



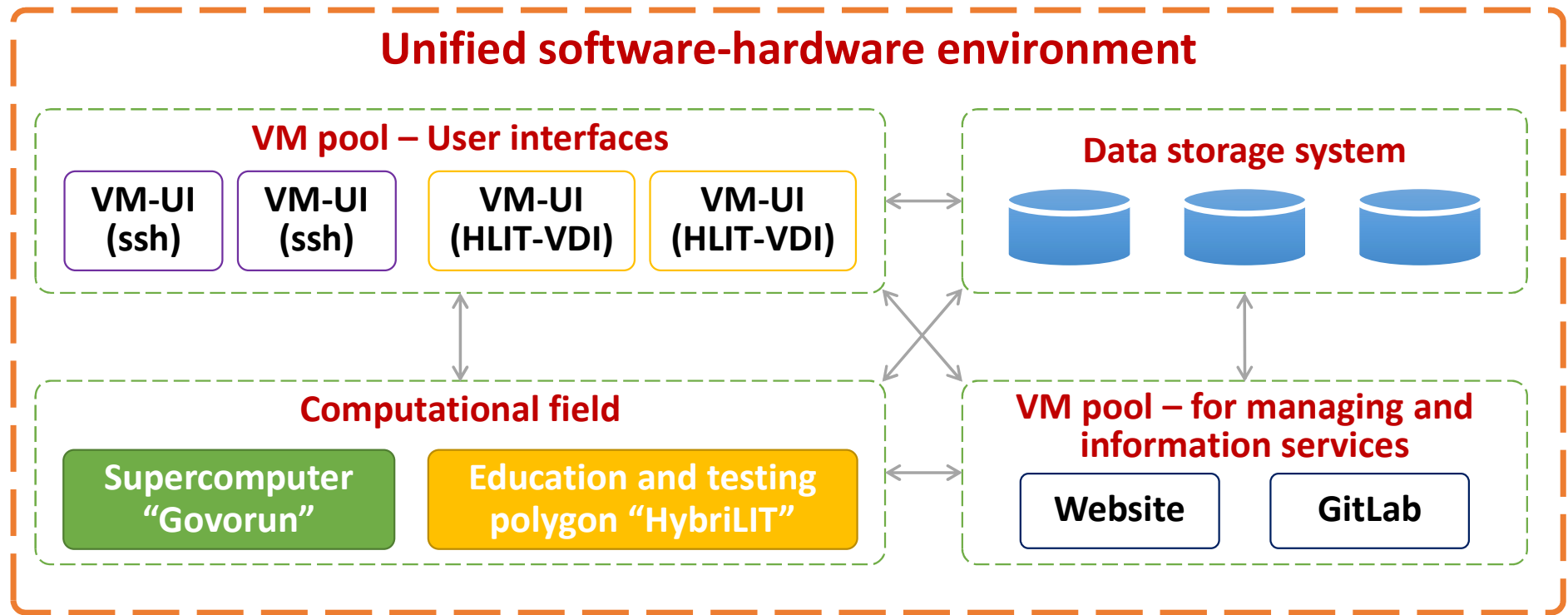
“GOVORUN” supercomputer for JINR tasks

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Meshcheryakov Laboratory of Information Technologies

**10th International Conference "Distributed Computing and Grid Technologies in Science and Education"
(GRID'2023)
3–7 Jul 2023**

MICC component: HybriLIT platform

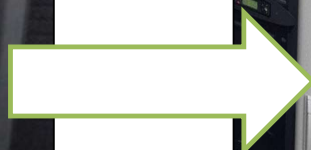


The **unified software and information environment** of the HybriLIT platform allows users to use the education and testing polygon is aimed at exploring the possibilities of novel computing architectures, IT-solutions, to develop and debug their applications, furthermore, carry out calculations on the supercomputer, which allows them to effectively use the supercomputer resources.

Development of the heterogeneous HybriLIT platform



Cluster HybriLIT 2014:
Full peak performance:
140 TFlops for single precision;
50 TFlops for double precision



#18 в Top50

"Govorun" supercomputer
First stage **2018**:
Full peak performance :
1 PFlops for single precision
500 TFlops for double precision
9th in the current edition of the **IO500** list (July 2018)



#10 в Top50

"Govorun" supercomputer
Second stage **2019**:
Full peak performance :
1.7 PFlops for single precision
860 TFlops for double precision
288 TB CCXD with I/O speed **>300** Gb/s
17th in the current edition of the **IO500** list (July 2020)



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

The CPU-component of the “Govorun” Supercomputer



The diagram illustrates the CPU component of the Govorun Supercomputer. It features a central image of a server rack with yellow boxes highlighting specific sections. To the left, a server module is labeled '21' and is associated with Intel Xeon Phi and Server Board components. Below it, a module labeled '14' is shown. To the right, a server module is labeled '88' and is associated with Intel Xeon Platinum, Server Board, and SSD components. Below it, a module labeled '4' is shown, associated with Intel Optane. A red text block describes the fast scalable parallel file system modules. Two green text boxes provide detailed specifications for the RSC Tornado nodes based on Intel Xeon Phi and Intel Xeon Scalable gen 2.

21

14

88

4

Modules of fast scalable parallel file system (*Lustre, EOS* etc.)

RSC Tornado nodes based on Intel® Xeon Phi™ :

- Intel® Xeon Phi™ 7290 processors (72 cores)
- Intel® Server Board S7200AP
- Intel® SSD DC S3520 (SATA, M.2)
- 96GB DDR4 2400 GHz RAM
- Intel® Omni-Path 100 Gb/s adapter

RSC Tornado nodes based on Intel® Xeon® Scalable gen 2:

- Intel® Xeon® Platinum 8268 processors (24 cores)
- Intel® Server Board S2600BP
- Intel® SSD DC S4510 (SATA, M.2), 2x Intel® SSD DC P4511 (NVMe, M.2) 2TB
- 192GB DDR4 2933 GHz RAM
- Intel® Omni-Path 100 Gb/s adapter

"Govorun" supercomputer modernization 2022



Computation field:
**+32 hyperconverged
compute nodes**

Hierarchical Storage:
**+8 distributed storage
nodes**

Performance: +239 Tflops
DAOS: +1.6 PB
Lustre, EOS: +8 PB

Current status:

**138 hyperconverged
compute nodes**
40 GPU accelerators

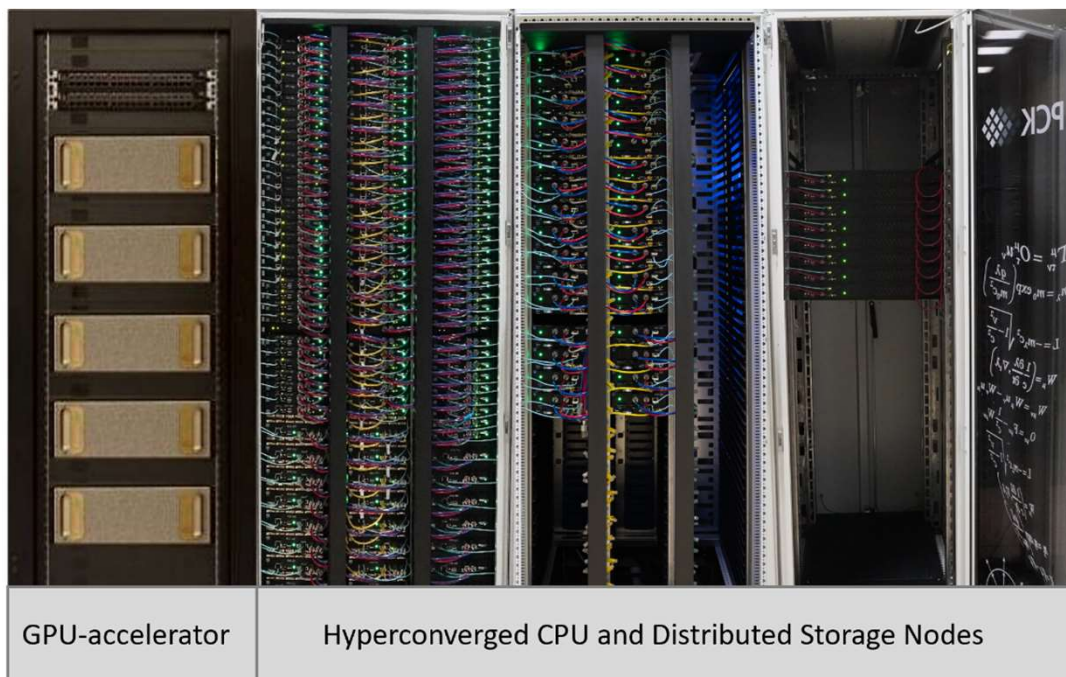
Total peak performance:

1.1 PFlops DP
2.2 PFlops SP

Total capacity of Hierarchical Storage:

8.6 PB

Data IO rate: **300 Gb/s**



+1,152 new computational
cores for the MPD

**Generated almost
31 million events
less then month!!!**

Performance
"new cores"/"old cores"
increase more than **1,5 times**

+0,4 PB for the MPD mass
production storages integrated
into the DIRAC File Catalog

+1 PB for the MPD EOS
storage

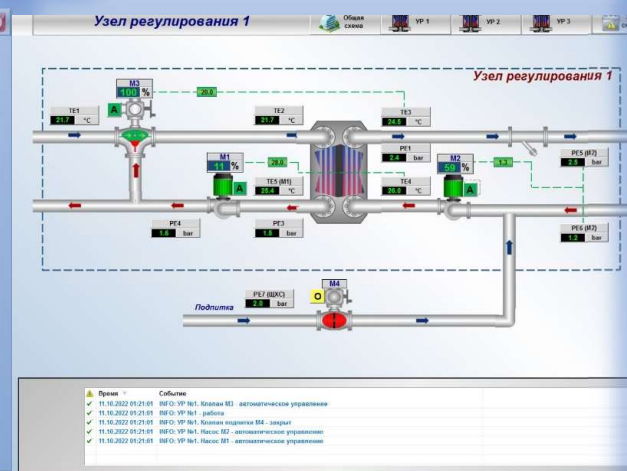
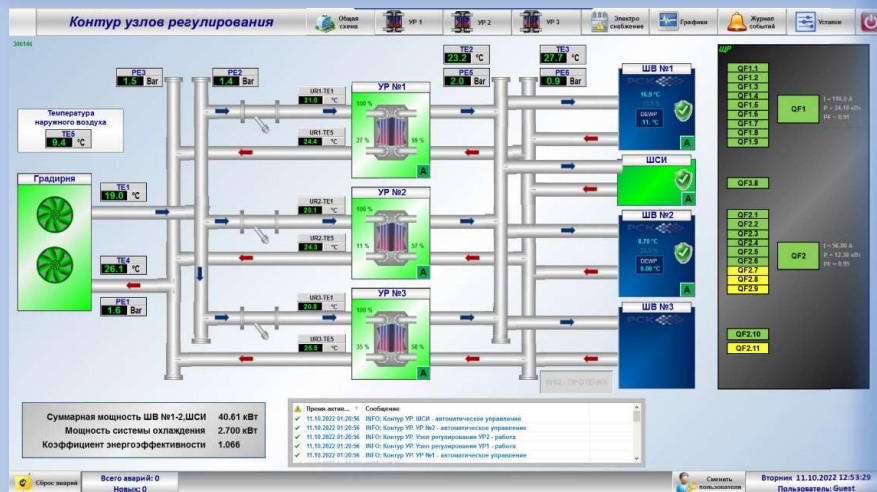
Engineering infrastructure



free cooling
24x7x365



PUE ~ 1,06



The GPU-component of the “Govorun” Supercomputer



The **GPU**-component consists of **5 NVIDIA DGX-1 servers**. Each server has **8 GPU NVIDIA Tesla V100** based on the latest architecture NVIDIA Volta. Moreover, one server NVIDIA DGX-1 has **40960** cores CUDA, which are equivalent to 800 high-performance central processors. A whole number of novel technologies are used in DGX-1, including the NVLink 2.0 wire with the bandwidth up to 300 Gb/s.

The GPU-component gives a users of the supercomputer a possibility to allow as massively parallel computation for general-purpose tasks using such technologies as CUDA and OpenCL, as well as use applications already adapted for this architecture. Also, GPU-component allow to use machine learning and deep learning algorithms for solving applied problems by neural network approach.



PYTORCH

theano



Caffe

Expanding the Opportunities of the Govorun Supercomputer to Solve ML/DL Task



GPU component

NEW!



5 NVIDIA DGX-1 servers
with
8 NVIDIA Tesla V100 GPUs
in each



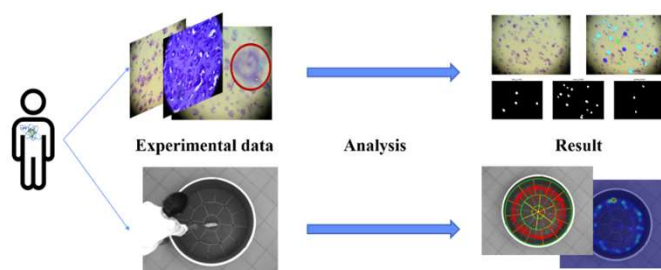
5 Niagara R4206SG servers
with
8 NVidia A100 GPUs in each

+ 40 GPU accelerators: 5 Niagara R4206SG servers with 8 NVIDIA A100 GPUs in each.

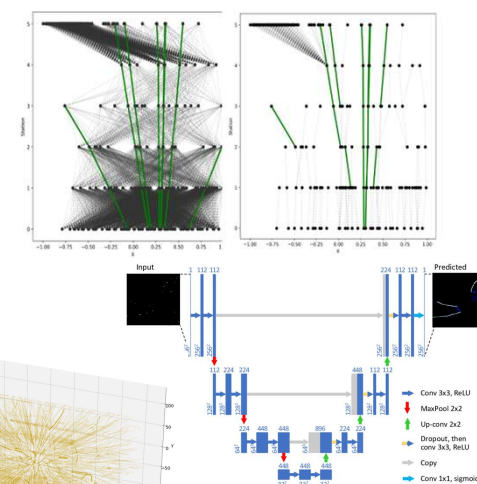
Total performance of the GPU: 300+600 Tflops for DP

Total peak performance of the SC “Govorun”: 1.7 Pflops for DP

The GPU-component gives a users of the supercomputer a possibility to use machine learning and deep learning algorithms for solving applied problems by neural network approach: process data from experiments at LRB in the frame of the Information System for radiation biology tasks; experimental data processing and analysis at the NICA accelerator complex and ect.

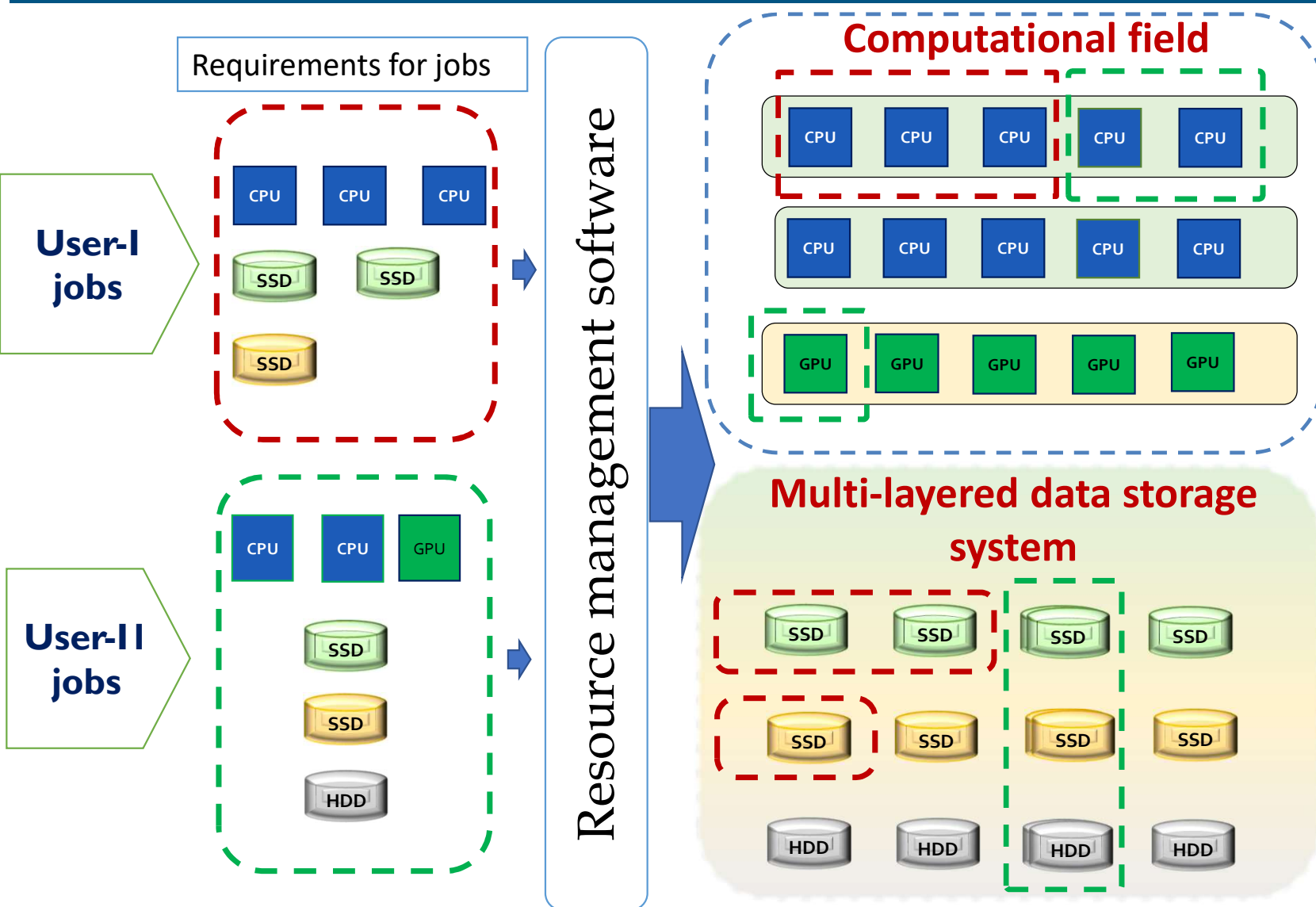


Information System for Radiation Biology Tasks



Data Processing and Analysis

Orchestration and hyperconvergence on the “Govorun” supercomputer

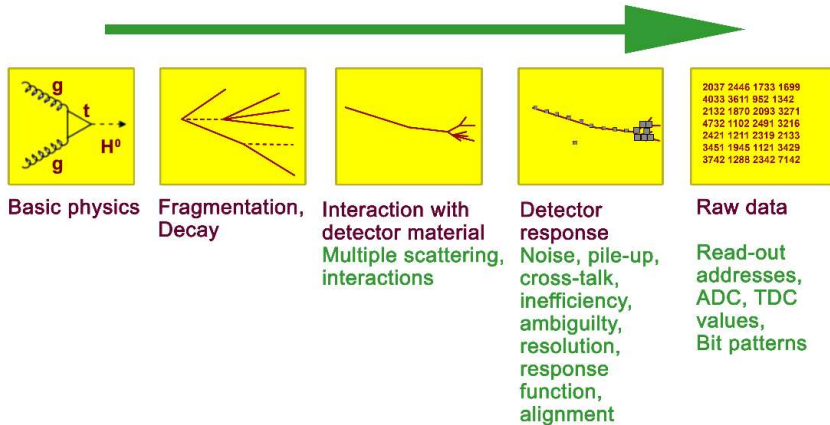


The “Govorun” supercomputer has unique properties for the flexibility of customizing the user’s job.

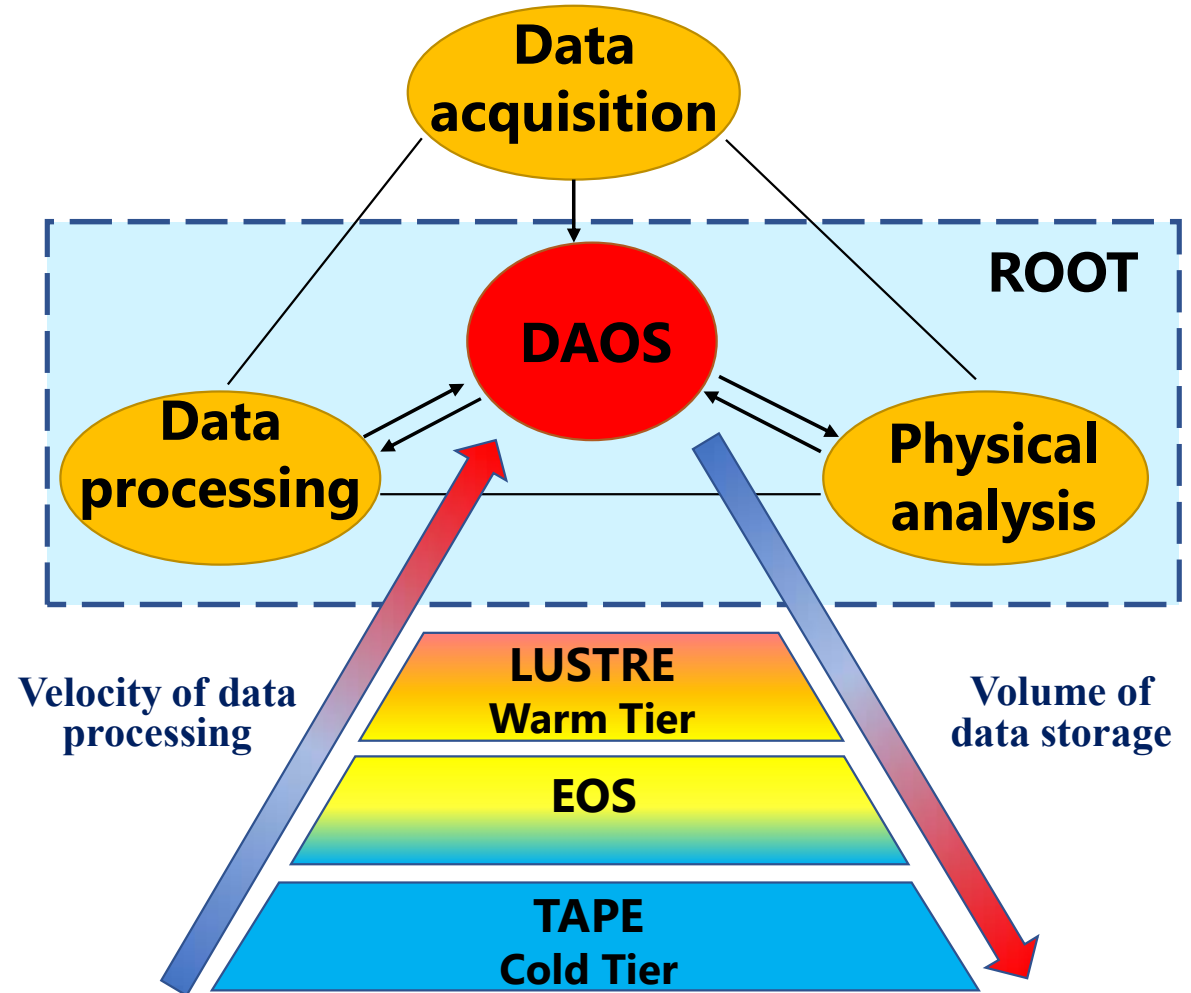
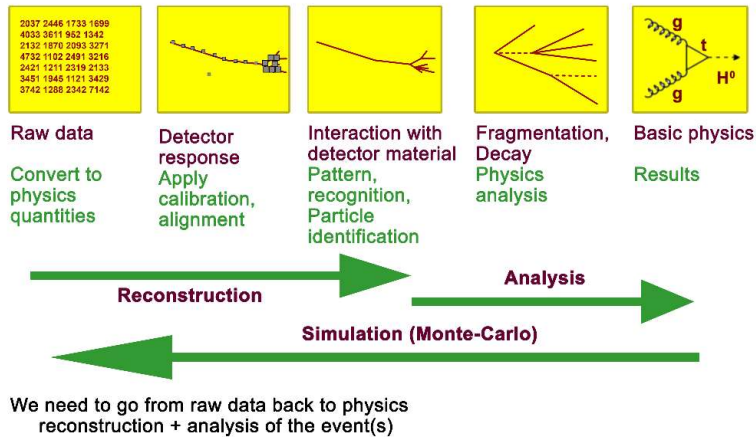
For his job the user can allocate the required number and type of computing nodes and the required volume and type of data storage systems.

This property enables the effective solution of different tasks, which makes the “Govorun” supercomputer a unique tool for research underway at JINR.

From Physics to raw data



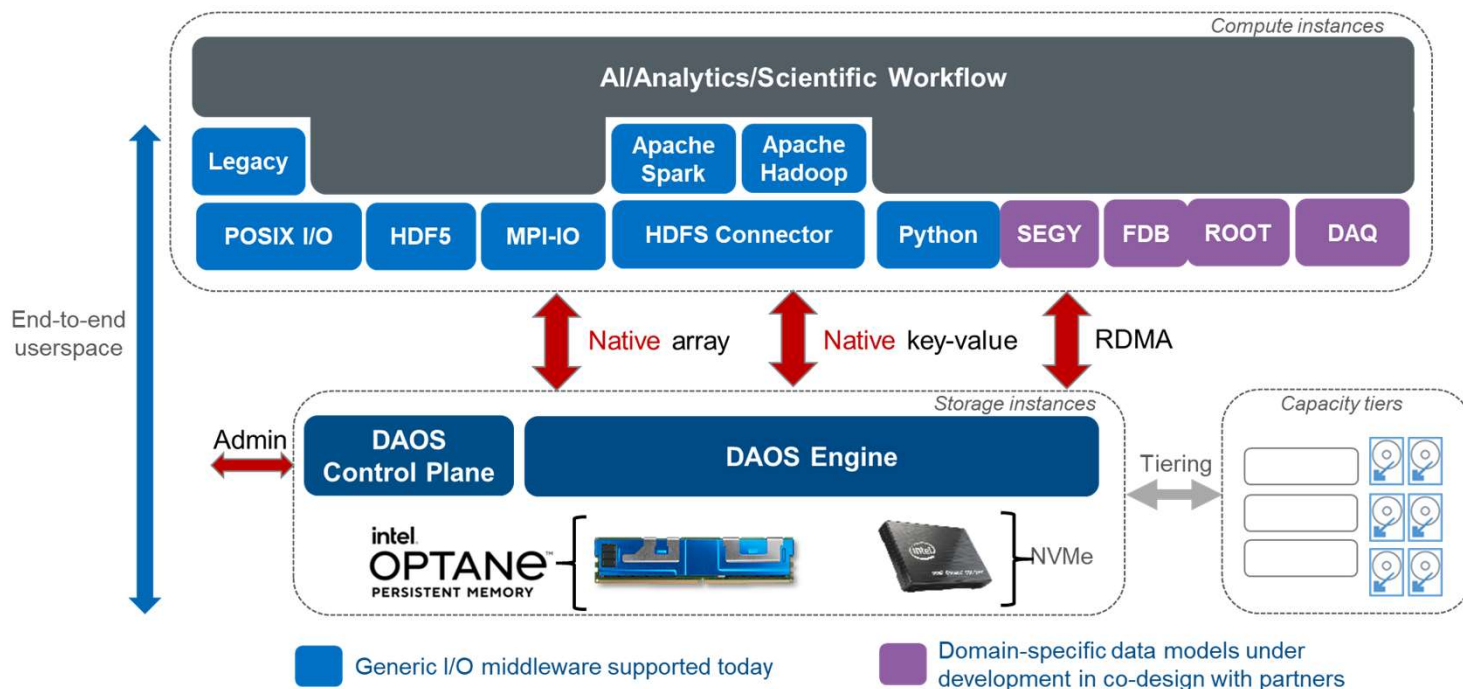
From raw data to Physics



DAOS: Promising technology for HPC, Big Data, AI



DAOS (Distributed Asynchronous Object Storage) Software Ecosystem



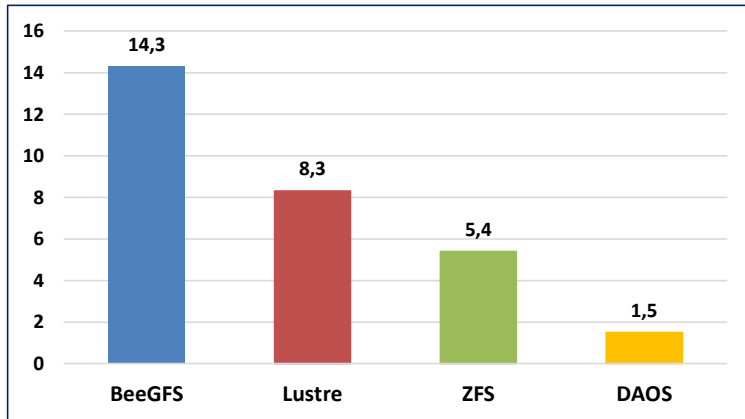
- Complex approach to build a hierarchical storage system
- DAOS is significant part of data acquisition and processing
- Different types of containers are used for different data processing stages
- No need of POSIX file system for most data operations
- Great system performance even for a few DAOS clients
- RSC Storage on-Demand software offers unique flexibility, speed, and convenience for DAOS users

The DAOS polygon on the supercomputer “Govorun” take the **1st** place among Russian supercomputers in the current **IO500** list

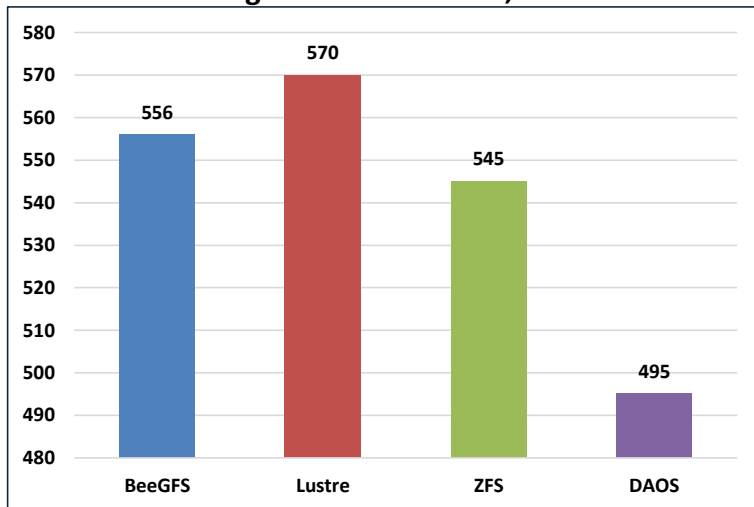
DAOS Testing. Results



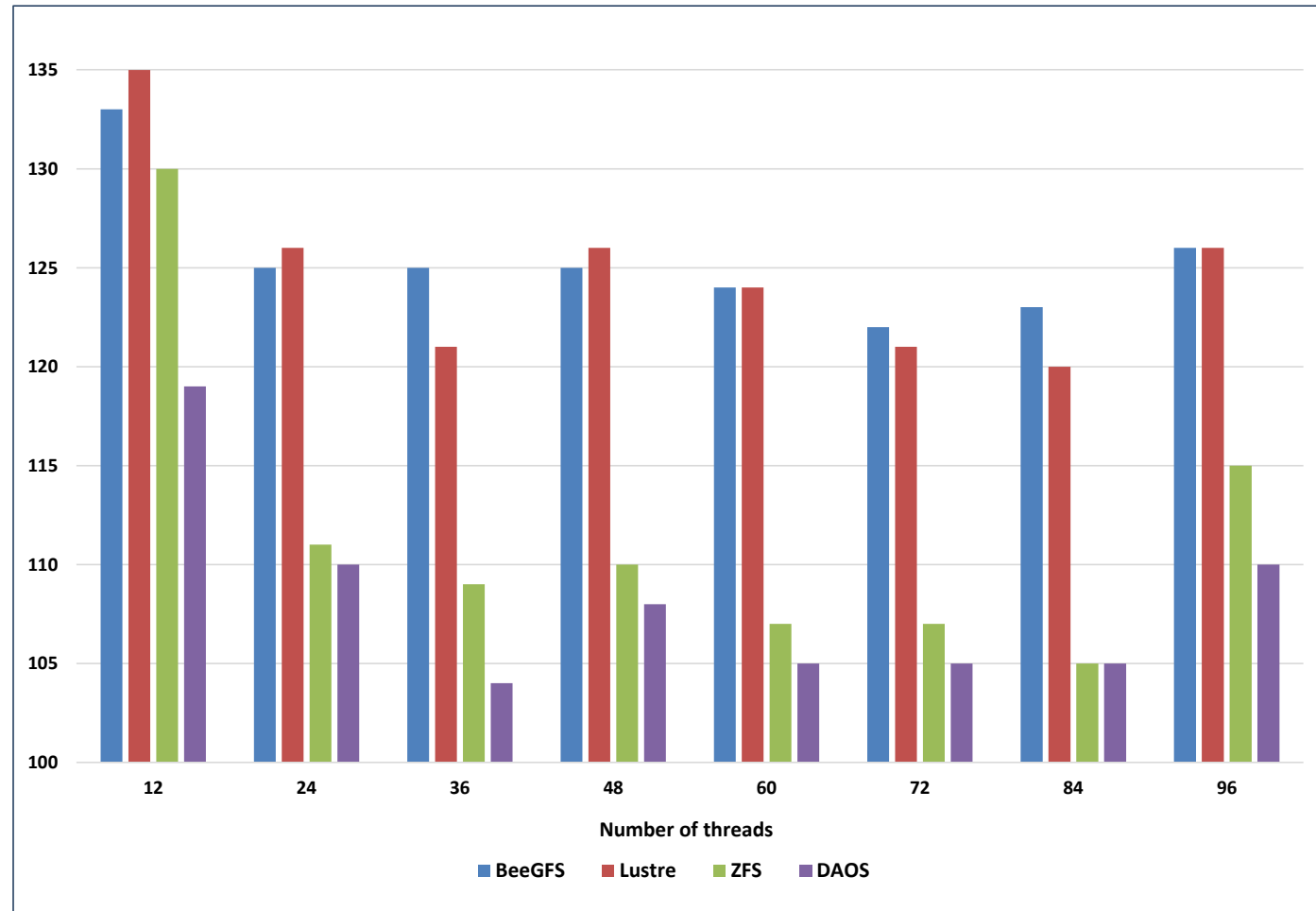
Time to load data into the model, sec



Average training time of one epoch in single-threaded mode, sec



Average training time of one training epoch, sec

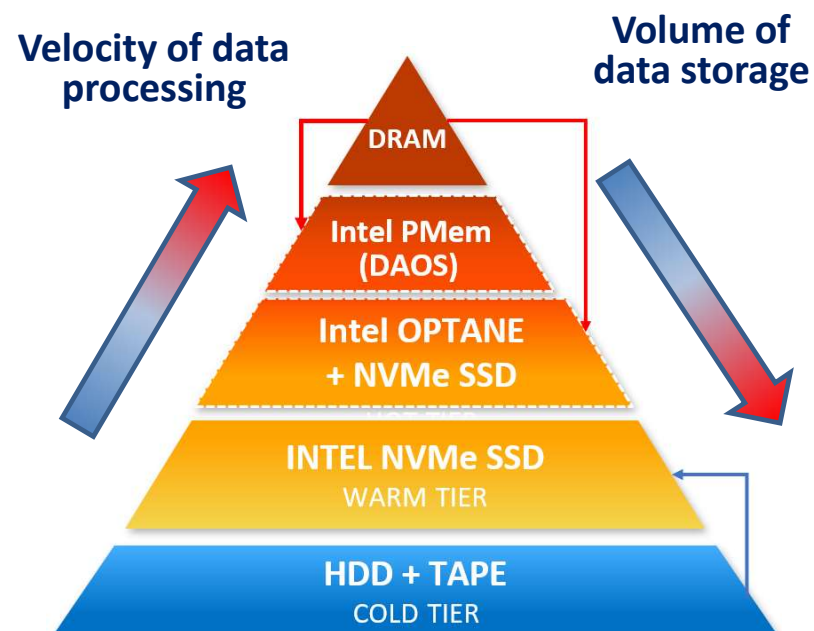
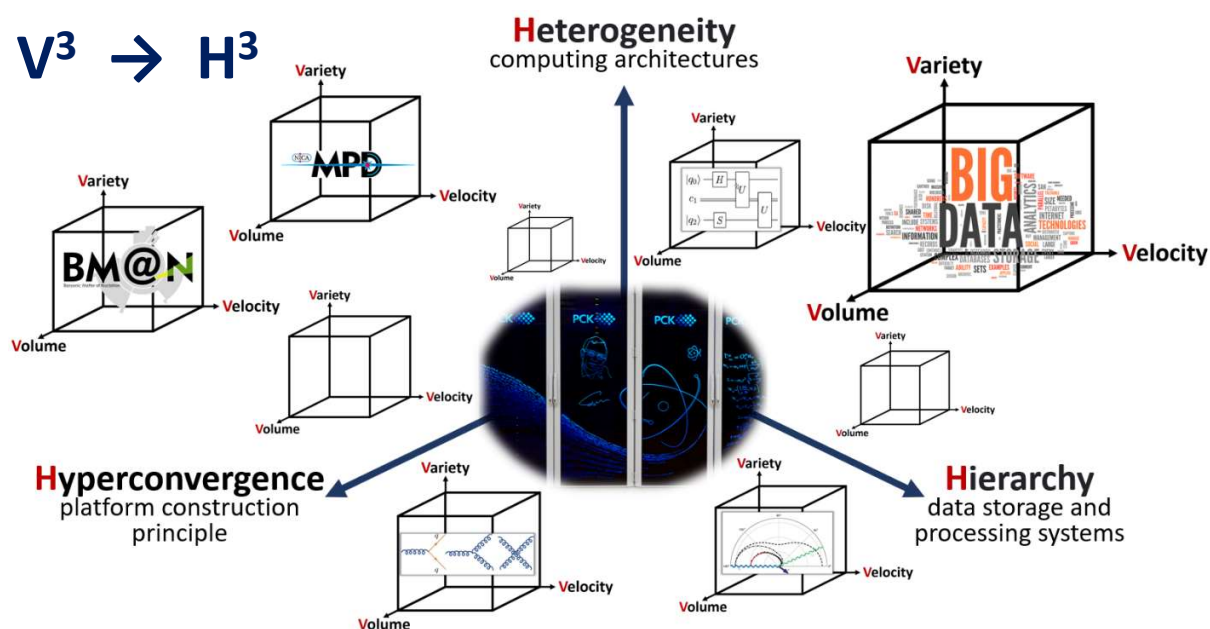


Big Data on the “Govorun” Supercomputer for NICA megaproject

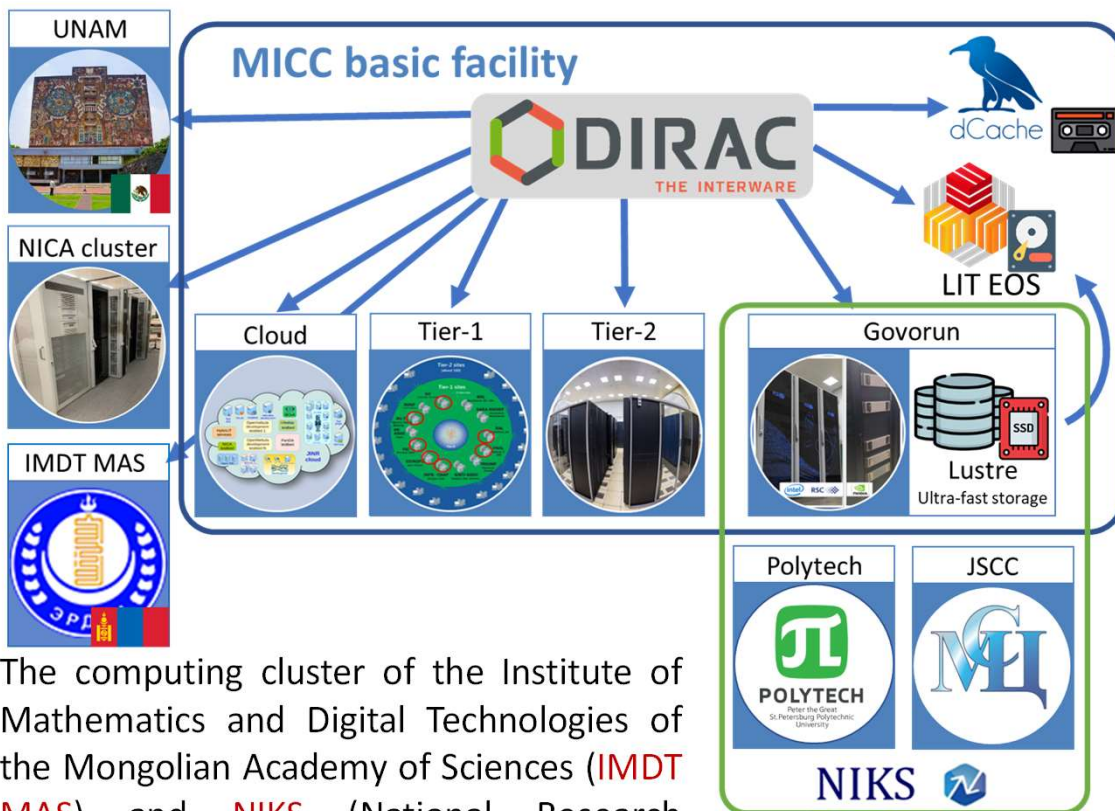


The DAOS polygon of the “Govorun” supercomputer takes the **1st** place among Russian supercomputers in terms of the data processing rate in the current **IO500 list**.

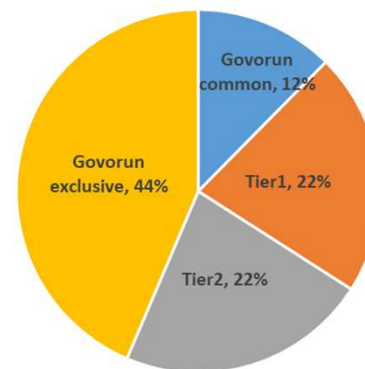
Heterogeneity
Hierarchy
Hyperconvergence → provide → **Variety**
Velocity
Volume



Heterogeneous distributed computing environment

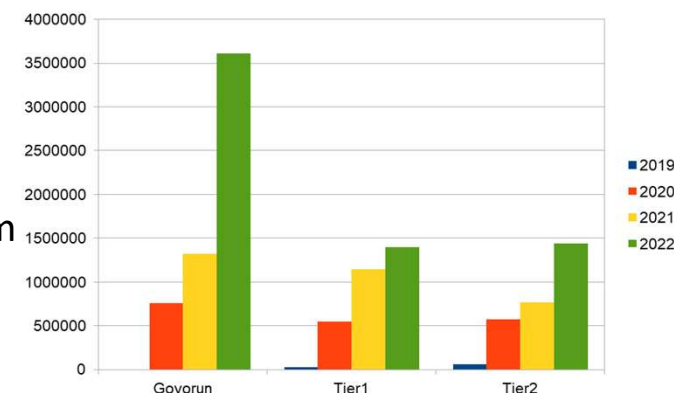


The computing cluster of the Institute of Mathematics and Digital Technologies of the Mongolian Academy of Sciences (IMDT MAS) and NIKS (National Research Computer Network, the Russia's largest research and education network) were integrated into the heterogeneous distributed environment based on the DIRAC platform.



Share of the use of different MICC components for MPD tasks in 2022: the SC "Govorun" resources are the most efficient for MPD tasks.

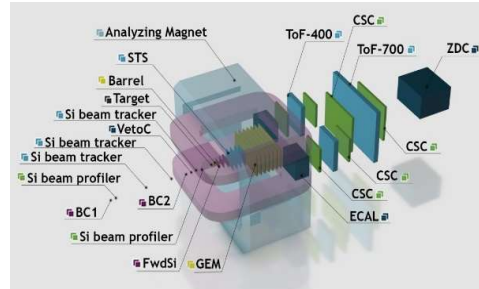
Increase in the share of the MICC computing resources on the DIRAC platform in normalized CPU HEP-SPEC06 days



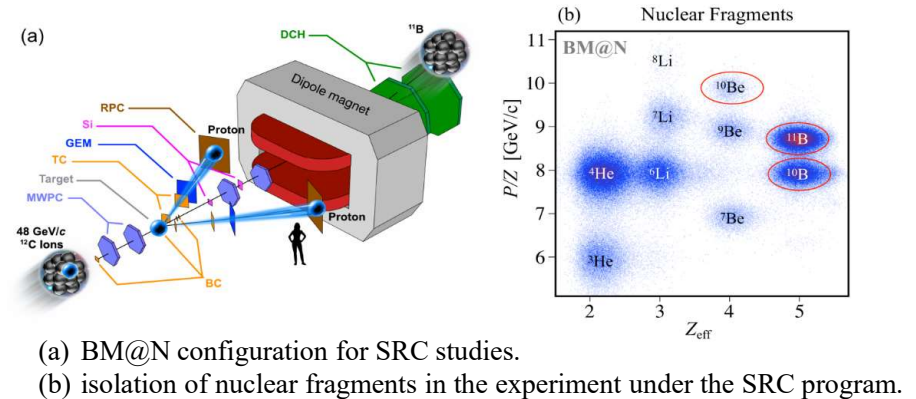
Summary statistics of using the DIRAC platform for MPD tasks in 2019-2022



The histogram illustrates the accounting data from the centers. The metric shown is Sum CPU Work, grouped by center and year.

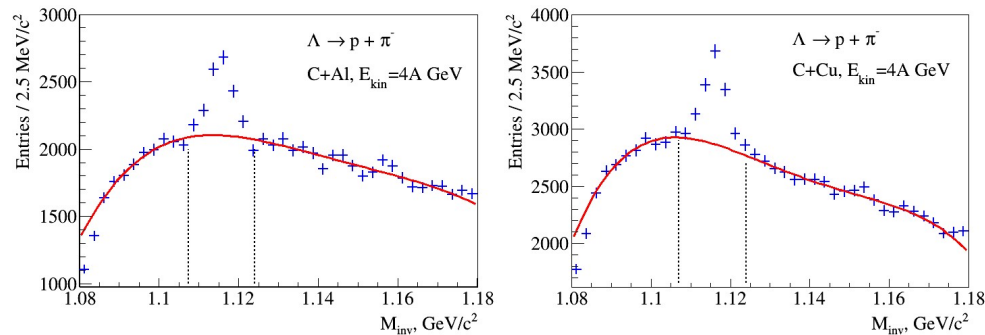


Full BM@N configuration for heavy ion studies in 2018.



(a) BM@N configuration for SRC studies.

(b) isolation of nuclear fragments in the experiment under the SRC program.

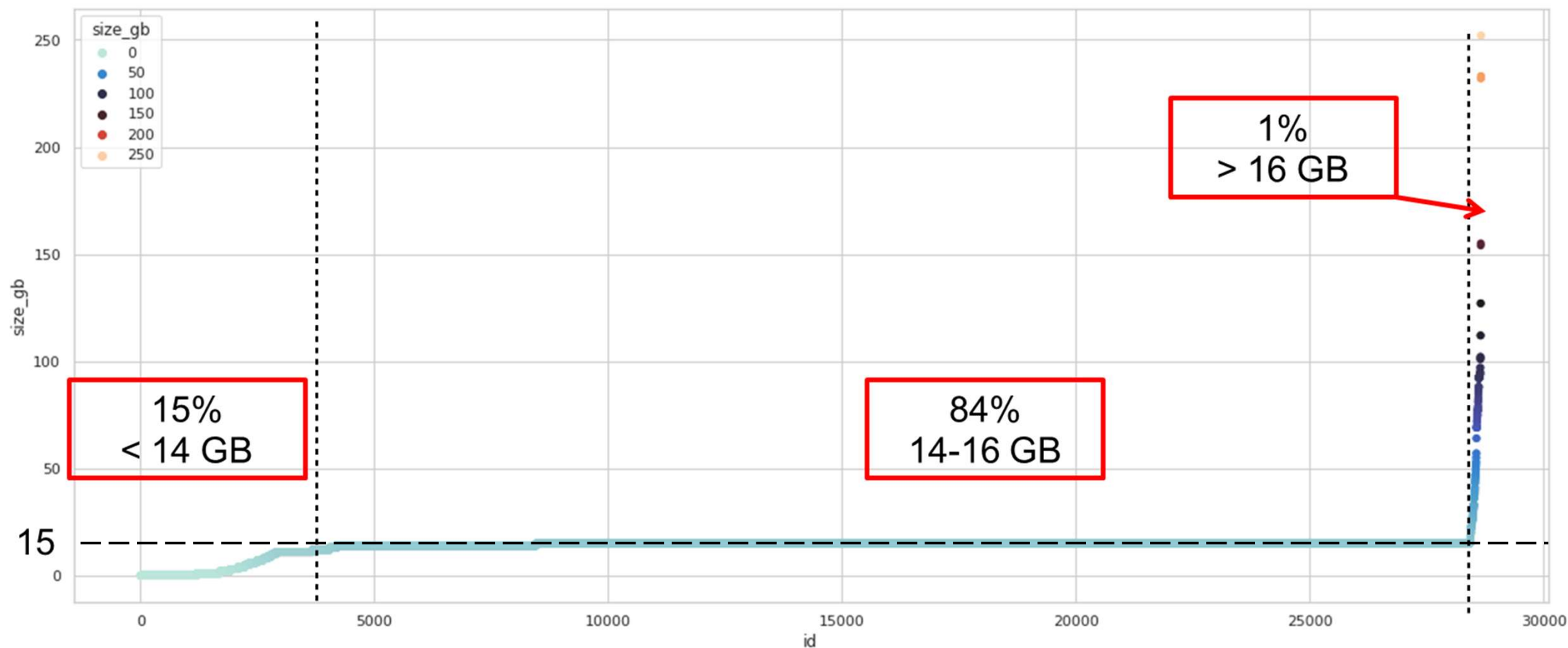


Signals of Λ -hyperons in the spectra of invariant masses (p, π^-) measured in C+Al and C+Cu interactions.

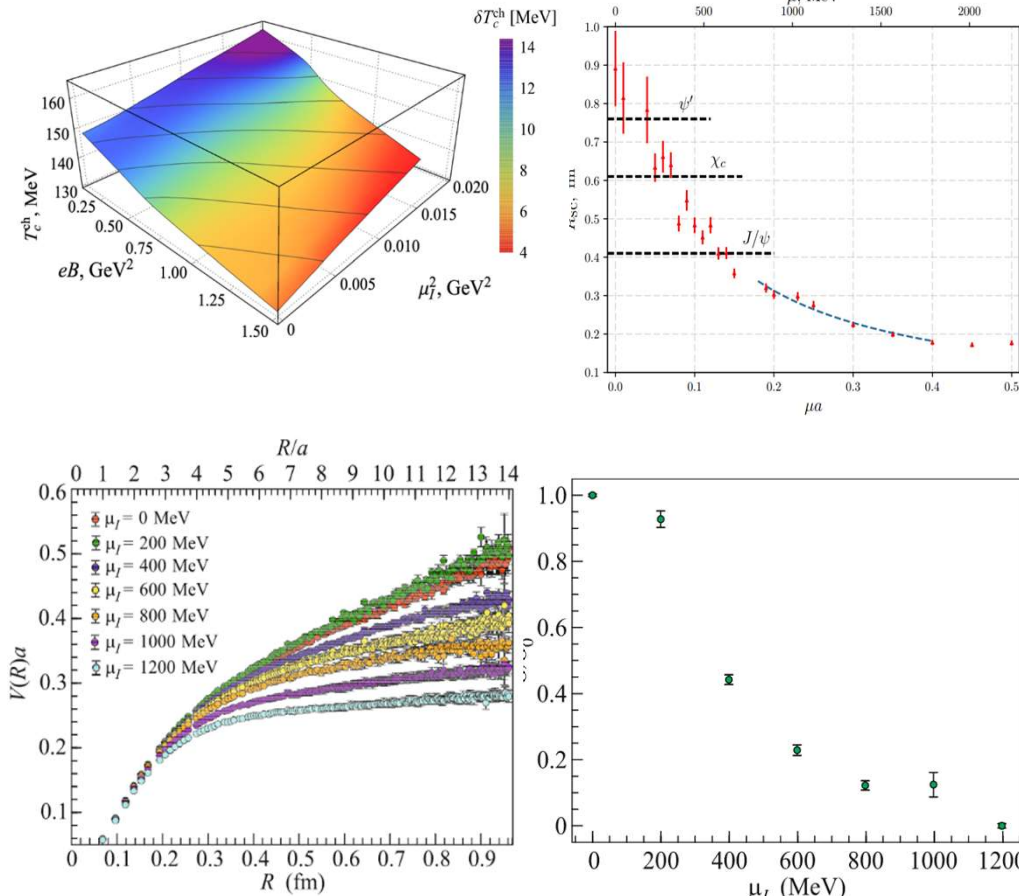
BM@N Collaboration. Production of Λ hyperons in 4 and 4.5 AGeV ^{12}C -nucleus interactions at the Nuclotron // The European Physical Journal A (awaiting publication)

- The analysis of experimental data acquired during the Nuclotron runs in 2016-2018 was performed. Special attention is paid to the study of interactions between beams of carbon and argon ions with fixed targets of different types. The reconstruction of particle tracks was carried out using the method of “cellular automata”.
- The modeling of the work of the experiment using generators of physical models, such as DCM-QGSM and URQMD, and the embedding procedure were performed.
- The staff of the BM@N collaboration from Russia, the USA, Israel, Germany, France and JINR, working on the program for the study of short-range correlations (SRC) of nucleons in nuclei, developed and applied a new experimental method for investigating the internal structure of the atomic nucleus in carbon-hydrogen interactions. [A publication based on the results of the SRC program of the BM@N experiment was sent to the scientific journal Nature.](#)
- The polarization of Λ -hyperons was studied using the model data of the DCM-QGSM generator of the BM@N experiment.

Computing for the NICA megaproject “Govorun” supercomputer for BM@N tasks



Из презентации И.С. Пелеванюка



The resources of the “Govorun” supercomputer were used to study the properties of quantum chromodynamics (QCD) and Dirac semimetals in a tight-binding mode under extreme external conditions using lattice modeling. The given study entails the inversion of large matrices, which is performed on video cards (GPU), as well as massive parallel CPU calculations, to implement the quantum Monte-Carlo method:

- The influence of the magnetic field on the confinement/deconfinement transition and the chiral transition at finite temperature and zero baryon density were investigated using the numerical modeling of lattice QCD with a physical quark mass.
- Quantum chromodynamics with non-zero isospin density taking into account dynamical u- d-, s-quarks in the Kogut-Susskind formulation was studied.
- The potential of the interaction between a static quark-antiquark pair in dense two-color QCD was investigated, and the confinement/deconfinement phenomenon was studied.
- The effect of the non-zero chiral chemical potential on dynamical chiral symmetry breaking for Dirac semimetals was studied.
- The influence of the external magnetic field on the electromagnetic conductivity of quark-gluon plasma was investigated.

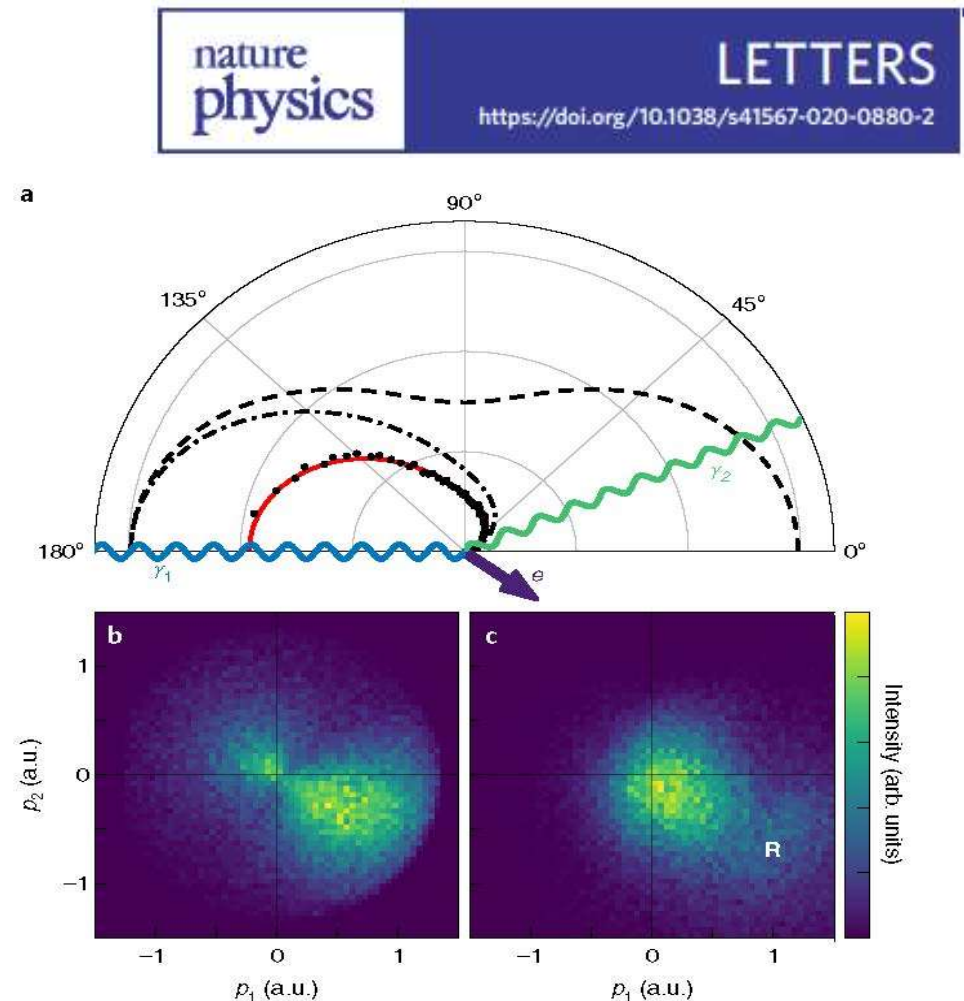
The results are published in the articles:

1. V. V. Braguta, M. N. Chernodub, A. Yu. Kotov, A. V. Molochkov, and A. A. Nikolaev, Phys. Rev. D 100 (2019), 114503, DOI: 10.1103/PhysRevD.100.114503, arXiv:1909.09547
2. V.V. Braguta , A.Yu. Kotov, A.A. Nikolaev, JETP Lett. 110 (2019) no.1, 1-4, DOI: 10.1134/S0021364019130083 (JETP Letters, 110 (2019) no.1, 3-6)
3. N. Astrakhantsev, V. Bornyakov, V. Braguta, E.M. Ilgenfritz, A.Y. Kotov, A. Nikolaev, A. Rothkopf, PoS Confinement2018 (2019), 154, DOI: 10.22323/1.336.0154
4. V. V. Braguta, M. I. Katsnelson, A. Yu. Kotov, and A. M. Trunin, Phys.Rev. B100 (2019), 085117, DOI: 10.1103/PhysRevB.100.085117 , e-Print: arXiv:1904.07003
5. N. Yu. Astrakhantsev, V. G. Bornyakov, V. V. Braguta, E.-M. Ilgenfritz, A. Yu. Kotov, A. A. Nikolaev, A. Rothkopf, JHEP 1905 (2019) 171, DOI: 10.1007/JHEP05(2019)171,e-Print: arXiv:1808.06466
6. <https://arxiv.org/abs/1902.09325>
7. <http://arxiv.org/abs/1910.08516>

Kinematically complete experimental study of Compton scattering at helium atoms near the threshold

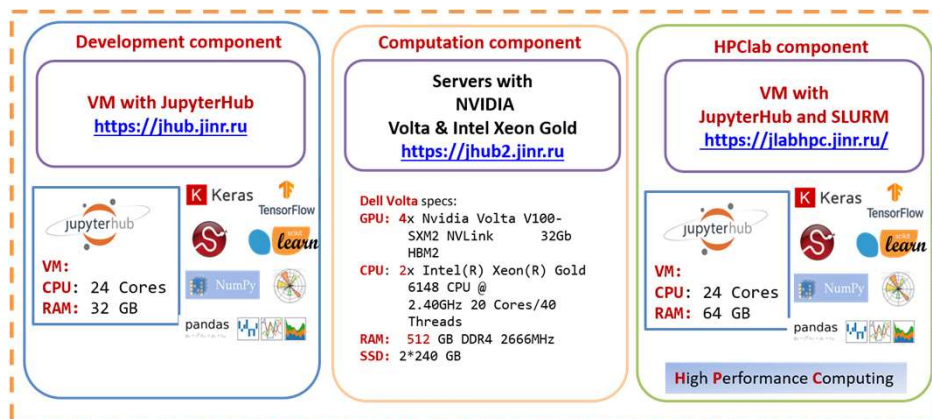


On 13 April, a scientific paper by an international scientific group was published in **Nature Physics**. A LIT staff member *O. Chuluunbaatar* and a BLTP employee *Yu. V. Popov* were members of the group in the frames of JINR international cooperation. The group conducted a kinematically complete experimental measurement of characteristics of Compton scattering at free atoms using the highly efficient method of COLD Target Recoil Ion Momentum Spectroscopy (COLTRIMS). The group also provided a **relevant theoretical description** of it which was carried out at the supercomputer “Govorun”.



Scheme of ionization by Compton scattering at $h\nu = 2.1$ keV

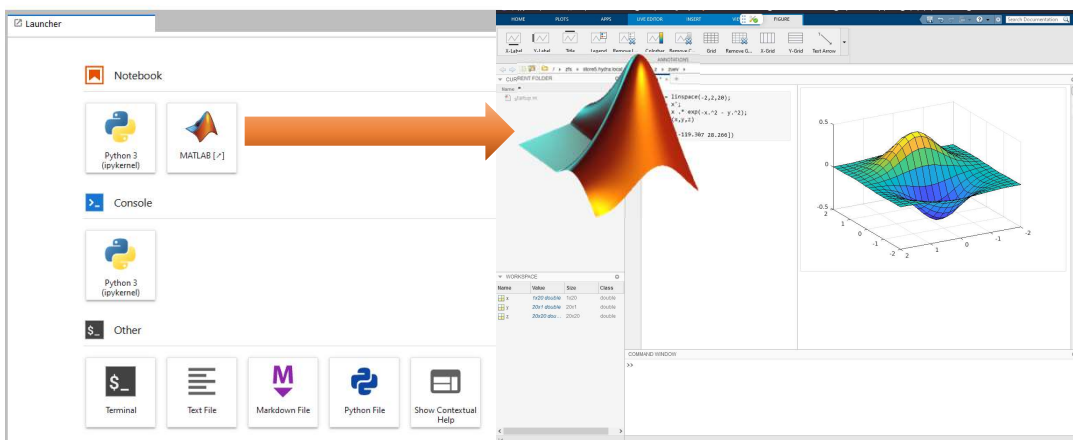
ML/DL/HPC Ecosystem of the HybriLIT Heterogeneous Platform: New Opportunities for Applied Research



The ML/DL/HPC ecosystem is now actively used for machine and deep learning tasks. At the same time, the accumulated tools and libraries can be more widely used for scientific research, including:

- numerical computations;
- parallel computing on CPUs and GPUs;
- visualization of results;
- accompanying them with the necessary formulas and explanations.

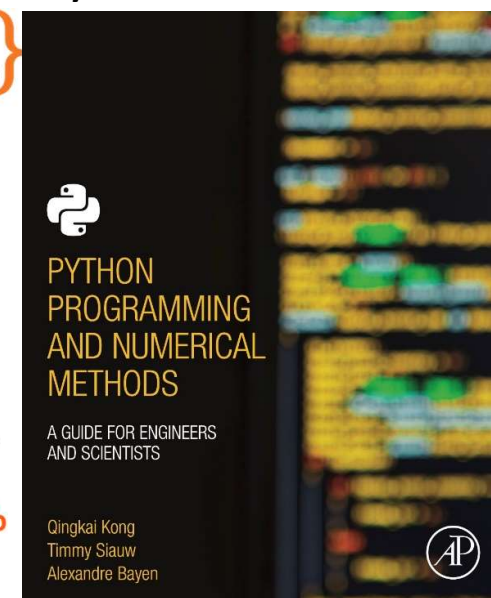
In 2022, on the ML/DL/HPC ecosystem, it became possible to run the MATLAB code in Jupyter Notebook, which allows one to effectively perform applied and scientific computations.



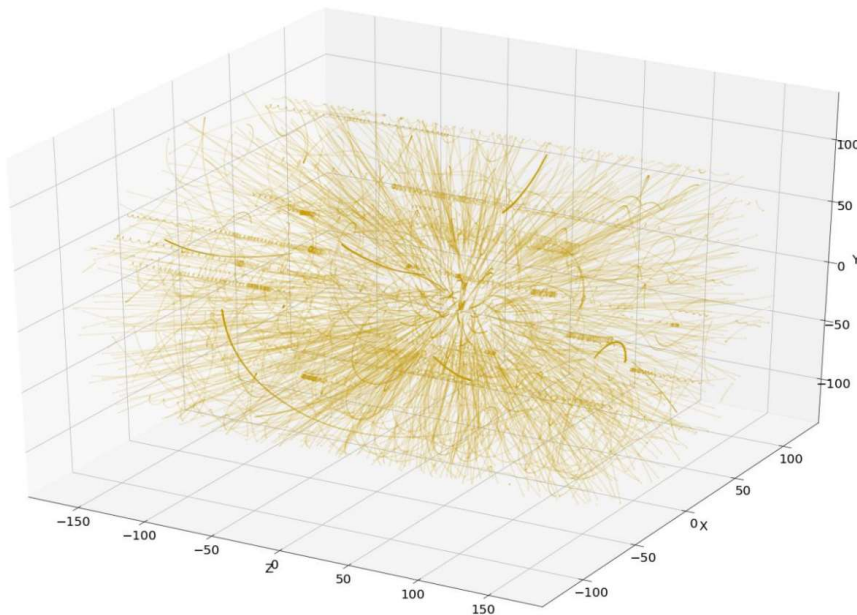
Python Numerical Methods



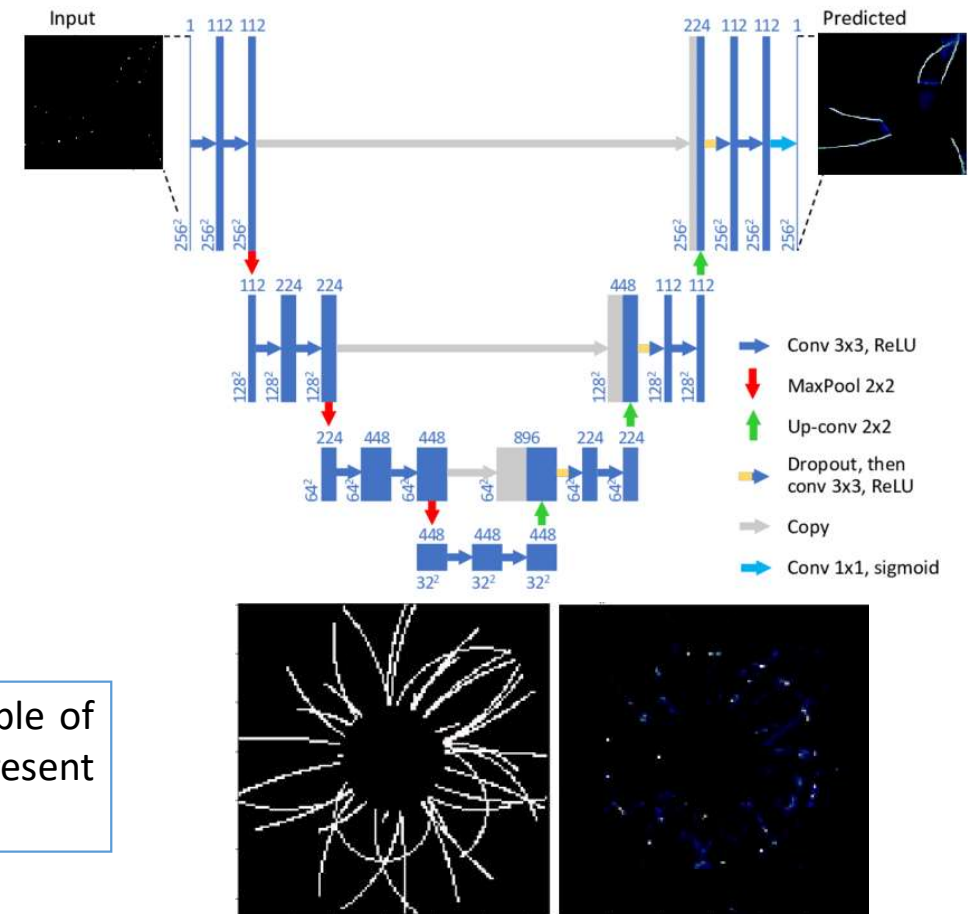
Parallel computations
with Joblib



A large number of tracks in events requires the development of approaches that have constant computational complexity regardless of the number of tracks in an event. The use of deep neural network architectures allows developing tracking one-pass algorithms that work in just single step.



Model experiments show that neural network models are capable of both interpolating tracks and creating an internal model to represent the results in the phase space of the track parameters.

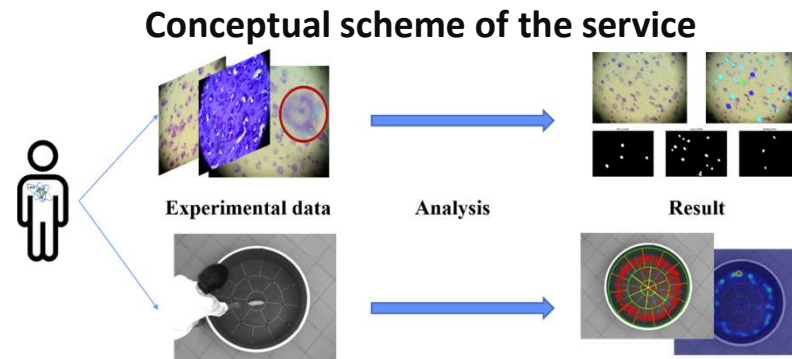




BIOHLIT information system for radiobiological studies

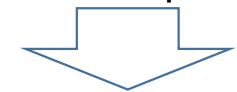


The information system allows one to store, quickly access and process data using a stack of neural network and classical algorithms of computer vision, providing a wide range of possibilities for automating routine tasks. It gives an increase in productivity, quality and speed of obtaining results.



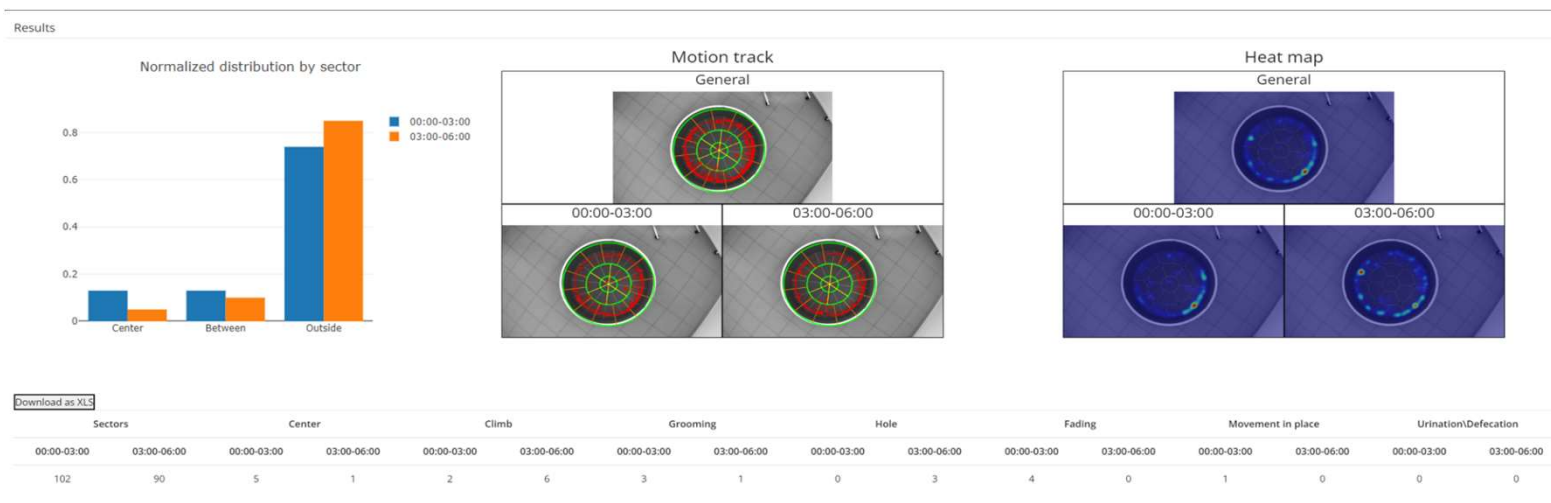
Developed algorithms:

- algorithms for the automated marking of the field of experimental setups,
- algorithms for tracking the animal's position in experimental setups of different types,
- algorithms for evaluating the animal's behavioral patterns.



The obtained information is stored in different forms:

- visualized track of the animal's movement,
- video file with tracking the animal's position,
- heat map by sectors,
- file that stores all the information for subsequent statistical analysis.



Study the dynamics of magnetization in a Phi-0 Josephson Junction



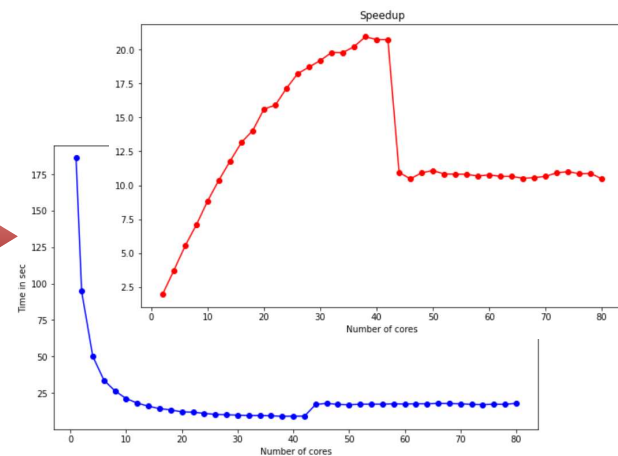
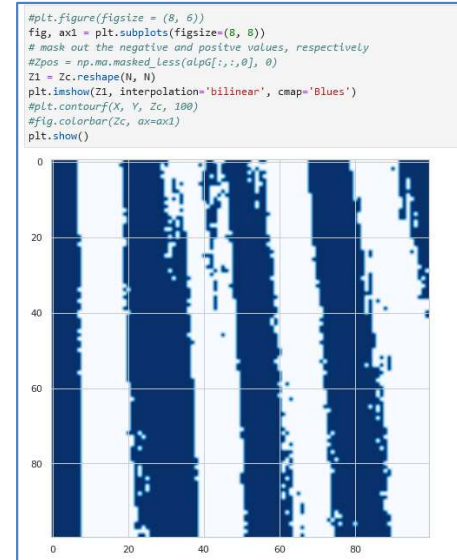
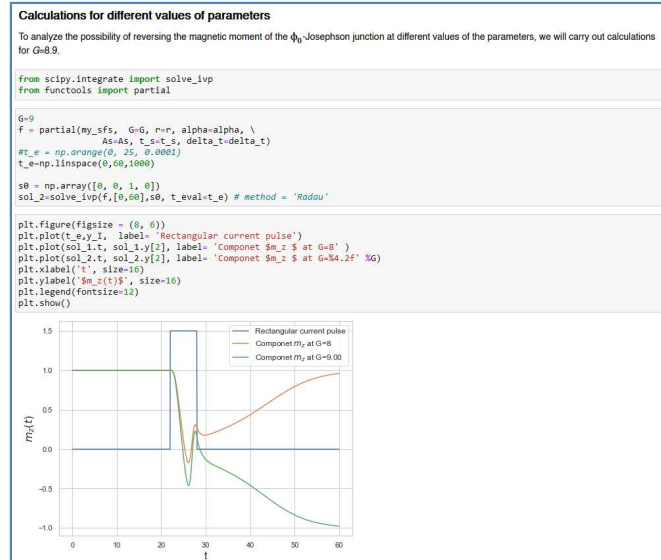
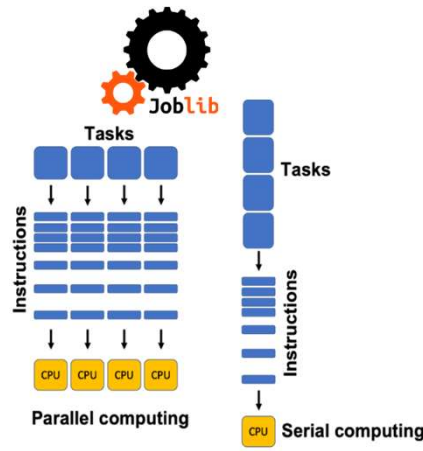
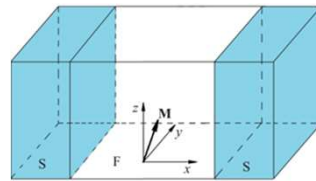
The dynamics of the magnetic moment M of the system under consideration is described by the Landau-Lifshitz-Gilbert equation:

$$\begin{aligned}\frac{dm_x}{dt} &= -\frac{1}{1+M^2\alpha^2} \{m_y H_z - m_z H_y + \alpha[m_x(M, H) - H_x]\}, \\ \frac{dm_y}{dt} &= -\frac{1}{1+M^2\alpha^2} \{m_z H_x - m_x H_z + \alpha[m_y(M, H) - H_y]\}, \\ \frac{dm_z}{dt} &= -\frac{1}{1+M^2\alpha^2} \{m_x H_y - m_y H_x + \alpha[m_z(M, H) - H_z]\},\end{aligned}$$

$M = [m_x, m_y, m_z]$ are the magnetic moment components; the effective field components $H = [H_x, H_y, H_z]$ depend on the Josephson phase difference ϕ and are defined as follows:

$$\begin{aligned}H_x(t) &= 0, \\ H_y &= Gr \sin(\phi(t) - tm_y(t)), \\ H_z(t) &= m_z(t).\end{aligned}$$

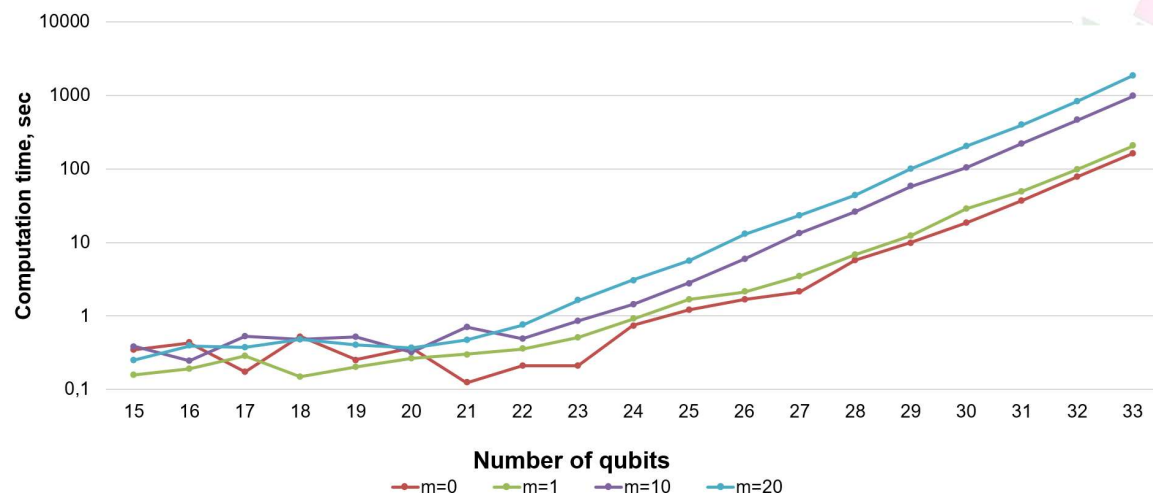
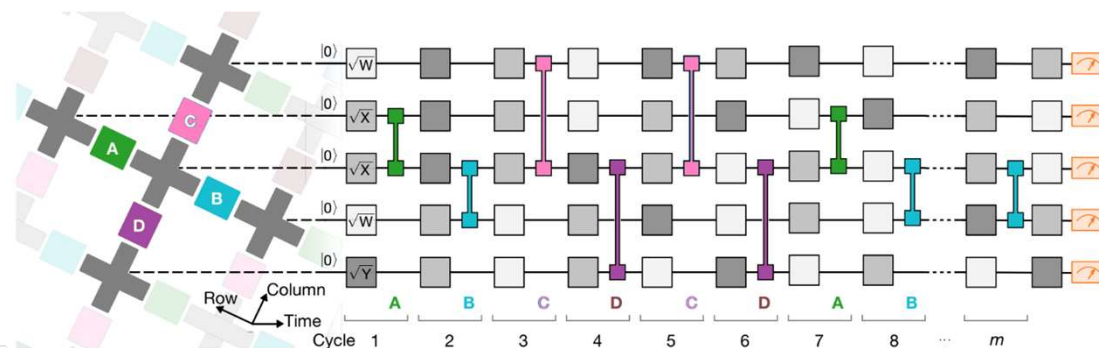
The equation for the Josephson phase difference $\phi(t)$ is determined from the equation for the electric current I flowing through the Josephson junction, measured in units of the critical current I_c :

$$\frac{d\phi}{dt} = -\frac{1}{w} \left(\sin(\phi - rm_y) + r \frac{dm_y}{dt} \right) + \frac{1}{w} I,$$


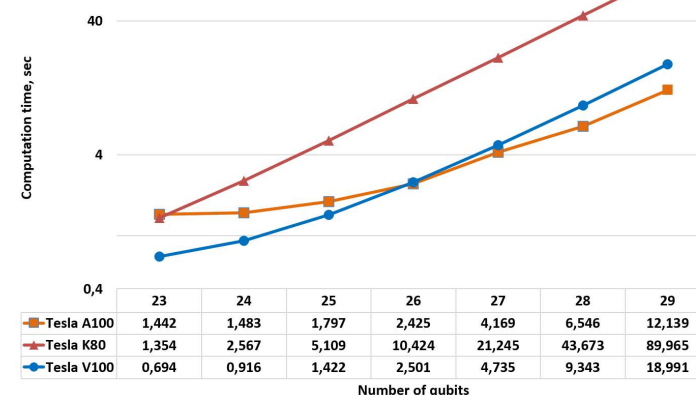
Quantum polygon



Quantum Exact Simulation Toolkit
<https://quest.qtechtheory.org/>



Time dependency on the number of qubits for CPU calculations with OpenMP technology



Time dependency calculations on the number of qubits for various GPUs

Для задач, решаемых в рамках Проекта была создана вычислительная система по требованию, содержащую 288 физических ядер (576 логических ядер) и файловое хранилище емкостью 7 ТБ под управлением файловой системы NFS. На этой системе проводились интенсивные расчеты с использованием ПО AMS, DIRAC, QuEST и др. для расчетов электронных свойств сверхтяжелых элементов. За время выполнения проекта было решено 4200 задач на которые было затрачено 740 000 ядро-часов

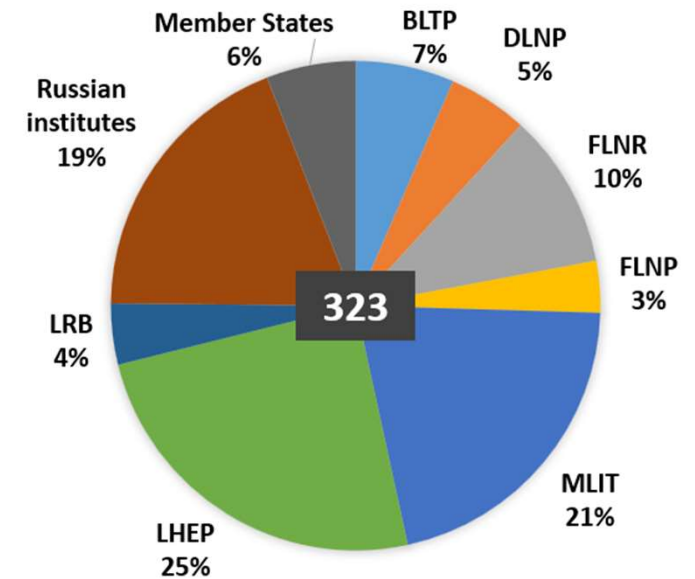
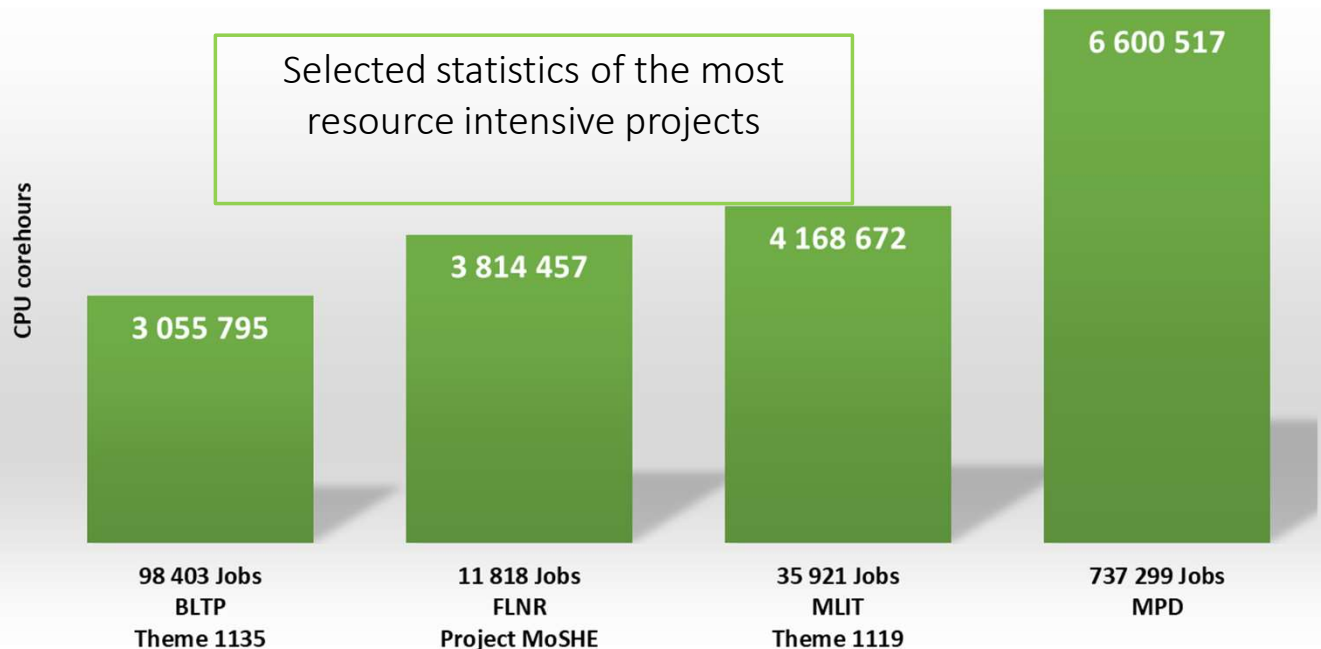
Using of the “Govorun” Supercomputer in 2022

The resources of the “Govorun” SC are used by scientific groups from all the Laboratories of the Institute within **25 themes** of the JINR Topical Plan.

The projects that mostly intensive use the CPU resources of the “Govorun” SC:

- NICA megaproject,
- simulation of complex physical systems,
- computations of the properties of atoms of superheavy elements,
- calculations of lattice quantum chromodynamics.

Selected statistics of the most resource intensive projects



During 2022, **890,911** jobs were performed on the **CPU** component of the “Govorun” SC, which corresponds to **18,543,076** core hours.

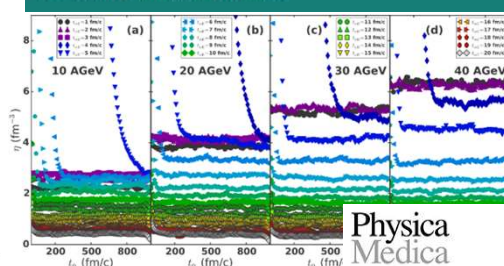
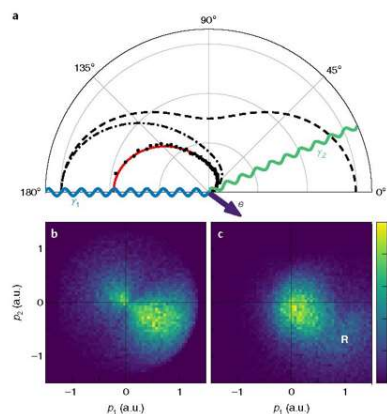
“Govorun” Supercomputer for JINR Tasks

nature
physics

LETTERS

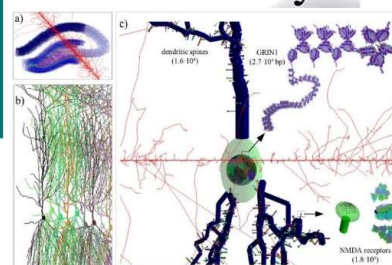
<https://doi.org/10.1038/s41567-020-0880-2>

PHYSICAL REVIEW C
covering nuclear physics

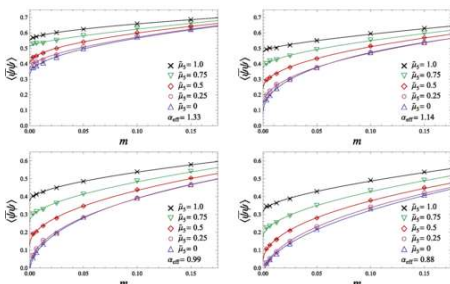


Advances in
Biomembranes and
Lipid Self-Assembly
Volume 31

Physica
Medica
European Journal
of Medical Physics



PHYSICAL REVIEW B
covering condensed matter and materials physics

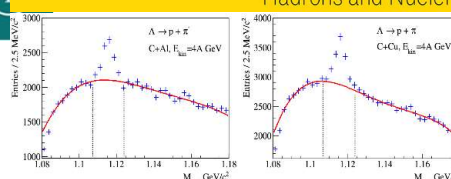


Edited by
S. Iglit, Michael Rappolt
Ana J. Garcia-Saez

The European Physical Journal

EPJ A
Recognized by European Physical Society

Hadrons and Nuclei



The resources of the “Govorun” supercomputer are used by scientific groups from all the Laboratories of the Institute within **25 themes of the JINR Topical Plan** for solving a wide range of tasks in the field of theoretical physics, as well as for the modeling and processing of experimental data.

Research results obtained using the supercomputer resources are presented in **260** publications.

Using the results obtained at the Govorun SC, 2 publications were prepared in Nature Physics:

- M. Kircher ... , **O. Chuluunbaatar** et al. Kinetically complete experimental study of Compton scattering at helium atoms near the threshold. Vol. 16. № 4. Pp. 756-760
- BM@N Collaboration. Unperturbed inverse kinematics nucleon knockout measurements with a 48 GeV/c carbon beam. Vol. 17. Pp. 693-699

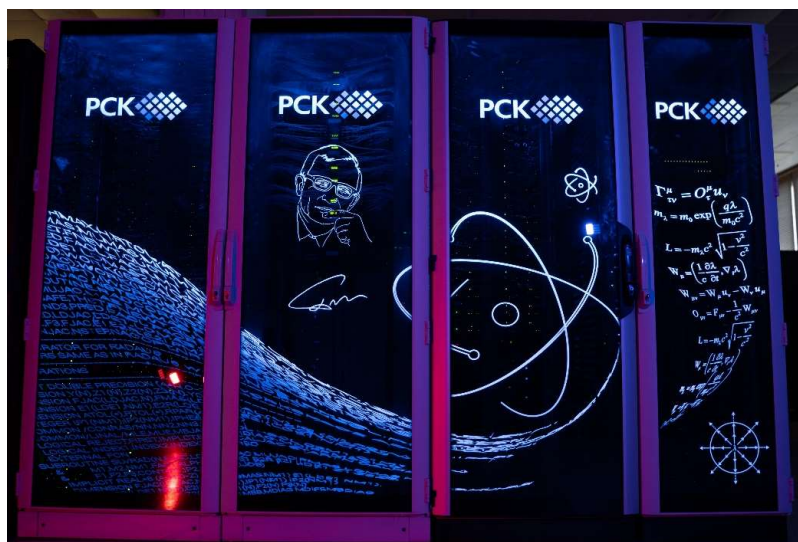
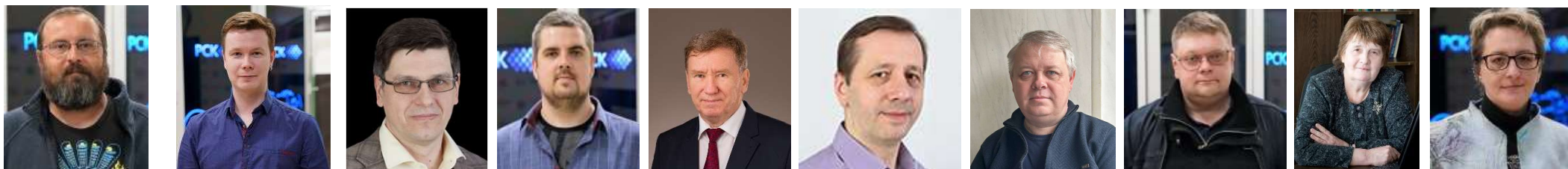


Applied Physics Research First Prize

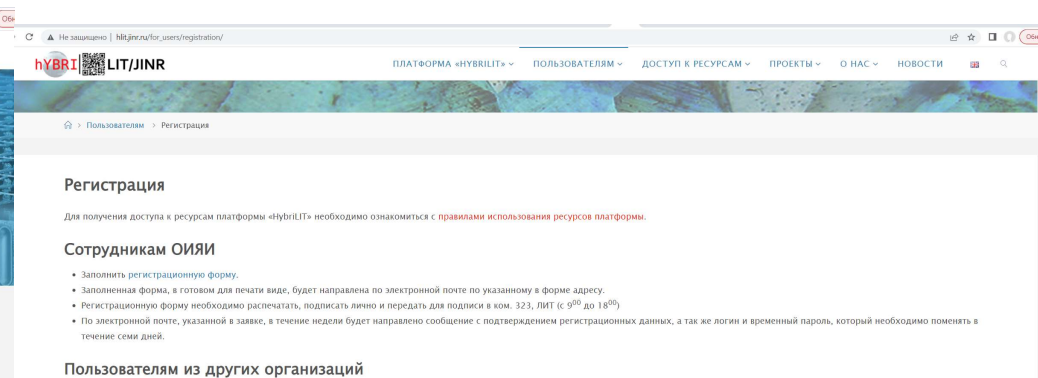


“Hyperconverged “Govorun” supercomputer for the implementation of the JINR scientific program”

D.V. Belyakov, A.S. Vorontsov, E.A. Druzhinin, M.I. Zuev, V.V. Korenkov, Yu.M. Migal, A.A. Moshkin, D.V. Podgany, T.A. Strizh, O.I. Streltsova



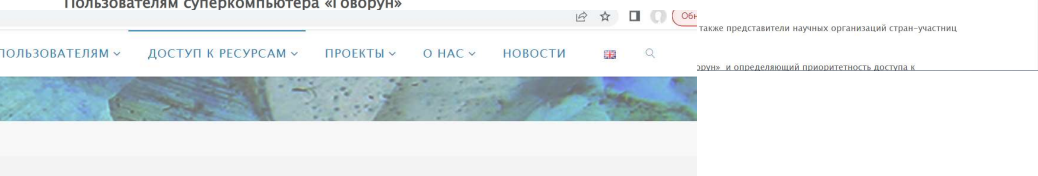
The creation of the “Govorun” supercomputer at JINR is an essential technological achievement being of great importance for the implementation of the JINR scientific program and international cooperation. The “Govorun” supercomputer is a unique scalable computing system with a hyperconverged and software-defined architecture. The technology of direct liquid cooling of CJSC “RSC Technologies” was chosen for the CPU component of the supercomputer. Due to liquid cooling, the average annual PUE indicator of the system, reflecting the level of energy efficiency, is less than 1.06. The operation experience of the SC “Govorun” has shown the relevance and effectiveness of using both novel hyperconverged computing architectures and the hierarchical data processing and storage system being part of it. The results obtained using the resources of the “Govorun” supercomputer are reflected in 204 user publications, two of them in the Nature Physics journal. At present, the resources of the “Govorun” supercomputer are used by scientific groups from all the Laboratories of the Institute within 25 themes of the JINR Topical Plan.



Гетерогенная платформа «HybriLIT» является частью Многофункционального информационно-вычислительного комплекса (МИВК), Лаборатории информационных технологий ОИЯИ, г. Дубна. Гетерогенная платформа состоит из Суперкомпьютера «Говорун» и учебно-тестового полигона «HybriLIT».

- CPU-компонента, базирующуюся на новейших архитектурах Intel (процессоров Intel Xeon Phi).
- GPU-компонента, базирующуюся на узлах NVIDIA DGX-1 Volta.

- Учебно-тестовый полигон имеет гетерогенную структуру вычислительных узлов: многоядерные процессоры, сопроцессоры Intel Xeon Phi и линейки графических процессоров, позволяющих студентам осваивать работу на новейших вычислительных архитектурах.



Запуск задач

Запуск задач

Полезные ссылки:

- Об учебно-тестовом полигоне
- JupyterHub
- Putty
- Установленное ПО
- Инструкция по работе

The background is a collage of images related to computing and science. On the left, there are server racks with many colorful cables plugged into them. In the center, there are four vertical panels with the 'PCK' logo and various scientific illustrations, including a portrait of a person and an atomic model. On the right, there are more server racks. At the bottom left, there are several NVIDIA server units. At the bottom right, there is a large server rack with its doors open, showing internal components.

Thank you for your attention

HYBRILIT HETEROGENEOUS PLATFORM at MLIT JINR:

[**http://hlit.jinr.ru**](http://hlit.jinr.ru)

SC Govorun included into unified supercomputer network of Russia



On 24 September, an agreement was signed in St. Petersburg on uniting three supercomputers, including the object of the scientific infrastructure of the JINR Member States – the “Govorun” supercomputer – into a single network. Its aim is to develop the National Research Computer Network of Russia.

Deputy Prime Minister of the Russian Federation Dmitry Chernyshenko



Director of the Meshcheryakov Laboratory of Information Technologies JINR Vladimir Korenkov

Rector of Peter the Great St. Petersburg Polytechnic University Andrey Rudskoi

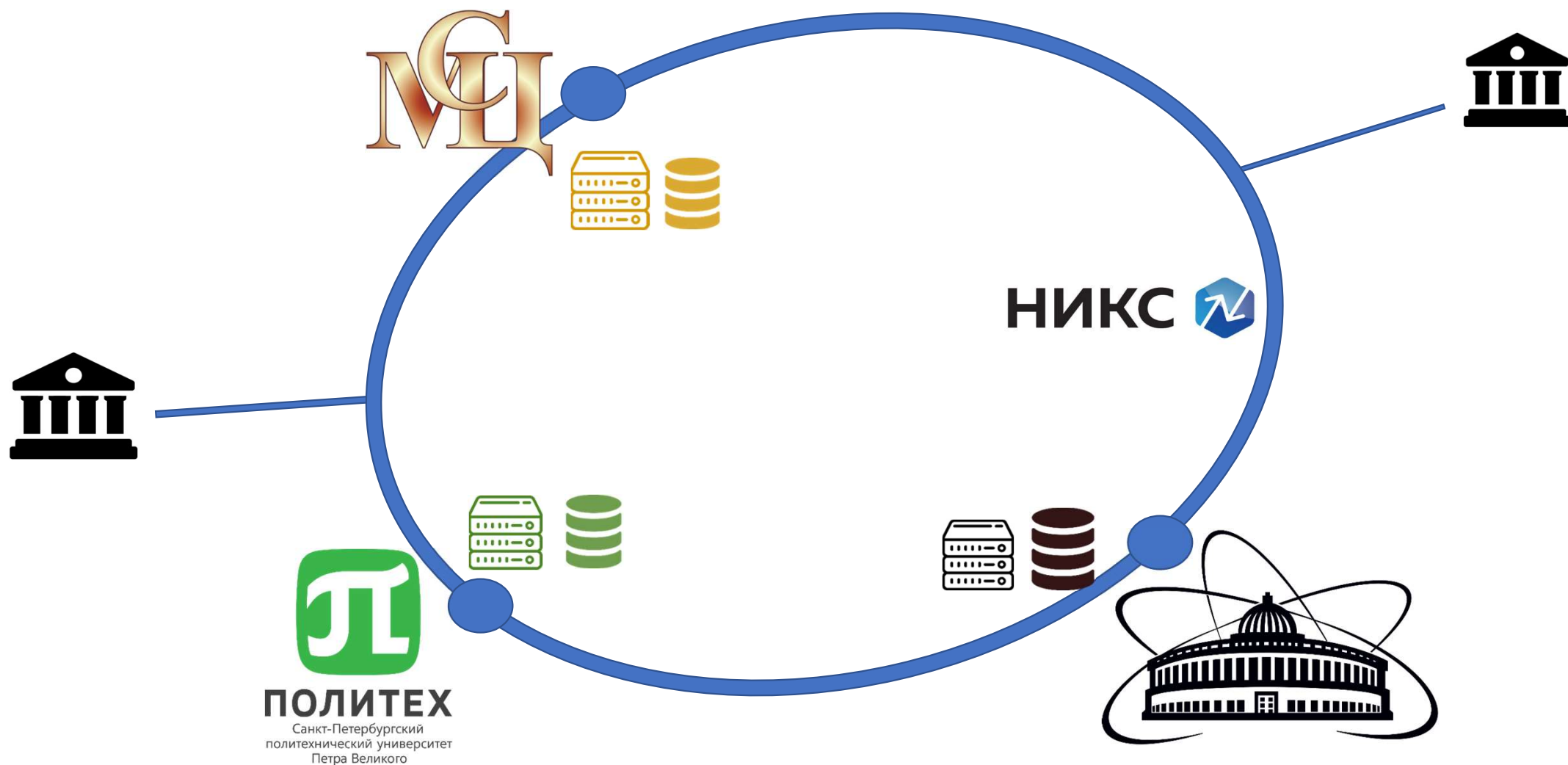
Director of the Joint Supercomputer Centre of the Russian Academy of Sciences Boris Shabanov

There is a unified scientific and educational space of information technologies being formed in Russia. Scientific world-level centres, scientific-educational and engineering centres gain an opportunity for distributed work with big data at megascience scientific facilities in supercomputer centres. Researchers and developers will be provided with global access to services of machine learning, big data analysis, supercomputer resources.





Объединенная географически распределенная суперкомпьютерная инфраструктура





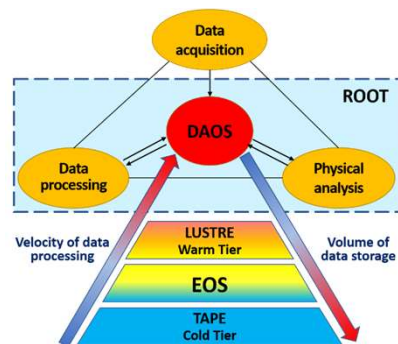
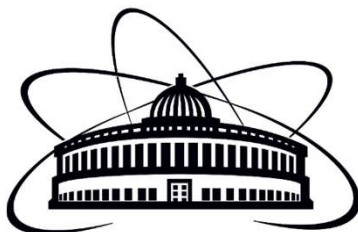
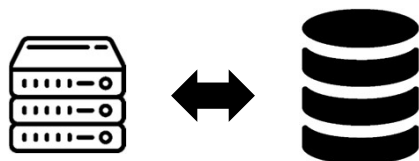
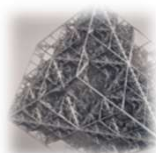
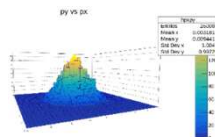
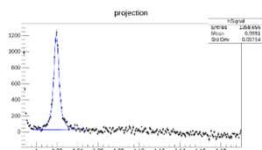
Объединенная географически распределенная суперкомпьютерная инфраструктура для мегапроекта NICA



На основе интеграции суперкомпьютеров ОИЯИ, Межведомственного суперкомпьютерного центра РАН и Санкт-Петербургского политехнического университета Петра Великого создана масштабируемая исследовательская инфраструктура нового уровня. Такая инфраструктура востребована для задач меганауки NICA.



Реконструкция траекторий, Физический анализ



Основным направлениями развития создаваемой инфраструктуры являются:

- объединение суперкомпьютерных ресурсов в интегрированную территориально распределённую сеть;
- создание экосистемы профессионального сообщества пользователей суперкомпьютерными ресурсами;
- совместное развитие средств хранения и обработки больших объемов данных;
- создание облачных цифровых сервисов для доступа к суперкомпьютерным ресурсам;
- создание сервисов машинного обучения и аналитики больших данных, распределенных витрин данных для пользователей научных и образовательных организаций.



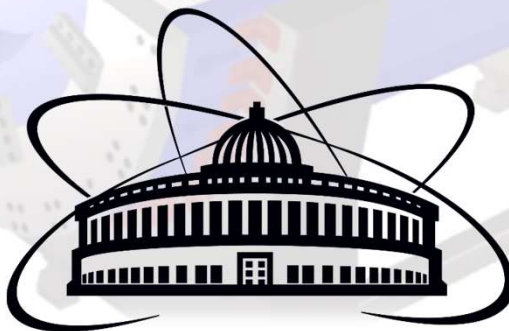
Объединенная географически распределенная суперкомпьютерная инфраструктура для мегапроекта NICA



Слияние физических
данных



ПОЛИТЕХ
Санкт-Петербургский
политехнический университет
Петра Великого





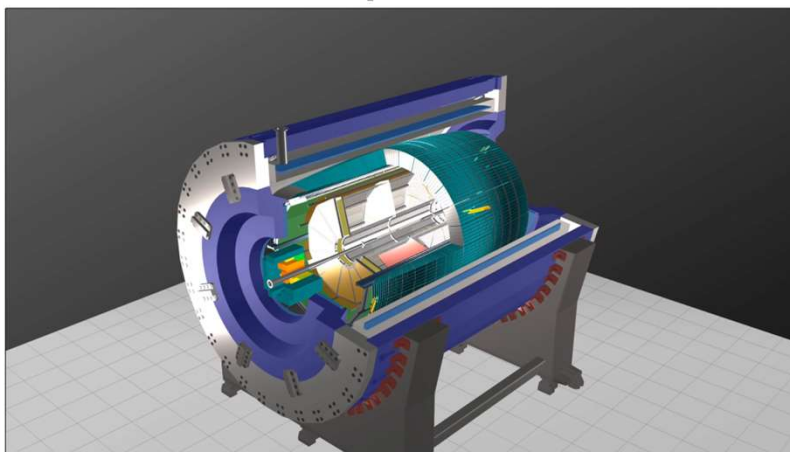
Объединенная географически распределенная суперкомпьютерная инфраструктура для мегапроекта NICA



ДАННЫЕ



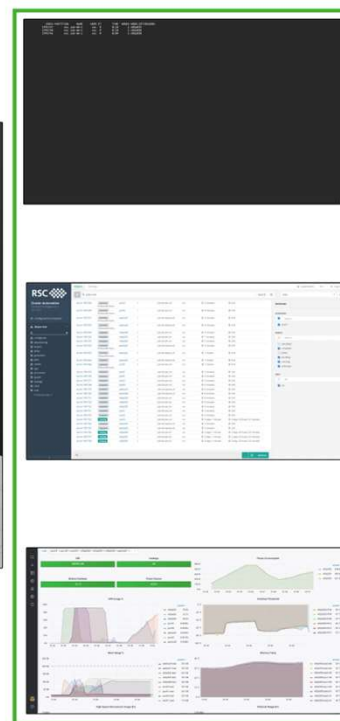
Центр управления виртуальным экспериментом Multi-Purpose Detector



00:00:44:19



ЗАДАЧИ



В январе 2022 года успешно завершен первый совместный эксперимент по использованию единой суперкомпьютерной инфраструктуры для задач мегасайенс-проекта NICA:

- ✓ для эксперимента MPD было запущено **3000** задач генерации данных;
- ✓ было сгенерировано порядка **3 миллиона событий**;
- ✓ полученные данные были переданы на СК «Говорун» для дальнейшей обработки и физического анализа.