

**DUBNA**

# DIRAC Interware as a service for high-throughput computing in JINR

Igor Pelevanyuk<sup>1,3</sup>, Andrei Tsaregorodtsev<sup>2,3</sup>

*<sup>1</sup>Joint Institute for Nuclear Research, Dubna, Russia*

*<sup>2</sup>CPPM, Aix-Marseille University, CNRS/IN2P3, Marseille, France*

*<sup>3</sup>Plekhanov Russian University of Economics, Moscow, Russia*

# Throughput vs Performance

High Performance - Sharing the workload of **interdependent** processes over multiple cores

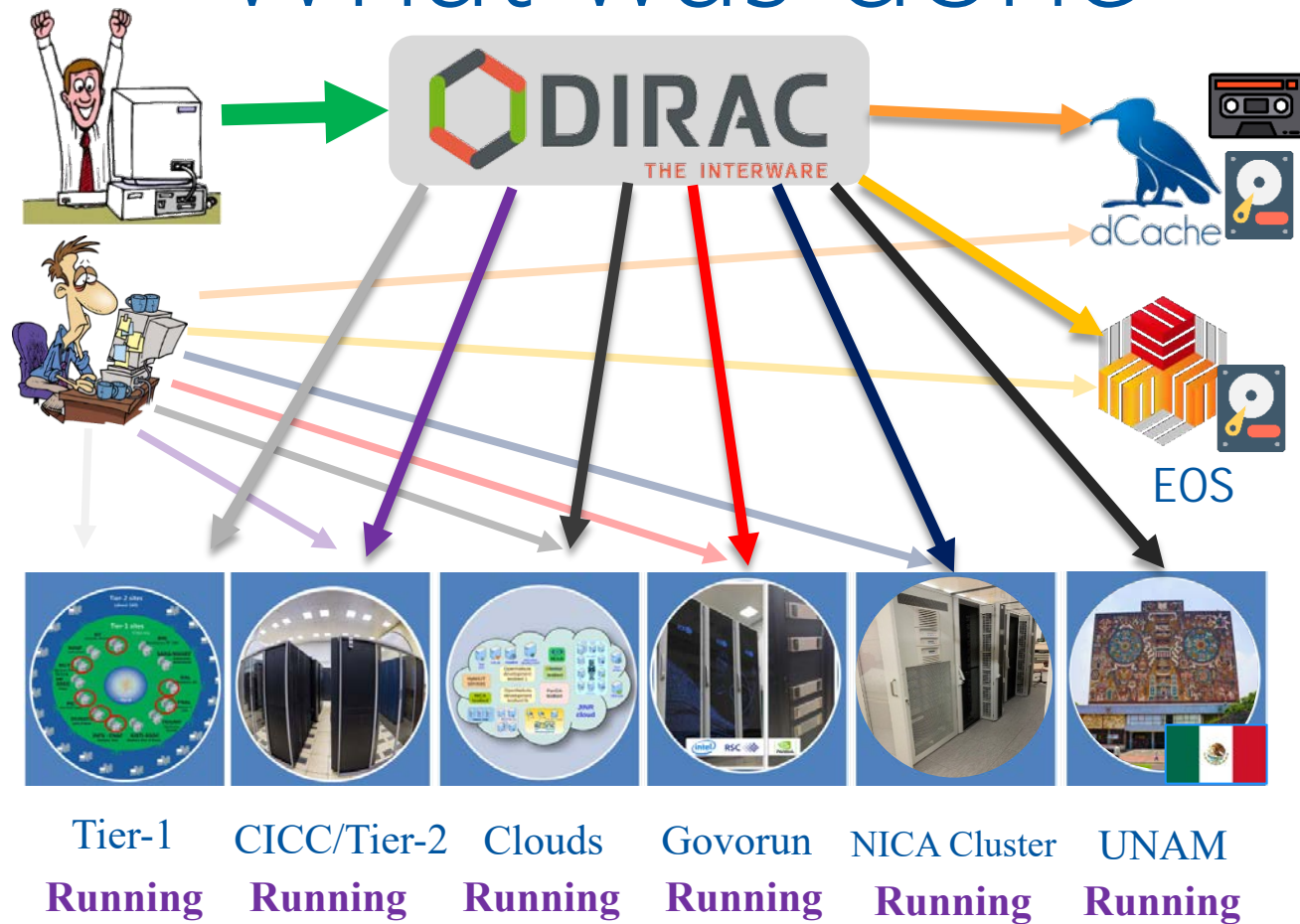
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Focus of this talk

High Throughput - Many **independent** processes that can run in 1 or few cores on the same computer

Example of jobs: Monte-Carlo generation, Data reconstruction

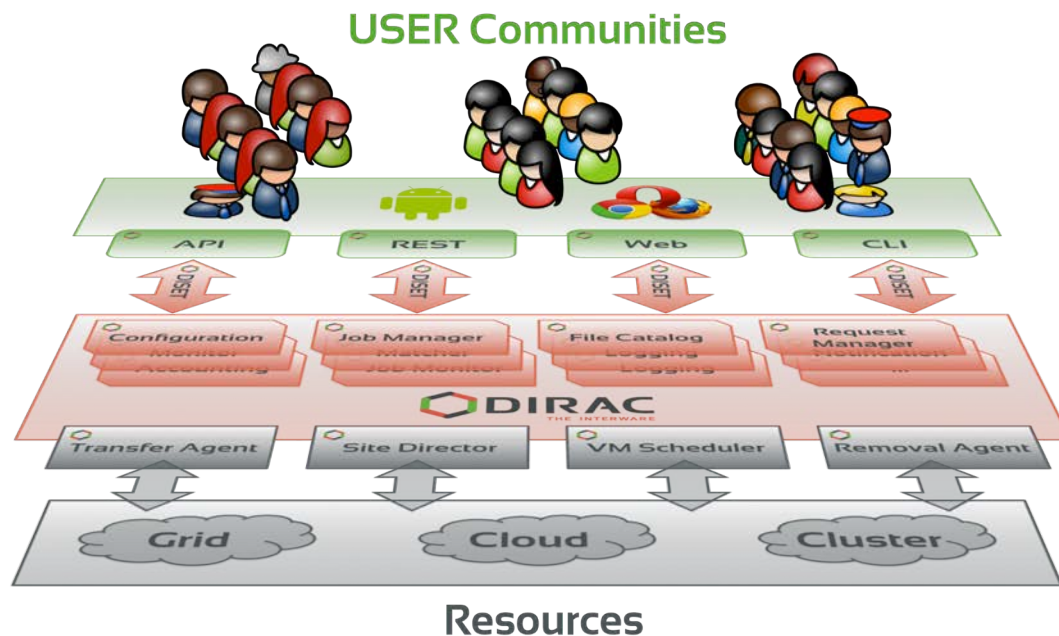
# What was done



The computing resources of the JINR Multifunctional Information and Computing Complex, clouds in JINR Member-States, cluster from Mexico University were combined using the DIRAC Interware.

# What is DIRAC?

DIRAC is a framework that provides all the necessary components to build ad-hoc grid infrastructures **interconnecting** computing resources of different types, allowing **interoperability** and simplifying **interfaces**. This allows to speak about the DIRAC *interware*.



Web

CLI

API

REST

# Why it is complex

Storage



**dCache**  
Disk, Tape



ceph

l.u.s.t.r.e.

Protocol

local, root

GridFTP, root

local

local

Auth Storage

Kerb. , x509

x509

ceph key

*HybriLIT*

Auth Jobs

Kerb. x509

x509

SSO

*HybriLIT*

Job Submit.

Slurm Grid

Grid

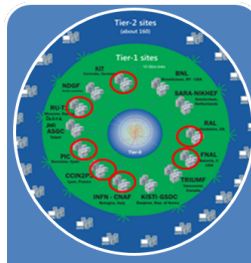
OpenNebula

Slurm

Component



**Tier-2/CICC**



**Tier-1**



**Cloud**



**Govoron/HybriLIT**

# Why DIRAC?

## 1. Single system for all aspects of computing



User Interface

API

Central configuration

Workload management

Data management

Integration tools

File Catalog

Workflow management

Metadata management

Accounting

Management

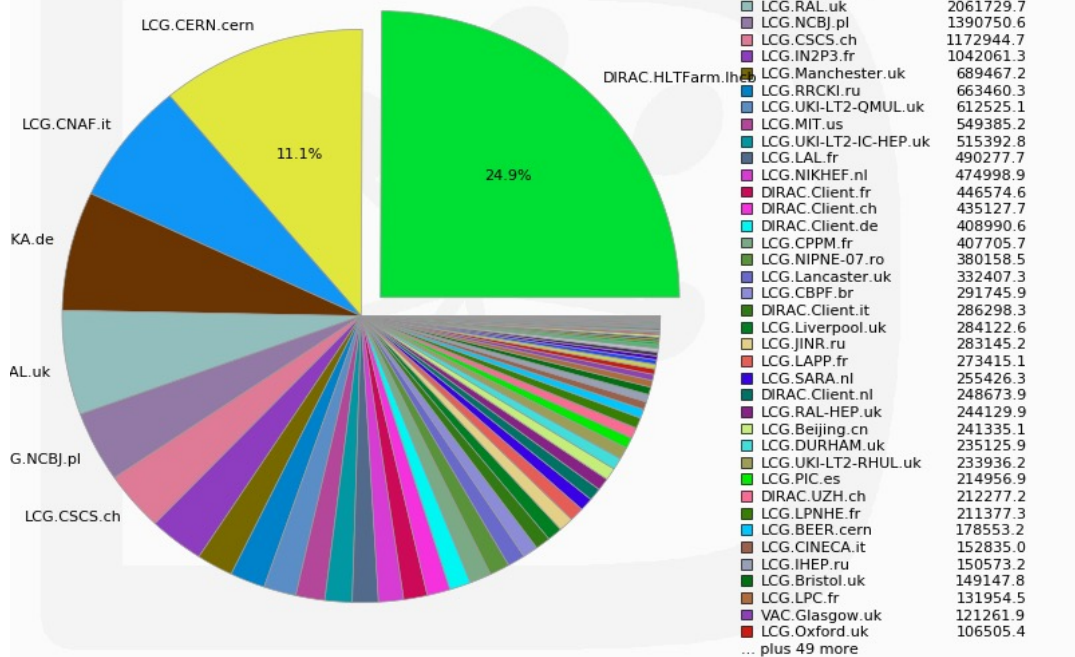


# Why DIRAC?

## 2. Good performance

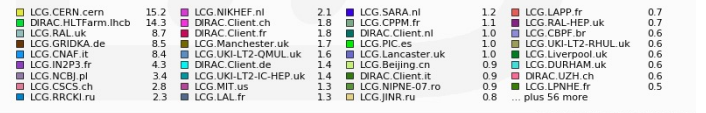
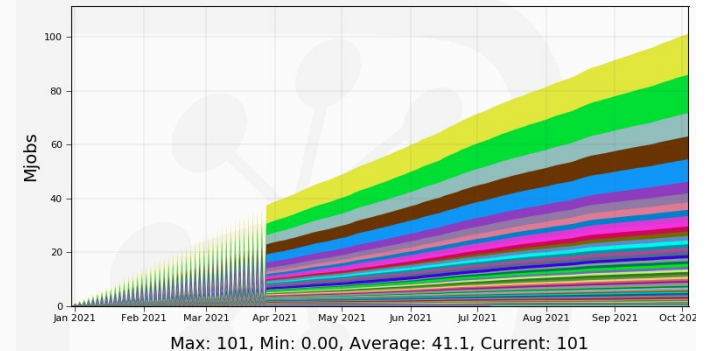
Wall time days used by Site

39 Weeks from Week 00 of 2021 to Week 40 of 2021

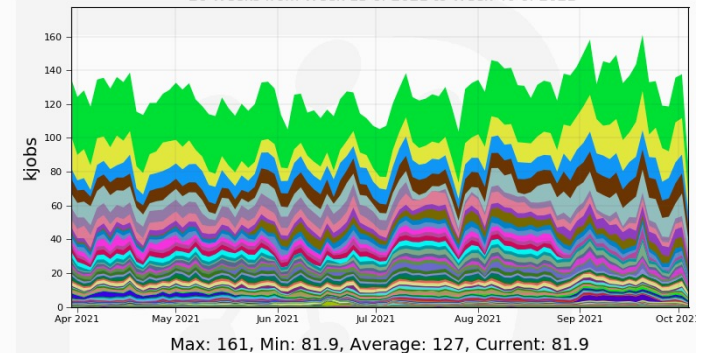


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Cumulative Jobs by Site  
39 Weeks from Week 52 of 2020 to Week 40 of 2021



Running jobs by Site  
26 Weeks from Week 13 of 2021 to Week 40 of 2021

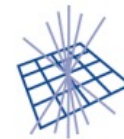


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# Why DIRAC?

## 3. Active users and developers community



GridPP  
UK Computing for Particle Physics

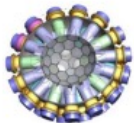
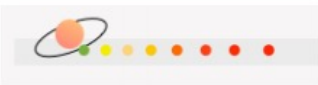


- ▶ Dedicated installations
  - ▶ LHCb, Belle II, CTA
- ▶ Multi-community services
  - ▶ ILC, CALICE
  - ▶ IHEP: BES III, Juno, CEPC
  - ▶ FG-DIRAC
  - ▶ GridPP
  - ▶ DIRAC4EGI
  - ▶ PNNL

▶ DIRAC@JINR

▶ DIRAC@CNAF

- ▶ Several DIRAC evaluations are ongoing
  - ▶ Auger, ELI, NICA, Virgo, LSST, ...



# History of DIRAC at JINR

2013 – Development of monitoring system for BES-III installation. First tries to setup and configure DIRAC infrastructure.

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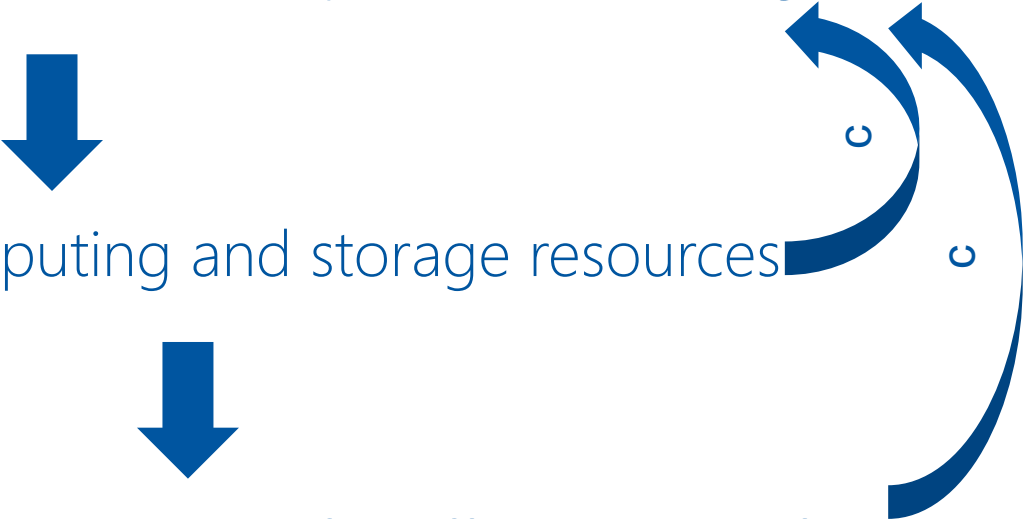
2017 – DIRAC Interware installed; basic configuration done. Used for educational purposes. **dCache** storage integrated, **Tier2** integrated.

2018 – **HybriLIT** integrated. **JINR cloud** integrated using OCCI protocol. Tests of full cycle of Monte-Carlo for **BM@N** were performed.

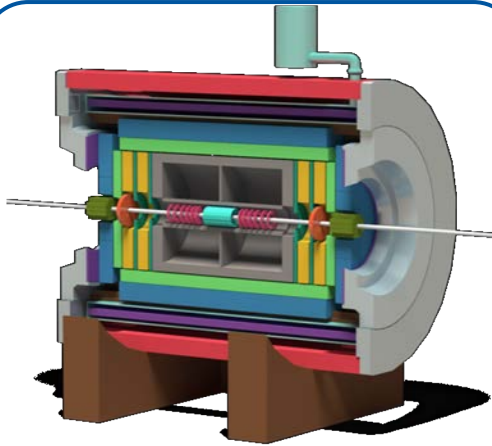
2019 – **Clouds** of JINR Member-States integrated by module developed in JINR. **MPD** starts using DIRAC for massive Monte-Carlo production. **Tier1**, **Govoron** and **EOS** integrated in DIRAC.

2020 – **Folding@Home** jobs submitted to clouds via DIRAC. **Baikal-GVD** jobs submitted to JINR and PRUE clouds.

# Steps

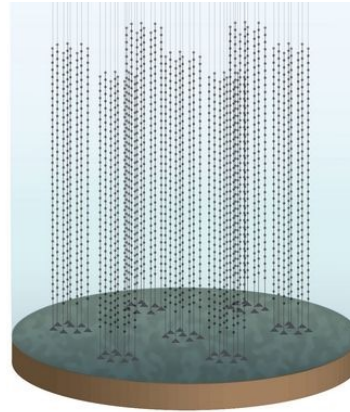
1. DIRAC setup, configuration, development and tuning
  2. Integration of computing and storage resources
  3. Elaboration of approaches for effective use of resources
- 
- ```
graph TD; A[1. DIRAC setup, configuration, development and tuning] --> B[2. Integration of computing and storage resources]; B --> C[3. Elaboration of approaches for effective use of resources]; C --> B; B --> A;
```

# What do we use DIRAC for?



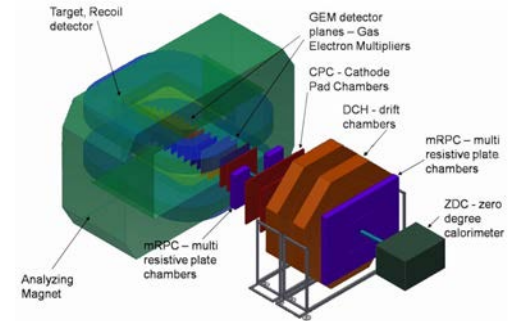
MPD@NICA

Monte-Carlo – Real  
Analysis – Maybe



Baikal-GVD

Monte-Carlo – Real



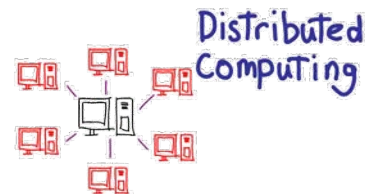
BM@N

Monte-Carlo – Real  
Reconstruction – Tests



**FOLDING  
@HOME**

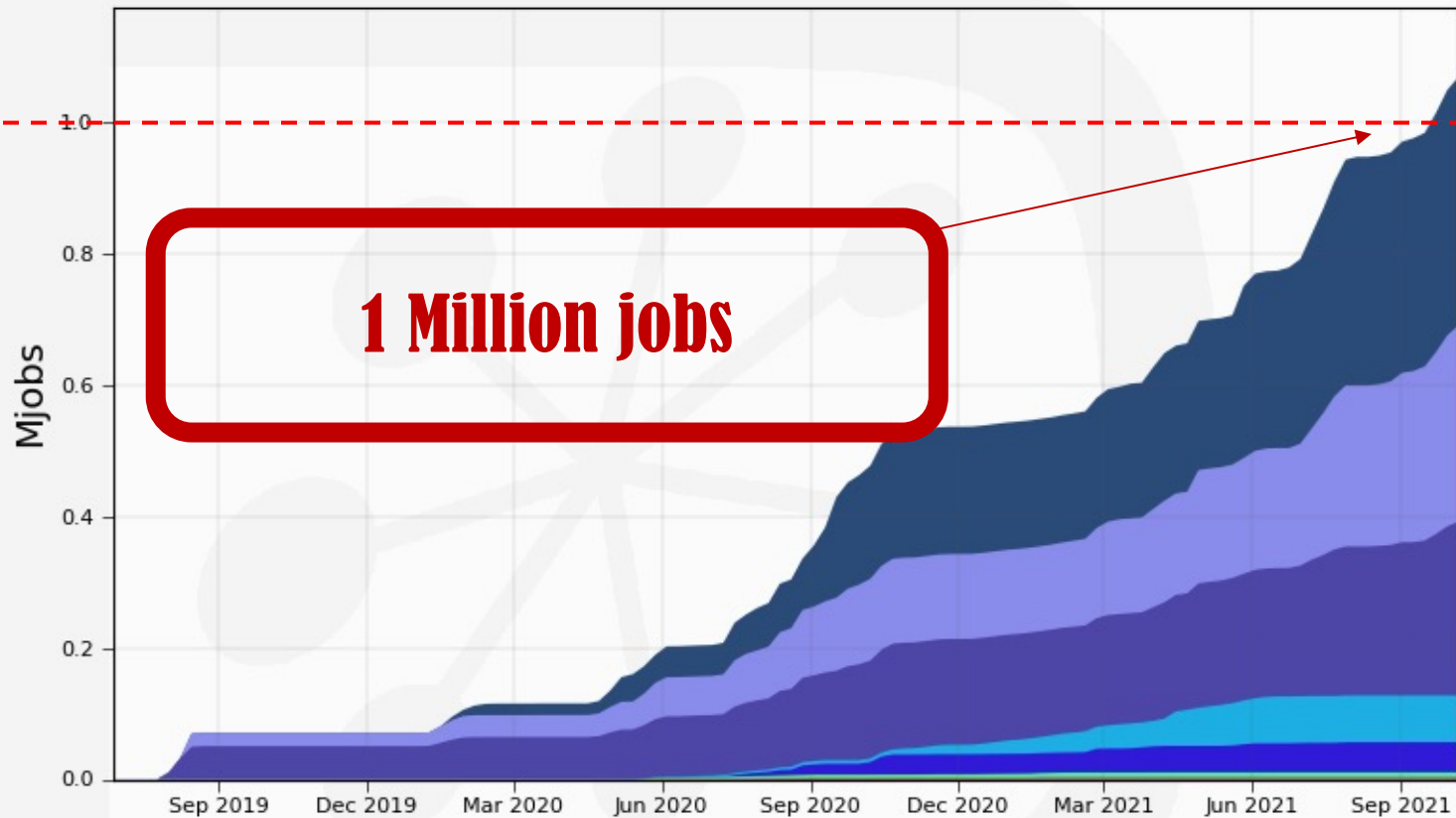
Folding@HOME



Teaching

# Statistics: jobs done

Cumulative Jobs by Site  
119 Weeks from Week 25 of 2019 to Week 40 of 2021

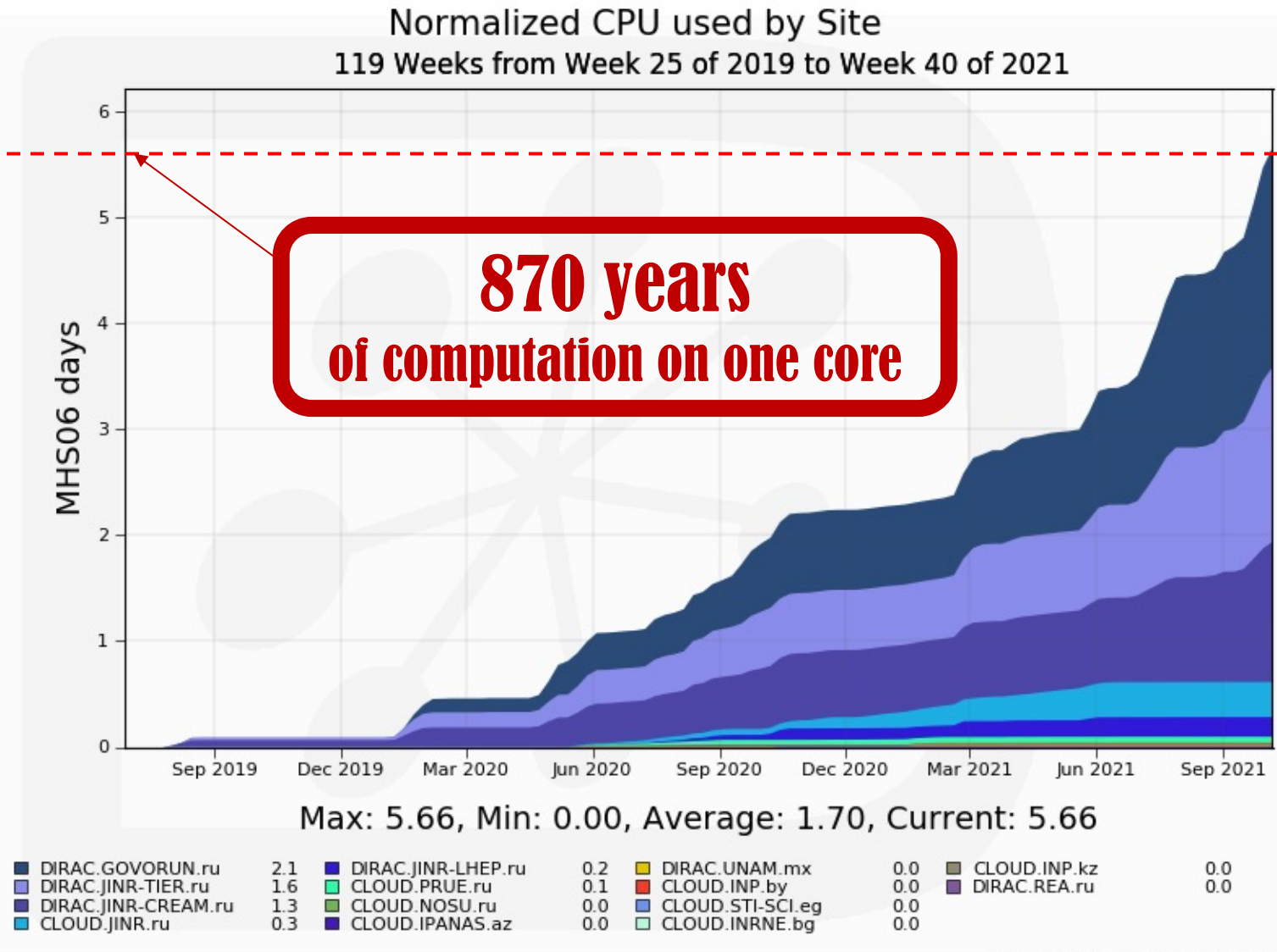


Max: 1.07, Min: 0.00, Average: 0.39, Current: 1.07

|                     |     |                    |     |                  |     |                |     |
|---------------------|-----|--------------------|-----|------------------|-----|----------------|-----|
| DIRAC.GOVORUN.ru    | 0.4 | DIRAC.JINR-LHEP.ru | 0.0 | CLOUD.IPANAS.az  | 0.0 | CLOUD.INP.kz   | 0.0 |
| DIRAC.JINR-TIER.ru  | 0.3 | CLOUD.PRUE.ru      | 0.0 | CLOUD.INP.by     | 0.0 | CLOUD.INRNE.bg | 0.0 |
| DIRAC.JINR-CREAM.ru | 0.3 | CLOUD.NOSU.ru      | 0.0 | CLOUD.STI-SCI.eg | 0.0 |                |     |
| CLOUD.JINR.ru       | 0.1 | DIRAC.UNAM.mx      | 0.0 | DIRAC.REA.ru     | 0.0 |                |     |

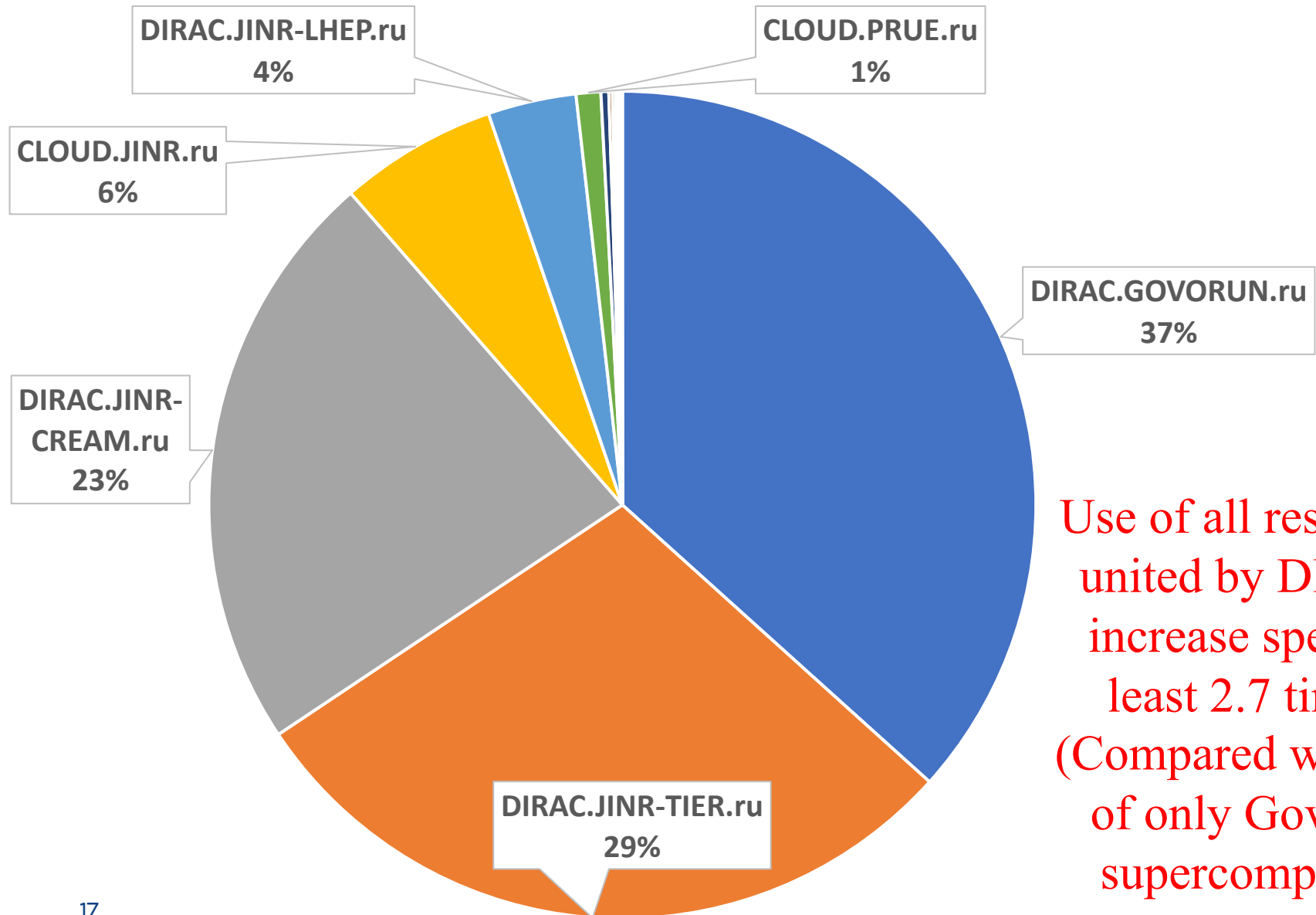
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# Statistics: normalized time



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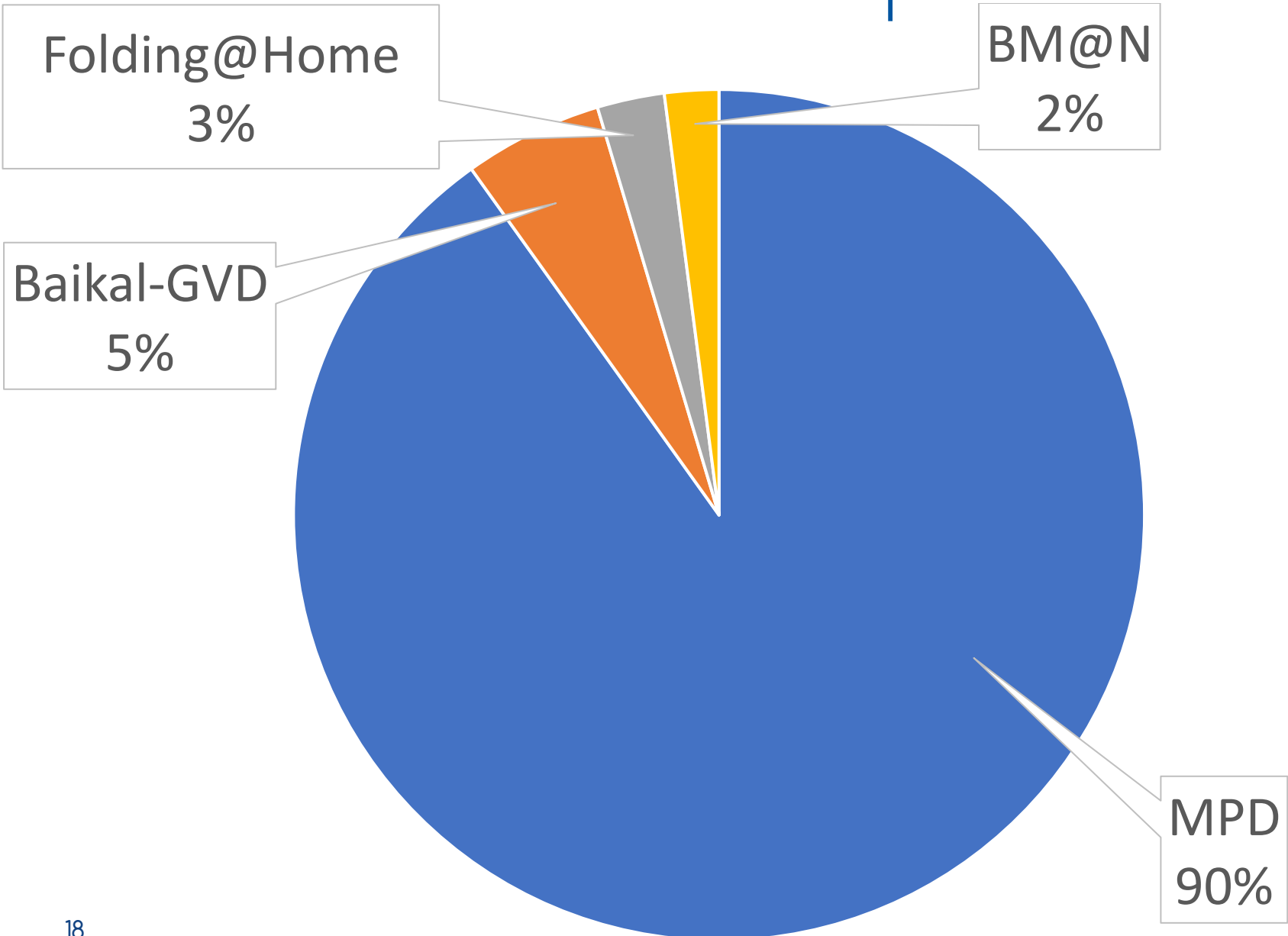
# Contribution: normalized time



Use of all resources  
united by DIRAC  
increase speed at  
least 2.7 times.  
(Compared with use  
of only Govorun  
supercomputer)



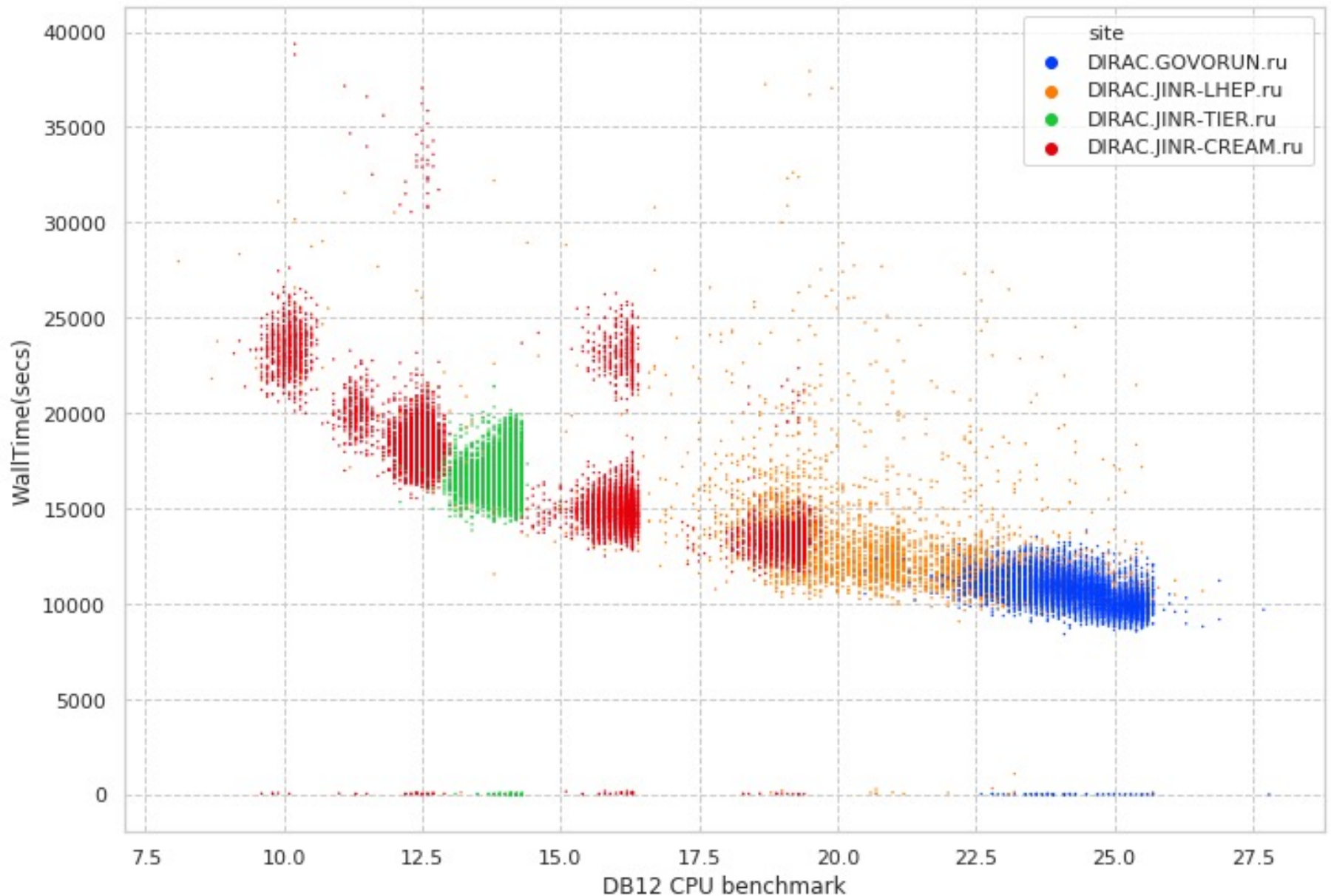
# Ratio: between experiments



# Individual CPU core performance study

- Centralized job management gives possibility for centralized and unified performance study of different computing resources.
- Before running user jobs DIRAC Pilots execute benchmark for CPU core they are running on.
- Benchmark is DiracBenchmark2012 or DB12. It evaluate just CPU core performance. Disk I/O, RAM speed, Network, CPU caches and other highly important aspects of performance are **neglected by DB12**.

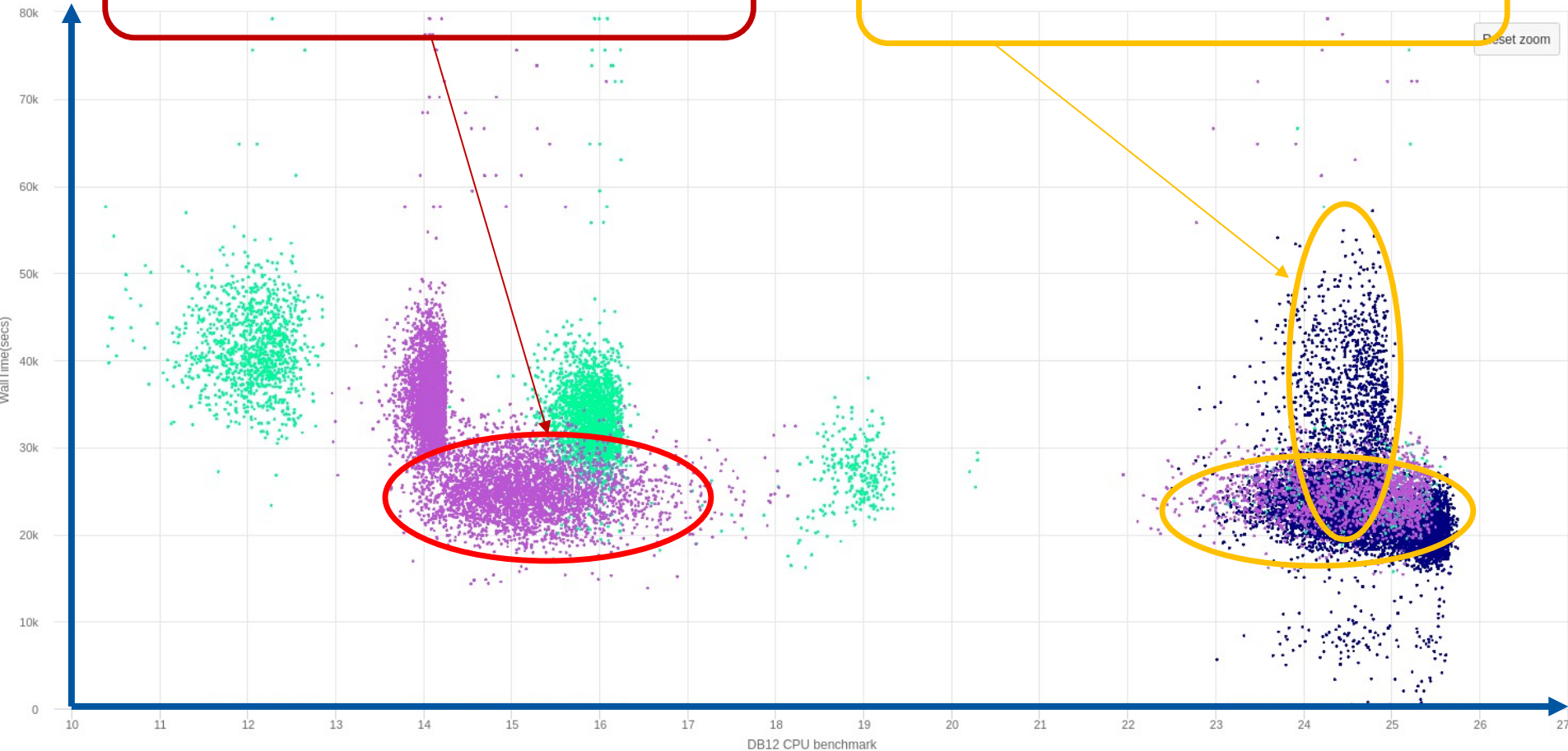
# New: performance analysis



# Discoveries

Wrong AMD processors  
estimation

Speed loss on high ram  
Govorun nodes



# Conclusion on MPD+DIRAC

- After 2 years of active operations, DIRAC proved to be useful and effective tool for HTC jobs in JINR.
- **>1M jobs** successfully done (830 years of wall time).
- So far, all available major computing resources were successfully integrated to DIRAC.
- DIRAC is used not only as **workload management system** but also as a **data management system**. And tests to use it as **workflow management system** were successfully performed.
- All this could not be possible without cooperation with users and resource administrators

# List of participants

**DIRAC:** Igor Pelevanyk, Andrey Tsaregorodtzev

**Baikal-GVD:** Dmitry Zaborov

**BM@N:** Konstantin Gertsenberger, Dmitry Tsvetkov

**MPD:** Oleg Rogachevskiy, Andrey Moshkin

**SPD:** Alexey Zhemchugov

**Responsible for resources:**

Cloud: Nikolay Kutovskiy, Nikita Balashov

dCache: Vladimir Trofimov

Govorun: Dmitry Podgainy, Dmitry Belyakov, Maxim Zuev

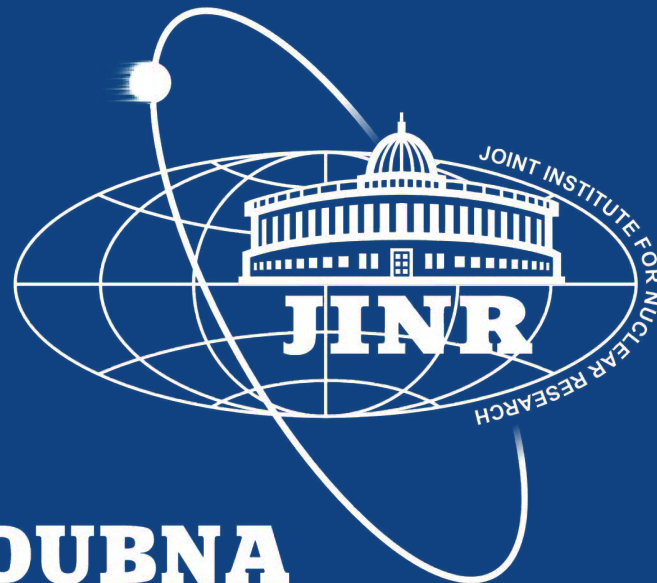
LHEP cluster: Boris Schinov

Tier-1,Tier-2, EOS: Valery Mitsyn

# Detailed articles

1. Gergel, V., V. Korenkov, I. Pelevanyuk, M. Sapunov, A. Tsaregorodtsev, and P. Zrelov. 2017. **Hybrid Distributed Computing Service Based on the DIRAC Interware**.
2. Korenkov, V., Pelevanyuk, I. & Tsaregorodtsev, A. 2019, "**Dirac system as a mediator between hybrid resources and data intensive domains**", CEUR Workshop Proceedings, pp. 73.
3. Balashov, N.A., Kuchumov, R.I., Kutovskiy, N.A., Pelevanyuk, I.S., Petrunin, V.N. & Tsaregorodtsev, A.Y. 2019, "**Cloud integration within the DIRAC Interware**", CEUR Workshop Proceedings, pp. 256.
4. Korenkov, V., Pelevanyuk, I. & Tsaregorodtsev, A. 2020, **Integration of the JINR hybrid computing resources with the DIRAC interware for data intensive applications**.
5. Kutovskiy, N., Mitsyn, V., Moshkin, A., Pelevanyuk, I., Podgayny, D., Rogachevsky, O., Shchinov, B., Trofimov, V. & Tsaregorodtsev, A. 2021, "**Integration of Distributed Heterogeneous Computing Resources for the MPD Experiment with DIRAC Interware**", Physics of Particles and Nuclei, vol. 52, no. 4, pp. 835-841.
6. Pelevanyuk, I., "**Performance evaluation of computing resources with DIRAC interware**", AIP Conference Proceedings 2377, 040006 (2021)





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