CERN/LHCC-2018-018
LHCC-134
May 2018

LARGE HADRON COLLIDER COMMITTEE

Minutes of the one-hundredth-and-thirty-fourth meeting held on

Wednesday and Thursday, 30-31 May 2018

OPEN SESSION – STATUS REPORTS

1. LHC Machine Status Report: Rende Steerenberg
2. ALICE Status Report: Sarah Porteboeuf
3. ATLAS Status Report: Antoine Marzin
4. CMS Status Report: Seema Sharma
5. LHCb Status Report: Alex Pearce
6. TOTEM Status Report: Fabio Ravera
7. RD42 Status Report: Harris Kagan
8. RD50 Status Report: Michael Moll
9. RD51 Status Report: Leszek Ropelewski
10. RD53 Status Report: Jorgen Christiansen

CLOSED SESSION:

Present: C. Bloise, H. Burkhardt, R. Calabrese, D. Denisov, J. Dunlop, E. Elsen, F. Forti (Chairperson), E. Kajfasz, P. Krizan, K. Krüger, F. Kunne, M. Kuze, A. Kuzmin, M. Mangano, C. Schwick, S. Smith, B. Panzer-Steindel, B. Petersen, C. Sfienti, D. Waters, T. Wengler (Scientific Secretary), W. Wisniewski, H. Wilkens

Excused: V. Beckmann, P. Newman

1. Procedure

The chairperson welcomed the committee members and reminded the committee that the minutes of the previous session were already approved by email. He then briefly discussed referee assignments for the RD collaborations. E. Kajfasz will remain the referee for RD42, while K. Krüger has taken over as referee for RD50. D. Denisov remains as referee for RD51 until the end of 2018 and will then hand over to C. Sfienti. On RD53 E. Kajfasz will be joined by R. Calabrese. Before the next session of the LHCC the MATHUSLA collaboration is expected to submit a Letter of Intent to install a large area surface detector on the surface above the ATLAS or CMS detectors to search for evidence of long-lived particles. Once submitted, the referees for a first assessment of this proposal will be F. Kunne, A. Kuzmin and M. Mangano. Further documents

expected over the summer are the LHCb Computing Model TDR, the RD53 extension proposal, and the LHCb Upgrade-II physics case.

2. Report from the Director of Research and Computing

The Director of Research and Computing (DRC) reported on issues related to the LHC. The LHC has had an excellent start-up in 2018, delivering already more than 15 fb^{-1} to both ATLAS and CMS. Should the rate of data collection remain this high for much of 2018, it will put considerable strain on the computing resources. Every effort will be made to provide enough storage for data recording, however data access and analysis might be delayed in some cases due to the large data volumes. The DRC reported on the very positive response in the recent Resources Review Board to the Phase-II TDRs. Both the technical designs and costing information was found to be very solid, and in line with the stated aims of the Phase-II upgrade programme. On the Phase-I upgrades some of the projects, such as the ATLAS New Small Wheel and the LHCb Upstream Tracker, are acquiring significant delays. So far, no change of the LS2 schedule is foreseen, however a review of the restart plans after LS2 will be held in the autumn of this year. Work on the European Strategy for particle physics is progressing, with many local and national discussions taking place over the last months. The location of public meetings discussing the strategy document will be announced during the June meeting of the CERN Council.

3. Report from the LHC Programme Co-ordinator

The changes of the LHC schedule from the last LHCC were presented. Due to the exceptionally efficient commissioning of the machine, physics data taking could start two weeks ahead of the original schedule (v1.1). The VdM scan and the 90m run have been scheduled to take place directly after the TS1 (which has been shortened).

The machine configuration for the 2018 data taking period has been practically left unchanged compared to 2017. This resulted in a record start up time. The optimal physics filling scheme (2556b) was reached 18 days after the first stable beams fill with three bunches. CMS and ATLAS already acquired more than 16 fb^{-1} and LHCb 0.56 fb^{-1}. The only significant issue encountered so far is the re-occurrence of beam dumps due to UFO-like activity in cell 16L2. So far three dumps have been encountered in the 2018 physics running period. To limit the number of dumps the intensity is currently limited to 1.15×10^{11} protons per bunch.

Crossing angle anti-levelling was modified in 2018 to quasi continuously follow a curve of constant dynamic aperture in the parameter space of the beam dynamics. In practice this is implemented as a function of the beam intensity defining when small anti-levelling steps of 1 µrad are being performed. In addition, ß* levelling has been introduced as anti-levelling at the end of the fill. This is an important commissioning step for the LHC, as this procedure will be critical for being able to level the luminosity at HL-LHC. With current settings losses are increasing when doing the levelling steps at the end of long fills due to the shrinking dynamic aperture at small crossing angles. In addition, brief luminosity transients were observed in the levelled experiments in IP 2 and 8. Corrections for these effects are being implemented.

For the VdM scans in 2018 a programme has been worked out which satisfies the partially conflicting requirements of ATLAS and CMS. A calibration transfer fill will be

performed directly after TS1 in order to minimise the activation of the ATLAS Tile calorimeter before this fill, whereas the actual VdM scans are performed after the TS1 intensity ramp up has sufficiently irradiated the main CMS luminosity detector (PLT).

The configuration for the 90m run has been worked out. It is foreseen to run initially with a bunch spacing of 100 ns (requested by ATLAS for the high-t range). The rest of the data will be taken with a 50 ns bunch spacing if possible. The beam configurations in the two experiments will be different but compatible. This arrangement should allow ATLAS to collect about 0.5 pb^{-1} at a pileup of μ~0.15 and 4 pb^{-1} at a pileup of μ~0.3 and CMS/TOTEM to collect between 8 pb^{-1} and 10 pb^{-1} within about 4 days of physics data taking. As a backup solution (if long range interactions in IP1 forbid to run with 50 ns) the entire run will be taken with 100 ns within the time budget of one week including setup time.

A further test for the high ß* run at injection energy has been performed. Initial analysis showed feasible beam conditions for TOTEM, however ATLAS was not able to extract a useful physics signal from their data so far. A thorough analysis of all data recorded and a close collaboration with machine experts will be crucial in order to understand the problematic background conditions in both experiments and to find a setup which allows both detectors to run.

- The **LHCC encourages** ATLAS to perform a detailed analysis of all data sets taken during the various tests in 2017 and 2018 and keep in close contact with the machine experts to find a workable setup for ALFA at either 900 GeV or 1.8 TeV centre of mass energy. The **LHCC encourages** the ATLAS management to ensure that enough effort is made available to complete these studies as soon as possible.

4. Test Beams

The operations at PS-East Area are progressing as scheduled. The operation with Pb beams at the CHARM facility can be reduced by a week, allowing to start then the cabling works for the East Area renovation program. The civil engineering works for the renovation program already started without interference with the test-beam programme. This year's Beam Lines for Schools competition received 195 proposals from 42 countries, 1538 high school students participated in preparing the proposals. The successful team(s) will be announced soon. At the SPS North Area, the cooldown schedule of NP02 allows to reschedule users of H2 towards the end of the year, allowing more beam time to NA61, CMS and CALICE calorimeters.

An additional week of beam time can be allocated to the GIF facility. The optimization of the operation of the injector complex allows to increase by 20% the number of fixed target cycles, compared to past year, to the benefit of the test-beam users. An extension of the GIF facility is proposed to address the high demand for the facility. This extension could be implemented in LS2.

5. Report from the UCG chairperson

The chairperson reported on the UCG reviews of the last three Phase-II TDRs, for the CMS Endcap Calorimeter TDR, and the ATLAS ITk Pixel and TDAQ TDRs. The reviews took place at CERN from April 10-13, 2018. UCG reports were submitted to the Research Board (RB) for its April meeting, and, after RB approval, were presented to

the Resources Review Board (RRB) on April 23. The corresponding UCG reports are listed in the documents section of these minutes.

6. Discussion with ALICE

Scientific output and current activities:

- ALICE continues to deliver high quality physics results, with 24 papers submitted since the last session of the LHCC, bringing the total number of publications to 225. Recent results include the measurement of hyper-triton and anti-hyper-triton cross-sections in PbPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV, charged multiplicity in XeXe collisions at $\sqrt{s_{NN}} = 5.44$ TeV and the direct photon elliptic flow in PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV.
- ALICE has had an excellent start to the 2018 run period and is taking data with an efficiency of larger than 95%, providing a good basis for the heavy ion run later this year. Special tests have already been performed for the TPC field cage, indicating stable operations for the 2018 PbPb running following the cleaning procedures during the YETS. Additional tests are planned for the near future to define the optimal parameters for data taking, to study the possibility of levelling at higher instantaneous luminosities during the heavy ion run and to test the stability of the detector at Run 3 equivalent conditions.

Phase-I upgrades:

- Good progress has been reported on the upgrade programme. The ITS project is making excellent progress and has significant schedule contingency. The last batch of GEMs for the TPC ROCs will be delivered at the beginning of June. The total yield is about 86% and two more batches will be produced in addition to the nominal production. Five IROCs and two OROCs have been installed in the cavern so far and intensive tests are being performed. The LS2 installation sequence and milestones have been defined and preparatory work and infrastructure is advanced.
- There is good progress in most areas of the electronics upgrade, however the CRU upgrade continues to be a cause of concern. There are delays in the production schedule for the production batch in India, with tendering now under way and two prototypes received and successfully tested from a candidate vendor. The test plan and QA of the boards have been presented and the procedure is described in detail in the call for tender.
- The document requested at the last session of the LHCC on the strategy for the critical O2 data storage has been produced and the plans presented therein are deemed reasonable.

- The **LHCC congratulates** ALICE on its continuing rich physics output, and on the progress made on its upgrade programme, in particular on the SAMPA chip, which is now on a path to completion two months ahead of the previous schedule.
- The **LHCC welcomes** the efforts by ALICE to ensure the largest possible number of ROCs (ideally 100%) can be tested in the cavern and is looking forward to an updated cavern ROC testing plan.
- The **LHCC is concerned** that the vendor selection for CRU production in India is delayed and prototypes from only one candidate vendor could be tested. The

LHCC encourages ALICE to maintain the planned thorough qualification of the CRU pre-series produced in India before proceeding to the main batch production. The **LHCC urges** ALICE to make sure the same evaluation procedure is applied as planned to all produced batches. Given the potential impact of further delays, the **LHCC requests** frequent updates on the status of the CRU production in particular in India between now and the next session of the LHCC.

7. Discussion with ATLAS

Scientific output and current activities:

- ATLAS continues to make excellent progress on its physics programme, with 746 papers submitted to date, including 25 since the last LHCC. Recent new results include new searches for W', Z' production and di-jet resonances using 80 fb^{-1} of data at 13 TeV, new differential Higgs cross-section measurements and measurements of charged particle suppression in PbPb and XeXe collisions.
- ATLAS has had an excellent start to 2018 data taking, with very high data taking efficiencies up to the highest instantaneous luminosities reached, and high availability across all sub-systems.
- Commissioning of the FTK Fast Tracker system and the AFP are ongoing. Good progress has been reported on the FTK commissioning, but the system is delayed with respect to original plans due to some hardware issues and in particular a shortage of effort in firmware development. Low efficiencies observed in the ToF detector of the AFP have been tracked to the lifetime of the employed PMTs, which will be replaced later in the summer.

Phase-I upgrades:

- Good progress has been reported on the LAr and TDAQ upgrades, which are on schedule and proceeding with important production readiness reviews over the summer.
- For the NSW project, good progress has been reported in many areas, however, the project remains a cause of serious concern. The two main critical items are the production of the Micromegas (MM) chambers, and the VMM readout chip. For the MM the cleaning protocol to address the observed HV instabilities has been established and is being implemented at the production sites, but full production has not yet started again. There are also concerns about the working point of the detectors being too close to the HV limit. The impact of mesh type and treatment as well as the gas mixture will be investigated over the next weeks, with a recommendation expected by the end of June for the mesh and by the next LHCC meeting in early September for the operating point. For the VMM chip the version VMM3a, while having fixed the known issues with version VMM3, shows an unexpected problem with the baseline, limiting the dynamic signal range for a fraction on the chips. Current investigations whether this issue might be caused by the chip packaging are expected to be concluded by the end of June, with a follow-up review scheduled for July.
- An NSW installation study group was created, with the task of prioritizing scenarios if a complete installation of the two NSW is not possible during LS2. The study group report indicates that the NSW should be installed as soon as feasible, even in the event of significant delay of the second wheel, leading to an asymmetric detector in Run 3.

Phase-II upgrades:

- Good progress has been reported in all areas of the Phase-II upgrades. By now all Technical Design Reports and UCG packages have been approved. Work continues on all projects with many of the remaining design choices converging. A project management plan and project management office are in development.
- The Technical Proposal for a High Granularity Timing Detector (HGTD) as part of the Phase-II upgrade was submitted to the LHCC in April. The project is challenging, the key items are the sensors and the ALTIROC ASIC. The location of the detector provides additional mechanical challenges. The submitted proposal demonstrates good progress in many areas since the submission of the EoI in November last year and outlines clear plans moving forward toward the submission of a TDR early in 2019.

- The **LHCC congratulates** ATLAS on the successful start-up of the detector in 2018 and the large amount of new physics results produced, as well as the good progress reported on the upgrades.
- The **LHCC notes** that a large fraction of the FTK effort relies on transitory physicist labour and that an experienced project engineer is currently missing. The **LHCC is concerned** about the progress on FTK and urges the ATLAS management to find additional resources on both project management and firmware development to avoid additional delays.
- The **LHCC notes** that, despite the progress in many areas, the NSW project is still an area for serious concern, in particular for the VMM chip and the Micromegas production. Improvements are evident in the management and control of NSW issues, however the installation of both or even one NSW during LS2 remains in serious doubt. The **LHCC welcomes** the establishment of the NSW installation study group and **encourages** ATLAS to continue its planning for cases where one or both NSW cannot be installed in LS2.
- The **LHCC commends** ATLAS for setting up the Phase-II project management office and encourages the ATLAS management to sufficiently populate it in order to provide the needed support for the upgrade coordinator.
- Based on the Technical Proposal review during the present session, the **LHCC recommends** that the HGTD project proceeds with the production of the TDR.

8. Discussion with CMS

Scientific output and current activities:

- CMS continues to make excellent progress on its physics programme, with 749 papers submitted to date, including 34 since the last LHCC. Recent results include the observation of ttH production, new searches for chargino and stop pair production, and results from XeXe collisions at 5.44 TeV.
- All the planned YETS activities were completed in time for beam commissioning. CMS has had a very successful start-up in 2018 and is taking data with high efficiency and very high fraction of available channels.
- The major YETS activity was the replacement of the DC-DC converters in the pixel detector. The investigations of the failures in 2017 continue, however there is still no clear explanation of the root causes, although progress has been made in

understanding the mechanism. In 2018, after a month of data taking, no new failures have been observed in the pixel detector.

- The LHC tunnel is still moving with respect to the CMS experiment with an average rate of 0.2 mm per year, causing undesirable effects such as asymmetric irradiation of the pixel detector. Plans for adjustment of the beam position during LS2 are being discussed between CMS and the machine groups.

Phase-I upgrades:

- The only remaining Phase-I upgrade for CMS (in addition to improvements for the pixel detector) concerns the front-end electronics and photosensors of the hadron barrel calorimeter, which will follow closely the already complete upgrade of the endcap calorimeter. The project is on track to be installed during LS2.

Phase-II upgrades:

- Good progress has been reported in all areas of the Phase-II upgrades. All Technical Design Reports and UCG packages submitted have been approved. The LHCC reviews of the L1-Trigger and DAQ/HLT Interim TDRs have been completed, with the corresponding TDR expected in 2020. Many of the recommendations made during the LHCC/UCG reviews are being actively pursued.
- An electronics and online systems workshop has been organized in June, to review the progress of common on-detector systems; it is critical that CERN provides on schedule delivery of specialized and widely used elements, such as the lpGBT.
- The second vendor for silicon detectors has withdrawn from the market survey, leading to the creation at CERN of a dedicated ATLAS-CMS group to carry out the negotiations with the sole supplier and minimize the schedule and financial risks. At this time the qualification of this supplier for sensor production on 8" wafers has not been completed.

- The **LHCC congratulates** CMS on its very productive physics programme as well as the substantial progress made on the upgrade projects.
- The **LHCC notes** the substantial effort that has already been made by CMS and CERN experts to understand the cause or causes of the DC-DC converter failure, and **strongly encourages** CMS and CERN to maintain these efforts until the failures are understood and addressed.
- The **LHCC notes** that the misalignment between CMS and the machine is reaching the limit of what can be compensated for with a magnetic "bump" and **encourages** CMS to work with the machine to define a plan for magnetic elements adjustment to regain alignment flexibility and maintain uniform irradiation of the pixel detector.
- The **LHCC welcomes** the signature of the CMS-TOTEM MoU, which, after the period 2018-21, will merge the two collaborations under CMS.
- The **LHCC is concerned** for the sole supplier situation of the very large silicon sensor procurement for ATLAS and CMS and **encourages** the experiments and CERN to put in action all possible measures to mitigate the corresponding risks.

9. Discussion with LHCb

Scientific output and current activities:

- LHCb continues to have a rich scientific output, with a total of 428 publications to date, including 12 new papers since the last session of the LHCC. New results include the most precise measurement of time-dependent CP-violation in B^0_s decays, the first measurement of CP violation in rare charm-hadron decays, as well as searches for new di-muon resonances in the Y mass region.
- LHCb has had an excellent start to 2018 data taking, with around 0.5 fb^{-1} recorded so far, and therefore good chances to reach the luminosity goal of 2.5 fb^{-1} delivered for 2018. In this respect longer fill lengths will be beneficial for LHCb.
- Only minor problems have been encountered during data taking so far this year. In particular network issues in the HLT caused inefficiencies leading the loss of around 20 pb^{-1}. Tuning the network parameters has meanwhile resolved these issues.

Phase-I upgrades:

- An in-depth review of the LHCb Phase-I upgrades was carried out in this session of the LHCC. Good progress has been reported on the VELO, which has experienced some delays but is still on schedule. SciFi, RICH, Calo and Muon upgrades are also progressing well, with no major issues identified.
- The upgrade of the online system is progressing well, with the overall infrastructure taking shape. On the HLT significant performance improvements have already been achieved, with further improvements under active study to reach the baseline performance. A functional HLT1 implementation will be evaluated by the end of this year, HLT2 will be evaluated at the end of 2019. The software and computing TDR has been submitted to the LHCC, with the computing model TDR expected during the summer.
- The upgrade of the UT is in crisis due to continuing problems with the SALT128 chip. Issues with the latest version of the chip include 40 MHz oscillations, inter-ASIC cross-talk and DC shifts in the analog front end as a function of the number of enabled ADCs. None of these problems are currently understood or reproducible in the SALT simulation. Several test stands are in operation and the help of a senior chip designer from CERN has been solicited in order to understand the problems. Also, a new simulation effort has been started at CERN.
- Interactions have taken place with the machines groups on the possible Upgrade-II of LHCb during LS4, exploring several possible running scenarios. A draft of the document detailing the physics case of such an upgrade is available, with the final version expected over the summer.

- The **LHCC congratulates** LHCb on its rich scientific output and successful start-up of data taking in 2018 and commends the collaboration for the progress made on its upgrade programme.
- The **LHCC recommends** a regular and frequent monitoring of the HLT1 code performance to assess the progress towards achieving the required input rate of 30 MHz at Run 3.
- The **LHCC considers the upgrade of the UT to be in crisis** due to the problems and delays reported for the SALT128 chip. The **LHCC supports** the activities of the LHCb and UT managements in trying to address the issue and optimise the

installation planning in order to successfully complete the UT installation in LS2. The **LHCC urges** LHCb to consider a partial redesign of the SALT128 chip, should the current efforts prove unsuccessful in determining the cause of the problems with the current chip design within the next few weeks. The **LHCC recommends** defining a clear decision path covering the next steps. The **LHCC notes** that given the complexity of this chip, it is essential that state-of-the art simulation software is used in the verification phase.

- On the Upgrade-II the **LHCC acknowledges** that no show-stoppers have been found so far in discussions with the machine groups, however the **LHCC notes** that several issues have been identified (e.g. D1 magnets, matching quadrupoles, issues with radiation tolerance of electronics) that require more detailed studies and an assessment of the costs to determine the feasibility of the luminosity target for this upgrade. Studies will continue in order to form a sound technical proposal of how this upgrade could be integrated into the HL-LHC baseline for LS4.

10. Discussion with TOTEM/PPS

CT-PPS organization and management issues:

- CMS and TOTEM signed an MoU to define the transition that will, after the period 2018-21, merge the two collaborations under CMS. TOTEM will continue as a standalone experiment until the completion of the cross-section measurements at 14 TeV, early in Run 3. The CT-PPS detector system will be renamed PPS and absorbed by CMS with immediate effect. The TOTEM CT-PPS institutions and collaborators have also acquired CMS membership, following the process defined by the MoU.

Physics results and projections:

- TOTEM has submitted the paper documenting the measurement of the differential elastic cross section, using data from the 2016 $\beta^* = 90$m run. The spectrum extends out to $-t \sim 4$ $(\text{GeV/c})^2$, and shows a very clear diffractive dip structure, well distinct in shape from what has been seen in proton-antiproton collisions.
- New simulation studies for PPS measurements with the expected statistics of Run 2 and 3 have been presented. The primary focus remains the study of the exclusive $pp \rightarrow ppVV$ processes ($V = W,Z,\gamma$), and the search for possible anomalous multiple gauge boson couplings. The projections show a great improvement in the sensitivity, possibly reaching SM sensitivity, with the inclusion of hadronic decays of W and Z bosons. New studies of production of axion-like particles coupled to di-photons were shown. Ongoing trigger developments, to be assessed during the 2018 run, will furthermore enable higher-statistics measurements of exclusive di-jet production, extending the reach at lower di-jet masses.

Detector status and 2018 operations:

- Successful alignment runs were carried out early in the run, with three different crossing angles and at two values of β^*.
- The PPS detector is fully functional, is routinely running in low-β^* fills and has collected so far ~14 out of the ~16 fb^{-1} logged by CMS.
- Plans for the TS1 activities are in place. Among others, these include fractional movements of the sensor positions, to overcome radiation damage, the installation of a piezoelectric motor to remotely reposition the pixel sensors at 220m and the

completion of the readout electronics for the vertical timing detectors required by the special run at $\beta^* = 90$m.
- A working group was established, to review the needs, and plan the resources, required by the maintenance and refurbishment of the TOTEM and PPS detectors in view of Run 3.

Special runs:

- The offline analyses of data taken during the commissioning run for the 900 GeV optics have shown that, in spite of the significant and largely misunderstood backgrounds, a reduction by ~2mm of the detector fiducial volume should allow for a measurement meeting the 0.01 target precision on the ρ parameter during the envisaged duration of the possible run.
- TOTEM is likewise satisfied with the current options for the running conditions of the $\beta^* = 90$m run.

- The **LHCC welcomes** the signature of the CMS-TOTEM MoU.
- The **LHCC welcomes** the ongoing studies of the physics reach of PPS, which will operate as a full CMS subsystem in Run 3 and is looking forward to the broader discussion of this potential in the framework of the new collaboration enhanced by the MoU.
- The **LHCC looks forward** to a successful $\beta^* = 90$m run after TS1 and **encourages** the continuation of studies to ensure a successful execution of the low-energy run. For the final definition of the ideal LHC configurations, the LHCC will rely on the recommendations emerging from the planning process moderated by the LHC programme coordinators.

11. Discussion with WLCG

WLCG and the experiment computing systems are working well. Both WLCG and the experiments should however prepare for the case that the good LHC performance leads to a resource strain. There are also sizable uncertainties in the projections of the resource demands for ATLAS and CMS for Run 3. Changes of the assumed input bandwidth should be communicated to WLCG as early as possible. For the moment the flat budget scenario still appears to be a reasonable baseline assumption. In general computing resources increasingly become a limiting factor. In particular a mechanism is needed to define priorities for the computing resources available at CERN. Recent progress on processing times in several areas have shown again that software development is absolutely critical to cope with current and future computing needs. Improvements in algorithmic processing or storage efficiency have the potential to save computing resources far in excess of the cost invested in the software. However, software experts still find it difficult to find long term positions at universities and labs. ATLAS has set up a working group to develop ways to achieve a change of mind in this area and help establish more specialist positions for physicists that are also software experts.

The WLCG Strategy Document has been received. A preliminary assessment found that the identified areas of R&D are reasonable and should be pursued. A review committee will be formed by the LHCC. The review of this document is an important milestone towards the HL-LHC computing TDR.

- The **LHCC congratulates** the WLCG and the experiments on the successful and

efficient use of the computing resources. The **LHCC notes** that the better than expected performance of the accelerator may lead to additional strain on the computing resources and **recommends** to already prepare for such a case.

- The **LHCC recognises** the need for a mechanism to prioritise requests for computing resources at CERN, which could be part of the WLCG scrutiny/pledging procedure.
- The **LHCC supports** the efforts of ATLAS to find ways to increase the number of positions for software experts in HEP and **encourages** the other experiments to join or undertake similar efforts.

12. Report on R&D Projects

The LHCC heard status reports from the R&D projects:

RD42: Development of Diamond Tracking Detectors for High Luminosity Experiments at the LHC

- The RD42 collaboration is commended for its excellent progress in design, fabrication, testing and performance of pCVD diamond detectors, both in planar and 3D technologies.
- An extension proposal has been presented to the LHCC in the present session for a 3-year period. The proposal programme is relevant for, but not restricted to, particle physics (upgrades of or future colliders and experiments), and states well defined and achievable milestones.
- Among the goals of the extension period are 3D diamond sensor fabrication and characterisation, proof-of-principle for diamond-based HL-LHC beam monitoring devices, further development of pCVD material and the development of 3D diamond pixel module prototypes.

- The **LHCC recommends** granting RD42 the 3-year extension requested, including CERN support at the level currently provided (access to CERN facilities, lab and office space, test beams). Progress will be reviewed every year by the LHCC.
- The **LHCC encourages** RD42 to keep sustaining and developing close links (and eventually projects) and commonalities with the LHC and future collider infrastructures and experiments.
- As it was already mentioned last year, the **LHCC strongly encourages** RD42 to update their web site expeditiously to improve their communication with the scientific community.

RD50: Development of Radiation Hard Semiconductor Devices for Very High Luminosity Colliders

- RD50 is a diverse but well-structured collaboration, with four separate activity areas on defect and material characterisation, detector characterisation, new detector structures, and the construction of full detector systems. RD50 has strong ties to the LHC experiments, which have already benefitted significantly from RD50 developments, in particular for the HL-LHC silicon detector upgrades. The collaboration is commended for its excellent progress over the last year.

- Among the main achievements are the development of p-type silicon strip and pixel technologies, double-column 3D detectors, an extensive evaluation of defect engineered silicon, the design and production of LGAD sensors and the development of several unique characterisation methods and systems for sensor and material analysis.
- A prolongation request for 5 years has been submitted to the present session of the LHCC. The proposal describes a clear, well-structured programme for each of the different activity areas covered in the collaboration.
- Among the goals of the extension programme are the development of sensors for extreme fluences (e.g. for FCC), further development of new sensor structures such as LGADs, 3D sensors, and HVCMOS sensors, as well as a strong effort on simulation and modelling radiation damage in silicon sensors.

- The **LHCC recommends** granting RD50 the 5-year extension requested, including CERN support at the level currently provided. Progress will be reviewed every year by the LHCC. The **LHCC considers** the structure of RD50, with a small but focussed core team and corresponding infrastructure at CERN, and many expert collaborators from around the world, to be an excellent setup. The **LHCC notes** that the CERN contribution to RD50 (access to facilities, person power) is crucial for the collaboration, and **strongly encourages** CERN to maintain its support of RD50.

RD51: Development of Micro-Pattern Gas Detectors Technologies

- RD51 is an established collaboration with the aim to develop Micro-Pattern Gas Detector (MPGD) technologies, to support experiments using this technology, and to disseminate the technology within particle physics and in other fields. The collaboration is well organised into seven working groups covering activities from new detector structures and electronics, to modelling, test facility management and industrialisation.
- The collaboration has achieved major progress in MPGD technologies, some of which have already been picked up by experiments: ALICE TPC readout, ATLAS NSW, CMS GE1/1 forward detectors, Compass RHICH detector. The committee congratulated the collaboration for its progress since the last review session.
- A prolongation request for 5 years has been submitted to the present session of the LHCC. Apart from the support of the ongoing projects, the proposal included plans to explore new materials and technologies to achieve ever better resolution in space and time and open the door to new use cases both in HEP and elsewhere.

- The **LHCC recommends** granting RD51 the 5-year extension requested, including CERN support at the level currently provided. Progress will be reviewed every year by the LHCC. The **LHCC considers** the working mode of RD51, with a small but focussed core team and corresponding infrastructure at CERN, attracting contributions and bright ideas to be explored from collaborators around the world, to be an excellent setup. The **LHCC notes** that the CERN contribution to RD51 as listed in the proposal is crucial for the collaboration, and **strongly encourages** CERN to maintain its support of RD51.

RD53: Development of Pixel Read-out Integrated Circuits for Extreme Rate and Radiation

- The RD53 collaboration is commended for their great success in achieving the very challenging design and production of the RD53A demonstrator chip, which is an essential step towards final production chips to be used in the pixel detectors of both ATLAS and CMS HL-LHC upgrades. Fully sharing resources and expertise and working as a single team for two competing experiments has proven to be a workable and very beneficial model for all involved and should be taken as an example for future projects in similar situations.
- A special joint ATLAS, CMS, RD53 Vidyo meeting was held on May 18, 2018 with the goal of reviewing the motivation for having different pixel readout chips for ATLAS and CMS.
- An impressive effort has been made by RD53 and both ATLAS and CMS in analysing how to minimize the differences between the productions chips of the two experiments. The resulting solution of different chip sizes utilising the same standard building blocks and periphery carries the maximum benefit of common elements without negatively impacting the tracker designs and projected performance of the Phase-II tracker upgrades of ATLAS and CMS.

- The **LHCC congratulates** RD53 on its achievement in producing the RD53A chip, and **strongly recommends** that the minimization of differences between ATLAS and CMS be maintained throughout the remainder of the project (for instance in the analog front-end and digital bottom of the chip).
- The **LHCC strongly supports** that the current operation of RD53 as a single design team be continued and reinforced. Institutions involved are urged to keep the current (number of) experienced people fully committed until the end of the project, i.e. until fully functional chips are available for both ATLAS and CMS.
- The **LHCC is looking forward** to receiving the RD53 extension proposal in line with the above recommendations in time for the September 2018 LHCC session.

13. General Comments

The following comments are applicable to more than one project.

- The **LHCC is concerned** for the sole supplier situation of the very large silicon sensor procurement for ATLAS and CMS and **encourages** the experiments and CERN to put in action all possible measures to mitigate the corresponding risks.
- The **LHCC notes** that it is critical that CERN provides on schedule delivery of specialized and widely used elements, such as the lpGBT.
- Given several issues with chip designs in the recent months, the **LHCC emphasises** the importance of using state-of-the-art simulation tools in verifying the chip designs in detail before prototype or final chips are produced.

14. REFEREES

The LHCC referee teams for this session are as follows:

ALICE: C. Bloise, J. Dunlop, P. Newman, C. Sfienti (Co-ordinator)

ATLAS: V. Beckmann, R. Calabrese, F. Kunne, W. Wisniewski (Co-ordinator)

CMS: D. Denisov (Co-ordinator), E. Kajfasz, A. Kuzmin, D. Waters

LHCb: P. Krizan (Co-ordinator), K. Krüger, T. Kuhr, M. Kuze

LHCf, MoEDAL, TOTEM: C. Bloise, A. Kuzmin, M. Mangano (Co-ordinator), P. Newman

LCG: V. Beckmann, J. Dunlop, T. Kuhr (Co-ordinator), D. Waters

R&D projects:

General: E. Kajfasz (Co-ordinator)
RD42: E. Kajfasz
RD50: K. Krüger
RD51: D. Denisov
RD53: E. Kajfasz, R. Calabrese

15. The LHCC received the following documents:

CERN-LHCC-2018-006	Minutes of the one hundred and thirty-third meeting of LHCC held on 1-2 March 2018
CERN-LHCC-2018-007	Technical Design Report for the Phase-I Upgrade of the LHCb Software and Computing
CERN-LHCC-2018-008/UCG-029	Report on the UCG review of the ATLAS Phase-II Trigger and DAQ TDR
CERN-LHCC-2018-009/UCG-030	Report on the UCG review of the ATLAS Phase-II ITk Pixel Tracker TDR
CERN-LHCC-2018-010/UCG-031	Report on the UCG review of the CMS Phase-II Endcap Calorimeter TDR
CERN-LHCC-2018-015	RD42 Prolongation Request
CERN-LHCC-2018-017	RD50 Prolongation Request
CERN-LHCC-2018-016	RD51 Prolongation Request
CERN-LHCC-2018-023	Technical Proposal for an ATLAS Phase-II High Granularity Timing Detector
CERN-LHCC-2018-019	WLCG Strategy Document

DATES FOR LHCC MEETINGS

Dates for 2018
28 Feb - 1 Mar
30-31 May
12-13 September
28-29 Nov

Thorsten Wengler
E–mail: Thorsten.Wengler@cern.ch
Tel. 71298

LHCC Secretariat: Patricia Mage (Bldg. 3/R-018) Tel. 78135
patricia.mage@cern.ch