Worldwide LHC Computing Grid

REPORT ON PROJECT STATUS, RESOURCES AND FINANCIAL PLAN

COMPUTING RESOURCES REVIEW BOARD
30TH OCTOBER 2012

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This status report covers the period from April – September 2012. Further details on progress, planning and resources, including accounting and reliability data, and detailed quarterly progress reports, can be found in the documents linked to the Reporting section on the WLCG web site.

CONTENTS

1. THE WLCG COLLABORATION

1.1. WLCG MOU SIGNATURE STATUS

As reported to the last meeting the proposal of the Republic of Korea to build a Tier 1 site at KISTI for ALICE was accepted. Since then the MoU has been signed.

The MoU with Slovakia for a Tier 2 site is in the signature process.

The list of Tier 1 and Tier 2 sites, together with the various contact names are available on the WLCG web site at http://cern.ch/lcg/mou.htm (Annex 1 and Annex 2). It is important that the lists of contact people given in these tables are kept up to date. Any changes should be signalled to lcg.office@cern.ch.

1.2. PROPOSALS FOR NEW TIER 1 SITES

At the WLCG Overview Board on September 28 2012, Russia proposed to build Tier 1 sites to support all four experiments. This would include two physical sites, one at the National Research Center "Kurchatov Institute" in Moscow which will provide resources for ALICE, ATLAS, and LHCb, and a second site at the Joint Institute for Nuclear Research in Dubna supporting CMS. The scale of resources proposed is some 10% of the global Tier 1 resource requirement for each experiment. The plan is to have the resources in place by November 2013, and to run a full-scale prototype for 1 year, aiming for full production status of the Tier 1 by the end of the long shutdown.

The proposal was approved by the Overview Board. Russia thus becomes the second Associate Tier 1 site.

2. WLCG STATUS AND OVERVIEW

2.1. THE WLCG SERVICE

During the time since the last Computing RRB meeting in April the experiments have taken a significant amount of data. During 2012, ATLAS and CMS have so far acquired over 15 fb^{-1}, which together with the data taken by ALICE and LHCb results in some 19 PB of data written to tape at the Tier 0. Given the extended running of the LHC into early 2013, it is likely that the total dataset for 2012 will be close to 30 PB.

The data taking and operation of the WLCG infrastructure has been rather smooth during the year, with no particular operational areas of concern. Grid workloads and use of resources continue to be consistently high with close to 100% of available CPU resource being used.

The additional data from the extended run of the accelerator means that computing activities of the experiments will be extended in time compared to the original plans, as there are no additional resources to allow for example planned re-processing activities in parallel with ongoing data taking.

ALICE has acquired over 1 PB of new pp data in 2012 so far, with some test runs with p-Pb beams producing some 2.5 M events. The p-Pb run in early 2013 (still in the 2012 resource year) will not require additional resources. ALICE reports excellent stability in the performance of all of their grid sites. To address the low efficiency (CPU/Wall clock time) of the individual user analyses, they have invested effort to move parts of that activity to the organised "analysis trains" which are far more efficient. Currently only around 20% of the ALICE activities are still in the "chaotic" class, with 80% being organised production or analysis trains.

ATLAS use of resources has been according to their estimated requirements for 2012, although the extended run adds an additional need that can only be accommodated during the shutdown, and the availability of disk space will be a limiting factor until the deployment of 2013 resources alleviates this. ATLAS actually has more CPU available to them than their pledges due to the efforts of their grid sites, and this has been essential to produce the needed amount of Monte Carlo. ATLAS have written in excess of 7 PB in the Tier 0. In 2012 they anticipate reprocessing of the full 8 TeV pp sample as well as the 2011 heavy ion data.

CMS has also made full use of the resources available to them with occupation of Tier 1 and Tier 2 sites often in excess of 100% of pledged resources. The Tier 0 is also operating well for CMS with good CPU efficiency. Due to the additional load of the "parked" data which has to be re-packed in the Tier 0 before archiving, they frequently make use of batch capacity above their Tier 0 capacity in order to catch up with the processing load, particularly after long or high luminosity fills. CMS now also make use of the data popularity tools (as does ATLAS) to more optimally manage the Tier 2 disk space. The CMS reconstruction code has improved in speed by a factor of 8 since 2010, with a 40% memory reduction.

LHCb during 2012 has managed the prompt processing of all the new data, as well as the "swimming" of the full 2011 sample to improve the vertex resolution (this is a very CPU intensive activity), as well as Monte Carlo production for 2011 and 2012 data. They have started the reprocessing of the 2012 sample and this has put their CPU use to around 100%. They have reduced the number of disk copies of data sets significantly in order to fit within their disk pledges. However they have a new DST format that contains a copy of the raw data and is thus significantly larger than the existing DST. This

allows the stripping process to be far more efficient, but the impact is that their tape needs have increased significantly and they currently have a shortfall projected to be ~5PB by March. The extended LHC run exacerbates the problem.

2.1.1. Tier 0 Performance

The performance of the Tier 0 mass storage system has been very smooth, with data volumes written to tape continuing to increase. Currently between 3.5 and 4 PB per month (1 PB/week) are written to Tier 0 tape, which can be compared to the ~2 PB /month during pp running in 2011. This increase is due to the increased luminosity and event sizes, but mainly due to the additional triggers that are being written compared to 2011.

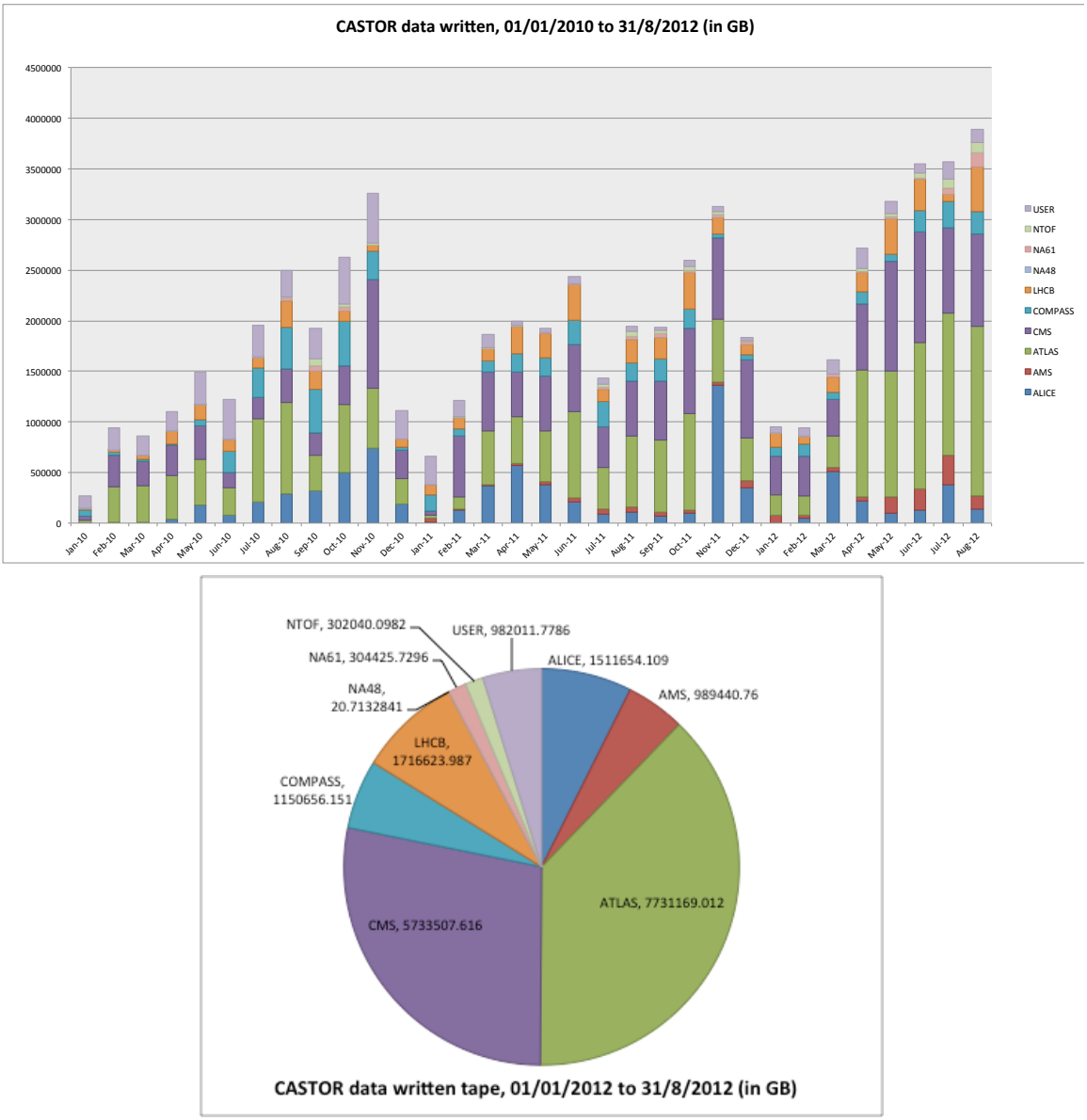

Figure 1: Data written to tape in 2010-12; (top) by month and experiment; (bottom) total written by experiment in 2012 to end August.

Figure 1 shows the monthly accumulation of data in since 2010. The increased rate in 2012 is clear. The accumulated data by experiment for 2012 are also shown in the Figure.

The data rates in and out of the Tier 0 mass storage service remain at high levels, up to 4 GB/s input and around 15 GB/s output on average over a year. Instantaneous rates can be significantly higher. There are no operational problems noted in managing these high rates.

2.1.2. WLCG Workloads

Figure 2 and Figure 3 show the continued high use of the grid infrastructure in terms of the numbers of jobs and CPU usage. These figures remain at a high level almost independent of the accelerator running periods as the grid manages differing workloads at different times but always at a high level. The fact that during the year these are essentially constant is another indication that the resource is fully used.

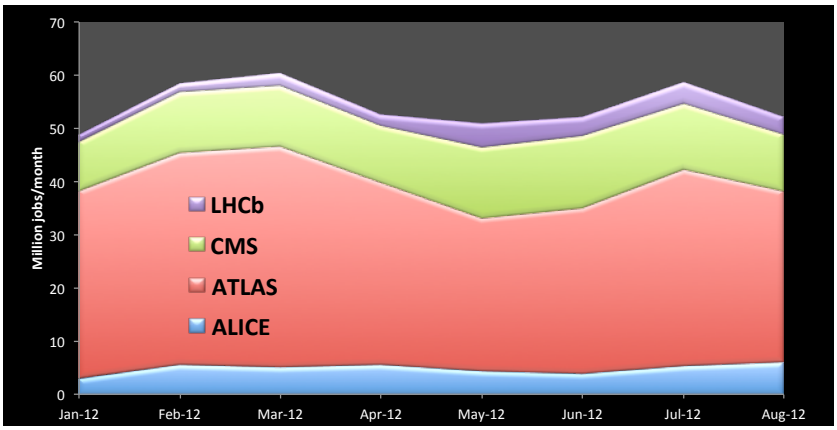

Figure 2: Continued evolution of jobs run per month; now in excess of 2 M /day

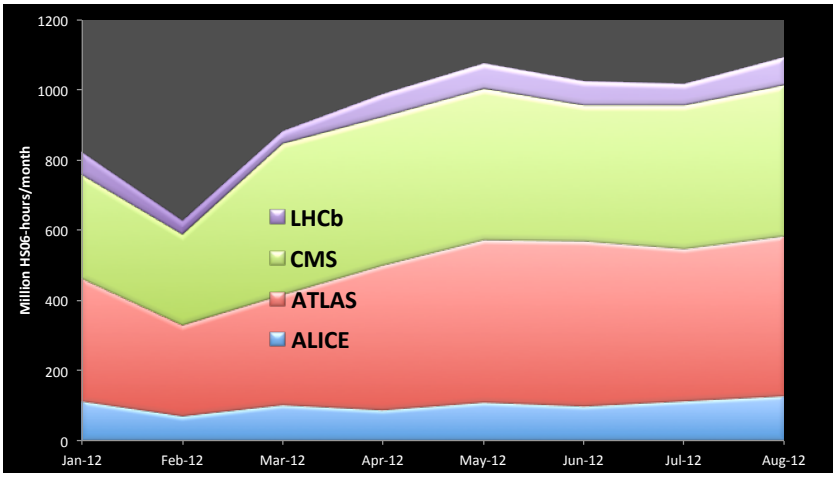

Figure 3: CPU use continues to grow; 10^9 HS06-hours/month (equiv. to ~150 k CPU continuous use)

More details on resource usage are given in Section 4.

2.1.3. Data transfers

Data transfer rates continue to be significant – transfers from CERN to Tier 1s are stable around 2 GB/s during the LHC running, while global transfers are continually above 10 GB/s on average, and recently close to 15 GB/s average. These are shown in the Figures below.

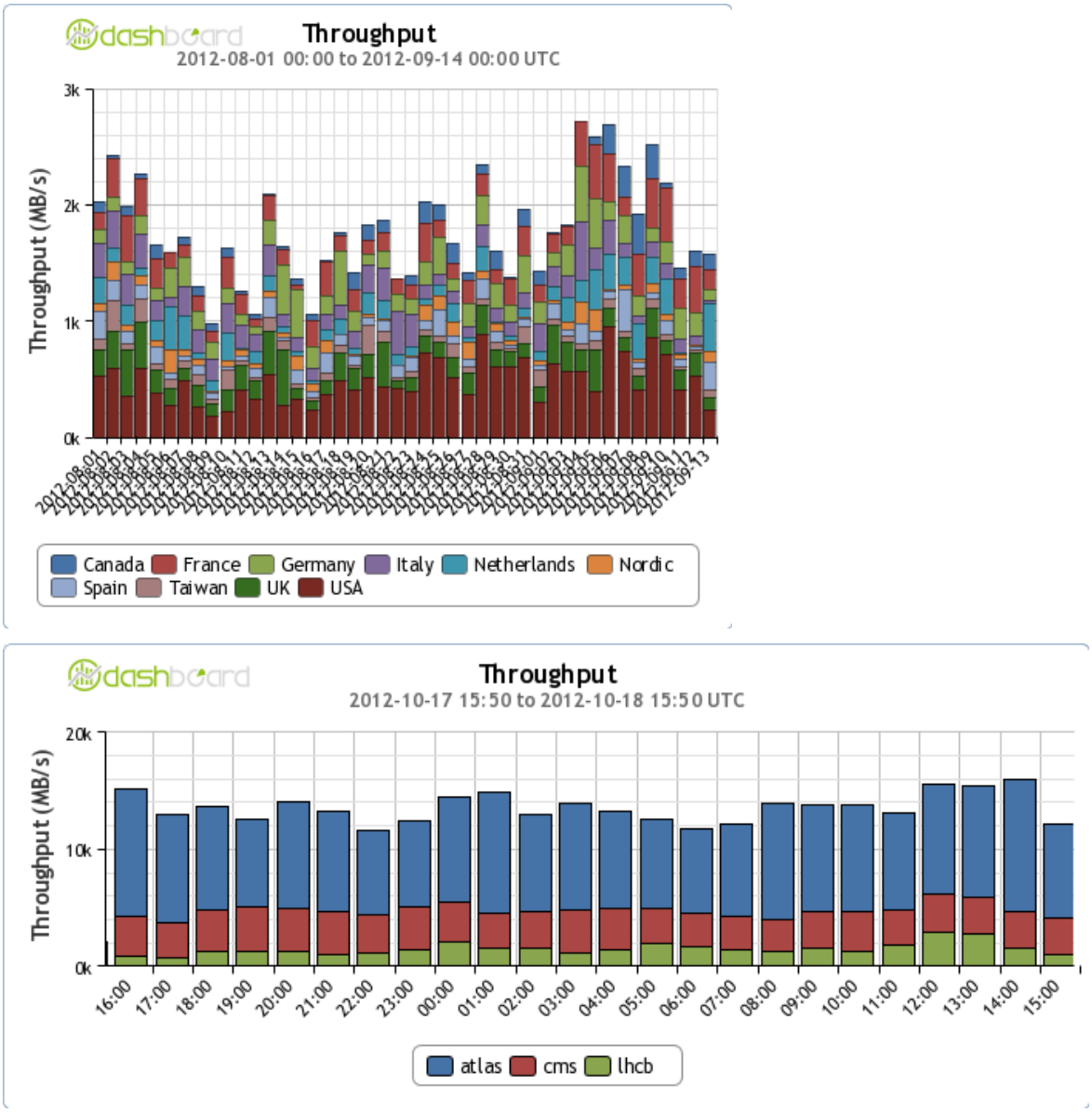

Figure 4: Data transfers: (top) CERN-Tier 1s, (bottom) recent example of global transfer rates ~15 GB/s

2.1.4. WLCG Service Status

As previously described, significant service interruptions require a documented follow up (Service Incident Report). The full list for this period, summarised in the Table below, can be consulted on-line at https://twiki.cern.ch/twiki/bin/view/LCG/WLCGServiceIncidents. The number of incidents serious enough to require this documented follow up continues to decrease.

Figure 5 shows the types of incidents and how this has evolved over the last several years. Also shown in the Figure are the lengths of time needed to resolve the problems. What can be observed is that the majority of problems now are those that take longer to resolve (and are probably thus the most complex ones), and are usually related to the physical infrastructure at a site, or are database-related. However, one should remember that the overall level is now significantly less than earlier, and at a

level that is considered to be sustainable in terms of the amount of effort required by sites for daily operations.

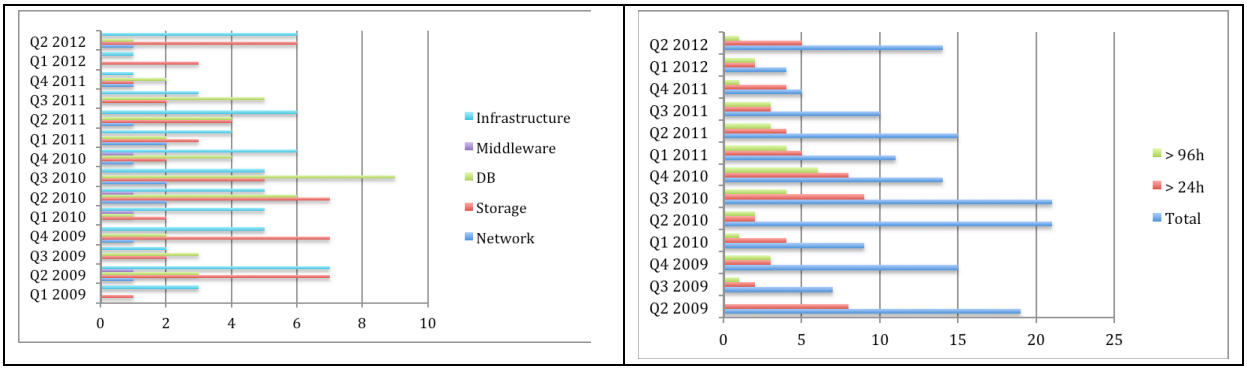

Figure 5: Service Incidents by quarter since 2009: (left) by type; (right) by time to resolve

Table 1: Service Incidents requiring follow-up: Q2-Q3 2012

Site	Service Area	Date	Duration	Service	Impact
CNAF	Storage	Sep 21-27	6d	StoRM	LHCb data unavailable and queue closed
IN2P3	Infrastructure	3-4 Jul	21h	CVMFS	ATLAS and LHCb job failures
IN2P3	Storage	1-2 Jul	30h	dCache	job and transfer failures, batch on hold
IN2P3	Network	29 Jun	4 h	Network	All outside connectivity lost
IN2P3	Infrastructure	24 Jun	36 h	CVMFS atIN2P3	ATLAS and LHCb jobs crashed, dCache overload by CMS jobs
PIC	WNs	21 Jun	1 h	PIC Tier1 Computing	About 17% of the WN capacity switched off due to cooling incident
CERN	Storage	18 Jun	~1h	CASTOR	c2atlas diskservers were not reachable for ~1h
CERN	Storage	5 Jun	1 h	CASTOR	communication problems and client timeouts

PIC	WNs	3-4 Jun	18 h	PIC Tier1 Computing	18h of service degradation: Number of cores reduced by 60% due to cooling incident
CERN	DB	22 May	1.5 h	CMS online DB	1.5 hours of high luminosity data lost
CERN	Storage	22 May	5-40 min	CASTOR	~1k unavailable files after transparent DB intervention
CERN	Infrastructure	19-20 April	1 day	batch	batch system down
CERN	Infrastructure	18-20 April	2 days	batch	ATLAS Tier-0 job submission system could not keep up with incoming RAW data
ASGC	Storage	11-12 April	24 h	CASTOR	hardware failure, DB crashed
TRIUMF	All Tier-1 services	10-11 April	20 h	All Tier-1 services	Two site-wide power failures
CERN	Storage	4 April	1.5 h	CASTOR	Name Server stuck, 3 CMS files had to be rewritten
CERN	Storage	2 April	many days (~10)	CASTOR	1 LHCb diskserver hardware issue (files unavailable, finally 3 file systems lost)

In general WLCG operations during this period have been smooth, although there has been an ongoing problem with the LSF batch system at CERN where response times under heavy load have not been acceptable. This issue is still being investigated with the vendor, but seems to be related to reaching some limitations of the system associated with the very heavy usage patterns, the large scale and complexity of the CERN set up. Some mitigations have been put in place and others are being implemented. However for the long term, it is clear that the strategy for the batch service must be reviewed, and this has been started.

2.2. SITE RELIABILITY

The reliabilities for the last 6 months for CERN and the Tier 1 sites are shown in Table 2.

Table 2: WLCG Tier0/1 Site Reliability - last 6 months

Apr 2012-Sep 2012

Average of 8 best sites (not always the same 8)

Month	Reliability
Apr 12	100
May 12	100
Jun 12	100
Jul 12	100
Aug 12	100
Sep 12	100

Average of ALL Tier-0 and Tier-1 sites

Month	Reliability
Apr 12	96
May 12	98
Jun 12	99
Jul 12	99
Aug 12	99
Sep 12	99

Detailed Monthly Site Reliability (OPS tests)

Site	Apr 12	May 12	Jun 12	Jul 12	Aug 12	Sep 12
CA-TRIUMF	99	99	100	100	100	98
CH-CERN	78	100	100	100	95	100
DE-KIT	100	99	100	100	100	99
ES-PIC	100	100	100	98	100	100
FR-CCIN2P3	100	100	100	100	100	100
GSDC-KISTI	79	86	85	94	91	94
IT-INFN-CNAF	100	98	100	100	100	99
NDGF	99	97	99	100	100	100
NL-T1	99	98	97	94	100	99
TW-ASGC	100	99	100	100	98	98
UK-T1-RAL	100	100	100	100	100	100
US-FNAL-CMS	100	100	100	100	99	100
US-T1-BNL	100	98	100	100	100	100
Target	97	97	97	97	97	97

Colors: Green > Target Orange > 90% Red < 90%

New in the Table is the addition of the reporting of the new KISTI Associate Tier 1, where a ramp-up in reliability can be seen through the reporting period. These reliabilities continue to be rather stable now for all Tier 1 sites, and the majority of the Tier 2s. Full reports on the availability and reliability of all sites, including the readiness measured by the experiments, can be consulted at http://cern.ch/lcg/reliability.htm.

2.3. APPLICATIONS AREA

2.3.1. ROOT

The ROOT team released a new version of ROOT v5-34-00 on June 5th. One interesting new feature of this release is the ROOT I/O package rewritten in Javascript. This allows the browsing and displaying of histograms in any ROOT file hosted on a web server, without any server side plugins. This is still work in progress. Also this new version came with a first version of a native graphics back-end for MacOS X using Cocoa that does not depend on X11 anymore. For a complete description of all new features see the release notes.

ROOT 5.34 is the last production release before the major release of ROOT 6 scheduled by the end of the year. It was agreed with the experiments that this version would be a 'Long Term Support' version, in which new features will be back ported from the trunk on request by the experiments.

2.3.2. Persistency Framework

New releases of CORAL and COOL have been prepared for LHCb, mainly motivated by the upgrade to ROOT 5.34. The CORAL release includes major improvements in the handling of connection instabilities (CORAL is now able to reconnect transparently if network glitches do not break a transaction context), as well as important fixes in the cleanup of stale OCI sessions (avoiding crashes reported in a few uncommon situations). This is also the first release on SLC6 and the first release where support for the LFC replica service component of CORAL has been dropped. Finally, the code base of CORAL and COOL has been ported to gcc47.

Investigated possible use of Kerberos authentication for Oracle databases. A test setup was successfully prepared to connect to a test database using the standard Kerberos ticket from the CERN KDC (i.e. the one also used for AFS).

Support was provided to LHCb about the problems they experienced when trying to connect to Gridka databases using CORAL. The problem is now understood as being due to the Oracle character set used at Gridka, which is different from the one used at CERN. Two possible solutions have been suggested and the issue is now being followed up within LHCb.

2.3.3. Simulation

The new 9.6-beta preview release of Geant4 has been provided in June as scheduled. The release included several non-physics developments and fixes: it corrects issues of event reproducibility for cases when starting from an intermediate event; checking of energy/momentum conservation for large errors is now enabled and hadronic processes now trigger re-sampling of the interaction if the default limits for energy/momentum conservation are exceeded. Physics enhancements include: improved description of diffraction cross-section and final state in the FTF physics model; a new model of gamma-nuclear and electro-nuclear interactions, gamma-nuclear reactions use the Bertini cascade; adoption of the Bertini model for nuclear capture at rest of pi-, K-, and Sigma-; improved cross-section for light ions; new total cross-section sets based on SAID data-base; handling of heavy-ion collisions with new version of the INCL cascade model. New data set G4EMLOW-6.27 includes Bremsstrahlung data files from NIST with extended grid, and probabilities of scattering off electrons.

The new neutron data set G4NDL-4.1 converts data from ENDF/B-VII.r1 for most isotopes. Regarding EM physics, the WentzelVI model is now used for multiple scattering of e+ and e- above 100 MeV in all physics-lists for HEP applications. Energy range of dEdx and other tables has been extended for monopoles with large mass, as required for the interpolation of dEdx for super-heavy monopoles. Validation of the last beta release has been performed on the GRID, and carried out using resources at CEA, CERN, and KEK, plus additional machines at LLR and Nikhef. Other technical features include: a default description for each hadronic process, where model or cross-section can now be printed in HTML by invoking new Description() methods. The new prototype of the multi-threaded Geant4 code, Geant4-MT, is now ready and based on the last production release 9.5.p01. It will be released in August. Two new notes have been published, both dealing with dedicated studies using the Simplified Calorimeter testing suite. The first describes the findings on the role of neutrons for the lateral hadronic shower profile (CERN-LCGAPP-2012-02); the second describes the technical implementation of the "shower moments analysis" and contains instructions on how to extend it (CERN-LCGAPP-2012-01). Following the 2012 planning meeting for Generator Services held last Spring, it was acknowledged experiments are satisfied with the way the project is currently running and are using the GENSER repository in all the productions.

2.4. PLANNING AND EVOLUTION

2.4.1. Technical Evolution of WLCG

During the last quarter the reports from the Technical Evolution Groups (TEG) were finalized. The reports are available in the WLCG document repository at: *https://cern.ch/wlcg-docs/Technical_Documents/Technical Evolution Strategy*. Following several discussions in the Management Board and in the Grid Deployment Board, and analysis of the TEG reports, several groups have been set up to address specific topics raised in the TEG work, or to finalize some of the work. The MB agreed the following working groups:

- Long term groups:
  - *WLCG Service Coordination and Commissioning.* This group will be the core operations and deployment coordination team in the future, and will manage ongoing operational issues as well as new deployments. It will replace some of the existing operations/deployment meetings and teams.
- Fixed-term groups:
  - *Storage Interfaces*. Should finalise the set of interfaces needed to storage systems, including the sub-set of SRM that is still useful, as well as things like monitoring and accounting interfaces needed.
  - *Data Federations*. To follow up on the work that has been done in the experiments on xrootd federations, and to assess what is required to make this into aservice.
  - *I/O Benchmarking*. To collect realistic workloads in order to optimize existing or planned site installations with respect to an expected I/O workload (eg CPU vs Network vs RAM vs SSD vs Disk cost); optimization of experiment I/O layer wrt to local and federated data access; optimization of SE implementations wrt to an expected I/O load; determination of aggregate I/O patterns of a real job population in order to obtain realistic parameters for the above and in order to identify changes of the real I/O over time.
  - *Monitoring*. To define a strategy, propose priorities and coordinate monitoring activities, to restrict the current divergence of activities.
  - *Risk Assessment*. To propose computer security risk mitigations/recommendations and following up on the risk assessment.

In addition to these, there will also be one-off meetings or follow-up discussions to address the following topics:

- *Traceability*. Define requirements on software/services and operational recommendations for sites.
- *Workload Management: CE extensions*. Define the scope, implementation and testing plans for CE extensions. Priority is for multi-core support.
- *Remaining uses of the WMS*. Document the remaining uses of the glite-WMS with the goal of removing WLCG dependence on this software.
- *Software Lifecycle Process*. Document a software lifecycle process for WLCG after the end of EMI. This should also coordinate with the OSG team where there are many commonalities now.

There is a proposal for a Collaboration to continue support/evolution of the DPM storage management software beyond the end of the EMI project, and several countries have expressed their intentions to join this collaboration. This will help the long-term support for this storage product.

2.4.2. Tier 0 Evolution

The consolidation work to provide additional critical power to the existing CERN Computer Centre is also on-going and is now scheduled to finish in November 2012 (one month later than originally planned). This extension will be available for the installation of equipment for the 2013 pledges.

The remote centre at the Wigner Institute in Budapest is also on track to enable first equipment installation in 2013 for early testing. The procurement of the 2x100 Gb networking between CERN and the new centre has also been completed, although the final connections to the Wigner centre have not yet been made. As mentioned in the previous RRB meeting, there were open questions on the possible effects of network latency between Geneva and Budapest centres. To this end a delay box has been used in the CERN production environment to simulate this latency. So far no effects have been observed, although tests are still ongoing.

Management procedures, including equipment installation and configuration, that are proposed for use with the remote centre have also been satisfactorily tested during 2012.

3. FUNDING AND EXPENDITURE FOR WLCG AT CERN

Table 3 shows the updated current and future estimated expenditure for the years 2012-2017 inclusive based on the CERN Medium term Plan and the current WLCG Personnel and Material planning.

Table 3: LHC Computing budget estimates for 2012-2017

LHC Future Computing Funding and Expenditure Estimates
(all figures in MCHF)

	2012	2013	2014	2015	2016	2017	TOTAL
Funding							
From CERN Budget							
- Personnel	16.4	17.9	17.8	17.7	18.0	18.4	**106.2**
- Materials *	25.8	22.9	23.1	21.2	20.3	20.3	**133.6**
Contributions via Team Accounts**							
- Personnel	1.0	0.5					**1.5**
- Materials							
Total							
- Personnel	**17.4**	**18.4**	**17.8**	**17.7**	**18.0**	**18.4**	**107.7**
- Materials	**25.8**	**22.9**	**23.1**	**21.2**	**20.3**	**20.3**	**133.6**
Total Funding	**43.2**	**41.3**	**40.9**	**39.0**	**38.2**	**38.7**	**241.3**
Expenditure							
- Personnel ***	**17.4**	**18.7**	**18.2**	**17.7**	**17.8**	**17.9**	**107.7**
- Materials	**26.6**	**21.7**	**19.5**	**27.0**	**24.0**	**22.5**	**141.2**
Total Planned Expenditure	**44.0**	**40.4**	**37.7**	**44.7**	**41.8**	**40.4**	**248.9**
Balance Personnel	**0.0**	**-0.3**	**-0.4**	**0.1**	**0.2**	**0.5**	**0.0**
Balance Materials	**-0.8**	**1.2**	**3.6**	**-5.8**	**-3.7**	**-2.2**	**-7.6**
Balance	**-0.8**	**0.9**	**3.2**	**-5.7**	**-3.6**	**-1.7**	**-7.6**

* Includes 4.9 MCHF carry-forward from 2011 to 2012-2015
** As planned to be pledged in the WLCG MoU (Annex 6.6)
*** Excluding EGI/EMI funded personnel and Computer Centre Operators

For personnel costs, nominative details continue to be entered in the CERN APT planning tool, including current personnel commitments, planned replacements and estimates for on-going recruitment from 2012 and beyond. There is little discrepancy relative to the budget and factors such as internal mobility, resignations, and later than expected start dates can impact these figures at any time.

The Materials planning is based on the current LCG resource planning, based on provisional requirements that evolve frequently, and on the latest LHC accelerator schedule. There are large uncertainties in predicted costs for 2015 onwards, in particular the estimates of the experiment computing requirements for 2015 and subsequent years. The fluctuations in spending from year to year are driven by specific anticipated expenditures such as commissioning the remote Tier 0 and

network equipment replacements. The cost estimates are less reliable for future years, and will evolve with time.

4. RESOURCES

4.1. RESOURCE ACCOUNTING

Full accounting reports are published monthly for the Tier 0, Tier 1, and Tier 2 sites. These reports are archived in the WLCG Document Repository.

4.1.1. CERN and Tier 1 Accounting

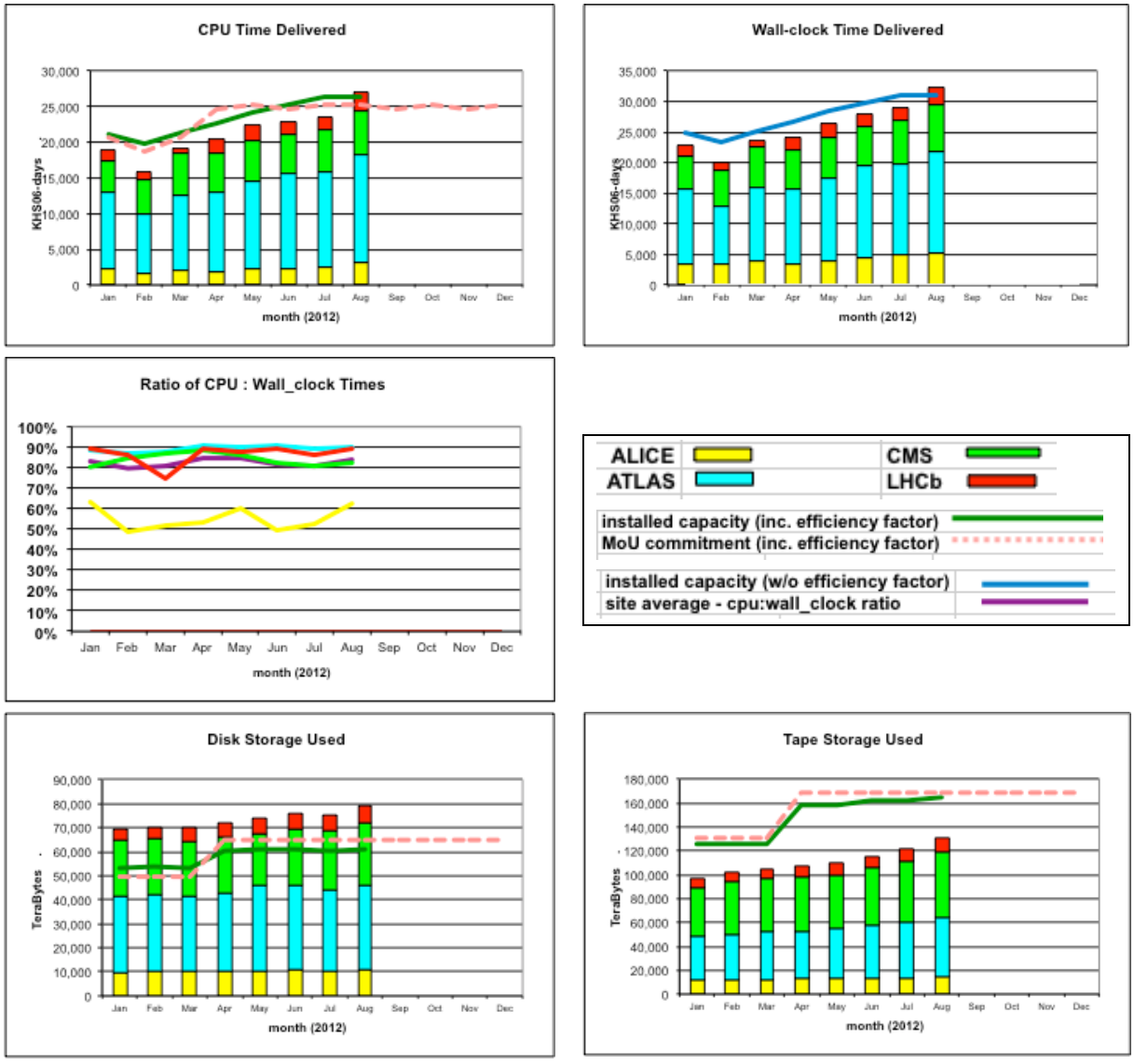

Figure 6: Accounting for Tier 0 + Tier 1s; Jan 2012 - Aug 2012

Figure 6 shows the summary of the usage of CPU, Disk, and Tape at the Tier 0 and Tier 1 sites for 2012. The use is compared globally with the pledges and installed capacity in this Figure, while in Figure 7 the experiments' use of CPU is compared to the pledges directly. As can be seen, the Tier 1 use is close to 100% almost all of the time. It is also clear that at certain times (e.g. early in the year, when the following year pledges start to be installed) the experiments are able to use more than the nominal pledges. LHCb and ALICE in particular can be seen to make use of significantly more than their nominal pledges when resources are available.

The earlier problems with low CPU efficiency for ALICE have been addressed through a series of actions, and these have improved the situation for the production and organised analysis activities. However, the efficiency is still lower for ad-hoc analysis activities, but ALICE are gradually moving more of this kind of work into their organised "analysis trains" to continue to improve the overall efficiency.

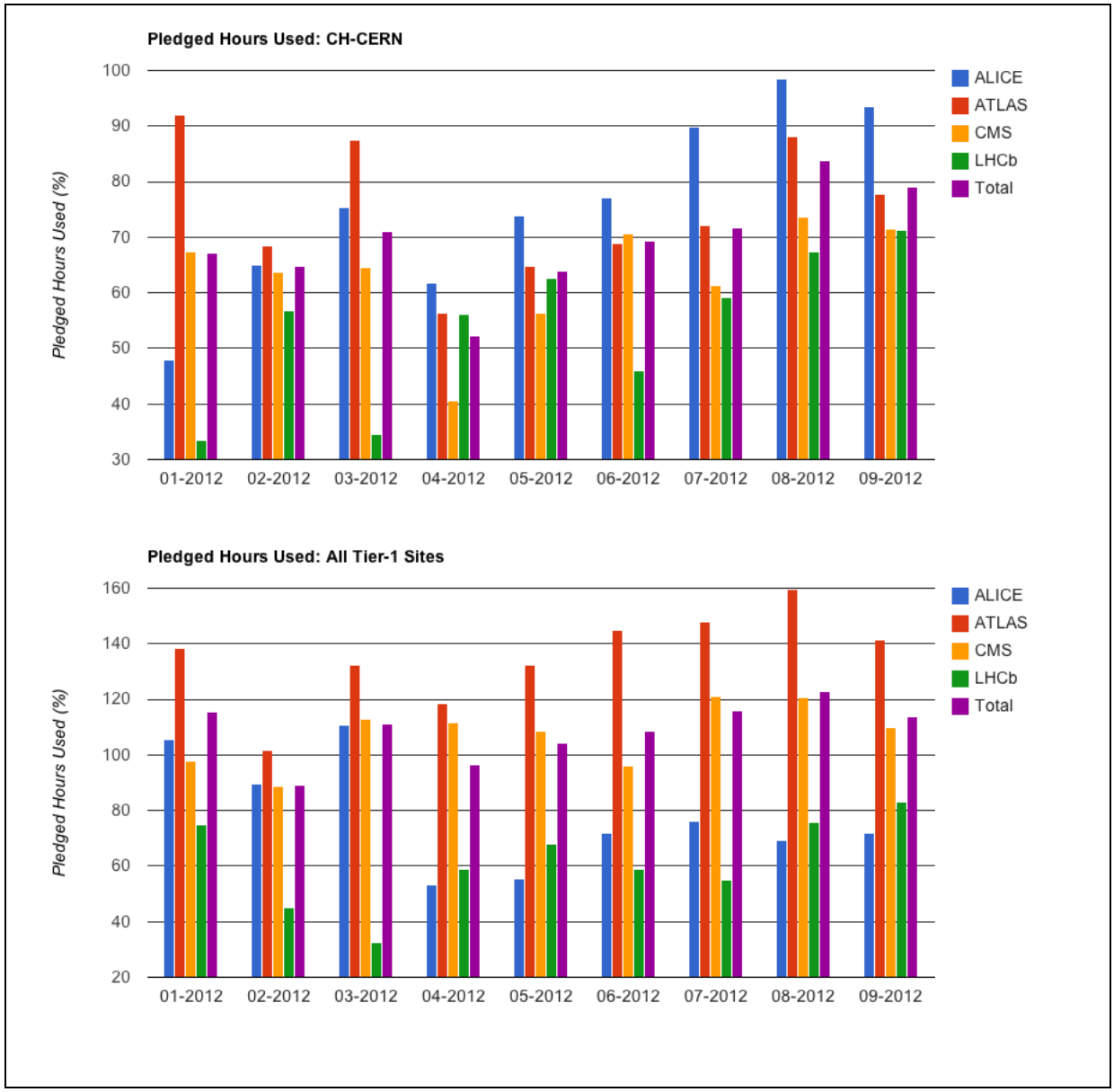

Figure 7: Comparison of CPU usage with pledges for 2012;(top) CERN; (bottom) Tier 1s

4.1.2. Tier 2 Accounting

Tier 2 accounting reports can also be found in the WLCG Document Repository.

Figure 10 shows the cumulative Tier 2 CPU delivered during 2012 by country. This partitioning is very close to that expected from the pledge values.

Figure 11 compares the Tier 2 CPU delivered in 2012 to date with the pledges, for each experiment and overall. Again, as was observed with the Tier 1s the overall use is at or even above 100% (indicating that often more resources are available than actually pledged).

Overall it is clear that resources in Tier 1 and Tier 2 sites are being very well used by all 4 experiments, and that there is very little free capacity. The exception is the Tier 0, where the capacity must be available for the periods when the accelerator is running, but is not necessarily used fully outside of those times. In the long shutdown, the experiments intend to make full use of the CERN resources as additional analysis capacity.

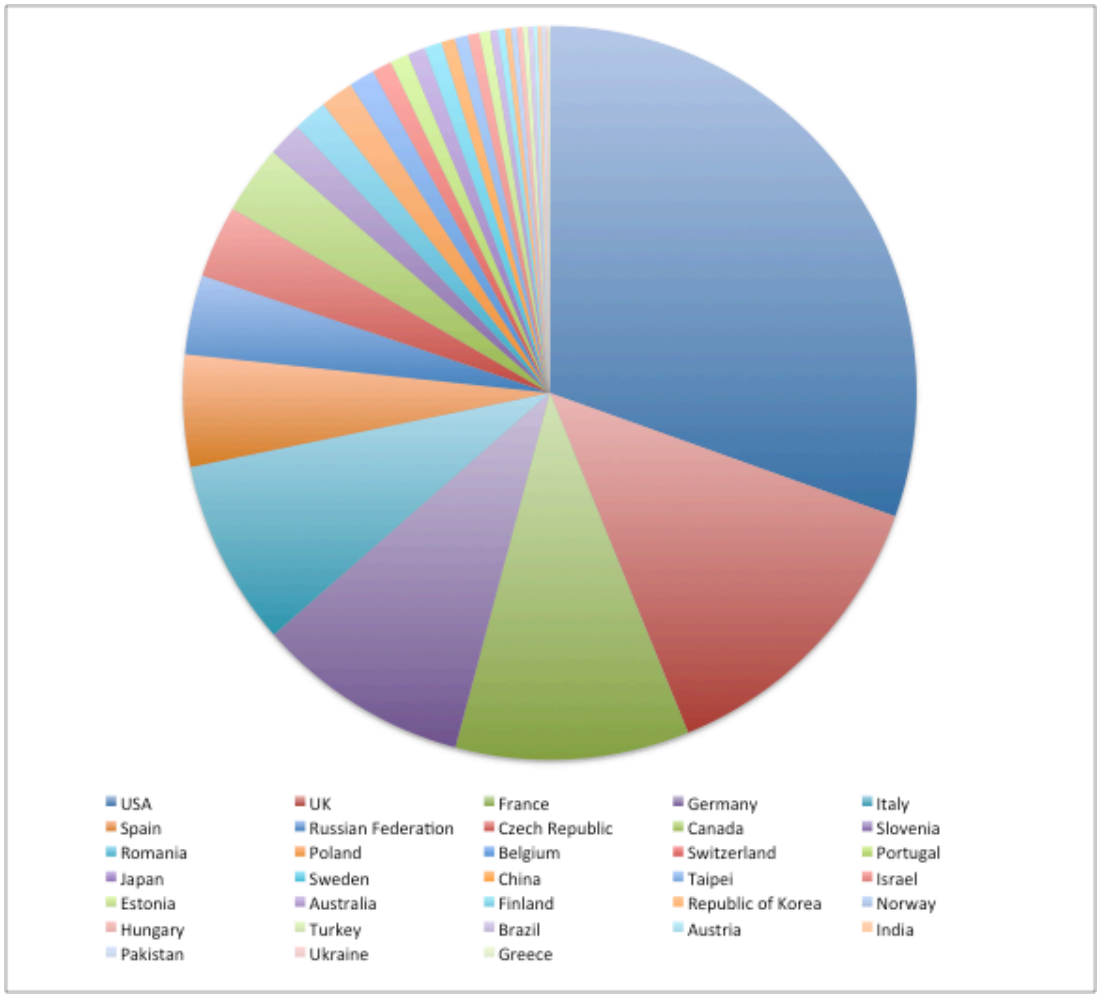

Figure 8: Tier 2 cumulative CPU time delivered by Country (Jan 2012 - Sep 2012)

It is clear from Figures 7 and 11 that ATLAS has access to a fairly significant amount of CPU in addition to the formally pledged amounts, both at Tier 1s and particularly at Tier 2 sites.

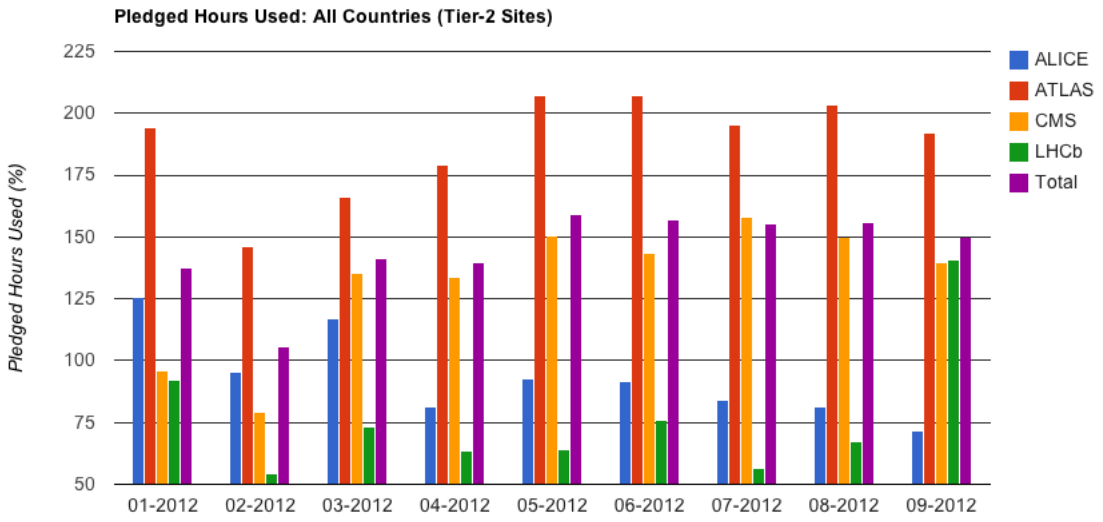

Figure 9: Comparison of CPU usage with pledges for 2012: Tier 2s

The comparison plots of CPU against pledge (such as Figure 7, 11) can be obtained from the MyWLCG portal (http://grid-monitoring.cern.ch/mywlcg/trends/) and in particular can be obtained country by country for the Tier 2s. This may be of interest to the RRB delegates.

4.2. STATUS OF EXPERIMENT REQUIREMENTS AND RESOURCE PLEDGES

As described at the previous RRB meeting, the requirements and pledges are now managed through the online REBUS tool. Figure 10 gives a snapshot of the situation for 2013 and 2014 as of October 2012 (but this can be consulted using the REBUS tool at any time). The annexes of this report give the detailed breakdown by experiment and federation for 2012, 2013 and 2014.

Tier	Pledge Type	ALICE	Required	Balance	ATLAS	Required	Balance	CMS	Required	Balance	LHCb	Required	Balance	SUM	Required	Balance
Tier 0	CPU (HEP-SPEC06)	90000	125000	-28%	111000	111000	0%	121000	121000	0%	34000	34000	0%	356000	391000	-9%
Tier 0	Disk (Tbytes)	8100	13400	-40%	10000	10000	0%	7000	7000	0%	4000	3500	14%	29100	33900	-14%
Tier 0	Tape (Tbytes)	22800	23500	-3%	27000	19000	42%	24000	23000	4%	6500	6200	5%	80300	71700	12%
Tier 1	CPU (HEP-SPEC06)	101155	95000	6%	333023	297000	12%	149650	145000	3%	92118	91000	1%	675946	628000	8%
Tier 1	Disk (Tbytes)	7174	10900	-34%	35316	29000	22%	23561	26000	-9%	6997	7600	-8%	73048	73500	-1%
Tier 1	Tape (Tbytes)	14119	19100	-26%	40763	34000	20%	48276	45000	7%	8711	6100	43%	111869	104200	7%
Tier 2	CPU (HEP-SPEC06)	138406	195000	-29%	390333	319000	22%	397176	350000	13%	47302	47000	1%	973217	911000	7%
Tier 2	Disk (Tbytes)	10906	19400	-44%	48552	49000	-1%	28806	26000	11%	69	0	0%	88333	94400	-6%

Tier	Pledge Type	ALICE	Required	Balance	ATLAS	Required	Balance	CMS	Required	Balance	LHCb	Required	Balance	SUM	Required	Balance
Tier 0	CPU (HEP-SPEC06)	90000	135000	-33%	111000	111000	0%	121000	121000	0%	34000	34000	0%	356000	401000	-11%
Tier 0	Disk (Tbytes)	8100	11040	-27%	10000	11000	-9%	7000	7000	0%	4000	5500	-27%	29100	34540	-16%
Tier 0	Tape (Tbytes)	26600	26100	2%	31000	31000	0%	25300	26000	-3%	7300	7300	0%	90200	90400	0%
Tier 1	CPU (HEP-SPEC06)	99724	151000	-34%	326731	373000	-12%	149850	175000	-14%	75618	110000	-31%	651923	809000	-19%
Tier 1	Disk (Tbytes)	6465	8900	-27%	32373	36000	-10%	22066	26000	-15%	5888	10400	-43%	66792	81300	-18%
Tier 1	Tape (Tbytes)	13572	23900	-43%	42377	53000	-20%	44660	60000	-26%	7467	11900	-37%	108076	148800	-27%
Tier 2	CPU (HEP-SPEC06)	130878	211000	-38%	392473	408000	-4%	381148	350000	9%	34102	46000	-26%	938601	1015000	-8%
Tier 2	Disk (Tbytes)	9918	15800	-37%	46388	56000	-17%	28317	29000	-2%	65	0	0%	84688	100800	-16%

Figure 10: Summary of pledge situation for 2013 and 2014: Experiment requirements updated since April 2012 RRB, compared to pledge data of September 2012. 2014 pledge data is incomplete.

The 2013 requirements have been updated somewhat with respect to the first estimates given in April 2012. These changes have been driven largely by the approximately 20% increase in the amount of data anticipated in 2012 due to the extended LHC running schedule. The 2014 requirements are close to the revised 2013 needs.

During the long shutdown the computing activities will include the reprocessing of the full 2010-2012 data samples, simulations in preparation for the higher energy LHC run following the shutdown, and of course on going physics analyses. The experiments have already taken several steps to limit the level of resources required, including reducing the number of copies of data resident on disk, the number of reprocessings performed, as well as continuing efforts to improve the overall efficiency of the software. Recall that over the past 2 years all experiments have significantly improved the software performance (in some cases by very large factors), driven by the need to manage the high pile-up levels.

4.2.1. Future resource requirements

The experiments have also made some first estimates of the likely needs for computing in the first years following the long shutdown. There are very many uncertainties in these estimates, not least the uncertainty on the likely running conditions and schedule of the LHC in 2015. However, it is clear that we must continue to maintain the capability to fully exploit the data that will be produced by the LHC and the detectors. **It is thus essential that the funding for the Tier 0, Tier 1 and Tier 2 centres be maintained at a level sufficient to provide resource increases in line with those that have been requested over the past several years.** As can be seen from recent reporting all of the resources requested by the experiments are fully used on a continual basis, and indeed significant non-pledged resources are also used well.

5. ANNEX: TIER 0, 1, 2 RESOURCES

WLCG Tier 0-1 Resources

Situation on 19 October 2012

CERN-RRB-2012-086

Annex 1

CERN Tier0 / CAF	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	356000	356000	356000	Offered	90000	111000	121000	34000	356000
				Required	125000	111000	121000	34000	391000
				% of Req.	**72%**	**100%**	**100%**	**100%**	**91%**
Disk (Tbytes)	27600	291000	29100	Offered	8100	10000	7000	4000	29100
				Required	13400	10000	7000	3500	33900
				% of Req.	**60%**	**100%**	**100%**	**114%**	**86%**
Tape (Tbytes)	67400	80300	90200	Offered	22800	27000	24000	6500	80300
				Required	23500	19000	23000	6200	71700
				% of Req.	**97%**	**142%**	**104%**	**105%**	**112%**

Canada Tier1	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	25900	31900	37300	Offered		31900			31900
				% of Total		11%			11%
Disk (Tbytes)	2700	3500	3600	Offered		3500			3500
				% of Total		12%			12%
Tape (Tbytes)	3600	4300	5300	Offered		4300			4300
				% of Total		13%			13%

KIT	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	106580	106575	106575	Offered	30000	39875	17500	19200	106575
				% of Total	32%	13%	12%	21%	17%
Disk (Tbytes)	9885	9250	9250	Offered	2225	3375	2200	1450	9250
				% of Total	20%	12%	8%	19%	13%
Tape (Tbytes)	15900	15900	15900	Offered	5250	4500	5100	1050	15900
				% of Total	27%	13%	11%	17%	15%

IN2P3 Lyon (Note 1)	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	68100	67350	0	Offered	7700	31350	11800	16500	67350
				% of Total	8%	11%	8%	18%	11%
Disk (Tbytes)	6480	7000	0	Offered	710	3540	1550	1200	7000
				% of Total	7%	12%	6%	16%	10%
Tape (Tbytes)	8800	10025	0	Offered	1050	3500	4075	1400	10025
				% of Total	5%	10%	9%	23%	10%

INFN CNAF	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	85000	88050	88050	Offered	18500	30300	22750	16500	88050
				% of Total	19%	10%	16%	18%	14%
Disk (Tbytes)	8500	9680	9680	Offered	1700	3300	3380	1300	9680
				% of Total	16%	11%	13%	17%	13%
Tape (Tbytes)	14100	15800	15800	Offered	3700	4000	6500	1600	15800
				% of Total	19%	12%	14%	26%	15%

Netherlands LHC/Tier1	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	55083	55083	55083	Offered	6220	35015		13848	55083
				% of Total	7%	12%		15%	11%
Disk (Tbytes)	4743	4743	4743	Offered	279	3456		1008	4743
				% of Total	3%	12%		13%	10%
Tape (Tbytes)	5393	6339	6475	Offered	74	4165		2100	6339
				% of Total	0%	12%		34%	11%

NDGF Tier1	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	25764	29010	28752	Offered	11775	17235			29010
				% of Total	12%	6%			7%
Disk (Tbytes)	2690	2710	2687	Offered	1080	1630			2710
				% of Total	10%	6%			7%
Tape (Tbytes)	3672	4280	4251	Offered	2155	2125			4280
				% of Total	11%	6%			8%

GSDC-KISTI (Note 2)	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	18800	25000	31250	Offered	25000				25000
				% of Total	26%				26%
Disk (Tbytes)	1000	1000	1000	Offered	1000				1000
				% of Total	9%				9%
Tape (Tbytes)	500	1500	2000	Offered	1500				1500
				% of Total	8%				8%

Spain PIC	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	26367	30804	33558	Offered		16269	8925	5610	30804
				% of Total		5%	6%	6%	6%
Disk (Tbytes)	2984	3550	3692	Offered		1785	1326	439	3550
				% of Total		6%	5%	6%	6%
Tape (Tbytes)	4743	5345	6370	Offered		2193	2601	551	5345
				% of Total		6%	6%	9%	6%

Taipei ASGC	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	33075	33874	39055	Offered		17199	16675		33874
				% of Total		6%	12%		8%
Disk (Tbytes)	3920	4275	4600	Offered		2250	2025		4275
				% of Total		8%	8%		8%
Tape (Tbytes)	4710	4000	4000	Offered		2000	2000		4000
				% of Total		6%	4%		5%

UK Tier1 (Note 3)	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	62055	76300	76300	Offered	1960	39880	14000	20460	76300
				% of Total	2%	13%	10%	22%	12%
Disk (Tbytes)	7118	8240	8240	Offered	180	4380	2080	1600	8240
				% of Total	2%	15%	8%	21%	11%
Tape (Tbytes)	10116	11780	11780	Offered	390	5380	4000	2010	11780
				% of Total	2%	16%	9%	33%	11%

US-ATLAS Tier1	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	60000	74000	86000	Offered		74000			74000
				% of Total		25%			25%
Disk (Tbytes)	6300	8100	8300	Offered		8100			8100
				% of Total		28%			28%
Tape (Tbytes)	8300	8600	12200	Offered		8600			8600
				% of Total		25%			25%

US-CMS Tier1	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	58000	58000	70000	Offered			58000		58000
				% of Total			40%		40%
Disk (Tbytes)	10000	11000	11000	Offered			11000		11000
				% of Total			42%		42%
Tape (Tbytes)	22000	24000	24000	Offered			24000		24000
				% of Total			53%		53%

Summary Ext. Tier1s	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	624724	675946	651923	Offered	101155	333023	149650	92118	675946
				Required	95000	297000	145000	91000	628000
				Balance	6%	12%	3%	1%	8%
Disk (Tbytes)	66320	73048	66792	Offered	7174	35316	23561	6997	73048
				Required	10900	29000	26000	7600	73500
				Balance	-34%	22%	-9%	-8%	-1%
Tape (Tbytes)	101834	111869	108076	Offered	14119	40763	48276	8711	111869
				Required	19100	34000	45000	6100	104200
				Balance	-26%	20%	7%	43%	7%

Ext. Tier1 Requ. 2013	ALICE	ATLAS	CMS	LHCb	SUM
CPU (HEP-SPEC06)	95,000	297,000	145,000	91,000	628,000
Disk (Tbytes)	10,900	29,000	26,000	7,600	73,500
Tape (Tbytes)	19,100	34,000	45,000	6,100	104,200

TIER 1 Notes

Note 1: France : No input from France for 2014.

Note 2: GSDC-KISTI : Associate Tier-1 approved at WLCG Overview Board on 9 March 2012, expected to provide full Tier-1 services within a year.

Note 3: UK : UK Tape is provisioned on demand. The full pledge will not be deployed until required.

Note: The requirements here are those approved at the April 2012 RRB, they have been updated for the October RRB meeting.

Australia, University of Melbourne	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	6500	7000	8800	Offered		7000			7000
				% of Total		2%			1%
Disk (Tbytes)	700	800	920	Offered		800			800
				% of Total		2%			1%

Austria, Austrian Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	5057	5057	5057	Offered		1857	3200		5057
				% of Total		1%	1%		2%
Disk (Tbytes)	420	620	420	Offered		120	500		620
				% of Total		0%	2%		1%

Belgium, Belgian Tier-2 Fed. FNRS/FWO	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	9600	12000	12000	Offered			12000		12000
				% of Total			3%		3%
Disk (Tbytes)	1560	1850	1850	Offered			1850		1850
				% of Total			7%		7%

Brazil, SPRACE, Sao Paulo	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	10000	13698	13698	Offered			13698		13698
				% of Total			4%		4%
Disk (Tbytes)	720	787	787	Offered			787		787
				% of Total			3%		3%

Canada, Canada-East Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	6650	8875	10200	Offered		8875			8875
				% of Total		3%			3%
Disk (Tbytes)	1175	1325	1400	Offered		1325			1325
				% of Total		3%			3%

Canada, Canada-West Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	6650	8875	10200	Offered		8875			8875
				% of Total		3%			3%
Disk (Tbytes)	1175	1325	1400	Offered		1325			1325
				% of Total		3%			3%

China, IHEP, Beijing	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	9600	9600	9600	Offered		4800	4800		9600
				% of Total		2%	1%		1%
Disk (Tbytes)	640	640	640	Offered		320	320		640
				% of Total		1%	1%		1%

Czech Rep., FZU, Prague	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	15000	13000	13000	Offered	5000	8000			13000
				% of Total	3%	3%			3%
Disk (Tbytes)	1450	1350	1350	Offered	450	900			1350
				% of Total	2%	2%			2%

Estonia, NICPB, Tallinn	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	10000	45000	45000	Offered			45000		45000
				% of Total			13%		13%
Disk (Tbytes)	750	1000	1000	Offered			1000		1000
				% of Total			4%		4%

Finland, NDGF/HIP Tier-2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	6300	6300	6300	Offered			6300		6300
				% of Total			2%		2%
Disk (Tbytes)	520	520	520	Offered			520		520
				% of Total			2%		2%

France, CC-IN2P3 AF, Lyon	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	23850	23850	0	Offered	2300	9750	6600	5200	23850
				% of Total	1%	3%	2%	11%	3%
Disk (Tbytes)	2030	2120	0	Offered	300	1310	510	0	2120
				% of Total	2%	3%	2%	-	2%

France, CPPM, Marseille	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	4264	6014	0	Offered		4014		2000	6014
				% of Total		1%		4%	2%
Disk (Tbytes)	404	604	0	Offered		600		4	604
				% of Total		1%		-	1%

France, GRIF, Paris	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	29053	30779	0	Offered	5850	10527	10360	4042	30779
				% of Total	3%	3%	3%	9%	3%
Disk (Tbytes)	2748	2861	0	Offered	474	1617	770	0	2861
				% of Total	2%	3%	3%	-	3%

France, IPHC, Strasbourg	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	11000	11000	11000	Offered	3500		7500		11000
				% of Total	2%		2%		2%
Disk (Tbytes)	800	800	800	Offered	200		600		800
				% of Total	1%		2%		2%

France, LAPP, Annecy	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	4800	5600	6400	Offered		4000		1600	5600
				% of Total		1%		3%	2%
Disk (Tbytes)	462	522	602	Offered		520		2	522
				% of Total		1%		-	1%

France, LPC, Clermont	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	6527	7027	7027	Offered	2278	3360		1389	7027
				% of Total	1%	1%		3%	1%
Disk (Tbytes)	677	796	796	Offered	178	616		2	796
				% of Total	1%	1%		-	1%

France, LPSC Grenoble	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	4222	4172	0	Offered	1252	2920			4172
				% of Total	1%	1%			1%
Disk (Tbytes)	519	574	0	Offered	125	449			574
				% of Total	0%	0%			0%

France, Subatech, Nantes	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3000	3000	3000	Offered	3000				3000
				% of Total	2%				2%
Disk (Tbytes)	310	310	310	Offered	310				310
				% of Total	2%				2%

Germany, ATLAS Federation, DESY	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12000	14400	14400	Offered		14400			14400
				% of Total		5%			5%
Disk (Tbytes)	1500	1560	1600	Offered		1560			1560
				% of Total		3%			3%

Germany, ATLAS Federation, U. Goettingen	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3853	3853	3853	Offered		3853			3853
				% of Total		1%			1%
Disk (Tbytes)	1000	1000	1000	Offered		1000			1000
				% of Total		2%			2%

Germany, CMS Federation DESY RWTH Aachen	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	23625	24190	22400	Offered			24190		24190
				% of Total			7%		7%
Disk (Tbytes)	1950	1850	1800	Offered			1850		1850
				% of Total			7%		7%

Germany, DESY-LHCb	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3200	3200	3200	Offered				3200	3200
				% of Total				7%	7%
Disk (Tbytes)	2	2	2	Offered				2	2
				% of Total				-	-

Germany, GSI, Darmstadt	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	7000	7000	7000	Offered	7000				7000
				% of Total	4%				4%
Disk (Tbytes)	550	550	550	Offered	550				550
				% of Total	3%				3%

Germany, ATLAS Federation Munich	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	11560	10537	10780	Offered		10537			10537
				% of Total		3%			3%
Disk (Tbytes)	1340	1423	1383	Offered		1423			1423
				% of Total		3%			3%

Germany, ATLAS Fed. Freiburg Wuppertal	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	8860	6504	5240	Offered		6504			6504
				% of Total		2%			2%
Disk (Tbytes)	1566	1308	1128	Offered		1308			1308
				% of Total		3%			3%

Greece, HEP Laboratory, University of Ioannina	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3040	1870	1870	Offered			1870		1870
				% of Total			1%		1%
Disk (Tbytes)	200	200	200	Offered			200		200
				% of Total			1%		1%

Hungary, HGCC Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3760	4300	5280	Offered	1100		3200		4300
				% of Total	1%		1%		1%
Disk (Tbytes)	204	282	324	Offered	72		210		282
				% of Total	0%		1%		1%

India, VECC/SINP, Kolkata	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	6000	6000	6000	Offered	6000				6000
				% of Total	3%				3%
Disk (Tbytes)	240	240	240	Offered	240				240
				% of Total	1%				1%

India, TIFR, Mumbai	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3000	7100	7100	Offered			7100		7100
				% of Total			2%		2%
Disk (Tbytes)	700	900	900	Offered			900		900
				% of Total			3%		3%

Israel, IL-HEP Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	4800	5400	6200	Offered		5400			5400
				% of Total		2%			2%
Disk (Tbytes)	735	840	900	Offered		840			840
				% of Total		2%			2%

Italy, INFN T2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	102100	115500	115500	Offered	30000	33000	45500	7000	115500
				% of Total	15%	10%	13%	15%	13%
Disk (Tbytes)	8200	9400	9400	Offered	2400	3500	3500		9400
				% of Total	12%	7%	13%		10%

Japan, ICEPP, Tokyo	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12000	16000	20000	Offered		16000			16000
				% of Total		5%			5%
Disk (Tbytes)	1200	1600	2000	Offered		1600			1600
				% of Total		3%			3%

Republic of Korea, KISTI, Daejeon	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	600	600	600	Offered	600				600
				% of Total	0%				0%
Disk (Tbytes)	50	50	50	Offered	50				50
				% of Total	0%				0%

Republic of Korea, CHEP of KNU, Daegu	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3600	6000	6100	Offered			6000		6000
				% of Total			2%		2%
Disk (Tbytes)	250	299	300	Offered			299		299
				% of Total			1%		1%

Norway, UNINETT SIGMA Tier2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	3275	3190	3190	Offered		3190			3190
				% of Total		1%			1%
Disk (Tbytes)	488	490	490	Offered		490			490
				% of Total		1%			1%

Pakistan, Pakistan Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	5440	6365	6365	Offered			6365		6365
				% of Total			2%		2%
Disk (Tbytes)	300	300	350	Offered			300		300
				% of Total			1%		1%

Poland, Polish Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	15800	17300	19400	Offered	4623	5300	4430	2947	17300
				% of Total	2%	2%	1%	6%	2%
Disk (Tbytes)	1010	1050	1100	Offered	320	520	210		1050
				% of Total	2%	1%	1%		1%

Portugal, LIP Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	6400	6400	6400	Offered		3200	3200		6400
				% of Total		1%	1%		1%
Disk (Tbytes)	420	420	420	Offered		220	200		420
				% of Total		0%	1%		1%

Romania, Romanian Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	32800	34500	37500	Offered	16000	14700		3800	34500
				% of Total	8%	5%		8%	6%
Disk (Tbytes)	2050	2120	2400	Offered	1240	840		40	2120
				% of Total	6%	2%		-	3%

Russian Federation, RDIG (note 1)	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	51498	69776	77716	Offered	18256	24171	27293	56	69776
				% of Total	9%	8%	8%	0%	8%
Disk (Tbytes)	4429	4972	5345	Offered	1301	1722	1945	4	4972
				% of Total	7%	4%	7%	-	5%

Slovenia, SiGNET, Jozef Stefan Inst.	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12000	15000	17000	Offered		15000			15000
				% of Total		5%			5%
Disk (Tbytes)	900	900	1100	Offered		900			900
				% of Total		2%			2%

Spain, ATLAS Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	13300	16050	22200	Offered		16050			16050
				% of Total		5%			5%
Disk (Tbytes)	2350	2800	3000	Offered		2800			2800
				% of Total		6%			6%

Spain, CMS Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	15750	20000	20000	Offered			20000		20000
				% of Total			6%		6%
Disk (Tbytes)	1300	1500	1500	Offered			1500		1500
				% of Total			6%		6%

Spain, LHCb Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	2800	2800	2800	Offered				2800	2800
				% of Total				6%	6%
Disk (Tbytes)	1	1	1	Offered				1	1
				% of Total				-	-

Sweden, SNIC Tier2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	7870	7870	7870	Offered	2820	5050			7870
				% of Total	1%	2%			2%
Disk (Tbytes)	920	920	920	Offered	400	520			920
				% of Total	2%	1%			1%

Switzerland, CHIPP, Manno	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	17670	28000	28000	Offered		14200	9200	4600	28000
				% of Total		4%	3%	10%	4%
Disk (Tbytes)	1226	1650	1650	Offered		995	645	10	1650
				% of Total		2%	2%	-	2%

Taipei, Taiwan Analysis Facility Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	5320	6000	7580	Offered		3000	3000		6000
				% of Total		1%	1%		1%
Disk (Tbytes)	600	650	850	Offered		390	260		650
				% of Total		1%	1%		1%

Turkey, Turkish Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	9800	9800	9800	Offered		5100	4700		9800
				% of Total		2%	1%		1%
Disk (Tbytes)	900	900	900	Offered		550	350		900
				% of Total		1%	1%		1%

UK, London	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	26225	27547	27547	Offered		10621	15717	1209	27547
				% of Total		3%	4%	3%	4%
Disk (Tbytes)	3079	3033	3033	Offered		1609	1423	1	3033
				% of Total		3%	5%	-	4%

UK, NorthGrid	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	15953	17049	17049	Offered		14118		2931	17049
				% of Total		4%		6%	5%
Disk (Tbytes)	2170	1842	1842	Offered		1841		1	1842
				% of Total		4%		-	4%

UK, ScotGrid	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	9635	9430	9430	Offered		6521		2909	9430
				% of Total		2%		6%	3%
Disk (Tbytes)	1291	1121	1121	Offered		1120		1	1121
				% of Total		2%		-	2%

UK, SouthGrid	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	17536	21349	21349	Offered	3320	4240	12283	1506	21349
				% of Total	2%	1%	4%	3%	2%
Disk (Tbytes)	1585	1863	1863	Offered	316	729	817	1	1863
				% of Total	2%	1%	3%	-	2%

Ukraine, Ukrainian Tier-2 Federation	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	4690	6930	9000	Offered	930		6000		6930
				% of Total	0%		2%		1%
Disk (Tbytes)	380	500	650	Offered	150		350		500
				% of Total	1%		1%		1%

USA, LBNL ALICE Berkeley CA	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12000	12900	18000	Offered	12900				12900
				% of Total	7%				7%
Disk (Tbytes)	1020	1200	1450	Offered	1200				1200
				% of Total	6%				6%

USA, LLNL ALICE, Livermore CA	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	11500	11500	11500	Offered	11500				11500
				% of Total	6%				6%
Disk (Tbytes)	650	650	650	Offered	650				650
				% of Total	3%				3%

USA, Northeast ATLAS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	15000	17000	Offered		15000			15000
				% of Total		5%			5%
Disk (Tbytes)	1648	2217	2342	Offered		2217			2217
				% of Total		5%			5%

USA, Southwest ATLAS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	15000	17000	Offered		15000			15000
				% of Total		5%			5%
Disk (Tbytes)	2200	2217	2342	Offered		2217			2217
				% of Total		5%			5%

USA, Midwest ATLAS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	22000	26000	Offered		22000			22000
				% of Total		7%			7%
Disk (Tbytes)	2200	3325	3513	Offered		3325			3325
				% of Total		7%			7%

USA, Great Lakes ATLAS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	15000	17000	Offered		15000			15000
				% of Total		5%			5%
Disk (Tbytes)	2200	2217	2342	Offered		2217			2217
				% of Total		5%			5%

USA, SLAC ATLAS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	15000	17000	Offered		15000			15000
				% of Total		5%			5%
Disk (Tbytes)	2200	2217	2342	Offered		2217			2217
				% of Total		5%			5%

USA, Caltech CMS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	12500	12500	Offered			12500		12500
				% of Total			4%		4%
Disk (Tbytes)	1000	1000	1100	Offered			1000		1000
				% of Total			4%		4%

USA, Florida CMS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	12500	12500	Offered			12500		12500
				% of Total			4%		4%
Disk (Tbytes)	1000	1000	1100	Offered			1000		1000
				% of Total			4%		4%

USA, MIT CMS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	12500	12500	Offered			12500		12500
				% of Total			4%		4%
Disk (Tbytes)	1000	1000	1100	Offered			1000		1000
				% of Total			4%		4%

USA, Nebraska CMS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	12500	12500	Offered			12500		12500
				% of Total			4%		4%
Disk (Tbytes)	1000	1000	1100	Offered			1000		1000
				% of Total			4%		4%

USA, Purdue CMS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	12500	12500	Offered			12500		12500
				% of Total			4%		4%
Disk (Tbytes)	1000	1000	1100	Offered			1000		1000
				% of Total			4%		4%

USA, UC San Diego CMS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	12500	12500	Offered			12500		12500
				% of Total			4%		4%
Disk (Tbytes)	1000	1000	1100	Offered			1000		1000
				% of Total			4%		4%

USA, U. Wisconsin CMS T2	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	12500	12500	12500	Offered			12500		12500
				% of Total			4%		4%
Disk (Tbytes)	1000	1000	1100	Offered			1000		1000
				% of Total			4%		4%

Summary Tier2s with Split in 2013	2012	2013	2014	Split 2013	ALICE	ATLAS	CMS	LHCb	SUM 2013
CPU (HEP-SPEC06)	828333	972557	958001	Offered	138229	390133	397006	47189	972557
				Required	195000	319000	350000	47000	911000
				Balance	-29%	22%	13%	0%	7%
Disk (Tbytes)	81264	88383	85788	Offered	10926	48572	28816	69	88383
				Required	19400	49000	26000	0	94400
				Balance	-44%	-1%	11%	-	-6%

Requirements 2013	ALICE	ATLAS	CMS	LHCb	SUM
CPU (HEP-SPEC06)	195,000	319,000	350,000	47,000	911000
Disk (Tbytes)	19,400	49,000	26,000	0	94400
Number of T2s					67

TIER 2 Notes

Note 1: Russia: CPU breakdown between VOs is not normally calculated as all CPU resources in all sites are available for all experiments. For the sake of REBUS, the 2013 disk VO allocation percentage has been used to calculate the theoretical breakdown between VOs.

Note: The requirements here are those approved at the April 2012 RRB, they have been updated for the October RRB meeting.

See also the online WLCG Resources Pledges database at: **http://wlcg-rebus.cern.ch/apps/pledges/resources/**