CERN-RRB-2013-013 REV
15 APRIL 2013

PRINCIPAL LHCC DELIBERATIONS

36TH MEETING OF THE CMS RESOURCES REVIEW BOARD

15 APRIL 2013

EMMANUEL TSESMELIS

SCIENTIFIC SECRETARY, LHCC

GENERAL

This document summarises the principal LHCC deliberations concerning CMS at the Committee's sessions in December 2012 and March 2013.

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. The highlight of the recent period has been the further understanding of the recently-discovered new particle that is consistent with a Higgs boson.

CONCERNS FROM THE PREVIOUS CMS RESOURCES REVIEW BOARD

No major concerns were reported to the previous CMS Resources Review Board.

STATUS OF THE EXPERIMENT

PHYSICS

CMS has an aggressive agenda for harvesting the full 2011-2012 dataset for physics. CMS has solid plans for accomplishing the major physics objectives. Forty analyses were approved for the 2013 Moriond conferences with another eighteen analyses expected to be approved imminently. CMS has 224 publications, with 18 in preparation, and has completed a long-range assessment of analyses that will be taken to publication. Timely completion of full dataset analyses with final alignments and calibrations is a priority to enable groups to shift effort towards preparations for LHC Run II as the shutdown progresses. Preliminary combined CMS and TOTEM results on diffractive dijet production and inelastic $dN_{ch}/d\eta$ are expected before summer 2013.

OPERATIONS

The CMS detector reached the end of LHC Run I operating well. CMS has completed a very successful 2012 proton-proton run, during which the LHC machine delivered an integrated luminosity to CMS exceeding 23 fb^{-1}. A very important few days of low-energy proton-proton running at the start of 2013 and proton-proton collision data with 25 ns bunch spacing were also accumulated.

The positive effect of the CMS automated recovery campaign to improve overall data-taking efficiency is clearly seen in the 2012 proton-proton data collection, where 93.5% of the luminosity delivered by the LHC to CMS was recorded (compared with 90.5% in 2011). It is encouraging to note that the Level-1 Trigger and the High-Level Trigger (HLT) were able to run with negligible dead-time up to the highest luminosities, always with full physics acceptance. 94.8 % of the recorded 2012 data have subsequently been certified as golden quality. For the 2013 proton-Pb data collection, 98.2% of delivered luminosity was recorded, with 97.5% of this recorded data certified as golden. Similar figures of 98.2% (98.4 %) were achieved for the 2013 low energy proton-proton data. The Physics Performance and Datasets (PPD) group had a big impact in its first year of existence. The PPD coordinated and reviewed the validation efforts of the Detector Performance Group (DPG) and the Physics Object Group (POG) to assure a high certification efficiency and physics performance.

The Long Shutdown 1 (LS1) is underway and the CMS detector is being opened up.

COMPUTING

The data reprocessing is on schedule with 20k processor cores used in parallel at the Tier-1 centres plus the CERN Tier-0 resources. There has been some reconfiguration of several of the larger Tier-2 centres to accommodate reconstruction of simulation events. On another note, the prototyping activity using the HLT resources as a Cloud to provide additional resources at the scale of an additional Tier-1 during the shutdown is making significant progress. This activity has involved collaborations with ATLAS and Cloud middleware providers. In parallel, CMS is conducting its first test of large scale opportunistic computing temporarily using 8k processor cores at the San Diego Super Computing Center to process some of the 2013 parked data.

On 21 February 2013 Academia Sinica, Taipei, informed the CERN Director-General that they intended to withdraw support for CMS as a Tier-1 and as a Tier-2 at ASGC due to a loss of some funding and a lack of CMS physicists in Taiwan.

LONG SHUTDOWN 1

The work scheduled for LS1 is considered an underpinning for the long-term operation of CMS. The programme of work has the following major elements: (1) muon upgrades, including the installation of the 4th layer end-cap Cathode Strip Chamber (CSC) and Resistive Plate Chamber (RPC) detectors and the YE4 shielding wall, plus the upgrade of the M1/1 CSC front-end electronics and displacement to outside the cavern of part of the electronics of the barrel muon Drift Tube detector; (2) the first stage of the Hadron Calorimeter (HCAL) phototransducer consolidation/upgrade (for the Hadron Calorimeter Outer HO and the Hadron Calorimeter Forward HF); (3) installation of the 45mm outer diameter beam pipe, necessary for the subsequent Pixel Tracker upgrade; and (4) installation of optical splitters in the Electromagnetic Calorimeter (ECAL) and 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 which has reached the end of its life cycle and the support of sub-detectors with new μTCA back-end electronics.

The highlights of the on-going work include reviews of the CSC upgrade. The ME4/2 construction is going well and some concerns were identified with the ME1/1 construction, notably, the feasibility of the cabling plan due to a choke point on the nose. Additionally, some patch panels and read-out boards still need to be produced. For the chambers themselves, the increased current leads to a small low voltage margin that constrains future firmware. The status of the RPC upgrade is that 17 RE4 chambers have been produced at CERN and in Ghent. The preliminary test of those chambers demonstrates a plateau and very low current and noise.

The components for the replacement of Photomultiplier Tube (PMT) and Silicon Photomultiplier (SiPM) photon detectors for the HF and HO are at CERN and are undergoing quality control. The μTCA back-end electronics had a successful slice test using prototype boards in parallel with the regular data stream using optical splitters during the proton-Pb run.

A key priority for the shutdown is enabling the Tracker to eventually operate with a coolant 30 degrees colder than its current operating temperature. This intervention, designed to mitigate the damaging effects of radiation, is an essential part of the programme aimed at maintaining the

performance of the tracking system up to a delivered integrated luminosity of around 500 fb^{-1}, after which replacement will become necessary. The preparatory work is going according to plan. The refurbishment of the cooling plant is going well and installation of new racks and pipe distribution and dedicated sniffer lines are on schedule. The new high performance dry gas plant has arrived at CERN and vapour barrier sealing concepts have been developed. In addition to this work, the shutdown period will be used for maintenance of the existing Pixel Detector, to evaluate the installation of a new Pixel Detector, and to get the evaporative cooling infrastructure ready for the new Pixel Detector. The aim is to be able to install the new Pixel Detector in an extended year-end Technical Stop in 2016-2017 within a period of about 4.5 months.

Radiation levels in the pit are a hindrance but not a concern. The individual dose levels in the first few weeks were well within the target range. However, decay times have been measured that are longer than expected, indicative of the presence of unknown materials.

Preparations for Run II are well underway with programmes of work being established by the technical and physics analysis groups. The HLT group has begun reviewing the online reconstruction of physics objects, aiming at improving their resolution and bringing it closer to the offline level, thus reducing the impact of tighter cuts. The use of more advanced algorithms may require an increase in the computing power of the HLT filter farm. With the improved algorithms in place, work in 2014 will be devoted to the physics filter optimisation and menu design. Additional dedicated manpower will be assigned during this time period to update infrastructures such as DAQ-related interfaces and configuration database infrastructure.

A high priority task for the Offline during LS1 includes rewriting of the core software to support different levels of parallelism to make better use of emerging computer architectures. Plans to improve the simulation include optimising CMS's use of Geant4 as well as commissioning data mixing (to simulate pile-up effects) for the FastSim and finishing the implementation for FullSim. Development is also needed to support physics and detector studies for the Phase-1 and Phase-2 upgrades. In terms of adapting algorithms for higher luminosity and energy, there will be new tracking algorithms and tuning of existing ones. The algorithm that only uses silicon clusters for seeding the iterations, for example, is under evaluation for the effect of increasing the tracking cluster charge thresholds. Such modifications will have consequences that will lead to retuning the tracking and Particle Flow algorithms.

For Run II, CMS is currently preparing for the possible need to continue to write out data from the HLT at 1 kHz in order to preserve thresholds, particularly for the Higgs research programme. The ramifications to the offline computing are estimated to be roughly a factor of 12.5 increase in offline CPU due to changes in the beam conditions. To counteract that factor in the context of the CMS request for computing resources submitted to the Computing Scrutiny Group and the CMS Resources Review Board, CMS anticipates algorithmic improvements as well as a limiting of full dataset re-processing to year-end technical stops. The latter provides stability for analyses while enabling the use of some Tier-1 resources for prompt processing during data collection. Other compromises could include reducing the number of Monte Carlo events generated per logged event and using the HLT farm as a computing resource during the year-end Technical Stops. These and other anticipated improvements leave the net effect of a factor of two increase needed for the Tier-0 and Tier-1 CPU plus ~30-50% for Tier-2 in 2015 plus a modest increase in storage. As the needs for 2014 are modest, the increase could be accommodated by combined spending of the 2014 and 2015 computing budgets in 2015.

Several other computing system activities are planned for the long shutdown to achieve a more flexible computing system such as deploying an *xrootd* based data federation that will allow sites to fall back to an alternate location while allowing users to interactively access anything stored on disk.

Improved disk management at Tier-1 centres could increase the flexibility of where workflows can run, and to allow opening the Tier-1 centres for analysis workflows. Additional automation of data management could achieve a more dynamic system.

UPGRADES

Technical Design Reports (TDRs) for the proposed upgrades to the Pixel Tracker and to the electronics of the HCAL were presented to the LHCC in September 2012, providing a complete and comprehensive roadmap for delivering the detectors. The last TDR, the Level-1 Trigger System TDR, has been reviewed by the CMS Collaboration and is currently being prepared for wider distribution after responses to the Collaboration comments are incorporated. Additionally, physics studies with a realistic trigger menu are being completed. The document contains a complete technical description. The motivation for the upgrade to the Level-1 Trigger system is to preserve excellent performance for searches, precision Higgs studies and heavy-ion physics during higher luminosity running expected after LS1. The TDR outlines projected trigger rates and representative physics studies to demonstrate the need for the upgrade. The Level1 Trigger upgrade design calls for the signal splitting to be installed in LS1 to allow the new trigger to be developed and commissioned in parallel to operations. The project organisation, cost and schedule are summarised in the TDR and the cost & schedule are now under internal review. The TDR is expected to be delivered to the LHCC shortly and will be reviewed prior to its June 2013 session.

The fifth focal area is the preparation for the Phase-2 upgrades. CMS is developing detector concepts to serve as baselines for a Technical Proposal in 2014. The simulation efforts required to support this activity have begun with a target to produce samples during summer 2013 to test concept designs, with the possibility of studying a few benchmark channels. More comprehensive physics studies are expected in the Technical Proposal.

Additionally, CMS and ATLAS have jointly initiated the High Luminosity HL-LHC Experiments ECFA Workshop that will also include participation from LHCb and ALICE. The goals of the workshop include identifying key performance parameters and technical questions and establishing areas of technical focus for detector, triggering and computing R&D. Moreover, there will be discussions of the benchmarks necessary to estimate the physics potential and demonstrate Phase-2 scientific capability. A steering committee has been established and the meeting format currently includes a day-long organisational meeting in June 2013 with a three-day workshop planned for October 2013.

Finally, the LHCC reviewed the upgrade plans for the forward region. CMS is reviewing proposals to implement a high-precision proton spectrometer, which could include collaboration with TOTEM. The progress of this review process will be reported to the LHCC at its session in June 2013.