OPEN SESSION – STATUS REPORTS

1. LHC Machine Status Report: Giulia Papotti
2. LHCb Status Report: Julian Wishahi
3. ATLAS Status Report: Rob Mcpherson
4. TOTEM Status Report: Joachim Bachler
5. ALICE Status Report: Chiara Zampolli
6. CMS Status Report: Petra Van Mulders
7. MoEDAL Status Report: James Pinfold
8. WLCG and Experiment Computing for Run 2: Ian Bird

CLOSED SESSION:


Apologies: T. Ullrich

1. EXECUTIVE SUMMARY

General

The LHC is delivering outstanding performance in 2016, with high peak luminosities and the fraction of the time in stable-beams routinely at 40%, and more than 60% in certain periods. The 2016 goal of delivering 25 fb$^{-1}$ to ATLAS and CMS has already been surpassed by 5 fb$^{-1}$, and the aim to have 5 fb$^{-1}$ available in time to be analysed for ICHEP has been exceeded by more than a factor of two. The experiments are operating well, with no significant problems reported and high data taking efficiencies. The large amount of data generated by the very successful running this year is pushing the available computing resources to the limit.
Report from the LHC Programme Co-ordinator

The LHC machine and injectors are working exceptionally well, with excellent availability and high peak luminosity (~20% higher than design). Several changes in schedule were implemented to increase the ICHEP dataset, and to facilitate the training of magnets to 7 TeV. There is currently a discrepancy of the luminosities reported by ATLAS and CMS which is not understood. This is a concern also for the potential implementation of luminosity levelling next year and needs to be understood urgently. The high $\beta^*$ run is on-going after successful commissioning. The planning for the 2017 setup needs to start now. One important question to address will be if the LHC should continue with BCMS beams (limit ~2400b) or instead aim for filling the machine (~2700b). A LPC/LPCC workshop on the forward physics programme will take place at end of October to discuss the longer-term forward physics programme and prepare for the dedicated discussion on this topic foreseen for the December session of the LHCC.

- The LHCC encourages ATLAS and CMS to make every effort to resolve the difference in reported luminosity values as soon as possible and recommends joint work of the luminosity groups of the two experiments and LHC experts to clarify the issue, possibly utilizing Z counting as physics benchmark.
- The LHCC recommends considering small changes to the schedule in an attempt to maximize the likelihood of full success of the pA running period, without jeopardizing the final push for integrated luminosity accumulation in the pp run. Advancing the machine setup operations or some of the actual pA running to before TS3, in the week when MD5 is scheduled, should be considered, to optimize the overall physics output of the programme.

Test Beams

The SPS is operating with limitations on the total amount of protons available per fixed target cycles to protect the SPS internal dump. This however does not affect the test-beam users thanks to the flexibility in the operation of the secondary beam lines. As in other years some users were not able to use their allocated beam time and this allowed slotting in new users and extending the run of others. The irradiation facilities are operating at full capacity. Some highlights of recent activities are a new beam telescope, AZALEA, prepared in the AIDA2020 framework, which will be available as infrastructure for the East Area users in need of precision tracking, and the Beam Line for Schools outreach program, with high school students performing experiments in the T9 beam line. The 2017 injector schedule is being prepared for approval at the next Research Board. It yields 25 weeks of proton physics and 8 weeks of Xenon physics at the SPS North Area, while the East Area at the PS will be operated with protons for 29 weeks. The test-beam users will soon be invited to submit their requests for 2017, with the aim to have a draft user schedule for the next committee meeting.

Report from the upgrade cost group (UCG)

The UCG reviewed both CMS and ATLAS within the current session of the LHCC. UCG recommendations are detailed in the reports submitted to the Research Board and listed below. TDRs are expected to arrive starting at the end of 2016, and the committee used the review to ascertain if the overall programme is still within its cost envelope. The overall status is very encouraging, both in terms of estimated cost and in terms of available funds. Observations include:
• The silicon pixels readout chip is on the critical path, and could cause serious schedule or cost risks. Fall-back plans should be developed in concert between ATLAS, CMS and RD53 to reduce this risk.
• The R&D programme is large and still very broad while approaching the TDRs. To converge when needed, the various projects should be concentrated as much as possible, with schedules and resources kept firmly in mind.
• All efforts should be made to move towards environmentally friendly gases, although this may be very difficult or impossible for some systems.
• A large amount of infrastructure work will be needed, with a significant part already during LS2. The resources and planning need to be detailed very soon.

ALICE

Scientific output and current activities:

• ALICE continuous to have a rich scientific output with a total of 164 papers submitted to date. The detector is operating well and has collected around 10 pb\(^{-1}\) of pp data so far, which represents 85\% of the target for pp data in 2016. The data taking efficiency is 92\%. Automatic luminosity levelling has been used for ALICE since June and is working well.
• RCU2 development has been completed, although the targeted 2 kHz link speed is currently only achieved in high occupancy PbPb runs. Firmware developments are under way to increase the link speed also in cases when data headers dominate the payload, where the limits are currently closer to 1.5 kHz.
• The TPC distortions have been partly understood, however the effort to completely understand the reasons behind these distortions and possible implications for the upgrade needs to continue with high priority.

• The LHCC acknowledges the efforts and progress made by the collaboration to understand the TPC distortions through an internal review, and reiterates its recommendation to form a task force of experts both from ALICE and external to fully understand the effect and the possible impact on the TPC upgrade.

Phase-I upgrades:

An in-depth review of the ALICE upgrade was carried out during this session of the LHCC.

• Very good progress was reported in all areas of the upgrade, with no major issues identified.
• In particular the ALPIDE pre-production chips have been received and all tests so far are very encouraging. Good progress was also reported for the SAMPA chip of the TPC upgrade. The delay of the PRR of the TPC is of some concern, and the experiment management is encouraged to closely monitor the situation.
• For the O2 upgrade a decision by CERN is needed soon on the new data centre in Prevesin.

• The LHCC acknowledges the good progress made on ALPIDE and SAMPA chips, and encourages the collaboration to continue the extensive and thorough testing and verification of the full functionality of these chips.
• The **LHCC recommends** that a decision be made as soon as possible by the CERN management on the new data centre in Prevessin, as this has implications for the upgrade of the readout system.

• The **LHCC suggests** that ALICE should engage soon with CERN to fully understand the resources needed for LS2 work.

**ATLAS**

Scientific output and current activities:

• ATLAS continues to make excellent progress on its physics programme, with 580 papers submitted to date, including 42 on Run 2 data.

• The detector is operating well, with no significant problems and good performance under the current high pile up conditions, with an average data taking efficiency of 92%, and up to 95% over the last two weeks. Among the issues observed and addressed were a water leak in the Tile calorimeter and a fast dump of the Toroid magnets due to a crash in the control system. Investigations are under way to see if additional redundancy can be added.

• ATLAS has recorded an excellent $27.1 \text{ fb}^{-1}$ to date, however it measures a delivered luminosity around 7% less than seen by CMS. ATLAS will collaborate with CMS in investigating this discrepancy in order to resolve it as soon as possible.

• The large amount of data recorded due to the better than expected performance of the LHC poses significant challenges for the computing system, and will require additional resources for 2017/18 in order to avoid cutting into the physics programme by limiting the recording rate.

Phase-I upgrades:

• All hardware is available for the barrel-only system of the FTK that is the goal for this year, however firmware development is experiencing delays. The AM06 chip has passed its final review and production for 2017 will start as soon as possible.

• The risk on the upgrade of the LAr electronics from delays on the production of the ASICs is reducing, but not fully solved yet. The project is still on schedule.

• Substantial progress has been made in all areas for the construction of the NSW; however the schedule remains very tight, in particular in view of recent problems with one industrial vendor, which need to be addressed urgently.

• The upgrade of the TDAQ system is progressing well, with no major schedule issues.

Phase-II upgrades:

A UCG progress review was held during this session of the LHCC, results are reported in the UCG section.

**CMS**

Scientific output and current activities:

• The physics programme of CMS is progressing well, with 532 papers submitted to date and many more in advanced stages of internal review.

• CMS has recorded a very large data set of about $30 \text{ fb}^{-1}$ to date, with more than 96% of readout channels active across all subsystems and data taking efficiencies
of around 92%. The luminosity measured by CMS is around 7% higher than reported by ATLAS. CMS will collaborate with ATLAS in investigating this discrepancy in order to resolve it as soon as possible.

- A relatively high loss of efficiency was observed in the inner barrel pixel layer, which will be addressed with the Phase-I pixel upgrade in the coming shutdown. A loss of efficiency in the strip tracker at high luminosity has already been addressed by optimizing parameters of the readout chip.
- The excellent LHC performance (above expectations) in both peak and integrated luminosities created challenges for computing, which will require careful management and additional resources in 2017/18 to avoid loss of valuable physics data.

Phase-I upgrades:

- The Phase-I upgrades are well under way, with the TDAQ upgrade already completed and the pixels and calorimeter upgrades on target for installation in the upcoming EYETS. CMS will carry out an in-depth review of installation readiness in October.
- Concerns at this point are the lack of contingency, where any delays or shortages of resources could affect the installation plan, and a few items for the HE calorimeter upgrade that are on the critical path, although currently still compatible with installation in the upcoming EYETS.

Phase-II upgrades:

A UCG progress review was held during this session of the LHCC, results are reported in the UCG section.

**LHCb**

Scientific output and current activities:

- LHCb has made excellent progress on their physics analysis, with a total of 334 papers submitted to date. The data recorded to date amounts to about 1.3 fb$^{-1}$, taken with a data taking efficiency of 88%.
- The detector is working well with no significant concerns. LHCb is ready for the Pb-p/p-Pb run which will provide a unique physics program for the experiment.

Phase-I upgrades:

- Good progress has been reported on all upgrades projects, with the upgrade globally on schedule. The VeloPix chip has been received, and initial tests show full functionality. The SALT128 chip was received and is performing well. It will have a critical engineering run later in 2016. Small delays have accumulated on some items on the critical path. The LHCb management will monitor these delays closely, and undertake a comprehensive review early in 2017 with focus on critical aspects, organization of construction and preparation for installation.
- An area of concern are the microchannel cooling plates for the VELO, with no bids received for the tender issued this summer. LHCb has entered direct negotiations with possible providers and is investigating a fall back solution, which would however result in a somewhat degraded impact parameter resolution. There is a risk of further delays to the schedule that needs to be closely monitored.
MoEDAL
The MoEDAL collaboration published its first physics results on a search for magnetic monopoles recently, based on data from prototype trapping detectors placed around the LHCb interaction point during pp collisions at $\sqrt{s} = 8$ TeV. More publications are expected soon, based on the full detector deployment in 2015/16. Given that the original request of 10 fb$^{-1}$ of data will not be realised in Run 2 (currently up to 6 fb$^{-1}$ are expected), the collaboration is preparing a proposal to extend the running to Run 3, with no impact on LHCb. In addition MoEDAL is working on a proposal to install a new detector component (MoEDAL Apparatus for Penetrating Particles - MAPP) for the detection of particles with small fractional charge of $\leq 0.1$, that are beyond the sensitivity of other LHC detectors, in a tunnel near the LHCb interaction point.

- The LHCC encourages the MoEDAL collaboration to produce concrete proposals for both the extension of the data taking into Run 3, and the new MAPP detector.

TOTEM
The collaboration reported on the publication of the elastic pp differential distribution at very small $|t|$, using the data from the 2012 $\sqrt{s} = 8$ TeV special run at $\beta^* = 1$ km. The paper has just been accepted by EPJC. Several other Run 1 analyses are still on-going and being finalised. The analysis of the joint CMS-TOTEM 2015 $\beta^* = 90$ m run, in particular the search for glueball candidates, is making steady progress. As algorithms have been developed to optimize tracking and vertexing in CMS for low-multiplicity events, CMS and TOTEM are encouraged to swiftly bring these studies to a conclusion and proceed to the publication of the results. CT-PPS has had a very successful run so far in 2016, with nearly 11 fb$^{-1}$ recorded to date. After the replacement of irradiated Silicon strip detectors during TS2, and the inclusion of the diamond timing detectors in the DAQ system, CT-PPS is fully available to take data until the end of the run. The TOTEM Roman Pot detectors are also successfully operating during the on-going $\beta^* = 2.5$ km run. With the design of the new CMS beampipe now being finalised, TOTEM is encouraged to develop a concrete proposal of how the available space may be populated with new tracking detectors to replace the T2 telescope after LS2, to ensure the space will not be filled in other ways beforehand.

- The LHCC welcomes the recently established TOTEM/CMS physics working group to further the analysis of the 2015 run and the data taken in 2016.
- The LHCC encourages TOTEM to develop a concrete proposal of how the available space around the new CMS beampipe may be populated with detectors.

WLCG
LCG computing is performing very well across the experiments, making full and efficient use of the available pledged resources and opportunistic resources made available to the experiments. The excellent performance of the computing systems and software is based on the many improvements made during LS1, and an on-going optimisation of the whole system. However the excellent performance of the LHC has produced data in significant excess of the expectations for 2016, pushing the available resources to their very limit. In particular the storage elements are continuously full despite aggressive storage content
management. More tapes have been procured to address the immediate needs, however a re-evaluation of the 2017/18 needs is on-going in order to determine at which level additional resources will be needed to take full advantage of the LHC performance. The future of computing for the HL-LHC is the subject of intensifying discussions, with a conceptual design targeted for 2017, and technical design reports to follow around 2020.

- The LHCC acknowledges the efforts of the experiments to improve the efficiency of the recorded data with respect to their physics goals, and that without additional computing resources data taking will eventually have to be scaled back below the capabilities of the machine and experiments, cutting into the physics programme.

2. PROCEDURE

The Chairman welcomed the new members of the LHCC, E. Kajfasz and J. Dunlop. The minutes of the one-hundredth-and-twenty-sixth LHCC meeting (LHCC-2016-008 / LHCC-126) were approved.

3. REPORT FROM THE DIRECTOR OF RESEARCH AND COMPUTING

The Director for Research and Computing reported on issues related to the LHC. Council in its recent meeting was very impressed by the good performance of the machine. The LHC is delivering outstanding performance in 2016, with high peak luminosities and the fraction of the time in stable-beams routinely at 40%, and more than 60% in certain periods. The 2016 goal of delivering 25 fb$^{-1}$ to ATLAS and CMS has already been surpassed by 5 fb$^{-1}$, and the aim to have 5 fb$^{-1}$ available in time to be analysed for ICHEP has been exceeded by more than a factor of two. The experiments are operating well, with no significant problems reported and high data taking efficiencies. The large amount of data generated by the very successful running this year is pushing the available computing resources to the limit. Investigations are under way whether the running mode of 2016 with below maximum currents in the machine would also be the optimal model in 2017 in terms of total accumulated integrated luminosity.

4. REPORT FROM THE LHC PROGRAMME COORDINATOR

The LHC machine and injectors are working exceptionally well, with excellent availability and high peak luminosity (~20% higher than design). Several changes in schedule were implemented to increase the ICHEP dataset, and to facilitate the training of magnets to 7 TeV. There is currently a discrepancy of the luminosities reported by ATLAS and CMS which is not understood. This is a concern also for the potential implementation of luminosity levelling next year and needs to be understood urgently. The high β* run is on-going after successful commissioning. The planning for the 2017 setup needs to start now. One important question to address will be if the LHC should continue with BCMS beams (limit ~2400b) or instead aim for filling the machine (~2700b). A LPC/LPCC workshop on the forward physics programme will take place at end of October to discuss the longer-term forward physics programme and prepare for the dedicated discussion on this topic foreseen for the December session of the LHCC.

5. REPORT FROM THE UPGRADE COST GROUP (UCG)

The UCG reviewed both CMS and ATLAS within the current session of the LHCC.
UCG recommendations are detailed in the reports submitted to the Research Board and listed below. TDRs are expected to arrive starting at the end of 2016, and the committee used the review to ascertain if the overall programme is still within its cost envelope. The overall status is very encouraging, both in terms of estimated cost and in terms of available funds. Observations include:

- The silicon pixels readout chip is on the critical path, and could cause serious schedule or cost risks. Fall-back plans should be developed in concert between ATLAS, CMS and RD53 to reduce this risk.
- The R&D programme is large and still very broad while approaching the TDRs. To converge when needed, the various projects should be concentrated as much as possible, with schedules and resources kept firmly in mind.
- All efforts should be made to move towards environmentally friendly gases, although this may be very difficult or impossible for some systems.
- A large amount of infrastructure work will be needed, with a significant part already during LS2. The resources and planning need to be detailed very soon.

References to the full ATLAS and CMS USC reports are given at the end of this document.

6. TEST BEAMS

The SPS is operating with limitations on the total amount of protons available per fixed target cycles to protect the SPS internal dump. This however does not affect the test-beam users thanks to the flexibility in the operation of the secondary beam lines. As in other years some users were not able to use their allocated beam time and this allowed slotting in new users and extending the run of others. The irradiation facilities are operating at full capacity. Some highlights of recent activities are a new beam telescope, AZALEA, prepared in the AIDA2020 framework, which will be available as infrastructure for the East Area users in need of precision tracking, and the Beam Line for Schools outreach program, with high school students performing experiments in the T9 beam line. The 2017 injector schedule is being prepared for approval at the next Research Board. It yields 25 weeks of proton physics and 8 weeks of Xenon physics at the SPS North Area, while the East Area at the PS will be operated with protons for 29 weeks. The test-beam users will soon be invited to submit their requests for 2017, with the aim to have a draft user schedule for the next committee meeting.

7. DISCUSSION WITH ALICE

Scientific output

The scientific output from the ALICE collaboration continues to be strong across a wide range of topics in pp, pPb and PbPb collisions at all available centre-of-mass energies, including the 5 TeV PbPb data taken in 2015. Since the last LHCC meeting, 10 new ALICE papers have been published in refereed journals, 2 new papers accepted and 5 submitted. The total number of paper submissions is 164 papers. Highlights of the recent results include detailed dynamics of J/\Psi suppression in PbPb relative to pp collisions at forward rapidities, surprisingly suggesting that the suppression becomes smaller with increasing centre-of-mass-energies. The centre-of-mass energy dependences of the \nu_2, \nu_3 and \nu_4 flow harmonics have also been measured up to 5 TeV, revealing small
increases relative to lower energies. ALICE is also producing data on beauty production using secondary vertex significances, which show interesting features and reiterate the case for upgrades to provide increased statistics and improved vertex resolution with minimal material budget.

Current activities and short-term plans
ALICE has run consistently and efficiently in 2016, being operational for 92% of the time when stable beams were delivered, with very few subsystem failures. An integrated luminosity of over 10 pb\(^{-1}\) has been seen and samples of up to 8.3 pb\(^{-1}\) collected for individual triggers. This represents approximately 85% of the target for pp running in 2016. Since mid-June, an automated procedure for luminosity levelling has been running successfully, which matches the target rate well and is saving set-up time. The interaction rate has been levelled at 100kHz for most of the year, with special conditions of up to 350 kHz for a 2-week period to improve statistics for calorimeter and muon-triggered samples. The RCU2 readout cards for the TPC have been successfully commissioned and minor optimisations of the firmware and other aspects of the readout chain have been performed. The experiment is ready for pPb running, with the strong priority on optimizing minimum bias statistics at 5 TeV, where a 1.5 kHz readout rate is anticipated. The LHCC congratulates the ALICE collaboration on its scientific output and successful 2016 data taking campaign.

TPC Distortions
ALICE has performed a wide-ranging programme of investigations into the previously reported large localised distortions in the TPC cluster positions measured in the IROCs in the 2015 run. In addition to characterising the distortions across all available data sets, special runs have been taken to investigate the sensitivity of the effect to interaction rate, readout rate, gating grid, anode and cover electrode voltages and water content in the gas. One affected area corresponds to a known issue with floating gating grid wires. The remainder follow a pattern of being in similar positions on the edges of specific chambers where the anode and gating wires are glued. There is a correlation between the amplitude of the distortions and the anode HV, whereas the problem appears to be independent of changes in the operation of the gating grid. The chambers affected are from a specific production batch, though other chambers from the same batch are unaffected. The correction procedures already in place for the pp run are applicable to pPb and no significant impact on the pPb run is expected. Since the problem appears to be specific to a particular batch in the production process for the MWPCs from the Run 1 readout chambers, there is no reason to expect it to persist with the upgraded chambers planned for Run 2. The collaboration is continuing its investigations through the creation of a task force. The LHCC reiterates its recommendation for the formation of a TPC task force including ALICE and external experts to better understand the origins of the TPC distortions and ascertain that adequate QA procedures are in place to avoid such problems with the upgraded readout chambers.

Phase-I upgrade in-depth review
The LHCC carried out an in-depth review of the upgrades of the ALICE experiment. The experiment is to be commended for having made impressive progress in all areas of the upgrade, which seems to be well on track. Pre-production devices of the final version
of the ALPIDE chip were received only shortly before the LHCC meeting. Many tests have already been carried out, including some beam tests. The results to date indicate that the chip meets all specifications. Validation is on-going and the production readiness review (PRR) is scheduled for October 2016. The collaboration is very much encouraged to fully characterize the chip even if it implies a modest delay of the PRR. Small samples of hybrid integrated circuits (HIC) and staves for both the inner and outer barrel of the inner tracking system (ITS) have been produced; characterization and tool validation are in progress. All automated module assembly machines are scheduled to be delivered before the end of the calendar year. The prototype machine at CERN has been available for over four months and has been fully exercised. The full mechanics for the ITS, including services, is in excellent shape. Tests of the full readout chain with a first version of the Readout Unit card are on-going. The ITS project is making excellent progress and has significant schedule contingency.

The muon forward tracker (MFT) project has implemented a new management structure and has developed a new project plan, resulting in a new schedule and milestones. A common ITS-MFT strategy is adopted where possible. The LHCC welcomes the new organizational structure and successful exploitation of synergies with the ITS. The laser soldering for the HIC has been abandoned and wire-bonding is the new baseline, as was done for the ITS. For the MFT, the chips are interconnected to an aluminium flexible printed circuit (FPC). It is suggested to consider developing a copper FPC as a possible backup in case of persistent problems with the aluminium based FPC. Electrical tests are on-going and an EDR for ladder production is planned for September 2016. The project, including the overall mechanical design, is progressing well.

The PRR for the TPC upgrade has been postponed from June to November 2016 to implement some modifications on the 4-GEM HV layout to improve their operational stability against discharges, which was agreed upon at the FDR in June. Thorough studies of the chamber layout are well motivated and should be pursued further. The final design modules, one IRÖC and one OROC, are being assembled at the production sites, where a well-organized plan of qualification tests is scheduled. It is recommended to carry out the study of the modules to the greatest detail through test-beam studies and bench tests, both for basic characterisation and to validate and tune the QA procedures for the mass production. The installation of the OROC in the ALICE cavern during TS3 for a long-term stability test in the LHC environment should have high priority. The GEM foil production plan has been agreed with the CERN PCB workshop. Completion is scheduled for the end of Q3 2018, eight months before ROC installation. Close monitoring of the QA tests and continuous feedback to the production are critically important to maintain the target of the high-quality GEMs to be assembled. The ROC work plan is rather complex, with different sites for advanced QA, framing, GEM assembly and ROC assembly, in Europe and the US. The first six months of 2017, when massive ROC production has to be brought to full operation, are crucial for the project. Careful monitoring of all activities to keep schedule delays under control is recommended.

The new readout system for ALICE is a paradigm shift for the experiment, where the data of all interactions is read out and compressed by the online reconstruction. A flexible and programmable architecture for triggered and continuous readout is being implemented with a full simulation to evaluate system performance. A GBT-based Read-Out Receiver Card (G-RORC) system has been developed to test the overall system design, data aggregation and formatting. The collaboration is to be congratulated on the overall impressive and thoughtful progress on the development of the trigger architecture.
and its verification. First elements of all components (CRU, CTP, FIT, TOF, MCH, MID) are in hand, on schedule and being exercised. A notable milestone is the availability of the SAMPA chip, used in the readout of the TPC and muon system. The chip is fully functional, though some issues have been uncovered. The LHCC is pleased with the progress on the SAMPA chip and strongly recommends continued verification, reproduction in simulations of current performance, and simulation of the chip performance over the full parameter space.

The development of the O² framework is proceeding well. A first implementation of the data quality control framework, including the condition and calibration database, has been implemented. The system is subjected to systematic benchmarking to characterize the different software elements. The dynamic deployment system (DDS) has been released and is being tested. An O² development cluster has been deployed to demonstrate workflow management, and evaluate all the tools. The TPC simulation software is being refined for the upgraded detector. The approach to quickly enable O² developers to become productive is very much supported. It is recommended that as many O² elements as possible are used in the beam test campaigns and that the whole framework is used for the simulation and verification of beam test results. The LHCC recommends that a decision be made as soon as possible by CERN management on the new data centre in Prevessin.

The preparatory work for the installation of all upgrades during LS2 is well advanced and adequate contingency has been included in the schedule. The committee suggests that ALICE engage soon with CERN management to fully understand the resources needed for the LS2 work. The LHCC commends the ALICE experiment on the notable achievements of the delivery of the ALPIDE and SAMPA chips and on the overall excellent progress. Persistent testing and schedule oversight is recommended.

8. DISCUSSION WITH ATLAS

Scientific output

ATLAS is operating very well in 2016; to date 27.1 fb⁻¹ of pp collision data have been recorded with a data-taking efficiency average of 92% overall, and 95% in the past few weeks. ATLAS systematically reports a luminosity that is about 7% lower than the figure reported by CMS. This issue is being investigated in collaboration with CMS and with the LHC programme coordinators.

The Collaboration presented 70 new results at ICHEP. To date ATLAS has submitted 580 scientific papers, 42 of which are on Run 2 data; the total includes an additional 42 papers since the previous LHCC session in May 2016. Updated results on Higgs boson production and searches for new particles were noted.

Current activities and short-term plans

The detector operational status is excellent, with close to 100% channel availability in all subsystems. Some minor points worthy of note include:

- The Inner B-Layer (IBL) is currently being operated at +5C so as to ameliorate the observed current increase in the read-out electronics; the detector will be operated cold in 2017.
• The Xe leak rate in the TRT has increased; more Xe will need to be procured for 2017 operations.
• Two Tile Calorimeter drawers have been disconnected from the readout due to problems, including one water leak.
• There was a fast dump of the Toroid magnets due to a crash in the control system. Investigations are under way to see if additional redundancy can be added.
• With AFP in-beam, ALFA is unable to run at high luminosity due to knock-on backgrounds.

A detailed programme of repairs and inspections to all detector subsystems is in preparation for the EYETS.

The trigger/DAQ and offline data processing systems are all working well and coping with the high-pileup conditions. However, the large amount of data recorded due to the better than expected performance of the LHC poses significant challenges for the computing system, and will require additional resources for 2017/18 in order to avoid cutting into the physics programme by limiting the recording rate.

**Phase-I upgrade**

The Phase-I upgrade projects status was reviewed. All projects are progressing.

• All hardware is available for the barrel-only system of the FTK that is the goal for this year, however firmware development is experiencing delays. The AM06 chip has passed its final review and production for 2017 will start as soon as possible.
• The risk on the upgrade of the LAr electronics from delays on the production of the ASICs is reducing, but not fully solved yet. The project is still on schedule.
• Substantial progress has been made in all areas for the construction of the NSW; however the schedule remains very tight, in particular in view of recent problems with one industrial vendor, which need to be addressed urgently.
• The upgrade of the TDAQ system is progressing well, with no major schedule issues.

**Phase-II upgrade**

A UCG progress review of the Phase-II upgrades was held during this session of the LHCC; results are reported in the UCG section.

9. **DISCUSSION WITH CMS**

**Scientific output**

The total number of papers submitted by CMS is 532 with an additional ~50 ready for internal review. Run 2 data provided 180 public results, including 44 submitted or soon to be submitted papers. CMS had a smooth transition from Run 1 to Run 2 analyses. A large number of new 13 TeV results are expected for the winter 2017 conferences.

Highlights of the recent results include a large number of high precision Standard Model measurements from inclusive vector boson production to complex final states, such as \( Z\gamma \), \( ttW \), \( V+jets \) and others. All of these studies are so far in agreement with the Standard Model, while providing invaluable information about the precise understanding of the
backgrounds for new physics. High precision measurements of top quark pair production have been accomplished by CMS at four energies from 5 to 13 TeV. Large Higgs boson data samples are starting to be accumulated at 13 TeV. These samples provide, for the first time, an opportunity to study in detail Higgs boson production and decay properties. Many new physics searches have been performed by CMS using up to 20 fb$^{-1}$ of recently collected data. None of them, for now, indicate the presence of physics beyond the Standard Model.

Two new groups have been accepted as full members of CMS and two more groups have joined as cooperating groups in September. More requests to join the collaboration are pending. CMS continues to attract new collaborators, which is an indication of an exciting programme ahead and an attractive work environment.

Current activities and short-term plans

Data collection at 13 TeV was smooth with ~92% data taking efficiency for the period May to September 2016. All CMS detectors are performing well with more than 96% of channels operating in each sub-system. Typical data quality certification efficiency is ~92.5%. The CMS magnet has been operating smoothly at full field from the beginning of data taking in 2016, indicating that the issues related to the magnet cooling system have been fully resolved. Several new detector elements, some of them part of the Phase I upgrade, have successfully been integrated into the data taking, including the upgraded Level 1 trigger, new readout for hadron calorimeters, and the CT-PPS.

Early in the summer of 2016 at high luminosity the silicon strip tracker exhibited a loss of efficiency, which was traced to low drain current in the readout chip. After chip parameters were adjusted, the performance of the strip tracker is back to normal.

CMS currently operates up to luminosities of 1.5 x 10$^{34}$ cm$^{-2}$s$^{-1}$ with high efficiency. Operation at even higher luminosities next year and beyond is under study with the LHC machine experts and ATLAS. The current ratio of ATLAS to CMS measured luminosities is ~93%. LHC accelerator experts and representatives from both experiments are investigating this discrepancy.

CMS computing is working well in 2016, however, the beyond expectations LHC performance this year, both in terms of peak luminosity and integrated luminosity pose significant challenges for the computing systems. Despite an intensive optimisation effort, an estimated additional ~12% more CPU, ~35% more disk space and ~24% more tapes will be needed to avoid loss of valuable physics data for 2017/18.

A detailed plan for the coming EYETS is being developed, including upgrade installation as well as repairs and reinforcements of existing detector elements as needed. A readiness review of these activities will be carried out by CMS in October/November.

Phase-I Upgrade

CMS has already installed and runs major parts of the Phase I upgrade and plans to install calorimeter upgrades (forward and endcap calorimeters) and new pixels detectors during the upcoming EYETS.

Calorimeter upgrades are progressing on schedule and the majority of the parts are already produced and tested. There are a few elements, such as forward calorimeter QIE cards,
where the production is still in progress. At the current rate all QIE cards should be assembled and fully tested in time for the installation.

Barrel and forward pixels upgrade demonstrated excellent progress over the summer with many technical issues resolved and production progressing faster than originally expected. For the barrel pixels, the PROC600 chip was fully tested and approved for use in layer 1, so modules for layer 1 will be equipped with electronics with high rate capability. The majority of the modules for the barrel detector have been assembled and large-scale production of the barrel cylinders has started. The forward pixel module assembly is completed and installation on the disks is progressing on schedule with the first half disk and half service cylinder already delivered to CERN for installation.

There is concern for the lack of contingency, where any delays or shortages of resources could affect the installation plan. CMS will carry out an in depth review of installation readiness in October.

The CMS software is under active development to be able to use all elements of the Phase-I upgrades as soon as they are installed and commissioned. Efforts are also devoted to the optimization of the Phase-II upgrades.

**Phase II Upgrade**

An in-depth UCG review of the Phase-II CMS upgrade has been performed during this session of the LHCC and the outcome is summarized in the UCG summary of these minutes.

10. **DISCUSSION WITH LHCB**

**Scientific output**

LHCb submitted 20 papers plus 9 conference reports since the last LHCC week yielding 334 submitted papers in total; an additional 16 papers are in the editorial board and 46 other analyses are under review. New results include observation of new tetraquark states, measurement of time-dependent and time-integrated CP violation in D0 meson two-body decays, first evidence of CP violation in $\Lambda_b$ decay, observation of the rarest hadronic B-decay mode $B^0 \rightarrow K^+K^-$ and first measurement of photon polarisation in the $B_s \rightarrow \phi\gamma$ decay. The LHCC commends LHCb for the very rich and diverse physics output.

**Current activities and short term plans**

The LHCb detector runs very well. Alignments and calibrations run smoothly for most sub-detectors. LHCb recorded an integrated luminosity of $L_{int}= 1.3 \text{ fb}^{-1}$ in 2016 with a data talking efficiency of 88%. The largest loss of 9% is due to dead time caused by bandwidth limitations, full read out buffers and L0 threshold, aggravated by the fewer than nominal bunches in the machine. The situation will improve next year when more bunches are present. Furthermore, LHCb is working on improvements to decrease the dead time still further. To adapt to the high LHC efficiency, LHCb will speed up HLT1 and HLT2, optimize the use of the farm, and adjust L0 thresholds that will improve purity of HLT1 selections. LHCb increased data storage with the Turbo stream to one third, reducing data stored with the full stream to two thirds (total rate: 12 kHz at 700 MB/s). Sample size improved significantly in Run 2, allowing storing a larger phase space zone for selected decay modes. LHCb commissioned a new concept of centralized Ntuple production for PID calibration and is finalizing the luminosity calibration. In the
upcoming p-Pb/Pb-p run, LHCb targets 20 nb⁻¹ at 8 TeV, to look for ψ(nS), Y(nS), Z⁰ production as well as associated heavy flavour production.

Before the end of the year, LHCb plans workshops on “Implications of LHCb measurements and future prospects” and on “LHCb Heavy Ion and Fixed Target physics”.

The LHCC commends LHCb for the excellent performance of the detector and for the successful operation of the Turbo stream, which is a Phase-I upgrade concept.

**Phase-I upgrades**

All milestones of the readjusted schedule have been met. Many EDRs/PRRs were held during the summer. For most systems the Phase-I upgrade is in the pre-production or production mode. Some systems are delayed on critical paths.

- The UT is progressing well. Sensors will be topside biased. A pitch adaptor is embedded on the sensor. Effects of radiation damage are being studied (TB: 10/16) before PRR (11/16). The SALT-128 ASIC is being tested extensively including irradiation (10/16) before the engineering run before the end of 2016. The design of SALT-128 hybrids started. Flex cables are under tests after significant design changes. The goal is to hold the PRR in 11/16. The peripheral electronics and mechanics progress well.

- The SciFI is making good progress. 1300 km of fibres have been delivered. All spools are within specs and a few residual bumps are easily removed. Fibre mat and module production has started. The first module production site passed the PRR. Due to observed light yield losses, the module cutting procedure was improved. The cold-box prototype performs well.

- The RICH upgrade shows excellent progress. The received MaPMT pre-series were qualified. Mass production will be launched soon. Tenders for CLARO ASIC and Elementary CELL are in preparation after successful PRRs. The Digital Board passed a successful EDR.

- Progress on CALO is good despite delayed EDRs for the FE, control and HV/monitoring/calibration boards. Irradiation tests show positive results. The ICECALv3 ASIC is fully qualified and productions will start in 11/16.

- Progress on Muons is fine except for the delayed additional-shielding EDR. The nSync chip is under test, the nODE board layout is ready and nPDM tests are well advanced.

- The online system is on track. The PCIe40 prototype is being produced (25 pieces). Developments on common readout firmware and ECS/TFC software progress well. The scalability of event building software was tested successfully.

- Computing progresses according to schedule. A TDR is planned for 2017. The software upgrade is based on an evolutionary path using Run 2 as a testbed and a revolutionary path using new collaborative working practices such as hackatons.

- Progress on the VELO is mixed. PRRs for sensor and cooling substrate were delayed.
  - The VeloPix was received. Initial tests show full functionality. To explore the full ASIC performance, necessary tests with the full electronic chain including sensors in a test beam are planned for 11/16.
  - New improved sensors were received from Hamamatsu. Sensors from Micron are expected. The sensor PRR is scheduled for 10/16 to select one type. The module design was finalized.
- All prototypes for electronics and readout integration exist and tests look fine.
- An improved RF foil prototype is in production.
- Mechanics is on the critical path. LHCb will allocate 1.5 FTE mechanical engineers and 1 FTE to help with implementing important modifications. The mechanics EDR is planned for 11/16.
- The microchannel cooling plates developed a delay, because zero bids were received for the tender. LHCb started negotiations with LETI to do a multi-phase process; first step: estimate bonding quality yield (10/16); second step: obtain full-size cooling plate (3/17). As plan B LHCb considers to use embedded pipes in milled pocofoam. The design proposed in 2013 was tested and is compatible with the mechanical design but degrades the impact parameter resolution by 20%. LHCb will follow both approaches in parallel. Another issue may consist of solder residues in corners of microchannels.

The LHCC acknowledges the overall good progress on the Phase-I upgrade. The LHCC is concerned about the recent problems with the microchannel cooling plates and will follow developments closely, recommending pursuing both approaches equally while favouring the original design. The LHCC acknowledges the decision of the LHCb management to hold an internal upgrade comprehensive review organized with focus on critical aspects, organization of construction and preparation for installation (early 2017). This will also address all other items on the critical path.

11. DISCUSSION WITH MOEDAL

The MoEDAL apparatus has been fully deployed around the LHCb interaction point throughout the 2015 and 2016 runs and has been exposed to an integrated luminosity of around 2 fb⁻¹. The collaboration has grown slightly in the past year with the addition of two new institutes and now numbers 66 authors. Its first physics paper, reporting a search for magnetic monopoles using prototypes of the MMT trapping detectors, has been published in JHEP and already shows some unique sensitivity. Further publications using the final detector configuration are in preparation. The collaboration is also preparing a proposal for continued running beyond LS2, based on realizing its integrated luminosity goals and possibly implementing new detector components.

The LHCC congratulates MoEDAL on its successful detector exposure and the milestone of its first paper. The collaboration is encouraged to continue working towards a proposal for continued running, properly evaluated in terms of quantitative science case and funding requirements.

12. DISCUSSION WITH TOTEM

The collaboration reported progress on various areas of physics analysis. The measurement of the elastic pp differential distribution at |t| > 6 x 10⁻⁴ GeV², using the data from the 2012 √s = 8 TeV special run at β* = 1 km, has been accepted for publication by EPJC. The luminosity independent measurement of total, elastic and inelastic cross sections at √s = 2.76 TeV (β* = 11m run of 2013) is being finalized. Several other Run 1 analyses are still in progress. The committee urges TOTEM (and CMS in the case of common data) to complete these analyses as soon as possible, in order to focus on the large amount of data that are being accumulated during Run 2. The analysis of the joint
CMS-TOTEM 2015 $\beta^* = 90$ m run, in particular the search for glueball candidates, is making steady progress. As algorithms have been developed to optimize tracking and vertexing in CMS for low-multiplicity events, CMS and TOTEM are encouraged to swiftly bring these studies to a conclusion and proceed to the publication of the results. This is considered essential to properly plan special runs at $\beta^* = 90$ m for the remainder of Run 2.

CT-PPS has had a successful run so far in 2016, with nearly 11 fb$^{-1}$ recorded to date, 4 of which have good quality silicon-strip data. The radiation damage suffered by the Si strips led to the interruption of data taking at the end of June. The reduced length of TS1 spoiled the foreseen opportunity to replace the detectors with new ones. CT-PPS started again taking data in the last week of August, when the effects of Si damage were reduced by the rest period and by a three-fold increase in HV. Irradiated Si-strip detectors were eventually replaced during TS2.

The construction of the diamond timing detectors was completed on time for their installation during TS1, the previously reported cross-talk noise issue having been solved. Firmware however did not become available until the end of the Summer, and the full DAQ system would be commissioned and deployed, starting with mini-DAQ tests, at the restart of low-$\beta^*$ operations, after the 2.5km run. At that point CT-PPS should be fully available to take data until the end of the 2016 run. The full readout chain developed for the diamond detectors will remain valid after replacement of the diamond detector with the foreseen ultra-fast silicon detectors (UFSDs).

Good progress was reported towards the delivery of the final detectors for CT-PPS. All 46 pixel modules (to replace the current SI strips) have been delivered, and are being qualified in Genova and Torino. An issue has been reported: due to non-uniform exposure to irradiation across the module geometry, some pixels cause a slight time delay in the formation of the signal, with the signal being attributed to the following bunch crossing. The problem can be solved reading out nearby crossings, but may naturally disappear once the detectors have integrated sufficient exposure to equalize the time response. This is not seen as a major obstacle.

UFSDs have been tested on the H8 test beam. 50 $\mu$m 1.2 x 1.2 mm$^2$ detectors provided the design time resolution of 35 ps / plane, at 230V. The timing resolution of a 3-plane configuration, at 240 V, was measured to be 14.8 ps. Irradiation studies are being carried out, and the detectors should be ready for installation in 2017. One concern is however the lack of available manpower to develop offline and analyses software.

At the time of the LHCC meeting, the TOTEM Roman Pot detectors were successfully operating during the $\beta^* = 2.5$ km run.

With the design of the new CMS beampipe now being finalised, TOTEM is encouraged to develop a concrete proposal of how the available space may be populated with new tracking detectors to replace the T2 telescope after LS2, to ensure the space will not be filled in other ways beforehand.

13. REPORT AND DISCUSSION WITH THE LCG REFEREES

LCG computing is performing very well across the experiments, making full and efficient use of the available pledged resources and opportunistic resources made available to the experiments. The excellent performance of the computing systems and software is based on the many improvements made during LS1, and an on-going optimisation of the whole system. However the excellent performance of the LHC has produced data in significant
excess of the expectations for 2016, pushing the available resources to their very limit. In particular the storage elements are continuously full despite aggressive storage content management. More tapes have been procured to address the immediate needs, and mitigation actions taken within the experiments: reduction of disk replicas, parking of some data on tape, use of data popularity to reduce not needed samples etc.

- LHC performance is above expectations: LHC live time (37% → > 60%), luminosity (1.0 x 10^{34} → 1.2 x 10^{34} cm^{-2}s^{-1} or better), pile-up (CMS, ATLAS) (21 → 33 on average).
- For 2016, the available resources will be sufficient; more tapes at CERN have been bought.
- A re-analysis of the 2017-2018 resources needs was initiated. It is expected that the previous estimates are exceeded by 15-30%. Note however that this analysis was just done in time for the RRB and not yet scrutinized by the RSG.

The LHCC acknowledges the efforts of the experiments to improve the efficiency of the recorded data with respect to their physics goals, and that without additional computing resources data taking will eventually have to be scaled back below the capabilities of the machine and experiments, cutting into the physics programme.

The future of computing for the HL-LHC is the subject of intensifying discussions, with a conceptual design targeted for 2017, and technical design reports to follow around 2020. The committee takes note of the raising interest on future computing in the wider scientific community, and supports the community white paper process. It recognizes there an excellent opportunity to embed the HL-LHC road map in a broader context.

14. CLOSEOUT WITH THE DIRECTOR GENERAL

The LHCC chairman summarised the meeting and informed and discussed with the Director General the status of the LHC experiments and their plans for future upgrades. The DG reported that HL-LHC was formally approved by Council in June, and that Council in its more recent meeting approved the creation of the credit line with the EU investment bank needed to ensure the spending profile for HL-LHC in peak years. CERN will also increase its staff levels in the procurement area to be able to cope with the large number of requests expected over the next years. With respect to the increased computing needs due to the excellent LHC performance the DG concurred that every effort should be made to avoid the loss of valuable physics data, however a delay in producing certain physics results is acceptable.

15. REFEREES

The LHCC referee teams for this session are as follows:

ALICE: C. Bloise, J. Dunlop, P. Newman, C. Sfienti, T. Ullrich (Co-ordinator)
ATLAS: P. Burrows (Co-ordinator), F. Kunne, M. Lancaster, B. Ratcliff
CMS: M. Demarteau, D. Denisov (Co-ordinator), E. Kajfasz, A. Kuzmin, H. Yamamoto
LHCb: C. Diaconu, G. Eigen (Co-ordinator), P. Krizan, T. Kuhr
LHCf, MoEDAL, TOTEM: M. Mangano (Co-ordinator), C. Bloise, A. Kuzmin, P. Newman
LCG: C. Diaconu (Co-ordinator), T. Kuhr, M. Lancaster, H. Yamamoto
16. The LHCC received the following documents:

- CERN-LHCC-2016-008 Minutes of the one hundred and twenty-sixth meeting of LHCC held on 25 and 26 May 2016
- CERN-LHCC-2016-011/UCG-020 UCG Report on ATLAS Phase II Upgrade
- CERN-LHCC-2016-012/UCG-021 UCG Report on CMS Phase II Upgrade

DATES FOR LHCC MEETINGS

Dates for 2016
30 November – 1 December

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

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