CERN/LHCC 2012-002
LHCC 108
8 December 2011

LARGE HADRON COLLIDER COMMITTEE

Minutes of the one-hundredth-and-eighth meeting held on
Wednesday and Thursday, 7-8 December 2011

OPEN SESSION I - Status Reports

1. LHC Machine Status Report: Steve Myers
2. ATLAS Status Report: David Strom
3. CMS Status Report: Anders Ryd
4. ALICE Status Report: Jacek Otwinowski
5. LHCb Status Report: Matthew Needham
6. TOTEM Status Report: Simone Giani
7. LHCf Status Report: Oscar Adriani

CLOSED SESSION:

Present: S. Bertolucci*, U. Bassler, P. Bloch, A. Boehnlein, H. Breuker, J.-C. Brient, C. Cecchi, M. Demarteau, E. Elsen (Chairman), D. d'Enterria, M. Ferro-Luzzi, G. Giudice, B. Gorini, C. Hawkes, R. Heuer*, W. Kuehn, D. Macina, M. Mangano, E. Meschi, S. Miscetti, T. Mori, A. Nomerotski, B. Panzer-Steindel, A.-L. Perrot, D. Pitzl, R. Roser, T. Sjöstrand, E. Tsesmelis (Scientific Secretary)

* part-time

1. PROCEDURE

The minutes of the one-hundredth-and-seventh LHCC meeting (LHCC 2011-010 / LHCC 107) were approved.

The Chairman thanked warmly M. Ferro-Luzzi, the outgoing LHC Programme Co-ordinator, for his contributions to the Committee and in particular for his dedicated engagement as co-ordinator between the LHC machine and experiments. The Chairman welcomed B. Gorini (ATLAS) and E. Meschi (CMS), the new LHC Programme Co-ordinators. The Chairman also welcomed the new Members M. Demarteau and A.-L. Perrot.

2. REPORT FROM THE DIRECTOR FOR RESEARCH AND SCIENTIFIC COMPUTING

The report from the Director for Research and Scientific Computing concentrated on issues related to the LHC. He reported on the outstanding performance of the LHC, including the rapid improvements in luminosity in 2011, underlining the record instantaneous and integrated luminosities, the latter having exceeded 5 fb^{-1} delivered to each of the experiments ATLAS and CMS. He informed the Committee that a seminar by ATLAS and CMS had been scheduled for 13 December 2011 covering the status of their searches for the Standard Model Higgs Boson. He also reported on the LHC running conditions for 2012 and informed the Committee that details of the beam parameters and run plan will be discussed at the LHC Performance Workshop in Chamonix on 6-10 February 2012.

3. REPORT FROM THE LHC PROGRAMME CO-ORDINATOR

The LHCC heard a report from the LHC Programme Co-ordinator. He reported on the progress since the previous LHCC session, on machine and experiment issues and on the schedule.

The performance of the LHC machine has been outstanding, delivering integrated luminosities exceeding considerably the expectations for both the proton-proton and Pb-ion runs and matched by record peak luminosities. The Co-ordinator also reported on the satellite collisions at IP2 (ALICE), on the tests to study high pile-up, the 90 m high-β optics and runs for TOTEM, gas-induced background affecting mostly ALICE and CMS to some extent, ALICE aperture issues, tests for 25 ns bunch-spacing, and the machine developments for proton-Pb runs. Preparations for the 2012 LHC run are well underway. Several forums will be held in the coming months to plan for the 2012 run and include a) the LHC Operations Workshop in Evian (12-14 December 2011); the LHC Performance Workshop in Chamonix (6-10 February 2012); and the LHC Lumi Days Workshop (29 February – 1 March 2012).

4. DISCUSSION WITH ATLAS

This LHCC meeting offered the Committee the natural opportunity to look back over the year and evaluate the progress made and obstacles that have been overcome. The LHCC **congratulates** ATLAS on all its achievements.

This year, ATLAS came into its own as an experiment. In 2011 alone, it submitted 73 papers thus far for publication in refereed journals and released ~160 conference notes. Twenty more papers are currently under review within the Collaboration and it is likely a few more may be released before December 2011 comes to a close. ATLAS performed a variety of searches for physics beyond the Standard Model and has placed stringent limits while SUSY limits are now approaching 1 TeV in many search channels. Similarly, other non-Standard-Model searches are also approaching 1 TeV or beyond. Thus far, no significant signs of non-Standard-Model physics have been shown. ATLAS has an impressive top quark programme, releasing a broad variety of results, including top quark mass and cross-section results as well as its own observation of "single-top" produced through the electroweak interaction. There are papers on a range of QCD and electroweak physics, including recently a broad range of di-boson results, diffractive physics, as well as a successful heavy-ion set of publications. Finally, the ATLAS search for the Higgs boson is well underway. ATLAS has published results in all of the significant decay channels and worked with CMS to combine their respective 2 fb^{-1} results presented at the International Symposium on Lepton Photon Interactions at High Energies in Mumbai in August 2011. ATLAS took important steps this fall to improve its simulation and reconstruction programs to better deal with the pile-up from multiple interactions. It has reprocessed its entire 5 fb^{-1} data set and is well positioned to have a full slate of results for this winter's conferences utilizing the full data set. Finally, the detector performed very well this year with no significant outstanding issues; ATLAS recorded data with 93.5% efficiency in 2011 and approximately 84-90% of the 5.6 fb^{-1} of delivered luminosity is available for physics analysis. In summary, ATLAS had an excellent 2011 and is well positioned to repeat that success in 2012.

The accelerator's performance exceeded all expectations in 2011, delivering 5.6 fb^{-1} of data to each of ATLAS and CMS. This performance was both a blessing and a challenge for the experiments. The obvious upside is that this statistical sample allowed for many more physics results than were planned. The challenge was multifold: determining a trigger strategy to maximize the physics to tape with a luminosity that far exceeded expectation, processing the data in a timely fashion, and being able to analyze events with upwards of 20 interactions per crossing.

Throughout most of 2011, the trigger menu was held mostly fixed in order to facilitate analyses by providing analyzers with a consistent data set. For instance, single lepton p_T thresholds were not changed. The average trigger rate in 2011 was between 300-350 Hz with peak rates exceeding 500 Hz at the beginning of machine fills. While

these rates were above their nominal specifications, it was done to maximize the physics potential for the experiment and the resulting output (data) stayed within what the offline computing systems were capable of handling. A new trigger menu is being developed for 2012 which will be capable of handling luminosities up to 10^{34} cm^{-2} s^{-1} at 7 TeV centre-of-mass energy. With this in place, the analyzers should expect again to have a consistent data set for all of 2012. If the machine luminosity is less than the projected 10^{34} cm^{-2} s^{-1}, only pre-scales are adjusted to maximize the physics written to tape. For 2012, the average output is planned for 400 Hz with peaks in excess of 550 Hz. Anticipating the discussion on the choice of beam energy for 2012 during the LHC Performance Workshop in Chamonix, ATLAS favours 4 TeV beam energy over 3.5 TeV because of the higher energy reach and higher (parton) luminosities, both of which help to increase the discovery potential for new physics. By the same token, ATLAS accepts running at 50 ns bunch spacing and hence higher pile-up because of the higher luminosities achievable.

The computing systems were stressed this year with the factor of 5 more integrated luminosity than was anticipated at the start of 2011. Nevertheless, the offline systems were able to keep up. There was no significant back-log of processing throughout most of 2011 and the 73 publication submissions is a good indicator that analyzers were able to get the computing resources they needed in order to be successful. ATLAS' flexible computing model continues to pay dividends. It is now using dynamic data placement to its Tier-2s. This ability better aligns the computing resources with the physics analysis needs of the experiment. With the increasing luminosity, the processing time per event has increased due to event complexity and combinatorics. The experiment is worried by the projected luminosities in 2012, and would like CERN to double its Tier-0 CPU to avoid a bottleneck. The request (made at the October 2011 meeting of the Resources Review Board) is beyond the initial request for 2012 (made at April 2011 meeting of the Resource Review Boards). The CERN IT Department has proposed to fulfill this request but that plan is not yet approved.

Finally, ATLAS has followed an ambitious programme to revamp and improve its reconstruction algorithms in order to manage well the increase in luminosity and in the number of interactions per crossing and to untangle these complicated events in a timely fashion. The experiment improved its tracking and muon alignment, improved its clustering in the Pixel Detector, and improved the simulation of calorimeter shower shapes as well as improved its reconstruction algorithms. Furthermore, the experiment now explicitly corrects for the bunch currents alleviating a potential problem due to spill-over from adjacent bunches which adds to the luminosity pile-up. The experiment reprocessed all of its data in September and October of this year and is now much better positioned to both complete effective analyses with the 5 fb^{-1} sample and to address the pile-up challenges waiting in 2012. The work did not end with the reprocessing. Upon completion of the reprocessing, a large campaign was undertaken in order to understand low-level detector performance, physics scale factors, alignment, efficiencies, performance versus luminosity etc. That work was accomplished in the latter part of October and November 2011.

The detector performed well in 2011. The one significant issue identified in 2011 is the potential problem with the optical links in the Pixel Detector. The off-detector optical transmitters that provide clock information to the Pixel Detector started to fail. There was some concern that it was only a matter of time before the optical links mounted on the detector also failed. As a result the experiment is undertaking an aggressive campaign to first understand these failures and then work to mitigate them. Currently, they are making new Service Quarter Panels (SQPs). These objects contain the drivers for the optical links. The idea of the rework is to relocate the optical links on the SQPs such that if there are failures, these SQPs could be accessed during a winter stop and the links replaced. Currently, most of the optical links are inaccessible while the detector is installed in the ATLAS cavern. There is now growing evidence that humidity contributes to these link failures. If the SQP rework is done, additional links could be installed improving the granularity of the system and perhaps making it easier for the detector to operate at a luminosity higher than design. A decision on

whether to replace the SQPs has not been made yet. ATLAS has established a "risk management team" to evaluate the risk to reward of replacing the SQP's. A report and decision is expected by summer 2012. No other significant issues were identified. In the last quarter the detector ran quite well. The high voltage trips in the LAr Calorimeter system are much less problematic at the highest luminosities than they were earlier in the year. Furthermore, the experiment has become a lot more sophisticated in the way it handles noise bursts – now only removing events at ± 1 s on either side of the event. Prior to that, the entire one-minute luminosity segment was removed. The Transition Radiation Tracker was problem-free and the Tile Calorimeter system still has power supply issues. Newly-designed power supplies are on order and all of them will be replaced in the upcoming shutdowns. Over the course of 2011, the experiment has reduced its shift crew from 20 per shift to 8 per shift, and with plans to reduce further in 2012 as more automation is completed.

The experiment has significant consolidation work planned for the 2011-2012 Technical Stop. ATLAS will install 40 new low-voltage power supplies for the Tile Calorimeter and 10 new power supplies for the LAr Calorimeter system. The End-cap muon chambers will be installed on one side of the detector (Insertable B-Layer (IBL) insertion side which will be off limits during the IBL insertion in 2013). The cryogenic compressors will be refurbished. They already have more hours on them than is suggested by the manufacturer. They will be removed from the ATLAS hall and trucked to the vendor who will recondition them. During this refurbishment, the magnets will remain at liquid nitrogen temperatures. A number of smaller projects will also be undertaken that are not mentioned here.

In terms of the upgrades, the experiment is on track for the upcoming Phase-0 shutdown in 2013. All of the major consolidation efforts such as the evaporative cooling plant, shielding improvements, and splitting of the toroid and solenoid cryogenic systems are on track and progressing well. The IBL is also respecting its aggressive schedule which would enable its insertion in the coming year. Most of the 3D and planar sensors are now in hand. The tooling is progressing and a preproduction flex cable could be used if the final version arrives too late. The LHCC expects a signed Memorandum of Understanding by its next meeting. The experiment did a mock-up beam pipe installation with the IBL in the much more difficult detector condition in which the existing Pixel Detector remains inside ATLAS during installation. This success gives the experiment options on how to proceed with the optical links.

Looking beyond Phase-0, the experiment is in the final weeks of completing its Letter of Intent detailing its Phase-1 upgrade plans. Those plans include new muon wheels with increased trigger granularity and track vectors, a Fast Track trigger (FTK) which utilizes the Semiconductor Tracker and Pixel Detector, a higher granularity calorimeter Level-1 trigger, the addition of topological information and adapting the Level-1 central trigger to deal with the new needs of luminosities beyond 10^{34} cm^{-2} s^{-1}. New detector stations for diffractive physics are planned at 220m (ATLAS Forward Physics AFP), new Tile Calorimeter crack-gap scintillators will be installed and finally the Trigger/DAQ will be upgraded. The Committee expects the Letter of Intent to be submitted in draft form in the next few weeks. The plan is to iterate on it in January and February 2012 so that the LHCC will be ready to approve it at its session in March 2012, in advance of the Resources Review Meeting in April 2012.

Finally, during the LHC heavy-ion run, which was completed during the first week of December 2011, 166 μb^{-1} were delivered and 158 μb^{-1} were written to tape for an average data taking efficiency of 95.5%. The detectors all performed well and the operational burden was spread over the entire Collaboration and not just with the heavy-ion community. The data sample collected this year is about 15 times that collected in 2010.

Just prior to the December 2011 session of the LHCC, LHCf submitted a request for proton-Pb running and to re-install its detector inside the ATLAS TAN absorber at the position of the ZDC. ATLAS Management agrees to do this and sees no significant obstacles.

5. DISCUSSION WITH CMS

The LHCC **congratulates** the CMS Collaboration on all its achievements and on the activity of the Collaboration in producing a rich set of public physics results with a well-understood detector. The 2011 physics analyses are going well—with results shown for top, SUSY, Exotics, and Higgs channels. CMS is on track to present 2011 full luminosity analyses for all Higgs channels in a special seminar on 13 December 2011. The Collaboration is finishing the 2010 programme of 76 (+4) analyses published and 5 of those analyses are from the heavy-ion programme. A comprehensive status of physics objects was presented, including tracking, jets, electromagnetic objects, and b-tagging. Tau-leptons are well understood, as demonstrated by the tag and probe studies in $Z\rightarrow\tau\tau$. Another notable success in object identification is that the Particle Flow algorithm is now in use in many analyses and is available in the High Level Trigger (HLT). The effects of pile-up are demonstrated to be largely understood and have been mitigated.

On the topic of LHC parameters in 2012, CMS is strongly in favor of $\sqrt{s}$ = 8 TeV from the start of run. CMS would prefer a 25 ns bunch spacing because of the lower pile-up of 11 events if the same luminosity could be delivered. Confronted with the prospects of ~10 fb^{-1} versus 16 fb^{-1} integrated luminosity for 2012 for 25 ns and 50 ns, respectively, the Collaboration chooses 50 ns bunch spacing for 2012. The studies performed to-date using Monte Carlo samples and special high-pile up runs conclude that 50 ns and ~30 pile-up events at the start of fill is tolerable with a 50% augmentation of the HLT filter farm and necessary operational changes under more detailed study including those required for production and HLT software. The impact on physics does not appear to be a serious problem and losses in efficiency are more than compensated for by the increase in integrated luminosity. Current quantifiable effects include $H\rightarrow\gamma\gamma$ where the photon identification efficiency falls with increasing pile-up. For $H\rightarrow WW$ and $H\rightarrow\tau\tau$, the concerns are missing transverse energy resolution and trigger, respectively. The first analysis for Standard Model physics is also reassuring. In particular, the extracted top mass in the lepton+jets channels appears to be stable with the pile-up up to 20, although the study needs to be extended to ~30 pile-up events. More studies will be carried out ahead of the LHC Performance Workshop in Chamonix in February 2012. CMS is also considering "data parking" for the 2012 run. This would utilize the possibility to increase the output data rate to the limit of the data acquisition system—with thresholds on triggers tuned for new physics that would otherwise be impossible to trigger on due to the limitations in the offline computing resources. This extra data would be written to tape and targeted for analysis during the long shutdown LS1 in 2013-2014 when the computing resources become available again. CMS is also considering ways in which some preliminary analysis for searches could take place *in situ* within the HLT, with the notion that interesting indications would then guide triggers to enable offline analysis. The LHCC encourages CMS to continue exploring ideas that maximize their physics potential.

CMS coped well with the operational running conditions in 2011. Overall for proton-proton running, the LHC delivered 5.72 fb^{-1} and CMS recorded 5.2 fb^{-1} with a data taking efficiency in 2011 of 91%. About 5.8% of the delivered luminosity was lost due to downtimes and dead-time accounted for 3.1%. About 90% of the recorded data is certified as 'all GOOD for all detectors'. Peak pile-up increased from 6 to 17 in 2011 and was successfully managed for detector performance and computing operations. Operationally, preparations for 2012 running include the plans for dealing with the fact that Single Event Upsets (SEUs) (and other unexplained exceptions) are increasing with luminosity and tuning the noise suppression algorithms in the calorimeters for higher pile-up.

In September 2011, CMS computing reported a new certified version (CMSSW_4_4) of the reconstruction software that solved some problems with resource utilization at the Tier-0. However, for the remainder of the 2011 proton-proton running, the decision was taken to stay with CMSSW_4_2 in order to facilitate getting the Higgs results out in December 2011 by keeping a stable version, although that required some creative resource usage. The differences in the tracking between CMSSW_4_2 and CMSSW_4_4 are largely technical ones to speed up the code by better managing memory to reduce the memory footprint and some recoding for speed-ups. There was also a change not to allow hits to be reused by multiple tracks, which in CMSSW_4_4 led to slightly better physics performance. CMSSW_4_4 was fully validated by September 2011. For heavy-ion running, analysis stability was not a consideration and since CMSSW_4_4 was validated, had comparable physics performance and made much better use of the computer resources, CMS switched to it for heavy-ion data processing. For proton-proton running, there was a data reprocessing with CMSSW_4_4, while Monte Carlo reprocessing with CMSSW_4_4 is underway so all of the 2011 data will have been processed with a consistent software release.

A tracking task force is investigating further gains in the reconstruction code that will be needed to accommodate the pile-up of 2012 running. It was pointed out that the CMS tracking threshold is currently 100 MeV and that there are likely more technical gains to be achieved, so it may be that the performance changes may have relatively low physics impact.

The 2011 heavy-ion run is progressing well and the commissioning proceeded quickly with 138 μb^{-1} collected as of this LHCC session. The triggers had been optimized to exploit the high delivered luminosity with ~10% output bandwidth devoted to minimum bias events, while devoting the rest of the bandwidth to high-p_T triggers targeted for specific physics analyses.

During 2011, CMS occasionally observed beam-induced pressure spikes in a region 18.3 m on the right side of the CMS detector. When this condition occurs, it requires a reduction in the Level-1 trigger rate to 50 kHz. The cause is not yet known, however radiography of areas near Point 2 and Point 8, where similar spikes were seen revealed 6 bellow modules with drooping RF-fingers due to broken retaining springs. One hypothesis is that the pressure spikes are initiated by electrical discharge between the disconnected fingers and the close-by metal of the bellow or the beam pipe. To investigate the problem at Point 5, a radiography survey will be performed during the year-end Technical Stop. In addition to the survey and possible bake-out of 18 ± 3 m region, there is a comprehensive list of work to be performed during the year-end Technical Stop, including installing Cathode Strip Chamber (CSC) and Resistive Plate Chamber (RPC) equipment - CSC4/RPC4 posts and RE4 demonstrators - and the obligatory and advisory annual maintenance of services. The CMS Technical Coordination is also extremely well advanced in planning for the first long shutdown LS1 in 2013-2014.

A brief status of progress towards the upgrades was presented following the successful November 2011 upgrade workshop at FNAL. Technical progress has been made in major areas, including construction of the CSC and RPC chambers, advances in Silicon Photon Multiplier R&D, where the 15 μm pixel size device from Hamamatsu now has acceptable dead time of 99% cell recovery after 15 ns. Detailed project schedules are in development and the Collaboration plans to submit the Technical Design Reports for the Pixel Detector and Hadron Calorimeter (HCAL) upgrades in the summer 2012.

CMS is transitioning to a new Spokesperson, Joe Incandela. The new management structure includes adjustments to improve operations and to bolster preparations for upgrades and future running by integrating management of the current and forward going programmes. For example, the deputy physics coordinator is now responsible for upgrade physics simulations. The LHCC extends **congratulations** to Guido Tonelli for the many successes during his tenure as CMS Spokesperson.

6. DISCUSSION WITH TOTEM

The LHCC was informed of the most recent progress in the analyses of 2011 TOTEM data and the Committee **congratulates** TOTEM on all its achievements. These include the near completion of the charged-particle rapidity distribution, using the T2 Telescope, the new analysis of the elastic rates with increased statistics and extended reach in t values, and the first studies of double-Pomeron-exchange and single-diffractive processes. Good collision data were obtained with $\beta^*=90$ m during the special run on 18 October 2011. The full detector systems were in good operating condition and fully integrated in the trigger and data acquisition. With the nearing completion of the physics commissioning of the T1 Telescope, these data should soon allow the determination of total cross-section using the luminosity-independent technique. The Committee looks forward to the completion of all these studies.

All TOTEM detectors are operational. No sign of radiation degradation has appeared in the Roman Pot silicon detectors, and a new FLUKA radiation model is now available. The movement control software has been updated, to correct potential problems that emerged during the running of the ALFA Roman Pots of ATLAS. A cooling-related problem affecting 5 planes of one quarter of the T2 Telescope will be fixed during the 2011-2012 Technical Stop.

The LHCC took note that the CMS trigger signals have been sent successfully to TOTEM during the heavy-ion run, and the common data thus collected are now being analyzed.

The TOTEM running strategy for 2012, as anticipated in previous reviews, hinges on three components. First of all, further running at $\beta^*=90$ m with four bunches of 6-7 $\times 10^{10}$ p/b, to carry out the alignment with data of the Roman Pot stations at 147 m, and to extend the October 2011 physics measurements, possibly also exploiting the CMS-delivered triggers. Second, running in standard fills at low β^*, to push to higher values of t the measurement of the elastic cross-section, and to perform double-Pomeron-exchange measurements using the Roman Pot stations at 147 m and 220 m as a spectrometer. Finally, the development of optics with β^* in excess of 800 m to allow the measurement of the elastic rate near the Coulomb interference region.

The LHCC **endorses** the first two points of this plan. Concerning the third point, the Committee recognizes the scientific interest of the measurement, and notes that any effort to achieve this high-β^* optics should be done in coordination with ALFA. The Committee also notes the existence of a broad spectrum of assessments on the technical challenge and feasibility of developing such optics in a reasonable time frame. The Committee feels that a clarification of this key issue is necessary before any recommendation can be made.

7. TEST BEAMS

The PS and SPS Physics Co-ordinator reported on the LHC test beams. The PS and SPS fixed-target proton runs for 2011 were completed on 21 November, while Pb-ion beams to the North Area were provided until 7 December. All beams have been running well and there were no issues of concern to report. The Co-ordinator thanked the machine and experimental area operation teams for the successful PS and SPS fixed-target runs in 2011. Planning for 2012 is under preparation, with the call for beam requests launched on 4 October 2011 with a deadline for submission set to 19 December 2011. The PS East Hall fixed-target programme is scheduled to start on 16 April 2012 and that at the SPS North Area on 7 May 2012. The PS and SPS fixed-target beams will run until 3 December 2012.

8. DISCUSSION WITH LHCb

The LHCC discussed the status of the LHCb experiment. The Committee **congratulates** LHCb on all its achievements.

The LHCb detector status has remained excellent up to the end of the proton-proton data-taking period. The availability of the detector components typically exceeds 98%

and often is better. The maintenance of the electrical network and cooling system has already started. A schedule to work on sub-detectors already exists, with the plan to bring back all systems to full efficiency before restarting in March 2012. LHCb has completed the 2011 data taking by achieving, via the luminosity leveling method, a sustainable instantaneous luminosity of 4×10^{32} cm^{-2} s^{-1} (μ=1.6). No major problems were found in this operation. Some 1100 pb^{-1} have been collected so far on tape. The overall efficiency for data taking is 91%; some 4% loss is attributed to genuine dead-time of data taking (at 3.5 kHz), another 4% arises from the DAQ itself, while the rest is associated with operation of the VELO detector and the high voltage system. LHCb has also obtained limited statistics with 25 ns bunch spacing that will be useful to reveal the amount of spill-over from previous bunches, as is of interest for the studies for the experiment upgrade.

LHCb expects to keep this luminosity leveling for the 2012 run. Some measures to improve the dead-time are in progress. LHCb favours starting with a beam energy of 4 TeV from the very beginning of the run. This will correspond to a net gain of 14% of signal events and a small increase in multiplicity. A 10% increase of the online farm infrastructure is expected to cope with this increase in signal events. LHCb expects to collect greater than 1.5 fb^{-1} of data during next year. They plan to keep reversing the field polarity after each 100 pb^{-1} collected, in order to have an easy handle on long-term systematics. The test with a different crossing angle, from the horizontal to the vertical plane, which makes the detector symmetric for field polarity reversal, has not yet been performed and has to be tried in early 2012.

The LHCC continues to be impressed by the high quality physics results achieved by the Collaboration and the Committee congratulates LHCb for this. As a physics highlight, the LHCC noted that recently a first 3.5σ observation of Direct CP violation in the charm system has been reported by LHCb. The interpretation of this CP violation as a clean signal for new physics has been mitigated in recent theory articles, however the experiment has in hand already twice the statistics and new methods of tagging, to be developed, and will surely improve the errors on this measurement. The Committee, therefore, acknowledges that the choice of having 1/3 of the Higher Level Trigger through-put dedicated to charm is meaningful. Many other physics results have been shown during the LHCC Open and Closed Sessions, with most of the analyses being based on a sample of 370 pb^{-1} or 600 pb^{-1}. The reprocessing of 2011 data has been completed a month earlier than anticipated, by using Tier-1 and for the first time Tier-2 resources. This provides the entire sample to be available for the winter conferences and upon this a long list of measurements are planned to be ready for Moriond in March 2012. Processing plans for 2012 have also been discussed and are adequate. LHCb aims to achieve a complete reprocessing of the entire 2012 sample at the end of next year. Assuming a collected sample of 2.5 fb^{-1} at the end of 2012, LHCb has a reasonable chance to observe a 3σ effect in the $B_s \rightarrow \mu\mu$ decay.

To date twenty papers have been published in refereed journals, thirteen papers are in collaboration-wide review and many other analyses will soon be turned into publications. The LHCC acknowledges the increase in the physics publication rate, which seems to have now reached a stable production pace. The LHCC encourages the Collaboration to maintain this vigorous physics analysis programme.

The LHCC appreciates the work done for the upgrade in the last three months by the recently instituted LHCb Steering Panel and by the Collaboration as a whole. Many technical workshops have taken place, showing a good vitality of this project despite the constraints in manpower provided by running the experiment and carrying out physics analyses. The LHCb Collaboration is now more confident in their upgrade plans due to a better understanding of the detector and to a successful running. In the baseline upgrade project, the TORCH (Timing of Internally Reflected Cherenkov light) detector, the main particle identification detector upgrade to improve performances at low momenta, is not considered any longer. However, a European grant has been awarded to this detector, thus allowing further R&D to be carried out and leaving open the option for its later-stage insertion. Apart from technical choices, LHCb is moving forward to complete an addendum to the upgrade Letter of Intent,

which will review R&D options and alternatives and will concentrate on cost and schedule. Setting of milestones will be a requirement as well as breaking down the costs by sub-detector. The evaluation of the cost for the common projects (Infrastructure, DAQ, Networking, and Computing) has also to be completed to clearly separate common funds and sub-detector costs. In the addendum, the interests and the possible commitments of each participating institution will also be stated, thus facilitating the discussion with the national funding agencies. The Committee expects to have the addendum ready for the June 2012 LHCC session. The Technical Design Reports will follow in 2013. The LHCC recognizes that this upgrade does not have sub-systems that can be staged efficiently. The installation of the upgrade detector is planned for the Long Shutdown II (LS2) to enable the Collaboration to run in the high-luminosity phase of the LHC. The Collaboration is working on a plan in which the effective time needed for the installation of the upgrade is evaluated, so to be integrated in the general framework of LHC shutdown schedule.

In this context, the need for a new building to house the upgraded online farm has been put forward. This building, proposed as an extension of the existing building SX8, should store the 5000 servers of the new farm and, possibly, the new control room and offices. The LHCC acknowledges that, as a minimum, it is essential for the upgrade to have the space, the cooling and the power for the new farm since the existing infrastructure will not be enough. Given the high realization cost (preliminary estimate of about 6 MCHF), the proposal of installing environmentally-friendly cooling and saving money while running, with respect to using old existing structures, is a good option. Apart from technical details, the tight time schedule requires an early decision on the approval of the construction of this building, in order to allow excavation during the Long Shutdown I (LS1). The LHCC supports this proposal and expects to hear more details on this project at future sessions of the Committee. On a more general level, the LHCC considers that the overall success of the LHCb upgrade could be limited by the available manpower and, therefore, endorses the idea of an enlargement of the Collaboration to new institutions.

9. DISCUSSION WITH ALICE

The LHCC **congratulates** the ALICE Collaboration for the successful operation of the detector during the current LHC beam period. An integrated luminosity 150 μb^{-1} has been recorded during the heavy-ion run. This corresponds to 18 times the statistics of the run in 2010 and was achieved by operating with more selective triggers and employing the High Level Trigger for Time Projection Chamber (TPC) data reduction. For proton-proton running, 500 million events using rare triggers were collected. Most detector components operated smoothly. Prior to Pb-Pb running, a successful accelerator test for proton-Pb collisions was conducted. A test with an enhanced satellite bunch at the level of 1.6% intensity showed that it is possible to utilize this method for luminosity containment in addition to the lateral separation, which is nowadays routinely employed.

One paper and 42 contributions to the Quark Matter 2011 conference proceedings have been published since the last LHCC review. Furthermore, four manuscripts were submitted for publication. During the Strange Quark Matter 2011 conference in September 2011, 28 talks have been presented and will be published in the proceedings.

New proton-proton physics results include a measurement of the inclusive J/ψ production cross section at $\sqrt{s} = 2.76$ TeV, a measurement of J/ψ polarization at 7 TeV, inclusive D-meson production cross sections at 7 TeV and the observation of a Λ_c signal at $\sqrt{s} = 7$ TeV.

For the muon detector, the readout system showed improved stability. Still, busy conditions of the muon chamber readout system occur, leading to a contribution of 2 % to data loss. Further measures to investigate the problem are planned for the 2011-2012 Technical Stop.

The alignment of the muon chambers is still not satisfactory, resulting in a significant loss of invariant mass resolution for charmonium and bottomonium resonances. With the magnetic field turned on, the observed position resolution in the bending plane is 0.35 mm, in contrast to a design value of 0.1 mm. The problem is believed to be related to the Geometric Monitoring System (GMS), which is operational and records time-dependent chamber displacements. However, applying the corresponding corrections does not lead to the expected improvement of the position resolution.

Furthermore, the Committee discussed the CPU and disk resource utilization problems that led to a very low analysis job efficiency of 30 % during June 2011. In the meantime, the situation was greatly improved by introducing analysis job trains and optimizing the utilization of the conditions database. Currently, job efficiencies of 70% (at Tier-1) and 80% (at Tier-2) are achieved. However, due to the large amount of newly-recorded data, a significant shortage of CPU and disc resources at Tier-0 will have to be expected for the 2011 heavy-ion run.

During the 2011-2012 Technical Stop, ALICE plans to install three additional Transition Radiation Detector (TRD) sectors and two Electromagnetic Calorimeter (EMCal) modules.

While the minimum-bias data have essentially been recorded ALICE will continue to take proton-proton data in 2012 with more selective triggers. ALICE plans for running in 2012 are little affected by the options considered: a 4-TeV beam energy provides a relatively small extension of the rapidity range in proton-proton mode. The occupancy is largely driven by the long collection time of the TPC. Hence, there is no marked preference for 25 ns over 50 ns running. The year 2012 will be concluded with proton-Pb runs, following initial encouraging tests with the machine. ALICE prefers to have both p-Pb and Pb-p runs to make best use of the asymmetric detector configuration, particularly in the forward directions.

Finally, the Committee discussed the evolving ALICE upgrade plans. In addition to the four projects considered previously – consisting of a high-granularity electromagnetic calorimeter at large pseudo-rapidities, an Inner Tracking System (ITS) upgrade, a forward muon tracker and a Very High Momentum Particle Identification (VMHPID) detector - ALICE is studying the option to increase the TPC's rate capability up to 50 kHz. Challenges include the space charge problem, the need for a high-performance readout and trigger system, the pattern recognition problem in case of overlapping events and the ion feedback situation. ALICE is aiming for a Letter of Intent for the upgrades by spring 2012, in time for presentation at the March LHCC session.

10. DISCUSSION WITH LHCf

The LHCC received the LHCf Letter of Intent putting forward the proposal for LHCf to participate in the possible proton-Pb run in 2012. The proposal foresees the installation of Arm-2 of the LHCf detector in the slot of the TAN absorber, currently occupied by the electromagnetic component of the ATLAS Zero Degree Calorimeter (ZDC). The three remaining TAN absorber slots would still host the ATLAS hadronic ZDC detectors. The proposal has been discussed by the proponents with the ATLAS Management, which has endorsed it. The Committee has independently verified the support of the ATLAS Collaboration, and recommends the acceptance of the Letter of Intent. A minor concern emerged during the discussion in relation to the short duration of the technical stop available for the installation (5 days), but this does not appear to be a critical obstacle. Finally, the Committee encourages the LHCf experiment to explore in more detail, and in collaboration with ATLAS, the potential for synergies in the exploitation of the collected data.

11. REPORT & DISCUSSION WITH LHC EXPERIMENT UPGRADE REFEREES

The LHCC heard a report from the LHC experiment upgrade referees, concentrating on the 10-year LHC plan and the upgrade plans for LHCb, ALICE, ATLAS, and CMS.

As at June 2011, the 10-year LHC plan consists of substantial running periods in 2011-2022, interspersed with Technical Stops over the winter months and a first Long Shutdown (LS1) in 2013-2014, a second Long Shutdown (LS2) in 2018 and installation of the High Luminosity LHC (HL-LHC) during a third Long Shutdown (LS3) in 2022. The LHCC noted the LHC luminosity profile for the years up to 2030 and the corresponding requirements for detector upgrades for the experiments.

LHCb proposes to upgrade the trigger/DAQ of the experiment to operate at 40 MHz, allowing the experiment to operate well into the next decade at 25 ns bunch spacing, at peak luminosities of up to 2×10^{33} cm^{-2} s^{-1} and integrating up to 50 fb^{-1}. The upgrades necessitate extra space and infrastructure for an extended High Level Trigger farm consisting of 5000 CPUs with 130 kW of power and cooling. The overall LHCb milestones include preparation of an Addendum to the LHCb Upgrade Letter of Intent (2012); technical review and choice of detector technologies (2012); Technical Design Reports and prototype validation (2013-2014); tendering and serial production (2014-2016); quality control and acceptance tests (2016-2017); and installation in 2018. The LHCC considers this schedule to be reasonable.

The ALICE upgrade plans focus on providing a substantial enlargement of the experiment's physics reach with increased detector coverage and enhanced measurement capabilities. The ALICE internal procedure for the upgrade included a Call for Expressions of Interest in spring 2011; a workshop on the physics motivation for the upgrades held on 12-13 July 2011; a call for Letters of Intent for autumn 2011; and a preliminary decision concerning approval of the upgrade projects by the end of 2011. The ALICE upgrade projects include work on the Inner Tracking System (ITS), the muon forward tracking, the forward calorimeter, and the very high momentum particle identification detector. Most upgrades are intended for Long Shutdown II (LS2) in 2018. Additional upgrades under consideration are improvements to the ALICE experiment read-out rate capabilities.

The LHCC also heard a report on the ATLAS upgrades. The ATLAS Phase-1 Letter of Intent, submitted in December 2011, will be reviewed by the LHCC in the coming months. The aim is to present conclusions from this review and the Committee's recommendation for the Research Board at the LHCC session in March 2012. The ATLAS Phase-1 upgrades include new Muon Small Wheels; a Fast Track processor (FTK); a higher-granularity Level-1 calorimeter trigger; a new forward physics detection station at 220 m from the interaction point and topological trigger processors combining Level-1 information from various regions of interest.

The referees also reported on progress with the CMS upgrade for Phase-1, concentrating on the Tracker, Muon System, the Hadron Calorimeter, and the Trigger/DAQ. Good progress was reported in all these projects.

The upcoming LHC experiment upgrade sessions will include reviews of the Letters of Intent and the Technical Design Reports, together with any accompanying addenda, for all experiments prior to the LHCC providing its recommendations to the Research Board.

12. REPORT & DISCUSSION WITH THE WLCG REFEREES

The Worldwide LHC Computing Grid (WLCG) has continued to operate very smoothly throughout the 2011 proton-proton and heavy-ion running periods. The experiments have been able to record and process data at high rates, and with levels of pile-up higher than originally anticipated, and without any major problems. At the same time, large samples of simulated data have been generated and reconstructed, data samples have been reprocessed, and many physics analyses have been completed and published, sometimes using data recorded only a few weeks beforehand. Once

again the Committee **congratulates** the WLCG team and the experiments on this impressive performance.

The Castor data service at Tier-0 coped with the increased load of the heavy-ion runs without problems. More than 6 GB/sec have been written to tape, with tests up to 12 GB/sec. Fewer tape drives have been needed, with each drive writing at close to its native drive speed.

ALICE suffered from a very low CPU usage efficiency, caused by overload of the conditions data system and the large number of "chaotic" user analysis jobs. This was especially true in June 2011, preceding the main summer conferences, when CPU/wall efficiency fell to 35%. Changes have been implemented to improve the efficiency to over 70% since September 2011 and further improvements are planned.

ATLAS production, analysis and reprocessing jobs have been running smoothly at all sites throughout 2011. Code optimization has improved the rate of increase of processing time, as a function of the number of interactions per bunch crossing, to be close to linear. The Tier-0 farm has been able to cope with the reconstruction of proton-proton data in 2011 with little backlog, and for the heavy-ion runs the backlog has been about two weeks.

CMS suffered from a high memory usage in the reconstruction of proton-proton events with a high level of pile-up, resulting in poor CPU efficiency at Tier-0. A new software version will reduce this problem significantly. The heavy-ion data has lower memory requirements, due to differences in the tracking. A new processing facility at Vanderbilt University has been commissioned for the 2011 heavy-ion data, to be used for skimming and analysis jobs. CMS has used close to 100% of its Tier-1 resources in 2011, mostly for data reprocessing and simulation, and Tier-2 resources have been heavily used for analysis jobs. Simulation production at 8 TeV for the 2012 run will start soon on the Tier-0 farm.

LHCb has recently modified its computing model so that data reconstruction can be run both at Tier-1 centres and also some selected Tier-2 sites that are well-connected to a Tier-1 site. This model was used for the end-of-year data reprocessing, which started at the end of September 2011 and ended on 20 November 2011, a month ahead of schedule. LHCb is about to start simulation of more than a billion events with 2011 conditions, as well as smaller samples for 2012 and upgrade studies. This will make opportunistic use of CPU capacity, including the online farm. Availability of disk space is critical, until the 2012 pledges are installed. LHCb envisages higher data rates in 2012, since the event size is larger at 8 TeV, and also because they are considering an increase in the bandwidth to disk, partly to accommodate a higher rate of events for charm physics.

Since the September 2011 LHCC session, the requests for computing resources for 2012-2013 from the experiments have been scrutinized by the Computing Resources Scrutiny Group (CRSG) and presented to the Computing Resources Review Board in October 2011. Following iteration with the CRSG, some small adjustments were made to the requests to take into account an assumed updated efficiency of 67% for the Tier-2 CPU in 2012 (70% in 2013) and some updates to disk and tape requests from CMS and ATLAS. Also, the ALICE requests for disk space at all sites, which had been increased in September 2011 (22 PB at Tier-0), were reduced back to the levels that ALICE had requested in April 2011 (14 PB at Tier-0, compared to 6 PB allocated in 2011). Nevertheless, the total requests for resources at Tier-0 still exceed what will be available at CERN in 2012 and 2013. It has therefore been decided to increase the Tier-0 resource allocations for each experiment roughly in proportion to that allocated in 2011. This satisfies the requests of ATLAS, CMS and LHCb, but leaves a significant shortfall in resources at Tier-0 (-22% CPU, -43% disk) for ALICE.

The ALICE Collaboration recognizes the constraints and believes that it will be possible to operate within these allocations in 2012, although it will make it more difficult to perform the physics analyses. They plan to control the number of replica data copies and improve the rate of deletion of obsolete files. Production of simulated

data will be reduced and new software will be introduced to improve the speed of reconstruction. A further increase in resources will still be required in 2013, to process the proton-Pb data to be recorded at the end of 2012. Funding agencies are being contacted individually to request funding for more disk space, which is also lacking at Tier-1 and Tier-2 sites.

There could be a more general shortage of disk space in 2012 due to the impact of flooding in Thailand, where much of the world's production is concentrated. Prices have already risen by 25-30% and the shortage could last for much of the year. Procurements of both disk and CPU servers are affected at most sites. All experiments need to make plans to cope with late and potentially reduced installation of capacity compared to what has been pledged for 2012.

Funding for computing resources is likely to remain under pressure in the future, as major equipment purchased some years ago will need to be replaced, in addition to providing any increase in capacity. The timescale involved for the cycle of requests, pledges, procurement and installation make any short-term changes in requirements difficult to accommodate.

The Committee encourages the experiments to make their accounting of and requests for computing resources realistic, in light of the limited funding available. It will not be possible to sustain the expectation that all physics analyses can be performed in "real time". Instead a more prioritized approach to data processing will be needed, with compromises in the speed at which some channels can be analysed.

13. CLOSE-OUT WITH THE DIRECTOR-GENERAL

The LHCC informed and discussed with the Director-General the status of the experiments and their plans for the future. Amongst the issues discussed were the LHC machine and experiment status, the status of the WLCG, plans for the 2012 LHC run, and the status of the LHC experiment upgrades.

14. A.O.B.

The next exhibition of student posters will be held during the LHCC's session in March 2012 and will cover students' work on a variety of LHC physics topics. In order to accommodate the student poster session, the next review of the RD39, RD42, RD50 and RD51 projects has been moved to the June 2012 of the Committee.

15. REFEREES

The LHCC referee teams are as follows:

ALICE: J.-C. Brient, D. d'Enterria, W. Kuehn (Co-ordinator)

ATLAS: U. Bassler, C. Cecchi, D. Pitzl, R. Roser (Co-ordinator)

CMS: A. Boehnlein (Co-ordinator), M. Demarteau, T. Mori, A. Nomerotski

LHCb: E. Elsen, C. Hawkes, S. Miscetti (Co-ordinator), T. Sjöstrand

TOTEM, LHCf, MoEDAL: U. Bassler, C. Cecchi, D. d'Enterria,
M. Mangano (Co-ordinator)

WLCG: A. Boehnlein, J.-C. Brient, C. Hawkes (Co-ordinator), T. Mori, T. Sjöstrand

Experiment Upgrades:

Co-ordinator: D. Pitzl

RD39: D. Pitzl

RD42: M. Demarteau, A. Nomerotski

RD50: A. Nomerotski

RD51: W. Kuehn

16. The LHCC received the following documents:

- Minutes of the one-hundred-and-seventh meeting held on Wednesday and Thursday, 21-22 September 2011 (LHCC-2011-010 / LHCC 107)
- LHCf Letter of Intent for a p-Pb run. A precise study of forward physics in √s_NN= 4.4 TeV proton-Lead ion collisions with LHCf at the LHC (LHCC-2011-015 LHCC-I-021)
- Letter of Intent for the Phase-I Upgrade of the ATLAS Experiment (CERN-LHCC-2011-012 ; LHCC-I-020)
- Introductory letter for the LHCf Letter of Intent for proton/Lead run (CERN-LHCC-2011-013 ; LHCC-G-156)*
- Summary of comments on earlier drafts to the ATLAS Letter of Intent for the Phase-I Upgrade (CERN-LHCC-2012-001 ; LHCC-I-020-ADD-1)*

*Private collection/CDS filing

17. DATES FOR LHCC MEETINGS

Dates for **2012**

21-22 March

13-14 June

26-27 September

5-6 December

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