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LHCC-130
May 2017

# LARGE HADRON COLLIDER COMMITTEE

Draft Minutes of the one-hundredth-and-thirtieth meeting held on

Wednesday and Thursday, 10 May and 11 May 2017

## OPEN SESSION – STATUS REPORTS

1. LHC Machine Status Report: Matteo Solfaroli
2. ALICE Status Report: Livio Bianchi
3. ATLAS Status Report: Iacopo Vivarelli
4. CMS Status Report: Giovanni Petrucciani
5. LHCb Status Report : Agnieszka Dziurda
6. TOTEM Status Report: Michele Quinto
7. RD42 Status Report: Harris Kagan
8. RD50 Status Report: Michael Moll
9. RD51 Status Report: Silvia Dalla Torre
10. RD52 Status Report: Roberto Ferrari



## CLOSED SESSION:

Present: C. Bloise, J. Boyd, V. Beckmann, H. Burkhardt, P. Burrows, D. Denisov, J. Dunlop, G. Eigen, E. Elsen, F. Forti (Chairperson), E. Kajfasz, M. Krammer, T. Kuhr, F. Kunne, M. Kuze, A. Kuzmin, M. Mangano, P. Newman, S. Smith, B. Panzer-Steindel, C. Sfienti, T. Wengler (Scientific Secretary), W. Wisniewski, H. Wilkens

### 1. Procedure

The chairman welcomed the new members of the committee: V. Beckmann, M. Kuze and D. Waters. The minutes of the one-hundredth-and-twenty-ninth LHCC meeting (LHCC-2017-004 / LHCC-129) were approved. The Technical Design Report for the ATLAS Inner Tracker Strip Detector has been received.

### 2. Report from the Director of Research and Computing

The Director of Research and Computing reported on issues related to the LHC. The LHC has restarted, with first collisions seen in the experiments, and stable beams for physics expected before the end of the month. This week saw the inauguration of the new Linac4, which is intended to replace the current Linac2 by LS2. However Linac4 already serves as a backup for Linac2 now. During the recent RRB several funding agencies expressed the strong wish to accelerate the approval process for the Phase-II TDRs in order to have a near to final money matrix available for Phase-II by the April

2018 session of the RRB. Also ATLAS and CMS prefer this accelerated schedule. The planning to accommodate this schedule while maintaining the full scientific scrutiny by the LHCC is currently under way. The DRC reported that CERN funds to cover host lab's duties until the end of LS2 have been secured in the MTP. The final document on the updated European Strategy for particle physics is expected for May 2020, and will be preceded by a collection of inputs on physics motivations and opportunities during 2019.

## 3. Report from the LHC Programme Co-ordinator

The extended year-end technical stop (EYETS) work finished with all activities successfully completed on schedule. The main actives were replacing an LHC dipole magnet which involved warming up sector 1-2, replacing the SPS beam dump, and the installation of the new CMS pixel detector. The EYETS work is expected to remove the limitations on the beam intensity that existed during 2016 running. The commissioning with beam started two days ahead of schedule and is progressing very well. It is likely that physics running will start ahead of schedule.

The details of the 2017 machine setup have been finalised, running with the Achromatic Telescopic Squeezing (ATS) optics scheme, 40 cm β*, and the BCMS injection scheme, leading to an expected peak luminosity of ~1.7 x $10^{34}$ $cm^{-2}s^{-1}$ (peak pileup of ~50). It is being considered to reduce the β* (to around 33 cm) later in the year which would lead to higher peak luminosity of ~1.9 x $10^{34}$ $cm^{-2}s^{-1}$, although there could be a limit on the luminosity from the cooling of the triplet magnets which is expected to be in the range ~1.75−2.0 x $10^{34}$ $cm^{-2}s^{-1}$, and the luminosity will need to be levelled at this level. The goal is to deliver an integrated luminosity of about 45/fb in the 145 days scheduled for physics in 2017 (although this depends on what special runs are scheduled in the year).

The optics has been modified to at least partially recover the acceptance loss for the CT-PPS experiment caused by the new scheme. A new low-power RF scheme (full detuning) will be used which modulates the bunch time and position, but is not expected to be problematic for the experiments. A scheme to reduce the crossing angle during the physics fills to increase the luminosity production has been developed, and pending successful commissioning will be used in 2017 running. A magnetic orbit bump will be used to re-align the beam in CMS by ~1.5mm in order to centre the beam in the detector.

The slight luminosity imbalance between ATLAS and CMS is still not resolved, in spite of several analysis attempts. The **LHCC encourages** the experiments to deploy fast, robust, and model independent methods (such as the Z counting) to assess the actual delivered luminosity.

There is a possibility of a very short (of order 10 hours) pilot physics run with Xe ion collisions, benefitting from having Xe in the injector chain for the fixed target programme.

## 4. Test Beams

The program for the SPS Xe ion run, with the 6 different momenta at which the SPS will be operated, has been prepared with the NA61 collaboration. Discussions are on-going for a short Xe run in the LHC, as well as operating with partially stripped ions (Xe39+) for the Gamma Factory proposal in the Physics Beyond Collider context.

During the Xe run for NA61, the ion beam can also be extracted to the H4 and H8 beam lines. Ten user groups applied for beam time in the test-beam lines, and have been scheduled according to their requests. The updated PS & SPS user schedule was presented, including a short scrubbing run in the SPS. Thanks to a smooth restart of the injector complex, PS and SPS beams where available for physics ahead of schedule. The two super conducting magnets in the North Area are being prepared for use and tests. The East Area irradiation facility will operate for 200 days for users. The CHARM mixed field facility is also preparing for a two week run with Xe ions from the PS. At the North Area Gamma Irradiation facility 25 different setups are scheduled, with typically up to 10 setups installed at the same time. With the addition of the neutrino platform to the test-beam users in 2018, and a potential Pb run for NA61, several options for the SPS FT program will be prepared for a decision towards the end of this year.

## 5. Discussion with ALICE

Scientific output and current activities:

- ALICE continues to deliver high quality physics results, with 3 papers published and 1 submitted since the last session of the LHCC, bringing the total number of publications to 178. An exciting enhancement of strangeness production has been observed in high-multiplicity in proton-proton collisions at 7 TeV. This result could indicate the production of quark-gluon plasma also in high-multiplicity pp collisions at very high energy. Many new results are expected for the summer conferences.
- Nearly all detectors made extensive use of the shutdown. The present L3 magnet power converters, dating from LEP times, cannot be operated beyond LS2. A plan for replacing the power converters, transformers and the polarity switch is being worked out. A successful campaign of cosmic ray data taking has allowed an initial alignment of the central detector and muon spectrometer before collisions.
- ALICE intends to record approximately 15/pb of pp data at 13 TeV in 2017 as reference for hard probe measurements in PbPb. The running conditions and trigger conditions will be optimized for this purpose, and will be very similar to the 2016 data taking conditions.

Phase-I upgrades:

- Excellent progress has been reported on the ALICE TPC Upgrade. The PRR for GEM and chamber production has been successfully passed in March. The reviewers suggested increasing the GEM4 resistor to increase protection against shorts, which the project has accepted after exploring the effects of this change on the gain of the chambers.
- The procedures for ROC production validation have been frozen for all sites. GEM production is on-going. First beam tests at the PS for an EDR IROC with six FEC is foreseen for the end of May. Successive beam test studies in the ALICE cavern are planned as well.
- A first full system test of the complete readout architecture has been performed. For CTP, CRU, FIT, MFT and MID some milestones have been significantly delayed. Those systems however do not appear to be on the critical path, with

sufficient contingencies still available. The LHCC will review these new milestones within the LS2 plan during the in-depth review planned for the LHCC meeting in September.

- A full scale SAMPA chip is available since June 2016 and has been extensively tested with TPC and MCH. A radiation test, performed at KVI in April, has shown Single-Event-Latchup (SEL), which was not expected for this technology. The assessment team has quickly identified the cause and a new layout has been proposed to overcome this problem.
- Beyond the baseline solution of v3 SAMPA, an improvement of the chip for the highest rates, by changing a feedback resistor, is planned. The LHCC urges the project to ensure that this development does not draw resources from v3 finalization and tests.

- The **LHCC congratulates** ALICE on the successful completion of the extensive shutdown activities, and on rich harvest of new physics results.
- The **LHCC congratulates** the TPC upgrade group for the enormous progress since the last LHCC meeting. The project is still at a critical stage. The LHCC **encourages** the TPC group to sustain this progress as it ramps up large-scale production.
- The **LHCC recognizes** the significant progress made by the SAMPA team. The time plan for the new chip however still remains critical. The **LHCC urges** the SAMPA team to stay focused on the baseline solution to ensure a timely production of the chips for detector integration. The **LHCC expects** a detailed manpower and tasks plan for the in-depth review in September.

## 6. Discussion with ATLAS

Scientific output and current activities:

- ATLAS continues to make excellent progress on its physics programme with 629 papers submitted to date, including 15 since the last LHCC. Recent new results include searches for the Higgs boson decaying to two muons as well as for resonances in di-lepton and di-jet final states, as well as searches for dark matter. A new measurement on the di-photon differential cross section using Run 1 data has also recently been published.
- A standard programme of maintenance and repairs has been carried out over the EYETS. Items include the refurbishment of the EC toroid air pads, the installation of new readout cards for the TRT and additional Read Out Drivers for the Pixel Layer 1 and the Tile calorimeter, as well as the exchange of a small number of LAr LV power supplies.
- The muon spectrometer has been equipped with additional chambers in the feet region to improve the acceptance in this region, and several CSC and TGC chambers have been repaired.
- The second arm of the AFP system has been installed. Both arms will be operated continuously in standard high-luminosity pp fills in 2017.
- The computing systems are performing well, with the resources assigned for 2017 thought to be sufficient.

Phase-I upgrades:

- Brief reports were received on the LAr and TDAQ Phase-I upgrade projects, with the main focus on the NSW upgrade. For the LAr upgrade all ASICs are making good progress, with schedule risks decreasing. The project is on track. Good progress was also reported on the TDAQ upgrade with all FDRs expected by December 2017, keeping the schedule on track as well.
- For the NSW many components are on schedule (mechanics, shielding, alignment system, services), and the Micromega readout PCB production, previously an item of concern, is making good progress.
- The sTGC cathode board production remains a major concern, despite very intense management follow-up and continuous local presence of the NSW technical team at the supplier, as well as an overall increased effort from ATLAS institutes. Additional suppliers have produced pre-series boards that look very promising, but still need to be fully qualified.
- ROC and VMM ASICs remain on the critical path for the NSW. In addition system integration and testing has to be addressed. Design updates might still be required depending on the test results.
- ATLAS expressed its appreciation for the additional help received from CERN on logistics, which helped to avoid additional delays in this area.
- 'Plan B' options have been studied for the NSW in case of continued schedule problems with respect to an installation in LS2. A chamber redesign appears not feasible on this time scale: other options under study would yield reduced functionality with respect to the original scope.

Phase-II upgrades:

- Brief reports were received on ITk pixels, LAr, TileCal, Muons, TDAQ projects and on infrastructure upgrades for Phase-II, with the TDR preparation generally on track. On the infrastructure a cost estimate for the common fund for power and cooling is expected for September.
- Good progress was reported on the ITk pixel upgrade layout and ASICs, with the TDR on target for December 2017.
- The TDR for the LAr upgrade would incur a 3 week delay should a section on the high granularity timing detectors (HGTD) be included, as the decision on whether to go forward with the HGTD is expected to be made at the end of September. In order to avoid delay in reviewing the LAr upgrade TDR ATLAS was encouraged to consider at this stage a separate 'LoI-style' document for the HGTD.

- The **LHCC congratulates** ATLAS on the successful completion of the extensive EYETS programme and the excellent progress in producing physics results.
- The **LHCC strongly endorses** the ramp-up of efforts to complete the NSW in time for installation in LS2, however the schedule remains a major concern despite the recent progress reported.

Report on the ATLAS ITk Strip TDR:

The LHCC conducted an in-depth review of the TDR for the ATLAS ITk Strip tracker system. The LHCC review team was augmented for the review with three experts, Alan Honma, Steve Nahn, and Paolo Petagna. The review process and outcomes are summarised briefly below.

- 20/11/16: An internal ATLAS TDR draft version was shared with the LHCC ATLAS referee team. Though largely complete, several chapters were missing from the document at that stage.
- 29/11/16: The ATLAS referees provided informal feedback on the internal draft at their regular LHCC Week meeting with the ATLAS management.
- Several external experts were added to the LHCC ATLAS referee team for the purpose of reviewing the TDR. The LHCC is grateful to Alan Honma, Steve Nahn and Paolo Petagna for serving in this capacity. The LHCC Chair and UCG Chair were also included to complete the membership of the LHCC ITk Strip TDR Review Team (the 'Review Team').
- 16/12/16: An updated draft TDR version was submitted to the Review Team. This was complete in layout with the exception of the chapter on Performance & Physics.
- 20/12/16: The Review Team met to agree the timetable for the subsequent review and to assign responsibilities among the Team members.
- 20/1/17: A complete draft TDR version, including the chapter on Performance & Physics, was submitted to the Review Team.
- 30/1/17: The Review Team met to discuss the draft TDR and identify a first round of issues requiring clarification and/or discussion. A list of questions was subsequently supplied to ATLAS.
- 8/2/17: The Review Team met with ATLAS ITk system representatives and ATLAS management to discuss the issues raised and the ATLAS responses, and to identify further items requiring clarification. A subsequent list of topics and suggestions for the format and scope of the formal LHCC review, was sent to the ATLAS management.
- 21/2/17: The Review Team conducted a formal review of the draft TDR. Detailed presentations were received from ATLAS on: 1) overview and rationale for the Strips (and implications for the Pixels) system layout; 2) performance and physics; 3) sensors and modules; 4) mechanics and cooling; 5) electronics, power supplies and cables; 6) integration and installation; 7) [with the UCG] management, schedule, risks, and finance.
- 23/2/17: The Review Team findings were presented to the LHCC in closed session. It was found that the TDR is a monumental document that contains a wealth of detail and represents the reference design for the ITk Strips system. The Strip tracker as proposed was found to be of a sound design. In conjunction with the proposed Pixel system the complete tracker will address the tracking performance required to do physics in the high-luminosity LHC era. The design will maintain the current tracker performance levels in an environment with event-pileup values as large as 200, as well as extending tracking coverage into the forward regions. While there are many technical issues and associated risks to be overcome, no 'show-stoppers' were identified.
- However, a number of presentational issues were identified and ATLAS was requested to make corresponding improvements for incorporation into the final

TDR. The most important of these was a request for a clearer presentation of the performance in terms of measurement capability in benchmark physics channels and in the context of representative models of Beyond-SM physics.

- LHCC gave its provisional approval of the draft TDR and recommended that the UCG review should proceed. It was agreed that, subject to satisfactory completion of the LHCC's requests, and subject to the findings of the UCG, the final TDR would be considered for approval at the May LHCC meeting.
- 7/4/17: The final version of the Strip TDR was made publicly available by ATLAS.
- 14/4/17: A package of additional materials to support the UCG review was made available by ATLAS to the UCG review team.
- 24/4/17: The UCG review team met with ATLAS ITk system representatives and ATLAS management for first-round discussions. Questions and comments were fed back to ATLAS in preparation for the formal review at the May LHCC week.
- 8-9/5/17: The UCG review team held a formal review of the Strip TDR. They concluded that the cost estimate, resources, schedule, and risk level are reasonable for the current stage of the project. They recommended Step 2 approval by the RB and RRB to allow resources to become available and MOUs to be signed. They recommended that, to ensure success, ATLAS, the LHCC and CERN management must closely monitor the funding situation and technical progress of this extremely complex project.
- 11/5/17: The LHCC, having satisfied itself that its requests for clarifications had been incorporated into the final TDR version, and noting that the UCG review had not identified any additional issues beyond those normal for a large project at this stage, formally recommended the Strip TDR for approval. The LHCC thanked and congratulated ATLAS for their achievement and for their prompt and constructive engagement with the review process.

## 7. Discussion with CMS

Scientific output and current activities:

- CMS continues to have a rich scientific output, with 601 paper submitted to date, and many new results expected for the LHCP conference in May. Recent results include new searches using boosted objects, as well as new measurements of the Higgs Boson fiducial and differential cross section in the 4l and $\gamma\gamma$ channels and a precise determination of the Higgs Boson mass in the 4l channel.
- The EYETS activities have been completed successfully, and the experiment is on schedule with re-commissioning for stable beams later this month.
- The cold box of the magnet cryogenics system shows evidence of a small amount of contamination, possibly a residual effect of the contamination issues successfully addressed last year. This contamination is expected to be cleared out of the system over the next few regeneration cycles without any additional measures needed, but will be monitored carefully.
- CMS computing and MC production is on track to provide the resources required for 2017.

Phase-I upgrades:

- The new pixel detector has been installed successfully and a first alignment has been carried out using cosmic ray data.
- The upgrade of the Forward Hadron Calorimeter involving the installation of new multi-anode PMTs had already been achieved by the February session of the LHCC. The Hadron Endcap Calorimeter upgrade has been postponed to the 2017/18 YETS, however keeping one new readout box in place for 2017 running to gain experience with the new electronics.

Phase-II upgrades:

- The HL-LHC upgrades are progressing well, with four TDRs to be finalised this year. The idea of an additional timing layer is being developed, with the potential to reduce the effective pile-up of events by a factor of 4-5. A conceptual design of this timing layer is expected later this year, with a TDR foreseen for the middle of 2018.
- During the EYETS five prototype chambers of the Phase-II upgrade muon chambers have been installed, to test their performance under real beam conditions before the installation planned during LS2.

- The **LHCC congratulates** CMS on the successful completion of the EYETS activities, including the timely installation of the new pixel detector, and on the continued rich output of its physics programme.
- **The LHCC urges** CMS to closely monitor the situation of the cold box of the cryogenics system and take any measures necessary to ensure a safe operation of the magnet system.

## 8. Discussion with LHCb

Scientific output and current activities:

- LHCb continuous to have a rich scientific output with a total of 376 publications to date, including 12 new papers since the last session of the LHCC. New results include the observation of five new $\Omega^0_c$ states, a measurement of the weak phase $\phi_s$ from $B^0_s \rightarrow J/\psi\, K^+K^-$ decays, and measurements of the $B^0_s$ and $D^-_s$ life times. The measurement of $R_{K*}$, the ratio of the $B \rightarrow K^*\mu\mu$ to $B \rightarrow K^*ee$ branching fractions, deviates in two bins of low di-lepton mass from the SM by more than $2\sigma$, increasing the number of $> 2\sigma$ effects in this mass region. Use of the SMOG system provided a measurement of antiproton production in pHe collisions at $\sqrt{s_{NN}} = 110$ GeV.
- All planned activities during the EYETS have been successfully accomplished, and the detector is in good condition and ready for 2017 data taking. Among the interventions during the EYETS were the repair of silicon tracker bonds, the HPD exchange for RICH 1&2, as well as the replacement of the Herschel scintillators.
- The automatic alignments and calibrations of all subsystems work well. The trigger, disk usage and farm usage have been optimized and the resources available are deemed sufficient for 2017 data taking.

Phase-I upgrades:

- An in-depth review of the LHCb Phase-I upgrades was carried out during the present session of the LHCC.
- Overall impressive progress on the ambitious LHCb upgrades has been reported. The upgrade effort appears well organized, with new upgrade coordinator positions created for detector, performance, resources, and data processing. The infrastructure is well managed as well.
- No delay is apparent at this point endangering the timely completion and installation of the upgrades in LS2. However, schedules are very tight in particular for the tracking related sub-systems.
- For the VELO, slippage in the technology decision and implementation of the cooling is a concern. For the UT the SALT ASIC remains a critical item. Given the significant revision of the SALT to be submitted in June (which as yet cannot be proven to be the final one) and the tight schedule for installation in LHCb, a more detailed plan including human resources, production lines readiness, and taking into account realistic scenario(s) needs to be provided. For the SciFi a small concern remains whether the Pacific5 ASIC will indeed be the last iteration. It also still remains to be shown that the lighter Flex cable (50% less copper) under development meets the requirements.
- On the data processing side it is crucial for LHCb that the decision on the location of their data center is not delayed, so that detailed planning and preparation work for the installation of the online farm can start. Despite much effort to optimize the use of CPU resources, the CPU performance of the event filter nodes is still a concern.
- It was remarked during the review that access to P8 for emergency services might be a problem during rush hours due to the new mall built close to it.

- The **LHCC congratulates** LHCb on the successful completion of the EYETS activities and on the continued production of high quality physics results.
- The **LHCC commends** LHCb on its progress on the Phase-I upgrades. The **LHCC notes** that the schedule remains tight on several items such as the VELO cooling and the SALT ASIC. The **LHCC urges** LHCb to closely monitor these items, considering them as collaboration-wide issues, and take decisions in a timely manner to ensure the installation schedule is not jeopardized.

## 9. Discussion with TOTEM

- Good progress was shown on the analysis of the 13 TeV cross-section, of the 2016 CT-PPS data, and of the CMS+TOTEM $\beta^*$=90m run of 2015. The search for glueball candidates is being extended to the tensor candidate, $f_J(2220)$, whose glueball interpretation predicts decays to pairs of K*, ρ and Φ mesons.
- The remaining activities foreseen for the EYETS have been completed successfully. All four detector technologies explored by TOTEM and CT-PPS are now deployed: silicon strip and 3D pixel tracking detectors, as well as

diamond and ultra fast silicon detectors (UFSDs) for the timing. CT-PPS is therefore now ready for the last commissioning steps before data taking.

- Tests of the full DAQ, integrated with CMS, and insertion tests are under way, with the final vertical positioning of the cylindrical horizontal pot foreseen for TS1, following the freezing of the vertical beam orbit displacement at IP5. Further insertion tests will be necessary after this.
- The new optics proposed by the LHC, and the new roman pots at 220 m, allow CT-PPS to maintain low-mass acceptance starting from ~300 GeV, as in 2016.
- TOTEM is continuing the R&D on new options for its timing detectors. The goal is to use the UFSDs developed for CT-PPS in TOTEM's vertical timing detectors (significant improvement in time resolution and in acceptance), and to use the new double-diamond detectors with CT-PPS (greater radiation resistance, with a time resolution comparable to that of UFSDs).
- The T2 telescopes have suffered irreversible radiation damage during 2016, and cannot be further used. TOTEM is considering the possibility, for a potential $\beta^*$=90m run in 2018, to use the CMS forward hadron calorimeter (HF) as a veto counter, replacing the T2's main functionality at the trigger and analysis level.
- For Run 3, when a total cross section measurement at $\sqrt{S}$=14 TeV is expected, TOTEM is considering to replace the T2 with a set of scintillators, located in the volume previously occupied by the CASTOR detector. These can be installed and removed within a few hours of the dedicated run.
- TOTEM has presented first projections of the running time and $\beta^*$ required for a measurement of the total cross section and $\rho$ parameter at $\sqrt{S}$=900 GeV. $\beta^*$=50m is sufficient to access the Coulomb-nuclear interference region, with 1-2 days of data taking possibly enough to reproduce the statistics of the 13 TeV run.

- The **LHCC congratulates** the TOTEM and CMS CT-PPS teams on the successful completion of the EYETS tasks, and **acknowledges** the efforts made by the accelerator colleagues and by the experiments to converge on a satisfactory optics. The **LHCC hopes** that these constraints will continue being taken into account by the future evolution of the optics design.
- The **LHCC notes** the need to perform insertion tests at several crossing angles, and **endorses** the request by the LPC to consider using interpolated calibration data to limit the number of such tests.
- The **LHCC encourages** TOTEM to initiate formal discussions with CMS, in view of the possible $\beta^*$=90m run in 2018, and of the possible replacement of T2 for the total cross section measurement at 14 TeV in Run 3.
- The **LHCC encourages,** at the first suitable opportunity, machine studies on a possible run at $\sqrt{S}$=900 GeV and $\beta^*$ in the range 50-100m, to assess the technical feasibility and reliably estimate the time cost of this run.

## 10. Discussion with WLCG

The WLCG continuous to operate well across the experiments; WLCG infrastructure and experiments are well prepared for 2017 data taking. The optimisation efforts to deal with the large 2016 data set have shown the desired effect. While efforts continue, no large gains are expected in addition at this point without significant investment that

would allow adjustments to the computing models. The process of allocating computing resources from year to year has been discussed, in particular a time line that would allow for more analysis of any issues and time to look for potential mitigations if necessary concerning the computing requests of the experiments before they are approved by the RRB. The proposal will be presented in a future meeting.

On the development of the computing model and software for the HL-LHC era, the Software Community White Paper is under preparation, and is expected to be available this summer. The HL-LHC computing TDR is due in 2020, covering technology expectations, ideas for computing models, a broad expectation of the cost, and a view of how to engineer the transition from the existing system. A strategy document will be provided towards the end of 2017, listing known problems and possible solutions, and the R&D program required to write the TDR.

- The **LHCC congratulates** the WLCG and the experiments for the efficient operation of the computing infrastructure and the successful implementation of the mitigation measures optimising the use of the computing resources.
- The **LHCC encourages** the development of an updated procedure to arrive at the computing requests for the experiments.
- The **LHCC notes** that 2018 will be a special year for ALICE due to the heavy ion run and **suggests** that efforts be made to temporarily supply computing resources beyond the flat budget, in order to facilitate a timely analysis of the data. However the **LHCC urges** that mitigation efforts by ALICE should also continue and a break down of the resource planning in quarters or months should be provided to evaluate the possibility of late resource installation in 2018 or the beginning of 2019.

## 11. 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 LHCC congratulates RD42 on it strong publication record and presence at international conferences. During the past year RD42 contributed strongly to diamond detector projects with both the accelerator and ALTAS/CMS. ATLAS/CMS BCM, BLM, DBM detectors will see collisions (again) soon, providing abort, luminosity and background functionality. The CMS diamond upgrade has been completed successfully.
- Work is also ongoing with ATLAS on HL-LHC for diamond luminosity monitoring and beam abort monitor upgrades. Prototyping is under way with a TDR planned for August.
- Much progress has been made on 3D detector prototypes (pCVD diamond), leading to the construction of the first 3D diamond pixel detector. The efficiency of the detector so far looks promising with the full analysis in progress.
- RD42 is continuing its close collaboration with diamond material manufacturers in order to improve the quality of the available material. Further goals for the coming year are continuing the development of HL-LHC devices and detector

prototypes of different geometries, in particular 3D pCVD devices with 50 μm x 50 μm cells, and irradiation studies and test beams to test new materials.

- The **LHCC congratulates** RD42 for its achievements during the past year and **recommends** continuing its support for another year, including the present level of office and lab space, and continued access to test beams, which is critical for the characterisation of the prototypes under development.
- The **LHCC recommends** a communication effort be make by RD42 to grant easier access to people external to RD42 to its work and achievements. Measures may include an update of the website and a category and document class ID on the CERN document server.
- The **LHCC requests** a plan to be presented at the next LHCC review of RD42 for the next three years, with clearly identified and traceable milestones and goals.

**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. As recommended by the LHCC, RD39 has recently joined RD50. RD50 has strong ties to the LHC experiments, which have already benefitted significantly from RD50 developments.
- Recent results on the defect and material characterization include the study of defects with strong impact on device performance after irradiation and a new defect and material engineering approach using nitrogen enriched silicon.
- The use of two-photon absorption TCT has been successfully applied in the device characterization of highly-irradiated silicon sensors.
- RD50 also continues to have a strong simulation effort, which recently led to a good reproduction of oxygen-rich p-silicon data irradiated with 24 GeV. Such simulations are crucial in aiding sensor design.
- On new structures RD50 developed LGADs (Low Gain Avalanche Detectors) for timing detector applications. LGADs from RD50 have been deployed during the EYETS in two Roman pots of the CT-PPS, with studies under way for their use in ATLAS AFP, as well as the ATLAS HGTD and CMS timing layer for Phase-II. Research is also progressing on HV-CMOS with the submission of a test sensor design to the foundry planned for the end of 2017.

- The **LHCC congratulates** RD50 on its achievements over the last year and **recommends** continuing the support for RD50 for another year.
- The **LHCC recognizes** the importance of the RD50 developments for the HL-LHC upgrades, and **notes** that in particular ATLAS and CMS have already significantly profited from RD50 developments.
- The **LHCC requests** a plan to be developed for the next three years, with clearly identified and traceable milestones and goals.

**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 several working groups covering activities from new detector structures and electronics, to modelling, test facility management and industrialisation.
- Projects recently supported by the collaboration range from the ATLAS NSW and ALICE TPC upgrades to CMS GE2/1 prototype production.
- RD51 is also pursuing generic R&D including precise timing with Micromegas, GEM optical readout and MPGDs that can be operated in noble liquid detectors.

- The **LHCC congratulates** RD51 on its achievements over the last year.
- The **LHCC considers** that RD51 is progressing well during its fourth year of the approved five-year term and **recommends** continuing limited support of the collaboration by CERN for another year.
- The **LHCC encourages** the collaboration to develop a proposal for a possible extension of the project beyond 2018.

**RD52:** Dual-Readout Calorimetry for High-Quality Energy Measurements

- RD52 is a generic detector R&D project, not linked to a particular detector, with the aim to improve the energy resolution by combining readouts of Cerenkov light signals and dE/dx scintillation light signals to determine the electromagnetic fraction in hadronic showers event-by-event.
- The concept has been shown to work in test-beam setups, and new results have recently been published by the collaboration.
- Plans for 2017 include the test of two new copper-fibre calorimeter modules, and investigating the use of SiPMs instead of standard PMT readout.
- RD52 is a small team, which however has recently received new support from INFN as part of an initiative for R&D for future accelerators.

- The **LHCC congratulates** RD52 on its achievements over the last year.
- The **LHCC notes** that the technology has so far not been adopted by an experiment, and there is no clear roadmap defined to this end. In order to remain as CERN R&D project, a new proposal should be presented, with clearly defined goals and milestones over the next three years, leading to the technology being far enough advanced that it may be considered by an experiment.

**WADAPT:** Wireless Allowing Power And Data Transmission

- WDAPT is a new collaboration asking for recognition as CERN R&D project, with the goal of developing wireless techniques in data and power transmission for applications in particle physics detectors.
- An informal review of the WADAPT LoI was conducted in January 2017 and

concluded that it was worth of further development, encouraging the proponents to prepare a full technical proposal following a set of recommendations from the referees. An updated version of the proposal was submitted in April and again informally reviewed by the referees, resulting in recommendations and suggestions to further improve the proposal, detailed below.

- A three-year research programme should be provided with clearly spelled-out milestones and deliverables to build and test a demonstrator for a future generic HEP silicon detector based on specific technologies, the configuration of which would allow a proof-of-principle within this timeframe.
- The proposal should contain a detailed development plan describing the organization and structure of the project, sharing of responsibilities and description of resources involved for each sub-project. In particular it should be clearly indicated who is responsible for each work package, and what the effort provided from each collaborating institute to the different milestones and deliverables will be.

- The **LHCC recognizes** that there are large potential benefits in the research being proposed and is eagerly looking forward to receiving a finalized Technical Proposal. The updated document should address the recommendations of the informal review as detailed above. The **LHCC notes** that a continuation of the research programme would then depend on the success of such a demonstrator.
- The **LHCC urges** the collaboration to clearly express the added value for this proposed research to become a CERN R&D project. In particular, a detailed list and timeframe of CERN resources and support that the project would need or could benefit from should be provided as part of the proposal.

## 12. 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, P. Burrows (Co-ordinator), F. Kunne, W. Wisniewski
CMS: D. Denisov (Co-ordinator), E. Kajfasz, A. Kuzmin, D. Waters
LHCb: G. Eigen (Co-ordinator), P. Krizan, 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)
R&D projects:
General: E. Kajfasz (Co-ordinator)
RD42: E. Kajfasz
RD50: G. Eigen
RD51: D. Denisov
RD52: P. Burrows

**13. The LHCC received the following documents:**

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| CERN-LHCC-2017-004 | Minutes of the one hundred and twenty-ninth meeting of LHCC held on 22 and 23 February 2017 |
| CERN-LHCC-2017-005 | Technical Design Report for the ATLAS Inner Tracker Strip Detector |

**DATES FOR LHCC MEETINGS**

Dates for 2017
22-23 February
10-11 May
13-14 September
29-30 November

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