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LHCC-116
11 February 2014

LARGE HADRON COLLIDER COMMITTEE

Minutes of the one-hundredth-and-sixteenth meeting held on
Wednesday and Thursday, 4-5 December 2013

OPEN SESSION - Status Reports

1. LHC Machine Status Report: Frederick Bordry
2. LHCb Status Report: Marco Adinolfi
3. ALICE Status Report: Constantinos Loizides
4. ATLAS Status Report: Luca Fiorini
5. CMS Status Report: Yurii Maravin
6. TOTEM Status Report: Emilio Radicioni

CLOSED SESSION:

Present: U. Bassler, S. Bertolucci, P. Bloch, A. Boehnlein, J.-C. Brient, H. Burkhardt, P. Burrows, C. Cecchi, M. Demarteau, D. Denisov, C. Diaconu, G. Eigen, E. Elsen (Chairperson), D. D'Enterria, G. Giudice, B. Gorini, M. Mangano, E. Meschi, S. Miscetti, T. Mori, B. Panzer-Steindel, R. Roser, S. Smith, C. Touramanis, E. Tsesmelis (Scientific Secretary), T. Ullrich, H. Wilkens

Apologies: R.-D. Heuer, A.-L. Perrot

1. EXECUTIVE SUMMARY

ALICE

Inner Tracking System (ITS) Technical Design Report (CERN-LHCC-2013-024)

– The LHCC **recommends** general approval of the ALICE Inner Tracking System Technical Design Report.

Trigger and DAQ Technical Design Report (CERN-LHCC-2013-019)

– The LHCC wishes to further evaluate latency aspects of the trigger and is seeking additional advice from an external expert with the goal to come to a conclusion at the next LHCC meeting.

Time Projection Chamber (TPC) (CERN-LHCC-2013-020)

– The LHCC acknowledges good progress in the quantitative understanding of the ion back flow, the key challenge of the new TPC, and encourages further simulations in evaluating the distortions and their effects.

– The LHCC is concerned about the lack of system tests and recommends further prototyping in test beams, including with different gas amplification stages and technologies in parallel to the baseline, which uses a 4-layer Gas Electron Multiplier (GEM).

ATLAS

Trigger/DAQ (CERN-LHCC-2013-018) and LAr Trigger (CERN-LHCC-2013-017) Technical Design Reports

– The LHCC **recommends** general approval of both the ATLAS Trigger/DAQ and LAr Trigger Technical Design Reports. This completes the LHCC deliberations on the four Phase-1 Technical Design Reports of ATLAS.

Inner B-Layer (IBL)

– The IBL suffered corrosion on several wire bonds. While it is still possible for ATLAS to make the remaining deadlines using spare parts, there is no remaining contingency.

CMS

– The Technical Proposal for Phase-2 upgrades is expected in September 2014 with proposed intermediate reports on R&D and calorimetry options.

– CMS and TOTEM presented a plan to sign a Memorandum of Understanding and an implementation plan for a joint Precision Proton Spectrometer physics programme.

– LHCC congratulated the outgoing CMS management team and welcomes the incoming team.

LHCb

– The LHCC received the Vertex Locator (VELO) (CERN-LHCC-2013-021) and Particle Identification (PID) (CERN-LHCC-2013-022) Technical Design Reports just prior to the Committee’s December 2013 meeting. Initial discussions have taken place and further evaluation will follow to reach a conclusion at the LHCC meeting in March 2014.

TOTEM

– The joint TOTEM-CMS upgrade project, while waiting for the approval of a formal agreement between the two experiments, is proceeding, but is on a critical path for the installation, during LS1, of at least two housings for the horizontal timing detectors and of two RF shields.

Upgrade Cost Group (UCG)

– The LHCC received the report from the UCG on the Technical Design Reports of the CMS Level 1 Trigger (CERN-LHCC-2013-011) and the ATLAS Fast Tracker (CERN-LHCC-2013-007) on costs and risks. The UCG **recommends** approval of the costs of both Technical Design Reports.

2. PROCEDURE

The minutes of the one-hundredth-and-fifteenth LHCC meeting (LHCC-2013-023 /LHCC115) were approved.

The Chairman thanked P. Bloch, the outgoing PH Department Head, for his many important contributions to the Committee.

3. REPORT FROM THE DIRECTOR FOR RESEARCH AND COMPUTING

The Director for Research and Computing reported on issues related to the LHC. He reported on the LHC schedule for the period beyond the Long Shutdown 1 (LS1). He also congratulated François Englert and Peter W. Higgs for being awarded the Nobel Prize in Physics for 2013 *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"*

4. REPORT FROM THE LHC PROGRAMME CO-ORDINATORS

The LHCC heard a report from the LHC Programme Co-ordinators, concentrating on plans regarding Run II for LHC operations as of 2015, *i.e.* following the Long Shutdown 1 (LS1).

The LHC programme coordinators presented considerations on the schedule for the LHC Run II start up. The running plan includes start of operations at 25 ns bunch spacing by the end of May 2015. The proposed strategy for the LHC start-up includes scrubbing runs at both 25 ns bunch spacing and also with the new scheme of using 5 ns doublet beams. The latter scheme exhibits a much lower multipacting threshold compared to the standard 25 ns beam. A main concern is the effectiveness of the scrubbing runs for LHC operation at 25 ns bunch spacing. An initial Van der Meer scan and an LHCf data-taking period will be scheduled for the first week of LHC running in 2015.

5. REPORT & DISCUSSION WITH LHC EXPERIMENT UPGRADE REFEREES

In preparation for this session of the LHCC, the Committee received four Technical Design Reports (TDRs), two from the ALICE experiment and two from the LHCb experiment. The Committee congratulates both experiments on the submission of these TDRs.

The LHCb experiment submitted the TDR on the Vertex Locator (VELO) upgrade (CERN/LHCC 2013-021), which had been discussed extensively at the previous LHCC meeting. After extensive evaluation of four options, the Collaboration proposes to replace the current VELO detector with a lightweight hybrid pixel detector capable of 40 MHz readout at a luminosity of 2×10^{33} cm^{-2} s^{-1}. Cooling will be provided by evaporative CO_2 circulating in micro-channel cooling substrates. The detector contains 41 million 55 µm × 55 µm pixels, read out by the custom developed VeloPix front-end ASIC. Track reconstruction speed and precision is enhanced relative to the current VELO detector even at the high occupancy conditions of the upgrade, due to the pixel geometry and a closest distance of approach to the LHC beams of just 5.1 mm for the first sensitive pixel. The new detector has close to 100% uniformity. The integrated micro-channel cooling has been tested with hydrophobic bonds up to a pressure of 700 bar and techniques have been developed for soldering cooling connectors to withstand this pressure. Although the VELO upgrade construction schedule is very tight, a dedicated team is making steady progress and continued optimisation of the overall detector is expected.

The LHCb experiment also submitted the TDR for the upgrade of the Particle Identification Detector (PID) (CERN-LHCC-2013-022), which contains upgrades to three key sub-detectors making up the particle identification system: the Ring Image Cherenkov (RICH) detector, the calorimeter and the muon system. The upgrades to each sub-detector were presented. Due to the unacceptably high occupancies in the RICH1 detector, the aerogel will be removed and the performance will be largely retained through a redesign of the optics. The opto-electronics read-out chain will be adapted to sustain a 40 MHz read-out at a luminosity of 2×10^{33} cm^{-2} s^{-1}. The current Hybrid Pixel Detectors (HPDs) have the read-out ASIC, which is limited to 1 MHz read-out rate, integrated in the device and will need to be replaced. The baseline new photodetector is a 64 pixel MAPMT with single photon sensitivity, average photoelectron yield of 40, pixel size less than 3 mm and time resolution better than 25 ns. A total of 1920 (2560) MAPMTs are required for the RICH1(2) detector(s). This spatial resolution is not needed for the RICH2 detector and the Collaboration is encouraged to develop other cost-effective options. Custom read-out ASICs, the CLARO and MAROC chips, are in development.

A pragmatic upgrade of the calorimeter is proposed. The Scintillating Pad Detector (SPD) and Preshower (PS) detector will be removed given their reduced importance with the removal of the Level-0 trigger after the upgrade. The innermost 288 channels of the current shashlik based EM calorimeter will be replaced due to radiation damage. All replacement modules are already in hand. No changes are foreseen for the hadronic calorimeter even though some deterioration in performance, especially for the innermost elements, is foreseen. The main element for the calorimeter is the upgrade of the front-end electronics to accept 40 MHz data rate and provide calorimeter information to the lower-level trigger decision framework. Given the different running conditions, i.e. pile-up and the removal of SPD/PS, different cluster shape algorithms need to be developed for the identification of photons and electrons. Two options are being considered for the read-out: an ASIC or commercial-off-the-shelf (COTS) based architecture. A down-select is anticipated for mid-2014. Both options are currently under active test. New clustering algorithms are being developed to compensate for the impact on low energy electrons and photons.

The third element of the particle identification system is the muon system. The current system consists of five muon stations (interleaved with iron walls), with two independent layers per station to increase redundancy. It is comprised of 1380 chambers for a total detector active area of 435 m^2. Since the particle flux will be too high after the upgrade, the most upstream station (M1) will be removed. The second station will require additional shielding in the inner region. The most downstream station (M5) will be susceptible to higher albedo, which can be remedied by adjusting the hit logic. Also for the muon system, the key element of the upgrade is 40 MHz read-out compatibility of the electronics. The main component of the new read-out is the new Off-Detector Electronics (nODE) board that will be equipped with a new custom ASIC, the nSYNC chip, which is an evolution of the present ASIC. The front-end electronics will be controlled and configured through a newly-designed control system using three new components: a new pulse distribution module (nPDM) board, a new service board (nSB), and a new backplane to dispatch the communications channels from the nPDM to the nSB boards. It is also planned to build a few spare chambers in case of poor performance of existing chambers or of radiation damage. Initial performance studies show that there will be a small (~5%) efficiency loss at 2×10^{33} cm^{-2} s^{-1} with respect to the 2012 conditions. The pion misidentification slightly increases due to higher occupancies, but it is expected that this can be (partially) recovered with additional particle identification criteria. Further improvements are expected and the Collaboration is working on an updated physics performance note to be submitted to the LHCC.

Since the two LHCb TDRs were submitted with little time before the December 2013 meeting of the LHCC, full evaluation of these reports will take place in the time before the next LHCC meeting.

ALICE submitted and presented the TDR for the new Inner Tracker System (ITS) (CERN-LHCC-2013-024). This project calls for a complete replacement of the inner tracking detectors by a seven-layer MAPS pixel detector with a total active area of 10.3 m^2, with 25 Giga-pixels. The upgrade is motivated by the requirements to improve the impact parameter resolution by a factor of three, to reduce the mass budget and the pixel size, to improve the overall tracking efficiency and momentum resolution and to have a faster read-out to enable heavy-ion collisions at 50 kHz. Four sensor architectures are being studied (MISTRAL, ASTRAL, CHERWELL2, and ALPIDE), which the Collaboration intends to continue exploration until mid-2014. All architectures have demonstrated adequate radiation hardness, good charge collection efficiency for pixel sizes of 20 – 60 µm and prototypes have been tested for all architectures. The sensors are exposed to modest radiation doses of 700 krad ionising and 10^{13} 1 MeV neq non-ionising dose, which includes a safety factor of 10. A rolling shutter architecture is foreseen with integration times ranging from 4 – 30 µs, depending on the specific architecture. The overall layout for the main components has been defined and their technical feasibility demonstrated. The mechanical design is still being optimized and an average material budget of 0.28% X_0 per layer has been achieved for the inner layers. Prototype staves have been made and all assembly steps are being exercised. The thermal management has been validated on prototype modules and it meets the requirements for all four pixel architecture options. An update on the physics reach was also completed for the TDR and full Monte Carlo studies have been done for, for example, the processes $\Lambda_c \rightarrow pK\pi$ and $D_s \rightarrow KK\pi$, which show the superior performance of the upgraded detector.

The ALICE experiment also presented the TDR for the upgrade of the Read-out and Trigger System. The upgraded detector is designed to record data at a rate of 50 kHz, with a design margin to 100 kHz. The trigger and electronics will have to be upgraded correspondingly. The TDR outlines a trigger architecture with continuous, trigger-less read-out of the muon chambers (MCH), the ITS and the Time Projection Chamber (TPC), while all other systems will be triggered. The triggered systems span a relatively large range of trigger latencies. A central trigger processor controls the interaction between the continuous and triggered read-out, and the data rate from detectors with and without multi-event buffers. The data from the continuous and triggered read-out are collected in time slices with a buffer exceeding 100 ms. The continuous read-out of detectors is synched with the triggered detectors using heart beat triggers sent at time frame boundary. The communication protocol between the trigger and timing distribution system and the common trigger and read-out processing units ensures that the relevant sub-detector information is available for each triggered event. Data is then processed through a common read-out unit (CRU). The CRU, which is based on the LHCb AMC40 read-out board, will be located in the control room. The cost defining factor is the optical fibre plant required for the read-out of the TPC with the associated GBTs. However, having the CRU in the control room enables access during operation and avoids putting the electronics in a radiation harsh environment. A relatively large number of new readout elements are required for the upgrade. The TPC requires 4320 new front-end cards with 17,000 SAMPA chips; the read-out for the muon system needs 33,000 SAMPA chips and the ITS required readout for 25 10^9 pixel channels. All the other systems, TOF, MUONID, FIT, ZDC, PHOS, TRD, EMCAL and HMPID will also need to be adapted to cope with the higher data rates. Given the large range of latencies in the proposed architecture the LHCC is seeking advice from an independent advisor before concluding.

The ALICE experiment also presented the status of the upgrade of the TPC (CERN-LHCC-2013-020). The main goal of the TPC upgrade is to allow for a continuous read-out with 50 kHz. This rate cannot be achieved with the current gated Multi-Wire Proportional Chamber (MWPC) read-out, which is limited to 3 kHz. The technology of choice for the upgrade is a multilayer Gas Electron Multiplier (GEM) read-out. The ALICE requirements for TPC operation with continuous read-out, are an ion back flow (IBF) into the drift space less than 1% and an energy resolution of 12% for a ^{55}Fe signal. A quadruple GEM stack with a Ne-CO_2-N_2 gas mixture with a mixture of foils with various pitches met these requirements for various operating conditions. Extensive Monte Carlo simulations were performed under the conditions of an IBF of 1% and a gain of 2000. These studies showed that the TPC standalone momentum resolution with GEMs is slightly worse than for MWPCs, but that the global track resolution including the ITS is the same. The dE/dx resolution is the same for the upgraded configuration compared to the current detector. The simulations also show that the TPC retains its performance under pile-up conditions. The space charge distortions with continuous read-out, however, are significant. Assuming again an IBF of 1% and a gain of 2000 with the Ne-CO_2-N_2 gas mixture, a Pb-Pb collider run at 50 kHz will result in the accumulation of ions from 8000 events in the drift volume and distortions at small r and z reach 20cm for r and 8 cm for φdr. To obtain the specified tracking resolutions, corrections at the per mille level are required and the space charge fluctuations need to be taken into account. Using a fluctuating space-charge map in the Monte Carlo, based on real data, to simulate track distortions, it was determined that the space charge map could be considered static over a timescale of 5 ms, that is, every 5 ms the map needs to be updated. It is of critical importance for the experiment to have a very robust and high performing online track finding algorithm. Because of the continuous read-out of the TPC, the TPC raw data has to be reduced by roughly a factor of 20 to be manageable. This is achieved through an online track reconstruction scheme where hits not assigned to tracks get discarded. As a result, the online reconstruction will have to be exceedingly high performing and requires inclusion of space-charge distortion corrections at the 5 ms level. A three-stage online calibration algorithm has been developed and tested. The procedure starts out with a reference map from Monte Carlo, which incorporates the readout geometry and known gain and IBF non-uniformities. An average correction map is then determined from high-statistics high p_T track samples, updated several times per fill. This accounts from slow variations of luminosity and ambient conditions. At the third level, this average map is scaled by the average of the actual TPC running conditions, updated every 5 ms. This calibration and correction algorithm was tested in Monte Carlo and a momentum resolution is obtained which is within a factor of two from the environment with no distortions. Offline the track reconstruction undergoes a last level of correction, when a high precision space charge map in conjunction with external tracking information from the ITS is used.

The LHCC congratulates the collaboration on the tremendous progress that is being made. The Committee remains concerned about the viability of the preferred technology solution and encourages the Collaboration to convince itself that none of the alternative technologies are viable. Furthermore, the simulations have been carried out at one reference point for the GEM performance. The phase space to achieve this performance seems narrow. It would be very helpful to understand what the sensitivity of the TPC performance would be for variations from the proposed nominal operating point of the TPC. The Committee urges the Collaboration to continue detailed tests of all aspects of the online and offline reconstruction to verify that the tracking specifications will be met, even if the GEM performance deviates from its nominal operating point. .

6. DISCUSSION WITH ATLAS

General Summary

Since the September 2013 session of the LHCC, ATLAS published a very important result declaring “strong evidence” for Higgs decays in the extremely challenging $H \rightarrow \tau\tau$ channel. They observed a signal with 4.1σ significance with 3.2σ expected. The shutdown for the most part is progressing very well with many most tasks on or ahead of schedule. The pixel detector is completely done and was lowered back into the pit for insertion three months early, for example. The one exception is the Inner B-Layer (IBL), which suffered a setback when corrosion was noticed on the wire bonds following condensation on the detector.

Physics

The Collaboration continues to produce physics publications but at a much-reduced rate these past three months with only six papers submitted since the previous LHCC meeting. Part of this lack of production has to do with lack of conferences in this period to drive results. The analysis teams are holding onto their results trying to get every bit out of the data. ATLAS has demonstrated a sustained 12-publications/month rate and will need to get back to that rate in order to get the 150 or so publications out before Run II takes over. Measures are being taken to increase this rate with active follow-up by the physics coordinators. On a positive note, the electron-gamma re-calibration is nearly finalised based on a much-improved understanding of the detector geometry. The Higgs $\rightarrow \gamma\gamma$ result has been kept intentionally blinded until this work is complete.

Long Shutdown 1 (LS1)

In terms of the shutdown, much of the infrastructure consolidation work is completed and all of it is on schedule. This is a significant endeavour with work going on in the cryogenic plants, silicon and pixel detector cooling plants, building AC power and air conditioning systems just to name a few. The Pixel detector is 3 months ahead of schedule and is ready for re-insertion with >99% of all channels working again – a number that is higher than even the optimistic estimates prior to this work. All of the services for the Pixel detector are in place and re-cabling/checkout will require a few months’ of work. Eight beam telescopes (six made with diamond technology and two with silicon technology) were mounted in on the pixel detector prior to re-installation of that device.

The IBL suffered a significant setback. During the testing of the staves, the temperature got too cold and they froze. As a result condensation formed on the devices and caused corrosion. The hypothesis for the corrosion is that the liquid interacted with halogens from the flex cable to form brine that attacked the wire bonds. Of the ten staves that had been assembled to date, five were severely impacted, three much less so and two were unaffected. Enough parts exist to refurbish the three and complete staves for a total of fourteen. Six additional sensors and new flex cables have been ordered just in case. In order to meet the 5 May 2014 deadline for insertion of the IBL into the Pixel system, mounting of tested staves must begin in March 2014. The experiment still believes it can be ready on this time frame.

The Transition Radiation Tracker (TRT) work is essentially done. All known leaks in the end caps have been addressed. The leaks in the barrel cannot be fixed in this shutdown. The focus of the group now is to perform R&D to see whether other gas mixtures that would produce less ozone could be used.

There were two issues with the new power supplies; both the LAr and Tile Calorimeter systems each suffered one failure. The LAr power supply fault was traced to a weakness in the cabling harness. That weakness has been fixed and the repair is being propagated to all 58 instances of it. In the case of the Tile Calorimeter, the epoxy that holds the transformer cover in place failed causing the cover to shift and short out the transformer. The manufacturer has come up with a fix and that has already been propagated to all of the supplies. Because the Pixel Detector is so far ahead of schedule, the End Cap C power supplies can be installed now removing some pressure in the 2014 schedule.

Much progress has been done on the muon systems. The Monitored Drift Tube (MDT) detector leak checking campaign is complete with one yet unfound leak. The Resistive Plate Chamber (RPC) leak check is underway. Progress has been slow going and so additional teams have been added. The Cathode Strip Chamber Small Wheel has been repaired on the surface. The fixture worked so well that the experiment is thinking about deploying it on the other Small Wheel *in situ*. The RODs for the muon system are being replaced to get the read-out from 70 kHz to the desired 100 kHz. The delays in the board production means the schedule is now tight for this installation.

Finally, the ALFA Roman Pots suffered from beam (RF) induced heating. These pots are being modified with new RF fingers to dampen the RF and lower the heating. Provisions for cooling will also be added in case the new fingers are insufficient. Lower acceptance PMTs are being installed in LUCID and there is still no final decision on ATLAS Forward Physics (AFP) programme – simulations and the physics case is progressing slowly.

Upgrades

The two remaining Phase 1 TDRs were reviewed at this meeting. These were for the LAr electronics upgrade (CERN-LHCC-2013-017) as well as the Trigger & DAQ upgrade (CERN-LHCC-2013-018). The LHCC approved the physics justification for these two. The Upgrade Cost Group (UCG) met for the first time during the week of the LHCC and looked at the ATLAS FTK trigger effort as one of its two test cases for developing a methodology to examine cost. This upgrade is very advanced and so this review was procedural. However, the UCG will examine the cost of the other three Phase 1 TDRs in detail at a special meeting prior to the next LHCC meeting.

7. DISCUSSION WITH CMS

General Summary

CMS is pursuing a full agenda in multiple areas: the physics harvest from Run I, the Long Shutdown 1 (LS1) consolidations and upgrades, preparations for Run II, developing and executing the Phase 1 upgrades and preparing for the Phase 2 upgrades

Physics

CMS has solid plans for accomplishing the major physics objectives and showed an impressive selection of new results that covered all major physics areas. CMS has 273 publications with twenty-five additional publications in preparation, and with about 100 more expected. The focus in Higgs studies is completing ‘legacy’ analyses, including an update to $H \rightarrow \gamma\gamma$ that utilises improved electromagnetic calorimeter calibrations. $H \rightarrow \tau\tau$ results have been publically presented. Over the next year, the focus will be on precision measurements with increased physics group involvement with Phase 1 and Phase 2 upgrade projects.

Long Shutdown 1 (LS1)

The work scheduled for LS1 is considered an underpinning for the long-term operation of CMS. As outlined in previous meetings’ minutes, the programme of work has the following major elements: (1) muon upgrades, including the installation of the 4^{th} layer endcap Cathode Strip Chambers (CSC) and Resistive Plate Chambers (RPC) and the YE4 shielding wall, plus upgrade of the ME1/1 CSC frontend electronics and placement off-detector of part of the barrel muon electronics; (2) the first stage of HCAL photodetectors consolidation/upgrade (HO, HF); (3) tracking system upgrades and consolidations including the installation of the 45 mm outer diameter beam pipe, necessary for the installation of the pixel tracker upgrade. A key priority for the shutdown is enabling the tracker to operate 25°C colder than its current operating temperature. Without this capability its performance degradation due to radiation would become significant beyond 500 fb^{-1} and indeed, with no intervention to allow some temperature reduction, performance degradation would become significant before 100 fb^{-1} (4) installation of optical splitters in the Electromagnetic Calorimeter and Cathode Strip Chamber (CSC) read-out to allow commissioning of the trigger upgrade in parallel to operation and (5) installation of a new central DAQ system (DAQ2) addressing the replacement of computing and network equipment for future connectivity and the support of sub-detectors with new µTCA back-end electronics.

The LS1 work on infrastructure and services is going according to plan. The SL53 building supplying office space, conference rooms and a visitor centre is scheduled for completion in spring 2014.

Assembly of chambers and refurbishment of electronics is on schedule for the muon system. For the CSC, 100% of the ME4/2 chambers have been assembled. For the ME1/1 refurbishment, fifty-three of the seventy-two chambers have been refurbished. Installation has been completed on the +Z side and the cabling and commissioning is in progress. The status of the RPC upgrade is on schedule with installation on-going on the +Z side. The service preparation is also on schedule with gas piping, and the cooling mini-manifold completed and the cabling underway.

The YE4 pushback system for the –Z end provides for a cosmic ray commissioning test at full field by allowing CSC and RE4 installation and commissioning to be performed as time permits after the test, which has provided schedule flexibility.

The silicon pixel detectors are on surface and stored cold in the pixel lab at Point 5, and the pixel repair and maintenance has started and is on schedule. The repair of the Forward Pixel (FPIX) is complete. Similarly for the Barrel Pixel (BPIX), 7/8 modules from Layer 3 have been replaced, with an anticipated 99% functioning channels after all repairs are complete. Calibrations at temperatures below 0°C have started.

With respect to the Phase 1 preparatory work, the Pixel Pilot Blade mechanics have been installed. All components are in hand and the sensors-chips have been bump-bonded. The CO_2 plant at the Tracker Integration Facility (TIF) has been commissioned, a positive indication for installation of CO_2 plants at Point 5 during LS1.

The beam pipe continues to experience delays. In September 2013, a handling error led to the pipe breaking at the just-completed final weld. The most practical option for repair was to cut out either side of the failed weld and weld in a new piece. This weld also failed. A third (and final) attempt was made, welding the thick weld of the conical section first, and CMS is awaiting the results of the straight section weld. If this weld holds, the beam pipe will be ready for installation as planned. As a fallback, an additional conical section is being machined from the last available Be ingot.

The first tests of silicon tracker cooling at -10°C and Pixels at -25°C were successfully completed in November. However after warming up for cooling plant maintenance, insulated pipe bundles of C_6F_{14} distribution show evidence of internal condensation. The areas of condensation appeared linked to areas of the skin vapour barrier with visible damage. The damaged areas will be repaired. The repairs will be checked by cool down/warm up cycles. Additionally, CMS is investigating additional instrumentation and other possible mitigations in case the problems are more wide spread than the areas of damaged skin.

Several related activities have been consolidated in the Beam Radiation Instrumentation and Luminosity (BRIL) project, and all activities are seeing good progress. Silicon cooling infrastructure for the Pixel Luminosity Telescope (PLT), a critical path item, has been installed and the on-detector integrated cooling mechanics are being finalized. A very fast front end ASIC has been successfully produced for the Beam Conditions Monitoring (BCMF). The Cerenkov detectors for the new Beam Halo Monitor will be commissioned. The 'BRIL' systems are on track for installation in September 2014.

For the Electromagnetic calorimeter (ECAL), 75 channels have been recovered in the minus endcap, which increases the number of working channels to 99.6%. For the HF and HO calorimeters, the components for the installation of PMTs and SiPMs also remain on schedule. For the HO SiPM project, 60% of the installation is complete. For the HF PMTs' installation, two quadrants have been installed, with commissioning in progress. The µTCA backend electronics had a production readiness review on 12 June 2013. The HE will be recalibrated with Co^{60} sources. This will provide useful information on the radiation damage in the endcap region.

On the 15 November 2013, it was discovered that there was severe overheating damage to one ECAL Endcap Preshower (ES) feed-through. A technical incident panel concluded that the likely cause was a set of under-rated filter capacitors built into these particular feed-throughs (four in total; two per endcap). Both ES endcaps are being removed to the surface for examination & repair, before being reinstalled in May/June 2014 before the beampipe installation. This repair has at most a two week impact on the overall schedule.

The unexpected issues with the endcap preshower detectors, the damage to the cooling system vapour barrier and the beam pipe production delays imply a schedule impact of several weeks.

The current assessments of the schedule show that CMS is on target for beam by 20 February 2015. A Technical Coordination Workshop is planned for late February 2014 to review progress and plot the pathway to "ready for CRAFT" and "ready for beam". This is likely to involve curtailing some maintenance activities to regain schedule contingency.

Run II Preparations

For computing, operations are continuing. The load on the Tier-0 remains less than anticipated, however, physics validation activity and upgrade studies are in the planning stages and are expected to take significant resources. The HLT Farm is ready for production tasks in offline ‘cloud’ mode.

The computing planning for Run II is on-going and is documented as part of the WLCG planning document. CMS intends to make flexible use of centres by moving 50% prompt reconstruction production to Tier-1 sites and reducing the number of planned data reprocessing, following on from the experience of Run I. Additionally, data federation will provide more transparent access to the data generally from Tier-1 and Tier-2 sites. This gives more flexibility and will enable the Tier-2 sites to participate without additional transfers in reprocessing of Monte Carlo samples and data if needed. Effort continues in tuning the Run II reconstruction with the additional challenge that hits in the tracking system from ‘Out of Time’ crossings leads to significant impact on the time budget at 25 ns. The additional hits result from low energy charged particle looping in the strong magnetic field of the CMS. A possible mitigation currently being validated is a charge deposition cut.

For the online system, sub-detector control computers are being replaced, with a number of systems migrated, and completion anticipated by April 2014. The new central DAQ system ‘DAQ2’ will support the legacy front end as well as the new µTCA based systems, support upgraded networking and computing technology for the event builder and the new file-based HLT, and the DAQ for the luminosity monitor. Most of the DAQ2 components have been demonstrated with small scale tests and the orders have been placed. The changeover schedule will begin in May 2014, with commissioning subsystem by subsystem with an anticipated completion by July. The new Trigger Control Distribution System (TCDS) has been demonstrated for basic Trigger Timing Control sequences and will be commissioned by May 2014. Within the electromagnetic calorimeter system, the recovery of single event upsets in firmware is making good progress.

A cosmic ray global run was performed in November. The goal was to read out all available sub-detectors, confirming the ability to run and reconstruct cosmic and calibration data. The latency was increased by 12 beam crossings, corresponding to the 2015 configuration. Tracker calibration data was collected while lowering the temperature to -10°C and other detectors also tested new systems or elements. The certification procedures including additional automation were exercised. There is a schedule for periodic global runs throughout 2014 to commission the installed, revised, and new hardware and check the integrity of all subsystems.

Upgrades

Phase 1 Upgrades

The Phase 1 upgrades include the construction of a new pixel detector, new photodetectors and electronics for the hadronic calorimeter and a new Level-1 trigger system.

For the Level-1 trigger system, the development of the parallel data path is on track. The latest prototype for the optical splitter and RM mezzanine board has improved jitter cleaning. A full crate slice test of 30 cards using ECAL and HF inputs has successfully been completed. There is significant focus on the study and development of algorithms.

The initial lot of Forward Pixel (FPIX) sensors from 6” wafers have been received and tested, with several sensors and read-out controllers sent for bump bonding. Prototype High Density Interconnects (HDIs) are being tested. The fabrication has begun on a prototype half-cylinder to be used for an insertion test in 2014. The final BPIX sensor order has been placed and the HDI delivery is imminent. The results of the tests of the prototype modules are expected to be available before the Pixel Engineering Design Review in October 2014.

For the HE and HB, SiPM R&D has successfully concluded, resulting in a device that has ~3× higher photo-detection efficiency (PDE) than the Hybrid Photon Detectors (HPD), as well as having much higher gain. Devices from two different vendors meet the specifications and CMS is currently developing the vendor selection process as the next step of the procurement process.

Phase 2 Upgrades

As the Phase 1 upgrades transition into construction and installation projects, CMS is organising the upgrade efforts for Phase 2 upgrade R&D and planning.

To facilitate early discussions with the Resource Review Board (RRB), CMS prepared a document for the October 2013 RRB meeting (CERN-RRB-2013-124) with a preview of the scope and a preliminary cost estimate. A draft of this document was made available to the LHCC. CMS will describe the overall program for Phase 2 in a Technical Proposal (2014), with a TDR for each upgrade project (~2016). CMS has presented the following schedule for the 2014 LHCC meetings: consolidated R&D report delivered in March 2014, a report on the calorimeter options in June 2014 with a Technical Proposal delivered in September 2014. The LHCC encourages CMS to maintain this schedule.

8. DISCUSSION WITH ALICE

Physics

ALICE continued to obtain a wide range of results in pp, p-Pb and Pb-Pb collisions. Since the last LHCC meeting in September 2013, 9 papers were published and 3 submitted. In total 76 physics papers have been published or submitted.

ALICE reported on an impressive number of new preliminary results in all collision systems with a slight focus on the dataset recorded during the p-Pb run in spring 2013. In particular, the recent measurements address aspects of initial and final state effects through the comprehensive comparison of collisions systems (pp/p-Pb/Pb-Pb). In p-Pb the study of collective phenomena such as the double ridge, the study of the balance function, two particle angular correlations at low-p_T, as well as quarkonia measurements in the forward region aim to shed more light on the surprising and puzzling features of the system created in proton-nucleus collisions at the LHC. ALICE finished several technical challenging analyses in Pb-Pb collisions such as pion femtoscopy versus the event plane and the measurement chaoticity from 3-pion cumulants. The LHCC congratulates ALICE to these accomplishments.

Long Shutdown 1 (LS1)

ALICE continues to stay on track with their LS1 schedule. Detector installation and consolidation efforts, as well as safety and infrastructure improvements are progressing well.

The support structure for the Dijet Calorimeter (DCal) and Photon Spectrometer (PHOS) super-modules within the L3 magnet is in place and five of the DCal modules were installed. The remaining three modules will be inserted in September 2014 after the new PHOS read-out electronics is installed and the four missing PHOS super modules, sitting between the DCal modules, are in place. PHOS read-out and trigger upgrades are on-going with the production of the new SRUs and TRUs starting early 2014.

The rework of the TRD low voltage cables and connectors in the back-frame is concluded. Six Transition Radiation Detector (TRD) super-modules were extracted, repaired and reinstalled between May and November 2014. Numerous fibre and cabling campaigns for essentially all subsystems are in progress.

DAQ hardware and software consolidation efforts are underway and the DAQ system is expected to be back online in June 2014. Consolidation efforts of the Higher Level Trigger (HLT) have started and will be completed in the third quarter of 2014. Major upcoming consolidation items are the upgrade of the TPC readout system (RCU2), an upgrade of the central trigger processor (CTP), as well as V0/T0 electronics relocation.

The TRD project manager informed the ALICE referees in great detail on the status of the TRD read-out board (ROB) production. The production of the remaining five TRD super-modules and their installation during LS1 remains a critical issue. Until summer 2010, 13.5 of the 18 TRDs were completed. They are equipped with 3080 ROBs with about 53000 multi-chip modules (MCMs) that where, at that time, produced with good yield (>90%). Starting August 2010 a series of production failures on the manufacturer's side brought the completion of the remaining TRD mules to a sudden halt. Lack of cooperation between MCM and ROB manufacturer and change of company ownership, as well as resulting contractual issues, caused serious problems. The TRD project management succeeded in overcoming the most serious issues and production of the remaining 812 ROB resumed in mid-2013, albeit slowly. Current projections suggest that it is likely that three of the five super-modules (12, 13, 14) can be put in place before or during the last installation slot in September 2014. The remaining two modules (4, 5) would then be installed during the winter shutdown at the end of 2015.

The installation of the new UPS system has been completed. The new system improves the power output in case of power failure from 160kVA to 800kVA. Around 400 low voltage cables from TRD, TPC, and Time-of-Flight (TOF), where the insulation was badly damaged by their own weight, were successfully repaired. This included the installation of new supports and the re-routing of the cables. Tests of the connections on the O-side were completed; the ones on the I-side are on-going. The upgrade of the water chillers, aiming at increasing the cooling power by 60% is well under way. This includes the installation of five new chillers, new pumps and heat exchangers. The replacement of the cooling tanks for TRD and TPC was accomplished. An upgrade of the L3 magnet ventilation system, to increase the airflow inside the magnet by 60%, is scheduled for January-February 2014.

In early 2014, ALICE plans to upgrade the SAA3 wall that is located on the RB26 side in order to protect the ALICE detectors from background coming along the beam line from the C-side affecting especially the muon trigger chambers.

As part of ALICE's infrastructure improvements, a complete rework of the ALICE control room is under way and will be completed in March 2014.

The ALICE Collaboration is very grateful for the various TI2 vacuum consolidation efforts that were conducted and are expected to minimise backgrounds in ALICE substantially. The vacuum upgrades included two additional NEG cartridges, a new optimized beam screen, NEG coated beam screen and aluminium jaws, and an 800 mm inner diameter vacuum chamber upgrade (NEG coated liner) among others.

As part of their safety improvements, ALICE is installing an N_2 fire extinguishing system for the central detectors. A computational fluid dynamics (CFD) study to evaluate the O_2 distribution inside L3 during N_2 discharge was completed and implementation of the system (SIEMENS) will start in December 2013. In addition, the installation of a CO_2 fire extinguishment system, similar to the one used in ATLAS, for 40 racks in the UX25 cavern (C-side) is underway and is expected to be completed by the end of December 2013.

Computing

The ALICE Grid now consists of over 100 sites holding 22 PB of disk space. Around 35k concurrent jobs are running at any time. Just recently the Global Science Experiment Data Hub Center (GSDC) Korea Institute of Science and Technology Information (KISTI) was added as a new Tier-1 location. The majority of jobs are related to Monte Carlo production (67%) followed by end user analysis (13%). The remainder is used for raw data production. All raw data collected in 2012-2013 is processed at least in Pass1 (some periods have Pass2). ALICE plans the re-processing of the pp data for all periods of 2011 and selected periods of 2010. To-date around 10^9 Monte Carlo events for pp, p-Pb, and Pb-Pb are available anchored to all data taking years from 2010 to 2013 with focus on 2012 and 2013. The production of the 2013 data was successfully completed on all levels. ALICE reports sufficient resources to fulfil all requests, although disk space remains critically low. Some backlog exists on the level of old raw data reconstruction and associated Monte Carlo. The upcoming challenges after Long Shutdown 2 (LS2) upgrades are, however, considerable. ALICE computing will have to handle 100 times more events and faces the convergence of online and offline (see below). The lack of new manpower is an issue, especially in the area of adapting new technologies that will require experienced professional programmers.

For Run III ALICE is considering to move to Root 6 and integrate it in in their framework (AliRoot 6) since Root 6 provides the much-needed I/O optimisation and offers capabilities of utilising hardware accelerators (e.g. FPGA, GPU). In this context ALICE is also considering collaboration with FAIR on FAIRRoot, a framework fully based on the ROOT system whose developers are planning to integrate zeroMQ a distributed multiprocess framework. ALICE sees the zeroMQ approach of FAIRRoot as a possible solution to the upcoming online/offline challenges.

Upgrades

The LHCC received two Technical Design Reports (TDRs) from ALICE, one for the new Inner Tracker System (ITS) (CERN-LHCC-2013-024) and one for the upgrade of the Read-out and Trigger System (CERN-LHCC-2013-019). The Committee congratulates the experiment on the submission of these TDRs. Both are discussed in detail in the section by the experiment upgrade referee in this document (see Section 4). ALICE intends to submit three additional TDRs: the upgrade of the TPC planned to be submitted end of January 2014, the upgrade of the Online and Offline system (O2) expected to be submitted in September 2014, and the new Muon Forward Tracker MFT. ALICE gave a comprehensive summary on the status of the TPC upgrade in the LHCC detector upgrade review session. Details and recommendations of the LHCC on the TPC upgrade efforts are also discussed in detail in the section by the experiment upgrade referee in this document (see Section 4).

The offline & online upgrade is mandatory to face the challenges of an unprecedented large flow of recorded data from the ALICE experiment of ~1.1 TByte/s after the LS2 upgrades. This is driven by the overall goal of the ALICE upgrades to collect 10 nb^{-1} in Pb-Pb collisions during Run III. The online system will have to record the full 50 kHz interaction rate while, at the same time, reducing the data flow to a manageable ~20 GB/s dictated by the data storage bandwidth and cost considerations. Due to the low signal-to-background ratio of many physics probes (e.g. low-p_T heavy flavour mesons) the classical event filter approach is not viable. ALICE's strategy to reduce the data bandwidth is to perform online reconstruction and store only clusters associated with useful tracks in an optimized format. The first steps towards an online data reduction have already been taken in recent years. Since the heavy-ion run in 2012 TPC raw data is discarded (except for a small fraction for quality assurance purposes) and replaced by TPC cluster reconstructed online in FPGAs.

The largest fraction of raw data is produced by the TPC with 1.1 TByte/s followed by TRD with 80 Gbyte/s and the ITS with 40 GByte/s. All remaining detectors combined only produce 20 GByte/s of raw data. ALICE targets a reduction factor in data bandwidth of 20 for TPC and 16 and 4 for TRD and ITS, respectively.

The overall system architecture and framework is already well defined. The online computing fabric for the upgraded ALICE is an integrated farm performing the detector read-out, the data buffering, the event building and the data processing. The event building and the data processing are performed in two steps: first for the data of parts of each detector, in First Level Processors (FLP) and then for the data of the complete event in Event Processing Nodes (EPN). The online computing fabric will consist of approximately 250 FLPs and 1,250 EPNs. A crucial factor for the tracking is the calibration. Especially the corrections for the distortion due to ion back flow in the TPC, pileup and drift time calibrations have to be sufficiently under control. The current TPC upgrade efforts and the O2 upgrade (especially the reconstruction software) are intricately linked.

The O2 upgrade is a common project from DAQ, HLT, and Offline Computing teams. ALICE divided the effort into 13 working groups with around 50 active participants. Efforts are progressing well and most hardware components, disks, processors (FPGAs, GPUs, multicore nodes), and network, are identified although the final decision on hardware components will naturally be taken late to make full use of Moore’s (processors), Kryder’s (storage) and Butters' (networking) laws.

9. DISCUSSION WITH LHCb

General Summary

The Long Shutdown 1 (LS1) work is proceeding well, with consolidation in advanced status of infrastructures for power, cooling and gas systems as well as a lot of maintenance, repair and consolidation of Muon, OT, IT and TT detectors. A total of 610 work packages have been completed. The only delay existing, with respect to the schedule, regards the consolidation of the Dipole Magnet. The replacement of the protection between the magnet coil and its support brackets, took more time than scheduled. Indeed there were delays both on the supply of the EPDM-PTFE stacks and on the preparation work for installation since some difficulty was encountered in the removal of the interface material in place. On-site machining of the support was needed to accommodate the extra thickness. Finally, the raw material for the stacks arrived and 1/8 of the job was done at beginning of December 2013. Completion of this consolidation work is expected by end of February 2014. The planning for 2014 will mostly concern the maintenance of RICH1, RICH2 and ECAL. For the RICH system, the replacement of malfunctioning HPDs will be carried out, while for the ECAL there will be a full replacement of the clear plastic fibres used for the LED calibration that were damaged by radiation. A total of 30 km of new quartz fibres will be installed with the mechanical preparation to route these cables already done. The LEDs will be replaced as well. LHCb expects to start working on Vacuum Chamber re-installation from June 2014. The LS1 programme proceeds well and the LHCC expects the two months delay accumulated on the Dipole Magnet consolidation to be re-absorbed in the execution of parallel activities.

Physics

The LHCb Collaboration continues to produce very high-quality scientific papers at high rate. Since the last meeting other seven papers were accepted for publication, the flattening of production rate being related to the preparation for winter conferences. Interesting new results have been presented at the open and close sessions such as a new measurement of D^0-D^0bar mixing, searches for CP violation in $D \rightarrow 3\pi$, observation of the decay $B_s \rightarrow J/\psi$ f1(1285) and decays of beauty baryons. The most intriguing result shown has been the measurement of CP violation in $B^{\pm} \rightarrow K^+K^-\pi^{\pm}$ and $B^{\pm} \rightarrow \pi^+\pi^-\pi^{\pm}$decays. Integrating the phase-space, the inclusive distributions show already a clear CP asymmetry, A_{CP}, with a different sign for $KK^-\pi$ (-14%) and $\pi\pi\pi$ (+12%) decays.. Much larger effects are observed in the Dalitz Plot distributions. For the $KK\pi$ case, the asymmetry looks to be very large above 1 GeV^2 in M^2_{KK} while for the $\pi\pi\pi$ case, it seems restricted to below 1 GeV^2 in $M^2\pi\pi$. These effects are not yet understood. The year 2013 was a golden year for LHCb resulting in a total of above 70 papers produced by the Collaboration. The plan for 2014 includes a prioritisation of the analysis subjects. About 80 papers are considered to be of higher quality and priority. Each Working Group will be responsible for its own physics output but the Collaboration management will try to strengthen the cross-Working Group operations. Finally, the studies on the upgrade sensitivity as well as the document on Upgrade Physics and Trigger have been updated. This latter paper will be used as supporting documentation to the TDRs with its final version expected to be released in early 2014.

Upgrades

The LHCb upgrade activities are advancing well and according to plan. Looking at the milestone profile, the LHCC observed that 50 milestones were reached out of 60 expected, with the right slope of deliverables observed in the last three months. More importantly, the major milestones were reached with the delivery of the first two TDRs on the VELO and on the PID system (RICH, Calorimeter and Muons). The next steps will be the delivery of the TDRs for the tracker (UT, CT) in March 2014 and for the Trigger and online system in June 2014. In the meantime, the Collaboration has still grown by adding one full member (Aachen) and one associate (Wuhan, China). The Aachen group has solid experience in fibre tracking devices that could be useful for the CT development, while the Chinese Central University in Wuhan is the second group joining from China. From the financial point of view, the negotiations with Funding Agencies proceed well. A clear status should be reached for spring 2014.

The VELO TDR upgrade (CERN-LHCC-2013-021) includes a clear presentation of requirements, physics performance and design specifications together with a list of R&D results. The technology choice of micro-channel-cooled pixels looks mature and the technical items are well detailed. The LHCC will do a more detailed review of this TDR in the next month and will meet with LHCb to go through a set of dedicated comments and questions. The plan is to work for approval in time for March 2014 meeting. The PID TDR (CERN-LHCC-2013-014) is well structured. It consists of RICH, Calorimeter and Muon systems. Some minor adjustment is still needed, such as to extend the description of the physics performance by adding a few significant measurements or plots based on this upgrade. Also for this TDR, much of the R&D has been carried out and many technical details reported. The LHCC observes that there is a risk/opportunity in cost saving for RICH-2 due to the still pending options of higher curvature lenses or larger area photomultipliers. The LHCC plans to proceed for approval with the same strategy as the one adopted for the VELO TDR.

A detailed status report was presented on the Upstream Tracker (UT) system. This system will be the upgrade of the existing Trigger Tracker and will consist of 4 planes of Silicon strips, with X, U ,V and X views. The UT main objectives are the reduction of the number of ghosts, the improvement on the trigger reconstruction time (2.6× faster) and the reconstruction of downstream K_s. The radiation hardness should be at the level of ~50 MRad at the innermost radius, R, and will be quickly decreasing for increasing R. For this reason, there are three types of Silicon sensors, the ones in the inner region will have higher segmentation (smaller strip width) while presenting a circular cut in the region near the beam-pipe. The Carbon Fibre staves are vertical and will provide mechanical support and cooling (CO_2 embedded in the frame) with the Si strip mounted on both sides and wire-bonded directly to the front-end electronics based on the SALT ASIC developed by AGH-UST. There will be hybrids, developed by INFN Milano, to provide interconnectivity between front-end and power/data lines. The read-out will be based on a TELL-40. Much progress has been achieved on the SALT ASIC and on the stave mechanics. The cooling is still under design. The Conceptual Design Report has been completed and a 5.4 MUSD funding request has been put forward to the NSF in the US, together with funding requests to Italy, Switzerland and Poland. The Tracker TDR should be delivered for March 2014.

The technology choice between a CT, based on Scintillating Fibres, and an upgrade of the Outer Tracker (OT) and Inner Tracker (IT) system is still underway. A dedicated meeting was held on 27 November 2013, but the committee's response has not yet been received by the LHCC. LHCb presented the progress on the Fibre Tracker technique since the previous meeting of the LHCC. The consolidated results on radiation hardness allowed to parametrise the degradation curve of the attenuation parameter, λ, as a function of the received dose. The degradation curve has been inserted in the simulation to estimate the maximum light yield loss expected for the fibre position closer to the beam pipe. This loss is ~ 30-40% higher than the one for a non-irradiated fibre. Successful construction of prototypes of 2.5 m length with 5 layers has been achieved, with measured light production and attenuation were consistent with expectations. For the SiPM cooling, a dedicated workshop has been held with cooling experts. As a baseline, the mono-phase cooling technique will be used. Much development has been done also for the electronics, where an overall design of the read-out board, based on the Pacific Chip, has been presented. An electronics review has been held in the middle of December 2013. The TDR should be completed for March 2014.

10. DISCUSSION WITH TOTEM

General Summary and Physics

The TOTEM Collaboration presented the status and plans of the analyses of the Run I data. After the completion of the flagship cross section measurements at 7 and 8 TeV, work is focused on a rich programme of diverse studies of final-state properties, including joint analyses with CMS. Analyses close to completion or in an advanced stage include: the rapidity spectra of charged particles in the T2 Telescope and CMS acceptance (currently under a collaboration review by CMS and TOTEM); the extraction of the Coulomb-hadronic interference from the very low-t data collected in the run with a β^* of 1000 m, and the extension to high-t values of the elastic cross-section measurement, from low-β^* runs; the study of final states (low-mass resonances, dijets) produced in the CMS acceptance via double pomeron exchange (DPE); soft- and hard- (with CMS) single diffraction measurements; and the determination of the total inelastic cross section at 2.76 TeV. The procedure commonly agreed to with CMS for the joint physics studies has been successful so far, and is now being tested in its entirety with the approval process of the charged rapidity spectra paper. The LHCC is impressed by the richness of the physics programme, and congratulates TOTEM. The Committee looks forward to the completion of further papers, in particular those in collaboration with CMS, and congratulates both experiments for the progress in their cooperation.

Long Shutdown 1 (LS1) and Upgrades

The Committee was updated on the progress in the consolidation work. All the Engineering Change Requests submitted at the time of the September 2013 LHCC meeting, dealing with the relocation of the Roman Pot (RP) detectors previously installed at 147 m, and with the installation of new absorbers (TCL4 and TCL6), have been approved, and work has started on all of them. The service work in the tunnel, and on the detector packages, is on schedule. No particular issues or concerns have emerged, and no item is on a critical path, with most items having a buffer of several weeks over their expected completion.

The Committee is satisfied with the smooth and effective running of the consolidation efforts.

Work on the joint TOTEM-CMS upgrade is likewise proceeding well. Prototype tests are ongoing for the RF shield (mounting & movement tests), the RP cylindrical housing (dimensions, vacuum, overpressure, mounting & movement), and the ferrite support (mounting, tooling). All tests are satisfactory. Purchases have started of components required for the production of the cylindrical RP station and horizontal bellow. So far all purchases or the joint project have been charged to TOTEM, saturating the available budget. Discussions are in place with CMS on the sharing of subsequent costs. The completion of the construction and installation is on a critical path, with tight deadlines for the remaining orders to be placed. There is nevertheless room for the installation of two horizontal RP stations for the timing detectors and of two horizontal RF shields.

The TOTEM and CMS Managements have drafted the principles of an agreement that, once approved, will be turned into a formal Memorandum of Understanding by CERN's Legal Office. The agreement was under review by the Collaboration Boards of the experiments at the time of the LHCC meeting.

The Committee acknowledges the support of the CERN management and of technical groups in various Departments that are helping the progress of this project while the formal agreement between TOTEM and CMS is being finalised. The project remains, however, on a critical path for the installation of the timing detector housings during LS1.

Much progress was also presented on the TOTEM R&D project for the installation of timing detectors on the existing vertical RPs, to allow the removal of pileup backgrounds in diffraction measurements done in high-luminosity, large-beta* runs. Work has focused on the study of the timing distribution infrastructure, on the optimization of the detector geometry, and on the selection of detector technology. No technological show-stoppers have been found. A prototype exists for the time distribution system, based on off-the-shelf components, and tests will be carried out through the spring 2014, with the goal of installation by end-2014. The geometry has converged to a 10-pixel design, repeated over four planes, leading to a resolution of 25-30 ps (the performance goal being 50 ps). The preferred diamond-based technology will be certified in 2014-2015, to start production of the detector packages in 2015/16. The installation could then take place in the technical winter stops during run 2.

The Committee congratulates TOTEM for the rapid progress in this area, and encourages the experiment to continue its efforts.

11. REPORT FROM THE UPGRADE COST GROUP (UCG)

The LHCC heard a report from the LHC Upgrade Cost Group (UCG).

The UCG will review all upgrade-related costs planned and incurred by the LHC experiments for their upgrade projects for the period after Long Shutdown 1 (LS1). In addition to the overall costs, the review will also include considerations on the availability of manpower and infrastructure support to assure the timely completion, installation and commissioning of the experiment systems. The UCG will prepare written reports, and together with the findings of the LHCC as regards the scientific and technical issues, will be submitted to the Research Board for the formal consideration and decision on approval of a Technical Design Report. Should the TDR be approved by the Research Board, the project will be followed by the Resources Review Board Scrutiny Group (RRB SG) in the standard scheme.

The UCG reviewed the ATLAS Fast Tracker (FTK) (CERN-LHCC-2013-007). The project consists almost entirely of electronics and aims to provide a global track reconstruction within 100 µs after each Level-1 trigger. The UCG findings are: a) conceptual design is reaching completion; b) costs estimates are based on industry quotes and previous experience; c) the total engineering manpower (about 7 FTEs spread over several part-time engineers) appears low; and the Associative Memory Chip (AM) ASIC is behind schedule due the challenging 65 nm technology. The delay in the AM chip is the main risk of the project, although only significant further issues will affect the 2016 run and have an impact on the physics. The cost risk is considered to be low. The UCG **recommends** to the LHCC approval of the FTK cost estimate. To assist the RRB SG in tracking the project, ATLAS should produce a resource-loaded schedule showing the number of necessary people and their expertise.

The UCG also reviewed the CMS Level-1 Trigger Upgrade (CERN-LHCC-2013-011). The project consists of replacing all parts of the current Level-1 trigger system. The UCG findings are: a) the project is considered to be large since it is of a size similar to that of the original Level-1 trigger project; the cost estimate is complete and reasonable; the project is making good progress but the schedule has slipped somewhat although if work in the cavern is completed by the end of LS1, the impact of minor delays on physics should be small; and manpower is short in some areas, particularly in producing initial algorithms; The UCG **recommends** to the LHCC approval of the Level-1 Trigger Upgrade cost estimate. CMS should tally the manpower by FTEs as requested by the RRB SG.

There will be a special meeting of the UCG in early 2014 to consider the three remaining ATLAS TDRs. The UCG also plans to consider the LHCb Vertex Locator (VELO) TDR and the ALICE Inner Tracking System (ITS) TDR at the March 2014 meeting of the LHCC. The rest of the Phase 1 TDRs will be considered with all deliberate speed.

The LHCC approved the cost estimates for the ATLAS FTK and the CMS Level-1 Trigger TDR for presentation to the Research Board.

12. REPORT AND DISCUSSION WITH THE WLCG REFEREES

Introduction

Together with the current simulation and analysis activities, which are proceeding very well, the main activities in the LHC experiments in the computing area are related to the preparation of the computing environments for the next phase.

Resources and RRB

The resource requirements for 2014-2017 were presented to the RRBs. Run II requests have become more definite since spring 2013 and assumed flat budgets, as previously suggested and reconfirmed as a reasonable and adequate approach. The ALICE and LHCb scrutinised requests have not always been met at the Tier-1 centres. The Computing Resources Scrutiny Group strongly supports on-going efforts to improve software efficiency and notes that resulting gains are already incorporated in the requests for Run II. The effectiveness of disk use is only partly reflected in occupancy. One would like to contemplate a metric to take account of access frequency. Networks have been exploited to reduce disk use and move processing between tiers. Concerns were raised that poorly- networked sites would be underused and that cost implications of providing network capacity could be high. The scrutiny procedure is streamlined by scrutinising in spring the year n+1 and in autumn year n+2.

Current activities and computing model improvements

LHCb has completed the incremental re-stripping, the HLT farm was used as standard contributor, as already proven before and regularly used for simulation as well. A campaign of software updates (Root6, SL6/gcc48, C++11) has been initiated. The resources usage is very satisfactory, with a special note on disk space, where the usage is close to 9.5 Pb for an available pledge of 11 Pb (until March 2014). Three sites summing 500 Tb have been commissioned as new Tier-2 configurations and more are planned, leading to an increase in the pledged disk space. The person-power for computing continues to be problematic.

ALICE has commissioned and is successfully using the new Tier-1 in KISTI (Korea). The CPU usage is uniform (35000 on average and up to 55000 jobs) and efficient (82% in Tier-1 centres). The jobs share simulation, reconstruction and analysis (12% of the total CPU in analysis trains). The production is dominated by simulation, 927 Mevents in 2013, with no backlog. All RAW 2012/2013 data is processed and there are plans to re-process 2010/11 samples. Some data access issues were observed in the Tier-1 centres; file pre-fetching is planned in order to improve the disk access. The CVMFS deployment is almost completed and will allow running Alien from the CVMFS sites.

ATLAS continues to use resources above pledges, in particular for CPU where the usage exceeds by ~30% the pledges. A large scale clean-up of disks was necessary in the Tier-1 centres in order to keep the consumption within the allocated space. The ambitious software improvements programme continues. Tuning of the simulation configurations may lead to significant gain of speed, although the gain in speed is more prominent for rather specific applications.

CMS process data successfully, with a CPU usage close to pledges. The HLT is used as standard and its upgrades strategies as well as the foreseen usage during the data taking are in preparation. Other planned improvements continue, as for example: data federation is about 80% deployed, on schedule for March 2014, and the disk/tape separation is expected by the end of the year. Integration testing and hardening activities are expected to proceed by March 2014, with full scale tests planned for the second half of 2014.

Preparation of models for 2015 data taking and beyond

The main strategy adopted by the experiments is to protect as much as possible the inclusive triggers and therefore reduce either the background when possible or adjust the computing models to adjust for the increased trigger rates. The plans for data recording rate will increase by a factor of two and the event sizes. The intensive activity in the LS1 seems to pay off: several critical areas of the computing models are tuned already or there is a clear plan to do so. Several adjustments in data distribution and reprocessing strategy help in reducing the resources pressure (as an example, the data access via network help in reducing the need for data multiplication and decrease the storage needs). In addition, several credible improvements are foreseen, some of which are already implemented (HLT, adaptation for ad-hoc computing, software optimisations). These proposals as well as plans for medium term in LHC computing and WLCG activities are summarised in the document « Update of the Computing Models of the WLCG and the LHC Experiments ». The LHCC scrutinised the document and made several editorial comments. The final version of the document is expected soon.

Conclusions

The experiments compute “out of the box” and often beyond pledges. LHCC congratulates the experiments and WLCG for this achievement, confirmed almost every day by new physics results. The resources projections assuming a flat budget in the next years are adopted by the experiments and confirmed by the RRBs. No trade on the physics mix has been considered, and the generic argument for the continuity in physics collection is generally adopted. To absorb the large increase in computing needs to maintain full physics sensitivity, large efforts are needed to adjust the computing models. These efforts are clearly oriented towards economy and stability, but a significant amount of innovation is proposed, giving the whole enterprise a high profile and attractiveness. The improvements, based on the experience gained during Run I, go beyond simple updates and simplification, use new paradigms (for instance in data distribution, opportunistic computing etc.) and will lead to a better environment in all aspects: processing, simulation, analysis and user interfaces. In addition, the collaborative approach developed in several areas by the experiments opens new avenues for further improvements and collaborations. It should be noted, however, that a few necessary steps, are not yet achieved, and need to be tested, implemented and commissioned. The data challenges prepared for mid-2014 will therefore be a crucial milestone in order to evaluate the feasibility of the new procedures and models.

13. TEST BEAMS

The PS and SPS Physics Co-ordinator reported on the LHC test beams. The 2014 fixed-target physics programme will resume on 15 July 2014 for the PS and on 13 October 2014 at the SPS. A new supercycle for the LHC injectors will offer an improved duty cycle to the fixed-target experiments. The call for beam time was sent out in October 2013 with the deadline for beam time submissions set to December 2013. The draft PS and SPS User Schedules will be available in early January 2014. For the moment, the number of requests is reasonable and could be arranged within the available beam time.

14. REFEREES

The LHCC referee teams for this session are as follows:

ALICE: J.-C. Brient, D. D’Enterria,), T. Ullrich (Co-ordinator)

ATLAS: U. Bassler, P. Burrows, C. Cecchi, R. Roser (Co-ordinator)

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

LHCb: C. Diaconu, G. Eigen, S. Miscetti (Co-ordinator)

TOTEM: U. Bassler, C. Cecchi, D. D’Enterria, M. Mangano (Co-ordinator)

LCG: A. Boehnlein, J.-C. Brient, C. Diaconu (Co-ordinator), T. Mori

Experiment Upgrades:

General: J.-C. Brient, M. Demarteau (Co-ordinator)

RD39: G. Eigen

RD42: M. Demarteau

RD50: G. Eigen

RD51: D. Denisov

15. The LHCC received the following documents:

CERN-LHCC-2013-023 Minutes of the one hundred and fifteenth meeting of LHCC

CERN-LHCC-2013-019 Upgrade of the ALICE Readout & Trigger System

CERN-LHCC-2013-021 LHCb VELO Upgrade Technical Design Report

CERN-LHCC-2013-022 LHCb PID Upgrade Technical Design Report

CERN-LHCC-2013-024 Upgrade of the ALICE Inner Tracking System

DATES FOR LHCC MEETINGS

Dates for **2014**

5 - 6 March

4 - 5 June

24 - 25 September

19 - 20 November

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