Tier-1 CMS at JINR: Status and Perspective

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The Tier-1 centre for the CMS experiment at JINR is a high-tech platform for computing systems and systems for long-term data storage with high concentration of network and server equipment. Work on this centre was carried out as part of the project "Creation of the automated system of data processing of experiments at the Large Hadron Collider (LHC) of the Tier-1 level and provision of grid-services for distributed analysis of these data" within the Federal target program (FTP) of the Ministry of Education and Science of the Russian Federation "Research and development on the priority directions of developing the scientific-technological complex of Russia for 2007-2013". On 28 September 2012, at the meeting of the Supervisory Board of the WLCG project a plan of creating a Tier-1 centre in Russia was accepted. In early 2015, a full-scale WLCG site of the Tier-1 level for the CMS experiment was commissioned at LIT, JINR. The importance of creating and maintaining such a centre is determined by several factors. First of all, the need for the development, modernization and expansion of computational performance and data storage capacity of the Tier-1 centre is dictated by the research program of the CMS experiment in which JINR physicists are actively involved as part of the RDMS CMS collaboration. Another important thing is that in the course of work on the creation and exploitation of the Tier-1 at JINR, an invaluable experience was gained that is already in demand and will be needed in the future to design, build and subsequently exploit the informational – computational centre for experiments within the NICA project. An overview of the JINR Tier-1 centre for the CMS experiment at the LHC is given. Special emphasis is placed on the results of the Tier-1 operation and future plans.

Keywords: WLCG, CMS, Tier-1,Grid

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Introduction

For more than a decade, the information and computing infrastructure of JINR [Korenkov, Strizh, Adam, Podgainy, 2015] created in LIT is being developed within the Central Information and Computing Complex (CICC) of JINR. In the last few years, in connection with work on the organization of the computing project for NICA [NICA], the commissioning of the Tier-1 centre for the CMS experiment [Astakhov, Baginyan, Belov, 2016], the implementations of a cloud computing structure [Baranov, Balashov, Kutovskiy, Semenov, 2016] and of a cluster for hybrid computing, the information-computing environment of JINR evolved in a Multifunctional Information and Computing Complex (MICC) of JINR.

Two very important components are the Tier-1 for CMS experiment at LHC (CERN), and the Tier-2 centre for all four experiments. Today it is clear that the grid computing model for LHC realised in the WLCG (Worldwide LHC Computing Grid) project [WLCG] has been extremely successful in providing a computing environment for achieving the physics goals of the LHC experiments during Run 1.

The first ideas of computing models for the LHC experiments were formulated in the MONARC project [Aderholz, 2000; Dobre, 2004] that suggested a hierarchical structure of the Tier 0,1,2 system for data processing based on the experiment computing models and the grid service. Within this model, data from experiments at the LHC are distributed worldwide between the participants of the collaborations, according to the hierarchical model. The raw data coming from the facilities are accumulated on tapes and pre-processed in the Tier-0 centre at CERN. These data are distributed among a number of large computing Tier-1 centres possessing a sufficient capacity to store large amounts of data and a round-the-clock surveillance system. The next level is the Tier-2 centres that receive data from the Tier-1 centres to analyze, solve the problems of simulation and transmit simulation data for storage to the Tier-1 centres. In addition, the Tier-1 centres provide a higher quality of service than the centres of the Tier-2 level.

JINR actively participates in the large-scale global grid-project WLCG from its start. The effective Tier-2 grid site was developed at JINR for serving all four experiments at the LHC. Since 2004, the JINR grid site has been a component of the global computing grid-infrastructure in frames of the Russian grid-infrastructure for intensive operations with data (RDIG) [Gavrilov, Golutvin, Kodolova, 2016].

The LHC Run2 (2015-2018) aims to crank up the amount of data collected by the experiments by a factor of ten compared to Run1. This requires growing computing resources (facilities) significantly.

The idea to create in Russia a Tier-1 centre for LHC experiments within the Worldwide LHC Computing Grid project was initiated by Minister of Education and Science of the Russian Federation. A decision was taken in November 2011 at a Session of the Committee on Russia-CERN cooperation. It proposed this centre to be built up on the base of the NRC "Kurchatov Institute" and the Joint Institute for Nuclear Research (JINR).

The official inauguration of the JINR Tier-1 level centre [Astakhov, Baginyan, Belov, 2015; Astakhov, Belov, Gorbunov, 2013] for the CMS experiment in March 2015 marked a significant enhancement of the JINR grid computing infrastructure. From this moment the JINR serves two grid sites: the Tier-1 for CMS and the Tier-2 for the ATLAS, ALICE, CMS and LHCb experiments at the LHC. This is an important addition to the global system for experimental processing of the data coming from both the Tier-0 level centre (CERN) and from the Tier-1 and Tier-2 centres of the global grid infrastructure of the CMS experiment.

The CMS Computing Model has been under continuous evolution since it was first formalized in the Computing TDR in 2005. For the Run2 the CMS is evolving the computing model to give more transparent access to the data and increase flexibility in work. The main changes with respect to the original computing model is that the Tier-1 centres will perform a significant fraction of the prompt reconstruction and will participate in user analysis, while also keeping their role in data and simulation

reprocessing. Tier-1s are expected to operate 24/7 and respond to issues out of normal business hours. The Tier-1 centres may be collocated with Archival Services - tape-based systems for data storage to give 2 copies of the RAW data in separate facilities. The reconstruction and reprocessing activities are performed today at the Tier-0 and Tier-1 sites, and require access to the raw data, and the recall of that data from the tape archives. Practically these activities need to be rather close to the archives in order to avoid large data transfers over network. A site should be capable of holding significant data sets online on disk and serving them over the network to other storage or compute resources. This would also require significant expertise in the management of large storage systems, at a very high level of reliability and availability. Such a site would require significant network bandwidth – multiple 10 Gb/s connections as a minimum.

Tier-1 functions

In accordance with the CMS computing model [Grandi, Stickland, Taylor, 2004], a Tier-1 centre is intended for long-term data archiving and processing of "raw" data coming from the detectors of experimental setup and for their preparation for subsequent analysis at the Tier-2 centres. In the computing model of the CMS at the Tier-1 there are two main types of stream job processing: data re-reconstruction and simulated data re-digitization/re-reconstruction. During the data re-reconstruction, Tier-1 sites process RAW data with the use of newer software and/or in view of updated calibration and alignment constants of detector systems as well as more exact information about the setup state during data taking. The output data are recorded in RECO (RECOnstructed data) and in AOD (Analysis Object Data) formats. The new CMS data model [Grandi, Bonacorsi, Colling, Fisk, Girone, 2014] introduces a new data format where duplicative intermediate ntuples are merged (Mini-AOD). RECO are the data containing the values of parameters of physical objects (tracks, interaction vertices, jets, electrons, muons, photons, etc.) as well as clusters and hits reconstructed from the RAW data with the usage of various algorithms. They are an output data stream from Tier-0 for redistribution over various Tier-1. The volume of one event is about 1.3-1.4 MB. These data can be used for the analysis, but they are inconvenient due to their large size. AOD represents a selective set of information from the RECO data. AOD events contain the parameters of high-level physics objects, plus sufficient additional information to allow kinematic refitting. AOD and Mini-AOD have a considerably smaller size, as compared to RECO (0.48 and 0.06 MB per one event), and is used for reconstruction of the final topology of a physical event and a subsequent analysis.

In addition, a Tier-1 provides selection of events from the reconstructed data by specified criteria (skimming). A similar selection can be carried out from "raw" (RAW) data or elsewhere from already reconstructed RECO data. These events pass through processing and accumulation similar to that during a re-reconstruction; then they are recorded in RECO format or in incorporated format (RAW-RECO).

In the Tier-1 level centers, similar to experimental data, there is a reprocessing of simulation data. The input data of GEN-SIM-RAW type are exposed to re-digitization (part of GEN-SIM data) for receiving updated versions of the simulated data such as RAW which are further reconstructed again (output is GEN-SIM-RECO and/or AODSIM data).

Thus, the main functions of the Tier-1 centre are as follows:

- Receiving of experimental data from a Tier-0 level centre in the volume determined by the WLCG agreement (WLCG MOU);
- Archiving and custodial storage of part of experimental RAW data;
- Consecutive and continuous data processing;
- Additional processing (skimming) of RAW, RECO and AOD data;
- Data reprocessing with the use of new software or new calibration and alignment constants of parts of the CMS setup;
- Making available AOD and Mini-AOD data-sets;

- Serving RECO, AOD, and Mini-AOD datasets to other Tier-1/Tier-2/Tier-3 centres for their duplicated storage (replication) and physical analysis;
- Running production reprocessing with the use of new software and new calibration and alignment constants of parts of the CMS setup, protected storage of the simulated events;
- Production of simulated data and analysis of data recorded by the CMS experiment.

The implementation of the Tier-1 centre functions is provided by various services of the computing model of the CMS collaboration with a high level of functionality and reliability.

JINR Tier-1 Structure

The JINR Tier-1 infrastructure includes four main systems: networking, service, data processing and data storage.

The network architecture of the Tier-1 at JINR was constructed with a double route between the access level and the server level [Baginyan, Dolbilov, Korenkov, 2016]. Each server have access to the network segment by two equivalent 10 Gbps links, with a total throughput of 20 Gbps.

The connection between the access level and distribution level has four 40 Gbps routes, which, consequently, allow data transmission 160 Gbps, the oversubscription being 1:3.

As a result of this architecture, the failure of one switch reduces the overall bandwidth of the network segment by only 25%. In this case, all servers continue to have access to the external network. The Tier-1 network segment is implemented on the Brocade VDX 6740 capable of data communication with more than 230 10-Gigabit Ethernet ports and 40 Gigabit Ethernet ports. The series comprises models with optical and copper 10 Gbps ports and 40 Gbps uplinks. A virtual factory has been designed to integrates up to 32 devices which are able to balance traffic over all the paths on their own.

The LHC Optical Private Network (LHCOPN) composed of many 10 Gbps links interconnecting the Tier-0 centre at CERN with the Tier-1 sites fulfilled its mission of providing stable high-capacity connectivity, with no major and remarkably few minor network service interruptions.

The Service System supports the EMI services (FTS, VO-BOX, EMI integration system) and infrastructural services (global and local monitoring system, DNS, installation services, certification).

The Data Processing System supports working nodes, OS Linux and EMI WN services.

The Data Storage System supports disk and mass storage. The dCache and Xrootd are used as a storage management system. One of the dCache installations is used with disk servers only as an operational storage to provide fast access to the data. The second dCache unit includes disk servers and a tape robot. The disk servers comprise a temporary buffer zone to exchange data with tapes, while the tape robot is intended for a long-time, practically eternal, storage of the data from the CMS.

The Tier-1 comprises

1. **Worker Node (WN):**

— 100 64-bit machines: 2 x CPU (Xeon X5675 @ 3.07GHz, 6 cores per processor); 48GB RAM, 2x1000GB SATA-II; 2x1GbE.

— 120 64-bit machines: 2 x CPU (Xeon E5-2680 v2 @ 2.80GHz, 10 cores per processor), 64GB RAM; 2x1000GB SATA-II; 2x1GbE.

Total: 3600 core/slots for batch.

2. **Storage System (SE) (dCache):**

Disk Only:

— 30 disk servers: 2 x CPU (Xeon E5-2650 @ 2.00GHz); 128GB RAM; 63TB h/w RAID6 (24x3000GB NL SAS); 2x10G.

— 12 disk server: 2 x CPU (Xeon E5-2660 v3 @ 2.60GHz); 128GB RAM; 76TB ZFS (16x6000GB NL SAS); 2x10G.

Total space: 2.8PB

— 3 head node machines: 2 x CPU (Xeon E5-2683 v3 @ 2.00GHz); 128GB RAM; 4x1000GB SAS h/w RAID10; 2x10G.

— 8 KVM (Kernel-based Virtual Machine) for access protocols support.

3. **Mass Storage System:**

— 8 disk servers: 2 x CPU (Xeon X5650 @2.67GHz); 96GB RAM; 63TB h/w RAID6 (24x3000GB SATAIII); 2x10G; Qlogic Dual 8Gb FC.

Total disk buffer space: 0.5PB.

— 1 tape robot: IBM TS3500, 2000xLTO Ultrium-6 data cartridges; 12xLTO Ultrium-6 tape drives FC8; 5400TB.

— 3 head node machines: 2 x CPU (Xeon E5-2683 v3 @ 2.00GHz); 128GB RAM; 4x1000GB SAS h/w RAID10; 2x10G.

— 6 KVM machines for access protocols support.

4. **WLCG Services:**

— 2 x VOBox (CMS PheDEx: CPU E3-1281 v3 @ 3.70GHz, 8 cores (HT on); 16G RAM; 2x1GbE.

— 17 virtual machines (KVM).

5. **Infrastructure Servers:**

— 4 machines: 2 x CPU (Xeon X5650 @ 2.67GHz); 48GB RAM; 2x1000GBGB SATA-II; 2x1GbE.

— 10 machines: 2 x CPU (Xeon E5-2683 v3 @ 2.00GHz); 128GB RAM; 4x1000GB SAS h/w RAID10; 2x10G.

6. **Software:**

— OS: Scientific Linux release 6 x86_64.

— WLCG services: EMI3/UMD3 sl6 x86_64.

— Batch system: Torque 4.2.10 (home made) and Maui 3.3.2 (home made).

7. **Storage System:** dCache-2.10, Enstore 4.2.2 for tape robot.

Monitoring system

The monitoring of all components and services is of particular importance for steady operation of the CMS Tier-1 centre. Control over stable operation of all components and services of the Tier-1 at JINR is assigned to a set of diagnostic software and hardware tools. Full monitoring includes two components: control over the centre equipment (computer servers, disk arrays, network switching equipment, tape storage systems, cooling and power) and control over services control.

To ensure a correct and reliable operation of the computer complex equipment and to provide relevant timely information about its work, a special monitoring system has been designed [Kashunin, 2015]. This system allows one to keep in check the climate-control and power supply systems, a local network equipment, telecommunication links and computing nodes, running jobs, disk and tape storage systems. An operation centre has been launched recently to allow real-time monitoring of the whole computing complex.

The monitoring of services and evaluation of accessibility, effectiveness and usability the Tier-1 centre is realized by using special tools developed by WLCG or the CMS collaboration in two main areas:

- monitoring of readiness the centres,
- monitoring of usage and performance of resources.

Statistics obtained in the results of the monitoring is published daily, and noticed failures are recorded in the GGUS ticket system used to track problems on sites. Statistics of opened/closed tickets can also serve as a criterion of the effectiveness of the Tier-1 site.

The report on the readiness of the site summarizes all metrics and represents a cumulative current status of the availability and performance of the site. The readiness status of the site is taken into account by the Central Control Unit when planning activities within the CMS collaboration. Both planned and unplanned downtimes of the site are taken into account.

The monitoring system of the sites readiness consists of the following three major subsystems:

- monitoring of the sites availability (Site Available Monitoring – SAM) includes tests which check-up the basic services of the site,
- monitoring of the test data processing flows,
- monitoring of the data transmission in order to compute the data transmission capability between sites.

The readiness of the site is evaluated on the base of indicators that depend on the results of these tests.

Within WLCG, all the grid services are periodically tested using the SAM tests which start the monitoring tasks with high priority every hour on the sites. These tests allow one to measure availability and reliability of the sites. The results are analyzed and visualized in the monitoring system CMS Dashboard [Andreeva, Cinquilli, Dieguez, 2012; CMS Dashboard]. The SAM tests can detect problems of the site, to rate and rank the site for its availability. An error in executing any of these tests means the unavailability of the service instance used to run the test.

The ability to process data is tested by running monitoring tasks on the sites similar to the tasks of real data processing. A special automated system has been designed to trigger and control the process of performing simulated (artificial) tasks for analysis of data which provide a constant load of the site processors. The system is used to test the ability of the site to perform certain tasks for the CMS in the required quantity. The regular submitting of jobs to all the CMS sites allows one to measure the daily success rate and to get the site efficiency rating. Hundreds of tasks are sent for execution every day at regular intervals of time to the Tier-1 centres.

To use the sites, one needs to have the data transfer annotations working. The procedure of certifying the link (annotation) is to demonstrate a site's ability to hold a certain average throughput during 24 hours (20 MB/s Tier-0 → Tier-1, Tier-1 ↔ Tier-1 and Tier-1 ↔ Tier-2 links, and 5 MB/s for Tier-2 ↔ Tier-1 and Tier-2 ↔ Tier-2 links). Debugging the data transfer (debug transfers) is performed through the artificial initiation of data transfers between the sites, which are used to evaluate the quality of communication lines between these sites. The quality of data transfer is constantly checked-up at low load (few kB/s) for all certified links. This allows one to quickly find problems in the data transfer not only at the network level, but also at the level of data transmission services and storage infrastructure.

The information collected by the tests of readiness of all CMS grid centres, is accumulated into the readiness database of sites Dashboard Site Status Board (SSB). It contains both a general conclusion about the readiness of the sites (Fig. 1) and a detailed information on all the criteria of the evaluation of the site condition (Fig. 2).

The values of all the metrics for 1 day are grouped into the so-called aggregate metric of the day (daily metric) which can take the meaning “OK” if all the criteria of readiness for the day are fulfilled (Fig. 3). In case of detecting at least one failed criterion, the value of the daily metrics turns into the “Error” status. On the basis of daily metrics the site readiness status is calculated. The sites must hold all the criteria during at least five days out of the last seven ones to be in the “Ready” status. An invalid value, on any criterion, transfers the site into the “Warning” status. Criteria violations for more than two days out of the last seven ones, transfers the site to the “Not-Ready” status. To return to the “Ready” status, the site must satisfy all the required criteria within 2 days.

For each site, displayed is a general picture of the metrics of the site readiness for the last 24 hours, 48 hours, one week, two weeks and one month (Fig. 4).

The status history of sites readiness is used to detect good/bad centres. Tasks are sent for execution to the site if it was in the “Ready” state for at least 90% of time for the last 15 days for the Tier-1. A list of the bad sites is available to the job run system to exclude these sites from data processing.

One of the main operations during operation of the CMS Tier-1 is a continuous monitoring of the efficiency of resource usage (number of slots in use, number of CPUs in use, utilization level with respect to all resources) and performance (number of tasks completed successfully, the efficiency of

using CPU). To optimize the efficiency, it is necessary to detect and resolve problems in the performance of sites, CMS or grid system jobs run, imbalances in the amount of data on the site as compared to the available computational resources, etc. At the moment, a balanced and most efficient use of the resources is necessary, because enormous loads are expected.

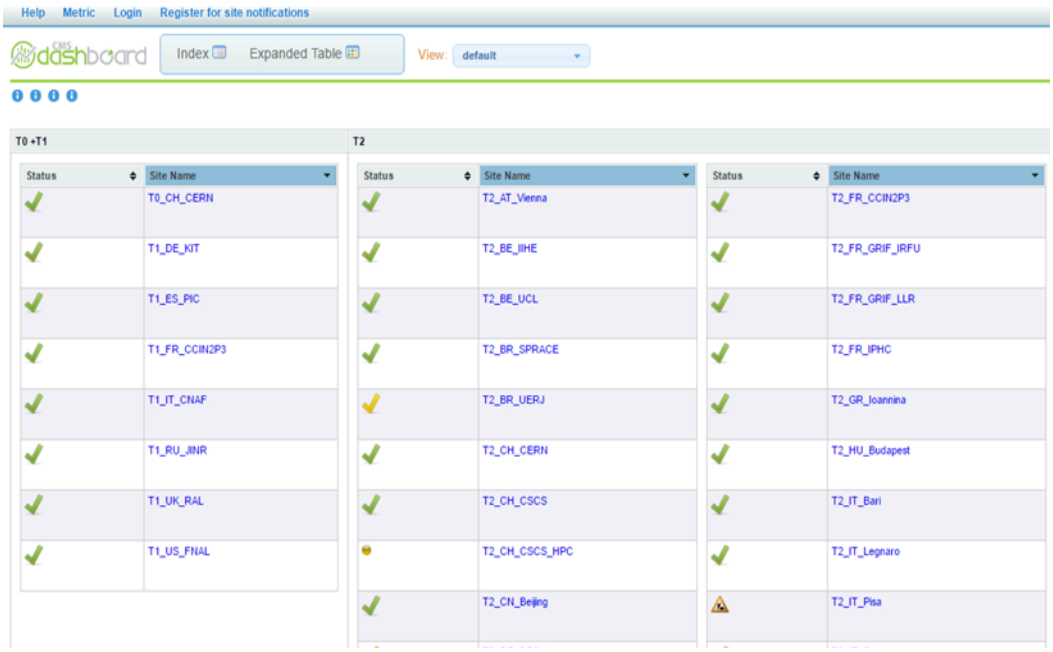

Fig. 1. General readiness status of the CMS sites

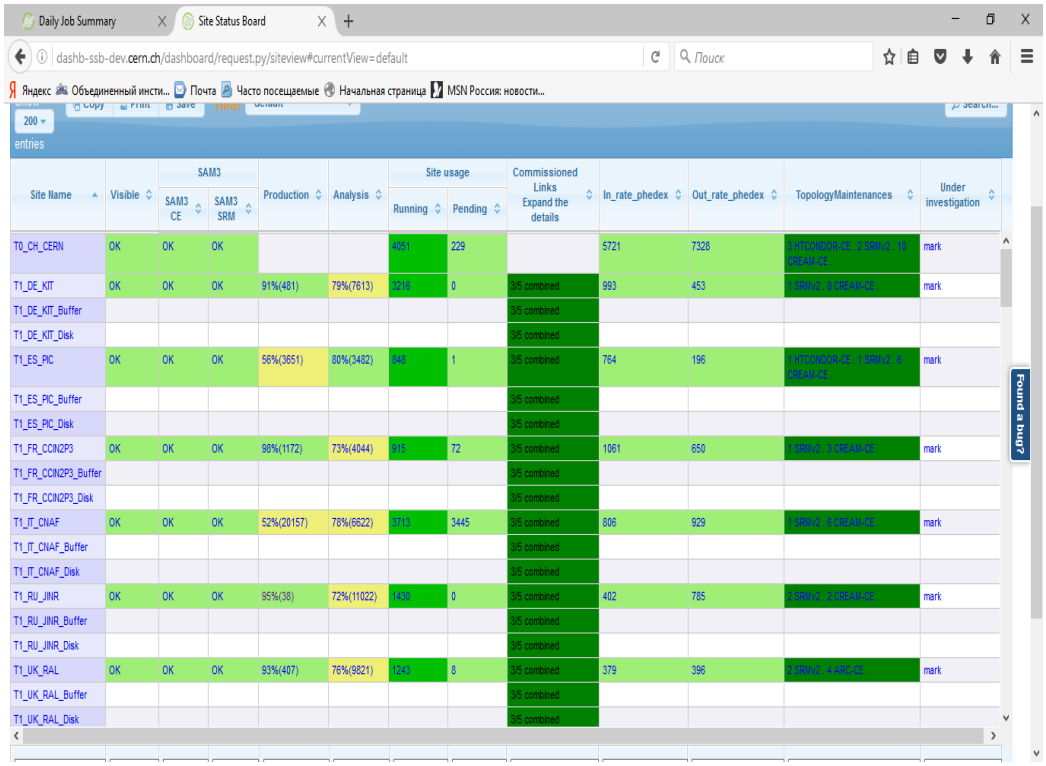

Fig. 2. Information table on the CMS sites readiness

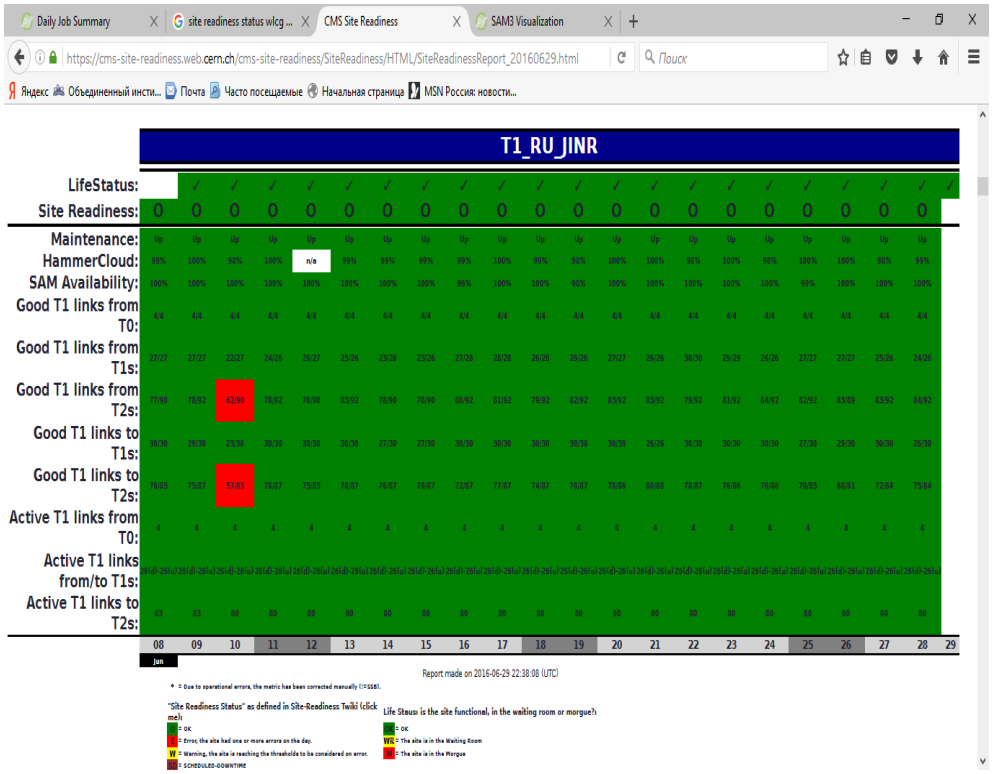

Fig. 3. Example of monitoring a readiness status of the T1_RU_JINR site

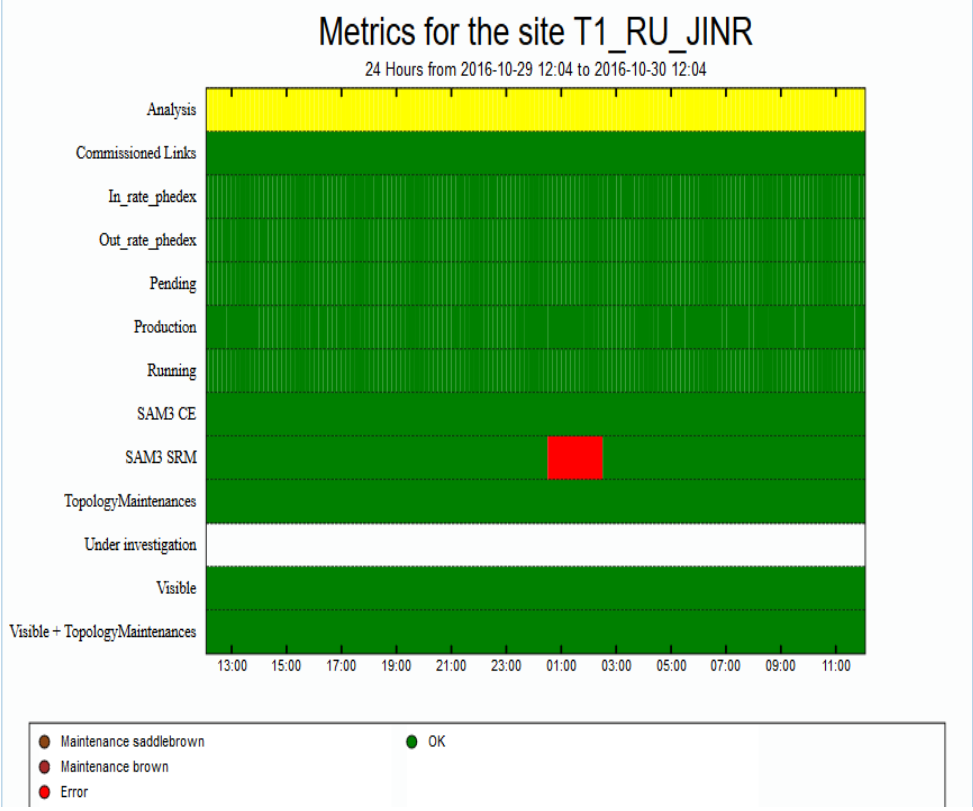

Fig. 4. Example of metrics of readiness of the T1_RU_JINR site for 1 week

Task performance is constantly monitored by calculating the percentage of successfully completed jobs and the efficiency of using CPU (CPU time/wall clock time). On average for the Tier-1, the share of successfully performed jobs generally reaches 90-95% (successful), the main share of failed runs is the errors of software (application failure) including errors in users' programming (the human factor) and the errors occurred due to unstable grid applications that do not exceed 2% (see Fig. 5). After several automatic restarts, the execution of almost all jobs is successful. Some of the streams of data processing at the Tier-1 centres, such as data selection or data aggregation, depend upon I/0, and it is reflected in the less efficient use of CPU, what can be seen in Figure 6.

The total number of successful and unsuccessfully completed jobs is shown in Figure 7.

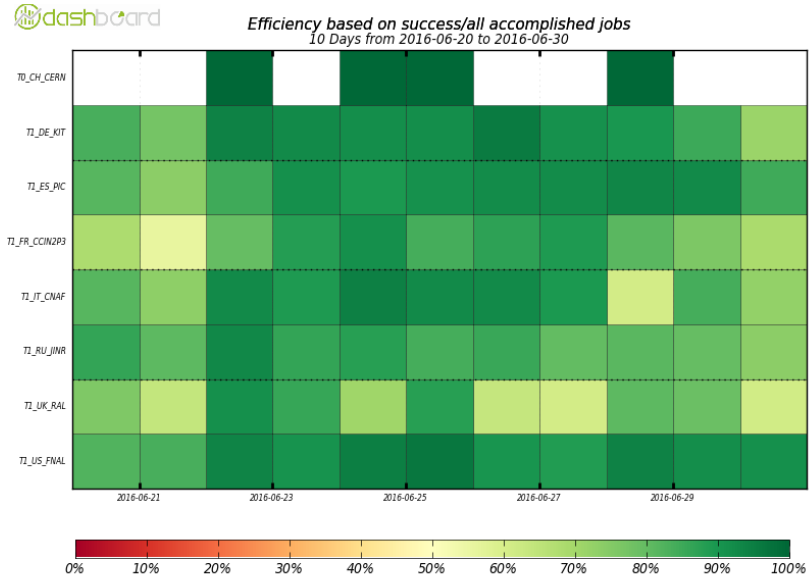

Fig. 5. The efficiency of task performance on the CMS sites of the Tier-1 level

Latest performance results

The contribution of the Tier–1 site at JINR to the processing of the CMS experiment data from March 2015 to June 2016 was 11%, while the greatest contribution to the data processing was provided by the FNAL (47%) site (Fig. 8). Summing up, since its launching in 2015, the JINR site has performed 3 039 672 jobs [http://dashb-cms-jobsmry.cern.ch/dashboard/request.py/dailysummary…]

Figure 9 shows the number of jobs completed (left) and submitted (right) at the CMS Tier-1 in June 2016. Number of events processed for good jobs in Million events at the CMS Tier-1 sites in June 2016 is shown on Figure 10.

Figure 11 shows the number of events processed at the JINR CMS Tier-1 in June 2016 by the CMS activities (production, reprocessing, analysis, etc.)

One of the main functions of the Tier-1 centres is the archival storage of raw experimental and simulated data. Figure 12 shows the load of our tape robot during 2016. Figure 13 illustrates the requests from the Tier-1 and Tier-2 centres to the JINR CMS Tier-1 for data in June 2016. The average rate for RAW data transfers to the JINR CMS Tier-1 site is 250-300 MB/s, more than 1 TB/hour was transferred.

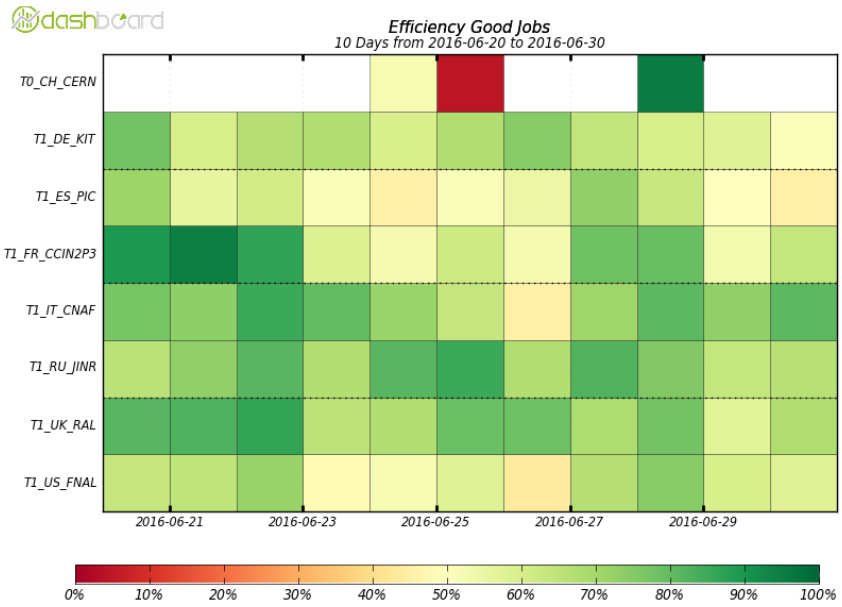

Fig. 6. The daily efficiency of CPU use at each of the Tier-1 centres

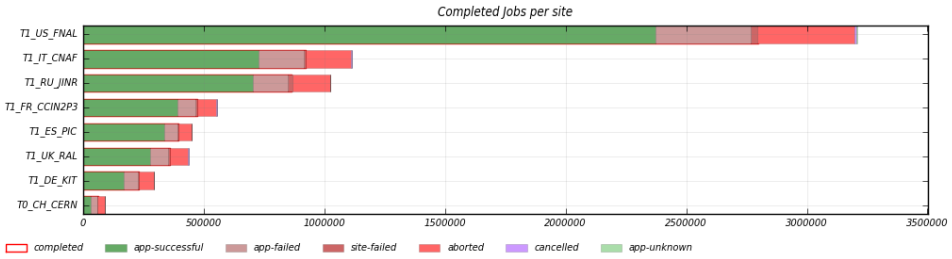

Fig. 7. The number of completed jobs on the CMS Tier-1 sites in June 2016

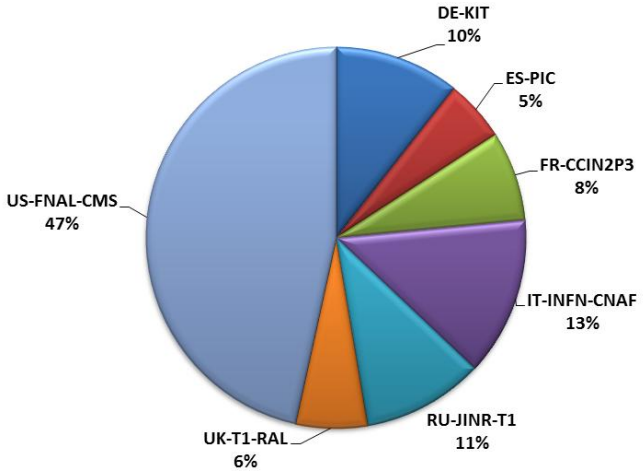

Fig. 8. Normalized CPU time by the CMS Tier-1 from March 2015 to June 2016

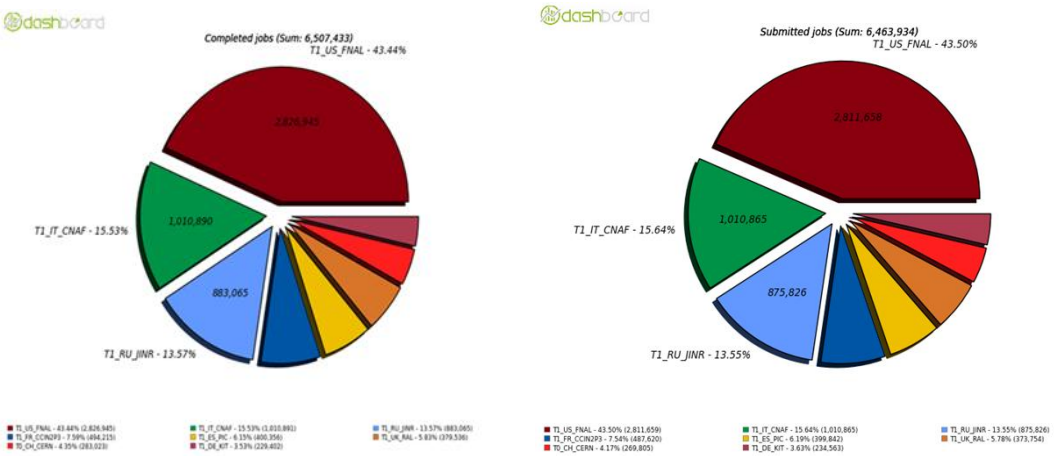

Fig.9. Total number of completed (left) and submitted (right) jobs at the CMS Tier-1 sites

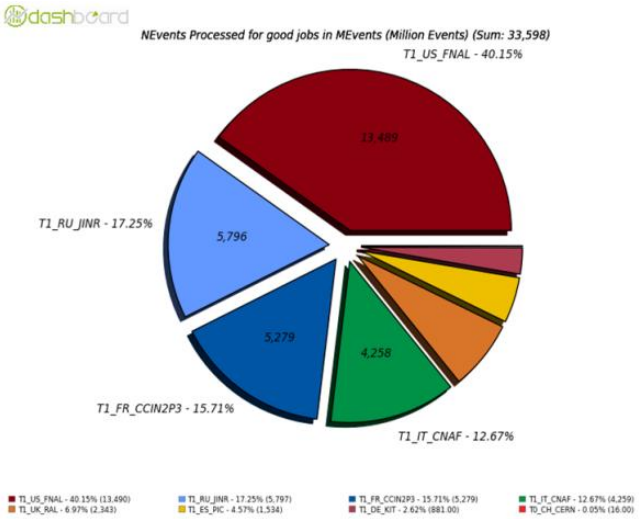

Fig.10. The total number of events processed at the JINR CMS Tier-1 in June 2016

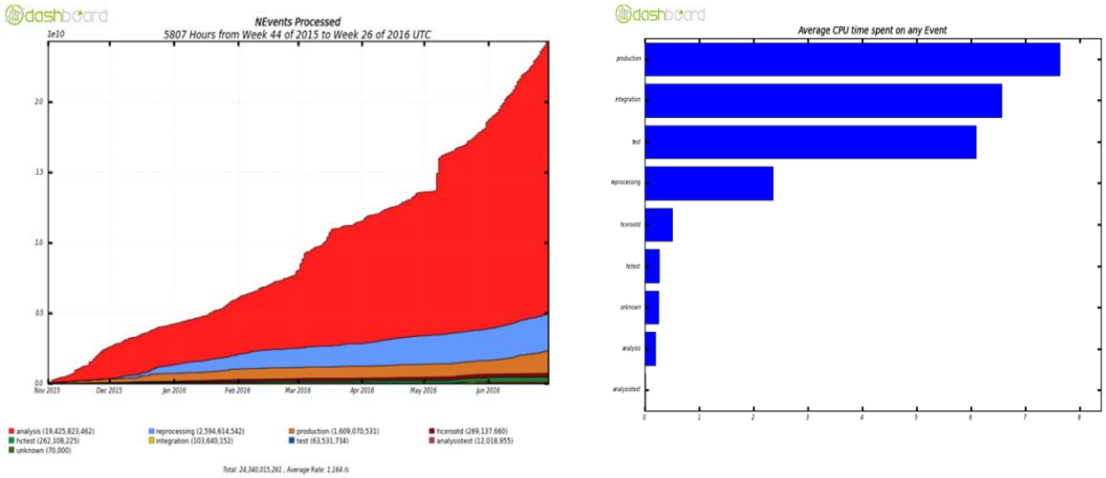

Fig.11. Number of events processed at the JINR CMS Tier-1 in June 2016 by the CMS activities (production, integration, reprocessing, analysis, etc.)

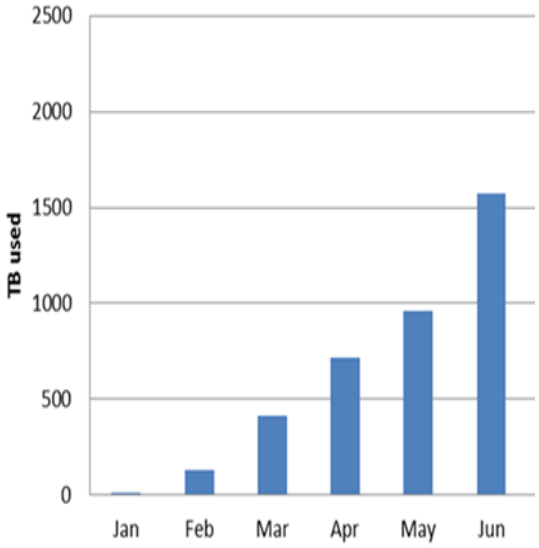

Fig. 12: JINR Tier-1 CMS tape robot load

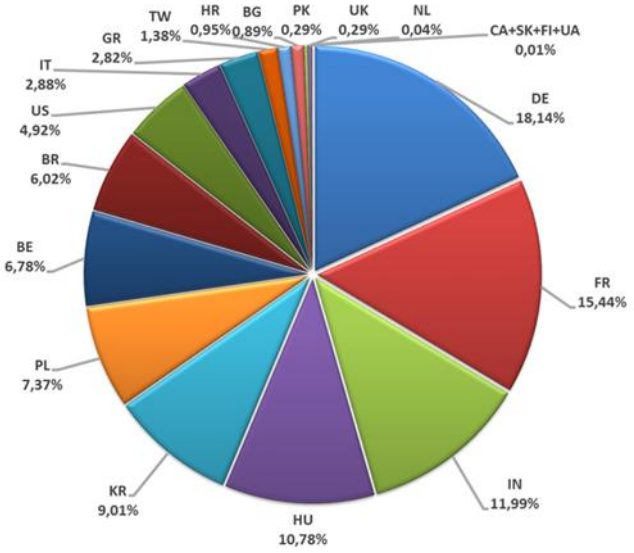

Fig.13. The requests from the Tier-1 and Tier-2 centres to the JINR CMS Tier-1 for data in June 2016

Development plans

As mentioned above, the ongoing upgrade of the LHC accelerator and its experimental facilities significantly increase the amount of data to be stored and processed remotely, because no single computer centre can provide local storage and processing of such amounts of data. All four LHC collaborations constantly raise requirements both to containers for storing data on tapes and disks and to the power of computing resources of all WLCG sites.

At the meeting of the WLCG Management Board of April 19, 2016 in the document entitled CERN–RRB–2016–049, April 2016 (https://indico.cern.ch/event/467565/ contributions/1976011/subcontributions/194936/attachments/1260049/1861735/crsg-april-2016-report.pdf) presented was a report of the WLCG resource group (WLCG Computing Resources Scrutiny Group) containing the analysis of the current usage of computing resources and data storages by all the LHC experiments on the basis of which plans – guidelines have been worked out for the development in 2017 and 2018 of the processor power, disk and tape storage in accordance with the requests of the LHC experiments themselves. The recommendations described in the document were approved at the meeting of the resource committees of CERN (LHC Experiments and WLCG Resources Review Boards) for the experiments at LHC (http://indico.cern.ch/event/503173/ other-view?view=lhcrrb). The plans-recommendations for 2017 are final, while the plans-recommendations for 2018 can be slightly adjusted during 2016.

According to the above-mentioned document, in 2016 the total capacity of all CMS centres of the Tier-1 level should be 400 kHS06, and the total volumes of disk and tape resources – 33 and 100 PB, respectively. There are seven CMS centres of the Tier-1 level, i.e. we can say that on average each of these centres has to provide the computing power of 57 kHS06, disk storage 4.7 PB and tape storage - 14 PB. In April 2016, the Tier-1 centre for CMS at JINR has a computing power capacity of 53 kHS06, 3.5 PB disks and a tape robot of 5 PB. The planned pace of the development of the Tier-1 level centres for CMS is shown in Table 1.

Table 1. Increase in the total volume of resource (how much in % per year and for 2 years)

	2016-2017	2017-2018	2016-2018
Processor power	37.5%	9%	50%
Disk storages	48%	18%	75%
Tape storages	35%	30%	75%

In 2018, the planned development of the resources of the CMS Tier-1 at JINR is to achieve a performance of 83.2 kHS06, and the volumes of disk and tape storage will be 6.1 PB and 20 PB, respectively. Note that the computing resources of the Tier-1 at JINR are at the level of the Tier-1 sites for CMS. Higher rates of growth of the JINR resources is due to the fact that for 2017-2019 planned is the purchase of additional computing resources based on the needs of the prototype of the off-line processing NICA based experiments on the computing, disk and tape resources of the Tier-1 centre for CMS at JINR.

Table 2 shows the planned growth of the Tier-1 resources in 2016-2019 in the planned absolute values with a percentage increase to a previous year.

Table 2. Planned growth of the JINR Tier-1 resources in 2016-2019

	2016	2017	2018	2019
Processor power of the core /kHS06	3400/54.4	4200/67.2 (24%)	5200/83.2 (23%)	10000/160 (52%)
Disk storages (TB)	3390	5070 (49%)	6100 (20%)	8000 (80%)
Tape storages (TB)	10000	20000 (100%)	20000 (0%)	20000 (100%)

Summary

First of all, the need for the development, modernization and expansion of computational performance and data storage capacity of the Tier-1 centre is dictated by the research program of the CMS experiment in which JINR physicists are actively involved as part of the RDMS CMS collaboration. In order to ensure reliable storage and faster access to the data, the latter are stored at least at two sites of the Tier-1 level. At the second stage of the LHC (Run2) all four experimental installations at the LHC have planned a significant, more than twofold, increase in the amount of received and stored data as compared with the first stage (Run1). After a few years it is planned to modernize the LHC accelerator and four experimental installations which will lead to an approximately 4 times increase of incoming data.

The creation and support of the Tier-1 site is an important factor in enhancing the prestige and expertise of JINR. There are only seven such centres for CMS in the world, and the JINR site has been already reached the third place in terms of resources and indicators of reliability, and according to the QoS demands for the Tier-1 level, should be as close to 100% in resource availability and reliability as possible.

Another important result is that in the course of work on the creation and operation of the Tier-1 at JINR, an invaluable experience was gained that is already in demand and will be needed in the future to design, build and subsequently exploit the informational – computational centre for experiments within the NICA project. The expected data volume and required computational resources for NICA are quite comparable with those we are expecting at the Tier-1 at JINR within the next 2 years. We believe that part of the prototype of the centre for storage and processing for the NICA

located at LIT JINR, should be created by analogy with the installation of the Tier-1 for CMS on compatible hardware and by using similar hard- and software solutions, while at the initial stage it is advisable to allocate part of the Tier-1 resources to perform the simulation tasks of the MPD collaboration of the NICA project.

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