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LHCC-115
11 December 2013

LARGE HADRON COLLIDER COMMITTEE

Minutes of the one-hundredth-and-fifteenth meeting held on
Wednesday and Thursday, 25-26 September 2013

OPEN SESSION - Status Reports

1. LHC Machine Status Report: Frederick Bordry
2. ATLAS Status Report: Isabelle Wingerter
3. CMS Status Report: Markus Klute
4. LHCb Status Report: Angelo Di Canto
5. ALICE Status Report: Alexander Kalweit
6. TOTEM Status Report: Kenneth Osterberg

CLOSED SESSION:

Present: U. Bassler, 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, A.-L. Perrot, R. Roser, S. Smith, C. Touramanis, E. Tsesmelis (Scientific Secretary), T. Ullrich, H. Wilkens

Apologies: S. Bertolucci, P. Bloch, R.-D. Heuer

1. EXECUTIVE SUMMARY

ATLAS

- Fast Track Trigger (FTK) Technical Design Report recommended for approval.
- Muon New Small Wheel (NSW) Technical Design Report recommended for approval.
- LAr Calorimeter Technical Design Report under review and detailed deliberations at December 2013 LHCC session.
- Trigger/DAQ Technical Design Report under review and detailed deliberations at December 2013 LHCC session.

CMS

- Phase 2 upgrades have been scoped. Preliminary cost estimate to be presented to Resources Review Board in October 2013 and a Technical Proposal to be submitted to the LHCC in 2014, with a draft available to the LHCC in early October 2013.

ALICE

- ALICE intends to submit the tentative Technical Design Report for the upgrade of the Time Projection Chamber (TPC) at the end of October 2013.
- ALICE intends to submit the Technical Design Report for the new Inner Tracker System (ITS) at the end of October 2013. The LHCC encourages the ALICE Collaboration to expedite convergence towards a baseline pixel-chip architecture.
- ALICE intends to submit the Technical Design Report for the upgrade of the electronics and trigger at the end of October 2013.
- Muon Forward Tracker (MFT) Addendum to the Letter of Intent endorsed and ALICE encouraged to prepare Technical Design Report.

LHCb

- Technology choices done for the Vertex Locator VELO (microchannel-cooled pixel) and for the Ring Imaging Cherenkov RICH (RICH-1 and RICH-2 with MAPMT).
- Submission of Technical Design Reports for VELO and Particle Identification expected for December 2013, while the Technical Design Reports for the Inner Tracker / Outer Tracker and Fibre Tracker are expected for March 2014.

TOTEM

- A critical item in the TOTEM upgrade programme, whose definition needs the most urgent action, is the housing for the Roman Pots that will host the upgrade detectors.
- CMS Collaboration endorsed common physics programme with TOTEM. CMS and TOTEM are preparing the corresponding Memorandum of Understanding.

R&D Projects

- Letter of Intent to form R&D collaboration on 3D sensors and micro-fabricated detector systems was not recommended for approval. The LHCC encouraged the proponents to work within work package three on ‘Microelectronics and Interconnection Technology’ of the Advanced Infrastructures for Detectors at Accelerators (AIDA) programme of the European Union.

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 the Long Shutdown 1 (LS1), including the availability of manpower and infrastructure support to assure the timely completion, installation and commissioning.

WLCG

- The Committee took note of the draft document submitted by the WLCG to the LHCC, which has the objective to clarify the evolution of the computing models from their original definition in the Technical Design Reports as a consequence of the extensive experience gained during Run I, but also following a voluntary decision to optimise the computing models in view of Run II.

2. PROCEDURE

The Chairperson welcomed Stewart Smith (Chairperson of the LHC Experiments Upgrade Cost Group) and Christos Touramanis (Chairperson of the Resources Review Board Scrutiny Group) to the LHCC. Both have a standing invitation to the sessions of the LHCC.

The minutes of the one-hundredth-and-fourteenth LHCC meeting (LHCC 2013-012 / LHCC 114) were approved.

3. 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 discussed the advantages and challenges posed to the experiments by increasing the collision energy from 8 TeV to 13 TeV. While the cross-sections for production of heavy new particles are about ten times higher at 13 TeV compared to 8 TeV, the minimum bias cross-section and the overall event multiplicities increase, thus making the event reconstruction more challenging. Running at 25ns bunch spacing is considered of paramount importance by all experiments to maximise their physics reach, even if it would result in a lower integrated luminosity for 2015. In addition, the event pile-up density should be minimised, and a slightly longer luminous region (by about 10%) may be beneficial in this respect. Luminosity levelling at 4-6 × 10^{32} cm^{-2} s^{-1} will be needed for LHCb. For heavy-ion operations, ALICE requests Pb-Pb collisions in both 2015 and 2016, while for 2017 ALICE requests proton-Pb collisions.

A number of special runs are also being considered for 2015. LHCf will need to run during the early stages of Run II (before an integrated luminosity of 500 pb^{-1} is delivered at Interaction Point 1). Moreover, van der Meer scans will need optics with round beams, a large β-function (≈15m), large emittance (≈ 3μm) and no crossing angle. High-β runs at 90m (before quadrupole cable installation) and at ≈2.5km afterwards will be requested.

4. REPORT & DISCUSSION WITH LHC EXPERIMENT UPGRADE REFEREES

At this session, the LHCC heard seven reports on the status and plans of the upgrades of the LHC experiments, a reflection of the intense activity within the community to prepare for the long-term future of the programme. Reports were given by all four collider experiments concentrating on the LHC 10-year plan.

ATLAS

The ATLAS experiment presented the Technical Design Report (TDR) for the Liquid Argon (LAr) Calorimeter Phase 1 Upgrade. This upgrade is motivated by the requirement to maintain thresholds within the 100 kHz Level-1 trigger bandwidth to improve the performance of the Level-1 single object triggers based on the calorimeter information. This is achieved by the use of 'Super-Cells' and an increase of the digitisation precision. Through the use of Super-Cells, the read-out granularity at the trigger level will match the hardware granularity. One $(\Delta\eta\times\Delta\varphi) = (0.1x0.1)$ trigger tower will map into 10 Super cells, with read-out for each of the four longitudinal layers and four azimuthal read-out segments for layers 2 and 3 each. This will enable the implementation of very effective shower shape variables at the trigger level, which provides for a more effective identification of electrons, photons and leptons, sharpens the electromagnetic, jet, and E_T-miss efficiency turn-on curves and allows for an event-by-event pile-up subtraction. Also the τ-lepton identification would see considerable improvement.

Although the relative lowering of the trigger thresholds is modest, the gain in trigger rate is substantial and the upgrade is well motivated. The front-end architecture will require a large number of LAr Trigger Digitizer Boards that will digitise all Super-Cell signals at 40 MHz and send the information to the back-end processing modules on fast links for feature extraction. Because of the ten-fold increase in the number of individual channels at the trigger level, maintaining the integrity of the analogue signals to preserve performance of the analogue system will be a challenge. The system is designed to be "fully compatible" with the Phase 2 upgrade in the sense that the current architecture can be retained and redeployed as a Level-0 trigger at a later stage.

For the ATLAS experiment to fully exploit its enhanced capabilities with the Fast Track Trigger (FTK) upgrade, the Muon Small Wheels and the Calorimeter LAr upgrade, the trigger and data acquisitions systems have to be upgraded as well, which were presented in the TDR for the Phase 1 Trigger/DAQ upgrade. As the luminosity, cross-sections and channel counts increase, the higher physics and data rates need to be handled by a much more selective Level-1 Trigger, and a High-Level Trigger (HLT) with significantly improved rejection power. Furthermore, the HLT processing time per event will increase given the increased complexity of the events. The upgraded architecture will make use of the increased granularity of the LAr calorimeter data, integrate the new Muon Small Wheel in the Level-1 Muon trigger, implement topological triggers, use the FTK information in the LHT and apply sophisticated algorithms that allow for corrections in the HLT using fast, full event, hardware tracking (FTK) and full calorimeter information. The compelling power of the upgraded architecture was shown with a sample Level-1 trigger menu. Improved HLT algorithms are crucial to maintain rejection in spite of the much more selective Level-1 trigger with the upgrade. Much work is on-going in the area of software development, which will also adapt to future use of many-core CPUs and co-processors, exploiting the growing parallelism. An initial estimate of the resources required to update the online software has been made, which indicates that the resources required are substantial.

At the June 2013 session of the LHCC, the Technical Design for the FTK was presented. There were, however, some remaining issues with the FTK vertex resolution being considerably worse than offline and that samples with the Insertable B-Layer (IBL) implemented had not been available. Results were presented in September 2013 where these two issues were addressed. As expected, the b-jet tagging performance improves in the FTK with the IBL implemented.

LHCb

The LHCb experiment presented the decision, taken during their recent technical design review, to employ the micro-channel based pixel sensor technology as the baseline for the upgrade of the Vertex Locator (VELO) detector. Two pixel sensor designs, using micro-channel cooling or using pocofoam cooling, and two strip sensor designs, again one using micro-channel cooling and one employing TPG cooling blocks, were considered. All options show improved performance over the current detector. The pixel option with micro-channel cooling represents the lowest material budget before the first measurement and has close to 100% uniformity with slightly better tracking efficiency. 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. Good progress is being made on the development of the read-out chip, the VELOPIX, which is based on the TimePix3 chip. The Committee would like to **congratulate** the experiment on the impressive amount of advanced R&D and is looking forward to a continued optimisation of the overall detector, which clearly holds the promise to deliver a wealth of high-precision data.

The LHCb experiment also presented its plans for the upgrade of the RICH detector. The current plan calls for removal of the aerogel from the Ring Image Cherenkov RICH1 detector. Improved optics and mechanics that reduces optical aberrations and optimises the available space is required only for RICH1. The opto-electronics chain will be adapted to sustain a 40 MHz read-out at a luminosity of 2×10^{33} cm^{-2}s^{-1}. The baseline photodetector is a 64 pixel MAPMT with single photon sensitivity, average photoelectron yield of 40, pixel size less than 3mm and time resolution better than 25ns. A custom read-out ASIC, the CLARO chip, is under development. Various options were studied to reduce the occupancy and improve optical errors, by using a longer radius of curvature and smaller angular tilts for the mirrors, and a larger focal plane area. Separation of pions and kaons up to 72 GeV at 3σ is obtained with an improvement in the kaon identification efficiency at the same pion misidentification rate of 15%. Notably, the $B_s \rightarrow \varphi\varphi$ decay channel, which gives information about the gluonic penguin contribution, with four kaons in the final state, will benefit substantially from the upgrade. The LHCC is looking forward to receiving the TDR for the RICH upgrade.

ALICE

A status update of Inner Tracker System (ITS) for the ALICE upgrade was presented. The 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.

Four sensor architectures are being studied and the collaboration intends to continue exploration until mid-2014, even after submission of the TDR. 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 1×10^{13} 1 MeV n_{eq} 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 mechanical design is being optimised 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. Further optimisation is being explored. The LHCC **congratulates** the experiment on the technical progress made and is looking forward to the TDR for the ITS, which the experiment anticipates to submit very soon.

The ALICE experiment also presented its plans for the electronics upgrade. 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 proposal calls for a continuous, trigger-less read-out of the muon chambers (MCH), the ITS and the Time Projection Chamber (TPC). All other systems will be triggered systems. 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 detectors are synchronised with the triggered detectors using heart beat triggers sent at time frame boundary. Data is then processed through a common read-out unit (CRU). The CRU can be located either in the cavern or in the control room. The preferred option is to have the CRU in the control room for which the cost defining factor is the optical fibre plant required for the read-out of the TPC with the associated GBTs. 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 read-out 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 of course the ITS requires 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. Although the scale of the electronics upgrade is significant, and will require significant resources, the upgrade should be relatively straightforward.

CMS

The CMS experiment presented preliminary plans and a cost estimate for the Phase 2 detector upgrades as well as the proposed process for continued planning. Radiation damage is a driving motivation for the upgrade after Run III. Using *in-situ* experience and radiation tests, CMS is developing and benchmarking damage models to project to Long Shutdown 3 (LS3) and beyond. The Collaboration is performing simulation studies to define the physics requirements for the detector upgrades to provide guidance for the detector specifications, such as coverage, resolutions and granularity that will motivate detailed designs. This process will result in a Technical Proposal in 2014 that will describe the overall programme for Phase 2, with a Technical Design Report for each upgrade project to be available in 2016. A more detailed discussion is presented in the CMS section of these minutes below.

Closing Discussion on R&D Letters of Intent

At its session in June 2013, the LHCC endorsed the creation of a new RD Collaboration, RD53, for the development of pixel read-out integrated circuits for extreme rate and radiation (CERN-LHCC-2013-002 / LHCC-I-024). The decision with regard to the second Letter of Intent (LoI), on 3D sensors and micro-fabricated detector systems (CERN-LHCC-2013-003 / LHCC-I-025), was deferred to provide the proponents an opportunity to address questions raised by the Committee.

The LHCC noted that the near term objectives of the second RD proposal were sufficiently covered by current efforts within existing collaborations. The RD collaboration was encouraged to articulate the strengths and value added of the proposal for the long-term particle physics programme. The proponents submitted an Addendum to the LoI with title ‘MEMS Sensors and Vertically Integrated Micro-Fabricated Systems’ (CERN-LHCC-2013-016), which outlined the intended added value with emphasis on the group’s long-term objectives and identified those areas where the development work would be different from existing efforts. The LHCC sees the promise of the proposed research and strongly encourages the proponents to continue their excellent work in this area. At the same time, however, there was consensus that the creation of a new RD group was not appropriate at this point in time. The LHCC **encouraged** the proponents to work within work package three on 'Microelectronics and interconnection technology' of the Advanced Infrastructures for Detectors at Accelerators (AIDA) programme of the European Union. This would allow for the building of a strong programme, within an existing multi-national effort, that could be continued after the current AIDA programme comes to an end.

5. DISCUSSION WITH ATLAS

General Summary

The LHCC considers that ATLAS has made excellent progress in all aspects of the experiment and the Committee **congratulates** the ATLAS Collaboration on its achievements.

This year continues to be a productive year for the ATLAS Collaboration. Physics continues to come out at a significant pace only slightly reduced while the Collaboration works on the current shutdown and prepares for both the Phase 1 and Phase 2 upgrades. The shutdown is progressing well and there is no reason to believe ATLAS will not complete its ambitious set of Long Shutdown 1 (LS1) projects on time. Yet even with all the activity, ATLAS has about 150 papers that it expects to publish prior to the start of Run 2.

ATLAS has presented four Phase 1 upgrade Technical Design Reports for approval by the LHCC. The Muon New Small Wheel (NSW) and Fast Track Trigger (FTK) were recommended for approval, while the LAr Calorimeter and Trigger/DAQ Technical Design Reports are scheduled for detailed consideration in December 2013.

The Insertable B-Layer (IBL) is progressing well but has a very tight schedule and there is little remaining contingency for this device to be installed this shutdown.

Physics

To date, ATLAS has published a total of 264 papers with collision data; 37 of which came out this year. ATLAS believes that there are at least 150 more papers to be published prior to the start of Run II. While this sounds ambitious, the ATLAS Collaboration has submitted ~130 papers in a single year. Much of the physics emphasis has been on the Higgs programme, where ATLAS has results in the H → bbbar, ttbarH; a Higgs → $\gamma\gamma$ differential cross section measurement; as well as a variety of Higgs property measurements. Twenty-four new SUSY searches with the full 20 fb^{-1} are now complete as well as several new top quark results, including the top mass in the dilepton channel and a combined dilepton+lepton+jets measurement yielding a 1.4 GeV uncertainty. The current top cross-section result in the dilepton channel has a 4.8% uncertainty, taking the precision of what the Tevatron was able to achieve one step forward. The ATLAS heavy-ion group is engaged and expects to have a number of proton-Pb results in Autumn 2013.

Computing

Much work is also on-going in the software and computing groups. The analysis model is changing to root-readable Analysis Object Data (AOD) and the plan will be to scale back to two copies of the raw data in anticipation of the larger trigger (and thus data volume) expected in Run II. Three task forces were established to focus effort in the critical software development areas. These task forces are to execute the new AOD, develop faster data reduction framework (improved skim techniques), and a re-design of the offline analysis framework that is a better fit with the current distributed computing model. These task forces are supposed to end in Spring 2014 so that the physics and computing groups can carry out a data challenge in April-June of 2014 and people can get experience with the new analysis model and job submission tools.

Long Shutdown 1

The Long Shutdown 1 (LS1) is progressing well and the work packages are being completed. The cryogenic systems for the two magnets have been split so that the two can be independently cooled. A back-up refrigeration system is also complete. The new gravity-fed cooling system for the inner tracker has been tested with a dummy load and is awaiting the reinsertion of the Pixel Detector before it is activated.

The Pixel Detector was removed from the pit and is being reworked with an entire new set of Service Quarter Panels (SQPs). Six of the 8 SQPs have been installed. The final two will be added in a few weeks once the diamond beam telescopes are installed. Finally, the inner support tube was installed, allowing for a relatively simple insertion of the Insertable B-Layer (IBL) with the Pixel Detector in-situ. When the Pixel Detector was extracted, 22 modules were expected to remain troublesome. The Pixel Detector team was able to repair 10 of them such that the detector will have greater than 99% of its channels working for the start of Run II.

The IBL has made excellent progress. The bump bonding is complete and 10 of the 14 required staves have been fabricated and tested. Stave assembly will be completed this calendar year. The process to mount the staves on the beam pipe has begun and the IBL team expects to be done by Christmas. If successful, this will give the ATLAS Collaboration January through March 2014 to test the full system on the bench. The plan is to install the IBL into the Pixel Detector in the collision hall in April 2014. The schedule is quite tight, but it has not slipped. With continued dedication the IBL will be inserted in April 2014.

The Transition Radiation Tracker (TRT) Xe-gas leaks have been addressed in the end-cap region, where the problem areas can be reached. Eleven of the 13 identified leaks have been fixed and the overall leak rate has been drastically reduced. The leaks in the barrel cannot be reached. The ATLAS Collaboration will have to live with them through skilful manipulation of the gas flow at the manifolds. It should be noted that currently the barrel leak rate is much lower than even in the modified end-cap regions. All chambers are scheduled for operation with Xe-gas so that particle identification capability will be preserved throughout.

Three quarters of the Tile Calorimeter power supplies have been installed. The corresponding drawers have also been reworked such that the connectors have been fixed. The remaining power supplies and drawers will be addressed once the ATLAS detector configuration is modified to allow access.

The LAr Calorimeter low-voltage power supplies are installed and ready to go.

In the Muon System, there is an active leak campaign in the Monitored Drift Tubes (MDT) detector. The two known major leaks have been found and repaired. The Resistive Plate Chamber (RPC) leak check is underway. Leaky inlets are either being repaired or replaced depending on severity of the leak. The small wheel is on the surface and five of the 29 Thin Gap Chambers (TGCs) are expected to arrive and be installed in November 2013.

Upgrades

In terms of the upgrades, the ATLAS Collaboration is working to complete all of the software needed to simulate the performance of the full Phase 1 upgrade. As regards Phase 2, the ECFA High Luminosity Experiments Workshop in early October 2013 will provide much opportunity for cross-experiment discussion and identification of further possibilities for common R&D. One outcome of the workshop should be better consistency in costing between experiments, while a further aim is to compare and contrast the physics performance of various proposed upgrades. Consideration is being given to ways to reduce costs without losing physics capability.

The LHCC currently has four of the ATLAS Phase 1 Technical Design Reports (TDRs) under review. The LHCC has reviewed further the Fast Track Trigger (FTK) and Muon Small Wheel TDRs, which were submitted prior to its session in June 2013. The LHCC **recommends** these reports for approval. The LHCC has had considerably less time with the LAr Calorimeter and Trigger / DAQ TDRs, both of which address the triggering capability of ATLAS in an effective manner. While the upgrades are well motivated, and realising that all four of these TDRs are tightly coupled, the LHCC will need to devote more time for adequate preparation and discussion before making a final recommendation on these the LAr and Trigger / DAQ TDRs.

6. DISCUSSION WITH CMS

General Summary

The LHCC considers that CMS has made excellent progress in all aspects of the experiment and the Committee **congratulates** the CMS Collaboration on its achievements.

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.

The Long Shutdown 1 work is proceeding well, and CMS has generated some time contingency by developing the ability to install and commission muon chambers on the –Z end after the full field magnet test.

Phase 2 upgrades have been scoped out based on considerations of detector longevity. A preliminary cost estimate and scope will be presented to the Resources Review Board in October 2013. A Technical Proposal is expected in 2014.

CMS and TOTEM are pursuing a Memorandum of Understanding and implementation plan for a joint precision forward proton spectrometer physics programme.

Physics

CMS is progressing well in the analysis of the full 2011-2012 dataset. 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 255 publications with twenty-five additional publications in preparation. The so-called “parked” datasets have been processed and made available to the analyses by early Summer 2013 with main analyses being pursued in B-Physics, Higgs Vector Boson Fusion and SUSY/Exotica searches.

Computing

For computing, the recent load on the Tier-1s has been less than anticipated. The 2011 legacy reprocessing is being finished, as is the generation of Monte Carlo samples for Run

II. Additional resources for computing for Run II are possible as there is interest in Korea (KISTI) to establish a modest Tier-1 that will also provide opportunities for data analysis to the local community. Furthermore, negotiations are underway to see if the Tier-1 resources at Academia Sinica (Taiwan) might be restored for CMS in time for the 2015 restart.

Work continues in preparation for Run II in the form of code optimisation. The new CMSSW software release shows a significant speed-up of a factor of 1.6 without impacting physics performance. Work will continue to understand other possible speed-ups and to evaluate physics impacts. Trigger studies and menu development continues to make progress. The DAQ system at Point 5 is being re-commissioned in preparation for a cosmic-ray global run in early November 2013, which will enable read-out tests and evaluation of changes in procedures for alignment and calibration, Data Quality Monitoring, and the exercise of the Tier-0. By December 2013, there will be a review of the monitoring consolidation project and a redesigned control room lay-out.

Long Shutdown 1

The work scheduled for Long Shutdown 1 (LS1) involves an extensive installation of Phase 1 upgrades, preparations for the remainder of Phase 1, maintenance and consolidation in preparation for LHC Run II, as well as work underpinning the long-term operation of CMS. As outlined at previous sessions of the LHCC, the programme of work has the following major elements: (1) muon upgrades, including the installation of the 4th layer end-cap Cathode Strip Chambers (CSC) and Resistive Plate Chambers (RPC) and the YE4 shielding wall, plus upgrade of the ME1/1 CSC front-end electronics and part of the first barrel muon layer electronics, as well as relocation off-detector of part of the barrel muon electronics; (2) the first stage of HCAL phototransducer consolidation/upgrade (HO, HF); (3) Tracking system upgrades and consolidations including the installation of the 45mm outer diameter beam pipe and the new detector cooling plant, necessary for the subsequent Pixel Tracker upgrade. A key priority for the shutdown is enabling the Tracker to operate 25 degrees colder than its current operating temperature. Without this intervention its performance degradation due to radiation would become significant before the designed maximum integrated luminosity of about 500 fb^{-1} is reached; (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; (5) installation of a new central DAQ system (DAQ2) addressing the replacement of computing and network equipment to plan for future connectivity and the support of sub-detectors with new μTCA back-end electronics; and (6) a major consolidation of the magnet cryogenic system, the detector power distribution system and the dry gas distribution system to improve robustness and redundancy and to eliminate risks to operating efficiency and detector lifetime.

The LS1 maintenance and consolidation 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. To increase the energy efficiency and reduce the carbon footprint, the building will feature LED lighting, heat pumps, window coatings and solar panels. Furthermore, heating may be supplied by extracting heat from the SF5 cooling towers.

Assembly of chambers and refurbishment of electronics is on schedule for the muon system. For the CSCs, 90% of the ME4/2 chambers have been assembled. For the ME1/1 refurbishment, twenty-two of the seventy-two chambers have been refurbished and eighteen have been fully tested in preparation for the first End-cap re-installation planned for October 2013. The two-chamber ME1/1 demonstrator was installed and successfully powered. The status of the RPC upgrade is on schedule with 77/144 chambers built, and 20/72 Super-modules ready for installation. The service preparation is also on schedule with gas piping, and the cooling mini-manifold completed and the cabling underway.

The YE-4 installation has started. The YE-4 installation at the +Z end will be completed by the end of October 2013. A YE-4 push-back system for the –Z end has been developed and approved in anticipation of the need for an option that would enable earlier closure for a cosmic-ray commissioning test at full field. The push-back system will allow for CSC and RE4 installation and commissioning to be performed as time permits after the test.

The silicon pixel tracking and vertexing detectors are on surface and stored cold in the pixel lab at Point 5, and the pixel repair & maintenance has started and is on schedule. The repair of the Forward Pixel (FPIX) is nearly complete. It is anticipated after repairs that only a single defective chip will remain. Similarly for the Barrel Pixel (BPIX), 8 modules from Layer 3 are being replaced, with an anticipated 98.9% functioning channels in the laboratory after all repairs are complete.

With respect to the Phase 1 preparatory work, the Pixel Pilot Blade components are in hand and the sensor-chips are being bump bonded. The CO_2 plant at the Tracker Integration Facility (TIF) is complete and being commissioned, a positive indication for installation of CO_2 plants at Point 5 during LS1. The new beam pipe support collars were delivered to the manufacturer. Over-constrained support tooling at the electron beam welding facility have led to one of the conical to cylindrical welds breaking during the set-up of the final weld. Repair involves cutting out either side of the failed weld and welding in a new piece. This option has the advantage of preserving the exact geometry required using the existing stock of spare beryllium and a tolerable delay with the acceptable risk of an additional weld.

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 finalised. A very fast front-end ASIC has been successfully produced for the Beam Conditions Monitoring (BCMF). The Beam Halo Monitor Engineering Design Review has been completed.

For the Hadronic Forward (HF) and Hadronic Outer (HO) calorimeters, the production of components for the replacement of PMTs and SiPMs also remains on schedule. For the HO SiPM project, 7/12 sectors have been successfully installed and tested. For the HF PMTs, installation of 25% of the Readout Boxes is anticipated by the end of June 2014. The µTCA backend electronics had a production readiness review on 12 June 2013.

Upgrades

PHASE 1 UPGRADES

The remaining Phase 1 upgrades include the construction of a new Pixel Detector, completion of the new photo-detectors and electronics for the hadronic calorimeter and a new Level-1 trigger system.

The Level-1 Trigger Upgrade Technical Design Report (TDR) for Phase 1 was presented to the LHCC after an internal CMS review. The Level-1 trigger upgrade goals are to use elements of upgraded detector systems to maintain sensitivity for electroweak scale physics and for TeV scale searches at levels comparable to Run I sensitivity. The Level-1 trigger upgrade project has a projected cost of 5.7 MCHF. The LHCC **recommends** approval of the CMS Level-1 Trigger Upgrade. The development of the parallel data path for the

Level-1 trigger upgrade is on track and 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 star 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 2013.

For the HF, SiPM R&D is proceeding extremely well with a device that has ~3x 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.

An additional proposed upgrade is a Precision Proton Spectrometer (PPS). CMS reviewed two proposals that would provide the capability to measure exclusive reactions of $p + p \rightarrow p + X + p$ where X is a state measured in the central region. The two proposals differ in technology, with one proposing a Moving Beam Pipe (MBP) and the other proposing Roman Pots (RP). For the exploratory phase in 2015, Roman Pots will be used. The CMS review committee noted that the anticipated performance of the PPS detector meets the physics goals and can manage the pile-up background and recommended approval of the physics motivations and proposed detector concept. The CMS review committee recommended collaboration with TOTEM on this programme with the details developed and reviewed to be encapsulated in an implementation plan and Memorandum of Understanding between CMS and TOTEM.

The LHCC strongly **encourages** CMS to follow up on this interest to the mutual benefit of both collaborations and in the interest of physics in general.

PHASE 2 UPGRADES

CMS presented preliminary plans and cost estimates for Phase 2 detector upgrades as well as the proposed process for continued planning. The driving considerations include projections for radiation ageing after Run III. Using in situ experience and radiation tests, CMS is developing and benchmarking radiation damage models to project to Long Shutdown 3 (LS3) and beyond. Degradation of physics performance will be modelled with the standard CMS software packages for which detector ageing has already been included. Furthermore, CMS is performing simulation studies to define the physics requirements for the detector upgrades to provide guidance for the detector specifications such as coverage, resolutions and granularity that will motivate detailed designs. This process will result in a Technical Proposal in 2014 that will describe the overall programme for Phase 2, and with a Technical Design Report for each upgrade project in 2016. To facilitate early discussions with the Resource Review Board (RRB), CMS has prepared a document for the October 2013 RRB meeting with a preview of the scope as currently understood and a preliminary cost estimate to facilitate early discussions. A draft of this document was made available to the LHCC.

The current scope is anticipated to include a complete replacement of the inner tracker systems. For the calorimeters, based on detailed studies of radiation damage effects of crystals and photo-detectors, the Electromagnetic Barrel will sustain the anticipated luminosity of 3000 fb^{-1} while the end-caps will collect less than 10% of light after an integrated luminosity of 500 fb^{-1} and will need replacement. Similarly, for the hadron calorimeter, the Barrel and Forward detectors are expected to have sufficient longevity while the end-caps will need to be replaced. While the existing muon system will not be replaced, it is anticipated to possibly extend the η coverage. Considerations for the trigger and data acquisition system include the possibility of 1 MHz read-out at Level-1, a Level-1 tracking trigger and a High Level Trigger (HLT) output rate of up to 10 kHz. CMS indicates that preliminary studies carried out so far indicate that a 30-month shutdown would be required to install these upgrades.

The LHCC congratulates CMS on outlining the scope of the upgrades and providing a costing. While it is too early for detailed comments prior to the Technical Proposal, the LHCC notes that CMS seeks to maintain computing costs as they are (i.e. flat) or even decreasing, although traditionally the computing costs are covered as operating costs. Likewise, the funding for detector R&D is traditionally outside of the formal project and thus was not covered as part of the documentation to be provided to the RRB. The LHCC notes that it would be useful to have an assessment of the areas of technical and financial risk where R&D is especially needed and the degree to which R&D programmes can be conducted in common with other experiments. The success of the upgrade depends on technical progress in all areas

The LHCC looks forward to seeing the full Technical Proposal and accompanying physics studies, including justifications for the detailed designs proposed for all major elements of the upgrade that need replacement.

7. DISCUSSION WITH ALICE

General Summary

The LHCC considers that ALICE has made excellent progress in all aspects of the experiment and the Committee **congratulates** the ALICE Collaboration on its achievements.

The Committee discussed the Addendum to the Letter of Intent by ALICE for a Muon Forward Tracker (MFT). The LHCC **congratulates** ALICE on the Letter of Intent and endorses the MFT upgrade plan. The Committee **encourages** further studies towards the upgrade and is looking forward to receiving the Technical Design Report.

Physics

ALICE has released the first papers based on the dataset recorded during the proton-Pb run of Spring 2013. ALICE has in total 74 physics papers published or submitted. Since the previous LHCC session in June 2013, eight new papers on results from proton-proton, proton-Pb, and Pb-Pb collisions were submitted and four have already been published.

Long Shutdown 1

ALICE continues to stay on track with their LS1 schedule. Consolidation efforts and installation of new components is progressing well. The installation of the new Uninterrupted Power Supply (UPS) system is close to be complete. The first phase of the chillers upgrade is concluded and the cavern is back on normal ventilation. Three new chillers were installed in the SU2 underground cavern and two more will be added in 2014. New heat exchangers were placed in SU and UW underground caverns. The support structure for the Photon Spectrometer (PHOS) and Dijet Calorimeter (DCAL) modules is installed; all DCAL modules were delivered to CERN and are currently tested and readied for installation.

The PHOS consolidation efforts continue. ALICE decided to adapt the upgraded Electromagnetic Calorimeter (EMCAL) read-out electronics for the PHOS detector. This implies changing from a read-out bus with Read-out Control Unit (RCU) to a point-to-point read-out using the Scalable Read-out Unit (SRU) developed within the framework of RD51. This upgrade improves the read-out speed from currently 1kHz to 50kHz. The first boards were already modified (using spare mezzanine boards from the EMCAL), while the remaining boards are in production.

The production of the remaining 5 Transition Radiation Detector (TRD) super-modules remains a critical item. These delays were caused by legal issues with the manufacturer and by technical problems with the produced Multi-Chip Modules (MCM). The latest shipment of Read-out Boards (ROBs) in July 2013 shows no problems (93% yield). During September 2013, enough ROBs were scheduled for delivery to equip half a super module. While the production is picking up, it remains far below what was originally envisioned. The LHCC will get a more detailed report on the status of the TRD production at its next session with ALICE in December 2013.

As part of the consolidation efforts, the electronics of the T0/V0 interaction trigger will be relocated to the C-side rack in order to reduce the time to deliver the trigger signal to the TRD. The TRD requires a pre-trigger that currently cannot be delivered by the standard T0/V0 trigger in time. In this scenario, the Level-0 trigger and pre-trigger are not fully correlated. The move shortens the present trigger signal by 200 ns, enough to synchronise the Level-0 and the pre-trigger. The required Central Trigger Processor upgrades are currently under development.

At the highest luminosities in proton-Pb collisions in 2013, some chambers of the Time Projection Chamber (TPC) would occasionally go into a mode where self-sustained radiation-induced discharge currents made the chamber inoperable. Even if the chambers did not trip, the jumping voltages made the data from that particular chamber unusable (out of a total of 72 TPC chambers). The only remedy to recover the affected chambers was to turn them off for an extended period of time (hours). Although the problem was infrequent during the past run, leading to a very modest deterioration of a small fraction of the data, there is a concern that with increased luminosities in Run II, it could become a significant limitation of performance.

Since Argon is less prone to glow discharge than Neon, ALICE decide to move from Ne-CO_2 to Ar-CO_2 for the TPC for Run II. Argon provides a factor two more primary ionisation electrons, thereby allowing lowering of the gain by the same factor. Argon also has 40% less gain fluctuations. The downside of this switch is the larger radiation length of Argon, which increases the multiple scattering. Argon ions are also considerably slower (factor ~2.5) thus requiring longer gating grid closing times to control the increased space charge induced distortions. As a consequence, the read-out rate of the TPC will decrease from 3 to 2kHz. Simulations show that Ar-CO_2 will not affect the p_T-resolution. There is only a slight deterioration at very-low p_T, while at high-p_T Argon seems even to perform better than Neon. The gas system only needs a re-calibration of the flow meters. ALICE plans to verify the effect on the momentum resolution with cosmic-rays and lasers in 2014. Switching back to Neon, should this become necessary, will require 4-6 weeks.

In order to improve the read-out stability and increase the data rate of the TPC, ALICE is in the process of upgrading the RCU2 readout system. The schematics of the Read-out Control Unit 2 (RCU2) prototype are almost finished and an internal review has been done. The lay-out process is well under way. The collaboration aims for an external review of the lay-out and the schematics at CERN in October 2013. The aggressive time plan envisions the finalisation of the design by April 2014, mass production of the RCU2 units to be done by June/July 2014, and installation starting in September 2014.

Upgrades

ALICE is continuing to make excellent progress on the design and R&D of the new Inner Tracker System (ITS). All issues appear well understood. The overall lay-out and technologies for the main components are defined and their technical feasibility was demonstrated. The ALICE Collaboration will retain all four pixel-chip architectures (MISTRAL, ASTRAL, CHERWELL2, and ALPIDE) for the near future and intends to finalise its choice by mid-2014. These different architectures vary significantly in read-out speed and power consumption, which will affect the overall system design. Tests have established that all four architectures provide excellent charge collection and detection efficiency and adequate radiation hardness. Given the scale of the project, the ALICE Collaboration is **encouraged** to expedite converging on a baseline solution. Full-scale prototypes of the staves for the inner and outer layers have been developed and are now being characterised and optimised. ALICE intends to submit the ITS Technical Design Report at the end of October 2013, but plans to continue R&D until the end of 2014. Production is envisioned to start in Q2 of 2015.

The main goal of the TPC upgrade is to allow for a continuous read-out with 50kHz, a rate that cannot be achieved with the current gated Multi-wire Proportional Chamber (MWPC) read-out chambers. The technology of choice is a multilayer Gas Electron Multiplier (GEM) read-out. Earlier tests with triple GEM systems resulted in 3% or higher ion back flow (IBF). To keep the field distortions at a manageable level, the Collaboration aims at an IBF of 1% at an effective gain of 2000. This goal was recently achieved with a quadruple GEM system in a Ne-CO_2-N_2 gas mixture. Argon- based mixtures are excluded due to their low ion mobility. Despite this success, the upgrade remains challenging. The space charge distortions have a temporal dependence plus large fluctuations due to multiplicity fluctuations and pile-up (~5 in Pb-Pb in Run III). Simulations conducted by ALICE show that at small r and z distortions reach dr = 20 cm and drφ = 8 cm at IBF~1%. Consequently, correction of the hit position will be required to maintain the nominal resolution. Due to the large fluctuations, ion space-charge maps will need to be updated on a time scale of ~1ms. Studies by the Collaboration show that the currently-achieved parameters for momentum and dE/dx resolution can be preserved. Due to the enormous data flow of ~1 TB/s at 50kHz the data has to be reduced to a manageable 20 GB/s rate to mass storage. ALICE aims to achieve this through a complex online reconstruction scheme that includes hit finding and tracking; hits not assigned to tracks and raw data get discarded. Consequently, the online reconstruction will have to include some form of distortion corrections, complicated by uncertainties in the drift time due to pileup. ALICE developed a two-stage scheme that does not require an external start time for the TPC, i.e. a “self-calibrating” procedure. In the first stage, cluster finding and tracking is performed with an average space charge map yielding a resolution in the order of 1 mm. Hits and tracks are written to permanent storage. The data is then further refined online in a second stage where tracking is redone using a high-precision space charge map in conjunction with external tracking information from the ITS. This scheme was validated by a toy Monte Carlo including continuous read-out conditions, event pile-up, vertex spread and space charge distortions. ALICE intends to submit the TPC upgrade Technical Design Report end of October 2013. R&D will continue with a focus on large-pitch GEMs, studies of faster gas mixtures (CF_4), and tests of alternative technologies such as MicroMegas and COBRA GEMs.

The LHCC **encourages** the ALICE Collaboration to establish the maximum level of distortions/IBF that can be tolerated without degrading tracking efficiency and momentum resolution. The Committee also recommends to continue detailed tests of all aspects of the online reconstruction scheme via realistic simulations to verify that the Stage-I reconstruction can indeed be performed without any dead time and that it provides the required tracking efficiency.

The ALICE electronics and trigger upgrade is necessary to adapt to the upgraded detectors and achieve a recorded data rate of 50kHz with a design margin of 100kHz for the read-out. The upgrade is complex since only the TPC, ITS and the muon chambers allow for a continuous trigger-less read-out, while all other subsystems require a valid trigger (e.g. EMCAL, PHOS, and the Time-of-Flight detector TOF). The upgrade requires many new electronic components, among them a new (simplified) Central Trigger Processor, a common readout unit (CRU) for the new/upgraded detectors, and detector data link (DDL) units. The CRU is based on the LHCb AMC40 read-out board. ALICE decided to place the CRU in the control room rather than in the cavern. The TPC is the cost-defining factor for the optical fibres. The overall scale of the upgrade is significant and is driven by the need for 4320 new front-end cards with 17,000 SAMPA chips for the TPC and 33,000 for the Muon System. The design of the SAMPA ASIC chip is in progress; first prototypes should become available in a few months. The Collaboration intends to submit the electronic and trigger upgrade Technical Design Report by the end of October 2013.

The LHCC discussed the Addendum to the Letter of Intent by ALICE for a Muon Forward Tracker (MFT). The proposed tracker consists of five planes of CMOS pixel sensors covering most of the muon spectrometer acceptance before the absorber. The matching of tracks from the Muon System to the MFT clusters allows the discrimination between prompt and displaced muons and improves the angular resolution, thus substantially enhancing the mass resolution of dimuons. To lower the cost, the proposed MFT is using a similar technology as the ITS (e.g. MAPS technology and read-out). The physics case is strong and it focuses on the Pb-Pb programme. The main drivers are quarkonia studies (J/ψ, ψ'), heavy-flavour measurements through semileptonic B- and D- decays, as well as $B \rightarrow J/\psi+X$ decays, and the measurement of low-mass dileptons. These probes allow the study of many aspects of the Quark-Gluon Plasma, such as deconfinement temperature, heavy quark transport coefficients, heavy-quark thermalisation, and chiral symmetry restoration. These measurements complement the physics programme of the ALICE central barrel. The LHCC **congratulates** ALICE in view of the Letter of Intent and endorses the MFT upgrade plan. The Committee encourages further studies towards the upgrade and is looking forward to receiving the Technical Design Report.

8. DISCUSSION WITH LHCb

General Summary

The LHCC considers that LHCb has made excellent progress in all aspects of the experiment and the Committee **congratulates** the LHCb Collaboration on its achievements.

The Committee took note of the following:

- Long Shutdown 1 activities proceed as planned and without major issues.
- Physics output and production pace are advancing well.
- Milestones for the LHCb upgrade are being followed as planned.

- Technology choices done for the Vertex Locator VELO (microchannel-cooled pixel) and for the Ring Imaging Cherenkov RICH (RICH-1 and RICH-2 with MAPMT);
- Submission of Technical Design Reports for VELO and Particle Identification is expected for December 2013, while the Technical Design Reports for the Inner Tracker / Outer Tracker and Fibre Tracker are expected for March 2014.

Physics

The LHCC **congratulates** the LHCb Collaboration for their high-quality scientific results. The Collaboration keeps producing very high-quality scientific papers at the rates of about 20 articles per three months. The most recent results include new observables in $B^0 \rightarrow K^*\mu\mu$, charm mixing and CP violation with $D^0 \rightarrow K\pi$, the measurement of the Λ_b lifetime and observation of the new decay $B_c^+ \rightarrow B_s\pi^+$. As a novelty, the LHCb Collaboration is aiming to produce the first joint papers with other LHC collaborations. For instance, the LHCb/CMS combination of the branching ratio measurements of $B_s \rightarrow\mu^+\mu^-$, $BR(B_s \rightarrow\mu^+\mu^-) = (2.9 \pm 0.7) \times 10^{-9}$, has strengthened the 4σ observation of LHCb and the 4.3σ observation of CMS. The plan is to update this work with a combined fit to the two data sets and then publish the result in *Nature Magazine*. Similarly, the measurement of the J/ψ production in proton-Pb collisions, both from prompt decays and from B-mesons, will end up in a combined paper with ALICE. Although much effort is dedicated to the LHCb upgrade, the Collaboration is still working to keep a very high paper production during Long Shutdown 1 (LS1), and more than an additional one hundred papers are expected.

Long Shutdown 1

The consolidation program of LS1 is proceeding well. The major interventions planned in this period are the preparation of additional shielding behind the M5 stations, completed at the beginning of September 2013, and the improvement of the primary cooling plant for the Inner Tracker / Outer Tracker systems, where an additional chiller has been installed and tested under pressure. Final commissioning of the cooling plant is under way. Moreover, the consolidation of the Dipole Magnet, consisting in the replacement of the protection between the magnet coil and its support brackets, is also proceeding well. A dedicated R&D programme has resulted in the choice of the suitable material, EPDM-PTFE stacks, which can sustain the mechanical deformation of the coil when cycling the magnet. A contract has been issued to procure it. There are also many additional interventions to be made regarding more standard detector improvements, such adding redundancy on the muon high-voltage system and fixing all ground connections. Similarly, for the Ring Image Cherenkov (RICH) detector, it is planned to open the boxes to permit the replacement of malfunctioning or broken Hybrid Pixel Detectors (HPDs). On the longer term, there will be also the replacement of the plastic fibres, which bring the LED light for the calorimeter calibration, to quartz fibres, in order to make them resistant to higher doses. In the meanwhile, dedicated commissioning weeks, when the full detector is turned on and read-out to check overall functionalities, are being held. The LHCC finds that the consolidation programme proceeding as planned without specific problems or delays.

Upgrades

The LHCb upgrade is progressing according to schedule. Out of the 42 expected, 34 milestones have been reached, where three of the missed milestones so far were not on the critical path.

Major steps were taken in the previous months with the choice of technology for the upgrade of the Vertex Locator (VELO) and Ring Imaging Cherenkov (RICH) detectors and with a continuous effort to complete the Technical Design Reports (TDRs). The VELO and Particle Identification (PID) TDRs, incorporating the RICH, Calorimeter and Muon detectors, should be ready for December 2013, while the TDRs for the Tracker (UT, CT) and Low Level Trigger (LLT) are expected for March 2014. In the meantime, the LHCb Collaboration is still growing by adding the Kurchatov Institute (Russia) as a new Associate Member. At present, the Kurchatov Institute provides a strong technical contribution to the Fibre Tracker and there is great potential for this institute becoming a new strong member. From the financial point of view, negotiations with Funding Agencies proceed well. Many members have responded positively, while negotiations are still in progress with the United Kingdom, USA and Russia.

For the VELO upgrade, LHCb selected the micro-channel-cooled Pixel technology. The decision was approved by the Collaboration in July 2013 after a dedicated Upgrade Technology Review (VUTR) at end of May 2013 and related upgrade meetings and technical boards. Four options were compared with the same upgrade simulation tools, equivalent foil thicknesses and minimum inner radius. In contrast to the current VELO, all options have integrated cooling. The material budget was similar between options with the Strips, which, however, showed a worse φ-dependence than Pixels due to overlapping foils at large angle. The impact parameter resolution and the efficiency were in all cases better than the current VELO, with the Pixels showing better performance than the Strips. On the other hand, the Strips show a secondary vertex resolution that is 20% better by having the first measured point slightly closer than the Pixels. However, this translates, via dilution, to a 15% statistical advantage and has still to be weighed by the difference in tracking efficiency. The decision on the Pixels was supported by all the Collaboration and was based essentially on two considerations: a) radiation effects have small impact on the efficiency and resolution and b) the track reconstruction performance was much faster than in the Strip option (7.6 ms/event to 2.8 ms/event). The report of VUTR referees indicated no show-stopper for any solution but **encouraged** to work on sensor prototyping and radiation hardness and recommended to make a risk assessment for the micro-channel cooling. The VUTR referees also observed that the VELO upgrade construction schedule is very tight. Since then, much progress has been made. The module lay-out has been improved and design of cooling connectors and the connectors' fixture are complete. Many tests were carried out such as that for the performance of micro-channel cooling and for the read-out via Timepix-3 chips. Prototyping of sensor and bump-bonding have been also carried out. A dedicated electronic review is planned for November 2013.

The final configuration choice has been made also for the RICH system: the RICH-1 and RICH-2 will be kept by modifying only the optics and mechanics of RICH-1, where the aerogel part will be removed. The opto-electronic chain will instead be upgraded for both RICH detectors in order to sustain the 40 MHz read-out rate. The RICH-1 mechanical modifications reduce occupancy and improve optical errors and consist of a larger radius of curvature for the mirrors, from 2.7m to 3.8m, and in smaller angular tilts. Performance studies are still being carried out as a function of various optics and optimisation on the photo-detector plane position and angular tilt. LHCb has shown by simulation that, with the version V7g of the optimised optics, the performance of the upgraded RICH, at 2×10^{33} cm^{-2} s^{-1}, will be practically equivalent to the actual one running at 2×10^{32} cm^{-2} s^{-1}. This corresponds to an improvement of a factor of five of the pion misidentification efficiency for standard values (90%) of kaon identification efficiency. For the photo-sensors, LHCb confirms the choice of 64 pixel MAPMT connected to custom front-end amplification chips and then to a read-out motherboard with a GBT link. The choice between CLARO and

MAROC chips has not yet been made. The lay-out of the photon detector module (number of PMTs/module and of Chips / motherboard) is also being updated.

Detailed status reports have been shown on the Fibre Tracker (FT) tracking reconstruction and data processing. The technology choice of a central tracker done with fibres, FT, with respect to the combination of an IT (silicon strips) and OT (straw tubes) is still under way. A review is planned for 27-28 November 2013. The viability of the fibre and SiPM choice has been discussed already in the meeting of March 2013, where the ionisation (neutron) damage to fibres (SiPM) has been shown. In the last months, this result has been consolidated with additional measurements. The FT consists of three stations (X-UV-X) of 250 µm diameter and 2.5 m long fibres organised in 5 layers/station, thus offering a very homogeneous and fast tracking system. The FT, however, presents many challenges such as a very large dimension, a high number of fibres (equivalent to 10.000 km length), a high precision in the mounting, the need for a light and precise support system, complicated cooling and electronics integration. Much progress has been shown on the stacking of four layers of 2.5 m long fibres done by means of a winding machine. The method is still not final, since few failures have been observed when producing prototype layers. Alternative stacking techniques are being developed. The integrated neutron flux on the SiPM should reach 6×1011 n cm^{-2} thus increasing the leakage current to unacceptable levels. For this reason, the SiPMs will be cooled to -40 °C. Thermal simulations and mock-ups are being developed.

The tracking reconstruction have been studied in various combinations with a more realistic simulation of the upgrade conditions: i) long tracks with VELO + FT, ii) upstream tracks VELO+UT and iii) VELO+UT extrapolated to FT to improve speed and reduce ghost rate. The conclusions are twofold: (a) efficiency (ghost rate) do not get degraded (increased) when simulating a pile-up corresponding to a luminosity from 1 up to 2 times 10^{33} cm^{-2} s^{-1}, (b) the pattern recognition is very fast from 5 to 10 ms showing that is possible to track most of the events on High-Level Trigger (HLT) level.

A status report of the data processing has also been presented. An evolution of the data processing is under way. Two options are still on the floor. A fat-core Event Builder, as described in the Framework Technical Design Report, called a new Uniform Event builder where the distance between DAQ components is reduced and the AMC-40 boards are replaced by read-out boards based on commercial PCI express link hosted on PC. In this new proposed version, an all-PC server battery will be in a building on the surface and fibre optics have to be routed from the pit to the surface. Test of OM3 versus OM4 fibres was successful showing that fibre length of 400 m are possible and the cost will remain within estimates. The biggest gain of the new option is that of allowing running at 20 MHz after LLT instead of 10 MHz for the same cost.

9. DISCUSSION WITH TOTEM

General Summary

The LHCC considers that TOTEM has made excellent progress in all aspects of the experiment and the Committee **congratulates** the TOTEM Collaboration on its achievements.

The Committee noted progress in the consolidation and upgrade of the TOTEM experiment. The CMS Collaboration has endorsed a common physics programme with TOTEM. A critical item in the upgrade programme, whose definition needs the most urgent action, is the housing for the Roman Pots that will host the upgrade detectors. The LHCC also took note of a new upgrade effort, relevant for the TOTEM-specific physics programme, aimed at reducing the pile-up induced background during special runs with large β^*, using timing information in the vertical Roman Pots.

Consolidation and Upgrades

The TOTEM consolidation and upgrade programme, as presented in the TOTEM Upgrade Proposal, includes several components. The consolidation part, specific to TOTEM and to be completed during Long Shutdown 1 (LS1), was endorsed by the LHCC in previous meetings and is currently under way. The upgrade component concerns a future physics programme dedicated to the study of central diffractive systems, to be carried out together with CMS. The corresponding upgrades of the TOTEM detectors, services and infrastructure are still under definition by a joint CMS/TOTEM study. Finally, to enable the deployment of the upgrade during the first Technical Stops of Run II, and to allow for the upgrade physics programme to take place during Run II, detector placeholders need to be designed, built and installed during LS1.

The consolidation work is so far on schedule. The Roman Pot detectors, which had been removed already before the LHCC session in June 2013, have been refurbished and are being readied for reinstallation. Vacuum tests, following the placement of the new ferrites, are to be scheduled. The Roman Pot stations at 147m have been removed, and will be reinstalled in the 200-220m region. Tests for the rotation of the nearest Roman Pot have been successfully performed in the H8 beamline of the SPS. The relevant Engineering Change Requests (ECRs) have been completed and submitted for approval. Cabling work has been completed on schedule, and other service works relative to the future relocation of the 147m stations (surveys, cooling lines, etc.) are being scheduled. ECRs have been also completed and submitted for the installation of new collimators - TCL4 and TCL6, respectively at 147m and behind the furthest Roman Pot station at 220m. The LHCC supports the request for the installation of TCL6, if this is ultimately deemed beneficial to the operation of the Roman Pots. While there does not appear at this time to be any item on a critical path, the LHCC would like to have access to the formal schedule that is driving all operations related to consolidation, with a precise definition of tasks, resources and deadlines.

The LHCC took note that the CMS Collaboration has endorsed the common physics programme with TOTEM. This will demand the realisation of new timing and tracking detectors, to be installed during a Technical Stop during Run II. CMS and TOTEM will first develop a Memorandum of Understanding (MoU), to define the respective responsibilities and the process to select the detector technologies and designs. The LHCC welcomes this development, and looks forward to the swift approval of the MoU and to receiving a concrete Technical Design Report from the CMS and TOTEM Collaborations addressing the ensemble of carriers and detectors for the upgrade.

A critical item in the upgrade programme, whose definition needs the most urgent action, is the housing for the Roman Pots that will host the upgrade detectors. These need to be installed during LS1, in order to be ready to receive the new detectors when available, during a Technical Stop during Run II, and allow the start of the physics programme. TOTEM, with engineering support from CMS, has started the design and prototyping of new cylindrical Roman Pots, designed to host any among the candidate detector technologies. Impedance calculations have been documented, as discussed in the TOTEM Upgrade Proposal, and evaluated as acceptable. Measurements on a prototype are deemed necessary to validate such calculations. A prototype has been built that will test its mechanical properties. An improved prototype must be built to allow for a more complete set of measurements prior to a final construction. Given that the final Roman Pot must be ready for installation before the beam bake-out - scheduled for the latter part of 2014, this preliminary step of the upgrade programme is now on a critical path. The LHCC invites TOTEM and CMS to converge as soon as possible on the design of the cylindrical Roman Pots to procure the relevant prototypes, to carry-out the tests, and enable the timely construction and installation of the final systems.

The LHCC also took note of a new upgrade effort, relevant for the TOTEM-specific physics programme, aimed at reducing the pile-up induced background during special runs with large β^*, using timing information in the vertical Roman Pots. This will enable TOTEM to take data during large-β^* runs (e.g. β^*=90m) with a luminosity increased by up to a factor of 10 larger than nominal. The LHCC welcomes these new studies, which are currently in an R&D phase.

10. REPORT FROM THE UPGRADE COST GROUP (UCG)

The Chairperson of the Upgrade Cost Group (UCG) reported on the group's launch. He provided details on the UCG's mandate, composition, procedure for reviewing and the reporting lines. The UCG will review all upgrade-related costs planned and incurred by the LHC experiments for their upgrade projects for the period after the Long Shutdown 1 (LS1), including the availability of manpower and infrastructure support to assure the timely completion, installation and commissioning. The UCG will meet adjacent to the LHCC meetings and each meeting will attempt to focus on Technical Design Reports involving similar technologies. The reports issued by the UCG will take the format of findings, comments and recommendations to the Research Board. The UCG's meeting in December 2013 will address the Trigger/DAQ Technical Design Reports of ATLAS and CMS.

11. REPORT AND DISCUSSION WITH THE WLCG REFEREES

Introduction

The LHCC **congratulates** the experiments and the WLCG team for building, maintaining, and exploiting the very solid computing environment for the LHC computing.

The Committee took note of the draft document submitted by the WLCG to the LHCC, which has the objective to clarify the evolution of the computing models from their original definition in the Technical Design Reports as a consequence of the extensive experience gained during Run I, but also following a voluntary decision to optimise the computing models in view of Run II.

Status of the WLCG

The LHC computing is operating stably and efficiently. The used resources are, however, regularly exceeding the pledges and efforts to improve the efficiency of data processing and analysis dominate current work of the WLCG. These efforts, together with future plans for LHC computing, are described in a draft document submitted by the WLCG to the LHCC. This draft document, requested by the LHCC in December 2012, was thoroughly discussed during the September 2013 session of the LHCC with the WLCG and the experiments computing coordinators. The Chair of the RRB Computing Resources Scrutiny Group (CRSG) followed the discussion remotely.

The document has the aim to clarify the evolution of the computing models from their original definition in the Technical Design Reports as a consequence of the extensive experience gained during Run I, but also following a voluntary decision to optimise the computing models in view of Run II. A non-negligible pressure from the available resources profile, assumed to be flat, was taken into account, although the quantity of collected data is expected to increase dramatically from 2015. The crucial parameters are the primary High Level Trigger (HLT) accept rate; event data streams for analysis, calibration and for archive-only purposes; and the event size at the various levels and streams. Efforts are deployed to improve code, core computing and data management. New possibilities to extend and enhance the classical computing models are introduced: fluidisation of the data distribution between Tier levels, projects to adapt the software to incoming technology (multi-core, cloud computing, fast networking), opportunistic access to external computing resources etc. The WLCG will continue to ensure a constant and efficient support for the experiments via the existing working groups, as well as within forums devoted to new computing paradigms (for instance concurrency forum). The idea of a software collaboration has been mentioned and the contours of it will need to be clarified with the LHC experiments and other adjacent collaborations (e.g. GEANT4) and forums which might be interested in such a structure. A thorough survey of the hardware evolutions is also included and used to estimate the performance evolutions expected on the hardware used for LHC computing. The breakdown by physics goals of the HLT output rate expected for Run II has not been intensively discussed so far with the LHCC. A detailed presentation of the choices made to justify the requested output data flow is highly desirable as a part of this document. The request for resources for each experiment have been recalculated taking into account the improvements in computing models and the reasonable hypothesis about the progress expected on technology in the next few years. The requests do fit for 2015 within a flat budget extrapolation, however the evolution for the longer term is less certain since all ingredients are expected to evolve rapidly, including possible large needs for computing corresponding to increased precision in data analysis after 2016.

The LHCC would like to **congratulate** the experiments and the WLCG team for building, maintaining and exploiting the very solid computing environment for LHC computing, which has been the basis for the exceptional physics results obtained by the experiments. The LHCC notes the successful efforts to improve the performance of the computing models, both within each collaboration and as common work. The LHCC recognises, in particular, the projects to simplify and streamline the data access and processing, with significant impact on resources requests. The document summarising the evolution of the computing models is an important milestone towards the next physics run and the boost in performance and luminosity at LHC. The document is expected to be submitted in its final form and discussed by the LHCC in its session of December 2013. The LHCC **recommends** that the hypothesis of flat future resources be removed from the assumptions; instead physics-motivated needs should be stated. The optimisation work towards best physics output should continue with the same momentum as in the past year, in parallel and beyond the preparation for the data taking restart in 2015. In particular, the LHCC **encourages** the continuation of the intensive collaboration amongst the experiments and with WLCG on topical issues, the exchange of methods and the sharing of software frameworks. In parallel with the planning work for the upgrade Phases I and II, the experiments should also clarify the timelines for defining consolidated models for computing.

12. TEST BEAMS

The PS and SPS Physics Co-ordinator reported on the LHC test beams. Much work is currently on-going in the LHC accelerator injector chain during Long Shutdown 1 (LS1). New irradiation facilities are under construction – a) PS-Irrad (proton and mixed field at the PS) and b) GIF++ (gamma and muon beam at the SPS). The 2014 fixed-target physics programme will resume on 15 July 2014 for the PS and on 13 October 2014 at the SPS. Significant overbooking of bean time is expected. The call for beam time will be 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. In 2015, an initial period of six weeks of Ar-ion beams for physics to the North Area will be followed by the completion of cabling works in the SPS and a proton fixed-target run.

13. 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

14. The LHCC received the following documents:

CERN-LHCC-2013-010 RD on 3D Sensors and MicroFabricated Systems

CERN-LHCC-2013-011 CMS Technical Design Report for the Level-1 Trigger Upgrade

CERN-LHCC-2013-014 Addendum of the Letter Of Intent for the Upgrade of the ALICE Experiment: The Muon Forward Tracker

CERN-LHCC-2013-016 MEMS sensors and Vertically Integrated Micro-Fabricated Systems

CERN-LHCC-2013-017 ATLAS Liquid Argon Calorimeter Phase-I Upgrade Technical Design Report

CERN-LHCC-2013-018 Technical Design Report for the Phase-I Upgrade of the ATLAS TDAQ System

DATES FOR LHCC MEETINGS

Dates for **2013**

4-5 December

Dates for **2014**

5 - 6 March

4 - 5 June

24 - 25 September

19 - 20 November

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