LARGE HADRON COLLIDER COMMITTEE
Minutes of the one-hundredth-and-twentieth-first meeting held on Wednesday and Thursday, 4-5 March 2015

OPEN SESSION – STATUS REPORTS
1. LHC Machine Status Report: Frederick Bordry
2. CMS Status Report: Jim Olsen
3. ATLAS Status Report: Philipp Fleischmann
4. LHCb Status Report: Vanya Belyaev
5. ALICE Status Report: Leonardo Milano
6. TOTEM Status Report: Michele Quinto

OPEN SESSION – LHC EXPERIMENT STUDENT POSTER EXHIBITION

CLOSED SESSION:

* part-time

Apologies: H. Burkhardt, R.-D. Heuer, T. Ullrich

1. EXECUTIVE SUMMARY

General
The physics output from all experiments is impressive in all fields, with in total hundreds of papers published or in the process of being published. The experimental techniques are becoming increasingly refined, allowing many precision measurements to be made even beyond expectations.

The LHCC heard a report on the plans for the LHC machine re-start, which is progressing well, and with about a two-week delay compared to the original plan due mainly to the higher-than-expected number of magnet quenches.

In June 2015 the LHCC will examine the requests for special runs, for 5 TeV centre-of-mass energy reference data, and for the machine fill structure for Pb-Pb running. The experiments have been requested to present their plans.
**Experiment Upgrades**

Approval of the experiment Phase-1 upgrade Technical Design Reports is almost complete. The LHCC is in the process of reviewing the remaining ALICE Technical Design Reports (for the Muon Forward Tracker (MFT) and the Time Projection Chamber (TPC)). The LHCC will present its recommendations at its session in June 2015. The LHCC expects to receive the ALICE Online-Offline (O2) Technical Design Report and the final ATLAS Forward Physics (AFP) Technical Design Report.

The definition of the process to approve the Phase-2 upgrade programme for the experiments is progressing well. The experiments are preparing Scoping Documents for three funding scenarios and will submit them during summer 2015. The LHCC will present its recommendations for the Scoping Documents at its session in September 2015. Deliberation at the Research Board is scheduled for its meeting prior to the October 2015 sessions of the Resources Review Boards (RRBs).

**LHCF**

The LHCC took note of the LHCF plans to take data during the LHC start-up period just before the Technical Stop 1 (TS1) for a combined physics analysis programme with ATLAS. To avoid radiation damage, the LHCF detectors must be removed before the LHC reaches 500 pb⁻¹ integrated luminosity. The LHCC supports the LHCF physics programme and encourages the experiment to develop with the machine back-up plans that would allow the experiment to carry out their physics measurements even in the case that unexpected problems prevent the implementation of the base plan.

**CMS**

The Long Shutdown 1 (LS1) activities have concluded successfully and the experiment is getting ready for data taking. Cosmic-ray runs with magnet on/off are being performed.

Run I analyses still in the progress will have to finish by 15 April 2015 to avoid interference with the Run II analysis programme (except for the W-mass measurement). Following this date, only best-effort basis support will be available within the Collaboration for the Run I data.

The Phase-1 CMS upgrades are proceeding according to plans. An in-depth review of the Phase-1 upgrades by the LHCC will be held in September 2015.

A draft of the Muon End-cap Gas Electron Multiplier (GEM) muon tracker Technical Design Report was received by the LHCC. The Muon End-cap GEM will provide improvements to the tracking and triggering of the CMS detector. Although it is mostly needed for High-Luminosity LHC (HL-LHC), the project is mature and it could be installed during Long Shutdown 2 (LS2). A set of four chambers will be installed in CMS in 2016 for a full slice test. The total cost of the detector is 3.7 MCHF and will not be reviewed by the UCG. The experiment is encouraged to submit the final version of the Technical Design Report for a recommendation at the LHCC’s meeting in June 2015.

The Technical Proposal for the Phase-2 CMS upgrade is delayed in order to complete the physics studies and to conclude on the choice for the end-cap calorimeter. Submission is now planned for 18 May 2015. The CMS Scoping Document submission is scheduled for July 2015.
TOTEM
Detector readiness for Run II: Roman Pots are installed; the T1 telescope is ready for installation; the T2 telescope is installed, and despite suffering some damage with one quarter of the telescope removed from the control loop the impact on the physics is minimal.

The Vertical Roman Pot timing detectors have shown a resolution of 100 ps and are on schedule for installation in September 2015.

The 3D sensors for the CMS-TOTEM Precision Proton Spectrometer (CT-PPS) are delayed because of a change of producer.

At the meeting of the LHC Machine Committee (LMC) on 18 March 2015, TOTEM will present a request for Roman Pot alignment during LHC machine start-up period.

LHCb

The Long Shutdown 1 (LS1) activities have been successfully concluded. In particular, 15% of the Hadron Calorimeter (HCAL) PMTs have been replaced due to ageing and the new High Level Trigger (HLT) scheme is commissioned.

The Yandex School of Data Analysis is a new LHCb Associate Member, bringing important expertise in computing and data analysis.

The LHCC carried out a review of the LHCb Phase-1 upgrade projects. Good progress is being made in all projects.

Scintillating Fibre Tracker (SciFi): "Bumps" in the fibre diameter is still an issue, but the CERN group understands the cause and has communicated a solution to the vendor Kuraray.

RICH: The delay in production of the final read-out chip (CLARO8), due to change from IBM process to TSMC, has caused a schedule delay of about eight months. The schedule has been adjusted with no significant impact on the overall LHCb schedule.

Vertex Locator (VELO):
Detector half-planes have been rotated by 45-degrees, compared to configuration presented in the Technical Design Report, to mitigate tight tolerances during insertion. The changed geometry required a new foil design. Machine impedance studies are ongoing. The LHCC encourages the experiment to prepare a document in common agreement with the machine.

Design of the VeloPix ASIC (based on TimePix3) is ongoing at full speed and with a rather aggressive schedule. Availability of VeloPix will drive the VELO project schedule.

Silicon Upstream Tracker (UT):
R&D on sensors, readout ASIC, and flex circuit is progressing well. The schedule has been re-organized with respect to the Technical Design Report to cope with technical problems. The LHCC expressed concern on the tight schedule for this project and will monitor the progress closely.

The next LHCb upgrade in-depth review will be held in March 2016.
**ATLAS**

The Long Shutdown 1 (LS1) detector consolidation is complete. All the ATLAS sub-systems have been integrated and have moved into 24/7 shift operation. Cosmic-ray runs with magnet on/off are being performed.

The LHCC reviewed the status of the ATLAS sub-detectors. The Transition Radiation Tracker (TRT) Xenon leaks are stable. The detector is set up to run Ar in the inner barrel and the detector performance is good. Bowing (200 µm) of the Insertable B-Layer (IBL) staves has been observed under large temperature changes, and this is being investigated further.

The LHCC received the preliminary Technical Design Report for the ATLAS Forward Physics (AFP) programme. The physics programme is very complementary to the ALFA (Absolute Luminosity For ATLAS) project (large-t acceptance, all $\beta^*$). The tracking detectors are based on the ATLAS IBL technology. The project calls for installation of a single arm with only tracking detectors in the fall 2015. This appears very ambitious and as a fallback both arms can be installed together at the end 2016. One arm is funded, while resources are requested for the second arm. Updates to the LHCC are expected in the next months and the Committee’s recommendation will be presented at its meeting in June 2015.

A draft version of the ATLAS Phase-2 Scoping Document is scheduled for submission to the LHCC prior to its June 2015 meeting.

**ALICE**

The detector re-commissioning is complete with the installation of the Transition Radiation Detector (TRD) modules, and the experiment is ready for LHC beam operation.

The new RCU2 pre-series read-out electronics for the Time Projection Chamber (TPC) has been successfully tested. The mass production is ongoing and installation is foreseen during the June 2015 Technical Stop 1 (TS1).

**Upgrade projects:**

The Inner Tracking System (ITS) upgrade project was approved in 2014, but the sensor technology choice is still pending. The pixel chip has been down-selected to two fully-compatible CMOS chip options: ALPIDE and MISTRAL-O. ALPIDE is the baseline option, while MISTRAL-O is optimized for the detector outer layers. Full validation is expected by end 2015.

The LHCC received the Muon Forward Tracker (MFT) Technical Design Report. The MFT adds significantly to the physics capabilities of ALICE, providing primary and secondary vertexing in a challenging rapidity region matched to the Muon Spectrometer. The project benefits from a large technical overlap with the ITS and the synergy between the two projects is being leveraged effectively. The schedule is tight and there is a concern about possible interference between the MFT and ITS construction. The LHCC encourages ALICE to move forward to complete the R&D phase in 2015 and to launch the production phase for all items in 2016. An updated version of the Technical Design Report will be prepared following the recommendations of the LHCC. The cost of the MFT project is 3.3 MCHF, and will not be reviewed by the UCG. The LHCC referees will conduct a small-scale cost and manpower review, aiming for a recommendation at
the June 2015 meeting of the Committee.

The LHCC received the Addendum to the Time Projection Chamber (TPC) Technical Design Report. Following the review of the TPC Technical Design Report in February 2014, an extensive R&D programme was launched by ALICE. The LHCC is impressed by the progress in the R&D campaign since then. The 4-GEM baseline (comprised of stacks of four Gas Electron Multiplier layers) has been extensively characterized, together with other alternative solutions. It has been shown to exceed the requirements of 1% ion back flow and 12% energy resolution, although with only a small contingency according to the prototype studies. The R&D studies have also indicated that the original specifications for the TPC can be relaxed. Given the crucial role in the ALICE physics programme of a TPC capable of operating up to 50 kHz, the limited margin remains a concern. The LHCC encourages ALICE to move forward with the current baseline design and to submit the documentation for the UCG cost review, whilst in parallel continuing a vigorous R&D campaign to explore chamber configurations that could provide additional operating margin. The LHCC expects to present its recommendation at its meeting in June 2015.

The Online-Offline (O²) Technical Design Report is in final preparation and is expected to be submitted to the LHCC and UCG on 20 April 2015, with an LHCC recommendation expected in June 2015.

**WLCG**

During the Long Shutdown 1 (LS1) the LHC experiments have undertaken an ambitious programme of software and computing updates, implementing in some cases frontier technologies (e.g. multi-thread and virtual computing).

The computing models have been updated to take into account the experience gained during the first LHC data-taking period and to further optimize the resources.

Common work across the experiments becomes increasingly important and beneficial. Well-established software and formats used in some experiments are also used by other experiments, thus improving the reliability and enhancing the community coherence and capabilities to react to new challenges.

In this context, the HEP Software Foundation is a timely initiative and the LHC experiments and WLCG are active partners during this initial phase.

The longer term is now prepared in all experiments and will be the next important milestone. Working groups for computing in the upgrade phases are being installed or exist already. A Technical Design Report is expected for this year (O² system for ALICE) and more are expected in the next years. The LHCC will follow closely the process in order to ensure that the computing models fit the specifications enabled by the ambitious detector upgrades.

2. **PROCEDURE**

The Chairman welcomed the new members of the LHCC: C. Bloise, T. Kuhr, M. Lancaster and B. Ratcliffe.

The minutes of the one-hundredth-and-twentieth LHCC meeting (LHCC-2014-025 / LHCC120) were approved.
3. REPORT FROM THE DIRECTOR OF RESEARCH AND COMPUTING

The Director for Research and Computing reported on issues related to CERN and the LHC. He reported on the successful completion of Long Shutdown 1 (LS1) and on the plans for the LHC machine re-start, which is progressing well with about a two-week delay compared to the original plan due mainly to the higher-than-expected number of magnet quenches. He also reported on the readiness of the LHC experiments for Run II and stated that the special LHC runs for 2015 will be discussed at a dedicated meeting during the June 2015 session of the LHCC. He also reported on the status of discussions regarding the process for the approval of the LHC experiment Phase-2 upgrades (see Section 5 below for further details).

4. REPORT AND DISCUSSION WITH THE EXPERIMENT UPGRADE REFEREES

The status of the current upgrade of one of the four main LHC experiments is reviewed at each of the LHCC meetings. An in-depth review of the LHCb Upgrade was held during this LHCC session. A detailed summary of the in-depth review is provided in the LHCb section of these minutes (see Section 13 below for further details). In summary, the LHCb upgrade projects are to be commended for the progress being made in all systems. The LHCC noted, however, that for both the LHCb Vertex Locator (VELO) and Silicon Upstream Tracker (UT) systems, the schedules are tight and careful monitoring of the milestones is suggested.

The LHCC also reviewed the status of the ATLAS Forward Proton (AFP) detector. A preliminary Technical Design Report for the AFP was received prior to this LHCC meeting. The AFP project is geared towards low $\beta^*$ and high luminosity collider running. The project consists of four Roman Pots with stations at 206 m and 214 m from the interaction point on both outgoing beams. The project will proceed in two phases. In the first phase, a single-arm spectrometer to study single diffractive production will be installed in the winter of 2015-2016. No time-of-flight would be available. In a second phase, the second arm would be installed, scheduled for the winter of 2016-2017. The AFP project would significantly improve the acceptance for events at small $t$ and is complementary to the physics reach of ALFA (Absolute Luminosity for ATLAS). Significant infrastructure is required to build AFP, all on a relatively tight schedule. The AFP project leverages much of the detector technology intrinsic to ATLAS and is a relatively small project in terms of core costs. The project is well motivated and the LHCC affirms that the forward physics programme is an essential complement of the LHC programme, with potential contributions to many areas, from perturbative QCD and non-perturbative dynamics to exotic Beyond the Standard Model (BSM) searches. Given the value to the physics programme, the LHCC encourages completion of the Technical Design Report for AFP and strongly encourages a synchronous AFP and TOTEM/CMS programme to provide parity and independent measurements, in particular in view of special run requests that affect the overall LHC schedule.

The CMS experiment submitted the Technical Design Report for the construction of Muon End-cap Gas Electron Multiplier (GEM) based muon chambers to be installed in front of current Cathode Strip Chambers (CSCs) during Long Shutdown 2 (LS2). This was originally a Phase-2 upgrade proposal, but moved up in time to be completed in Phase-1. The new precision chambers will guarantee high muon tracking performance during late Phase-1 and throughout Phase-2, will improve the Level-1 and High Level Trigger muon momentum resolution, will reduce or maintain the global muon trigger
rate and will restore redundancy. The mature design is based on triple GEM gas amplification chambers. Six generations of prototypes have been built to date and six production sites are ready for production. Each site has assembled prototypes and has significant expertise. A cosmic-ray test stand is available at the Tracker Integration Facility (TIF) for long-term testing and an integration setup is available in Building 904. A detailed production schedule was presented. Currently, a critical component that is still missing is the VFAT3 ASIC electronics. Submission of this ASIC is foreseen in the third quarter of 2015, with a possible second submission in the second quarter of 2016.

The LHCC **commends** the Collaboration on this strategic move of the project from Phase-2 to Phase-1, creating contingency in schedule and budget and is looking forward to the final version of the Technical Design Report.

The ALICE Collaboration submitted the Technical Design Report for the Muon Forward Tracker (MFT) ahead of this LHCC meeting. The MFT provides vertexing for the ALICE Muon Spectrometer (MS) at forward rapidity, which helps in the discrimination between prompt and b-decay J/ψ down to pT=0 and enables open heavy flavour and charmonium studies. The MFT is a silicon pixel tracker complementing the acceptance of the ALICE Inner Tracking System (ITS). The project consists of 896 silicon pixel sensors (with an area of 0.4 m²) in 280 ladders, arranged in five disks. Each disk consists of two detection planes and is divided in two halves. The project is very synergetic with the ITS and provides for significant leverage of resources, component production and assembly techniques. The sensors and Flexible Printed Circuit (FPC) form a Hybrid Integrated Circuit (HIC) that carries one to five sensors and is at the heart of the detector. The FPC is the main contributor to the material budget (38%), followed by the cooling (19.5%) and silicon pixel sensor (16%). The readout system is identical to the readout for the ITS. The proposal is technically sound. The schedule, however, is tight and the demand for resources is high. Some resources may be required by both the ITS and MFT projects. It is noted that the MFT has to be completed before the ITS due to the installation schedule. The Collaboration is encouraged to complete the R&D phase as quickly as possible and aim at launching the production phase for all components in 2016. Careful attention to the schedule will be required. An updated version of the Technical Design Report will be prepared following the recommendations of the LHCC. The cost of the MFT project is 3.3 MCHF, and will not be reviewed by the UCG. The LHCC referees will conduct a small-scale cost and manpower review, aiming for a recommendation at the June 2015 meeting of the Committee.

The ALICE Collaboration also gave an update on the status of the ITS, a large-volume CMOS silicon pixel detector, consisting of three inner barrel and four outer barrel layers. To achieve the physics goals, a point resolution of 5 µm (10 µm) is required for the inner (outer) layers and a maximum power density of 300 mW/cm² (100 mW/cm²) for the inner (outer) layers. The radiation tolerance has been updated since the Technical Design Report and the sensors, with adequate safety margin, have to withstand a total ionization dose of 2700 (100) krad and a non-ionizing energy loss dose of 1.7×10¹³ (1.0×10¹²) 1MeV n_{eq}/cm² for the inner (outer) layers. The CMOS pixel sensor technology using the TowerJazz 180 nm CMOS Imaging Process is the technology of choice. Two pixel architectures, with full pin-to-pin compatibility, are being considered: ALPIDE and MISTRAL-O. The MISTRAL-O chip is being optimized for the outer barrel layers where the requirements are less stringent. The current prototype chips achieve an event time resolution of ~2 µs (~20 µs) and power consumption of 39 (97) mW/cm² for the ALPIDE (MISTRAL-O) chips. An aggressive development plan for the ALPIDE chip is proposed. In March 2015 a second full-scale prototype version,
pALPIDE-2, will become available with a final interface that allows for integration into ITS and MFT modules. This will be followed in July 2015 by pALPIDE-3 with all the final features, and with pALPIDE-4 in December 2015 as a preproduction run. The schedule for MISTRAL-O calls for submission of an optimized architecture with all final features in July 2015. Integration into detector modules for MISTRAL-O is planned for October 2015. The implications of the reduced spatial resolution, should the MISTRAL-O be used in the inner barrel, will be studied. Beam and irradiation tests of the current prototype chips of both architectures show excellent performance. The LHCC encourages ALICE to carry out a full validation of both architectures before the end of this year.

5. REPORT FROM THE UPGRADE COST GROUP (UCG)

The LHCC heard a report from the UCG, concentrating on the status of the Phase-1 and Phase-2 upgrades of the LHC experiments. The Chairperson of the UCG presented the status of deliberations by the Research Board, the LHCC and UCG of the Phase-1 upgrade Technical Design Reports. He also reported on the process for the approval of the LHC experiment Phase-2 upgrades. The process consists of a) the approval of the preliminary design for the complete set of Phase-2 upgrades, b) the approval of the baseline design, cost and schedule c) the approval for construction and d) the approval for operations. The LHCC will submit a report to the April 2015 sessions of the Resource Review Boards detailing this approval process.

6. REPORT FROM THE LHC PROGRAMME CO-ORDINATORS

The LHCC heard a report from the LHC Programme Co-ordinators, concentrating on the immediate plans for LHC operation and the longer-term plans for LHC Run II. The Co-ordinators presented the schedule for the LHC start-up period, covering the Sector test of TED absorber shots for ALICE and LHCb, the beam splash tests for all experiments at the end of the LHC commissioning phase as well as the LHCf and van der Meer scan runs. The Co-ordinators presented the requests from the experiments for the van der Meer scan runs, summarizing that the scan conditions and protocols should be equivalent to those of November 2012. The LHCf run plan has also been finalized and it accommodates the removal of the LHCf detector before an integrated luminosity of 500 pb\(^{-1}\). A dedicated discussion on planning for the special runs in 2015 will be held during the LHCC session in June 2015. For the longer term, the LHCC will address the outstanding issues, including the use of high-brightness beams and the consequences for the expected integrated luminosity and pile-up; the exact schedule for proton-proton reference energy runs for the heavy-ion physics programme; and the schedule for proton-Pb and Pb-Pb in 2018 in view of the shutdown of the PS Booster in 2018.

7. DISCUSSION WITH LHCf

Physics

Since the LHCC meeting in November 2014, LHCf has completed two physics analyses: a) the measurement of very forward neutron energy spectra from proton-proton collisions at \( \sqrt{s} = 7 \) TeV has just been submitted for publication and b) an update of \( p^0 \) spectra from Run I (proton-proton collisions at \( \sqrt{s}=2.73 \) and 7 TeV and proton-Pb collisions at \( \sqrt{s} =5.02 \) TeV), including events with two photons in the same calorimeter tower, is under Collaboration review.
In the new paper, LHC neutron energy spectra in the very forward region (\(\eta > 8.81\)) are compared with Monte Carlo predictions of several models and the LHC data show harder energy spectra than expected from simulations. Moreover, LHC data require a more abundant neutron-to-photon production rate than obtained from Monte Carlo codes.

The LHCf physics goal to provide input from LHC measurements for the analysis of air shower data dominated by very forward processes is being extended to include joint analyses of LHCf and ATLAS data. The analysis collaboration between LHCf and ATLAS has started and the physics programme is being defined by carrying-out the feasibility tests for joint data analysis on the sample of proton-Pb collision data taken in 2013. The analysis of common data confirms the success of the operation, with 99.7% of events matched. The physics goals for the 2015 LHCf run are: a) the study of forward particle production in diffractive and non-diffractive processes and b) the measurement of the total cross-section and multiplicity distribution of proton-proton interactions, on the basis of \(5 \times 10^6\) common triggers. The LHCC encourages LHCf to finalize the physics case studies undertaken with the ATLAS Collaboration.

**Run II**

The LHCf detectors are ready in the LHC tunnel since November 2014. The upgrade of the trigger system for full matching of joint data with ATLAS is ready to be installed in March 2015. Test runs of the common LHCf-ATLAS DAQ system are planned to be carried-out with the first circulating beams in the LHC in order to be ready for trigger exchange in the low-luminosity run in May 2015.

Special LHC runs dedicated to van der Meer scans and to the LHCf, with beam separation at Interaction Point 1 (IP1) giving low pile-up, are scheduled from 27-31 May 2015. LHCf is evaluating data taking feasibility during the van der Meer scan runs. A Technical Stop of the LHC (TS1) is planned just after the special runs. A secondary, back-up period of data-taking at the end of TS1 is proposed by LHCf in case of problems during the dedicated run. The removal of the LHCf detectors is scheduled during TS1 (or soon after the back-up run).

The LHCC supports the LHCf operation plans and the development with the LHC Programme Co-ordinators of a back-up plan for a successful physics run in 2015.

**8. TEST BEAMS**

The PS and SPS Physics Co-ordinator reported on the LHC test beams. He presented the experimental areas and beam characteristics of the test beam facilities at the PS East Hall and at the SPS North Area. The Co-ordinator also provided a report on the various irradiations facilities at the PS and SPS, covering the IRRAD proton and the mixed-field CHARM facilities at the PS East Area and the GIF++ gamma irradiation facility at the SPS North Area. The PS East Area facilities started operation in 2014 while the GIF++ is scheduled to start operation in mid-March 2015. He also reported that the European Commission approved the AIDA-2020 funding request in Horizon 2020 and will fund users of test beam and irradiation facilities in Europe. He concluded by showing the PS and SPS User Schedules for 2015.
9. **LHC EXPERIMENT STUDENT POSTER SESSION**

An exhibition of student posters was held in the Main Building and covered students' work on a wide variety of LHC physics topics. The LHCC Members had ample opportunity to interact with the students and there was broad participation in the event from interested parties. As for the previous such annual sessions since 2011, this event was again deemed to be a great success and is expected to be repeated in the future.

10. **DISCUSSION WITH CMS**

**Physics**

The CMS Collaboration is progressing full speed with the analysis of Run I 7 TeV and 8 TeV centre-of-mass data. In total 378 papers have been submitted by the time of the LHCC meeting in March 2015. The largest number of published papers is on "Exotica Searches" as is natural for the main area of studies at the energy frontier collider. The rate of the publications is recently steady at ~3 papers per week. Since the previous LHCC meeting all CMS physics groups submitted new publications with the largest number in the Higgs groups where milestone papers on Run I results have been submitted. One of the concerns of the Collaboration is potential interference of the continuing Run I analyses with start-up of Run II at 13 TeV centre-of-mass energy, where exciting physics results might come pretty quickly. With input from all physics groups and the rest of the Collaboration, CMS developed a Run I publication strategy. This strategy includes submission of ~70 high-impact papers in the next 3-4 months. Many of these papers are in the final stages of the internal reviews and some require editorial work only. Deadline is set for 15 April 2015 for Run I analyses to converge. Beyond this date Run I analyses will have support on a "best-effort" level only and this includes reviews as Run II final preparations and analysis of incoming data is to take priority. The above Run I analysis strategy has been agreed at all collaboration levels and is being implemented. A notable exception to this rule is the W-mass analysis.

Among the highlights of the recent CMS publications is the search for the Standard Model like Higgs boson in WW and ZZ decays at high mass. Combination of these searches provides strong exclusion in the mass range 145 to 1000 GeV, which excludes the full high mass range allowed for the Standard Model Higgs boson. The legacy Run I CMS Standard Model Higgs paper provides in-depth information about the newly-discovered particle. Its mass is measured to a precision of ~0.3 GeV and is equal to 125.0 GeV. All measured properties of the Higgs boson are in very good agreement with the Standard Model predictions, including Higgs boson couplings to bosons and fermions.

**CMS Preparations for LHC Run II**

CMS is progressing with final activities in preparations for 2015 data taking at 13 TeV centre-of-mass energy. The solenoid magnet has been successfully tested in November 2014 at full current. In December 2014 the detector was re-opened to install the Pixel detector after the 25% of the Barrel Pixel (BPIX) modules in one quadrant that were found to be unresponsive have been repaired. The cause of the problem has been traced to electrochemical reactions due to excessive humidity introduced during handling of the detector. Installation progressed smoothly and the full Pixel detector is now in smooth operation with detector cooled to -10 °C and over 99% of the channels working. The tracking strip silicon detector is also ready for the beam operating at -15 °C with
initial cosmic-ray alignment being good. All parts of the Run II calorimetry are in place and the calibration process for 25 ns beam timing has been developed. The Pixel Luminosity Telescope (PLT) and Beam Condition Monitors (BCMs) have been installed and commissioning is progressing smoothly. In the muon system all Cathode Strip Chamber (CSC) detectors are working well with nominal gas flow and high voltages applied. Installation of all original CMS design chambers has been completed during Long Shutdown 1 (LS1). The muon Drift Tube (DT) detector in the central rapidity region have all planned upgrades accomplished and are in smooth operation. An extra 144 muon system Resistive Plate Chambers (RPCs) have been installed during LS1 and all chambers are operating with an efficiency of ~95% on a par with Run I performance.

Before beam operation, all CMS systems are commissioned using cosmic-rays. In February and March 2015 cosmic-ray runs with no magnetic field (used for detectors alignment) have been collected with ~170 million triggers accumulated. From the middle of March 2015 cosmic-ray data taking with solenoid ON is expected to test all detectors in close to real beam environment as well as collect data for the detector alignment.

CMS developed an in-depth plan for the initial commissioning of the detector with colliding beams. This commissioning includes adjusting timing of different detectors, high voltage scans, final in situ alignment as well as Van der Meer scans to calibrate the LHC luminosity. The CMS Collaboration, together with the LHCf Collaboration, is ready to use the LHCf detector for the data collection during the initial low-luminosity operation of the LHC at 13 TeV centre-of-mass energy.

The CMS collision hall and infrastructure are getting older and require careful maintenance. Specific areas of concern recently included concrete floor under a fraction of the detector as well as rusty cooling water valves, which required replacement.

First versions of the Run II trigger menus are now available for both Level-1 trigger and High Level Trigger (HLT). The menus cover luminosities up to $7 \times 10^{33}$ cm$^{-2}$ s$^{-1}$ at 25 ns bunch spacing and up to $5 \times 10^{33}$ cm$^{-2}$ s$^{-1}$ for 50 ns bunch spacing. CMS has developed updated versions of the trigger menus for the luminosity up to $1.2 \times 10^{34}$ cm$^{-2}$ s$^{-1}$ at 25 ns bunch spacing; it covers the most challenging scenario of doubling both the LHC energy and luminosity. Physics acceptance of the list is similar to the 2012 run due to substantial upgrades to both hardware and software during LS1. The CPU time per event in the HLT is within budget (assuming an upgraded filter farm). Preliminary rate estimates indicate that the total rate will fit within the budget of an average rate of 1 kHz to tape with a peak up to 1.35 kHz at the beginning of the fills.

During LS1 substantial software upgrades have been accomplished by CMS in all areas including triggering, data processing, and physics analysis. For example, substantial CPU reduction in processing of the LHC data have been accomplished, which will provide an opportunity to reconstruct timely all data collected by CMS at 13 TeV centre-of-mass energy. For the data analysis CMS has developed and deployed a new ten-times smaller data format, the so-called "MiniAOD". This format is expected to speed up and simplify data analysis of the 13 TeV centre-of-mass energy LHC data considerably. Preparations for the Run II Monte Carlo simulation are progressing well, with PYTHIA8 samples already produced for one-third of the physics groups requests and GIGI-RECO expected to provide samples of events at 25 ns and 50 ns by the end of March 2015 using a realistic set of alignment and calibration data obtained for Run II. Reconstruction
and analysis framework are progressing well for processing of soon to be coming Run II data.

CMS is also getting ready for the late 2015 heavy-ion run. Expected peak Pb-Pb collision rates will be ~30 kHz or four times higher compared to the LHC design value. This will require implementation of the trigger menu to perform high-pT physics studies with expected luminosity to be delivered of ~1 nb^-1. Such a high-luminosity heavy-ion run will require optimization of the fill length due to rapid ion burn-off. Consultations between ATLAS, CMS, ALICE and LHC accelerator experts should start well in advance of the heavy-ion run to optimize and agree on the heavy ion luminosity delivery strategy.

The CMS Collaboration is progressing well towards the readiness for the Run II data on all fronts: from technical preparations to physics analysis tools. A large number of Monte Carlo based "analyses" are performed using Run II software and Monte Carlo generation. The Collaboration is rightfully concentrating on those analysis areas where the energy increase provides immediate improvements even with limited integrated luminosity.

**CMS Phase-1 Upgrades**

CMS is progressing well with the Phase-1 upgrades. For the Hadron Calorimeter (HCAL) upgrade, the work is spread out over time from LS1 to Long Shutdown II (LS2). This is progressing on schedule with the back-end upgrade of the Hadron Forward (HF) calorimeter already completed and commissioning in progress. The other parallel HCAL upgrade efforts are progressing, consistent with the planned delivery schedule. HF back-end has been installed during the LS1 while the upgraded front-end electronics is planned to be installed during the year-end Technical Stop 2015-2016. The back-end of the Hadron Barrel (HB) calorimeter and Hadron End-cap (HE) back-end upgrades will be installed in May-June 2015 in parallel to data taking. The final upgrade of the HB and HE readout (replacement of the HPD hybrid photon detectors with SiPM silicon photomultipliers), which requires major interruptions in the operations and long access, will be installed during LS1.

The Phase-1 Pixel detector upgrade is progressing as planned with the goal to install it during the extended year-end Technical Stop 2016-2017. During LS1 prototypes of the forward pixel blades have been installed in the CMS detector and will provide operational experience during the initial part of Run II. According to radiation aging tests it is now expected that the full Phase-1 upgrade Pixel detector (barrel and forward) will survive ~500 fb^-1 without replacement. This will provide operation of this detector all the way to the Phase-2 upgrade period.

The LHCC plans for an in-depth review of the CMS Phase-1 upgrade during the September 2015 meeting.

**CMS Phase-2 Technical Proposal**

All basic technologies for the CMS Phase-2 upgrade have been finalized in 2014, except for the choice of the forward calorimetry. CMS decided to postpone the final selection of the forward calorimeter technology to April 2015 and developed a procedure how to converge in the most effective way to the benefit of the Collaboration and all involved. The small delay (by about two months) with the selection is due to the rapid rate of new information becoming available in early 2015.

After the selection of the forward calorimetry, CMS plans to submit the Phase-2 upgrade Technical Proposal to the LHCC for review in the second half of May 2015. Assuming
no major technical issues are uncovered during the Phase-2 upgrade proposal review by the LHCC during the summer, approval of the Technical Proposal could be considered at the September 2015 LHCC meeting.

In parallel with the discussion of the Technical Proposal, CMS will be working on the "scoping" document requested by the CERN Director-General in 2014. The document will consider two scenarios of the core cost reduction to 235 million and 200 million CHF and will quantify the effects of this reduction on the physics reach. The scoping document is expected to be delivered to the LHCC in late July 2015 with review of the document completed by the LHCC at the September 2015 LHCC meeting.

Before the March 2015 LHCC meeting, LHCC members were presented with the Phase-2 Technical Design Report describing the Muon Endcap GEM Upgrade. This upgrade is critical for keeping the muon triggering and reconstruction at the design levels during high-luminosity operation, will help significantly at the ultimate luminosity expected during Run III and is expected to be installed during LS2, i.e. before Run III and the high-luminosity LHC era. The core cost of this upgrade is estimated at 3.7 MCHF and the design is based on triple-GEM Gas Electron Multiplier chambers. This upgrade will substantially improve muon triggering in the rapidity region 1.5-2.2 where currently only a small number of muon tracking detectors are available. The total number of GEM chambers on both sides of CMS is 144, each covering 10° with some overlap. The preliminary review of the GEM Technical Design Report indicates that the proposal has well-defined specifications as well as an excellent R&D stage completed. Six sites for the production of the chambers have been selected (including CERN) and all GEMs are to be manufactured at CERN. The ASIC electronics for the GEM readout is almost finalized and the tests are on-going. Installation of the final design chamber with the readout electronics as a "slice test" is planned during the year-end Technical Stop in 2016. Based on the received documentation and tour of the production and test facilities at CERN, the experiment is encouraged to submit the final version of the Technical Design Report for a recommendation at the LHCC’s meeting in June 2015.

11. DISCUSSION WITH TOTEM

Introduction

The meeting of the LHCC referees with TOTEM reviewed the status of readiness for Run II, the progress of the upgrade projects, the analysis status and the planning for the schedule of special runs. The CMS-Proton Precision Proton Spectrometer (CT-PPS) was also reviewed (see Section 12 below for further details).

Physics

Three articles are being finalized by TOTEM and cover the deviation from a purely exponential behaviour of the elastic-scattering differential cross sections at low |t|; the Coulomb-hadronic interference at 8 TeV centre-of-mass energy; and the search, with CMS, for low-mass resonances in central exclusive production. The LHCC looks forward to the completion of these papers. Several other analyses are in progress, including the cross-section measurements at 2.76 TeV centre-of-mass energy, various studies of hard diffraction with CMS, and analyses of data from the 2013 proton-nucleus run.

Studies have started on the potential of missing mass measurements with CT-PPS to probe explicit models of new physics (e.g. in Supersymmetry) in regions of parameter
space that cannot be accessed by the standard searches. The Committee looks forward to the continuation and extension of these studies.

**Long Shutdown 1 (LS1)**

The Roman Pot detectors have been fully installed and movement tests have been completed in the tunnel. The tests, from the CERN Control Centre, of the Roman Pot movement calibration and interlock controls were scheduled for 3 March 2015. The T1 telescopes had been ready for installation for some time, and the installation is approved and is expected to be on time. The T2 telescopes have been installed and tested since October 2014. A minor damage, following mechanical stress during installation, has been fixed successfully. On 12 February 2015, the control loop on the minus-near quarter started behaving erratically. The problem is attributed to a loose connector, a possible residue of the October 2014 mishap. Schedule constraints suggest that fixing this should wait for the end-of-year Technical Stop. The study of the impact on the physics programme for 2015 (e.g. cross sections and low-mass central exclusive production) concluded that the absence of this element would only reduce by $O(1\%)$ the rapidity gap efficiency for the selection of exclusive production. This quarter sector has therefore been removed from the data acquisition for 2015.

**Run II**

TOTEM is interested in taking data with the Roman Pots during the low-luminosity runs dedicated to LHCf and to van der Meer scans. Data would be collected in conjunction with CMS. Taking data on this occasion requires insertion and alignment studies before the first LHC Technical Stop. This request will be brought by TOTEM to the session of the LHC Machine Committee (LMC) on 18 March 2015. The LHCC endorses the request, but leaves it to the LMC and LHC Programme Committee (LPC) to take the final decision. For what concerns the physics runs with $\beta^*=90\text{m}$, the LHCC decided to discuss the details at its session in June 2015.

**TOTEM Upgrades**

New test beam sessions since the November LHCC meeting have led to further progress in the design of the detectors for timing in the vertical Roman Pots. The time resolution of the largest pixels was measured to be 130 ps (compared to the 90 ps of the smaller pixels, reported in November 2014). Improvements to the amplifier chain reduced this to 90 ps, under the 100 ps target required to ensure the 50 ps resolution of the 4-layer detector. The design is now finalized, and detectors are ready for production.

**12. DISCUSSION ON THE CMS-TOTEM PRECISION PROTON SPECTROMETER**

The status of the joint CMS-TOTEM Precision Proton Spectrometer (CT-PPS) project was reviewed by the LHCC. The Roman Pots are installed in the LHC tunnel and are ready for insertion. The monitors for radiation, pressure and temperature, used to study the operating conditions of the timing detectors in the dedicated horizontal Roman Pots, are ready for installation before the end of Long Shutdown 1 (LS1) or during the first LHC Technical Stop in 2015. The prototype of the timing detector, after mechanical integration tests at CERN in mid-March 2015, will undergo beam tests at Fermilab at the end of April 2015. Funds to build the four final detectors will be requested upon successful completion of the tests, and the detectors could be available at CERN in July/August 2015. The manufacture of the 3D silicon pixel sensors for the tracking detectors has been moved from the previous company to the firm CNM. The production lay-outs are expected to be ready by end of March 2015, but full delivery of the sensors
may not be guaranteed before end of 2015, with a first batch made available by October 2015. This raises concerns on the time left available for testing of the final detectors before installation in winter 2016. Test beam studies at Fermilab (June and October 2015) will meanwhile be performed on CNM sensors available from the ATLAS Insertable B-Layer (IBL) production. DAQ boards for both timing and tracking detectors share the technology employed for the upgrade of the CMS pixel tracker, and will be part of the production for the Tracker starting in March 2015. R&D efforts on the evolution of timing detectors, and on movable beam pipes, are in progress.

13. DISCUSSION WITH LHCb

Physics
The scientific publication rate of the LHCb Collaboration proceeds well. Since the previous LHCC meeting in November 2014, 28 new papers were submitted or published by LHCb. The publication rate in 2014 has practically matched that of 2013. Many physics highlights were presented during the meeting and at the student poster session. The most remarkable result, however, was the 3 fb$^{-1}$ analysis of the golden mode for CPV in the $B^0$ system, the $B^0 \rightarrow J/\psi K_s$. LHCb extracted a value of $\sin^2 \beta = 0.731 \pm 0.035$ (stat.) ± 0.020 (syst.), and whose statistical error is already competitive to that measured at the B-factories.

LHCb Collaboration
The LHCb Collaboration is still growing. The Yandex School of Data Analysis has become a new LHCb Associated Member, bringing new important expertise in computing and data analysis. The application of the University of China Academy of Science (UCAS), which would also contribute to computing, is under evaluation. From the financial point of view, the money flow for the upgrade is reasonable although not all Memoranda of Understanding have been signed yet. The impact of the large variation of the Euro to the Swiss franc exchange rate on the upgrade is being evaluated. Many of the largest procurements seem to be unaffected by this change.

Long Shutdown 1 (LS1)
The maintenance and consolidation of the LHCb detector, in preparation for Run II, has been completed. The latest operations to be carried out were: (i) the exchange of the Hybrid Photon Detector (HPD) for RICH2-C Ring Cherenkov detector, and (ii) the installation of Herschel Forward Shower Scintillating Counters and the replacement of 15% of Hadron Calorimeter (HCAL) PMT that, due to ageing, were driving a high current. In Run II, an online gain correction as a function of observed occupancy will be implemented for the HCAL in order to keep the calorimeter trigger rate constant.

An important test of functionality of the full detector and of the data-taking organization has been carried out by means of the so-called LHC TED shots. These shots are produced by the LHC beam being sent from the transfer line to a concrete bloc resulting in beam-splashes inside LHCb. The first shots were carried-out, for a few days, at the end of November 2014, with the rate of one shot/minute, and were repeated in the first week of March 2015. Data taking was organized in shifts of 24/7 with a standard crew composition. The detector was configured with all sub-systems inserted and data were collected by means of a Scintillating Pad Detector (SPD) trigger. The data flow from the DAQ to the offline farm was also tested by means of a dummy pass-through Higher Level Trigger (HLT). Another relevant preparation step for Run II is the commissioning of the new “split” HLT system. The output of a fast first-stage trigger, HLT-1, based on
partial-track and object reconstruction, is written at 150 kHz on a disk accessible to a calibration and alignment procedure running on the same HLT farm. Once this procedure is finished, and parameters are stored in the database, an HLT-2 algorithm uses this information to perform a full event reconstruction and further streams down the events. The final data output to disk has a rate of 12.5 kHz and is composed by 5 kHz of fully reconstructed events, 5 kHz of parked data sample for future reconstruction and 2.5 kHz of Turbo stream events, where only the information coming from HLT-2 is used for the analysis stage. Most of the system has already been commissioned by injecting Run I data files in the online system.

Standard LHCb shifts will restart at the end of March 2015. First collisions will be used for the initial calibration of the detector and to perform time alignment, setting of thresholds, tracker alignment, amongst other tasks. Special runs for luminosity measurements are planned both with the van Der Meer scan and with the usage of SMOG, the System of Measuring Overlap with Gas. This initial period will be also useful for further checks and for commissioning the new split HLT. The 2015 data-taking plan sees a first set of data recorded during the luminosity ramp up at 50 ns, dedicated to the determination of the cross-sections at the new energy. Two fills with low luminosity will be collected without any trigger bias for Minimum Bias events. The luminosity will be levelled to keep the number of pile-up events at an average value of $\mu=1.1$. The goal is to keep $\mu$ stable while increasing the number of bunches as the luminosity increases to $4\times10^{32}$ cm$^{-2}$ s$^{-1}$ for the nominal 25 ns bunch period.

**LHCb Upgrades**

The LHCC has carried out an in-depth review of the LHCb upgrade projects. The Committee finds that good progress has been achieved on all sub-systems.

For the Scintillating Fibre Tracker (SciFi) detector, the latest samples of Kuraray fibres show much larger attenuation lengths and now agree with specifications. The bumps in the fibre diameter are still an open issue but the LHCb group has developed a method to handle them during the winding procedure when their rate of occurrence is maintained below one per kilometre. Proposals on how to reduce the occurrence of bumps have been conveyed to the vendor and are being evaluated by them. A fibre irradiation campaign, at low doses, has been completed and the observed damage agrees well with the model used in the Technical Design Report. LHCb has also tested the latest SiPM silicon PMT versions with trenches: the Hamamatsu detectors show a reduced noise while the KETEK detectors still have minor packaging problems. Radiation hardness tests of the SiPMs are in progress. An Engineering Design Review for the assembly of the fibre mats and modules is planned for July 2015. Progress has been shown also for the Pacific chip, whose final version with 64 channels will be submitted in April 2015. For the Particle Identification (PID) detectors, no concern exists for the Calorimeter and Muon systems where the main choices have been made and many Engineering Design Reviews are planned for the coming months. A more delicate situation exists on the RICH system where a further iteration on the read-out chip, the Claro, has been considered necessary. This corresponding submission, the Claro8v2, is expected in April 2015, and leads to a shift of around eight months in the completion of the related Progress Readiness Review milestone. The schedule will be adjusted accordingly to accommodate this delay, but no impact is expected on the overall project completion, since the critical path is still driven by the Multi-Anode PMT (MAPMT) delivery (March 2016). Apart from this issue, a successful RICH detector test beam campaign has been carried out with the Hamamatsu MAPMT and an intense irradiation
programme is ongoing. We commend the collaboration for the overall good progresses on SciFi and PID systems.

On the Vertex Locator (VELO) system, two changes were produced on the detector layout with respect to the Technical Design Report configuration: (i) the half-planes were rotated by 45-degrees to mitigate the tight tolerances during insertion into the RF box allowing an independent partial detector movement, and (ii) the spacing between stations was regularized through the engineering design. Both lay-out changes were tested with simulations showing no performance changes. The rotated geometry also required a new RF foil corrugated design. The upgraded VELO will have a reduced aperture of 3.5 mm (it is 5.1 mm in the current version) making machine impedance studies very important since preliminary studies show non-zero longitudinal impedance. The LHCC encourages LHCb to prepare a document in common agreement with the machine for the VELO integration into the LHC. The design of the Velopix ASIC read-out electronics chip, based on 130 nm CMOS technology, is on-going and with a very aggressive schedule. The chip design is based on the TimePix3 chip but with much higher requirements for speed and radiation hardness. The aim is to submit the first Velopix version in September 2015, with currently seven designers working on the project. A very tight schedule exists for obtaining the submission of the final chip in April 2016. The Velopix availability drives the VELO project schedule. For the rest of the detector components: (i) sensor tests were carried out both for Hamamatsu and Micron detectors, (ii) bonding to hybrids was done, (3) sensors were tested both in the laboratory and at test beams and (iv) irradiation with neutron and protons have been carried out. A sensor review is scheduled for April 2015. For the cooling substrate, the Technical Design Report design has been modified but preliminary pressure and vacuum soldering tests look reasonable. For the module production, two designs (single point support with respect to the carbon fibre frame) are being evaluated. The LHCC recognizes the impressive quality of work done for the VELO system. The project looks well managed and guided by a highly-competent technical team. Maintaining the schedule will require great diligence by the group.

For the silicon Upstream Tracker (UT) much progress has been made on the sensor side, where Micron and Hamamatsu sensors have been tested in the laboratory with a source and infrared laser. Test beam with minimum-ionizing particles have also been completed both before and after irradiation. A second R&D phase has started to: (i) test the performance of detectors with a circular cut (type D sensors), (ii) measure the new Hamamatsu sensors and (iii) decide between internal or external pitch adapter. For the read-out chip, the submission of the eight-channel, fully-functional SALT ASIC was delayed by three months due to the change to the TSMC 130 nm technology. A test of this eight-channel version will be carried both at a dedicated test stand and with a full slice test. Radiation hardness and Single Event Upset (SEU) tests are also scheduled. Some difficulties have been found in the procurement of a full-length flex cable, with final delivery of five cables achieved after many delays. A modified design with a shorter-length flex is in progress to improve ease in manufacturing. For the sensor-hybrid module, R&D is in progress to consolidate the stiffener and the flex circuit into a thick film circuit. The core stave design is advanced but a final decision for the cooling options is still under way by comparing the snake-tube baseline to a parallel line cooling. The completion of the R&D phase-2 will freeze the type and dimension of the sensors, as well as that of the hybrid modules, so that a final core production stave can be designed. In order to do so, four reviews are scheduled this summer aiming at starting the stave core construction in the coming fall. The schedule looks tight but still feasible.
The design of the CO₂ cooling system is done in collaboration with the VELO group. The LHCC concludes that for the UT a lot of progress has been achieved after the approval of the Technical Design Report and that the R&D proceeds well. However, many open points remain to be addressed and the schedule for the construction of the production staves is very tight. The Committee requests that LHCb presents a detailed plan for the stave production phase and to make more explicit the dependence between milestones and sub-project schedules. This will help to monitor the progress and to assess in time any further possible delay.

14. DISCUSSION WITH ATLAS

Physics

The total number of ATLAS physics publications has reached 394, an additional 24 since the previous LHCC meeting. Furthermore, more than 40 papers are in collaboration review and 110 editorial boards are in progress. The Run I analyses of Higgs physics, SUSY searches, exotics and detector performance are in the process of being wrapped up. It is estimated that an additional roughly 90 analyses, mainly Standard Model measurements, could also eventually proceed towards editorial board review.

A number of interesting new measurements were highlighted in the Open Session, including searches for Beyond the Standard Model (BSM) H → quarkonium γ, and A → ZH, as well as new measurements of Wγγ and try production. Results of searches for di-lepton resonances, electroweakinos, and dark matter were also presented. In addition, a new combined ATLAS/LHCf result on forward neutron production in the 2013 proton-Pb data sample was presented by LHCf in the Closed Session, and was warmly welcomed.

Long Shutdown 1 (LS1)

The Long Shutdown 1 (LS1) ATLAS detector consolidation is complete. All the sub-systems have been integrated and ATLAS has progressed to 24/7 shift operations. Cosmic-ray runs with magnet on/off are being performed.

The beam pipe has been under vacuum since mid-February 2015; the Beam Condition Monitor and Diamond Beam Telescope are operational. The Insertable B-layer (IBL) cooling plant is working well. The upgraded DAQ for the pixels system is being commissioned. The Semiconductor Tracker (SCT) remains 99% channel operational and a cooling loop leak was fixed. The new Thermosyphon cooling system is being commissioned with a dummy load and will replace the existing compressor plant when its performance has been verified.

The expected Transition Radiation Tracker (TRT) Xenon leak-rate is stable, and it is planned to use Argon instead in the inner barrel. This hybrid gas system has been simulated and the particle identification algorithm optimized to recover the electron identification performance. There has been a significant effort to deliver the 100 kHz Level-1 readout rate. Fixes will be applied (as required) during technical stops to power supplies that demonstrate overshoot upon beam dump. The Marathon power supply water cooling system was overhauled; in the future the cooling may be switched over to the muon cooling plant which is easier to access and maintain.

Following consideration by an expert panel on the grounding fault issue, the Liquid Argon calorimeter was closed up before the end of 2014. No anomalous noise has been observed in cosmic-ray data. The magnet temperature and pressure sensors in the He
dewar were replaced. One Tile Calorimeter barrel drawer, representing 1/256 of the complete system, remains with a connector problem.

The muon-system Cathode Strip Detector (CSC) repairs were completed. The large end-cap leaks in the Monitored Drift Tubes (MDTs) were fixed. The repair of leaks on the Resistive Plate Chamber (RPC) detector is ongoing; 90% of the leaks have been repaired and IsoSF₆ emissions will be monitored. Twenty-six Thin Gap Chambers (TGCs) were repaired, with one remaining that cannot be accessed during LS1.

The Detector Control System (DCS) was overhauled and new systems have been integrated. Significant upgrades have been made to the trigger and DAQ systems. There are new Level-1 Calorimeter (L1CALO) boards and upgraded firmware. The first L1TOPO card has been tested and the second is being commissioned. The Central Trigger Processor (CTP) has been installed and all sub-systems have been integrated. The Higher Level Trigger (HLT) menus are almost finalized and are expected to deliver up to 1 kHz rate. The networking and data flow architecture has been overhauled and tested.

All sub-systems were integrated for the Milestone Week 8 (M8) operational tests. ATLAS is now running 24/7 shift operations. Continuous runs of up to 20 hours duration were taken. Cosmic-ray data have been recorded with the magnet off and on, with about 100M events total, 9M in the inner detector and 100k events in the IBL having been recorded. This has allowed first-order module-level alignment of the IBL and pixel detector. 100kHz Level-1 trigger readout was achieved at the sub-system level and up to 86 kHz at the CTP level. Handshakes with the LHC have been recommissioned.

Bowing of the IBL staves, of up to 200 μm under large temperature changes, was observed via analysis of the M8 data samples. This is under further study. The effect may be explicable a posteriori in terms of thermal expansion coefficient mismatches in the stave components.

Significant improvements have been made to the offline system. The data workflow has been upgraded, including automatic Tier-0 reconstruction, calibration loop, and improved data quality assessment. The event reconstruction time has been improved by an impressive factor of 4.2. The official release of the new reconstruction version is about two months delayed and is scheduled for mid-March 2015. The new analysis framework, XAOD, is now being used and the new production and data management system, RUCIO, has been commissioned. The next major Monte Carlo generation production run is scheduled to start in late March 2015 with the aim to generate 500M events (50ns bunch spacing) + 1B events (25ns bunch spacing).

**ATLAS Upgrades**

Detector upgrades were not a major focus of this LHCC meeting. However, it was noted that milestones for tracking of the Phase-1 upgrade projects have been generated by ATLAS and shared with the referees. A draft version of the ATLAS Phase-2 Scoping Document is scheduled for submission to the LHCC prior to its June 2015 meeting.

ATLAS has approved the Forward Physics (AFP) project and a draft of its Technical Design Report was circulated. The physics programme is very complementary to that of ALFA (large-t acceptance, all β⁺), the Absolute Luminosity for ATLAS project. The tracking detectors are based on the ATLAS IBL technology. The project calls for installation of a single arm with only tracking detectors in autumn 2015. This appears very ambitious and as a fall-back both arms can be installed together at the end of 2016.
One arm is funded, while resources are requested for the second arm. Updates are expected in time for the LHCC’s consideration at its June 2015 meeting.

15. DISCUSSION WITH ALICE

Physics

Since the previous LHCC meeting in November 2014, ALICE has published seven physics papers and six more have been submitted for publication. One manuscript submitted for publication before November 2014 has also been accepted for publication, bringing the total number of ALICE papers to 106. The new publications include the first paper on jet energy loss in Pb-Pb using full jet reconstruction and a study of K0* (892) and φ (1020) production in Pb–Pb collisions that provides insight into rescattering and regeneration processes in the medium between hadronization and kinematical freeze-out. Several new papers elucidate the physics of proton-Pb collisions, among them the study of multi-parton interactions through measurement of the multiplicity dependence of jet-like two-particle correlations, the study of 2π Hanbury-Brown-Twiss (HBT) correlations, as well as the study of the centrality dependence of particle production with a novel method to define centrality classes using different event activity estimators. The LHCC congratulates the ALICE Collaboration on these accomplishments.

Long Shutdown 1 (LS1) and Recommissioning

The last five Transition Radiation Detector (TRD) modules were successfully installed at the end of 2014. The Dijet Calorimeter (DCal) and Photon Spectrometer (PHOS) installation is also finished, resulting in a complete reshaping of the bottom part of ALICE that included the modification of existing services. Shower counters for the ALICE Diffractive Detector (AD) programme were installed in the RB26 tunnel on the C-side, while the A-side counters as well as the optical fibres for the AD are in the cavern ready for installation. All shielding blocks were reinstalled, the central beam pipe is under vacuum and the L3 magnet doors were closed in December 2014.

The Magnet Safety System (MSS) for the ALICE magnets was rebuilt using new industrial solutions, replacing the old VME-based systems. The magnets have been restarted in Seek 2 of 2015, including a full test of the various interlock chains and the cooling system. The polarity switch was checked in Week 3 before a 4-week-long continuous operation test in January/February 2015.

The new RCU2 pre-series read-out electronics for the Time Projection Chamber (TPC) has been successfully tested and its functionality verified. The test installation on one TPC sector (RCU2 and backplanes) was completed at the end of January 2015. The mass production is on-going and installation is foreseen during the June 2015 Technical Stop 1 (TS1).

This concludes the detector recommissioning and the experiment is ready for LHC beam operation. The LHCC congratulates ALICE on these accomplishments.

Most ALICE sub-detectors are integrated into the DAQ, trigger, and detector control system, that where upgraded during LS1. ALICE has been taking cosmic-ray events for recommissioning and calibrating the various sub-systems. Currently 11 out of 17 detectors are included in routine cosmic-ray runs. In these runs the new production cluster of the upgraded Higher Level Trigger (HLT) is deployed using a new software framework to handle the new DAQ sequences.
ALICE is making good progress in preparing for the upcoming LHC injection tests.

**ALICE Upgrades**

**Inner Tracking System**

The Inner Tracking System (ITS) upgrade project was approved in 2014, but the sensor technology choice is still pending. The availability of the pixel chip is the critical path item for both the ITS and the Muon Forward Tracker (MFT). The pixel chip has been down-selected to two fully-compatible CMOS chip options: ALPIDE and MISTRAL-O. The ALPIDE chip is the current baseline option, although a full validation of both architectures will take until the end of this year.

The available ALPIDE full-scale prototype (p-ALPIDE-1) includes most of the features of the final chip. The extensive characterization done so far shows a large margin over the design requirements. The integration of the chip onto the detector modules will start in April 2015 and should be finalized by December 2015, at which point pre-series production will start.

The MISTRAL-O chip is being optimized for the outer barrel layers where the higher spatial resolution provided by the ALPIDE is not required. The current prototype (MISTRAL FSBB-M0) shows very good performance. The submission of a full-scale prototype with all final features is scheduled for July 2015; integration into detector modules is planned for October 2015. The implications of the reduced spatial resolution, should the MISTRAL-O be used also for the inner barrel, needs to be studied.

The full pin-to-pin compatibility of both architectures would allow switching from one to the other with minimum overhead. The possibility to deploy different sensors for the inner and outer barrel is currently evaluated. This would mitigate possible technical risks with the ALPIDE chip and technical risks with the TPC, especially for the Inner Read-out Chamber (IROC) modules. The LHCC encourages ALICE to fully pursue both chip options.

**Muon Forward Tracker**

The Muon Forward Tracker (MFT) proposed by ALICE adds significantly to the physics capabilities of the experiment, providing primary and secondary vertexing in a challenging rapidity region matched to the Muon Spectrometer. The Letter of Intent for the MFT was endorsed by the LHCC in September 2013. On 19 January 2015 ALICE submitted the MFT Technical Design Report to the LHCC. The proposed detector consists of five disks of silicon pixel sensors (MAPS) with 0.6% of X/X0 per disk, covering a pseudorapidity range of \(-3.6 < \eta < -2.45\). The MFT’s read-out electronics are designed to achieve ~50 kHz in Pb-Pb collision mode and 200 kHz in proton-proton mode. Sensors and PC boards are water-cooled. The design of the cooling system is optimized for the ALPIDE chip. The project benefits from a large technical overlap with the planned ALICE ITS and the synergy is being effectively leveraged.

The MFT technical feasibility has been demonstrated in the Technical Design Report to the LHCC’s satisfaction. Nevertheless, the schedule is tight and there is a concern about possible interference regarding resources between the MFT and ITS construction. The LHCC encourages ALICE to move forward to complete the R&D phase in 2015 and to launch the production phase for all items in 2016. An updated version of the Technical Design Report without major changes will be prepared following the recommendations of the LHCC.
The cost of the MFT project is 3.3 MCHF, and will not be reviewed by the UCG. The LHCC referees will conduct a small-scale cost and manpower review, aiming for a final decision at the June 2015 meeting of the Committee. ALICE is asked to provide a document similar in form and scope to that used in the UCG process several weeks before the June 2015 LHCC meeting in order to give the Committee sufficient time for the review.

**Time Projection Chamber**

The Time Projection Chamber (TPC) is crucial to the success of the ALICE upgrade. The TPC’s unique features are its tracking capabilities down to $p_T \sim 200$ MeV/c and its particle identification performance over a broad range of momenta as highlighted in the ALICE Upgrade Letter of Intent. Key physics elements, such as low-mass di-lepton studies, measurements of heavy-flavour suppression and quarkonia production, rely predominantly on the TPC’s performance.

On 2 February 2015 the LHCC received the Addendum to the TPC Technical Design Report, which summarized the results of the extensive R&D programme conducted in the year following the first TPC Technical Design Report review in February 2014. Impressive progress has been made in this R&D campaign, including a detailed characterization of the 4-GEM solution, both geometrically and with respect to voltage distributions, using small prototypes. A successful test beam campaign with the Gas Electron Multiplier (GEM) detectors 4-GEM and 2-GEM+MicroMegas IROC prototypes in December 2014 provided further important results. Other technologies, such as a 2GEM+MicroMegas solution have been explored but not with the same rigour. Substantially more R&D would be necessary for this and other technologies in order to explore their potential for a more comfortable solution.

It is unlikely that substantial improvements over the baseline design can be achieved through further R&D in the short term. Given the pressing need to make progress towards the start of production in autumn 2015, ALICE decided for the 4-GEM solution as the baseline technology choice. This implies some technical risk insofar as the original ion backflow (IBF) and dE/dx resolution specifications are met with only a small contingency according to the prototype studies. In the addendum, ALICE has shown through simulations that failing to meet the original specifications by a relatively small margin (IBF increasing from 1% to 2% and energy resolution from 12% to 14%), does not have a severe effect on the physics programme. Despite these findings the LHCC remains concerned about the construction and operational constraints that such small margins imply, especially given the crucial role of the TPC for the ALICE physics programme and the requirement of operating up to 50 kHz.

The success of the ALICE upgrade relies on simultaneous high performance of the TPC and the ITS. Neither the ITS nor the TPC standalone tracking are able to cope with the performance requirements outlined in the ALICE Upgrade Letter of Intent. Only the combined use of both is capable of delivering the design performance. Distortions in the TPC have considerable implications for the calibration. The onus will be on the O² system and its flexibility in reacting to different running conditions.

The LHCC encourages ALICE to move forward with the current baseline design and to submit the documentation for the UCG cost review, whilst in parallel continuing a vigorous R&D programme to continue to optimize the chamber configuration and operational parameters (such as gas mixture and GEM foil hole pitches) and to explore alternative chamber designs. The LHCC expects to present its recommendation at its meeting in June 2015.
Online-Offline ($O^2$)

The Online-Offline ($O^2$) Technical Design Report is in the final preparation stage and is expected to be submitted to the LHCC and UCG on 20 April 2015. In late March, ALICE is holding an internal review of the project that includes reviewers from ATLAS, LHCb, and STAR. The targeted submission date will allow the LHCC a thorough review of the project before its June 2015 meeting.

16. DISCUSSION WITH THE WLCG REFEREES

General

During Long Shutdown 1 (LS1) the LHC experiments have undertaken an ambitious programme of software and computing updates, implementing in some cases frontier technologies (e.g. multi-thread and virtual computing). The computing models have been updated to take into account the experience gained during the first LHC data-taking period and to further optimize the resources. Examples are: usage of high-level trigger farms for processing, data management optimizations (such as data federations and lifetime parameterization) as well as new analysis-optimized formats. Common work across the experiments becomes increasingly important and beneficial. Well-established software and formats used in some experiments are used by other experiments, thus improving the reliability and enhancing the community coherence and capabilities to react to new challenges. In this context, the HEP Software Foundation is a timely initiative and the LHC experiments and WLCG are active partners during this initial phase. Due to the hard work to optimize the software, the data distribution and the processing workflows, the computing needs do fit within a flat budget for the next two years. However, this item should be given constant attention in particular by monitoring the behaviour of the new computing models during the first large-scale data processing and analysis of the Run II data. The WLCG infrastructure support, including the recent funding received from the EU/H2020, is adequate. The longer term is now prepared in all experiments and will be the next important milestone. Working groups for computing in the upgrade phases are being installed or exist already. A Technical Design Report (TDR) is expected for this year (for the ALICE Online-Offline $O^2$ system) and more are expected in the next years. The LHCC will follow closely the process in order to ensure that the computing models fit the specifications enabled by the ambitious detector upgrades.

The WLCG resources pledges and the on-going installation record cover the requests and no issues are foreseen for the start of the data taking in 2015. The Wigner centre now covers the expected capacity. The HEP Software Foundation has held a successful workshop in SLAC in January 2015. Several working groups have been proposed on various areas: communication on technical issues (forum), training, software, infrastructure etc. Other items are also under consideration (such as licences and consultancy). Upcoming computing events, like CHEP Conference in April 2015, will offer opportunities to inform the broader HEP community and encourage participation.

ALICE

ALICE had a successful usage of the computing resources. The main objectives remain the preparation for Run II, which is very well advanced, while the reprocessing of Run I data is finished. The sharing of jobs remains stable, in particular for the organized analysis, for which enhancement efforts have been done in the past. The CPU efficiency remains above 75%, with a recent I/O perturbation observed during the proton-proton
data reprocessing due to the faster event cycling. Resources request is stable and in agreement with the previous estimations. The O² project preparations are in progress, and a new scheme for distributed computing is under study. This new proposal assumes larger, parallel-like analyses facilities to absorb efficiently the massive data flux produced by the front- and back-end computing, which will be based on new architecture hardware. The Technical Design Report is in preparation and will be submitted to the LHCC by mid April 2015.

**ATLAS**

ATLAS has already reported many improvements in software (reconstruction, simulation, and analysis workflows) and data management (distribution, workload, and life-time cycle), some of which are spectacular. These improvements are confirmed by the intense usage as observed during the past months.

The new analysis framework definition and tests have progressed well and the lifetime studies have converged to a clean-up strategy that may lead to significant savings of resources. During these studies, the need for resources planning update have been observed, in particular due to a more realistic distribution of the lifetime categories and simulation flavours (less abrupt takeover of the fast simulation and a constant full simulation flow), leading to a significant increase of the tape needs. The CPU resources requests will also be updated to take into account the situation observed in the past where the usage always exceeded the pledges. The planning for Run III and beyond is considered to be urgent and is underway and the working group devoted to the future computing is in place.

**CMS**

As all other experiments, CMS devoted the LS1 work on software and computing in order to improve the efficiency and the performance. Many model updates were operated and consolidated over the past months, including the usage of the high-level farm, a functional data federation, redefinitions of the processing and analysis workflows, distributed analysis tools, reconstruction and simulation software, new data format for analysis and the ability to perform opportunistic computing. As an example, one can cite the significant improvement in reconstruction speed and the simulation upgrades, where, together with a gain of 50% in speed due to technical improvement, the usage of the newest Geant4 version (4.10) was critical for use of multi-threaded framework, giving therefore access to more resources. Along with regular usage of the new features, full-scale tests have started to be performed, such as the reconstruction in Tier-0s and the launch of a large-scale simulation campaign in view of the Run II data analysis. The computing upgrade projects (for Run III and beyond) have already been initiated, with many objectives and ideas explored in dedicated working groups.

**LHCb**

LHCb completed the last stripping of the Run I data within three months. A small incident led to a data loss of about 1%, recoverable, due a disk failure during a transient phase. The new version of the simulation framework (SIM09) became the default, while the split High Level Trigger (HLT) is commissioned. In addition to the successful improvements reported during LS1, a recent breakthrough was reported in the improvement of the online software, where the optimization effort led to an improvement by 30% in the number of cycles, an improvement that will benefit the offline software as well. The Turbo-stream is ready to be used for Run II and the Dirac file catalogue migration is completed. A study of data popularity, performed using a
multi-variate analysis, may lead to a significant saving in storage (of about 1 Petabyte) but no automatic policy has so far been decided. Concerning the upgrade programme, the main feature relevant for the offline computing is the increase of the event rate to typically 100 kHz (from 12.5 kHz foreseen in Run II). The data processing in those conditions needs a full architecture study and a computing upgrade project is being installed in LHCb with the goal of producing a technical design in about two years.

17. CLOSE-OUT WITH THE DIRECTOR OF RESEARCH AND COMPUTING

The LHCC informed and discussed with the Director of Research and Computing the status of the LHC experiments and their plans for their future upgrades. The discussion concentrated on the status of the LHC machine, experiments and computing in view of LHC Run II; the status of the physics analysis of all experiments; activities during Long Shutdown 1 (LS1); and upgrades of the LHC experiments.

18. REFEREES

The LHCC referee teams for this session are as follows:

ALICE: C. Bloise, P. Newman, T. Ullrich (Co-ordinator)
ATLAS: P. Burrows (Co-ordinator), M. Lancaster, B. Ratcliff
CMS: M. Demarteau, D. Denisov (Co-ordinator), H. Yamamoto
LHCb: C. Diaconu, G. Eigen, T. Kuhr, S. Miscetti (Co-ordinator)
LHCf, MoEDAL, TOTEM: C. Bloise, M. Mangano (Co-ordinator), P. Newman
LCG: C. Diaconu (Co-ordinator), T. Kuhr, M. Lancaster, H. Yamamoto

Experiment Upgrades:

General: M. Demarteau (Co-ordinator)
RD39: G. Eigen
RD42: M. Demarteau
RD50: G. Eigen
RD51: D. Denisov
RD52: P. Burrows
RD53: M. Demarteau

19. The LHCC received the following documents:

CERN-LHCC-2014-025: Minutes of the one hundred and twentieth meeting of LHCC held on 19 and 20 November 2014
CERN-LHCC-2014-026: Scope and implementation plan of the CT---PPS baseline program
CERN-LHCC-2015-002: Addendum to the Technical Design Report for the Upgrade of the ALICE Time Projection Chamber
DATES FOR LHCC MEETINGS

Dates for 2015
3 – 4 June
23 – 24 September
2 – 3 December

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