Hyperconverged multi-layered system of processing and storing data from super-hot to super-cold on the “Govorun” supercomputer

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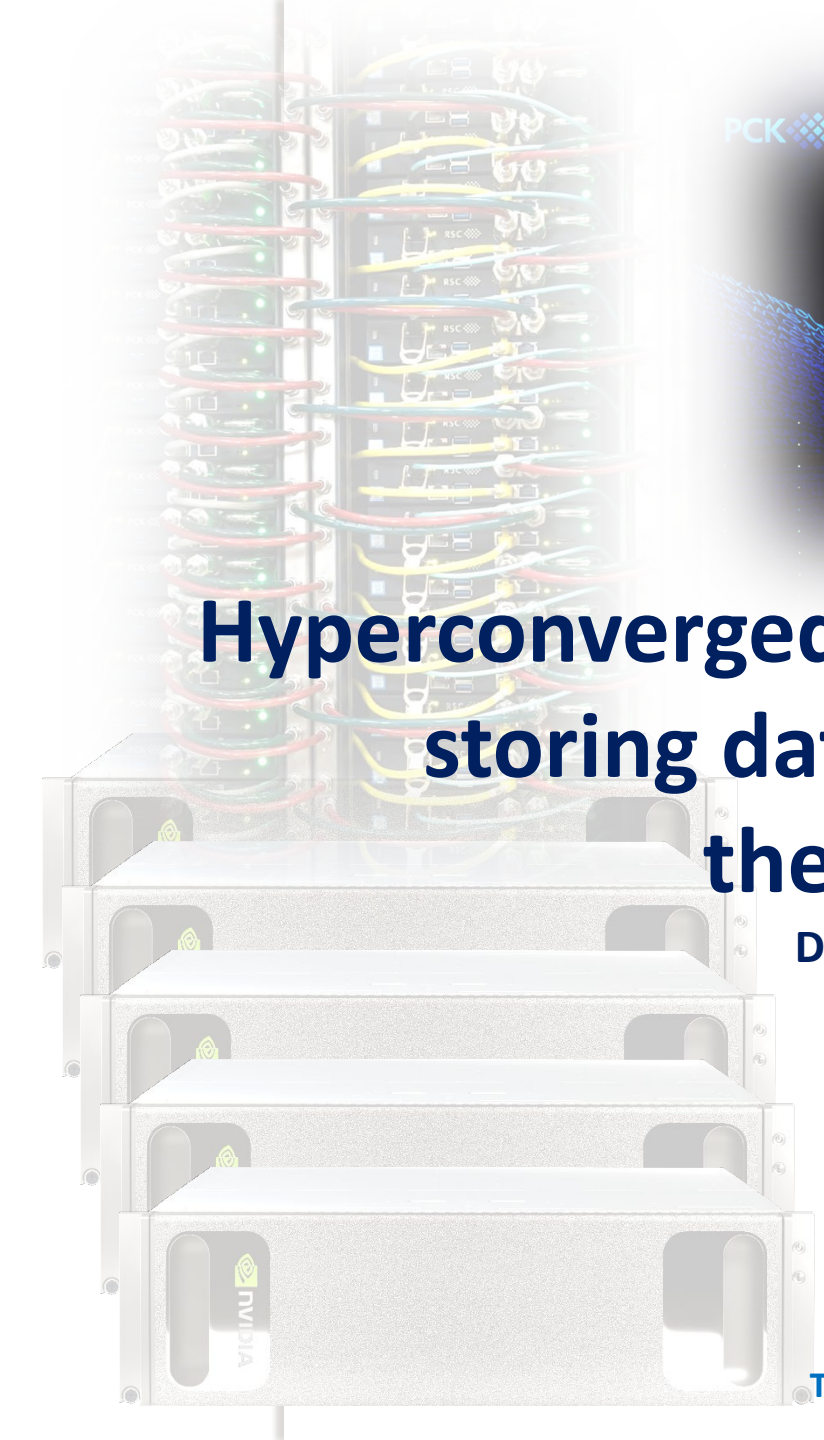
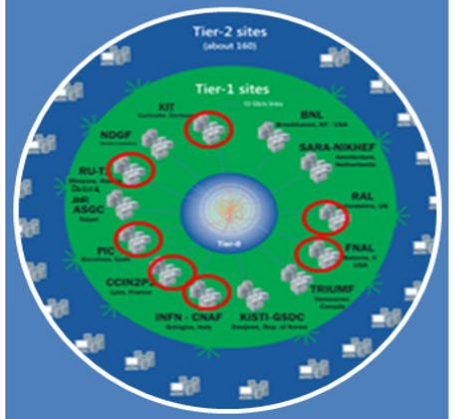
Joint Institute for Nuclear Research



MICC component: Heterogeneous platform HybriLIT



Grid-Tier1:
10688 cores
10.85 PB disk
11.5+40 PB tape

Grid-Tier2 CICC:
4728 cores
2.7 PB disk

Cloud:
1872 CPU
8.142 TB RAM
1.3 PB disk

HybriLIT:
860 FLOPS DP
300 Gb/s Data IO rate

https://micc.jinr.ru

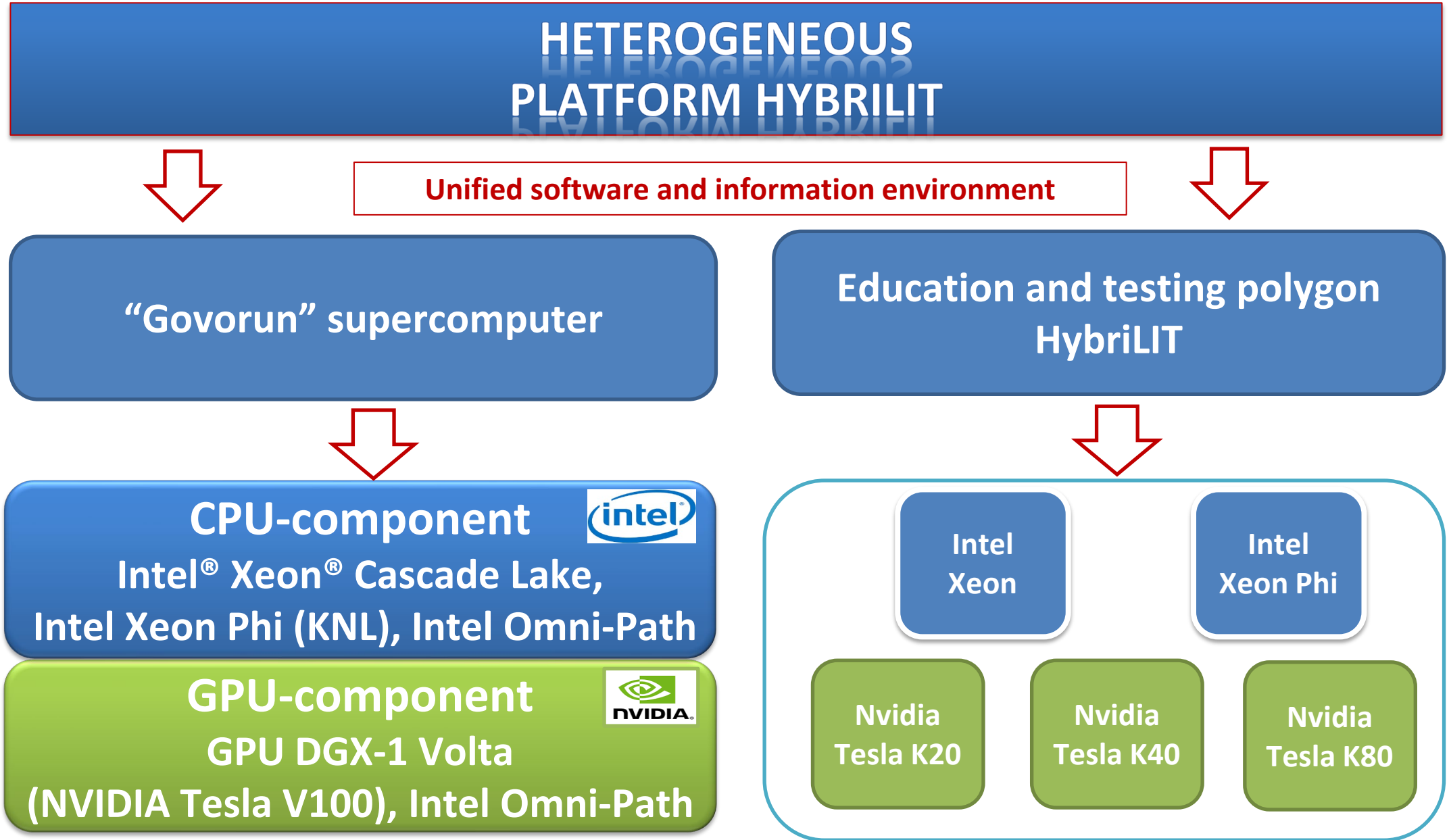
NICA off-line cluster and storage system

DATALAKE 4740TB

Network infrastructure: LAN: 100 Gbps WAN: 2x100 Gbps

Engineering infrastructure

MICC component: Heterogeneous platform HybriLIT



“Govorun” supercomputer

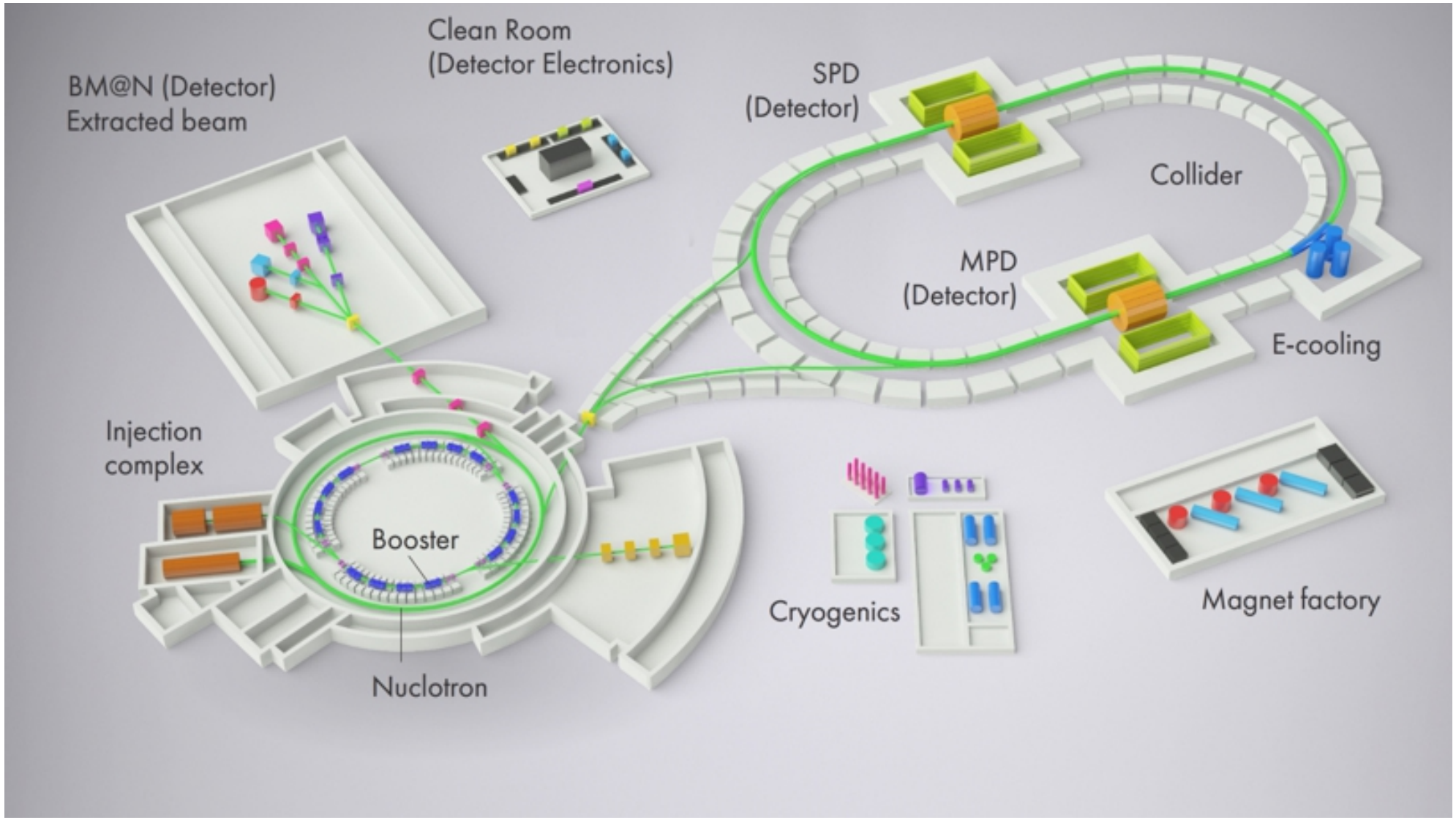
GPU-component
based on NVIDIA DGX-1 Volta.

CPU-component
based on the newest Intel architectures:
Intel Xeon Phi gen.2 and
Intel CascadeLake processors

The “Govorun” supercomputer is a hyper-converged software-defined system and has unique properties in terms of flexibility of customization for the users’ task, ensuring the most efficient use of the computational resources of the supercomputer, depending on the type of tasks being solved.
The “Govorun” supercomputer takes **11 (CPU-component)** and **21 (GPU-component)** places in the current edition of the **TOP50** list, as well as **17th** in the current edition of the **IO500** list (July 2020) and is the first in terms of data processing speed among Russian supercomputers.

Total peak performance:
1.7 PFLOPS SP
860 TFLOPS DP
300 Gb/s Data IO rate

Nuclotron based Ion Collider fAcility

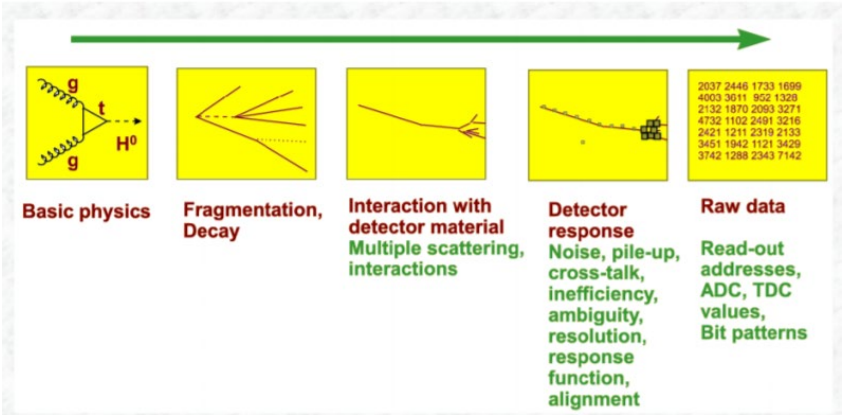


Three experiments:

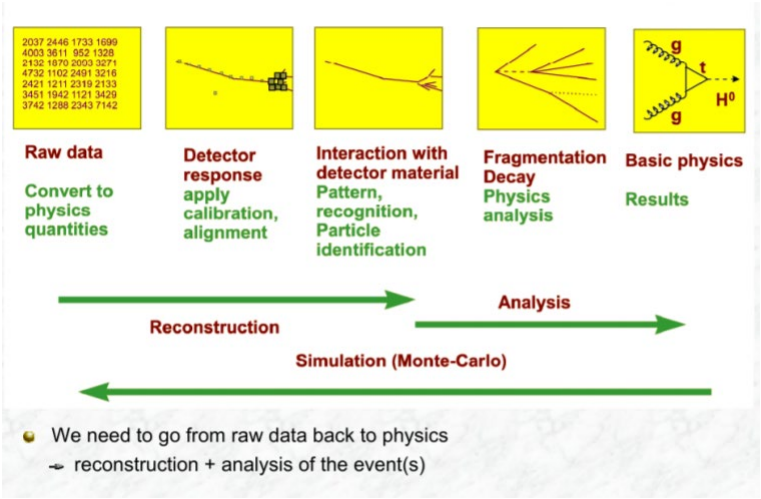
- **BM@N**
- **MPD**
- **SPD**

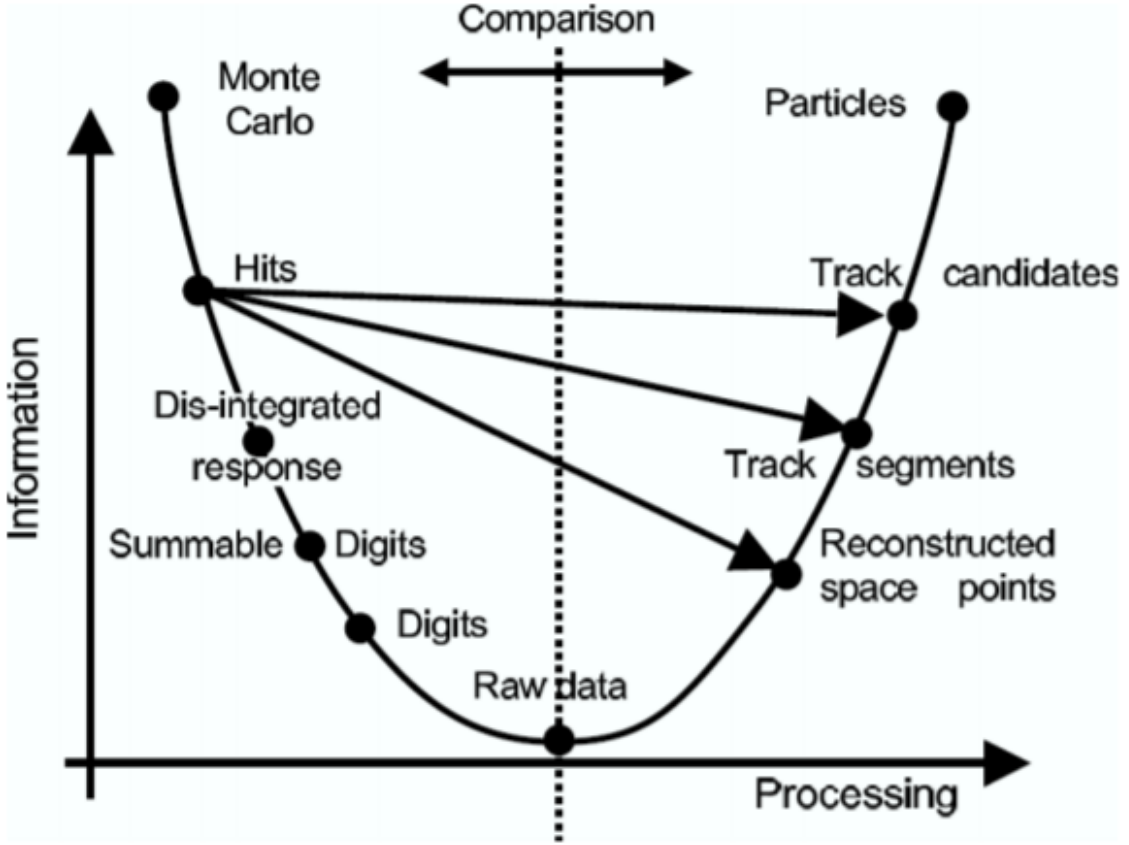
HEP experiments data flow

From Physics to raw data



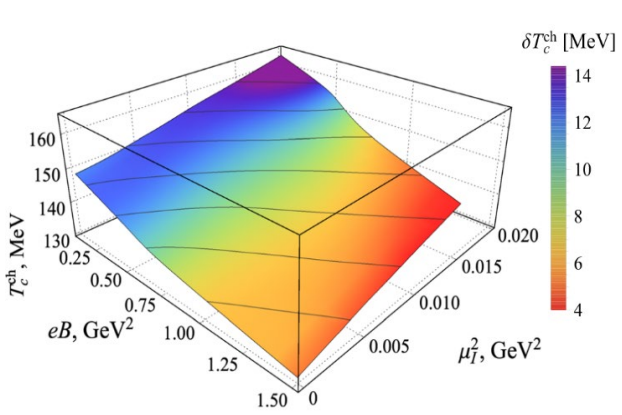
From raw data to Physics

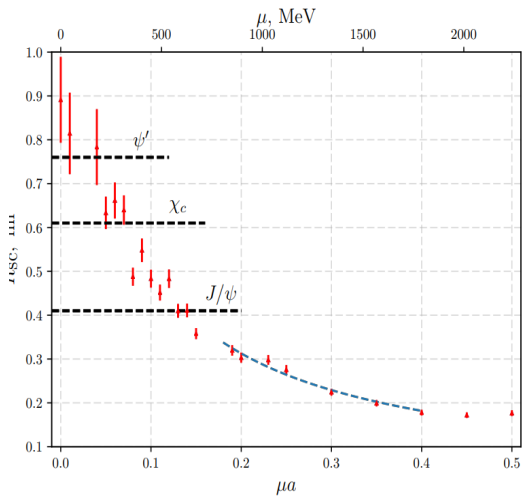


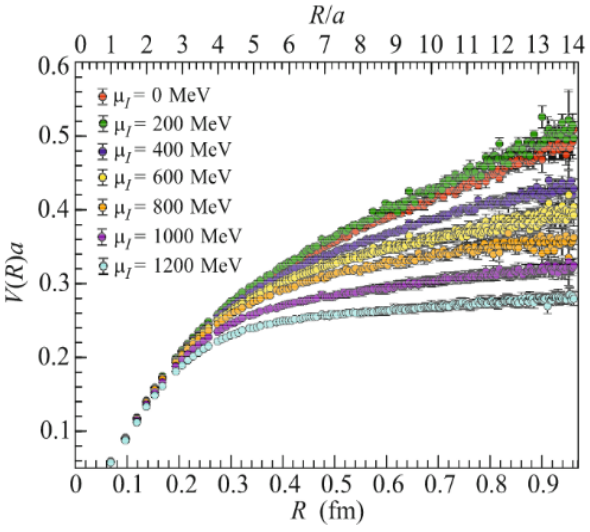


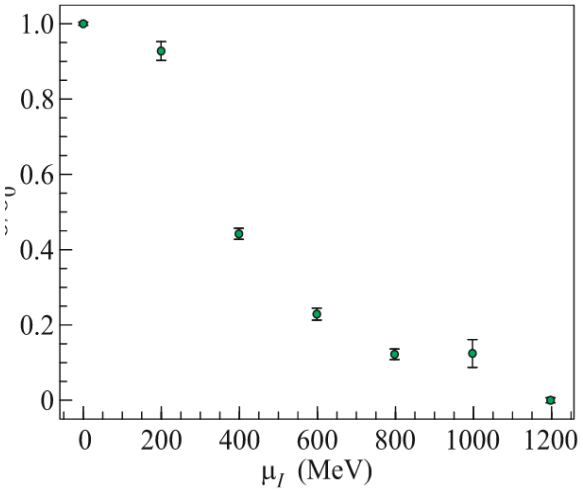
Slide courtesy of O.V. Rogachevsky, VBLHEP JINR

“Govorun” supercomputer for QCD tasks









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

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

1. V.V. Braguta, M.N. Chernodub, A.Yu. Kotov, A.V. Molochkov, 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 (Письма ЖЭТФ, 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, A.M. Trunin, Phys.Rev. B100 (2019), 085117, DOI: 10.1103/PhysRevB.100.085117 , e-Print: arXiv:1904.07003

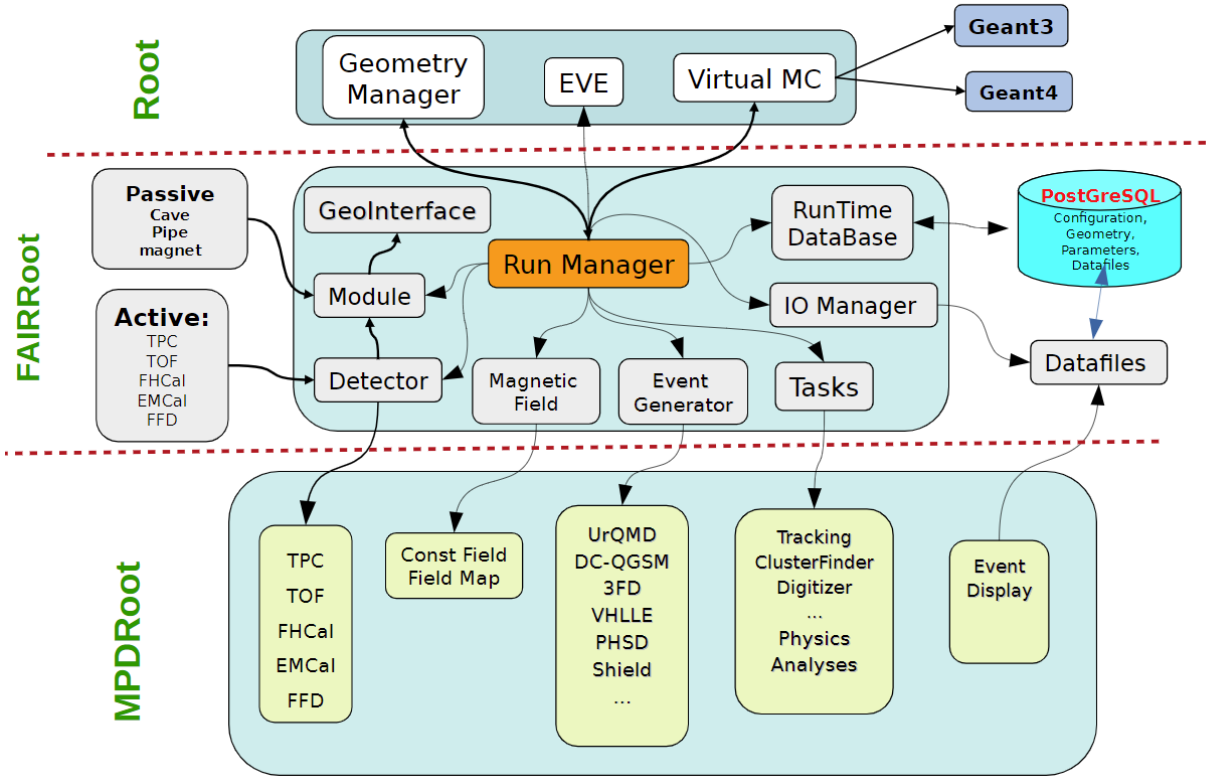
5. N.Yu. Astrakhantsev, V.G. Bornyakov, V.V. Braguta, E.-M. Ilgenfritz, A.Yu. Kotov, A.A. Nikolaev, A. Rothkopf, JHEP 1905 (2019) 171, DOI: 10.1007/JHEP05(2019)171,e-Print: arXiv:1808.06466

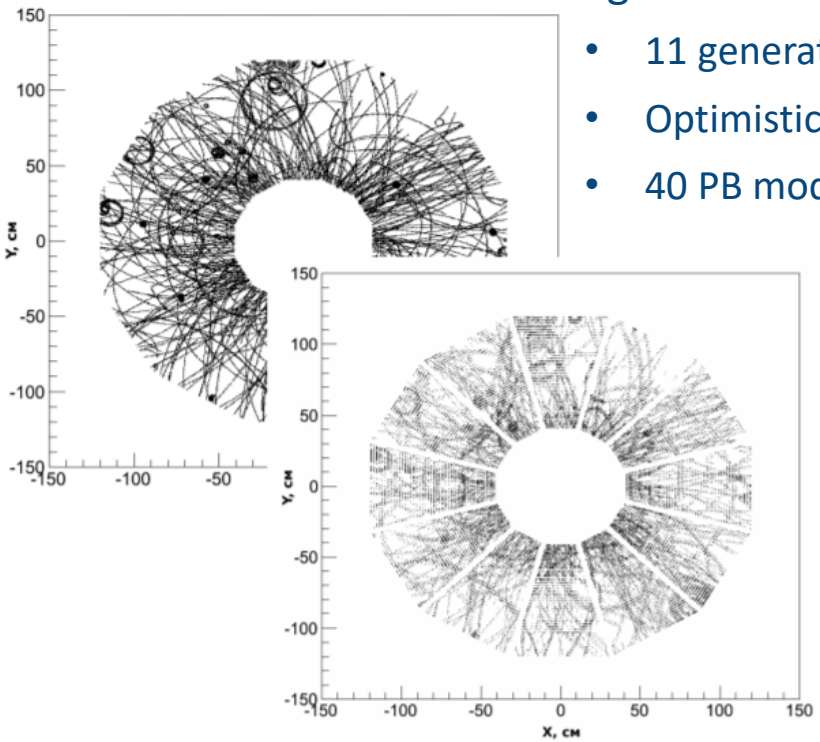
6. https://arxiv.org/abs/1902.09325

7. http://arxiv.org/abs/1910.08516

MPD NICA software

MpdRoot structure

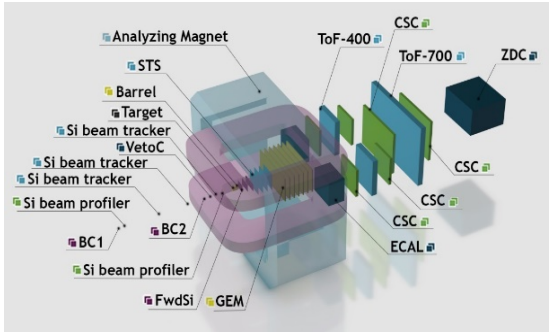




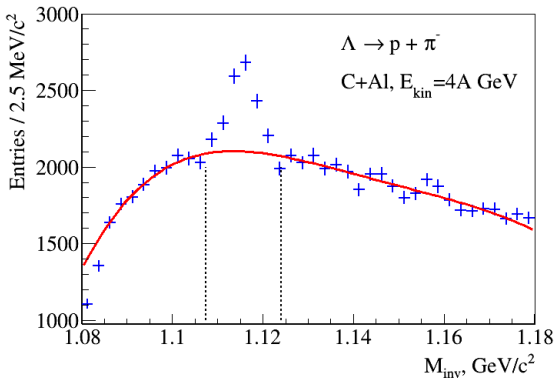
- Target is ~300 mln. events/generator
  - 11 generators
  - Optimistically 1 mln. jobs
  - 40 PB model data only

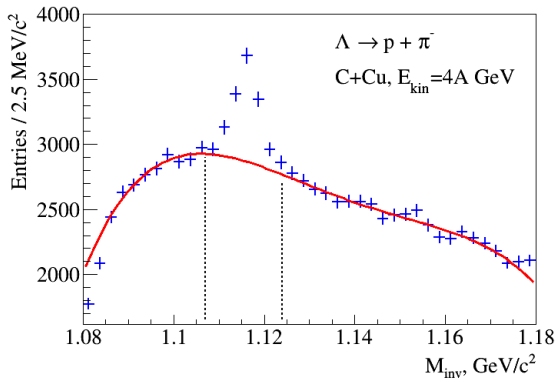
Slide courtesy of
O.V. Rogachevsky,
VBLHEP JINR

Computing for the NICA megasience project “Govorun” supercomputer for BM@N experiment



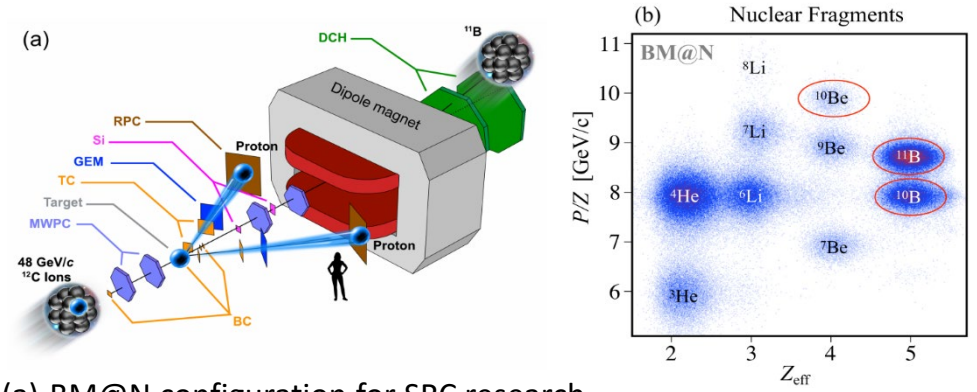
Full BM@N configuration for heavy ion research in 2018





Signals Λ of 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 2 carbon-nucleus interactions at the Nuclotron // The European Physical Journal A (готовится к публикации)

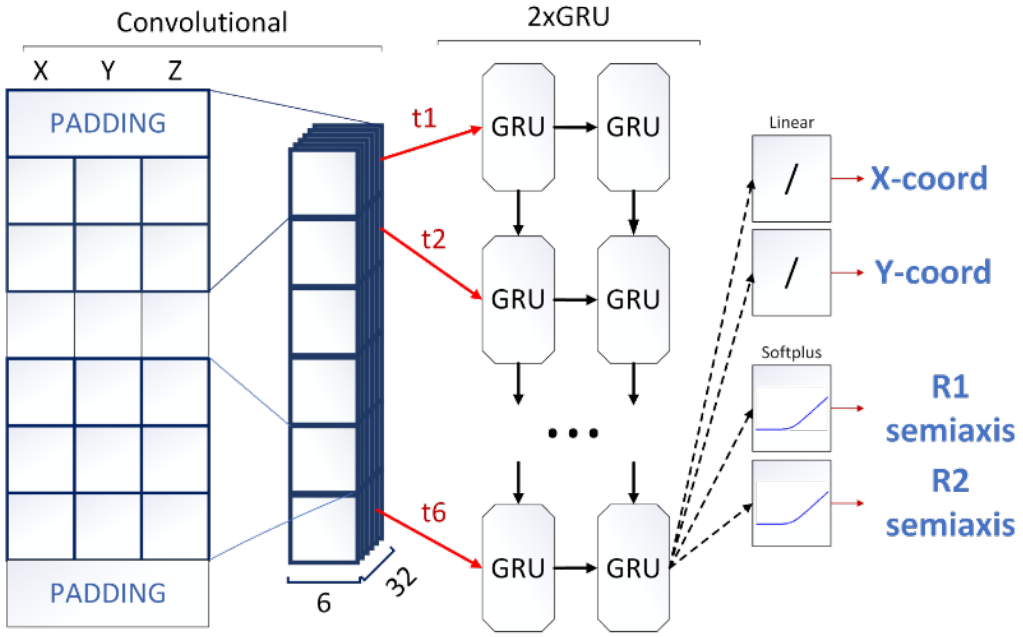


(a) BM@N configuration for SRC research.
(b) isolation of nuclear fragments in an experiment using the SRC program.

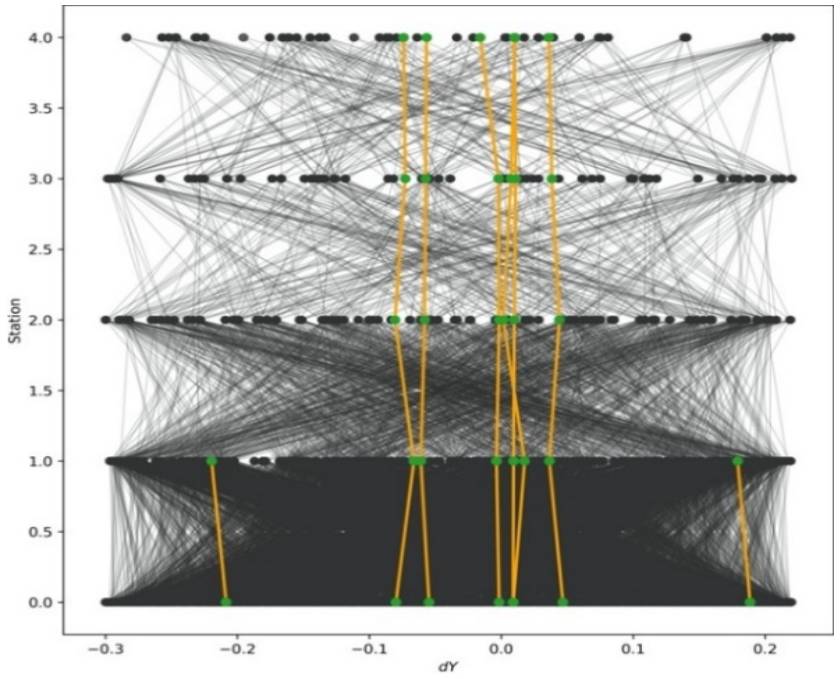
- The analysis of the experimental data collected in the Nuclotron sessions in 2016-2018 is carried out. Special attention is paid to the study of interactions between beams of carbon and argon ions with fixed targets of various types. The particle tracks were reconstructed using the "cellular automata" method.
- The simulation of the experiment was carried out using generators of physical models, such as DCM-QGSM and UrQMD, and the embedding procedure was performed.
- Collaborators BM@N from Russia, USA, Israel, Germany, France and JINR, working on the program for studying short range correlation (SRC) in nuclei, have developed and applied a new experimental method for studying the internal structure of the atomic nucleus in carbon-hydrogen interactions. **Based on the results of the SRC program of the BM@N experiment, publication was sent to the 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 megasience project
ML/DL for particle track reconstruction tasks

Global recognition of tracks among the noises is carried out immediately over the entire picture of the event. The GraphNet program is based on the use of graph neural networks for tracking. An event is represented as a graph with samples as nodes, and then this graph is inverted into a linear graph, when the edges are represented by nodes and the nodes of the original graph are represented by edges. In this case, information about the curvature of track segments is embedded in the edges of the graph, which simplifies the recognition of tracks in the sea of fakes and noises.



TrackNETv2 neural network diagram

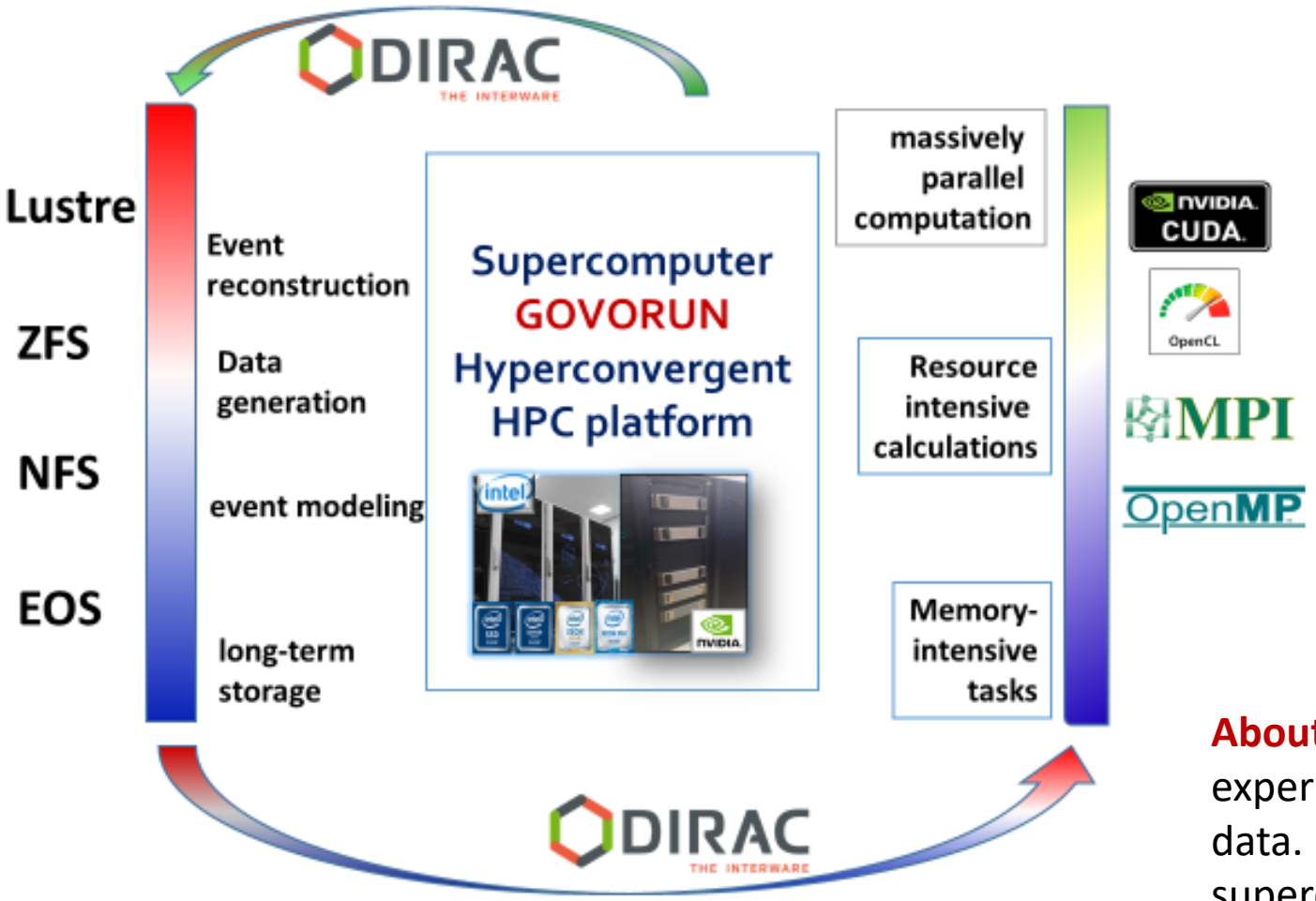


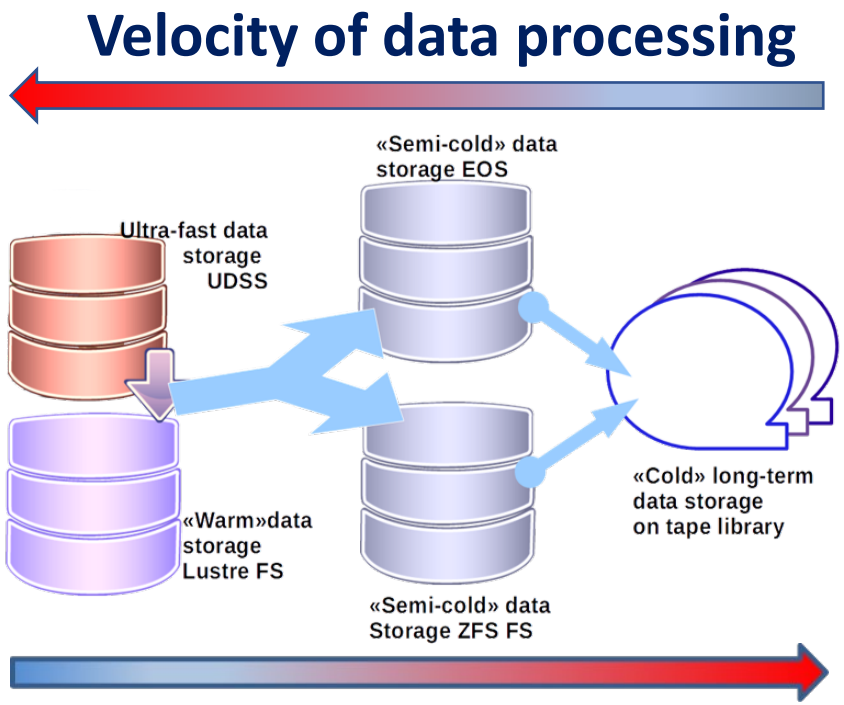
Graphical representation of C+C 4 GeV events of the BM@N experiment.
Black nodes and edges correspond to fakes, green nodes and yellow edges correspond to found tracks.

The results of the test run on "Govorun" supercomputer allow to roughly estimate the processing speed of one event of a future HL-LHC or NICA detector with 10,000 tracks at a level of 3 μs.

P. Goncharov, G. Ososkov, D. Baranov, https://doi.org/10.1063/1.5130102,
P. Goncharov, E. Shchavelev, G. Ososkov, D. Baranov, http://ceur-ws.org/Vol-2507/280-284-paper-50.pdf

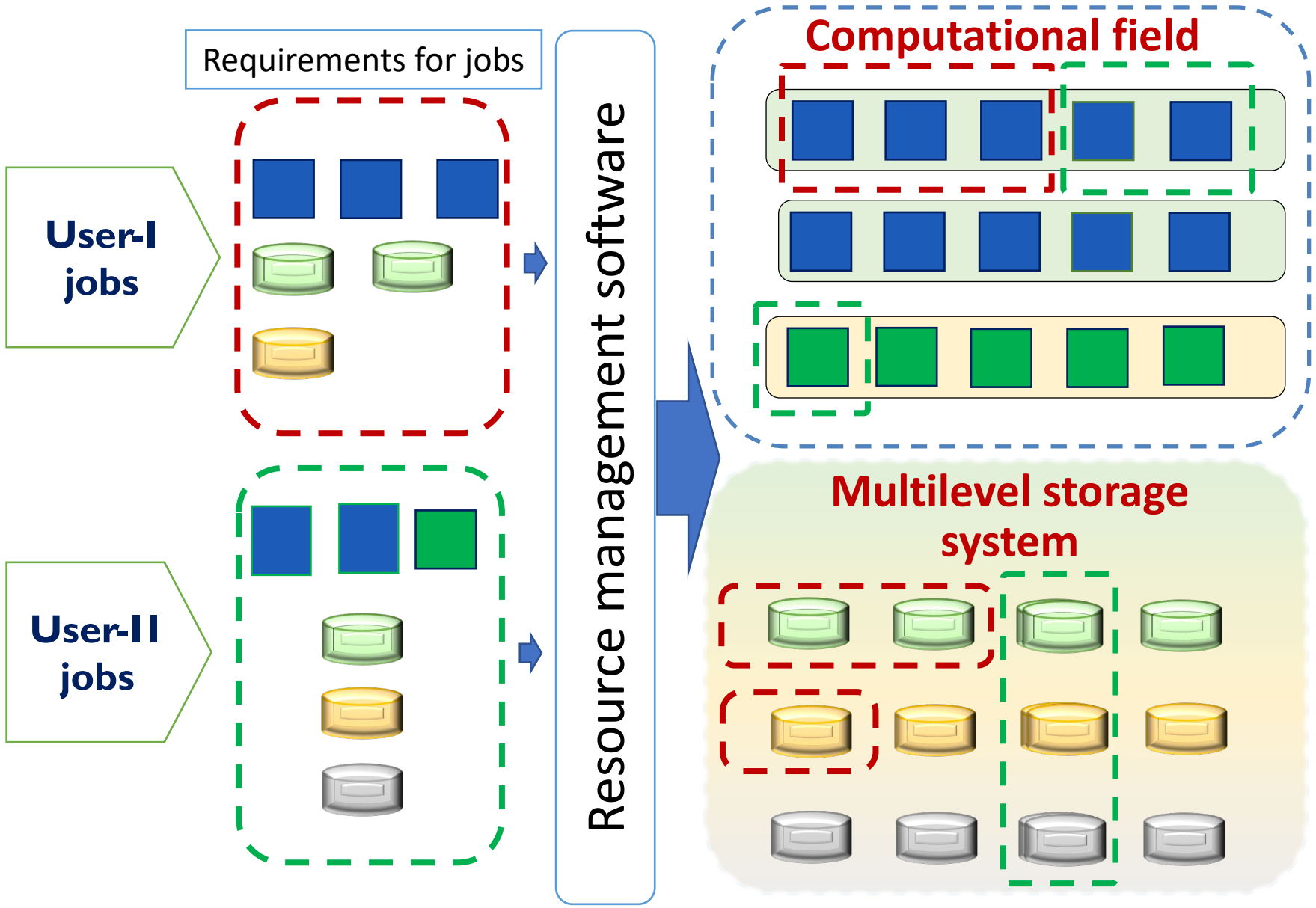
Technologies for storing, processing and analyzing experimental data in the NICA megasience project





About 2 million events were generated for the MPD experiment using the hierarchical structure of working with data. The acceleration of calculations on the upgraded supercomputer in comparison with the previous configuration was **1.45 times**.

Orchestration and hyperconvergence on the “Govorun” supercomputer

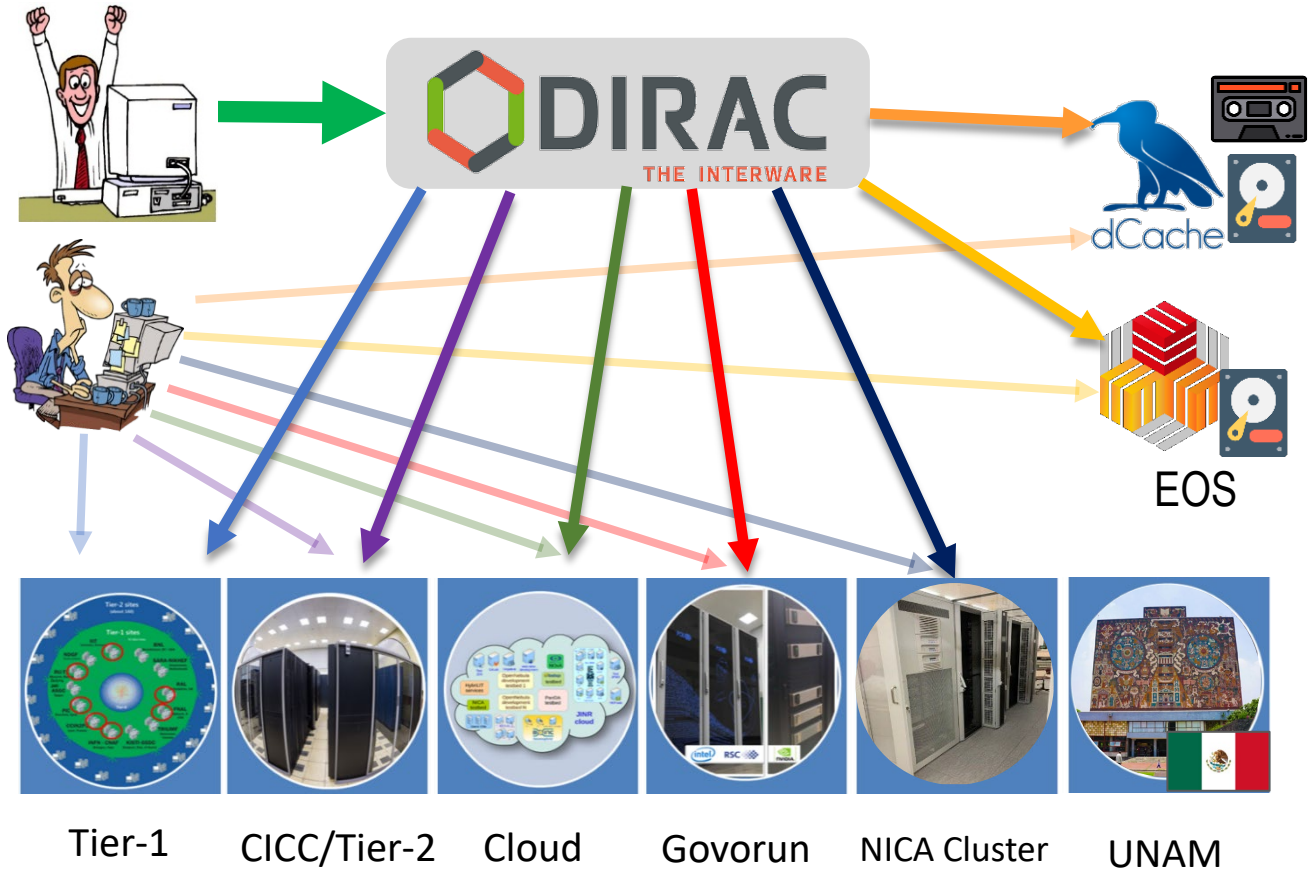


The “Govorun” supercomputer is a hyper-converged software-defined system and has unique properties in terms of flexibility in customization to the users’ task.

The user can allocate the required number, type of computing nodes and the required volume and type of data storage systems for his task.

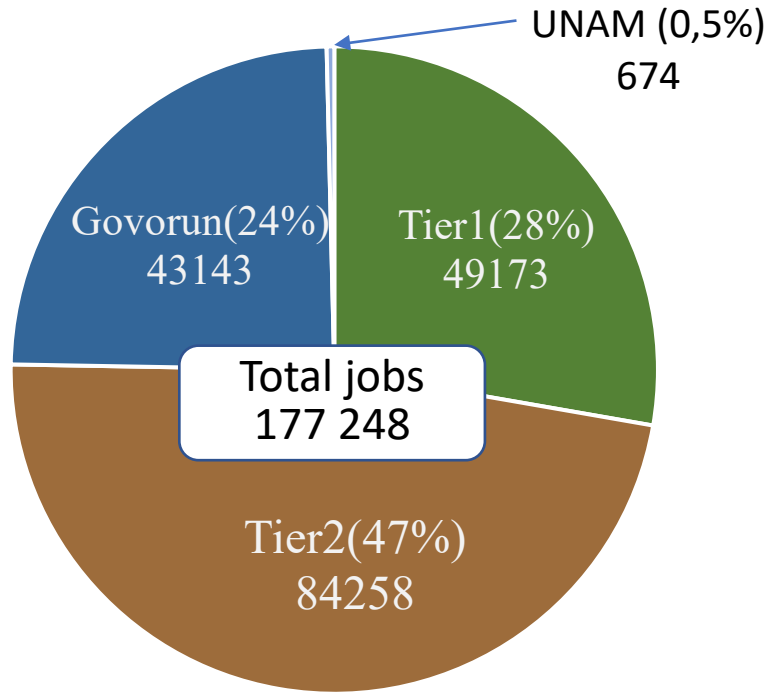
This property makes it possible to effectively solve problems of different types, which makes the “Govorun” supercomputer a unique tool for research carried out at JINR.

JINR computing resources integration for the MPD experiment



The computing resources of the JINR Multifunctional Information and Computing Complex were combined using the DIRAC Interware: Tier1/Tier2, Member States cloud resources, “Govorun” supercomputer, NICA Cluster.

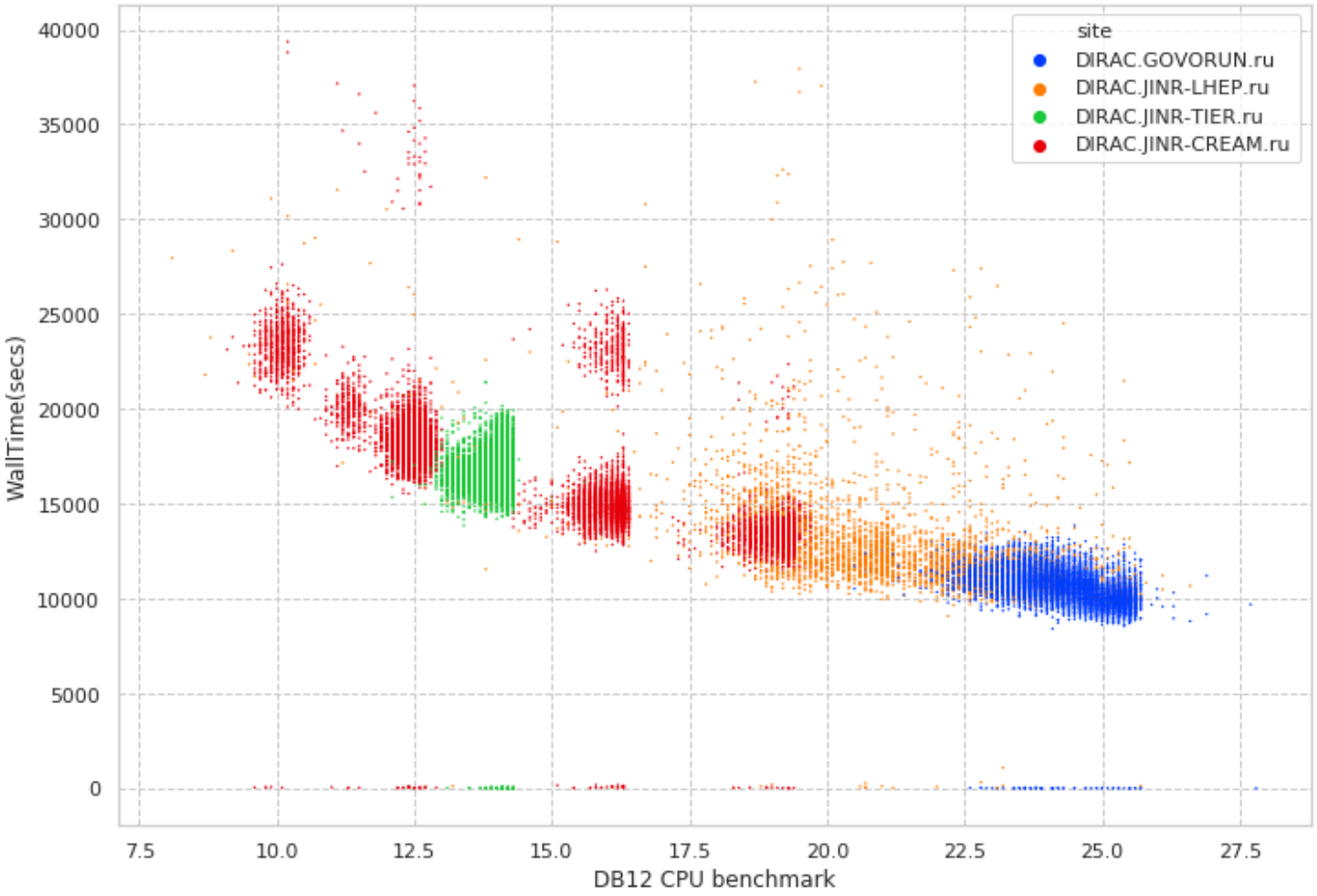
More than **175,000 jobs** were performed on the Tier1/Tier2 components and the “Govorun” supercomputer using the DIRAC platform in the framework of Monte-Carlo data simulation for the MPD experiment. A new UNAM cluster has been added recently.



Distribution of simulation jobs by the computing resources via DIRAC

Computing for the NICA megasience project “Govorun” supercomputer for MPD experiment

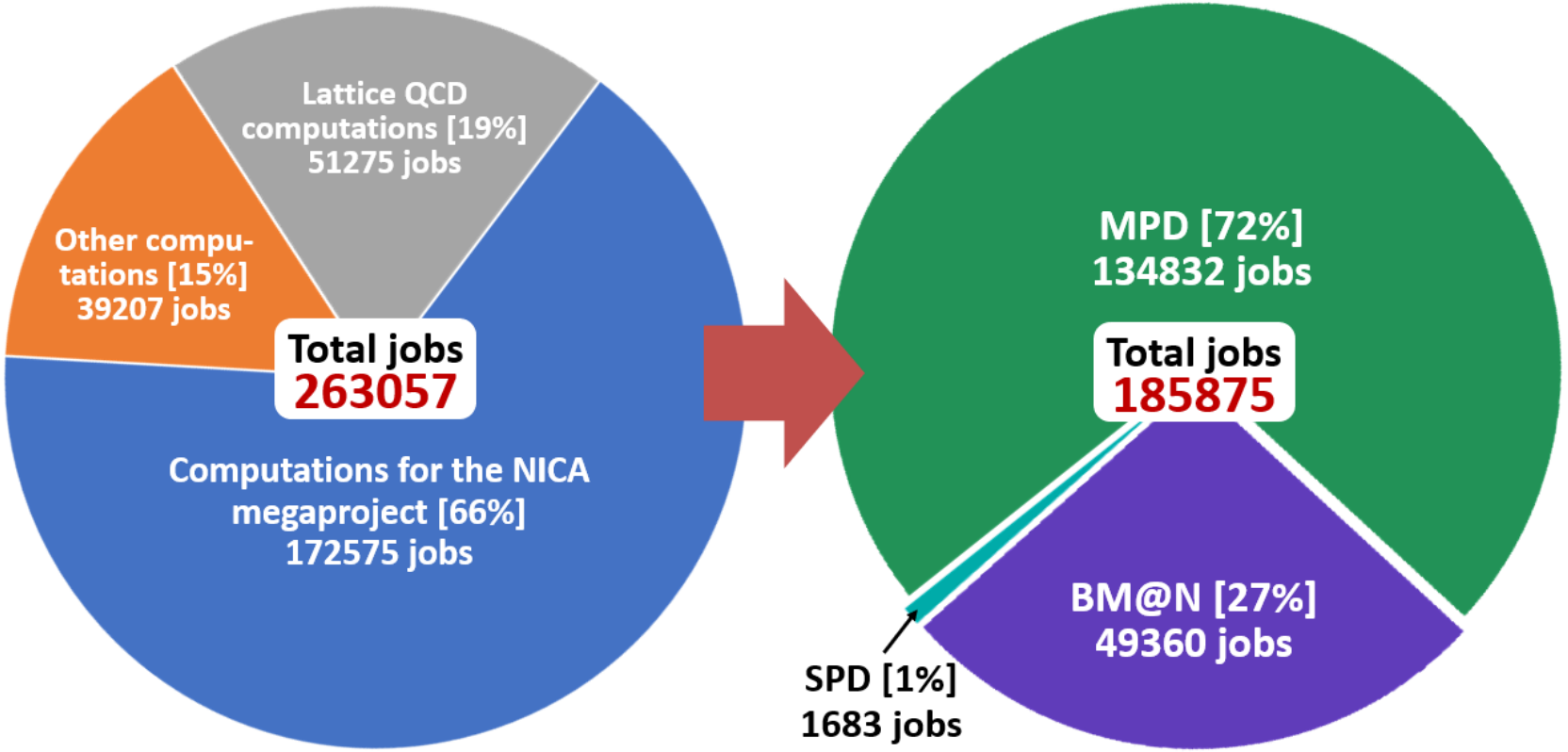
The practice of using various computing resources of JINR and other institutes of the MPD collaboration has shown that at the moment **the most effective is the use of computing resources on the “Govorun” supercomputer.**



The use of only 270 computational cores (such a limited resource is associated with insufficient resources and high load of the supercomputer) provides data processing equivalent to the use of 450-500 cores on other available computing resources, such as Tier-1, 2 and the NICA computing cluster. On the computing resources of JINR and the National Autonomous University of Mexico, the MPD collaboration for 2020 simulated and processed over **50 million events**, a quarter of which were carried out directly at the “Govorun”.

The unique composition of the “Govorun” supercomputer equipment, which includes a super-fast data access system and computing nodes with a large amount of RAM (3 TB per node), made it possible to process the same number of events on almost half the number of computing cores as on other available computing resources.

“Govorun” supercomputer for NICA

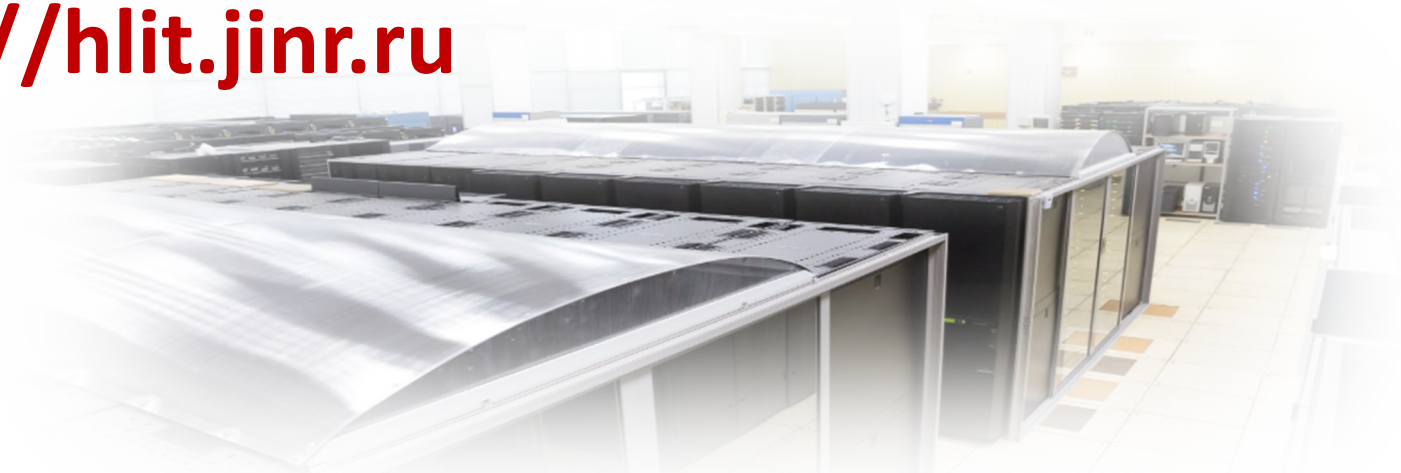


The “Govorun” supercomputer, which is a hyper-converged software-defined system, has unique properties in terms of flexibility in customization to the user's task, which allows efficiently solving various types of problems, which **makes the “Govorun” supercomputer a unique tool for computing the NICA megascience project**.

Thank you for your attention!

HETEROGENEOUS PLATFORM HYBRILIT IN LIT JINR:

http://hlit.jinr.ru



The studies in this direction were supported by the RFBR special grant (“Megascience – NICA”), № 18-02-40101.