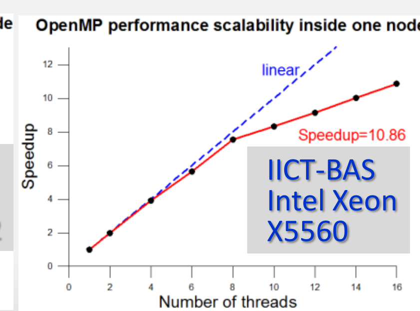
The phase dynamics of the IJJ-BSCO is described by a system of **perturbed 2D Sine-Gordon equations**.

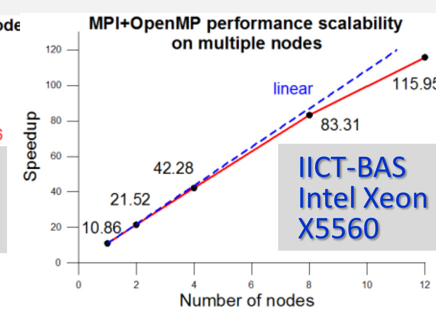
Hybrid MPI+OpenMP Parallelization of a Leapfrog Algorithm for Solving Systems of 2D Sine-Gordon Equations



Computational challenges in solving this system:
Discretization of the 2D domain may ask for 10^6–10^8 mesh points.
Stable integration scheme with respect to the time variable depends on problem parameters and may ask for 10^8–10^9 time steps.







Ivan Hristov, Radoslava Hristova, Stefka Dimova Sofia University, Bulgaria / LIT, JINR, May 26, 2016 Seminar in LIT-JINR

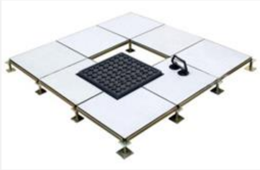
MICC Engineering Infrastructure

Fibre Optic & Data Structured Cabling System

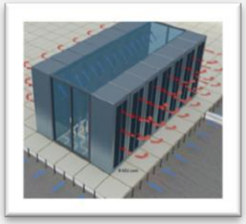
Diesel generator set

Uninterruptible power supply

Raised Flooring System



High Density Heat Containment System



Computer Room Air Conditioner

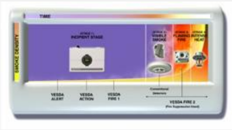
Water Detection System

MICC Monitoring System

Biometric Access System

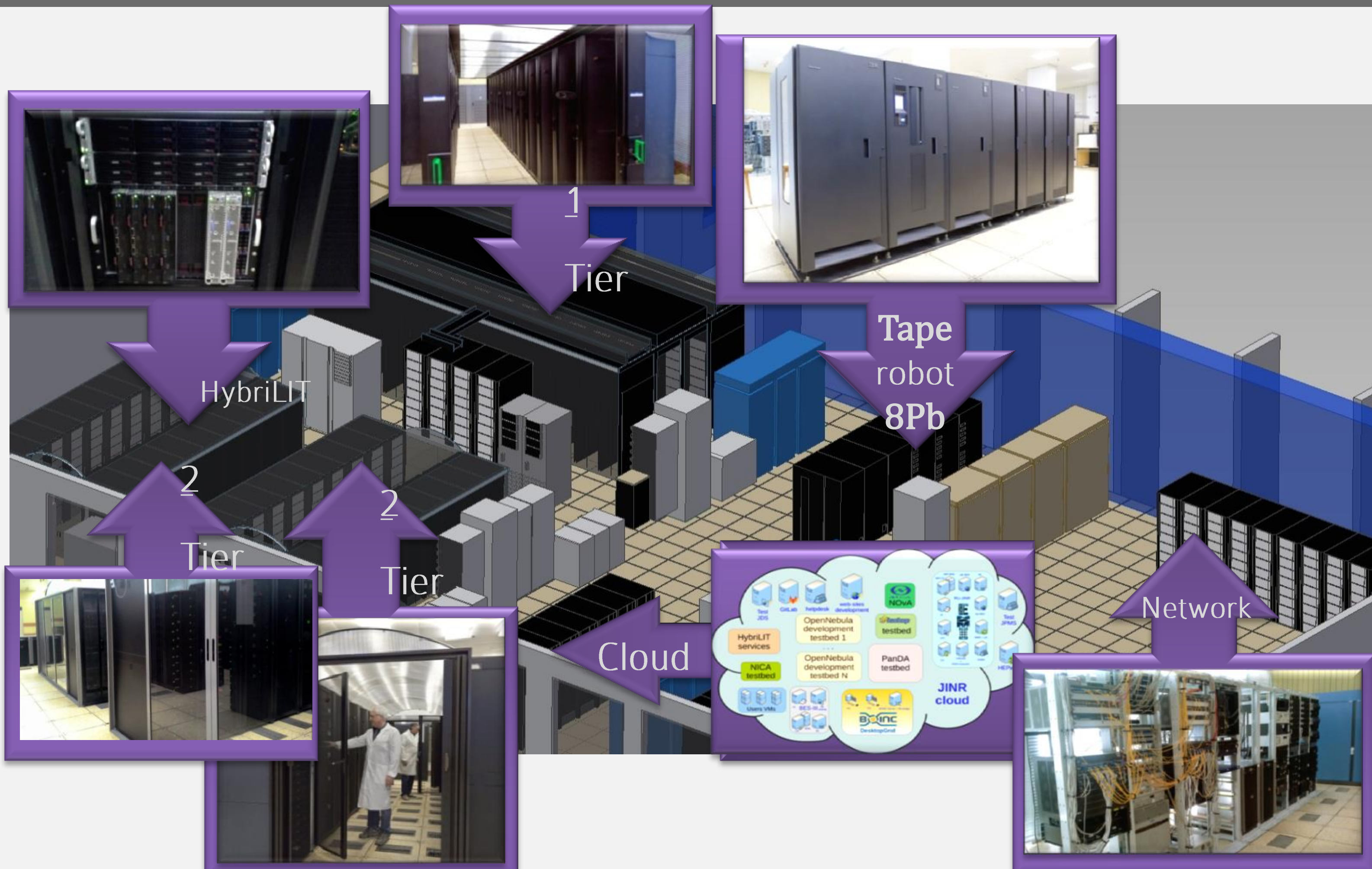
Fire Suppression System

Surveillance System



VESDA (Very Early Smoke Detection Apparatus)

Data storage, processing, analysis



During three years more than **15 million** tasks have been carried out at the Computing center of JINR

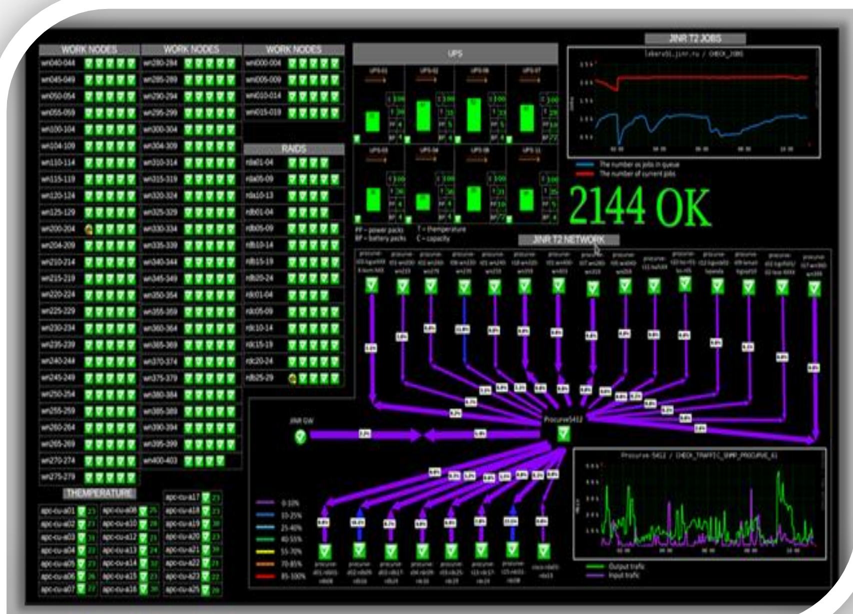
MICC Control Room

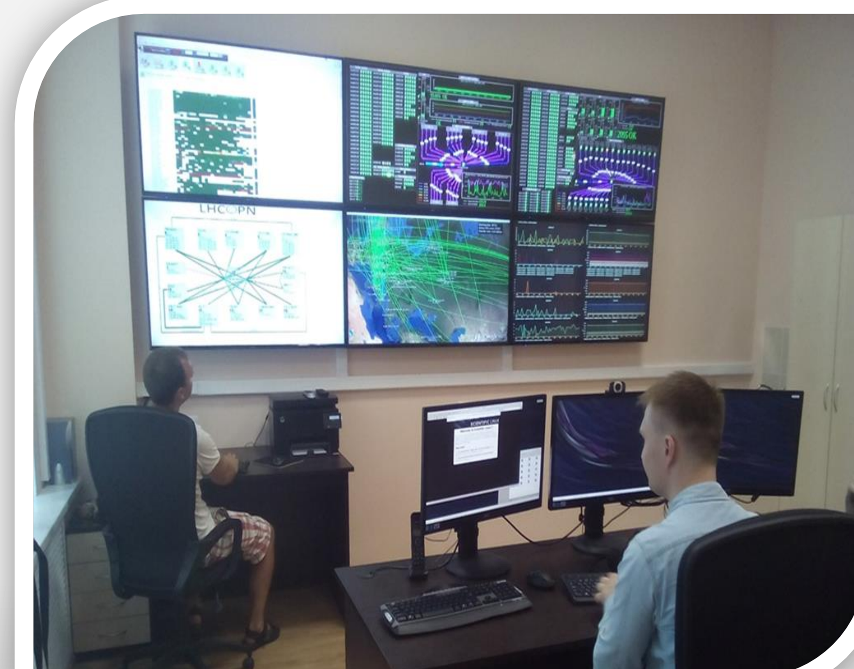
The monitoring system of the JINR Computing Complex has been developed and put into exploitation.

System allows one, in a real time mode, to observe the whole computing complex state and send the system alerts to users via e-mail, sms, etc.

690 elements are under observation

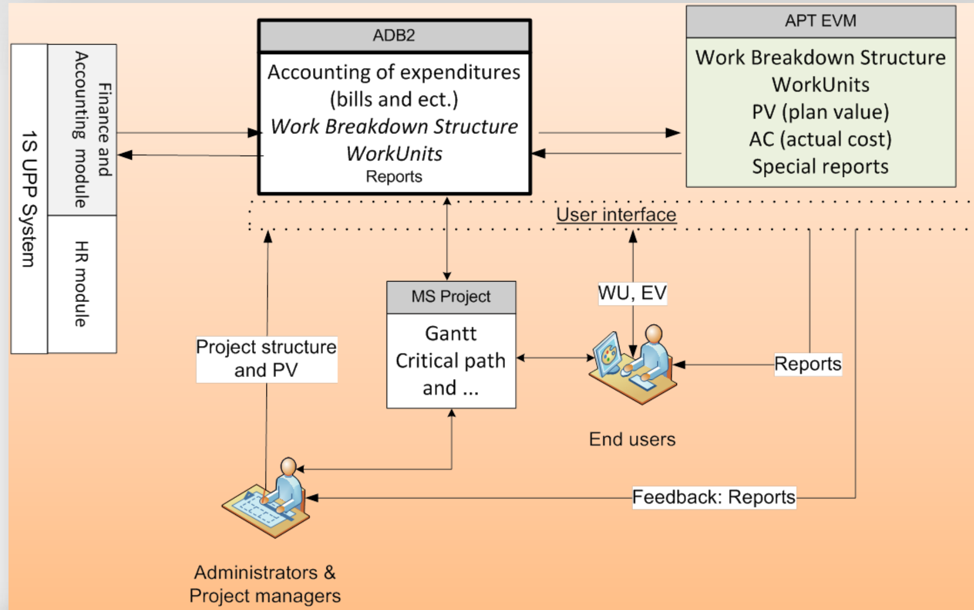
3497 checks in real time





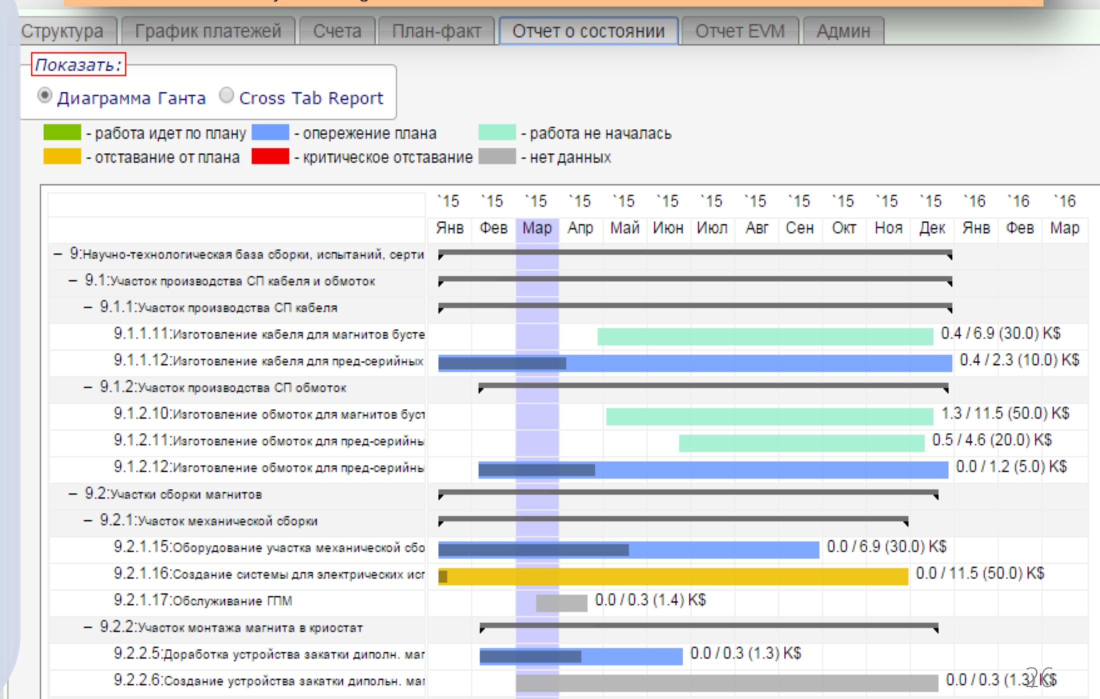
NICA Project Management Information System

A flexible instrument was created by extending the existing PMIS system ADB2 for the needs of the NICA project developed in the process of system APT EVM. In addition, the project plan is to further expand the PMIS NICA for the implementation of ADB2 integration with MS Project.Prof.



NICA PMIS has the following features:

- Control over the project structure (WBS);
- Planning and replanning the project work;
- Versions of the project plans (baselines);
- Monitoring of the implementation of the project in terms of AC (actual payments) and EV (earned value);
- System alerts users via e-mail (for the timely report on the progress of the work);
- Charts by the method of EVM (PV, AC, EV).

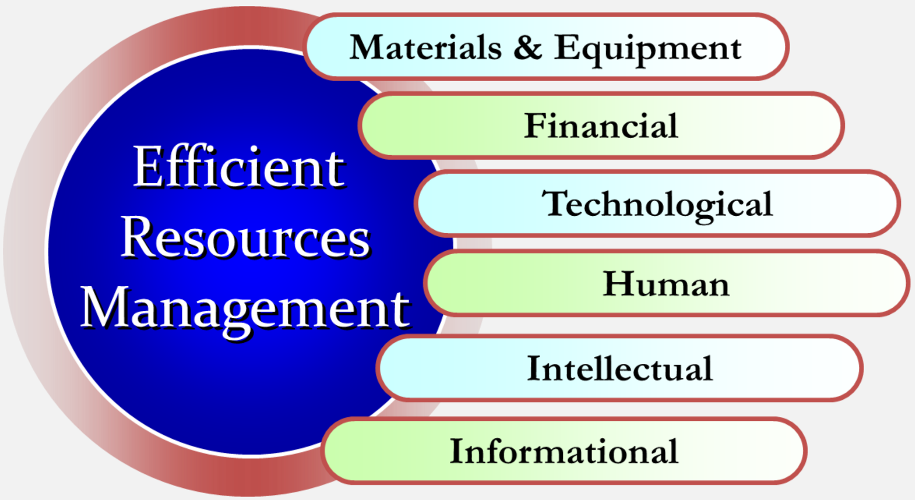


JINR Corporative Information System

- General 1C:Enterprise 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



Electronic document handling system EDH “Dubna”

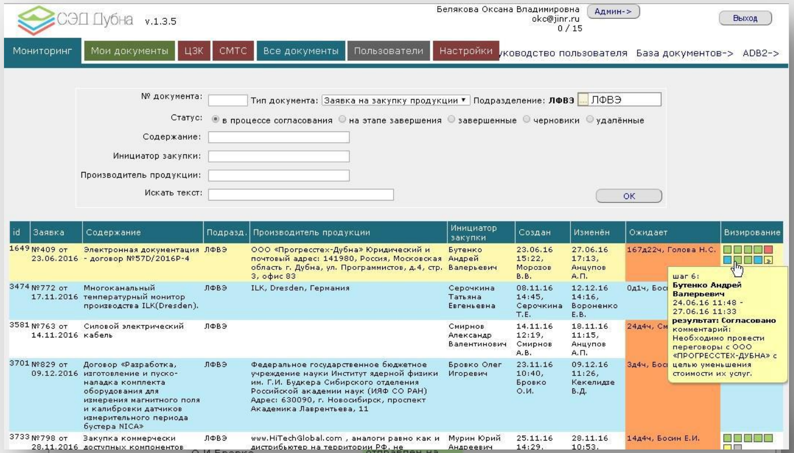
СЭД Дубна v.1.3.5

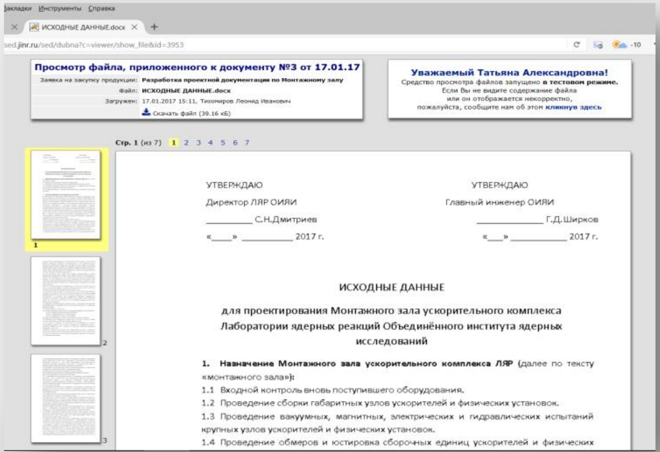
Continued development and maintenance of an electronic document management system EDH "Dubna".

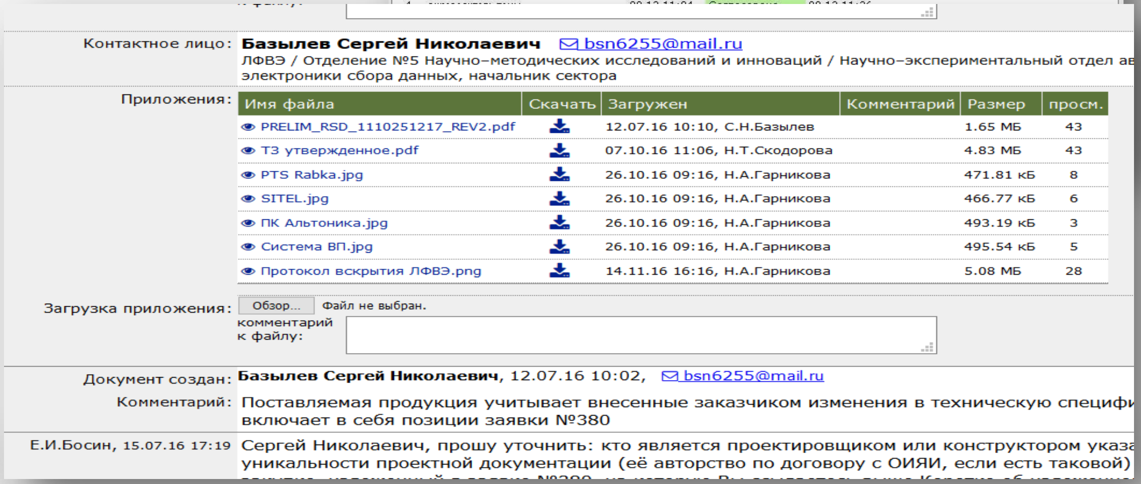
Processed more than 1000 documents

Developed variety of specialized reports

In the year 2017 substantial increase in the number of documents processed in EDH "Dubna“ was planned.



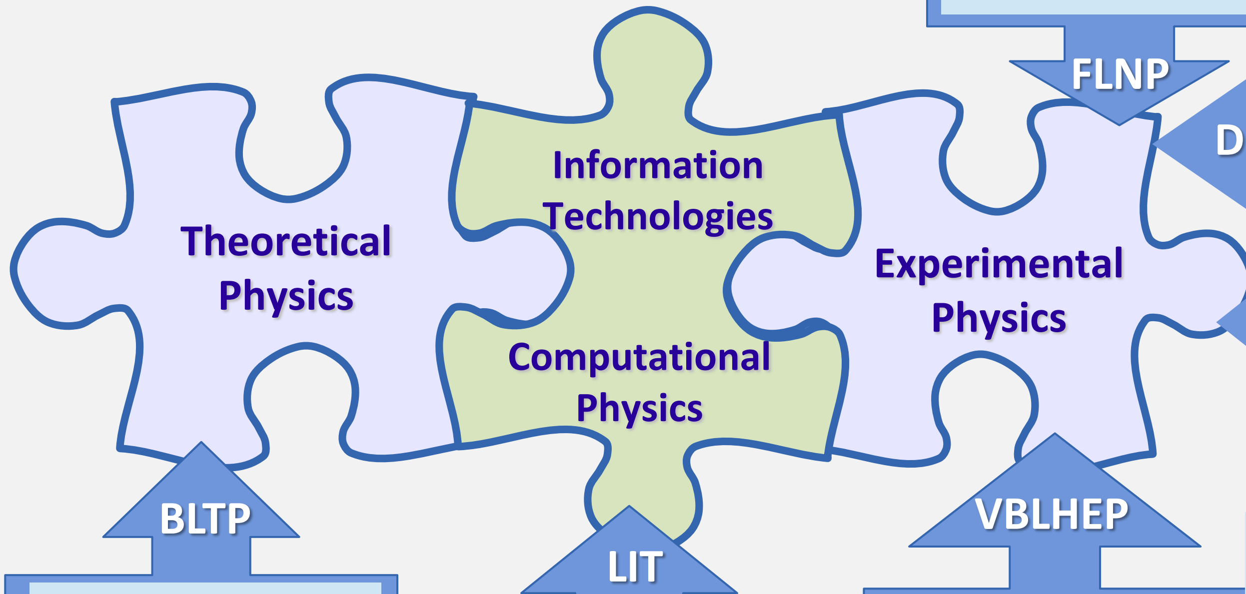




Information technologies – expected results in 2017 – 2023

- Creation of a JINR Multifunctional Information and Computing Complex (MICC) of a global level for the development of advanced information technology
- Development of a territorially distributed research environment to provide the use of the Complex capacities by the JINR and cooperating centres worldwide
- Research in the field of intensive operations with mass data in the distributed systems (Big Data), development of corresponding tools and methods of visualization, including 3D
- Research on issues of optimizing the processes of using the existing capacities, in particular supercomputers, for data processing in distributed environment and their integration into a unified distributed computing system
- Creation of a software technological complex providing introduction of cloud technologies for organization of research by distributed user groups, introduction of intellectual methods of new generation grid-cloud structures management
- Research in the field of the global monitoring of the distributed computing systems
- Development of new parallel applications, cross-platform and multi-algorithm software complexes in a heterogeneous computing environment that allow one to expand a spectrum of computationally intensive solved fundamental scientific problems

LIT participates in 48 projects of 30 JINR topics of the 2017 Topical Plan of JINR



FLNP

04-4-1122-2015/2017 [1]
Leaders: S.A. Kulikov, V.I. Prikhodko

03-4-1128-2017/2019 [1]
Leader: V.N. Shvetsov, Deputies: Yu.N. Kopatch, E.V. Lychagin, P.V. Sedyshev

04-4-1121-2015/2017 [1]
Leaders: D.P. Kozlenko, V.L. Aksenov, A.M. Balagurov

DLNP

02-2-1099-2010/2018 [1]
Leaders: D.V. Naumov, A.G. Olshevskiy

02-2-1125-2015/2017 [2]
Leader: L.G. Tkatchev, Deputy: V.M. Grebenyuk

03-2-1101-2010/2017 [2]
Leader: A.V. Kulikov, Deputy: Z.Tsamalaidze

02-2-1124-2015/2017 [1]
Leader: V.V. Glagolev, Scientific leader: J.A. Budagov

03-2-1102-2010/2018 [2]
Leaders: G.A. Karamysheva, S.L. Yakovenko, Scientific leader: L.M. Onischenko

02-2-1123-2015/2019 [1]
Leader: A.S. Zhemchugov

FLNR

04-5-1131-2017/2021 [1]
Leaders: S.N. Dmitriev, P.Yu. Apel

03-0-1129-2017/2021 [1]
Leaders: G.G. Gulbekyan, S.N. Dmitriev, M.G. Itkis, Scientific leader: Yu.Ts. Oganessian

03-5-1130-2017/2021 [1]
Leaders: M.G. Itkis, Scientific leader: Yu.Ts. Oganessian

BLTP

01-3-1113-2014/2018 [2]
Leaders: D.I. Kazakov, O.V. Teryaev, A.B. Arbuzov

01-3-1114-2014/2018 [2]
Leaders: V.V. Voronov, A.I. Vdovin, N.V. Antonenko

01-3-1115-2014/2018 [2]
Leaders: V.A. Osipov, A.M. Povolotskii

01-3-1116-2014/2018 [1]
Leaders: A.P. Isaev, A.S. Sorin, Deputy: S.O. Krivonos, Scientific leader: A.T. Filippov

01-3-1117-2014/2018 [1]
Leaders: V.V. Voronov, A.S. Sorin, Scientific leader: A.T. Filippov

LIT

05-6-1118-2014/2019
Information and Computing Infrastructure of JINR

05-6-1119-2014/2019
Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data

VBLHEP

02-1-1097-2010/2018 [2]
Leader: A.D. Kovalenko, Deputies: N.M. Piskunov, V.P. Ladygin, M. Finger (Jr.), R.A. Shindin

02-1-1088-2009/2019 [2]
Leader: A.S. Vodopyanov

02-1-1106-2011/2019 [2]
Leader: A. Malakhov, V. Ivanov

02-0-1066-2007/2020 [4]
Leaders: R. Lednicky, Yu.A. Panebratsev

02-0-1065-2007/2019 [4]
Leaders: A.S. Sorin, V.D. Kekelidze, G.V. Trubnikov, Deputies A.D. Kovalenko, I.N. Meshkov

02-0-1085-2009/2019 [1]
Leader: A.P. Nagaytsev, Scientific leader: I.A. Savin

02-0-1083-2009/2019 [5]
Leader: A. Zarubin, Scientific leader: I.A. Golutvin

02-0-1081-2009/2019 [1]
Leader: V.A. Bednyakov, Deputies: E.V. Khramov, A.P. Cheplakov

02-0-1108-2011/2017 [1]
Leader: G.D. Alexeev, Deputies: A.N. Skachkova, A.S. Vodopyanov

05-8-1037-2001/2019 [1]
Leader: N.A. Russakovich

06-0-1120-2014/2018 [1]
Leaders: V.A. Matveev, S.Z. Pakuliak

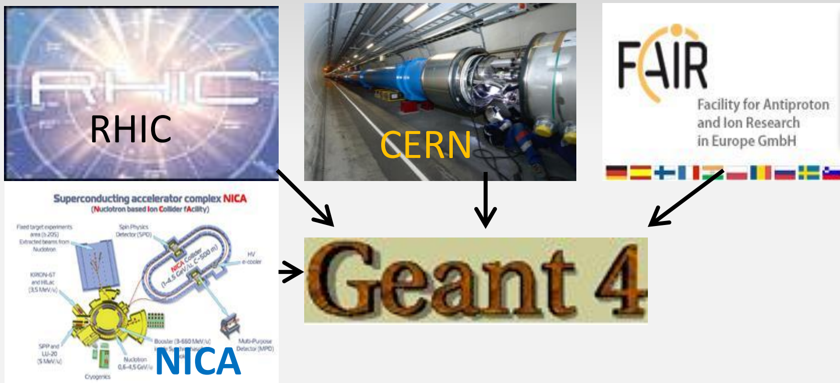
Methods, Algorithms and Software for Modeling Physical Systems, Mathematical Processing and Analysis of Experimental Data Theme 1119

- 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 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

Software development

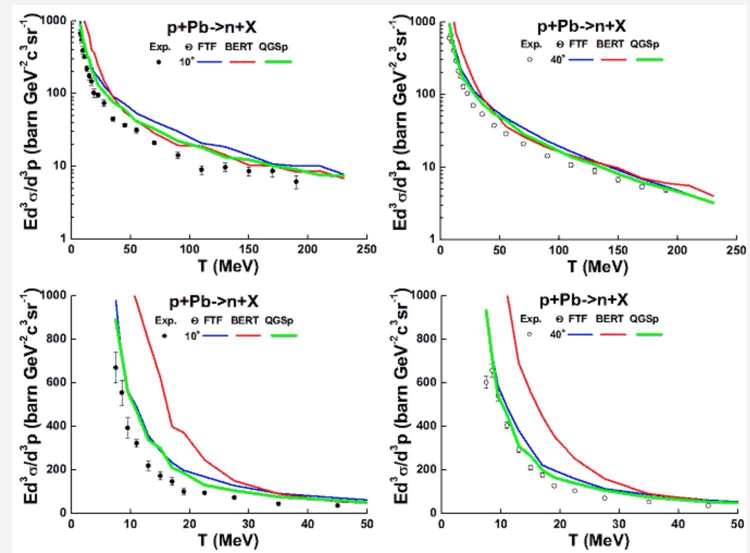
Parallel software will be the mainstream since it enables substantial reduction of CPU time

- Development and support of **program libraries** of general and special purpose
- Creation and support of program libraries and software complexes implemented with **parallel programming techniques** CUDA, OpenCL, MPI+CUDA, OpenMP, 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

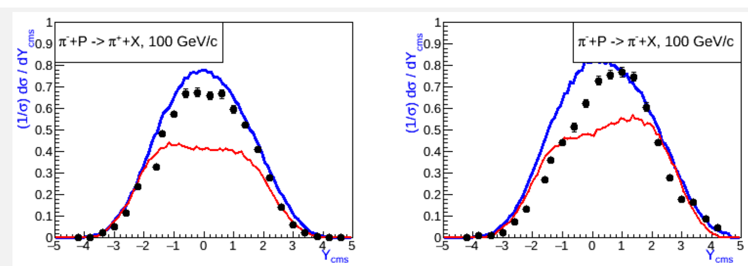


Improvement of QGSp in Geant4

Now FTFP_BERT Physics List is a favorite Physics List of Geant4
Physics List – QGSp_BERT used by ATLAS and CMS



Slow neutron production, ITEP experimental data (1983)
[Shower shape improvement]



πP interactions at 100 GeV/c
Red lines – old QGSp Blue lines – new QGSp

Geant4 – toolkit for simulating particle passage through matter.
Areas of application: high energy, nuclear and accelerator physics, medical and space science.
Main task – Simulation of hadronic interactions and electromagnetic showers.
Main yield of LIT: Development of Fritiof (FTF) hadronic model; Simulation of interactions: (1) π, K, p, n, Λ, Nucleus+Nucleus (2) Anti-proton, Anti-Nucleus+Nucleus
Specific tasks solved: • 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
Future tasks: •• Contribution to code parallelization within Geant 4 modules

The present status of Geant4 was defined with the important co-authorships of A. Galoyan (VBLHEP) and V.V. Uzhinsky (LIT). See, Nuclear Instruments and Methods, A835 (2016) 186–225, DOI: 10.1016/j.nima.2016.06.125

• Dedicated Support for Experimental Data Processing and Analysis

– **Automation upgrade of on-line data acquisition and processing**

[Instance: •• For the future modernizations of **YUMO spectrometer** at IBR2]

– **Reliable statistical inferences under low statistics and incomplete observation**

[Instance: •• This **is a permanent problem asked for scrutiny by the low-statistcs experiments**]

– **New mathematical methods and emerging software for reliable data acquisition**

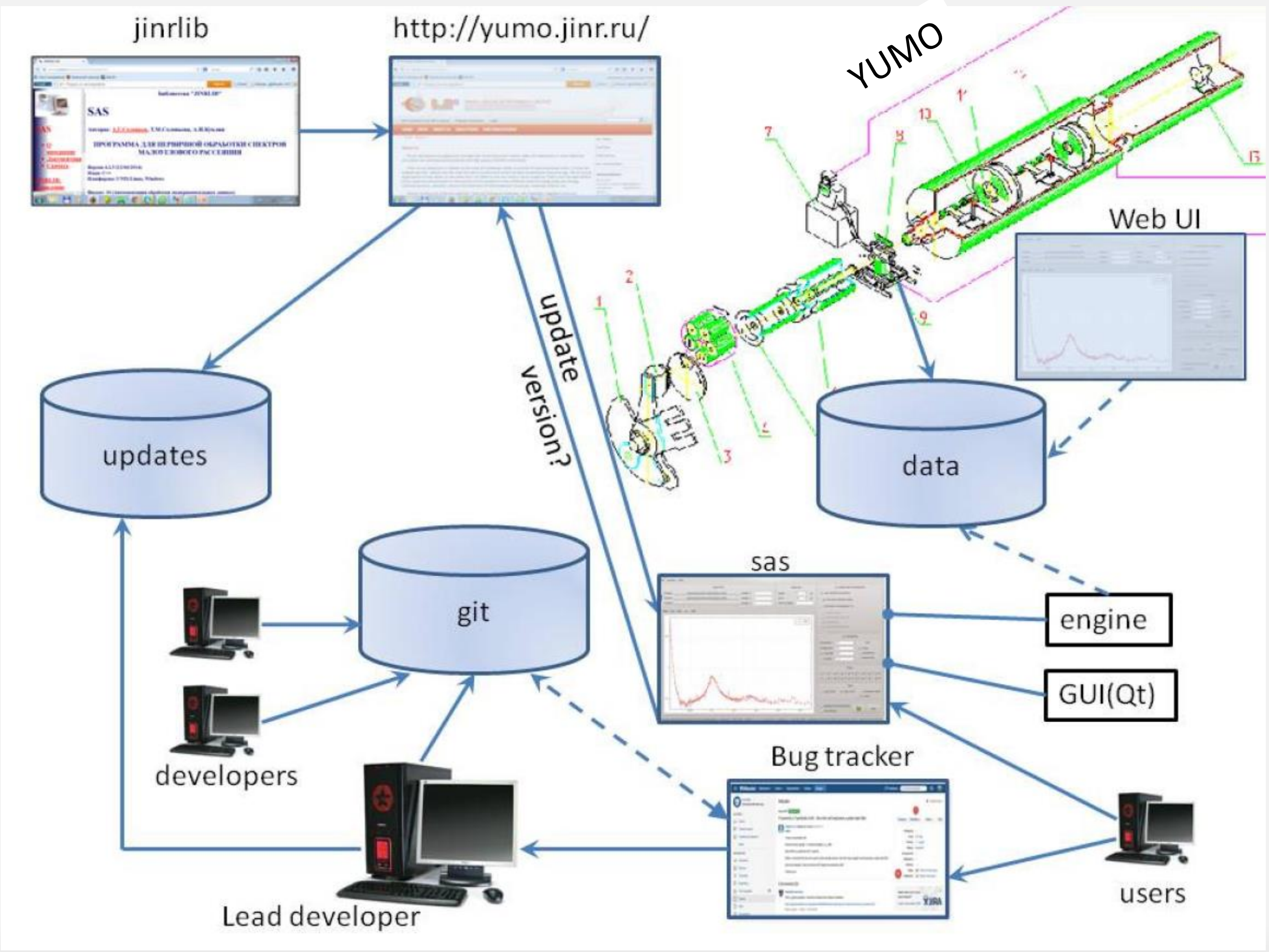
[Instances: •• Methods for dynamical image recognition under neutron diffraction on poly-crystals enabling analysis of crystalline matter concerning crystallographic symmetry analysis, microstructural analysis , investigation of the kinetics of the matter processes at **FLNP detectors**;

•• Methods for solving problems of the high "intellectuality" pattern recognition serving to the elaboration of new software for the automatic calibration of multi-detector systems in **FLNR**;

•• Methods for solving ill-posed problems which emerge in the analysis of multidimensional distributions enabling elaboration of new software for the determination of times of decay by scintillators using an autocorrelation delayed coincidence time spectrometer in **DLNP**]

– **New segment building algorithm for the Cathode Strip Chamber (CSC) of the CMS facility**

Automation of on-line data storage on modernized YUMO spectrometer

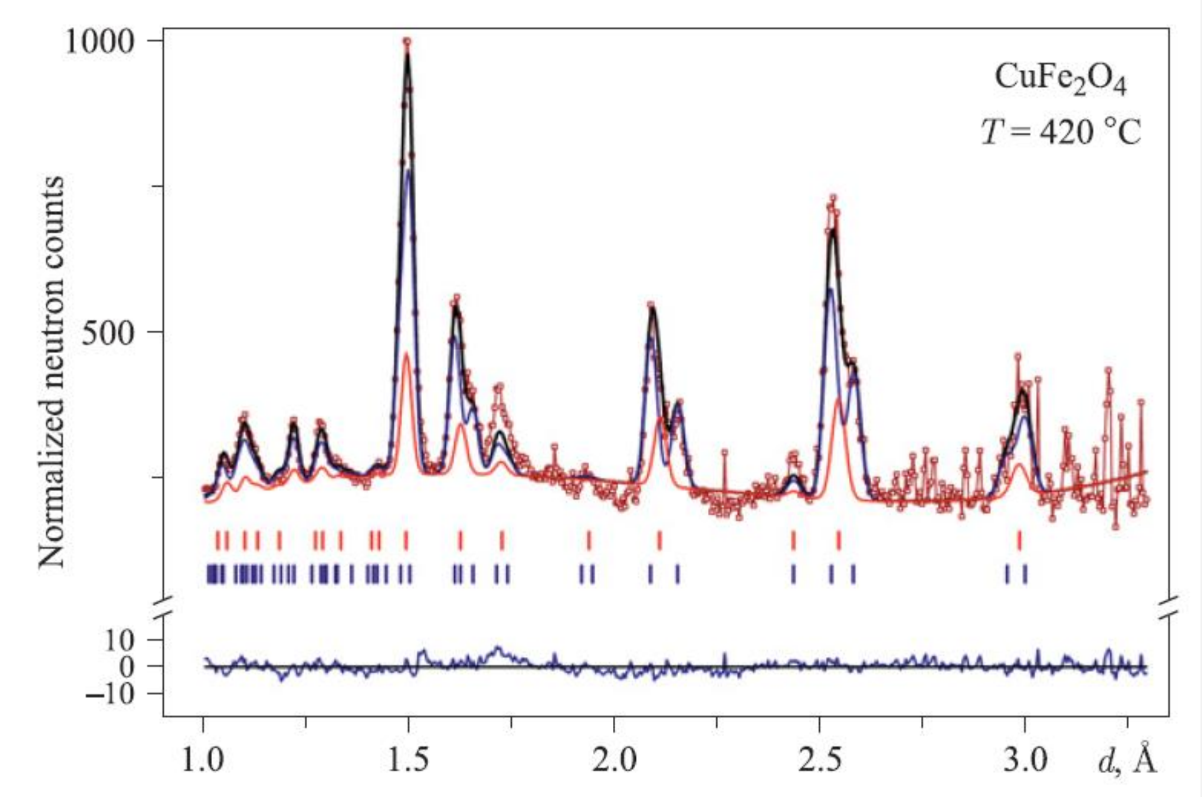


A.G. Soloviev, T.M. Solovieva (LIT), A.V. Rogachev, A.I. Kuklin (FLNP) [under development]

Real-Time Visualization and Analysis of Neutron Diffraction Data

Packages MAPS and **SPEVA** were developed for preliminary analysis and final mathematical processing of *large neutron diffraction data* got in studies of transition processes in crystals. They secure automatic visualization of 2D data obtained at HRFD-diffractometer with time of flight scanning, respectively analysis of atomic structure changes during transition processes

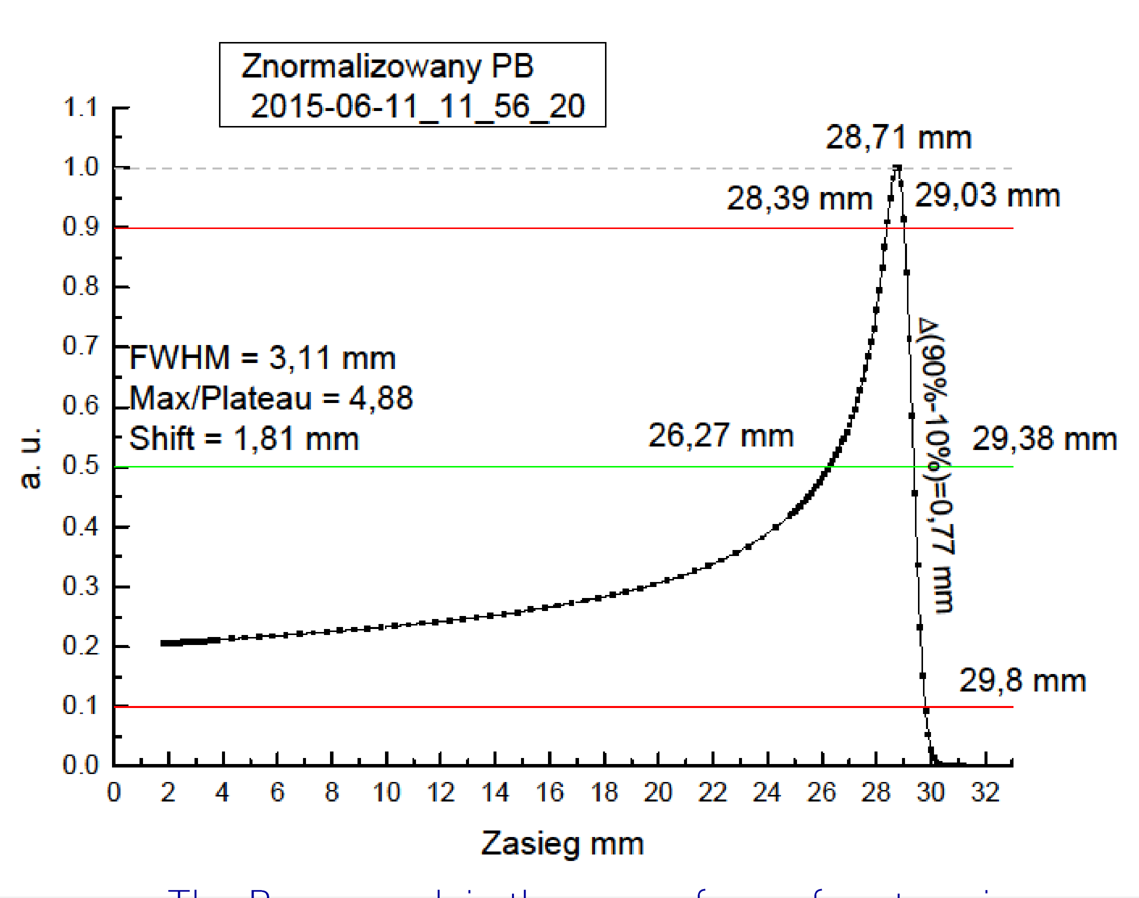
An instance:
Structural phase transition between cubic (in red) and tetragonal (in blue) phases resolved in the diffraction spectrum of $CuFe_2O_4$ at the temperature T= 420 ^{0}C



V.B. Zlokazov, D.A. Balagurov, I.A. Bobrikov, N.Yu. Samoilova, A.M. Balagurov, JINR Preprint P3-2014-94;
V.B. Zlokazov, I.A. Bobrikov, A.M. Balagurov, EPJ WoC 108, 02049 (2016)

Strength of the mathematical modeling in the performance increase of the AIC-144 cyclotron

The development of mathematical models [LIT&DLNP] for the *creation of the main operation mode of the AIC-144 isochronous cyclotron*, located in the Institute of Nuclear Physics of the Polish Academy of Sciences, Krakow, Poland. [As a result of the successful simulation, AIC-144 was launched in the main operation mode, for the **proton therapy of eye melanoma**. The extracted proton beam shows the *best world rating* (smallest length of trailing edge of the Bragg peak). The JINR second prize in 2014]



The Bragg peak in the case of run of protons in water for the AIC-144 main operation mode

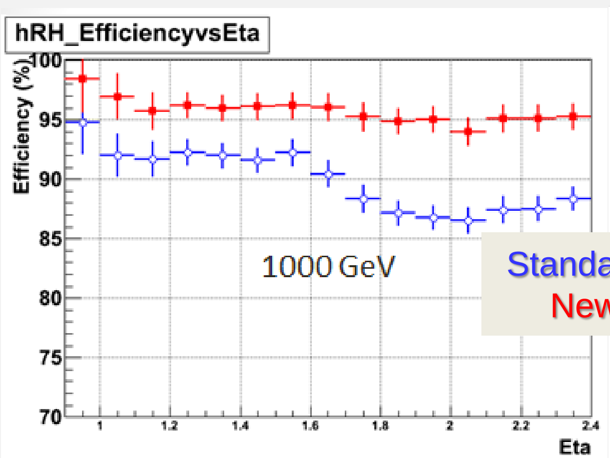
Collaboration DLNP – LIT – NINP PAS Cracow, Poland (K. Daniel, K. Gugula, J. Sulikowsky [INP, PAS], I.V. Amirkhanov [LIT], G.A. Karamysheva, I.N. Kiyan, N.A. Morozov, E.V. Samsonov [DLNP]
I.V. Amirkhanov, G.A. Karamysheva, I.N. Kiyan, J. Sulikowsky, PEPAN Letters, 2015, Vol. 12, pp. 673-677.)

New segment building algorithm for the Cathode Strip Chamber (CSC) of the CMS facility

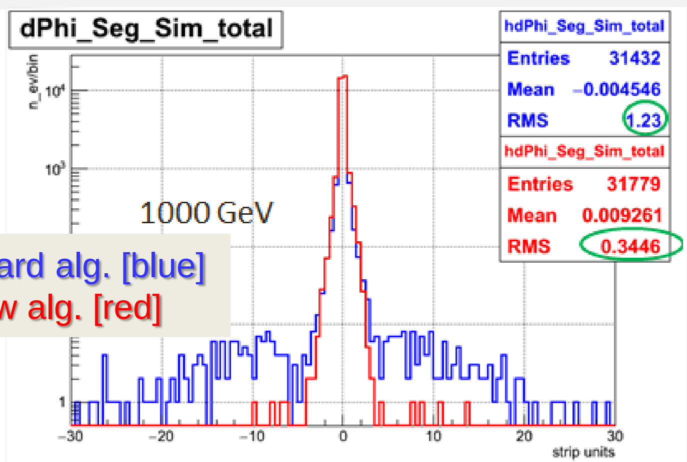
Purpose: to improve the reconstruction for high hit rate and big backgrounds due to luminosity increase

The new algorithm was implemented in the official CMS software package in July, 2016, extensive testing period until end of January 2017. It proved to be *effective, stable and robust*.

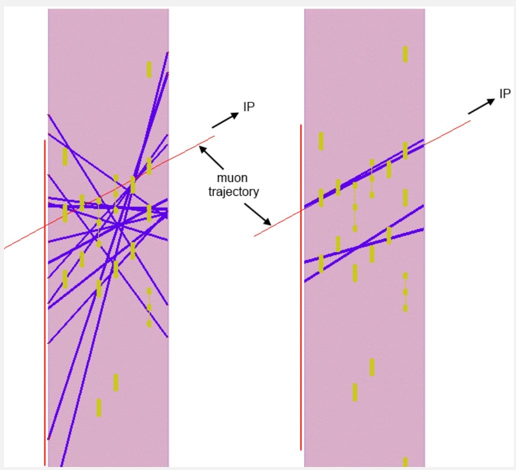
Future: Further reconstruction procedure refinements, its use as reconstruction algorithm for the new GEM detectors that will be included in the experimental setup for the next major upgrade.



Reconstruction efficiency vs. pseudorapidity (new alg. efficiency is high and almost constant, standard alg. eff. decreases with the increase of the pseudorapidity)



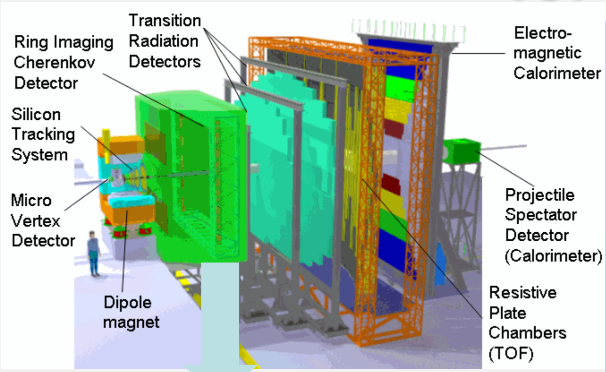
Distance in strip units between the reconstructed and the simulated segment (3.5 times signal improvement)

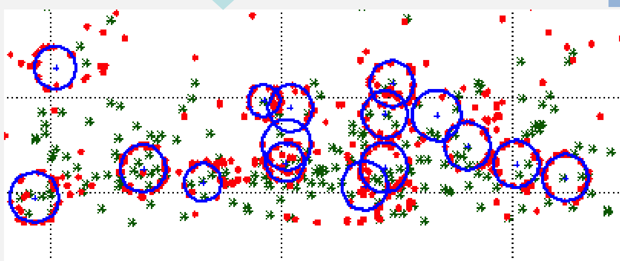


Example of a high hit multiplicity event reconstruction (standard alg. – left, new alg. – right) [# of fake segments: is considerably reduced]

I. Golutvin, V. Karjavin, V. Palichik, N. Voytishin and A. Zarubin, EPJ WoC, vol. 108, 02023, 2016 DOI: http://dx.doi.org/10.1051/epjconf/201610802023

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





Event reconstruction algorithms:

1)Tracking: Kalman filter and track following;

2) Ring reconstruction: Hough Transform, COP, ellipse fitting;

3) Electron identification in RICH: ANN and cuts.

Modern technologies for parallelization:

1) Vectorization (SIMD - Single Instruction Multiple Data);

2) Multithreading (many cores CPU).

Results:

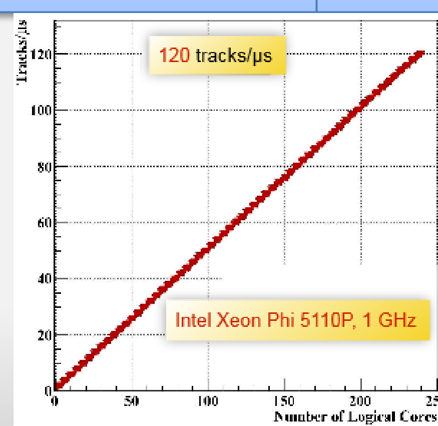
1) High efficiency of track and ring reconstruction (93-95%);

2) Very fast algorithms (few ms per event).

Task	Initial Time [ms/event]	Parallel Time [ms/event]	Speedup
Tracking	730	1.5	487
Ring reconstruction	375	2.5	143

Tasks:

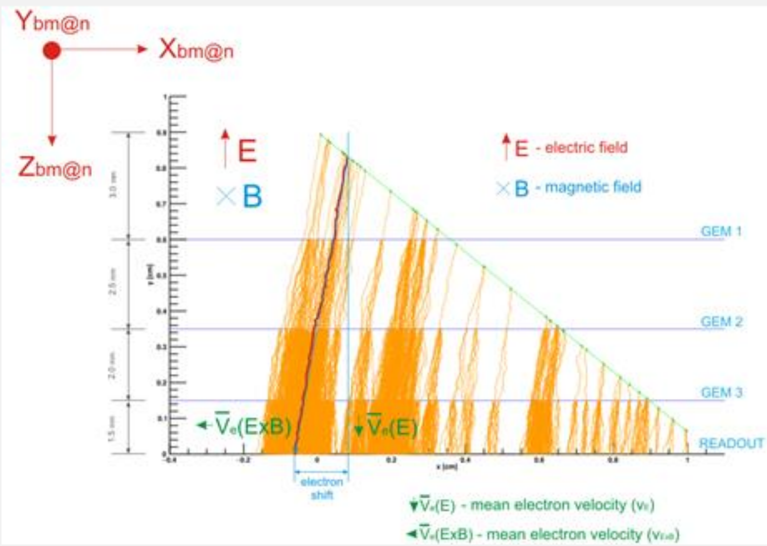
- global track reconstruction;
- event reconstruction in RICH;
- electron identification in TRD;
- clustering in MVD, STS and MUCH;
- participation in FLES (First Level Event Selection);
- development of the Concept of CBM Databases;
- magnetic field calculations;
- beam time data analysis of RICH and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

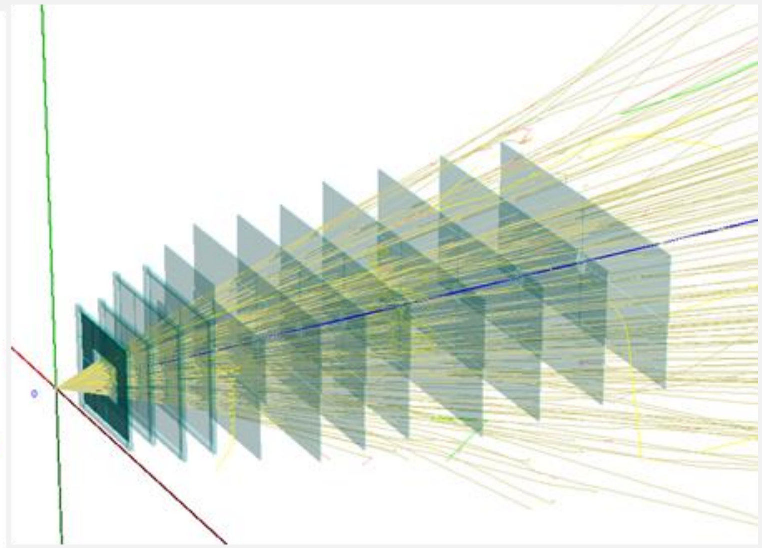


Fast parallel algorithms were developed for event reconstruction in the CBM

Software for BM@N GEM (Gas Electron Multiplier) tracker

- **Realistic Simulation of GEM detector** needs development of data generation algorithms which take into account features controlling the actual data in the GEM chamber: the signal deviation under external magnetic fields and the influence of the angular deviation of the flying particle from the beam axes to the shape and the size of the strip cluster (signal). (See **left** figure)
- The **hit reconstruction algorithms** restore the coordinates of the particle trajectories across the detector planes (hits). The hits serve as inputs to track finding methods.





Left: Garfield++ modeling of the process of formation of **avalanches of electrons** (signal) inside the GEM chamber. The green line denotes the track of the particle traversing the GEM chamber. The orange color marks electron trajectories provoking avalanches. The avalanche signal is registered by the readout plane.
Right: Realistic version of the complete GEM detector configuration in the BM@N experiment

Intensive work is underway!

D. Baranov, S. Merts, G. Ososkov, O. Rogachevsky, EPJ WoC, vol. 108, 02012, 2016 DOI:http://dx.doi.org/10.1051/epjconf/201610802012

• 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]

– **Modeling 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]

Symbolic-numeric simulation of slender structures (rods, fibers, cilia, flagella, etc.)

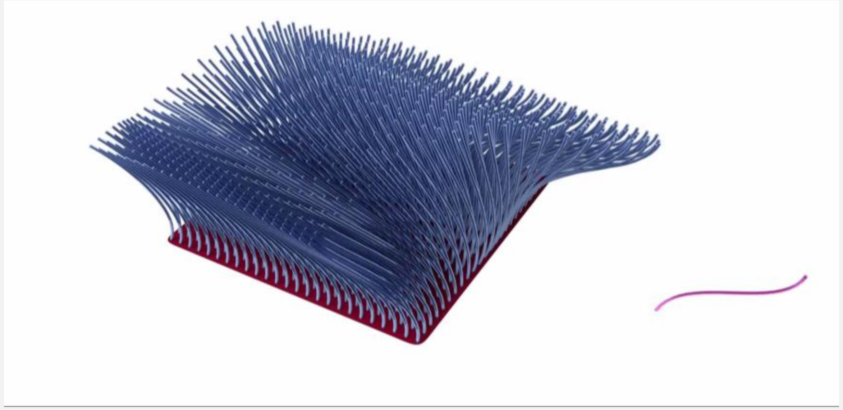
Governing system of 12 nonlinear very stiff partial differential-algebraic equations:

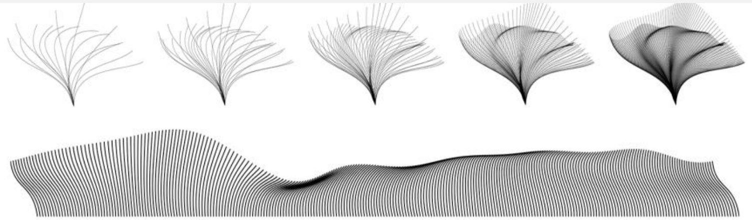
$$\rho A \partial_t \vec{v} = \partial_s \vec{n} + \vec{f}, \quad \rho I \partial_t \vec{\omega} = \partial_s \vec{m} + \mathrm{adiag}(1,-1)\,\vec{n} + \vec{l}, \quad \partial_t \vec{\kappa} = \partial_s \vec{\omega}, \quad \partial_s \vec{v} = \mathrm{adiag}(1,-1)\,\vec{\omega}, \quad \vec{\omega}\ \mathrm{adiag}(1,-1)\,\vec{\kappa}^T = 0, \quad \vec{v}\ \mathrm{adiag}(1,-1)\,\vec{\kappa}^T = 0$$

To obviate stiffness, the solution derived by the authors from LIT JINR and HMTI-BAS (Minsk) combined computer algebra and numerical methods: analytical solution of the parameter-free part of the system and numerical for the remaining

Demonstration: simulation of the beating pattern of a cilium (of interest in the context of simulations in biology and biophysics, e.g., cilia carpets in the interior of the lung are responsible for the mucus transport).

As compared to a pure numerical solution, the step size can be increased by three orders of magnitude, which leads to two orders of magnitude decrease of CPU time.

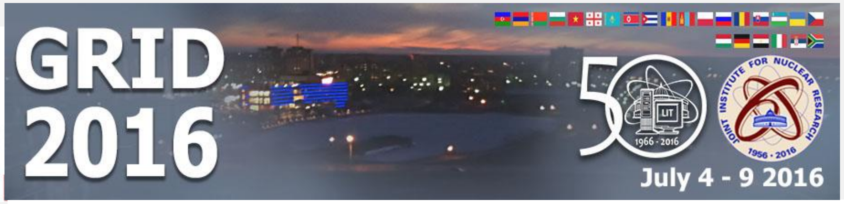




Simulation of a cilia carpet (top) composed of multiple cilia beating in a meta-chronal rhythm (middle) produces the appearance of a wave.

D.Michels (Stanford U), D.Lyakhov (HMTI, Minsk), V.Gerdt (LIT), G.Sobottka, A.Weber (Univ. Bonn), LNCS 9301, 2015, pp.320–331

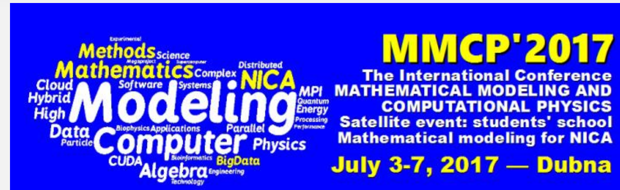
LIT traditional conferences



Distributed Computing and Grid-technologies in Science and Education

Mathematics. Computing. Education

DIGITAL LIBRARIES:
ADVANCED METHODS AND TECHNOLOGIES
DIGITAL COLLECTIONS



LIT schools

JINR / CERN

GRID AND ADVANCED INFORMATION SYSTEMS

International Conference-School for Young Scientists

"Modern Problems of Applied Mathematics & Computer Science"

August 22 - 27, 2012, Dubna, Russia

MPAMCS 2012

INFORMATION

Thank you for attention!

HybriLIT: heterogeneous computation cluster

Summary of current version

252 CPU-cores, 77184 GPU-cores,
182 PHI-cores; 2.4 TB RAM; 55.2 TB HDD

Peak performance:
with single precision 142 TFlops;
with double precision 50 TFlops

Dell PowerEdge
- 2x Intel Xeon CPU E5-2695v3; - 4x NVIDIA TESLA K80

Supermicro SuperBlade Chassis

-2x Intel Xeon CPU E5-2695v3
-2x NVIDIA TESLA K80

- 2x Intel Xeon CPU E5-2695v2
3x NVIDIA TESLA K40

- 2x Intel Xeon CPU E5-2695v2
- 6x HDD 1.2 TB

- 2x Intel Xeon CPU E5-2695v2
- NVIDIA TESLA K20X
- Intel Xeon Phi Coprocessor 5110P

-2x Intel Xeon CPU E5-2695v2
- 2x Intel Xeon Phi Coprocessor 7120P

LIT

hYBRI

HybriLIT: heterogeneous computation cluster

The cluster contains 10 computational nodes with graphical accelerators NVIDIA Tesla K20X, K40, K80, Intel Xeon Phi 7120P, 5110 coprocessors. All computational nodes include two Intel Xeon E5-2695v2 and V3 processors each.

Computation component HybriLIT

TOTAL RESOURCES

- 252CPU cores;
- 77184 CUDA cores;
- 182 MIC cores;
- ~2,5 Tb RAM;
- ~57 Tb HDD.

HARDWARE

SuperBlade Chassis including 10 calculation blades for run user tasks.

7 blades include specific **GPU accelerator** sets. Driven by **NVIDIA CUDA** software.

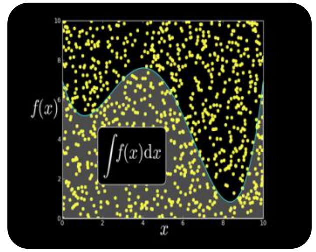
1 blade includes **2 PHI accelerators**. Driven by **Intel MPSS** software.

1 blade includes **1 PHI** and **1 GPU accelerators**. Mixed **NVIDIA CUDA** and **Intel MPSS** software.

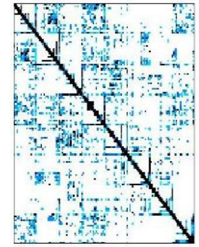
1 blade includes **2 multi-core CPU processors**. Large ~7 Tb storage area

Some GPU-accelerated Libraries

NVIDIA cuBLAS



NVIDIA cuRAND



NVIDIA cuSPARSE

NVIDIA NPP

GPU VSIPL

Vector Signal Image Processing

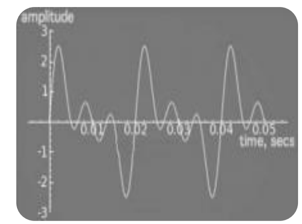
CULA tools

GPU Accelerated Linear Algebra

MAGMA

Matrix Algebra on GPU and Multicore

open source initiative



NVIDIA cuFFT

ROGUE WAVE SOFTWARE

IMSL Library

ArrayFire Matrix Computations

CUSP

Sparse Linear Algebra

Thrust

C++ STL Features for CUDA

Source: https://developer.nvidia.com/cuda-education. (Will Ramey ,NVIDIA Corporation)