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DIRAC Interware as a service for high-thoughput computing in JINR

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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
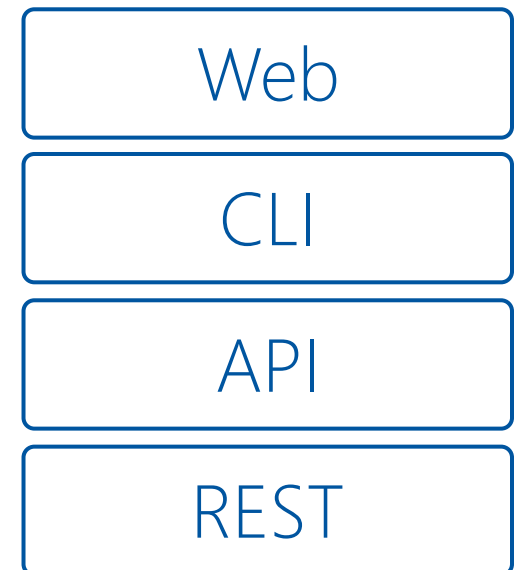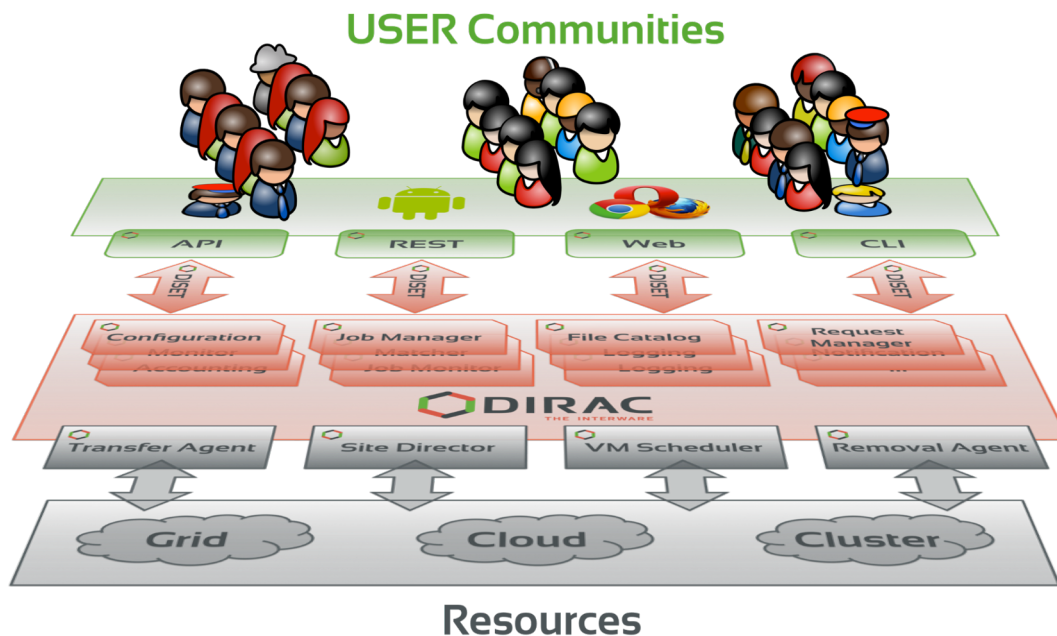
What was done

Tier-1 CICC/Tier-2 Clouds Govorun NICA Cluster UNAM

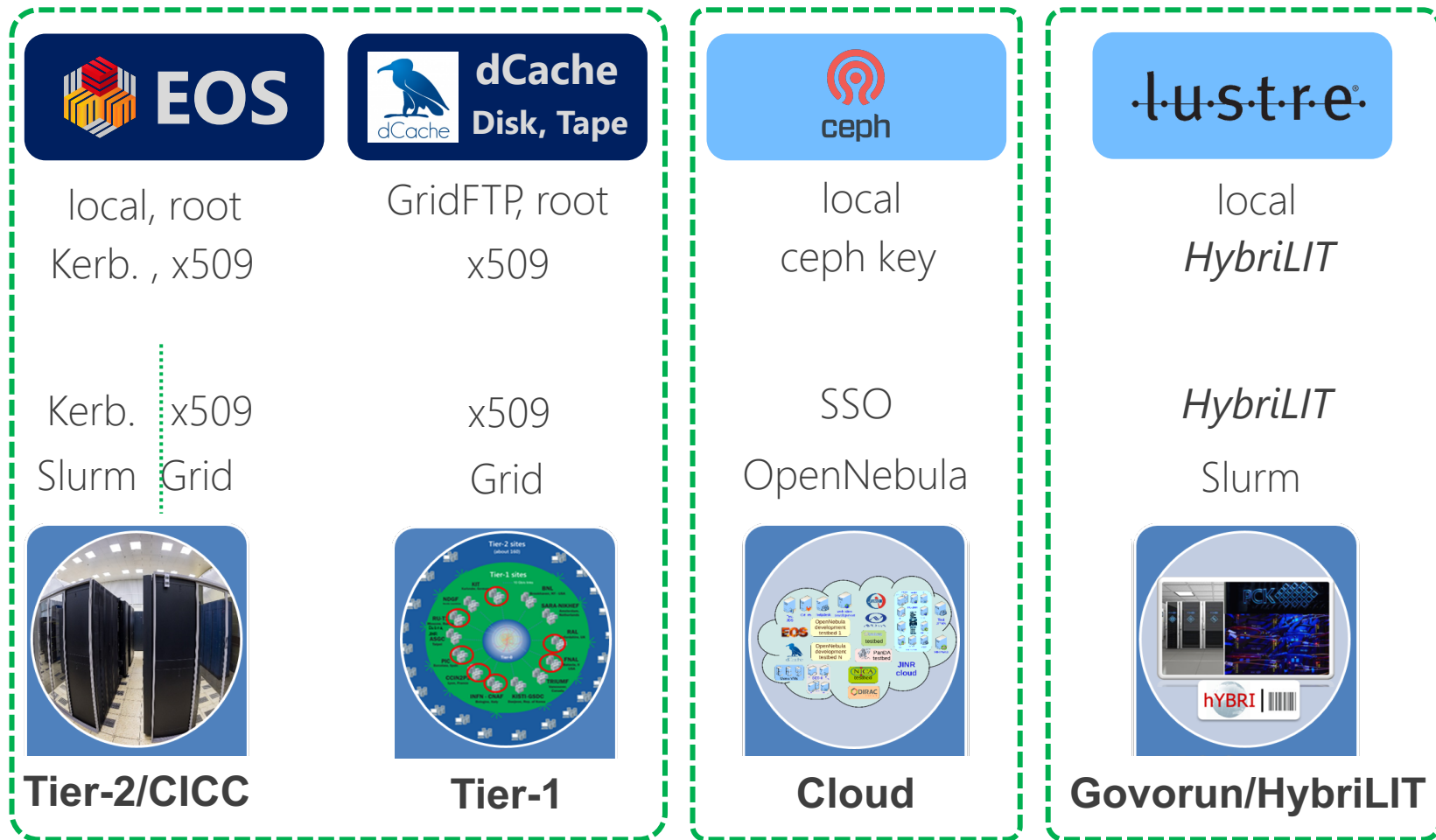**Running** **Running** **Running** **Running** **Running** **Running**

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*.

Why it is complex

	Tier-2/CICC	Tier-1	Cloud	Govorun/HybriLIT
Storage	EOS	dCache Disk, Tape	ceph	lustre
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				

* This is a simplified schema to demonstrate complexity and variability of protocols and accesses approaches

Why DIRAC?

1. Single system for all aspects of computing

DIRAC
THE INTERWARE

User Interface

API

Central configuration

Workload management

Data management

Integration tools

File Catalog
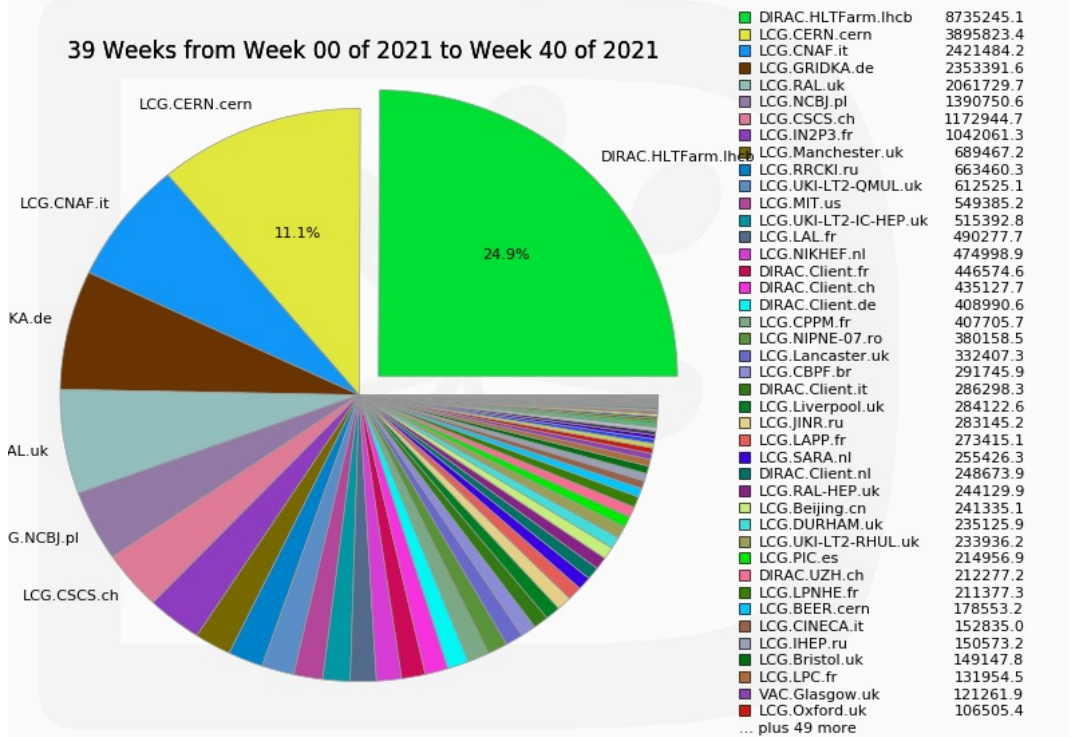
Workflow management

Metadata management

Accounting

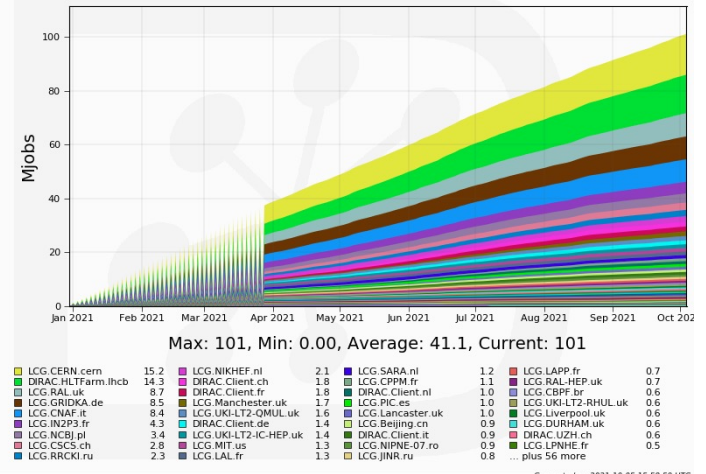Management

Why DIRAC?
2. Good performance

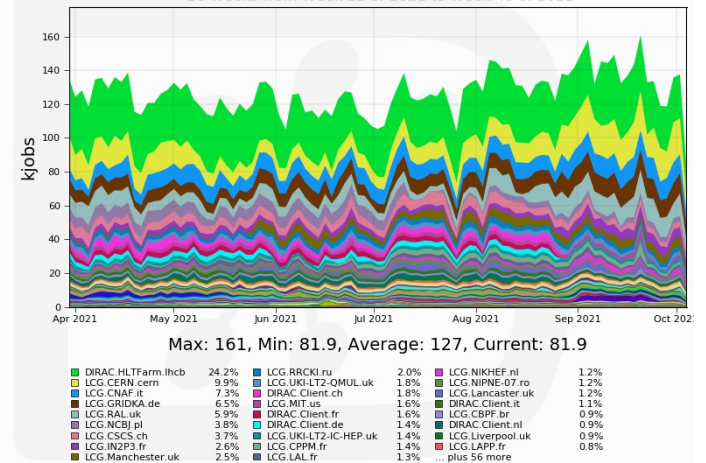### Wall time days used by Site

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

Site	Value
DIRAC.HLTFarm.lhcb	8735245.1
LCG.CERN.cern	3895823.4
LCG.CNAF.it	2421484.2
LCG.GRIDKA.de	2353391.6
LCG.RAL.uk	2061729.7
LCG.NCBJ.pl	1390750.6
LCG.CSCS.ch	1172944.7
LCG.IN2P3.fr	1042061.3
LCG.Manchester.uk	689467.2
LCG.RRCKI.ru	663460.3
LCG.UKI-LT2-QMUL.uk	612525.1
LCG.MIT.us	549385.2
LCG.UKI-LT2-IC-HEP.uk	515392.8
LCG.LAL.fr	490277.7
LCG.NIKHEF.nl	474998.9
DIRAC.Client.fr	446574.6
DIRAC.Client.ch	435127.7
DIRAC.Client.de	408990.6
LCG.CPPM.fr	407705.7
LCG.NIPNE-07.ro	380158.5
LCG.Lancaster.uk	332407.3
LCG.CBPF.br	291745.9
DIRAC.Client.it	286298.3
LCG.Liverpool.uk	284122.6
LCG.JINR.ru	283145.2
LCG.LAPP.fr	273415.1
LCG.SARA.nl	255426.3
DIRAC.Client.nl	248673.9
LCG.RAL-HEP.uk	244129.9
LCG.Beijing.cn	241335.1
LCG.DURHAM.uk	235125.9
LCG.UKI-LT2-RHUL.uk	233936.2
LCG.PIC.es	214956.9
DIRAC.UZH.ch	212277.2
LCG.LPNHE.fr	211377.3
LCG.BEER.cern	178553.2
LCG.CINECA.it	152835.0
LCG.IHEP.ru	150573.2
LCG.Bristol.uk	149147.8
LCG.LPC.fr	131954.5
VAC.Glasgow.uk	121261.9
LCG.Oxford.uk	106505.4
… plus 49 more	

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

Max: 101, Min: 0.00, Average: 41.1, Current: 101

LCG.CERN.cern	15.2	LCG.NIKHEF.nl	2.1	LCG.SARA.nl	1.2	LCG.LAPP.fr	0.7
DIRAC.HLTFarm.lhcb	14.3	DIRAC.Client.ch	1.8	LCG.CPPM.fr	1.1	LCG.RAL-HEP.uk	0.7
LCG.RAL.uk	8.7	DIRAC.Client.fr	1.8	DIRAC.Client.nl	1.0	LCG.CBPF.br	0.6
LCG.GRIDKA.de	8.5	LCG.Manchester.uk	1.7	LCG.PIC.es	1.0	LCG.UKI-LT2-RHUL.uk	0.6
LCG.CNAF.it	8.4	LCG.UKI-LT2-QMUL.uk	1.6	LCG.Lancaster.uk	1.0	LCG.Liverpool.uk	0.6
LCG.IN2P3.fr	4.3	DIRAC.Client.de	1.4	LCG.Beijing.cn	0.9	LCG.DURHAM.uk	0.6
LCG.NCBJ.pl	3.4	LCG.UKI-LT2-IC-HEP.uk	1.4	DIRAC.Client.it	0.9	DIRAC.UZH.ch	0.6
LCG.CSCS.ch	2.8	LCG.MIT.us	1.3	LCG.NIPNE-07.ro	0.9	LCG.LPNHE.fr	0.5
LCG.RRCKI.ru	2.3	LCG.LAL.fr	1.3	LCG.JINR.ru	0.8	… plus 56 more	

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

Max: 161, Min: 81.9, Average: 127, Current: 81.9

DIRAC.HLTFarm.lhcb	24.2%	LCG.RRCKI.ru	2.0%	LCG.NIKHEF.nl	1.2%
LCG.CERN.cern	9.9%	LCG.UKI-LT2-QMUL.uk	1.8%	LCG.NIPNE-07.ro	1.2%
LCG.CNAF.it	7.3%	DIRAC.Client.ch	1.8%	LCG.Lancaster.uk	1.2%
LCG.GRIDKA.de	6.5%	LCG.MIT.us	1.6%	DIRAC.Client.it	1.1%
LCG.RAL.uk	5.9%	DIRAC.Client.fr	1.6%	LCG.CBPF.br	0.9%
LCG.NCBJ.pl	3.8%	DIRAC.Client.de	1.4%	DIRAC.Client.nl	0.9%
LCG.CSCS.ch	3.7%	LCG.UKI-LT2-IC-HEP.uk	1.4%	LCG.Liverpool.uk	0.9%
LCG.IN2P3.fr	2.6%	LCG.CPPM.fr	1.4%	LCG.LAPP.fr	0.8%
LCG.Manchester.uk	2.5%	LCG.LAL.fr	1.3%	… plus 56 more	

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Why DIRAC?

3. Active users and developers community
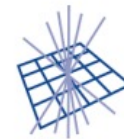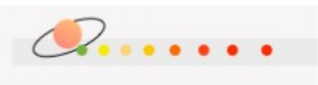
- Dedicated installations
    - LHCb, Belle II, CTA
- Multi-community services
    - ILC, CALICE
    - IHEP: BES III, Juno, CEPC
    - FG-DIRAC
    - GridPP
    - DIRAC4EGI
    - PNNL
    - DIRAC@JINR
    - DIRAC@CNAF
- Several DIRAC evaluations are ongoing
    - Auger, ELI, NICA, Virgo, LSST, …

History of DIRAC at JINR

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

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, Govorun 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

What do we use DIRAC for?
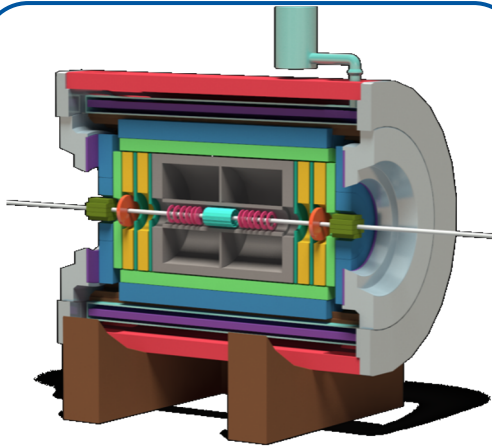
MPD@NICA

Monte-Carlo – Real
Analysis – Maybe
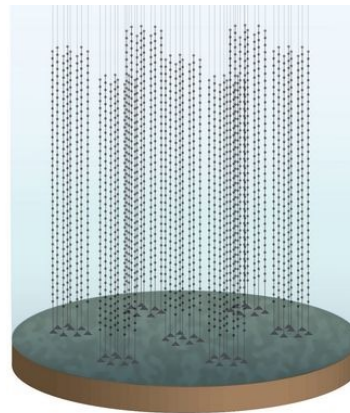
Baikal-GVD

Monte-Carlo – Real
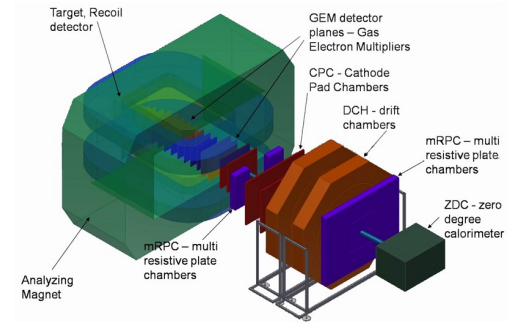
BM@N

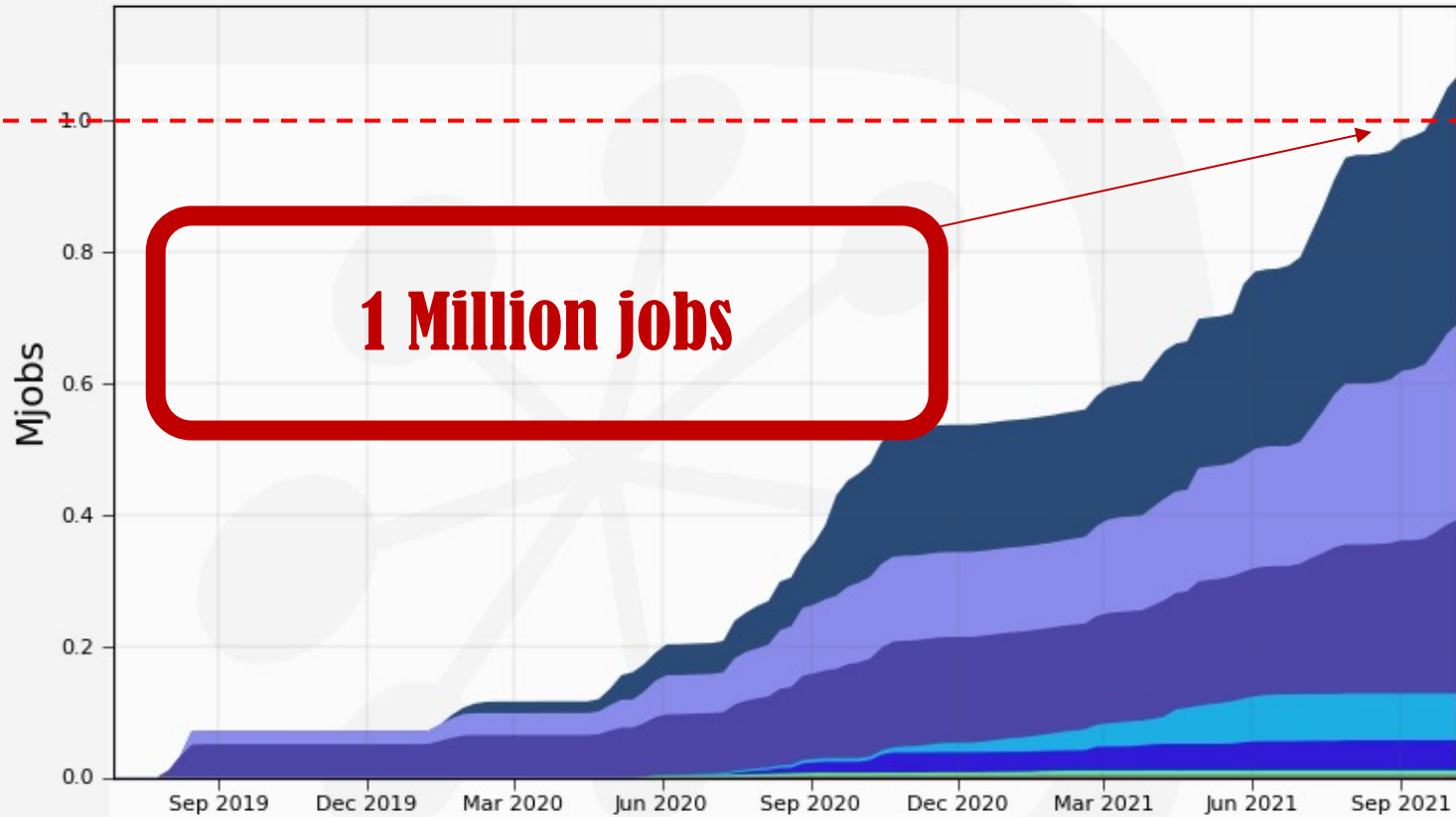Monte-Carlo – Real
Reconstruction – Tests

Folding@HOME
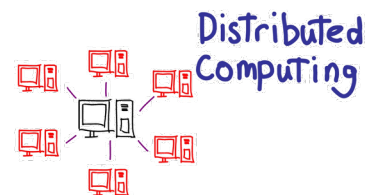
Teaching

Statistics: jobs done

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

1 Million jobs

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

Normalized CPU used by Site
119 Weeks from Week 25 of 2019 to Week 40 of 2021

870 years
of computation on one core
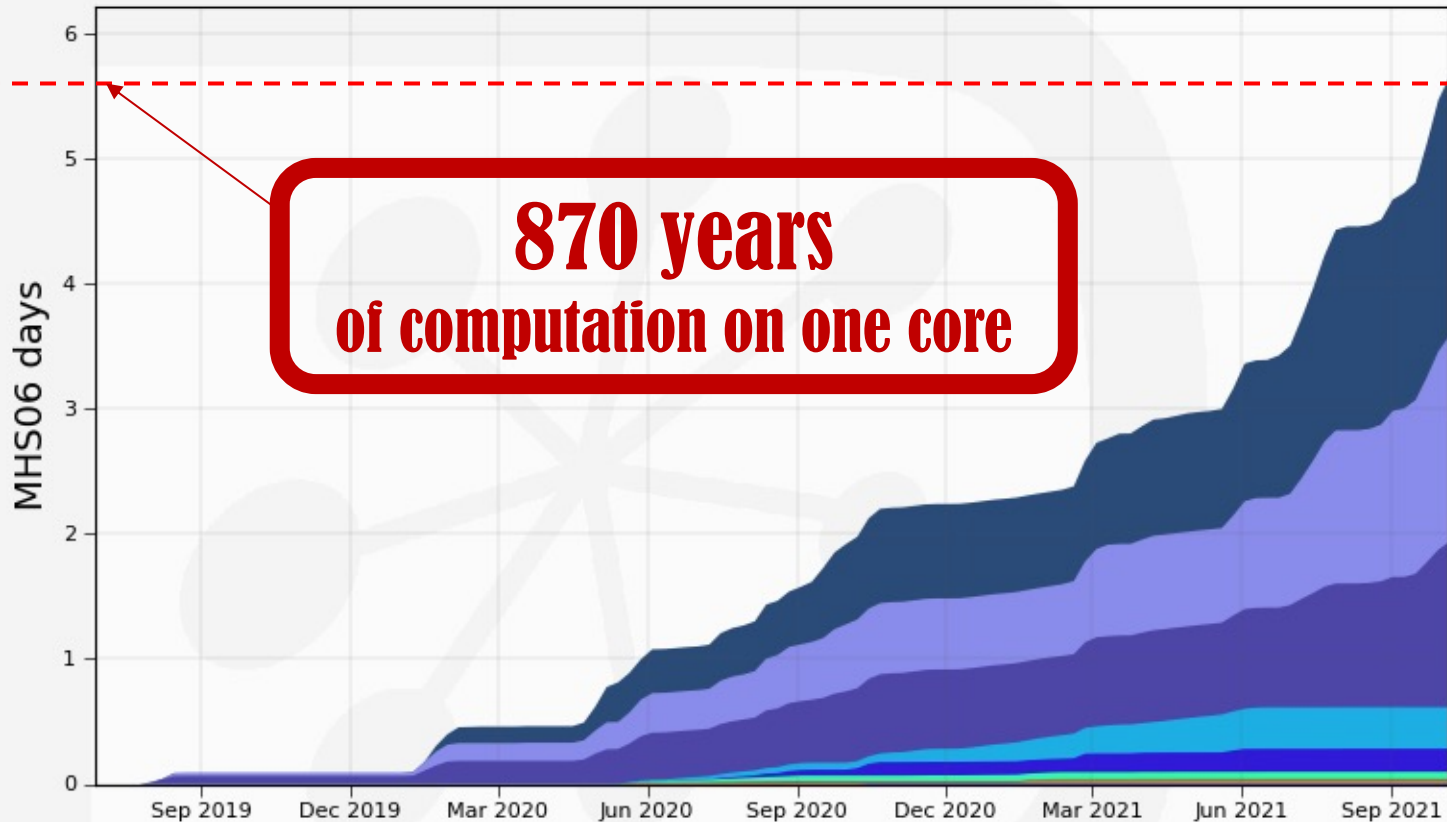
Max: 5.66, Min: 0.00, Average: 1.70, Current: 5.66

DIRAC.GOVORUN.ru	2.1	DIRAC.JINR-LHEP.ru	0.2	DIRAC.UNAM.mx	0.0	CLOUD.INP.kz	0.0
DIRAC.JINR-TIER.ru	1.6	CLOUD.PRUE.ru	0.1	CLOUD.INP.by	0.0	DIRAC.REA.ru	0.0
DIRAC.JINR-CREAM.ru	1.3	CLOUD.NOSU.ru	0.0	CLOUD.STI-SCI.eg	0.0		
CLOUD.JINR.ru	0.3	CLOUD.IPANAS.az	0.0	CLOUD.INRNE.bg	0.0		

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Contribution: normalized time

DIRAC.JINR-LHEP.ru 4%

CLOUD.PRUE.ru 1%

CLOUD.JINR.ru 6%

DIRAC.JINR-CREAM.ru 23%

DIRAC.GOVORUN.ru 37%

DIRAC.JINR-TIER.ru 29%
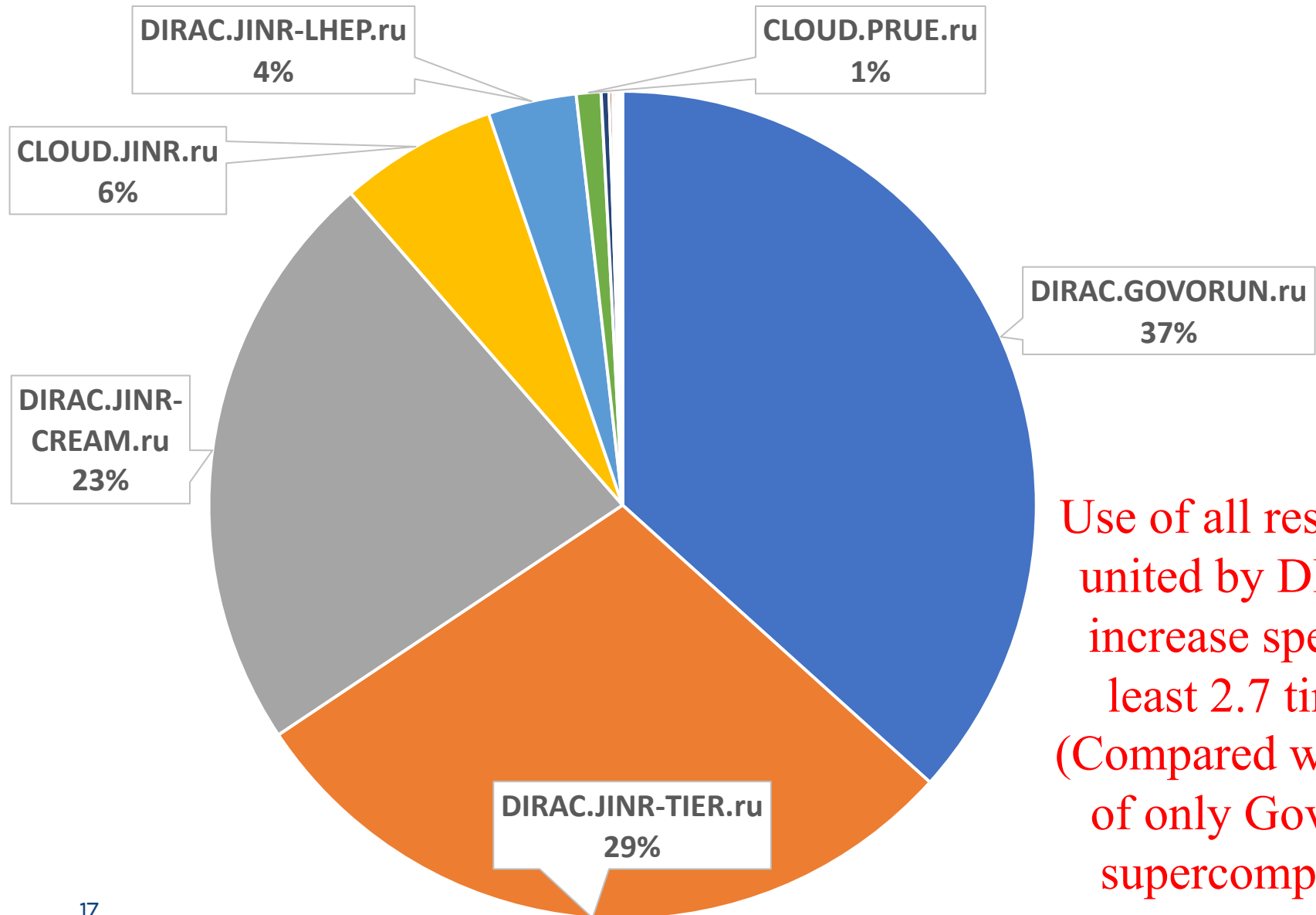
Use of all resources united by DIRAC increase speed at least 2.7 times. (Compared with use of only Govorun supercomputer)

Ratio: between experiments


Folding@Home
3%

BM@N
2%

Baikal-GVD
5%

MPD
90%
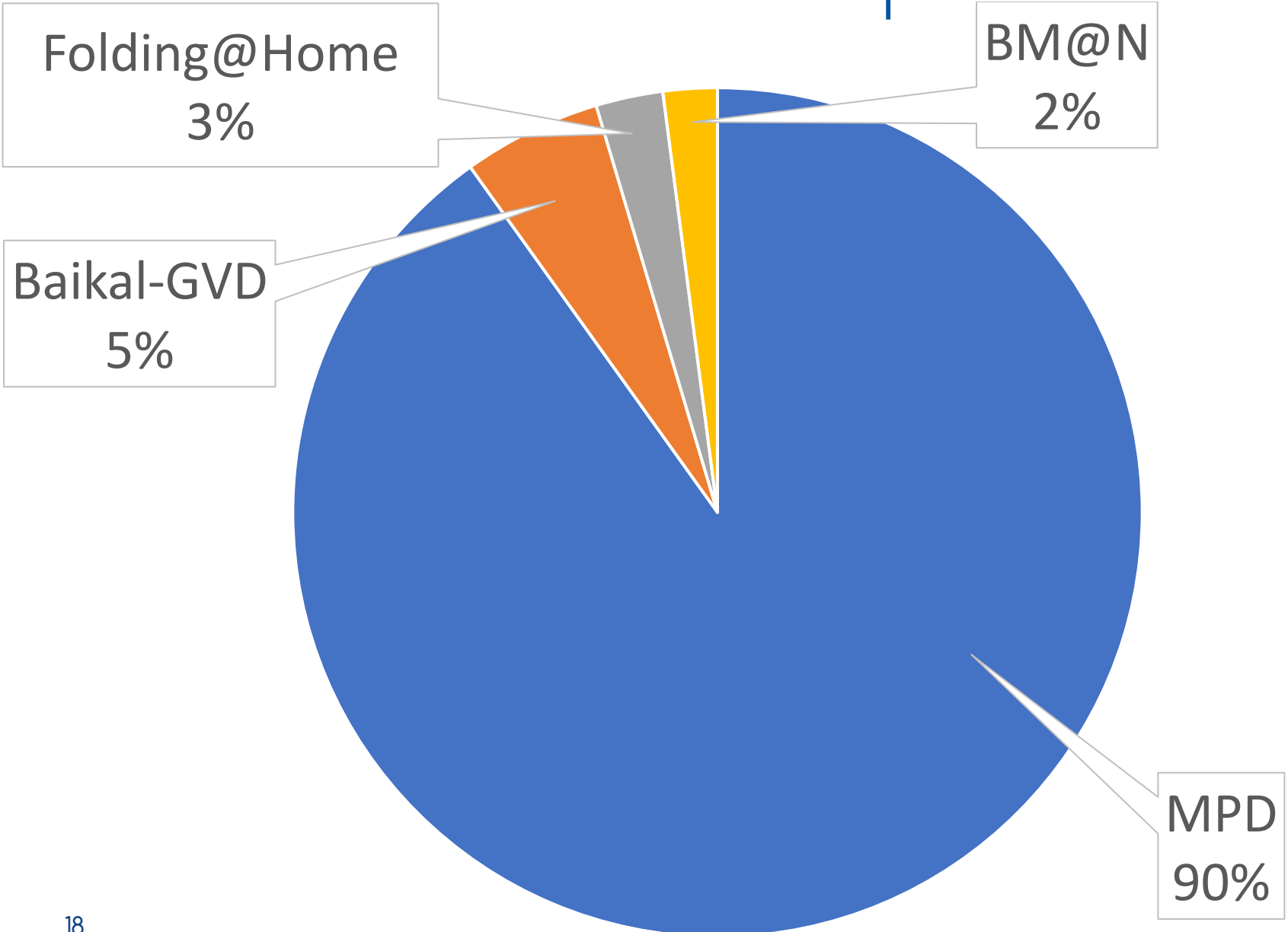
Individual CPU core performance study

- 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

21
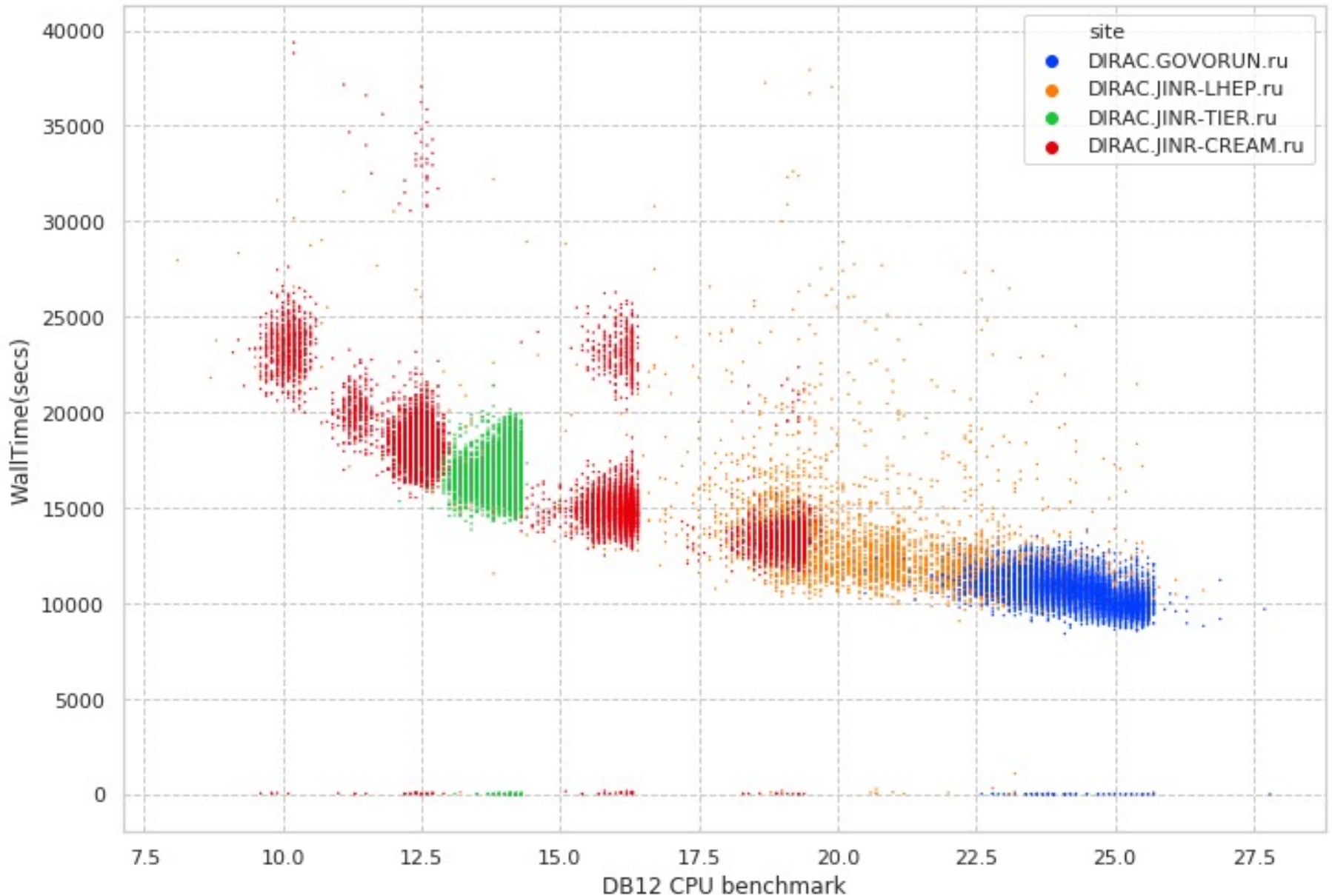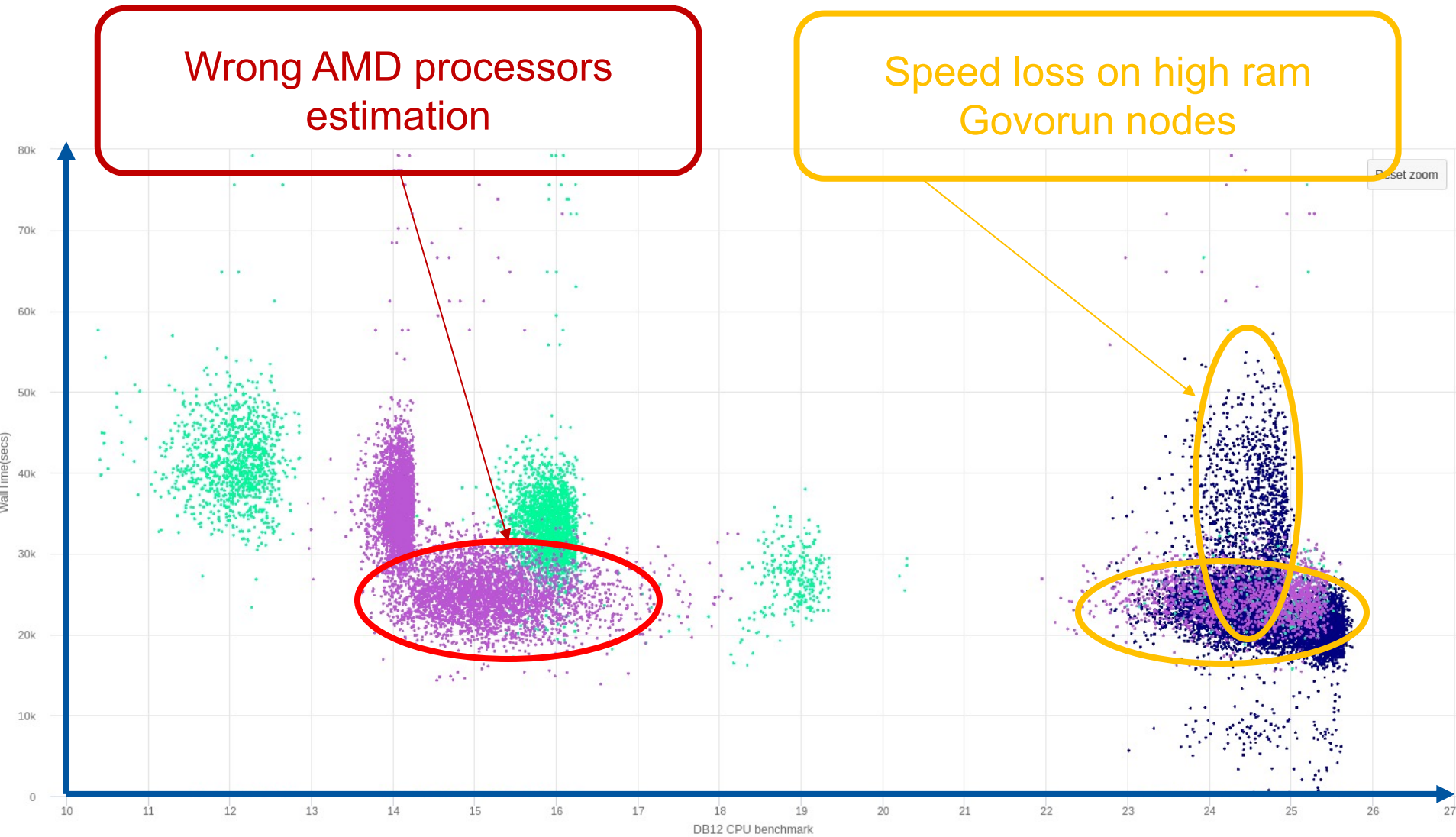
Conclusion on MPD+DIRAC

- 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
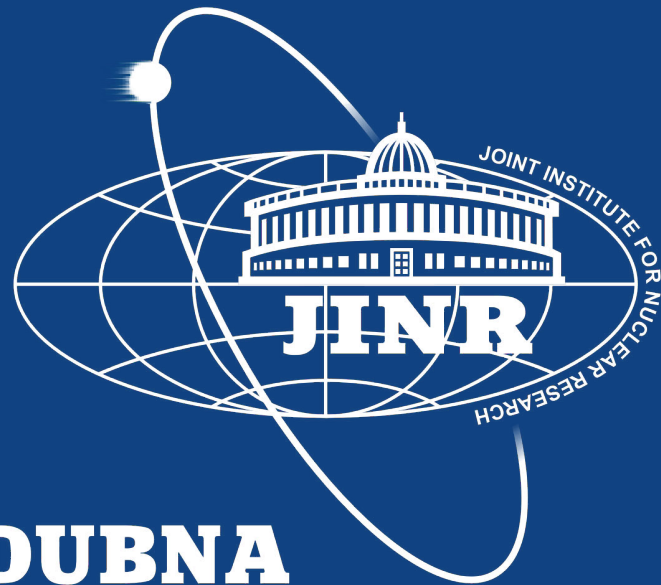dCache: Vladimir Trofimov
Govorun: Dmitry Podgainy, Dmitry Belyakov, Maxim Zuev
LHEP cluster: Boris Schinov
Tier-1,Tier-2, EOS: Valery Mitsyn

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)