Status of CMS

Progress Summary Report for October 2009 RRB29

The CMS detector is ready for LHC beam now foreseen in mid-November 2009.

At the time of RRB28 in April, CMS was nearing completion of the shutdown program of maintenance and repair activities, as well as the installation of the preshower subdetectors. Analysis of 300 M events acquired in the six-week CRAFT08 cosmics run at nominal field of 3.8 T was well advanced. Recommissioning of the CMS detector and full data-flow path had already begun, albeit without the tracker, since the overhaul of its cooling system was still ongoing.

Since April, broad progress has continued largely as foreseen. With CMS closed in July and with the tracker operational, in July and August another set of 300M events was acquired in the CRAFT09 cosmics run at 3.8 T, as well as a large set of events with field off. Trigger, data acquisition, alignment/calibration, and prompt reconstruction were all extensively exercised. The forward region was re-engineered in order to reduce risk, and CASTOR was re-inserted. Meanwhile improvements in offline software, computing infrastructure, and physics analysis were implemented and demonstrated on several hundred million simulated events.

Installation and Infrastructure

Status

The 2008-2009 shutdown activities over 7.5 months included some 600 individually designated tasks involving 120 major logistical operations and 100 survey operations. The programme was completed while maintaining stringent safety standards, and largely according to schedule by working long days and on Saturdays as needed. Every major element of the detector had some maintenance or repair performed on it, with the forward pixels removed to the Meyrin site, repaired and re-installed, and with the preshower detectors installed for the first time. As noted in the Muon section below, 5 spare ME4 chambers were mounted in the ME4/2 region which was descoped in CMS construction.

An urgent, complex programme to protect the underground caverns (USC/UXC) against overpressure before high powering tests of LHC sectors 4-5/5-6 was completed, thanks to a very successful collaboration among CMS and multiple CERN departments.

Much was learned from several technical incidents such as faulty bearings in pumps, a poorly scheduled intervention on a HVAC circuit, gas/inertion incidents, and a leak in a cooling circuit. Each incident is examined in detail, and we continue implementing improvements to systems and procedures (within CMS and CERN-wide).

While nearly all magnetic field shielding issues have been resolved, there remains a portion of CASTOR for which the phototubes are in a region where the field direction is unfavourable for operation. The remaining challenge is to find a compromise between radiation shielding, CASTOR magnetic field shielding, and minimum forces and fields in the rotating shielding/triplet region.

Overall, the magnet and technical systems performance after shutdown was reasonable during CRAFT09, especially considering that the run was during the vacation month of August. Still, CMS is still looking for ways to improve. In general CMS is moving to operating procedures which not only continue to protect the detector but which also optimise its availability for collecting collision data.

After CRAFT09, a technical stop in September was required for the annual comprehensive cooling maintenance. During this time compatible activities such as survey and adjustment of the TAS and beam-pipe, rack turbine exchanges, and adjustments to the forward regions were performed. Final reviews of sub-detector beam-readiness and action matrices during beam operation are underway.

The result is that CMS is ready for sustained beam operation in the coming run, there remaining only the last steps before beam, notably pump-down of the beam pipe, which is postponed for safety reasons until the latest prudent date.

Meanwhile, as discussed below in the section on the Financial Plan, CMS plans for facilities at CERN for operation support, maintenance and upgrade are crystallizing.

Magnet

Status

After extensive preparations for magnet re-commissioning, the first ramp was on 10 July 2009. Upon reaching 1.2 T, there was unexpected movement of the +z (empty) CASTOR table. After further work on blocking movement in both directions, magnet re-commissioning was successfully resumed. The magnet was at the nominal field of 3.8 T for most of the CRAFT cosmics run in August.

After a site-wide 18 kV power cut caused by a thunderstorm, there was a fast dump of the magnet. The precise sequence of events and avoidance of such dumps in the future (including connection to storm warning network) is under review.

Commissioning

Status

Following the last RRB, CMS continued the regular weekly global runs lasting between 2 and 3 days, and in the period between July 23 and September 1 conducted the CRAFT cosmics run, taking data continuously with the solenoid at nominal field of 3.8 T most of the time. 320 million cosmics triggers were collected with field on and all tracking detectors included in the data, as well as 150 million triggers without magnetic field. The detector operated stably at Level-1 trigger rates in excess of 90 KHz.

Highlights of CRAFT run included: stress-testing the global data acquisition using Level 1 trigger rates comparable to that expected for the LHC (generated in part by random trigger generators); collecting a significant fraction of the triggers with the silicon strips readout in de-convolution mode (as opposed to peak mode), the mode we will use during LHC operation; exercising the LHC-like Tier-0 workflow of prompt reconstruction delayed by 48 hours in order to allow key prompt calibrations from tracker and muon systems to be computed and loaded in the database; exercising the LHC startup suite of Level-1 and High-Level Trigger menus (including loading of tight/pointing look-up tables in the muon trigger.

The live time of CMS integrated over the whole 6 weeks running period was 71%. Excluding the effect of service faults (such as power outages and cooling failures) the purely operational efficiency was 81%. Detailed investigations are ongoing on the reasons for the interruptions; some issues are already fixed and work is in progress for improving other areas. Typical causes were hardware faults (such as power supply failures) and firmware/control software problems. We expect to solve much of this last category of problems, and recover an additional 10% operational efficiency by the time of LHC operation.

Both endcaps were read-out completely (including the RPC on the negative side that was not previously fully commissioned). Since early July we have been acquiring data from part of the preshower, and since mid-August the whole preshower detector was read out along with the other CMS detectors.

Meanwhile, an important focus of all Detector Performance Groups (DPGs) has been the analysis of CRAFT data from 2008, with many results aimed for publication in JINST in a special volume containing over 20 CMS publications.

In addition, extensive new contributions and enhancements to the offline software algorithms used by the detector subsystems have been deployed in the CMSSW 3.x.y release series to be used with this year's LHC data-taking. The 3.1 release was ready in time for the CRAFT09 run, and the High-Level Trigger filters used during the run were based on this release.

The alignment and calibration studies have seen further improvement of the constants derived in the course of the analysis of the 2008 CRAFT cosmic run. For example, corrections in the magnetic field map have led to a whole series of updated database payloads. This updated set of conditions has formed a major input to a reprocessing of the whole CRAFT dataset, and has been the basis of data-taking with cosmic muons during this year's running. The favorable outcome of the CRAFT alignment and calibration campaign has also resulted in improvement of the misalignment and miscalibration scenarios that will be available for use in the mass production of Monte Carlo events with the new 3.1.X software release in preparation for the upcoming data-taking period.

Further discussion of many commissioning and Detector Performance Group (DPG) activities is included in the subdetector sections below.

Tracker

Status

A series of important milestones have been passed during the last 6 months. With the delivery of refurbished cooling systems, the Pixels and Silicon Strip Tracker (SST) have been brought back into operation after long shutdowns.

The Pixel system has been operating since re-insertion of Forward Pixels in April, and has been running at 4˚C since mid-May when the bulkhead thermal screen was commissioned. In mid-June the Strip Tracker was powered up in its entirety, with cooling fluid circulating at 4˚C, allowing commissioning to proceed at good speed.

Leak tests of the refurbished cooling plants after filling with C_6F_{14} coolant showed no significant leakage on either Pixel or SS1 (silicon strip 1) plants, with SS2 plant leaking at only 250 g/day. These figures mark a success in attaining the primary objective of suppressing the leaks at the cooling plants that were experienced last year. For the Strip Tracker, two cooling lines out of 180 were found to leak outside of the cooling plants and one line will certainly be kept closed.

The Silicon Strip Tracker and Pixel detectors were fully commissioned from mid-June to mid-July and participated successfully in the CMS CRAFT09 exercise from the start. During CRAFT09 about 9 M cosmic tracks in the SST have been collected with the front-end configured in "peak" and then "deconvolution" readout modes. Deconvolution mode confines the output signals from the front-end chips to a single bunch crossing, which is the intended mode of readout with beam collisions. The signal/noise and detector performance were both very stable during CRAFT09 (in agreement with expectations and reproducible with respect to CRAFT08). Special firmware for operating the strip

FEDs (DAQ readout boards) in "zero-suppression" mode has been deployed and it has been verified that the Tracker can be fully read out at a trigger rate above 100 KHz.

During a special test of the SS2 cooling plant, in which the correct procedures had not been followed, an overpressure in TIB cooling pipes deformed them sufficiently to touch sensors and induce electrical shorts. As a consequence ~ 0.4% of the Tracker modules will not hold the bias voltage. Various actions have been undertaken to prevent a repeat of the incident and, as is usual in such cases, the Technical Coordinator has convened an incident analysis panel.

The Tracker DPG activities focused on the software developments for the CMSSW 3.1 release, the preparation of data taking in CRAFT09 and with first collisions, and the final analyses and publications of 3 papers related to CRAFT08 data.

In the CMSSW 3.1 release, more realistic operating conditions of the Pixels and Strips have been implemented for Monte Carlo simulations. To improve the local reconstruction performance, the main improvements concerned the handling of the Tracker status from different origins: storage of noisy and dead Pixel channels in the calibration payload, use of DCS HV and LV status for the Strips, implementation of an online masking of noisy channels and protections against corrupted data at the FED unpacking. Additionally, for calibrations, new or improved parameters of the Pixels hits were introduced, while for the SST, the database transfer of the electronics optical gains is now available. Regarding the track reconstruction, new features include a pixel-less seeding, V^0 and dE/dx producers and a new sequence allowing track reconstruction down to a transverse momentum of ~ 100 MeV/c.

The first analysis of the CRAFT09 data shows improvements in the alignment precision with respect to the already excellent results of CRAFT08. It also shows, as expected, that the Pixel detector position has changed by about 100 μm as a result of extraction and re-insertion.

Electromagnetic Calorimeter

Status

Barrel and Endcap Crystals: Data were collected with both the endcap and the barrel calorimeters. The barrel calorimeter trigger was operational for all of CRAFT. The endcap calorimeter trigger system, comprising the trigger concentrator cards (EE-TCC) and selective readout processor (SRP), was commissioned during the running. As the EE-TCCs were only partially installed during CRAFT (because of manufacturing delays), only the commissioning of the trigger for one of the endcap calorimeters (EE+) was completed in time for it to be operational for the last three weeks of data taking. After CRAFT the EE- TCC installation was completed and commissioning is underway. During the CRAFT running the complete monitoring sequence, which consists of laser and LED light injection to the crystals and a test pulse input to front end electronics, was included within the data stream, with approximately 4000 complete cycles completed. Results from this data show stability at the one part per thousand level.

Analyses of ECAL CRAFT08 data have been finalized and are being written up for publication. Several system aspects have been tested, including thermal stability and stability of the transparency monitoring. Noise characteristics and system stability agree with specifications on average. The correctness of the energy scale and a coarse validation of the inter-calibration have been achieved with cosmic muon signals in ECAL barrel; last year's beam splash data have been exploited to reduce the residual miscalibration in the endcaps at startup.

Preshower: The installation of the two ECAL preshower detectors, which are placed in front of the endcap calorimeters, was completed in April. Apart from some optical ribbons that had to be replaced, the process went rather smoothly. All power supplies were installed and operational and the cooling system is fully functional with no significant leaks. Only 66 of the 137000 channels were found after installation to be non-operational. Some of the Preshower Data Concentrator Cards failed in production and these were replaced by the manufacturer, allowing both preshower detectors to be fully commissioned by the end of September.

Hadron Calorimeter

Status

HCAL has participated in all global runs during 2008 and 2009 and verified its calibration using cosmic rays. It has also participated in many of the Global Calorimeter Trigger and Global Trigger commissioning studies. HCAL timing was verified during the splash events of the LHC startup.

The first generation Data Concentrator Card (DCC), the HCAL FED, had several limitations and maintenance issues. The DCCs were replaced with a more versatile version in June, 2009.

HPD noise has been studied extensively. During the CRAFT08 a number of HPD channels were flagged as having unacceptable noise rates (in HB, HE and HO). All of these HPDs were replaced. The operating voltage for HB and HE has been set at an average value of 7 kV, with that of HO Rings 2 and 3 at 6.5 kV. Ring 0 of HO continues to operate without problem at 8 kV. In the long run, HCAL plans to replace the HO HPDs with silicon photomultipliers (SiPMs). Two readout boxes worth of SiPMs were installed during the 2009 shutdown for the test of these devices under real operating conditions, and are operating very well.

We have confirmed that the HF PMTs can operate in the fringe field when the CMS magnet is at the full value of 3.8 Tesla. We continue to investigate the potential problem of large pulses induced by the interaction of muons and other charged particles in the PMT windows. This effect was studied in the test beam, along with alternative PMTs for which the effect is greatly reduced.

The Detector Performance Group has established the initial operating settings for HCAL and updated the Monte Carlo simulation code. Only ~20 out of 10,000 channels have readout problems. Many software improvements have been included in the CMSSW 3.1 release. Conditions, such as the zero suppression thresholds and the noise description, have been updated in order to match the detector conditions.

Algorithms have been developed that make use of the time structure of the signal, the pattern of energy deposits relative to neighboring channels, and information from other detectors than HCAL in order to effectively identify spurious signals and reduce the contamination to a negligible level.

The Zero Degree Calorimeter (ZDC) is installed and commissioned, and operates along with the rest of HCAL in global CMS operation. A novel engineering design for the ZDC lifting fixture, needed for removing ZDC for high intensity operation, is under final engineering review. The lifting fixture will be tested in the surface hall before being installed underground.

CASTOR was installed in June 2009 along with modifications to the support table and shielding to improve mechanically stability with field. It is currently being commissioned using a stand-alone DAQ, and will be integrated into CMS readout in the near future. The field varies significantly in strength and direction in this region, and the PMT's in part of the detector currently did not operate at full field during CRAFT. Additional shielding has been put in place.

Muon Detector

Status

Endcap Cathode Strip Chambers (CSC): During the CRAFT08 runs the CSC chambers performed very well with about 97% of the chambers operating. During the shutdown from January to August 2009 the CSC group performed maintenance and repairs, replacing on-board fuses and exchanging front-end circuit boards. By May 2009, 100% of the chambers were operational with 98% of the channels delivering good data. The CSCs participated fully in CRAFT09, and the data are now being analyzed.

Important advances with the firmware have been validated. At the same time, the analysis of last year's CRAFT data has progressed on several fronts. The spatial resolution and efficiency of most chambers have been established. The tests of the magnetic field map in the end caps is converging, and new ways to use the CRAFT data for track-based alignment have been devised. A careful comparison of a recently generated set of cosmic ray Monte Carlo events to the CRAFT data shows very good agreement in many distributions.

Throughout the shutdown period, software for operating, controlling and monitoring the CSCs was improved. Beginning in April the CSC group started full time shifts to exercise all systems, and has been making good progress in observing and correcting the problems that occur over time.

The CF_4 gas recovery design was finished by summer 2009 and approved for production. After deployment in early 2010, it will recover about 70% of the gas and thus pay back its cost in less than two years. Throughout the shutdown, we have been using a 5% CF_4 mixture (instead of 10%) and saving roughly half on the gas expenses for 2009.

During the first year of operation in 2008, we observed a drift of high voltages with a fraction of channels failing the specifications. The origin of the problem was tracked down to a faulty batch of HV resistors. In Jan-Apr 2009, we conducted a massive replacement of HV resistors for all 9,000 channels in the system. This completely eradicated the problem.

In July we added 5 large spare chambers onto the positive endcap as ME+4/2 chambers, one of the rings which was descoped for construction. They are now cabled and fully operational so the CSC chamber count becomes 473.

Barrel Drift Tubes (DT): Since completion of DT maintenance and repair work in April, the focus has been on preparations for the LHC run. The thrust of the DT group was then directed towards system safety and reliability, and towards enlarging the pool of experts and shifters. Analysis of the CRAFT08 data has provided details on the performance and a first set of calibration constants. In CRAFT09 the readout and trigger were tested in the configuration to be used for LHC run.

The detector safety and detector control systems (DSS and DCS) were consolidated. Flow-meters inserted in the cooling system provide on-line information; electronics racks have thermostats and fire detection systems; power to the minicrates is cut when DCS communication is lost. Water leak detection cables were installed on the wheels and in the tower racks; they provide an early warning before the HV trips and help in localizing the leak.

New firmware has been loaded in the Readout and Trigger electronics at all levels: chamber Minicrates, Sector Collectors in the towers, DDU system (FED to the CMS DAQ; one DDU board per wheel) and DT Regional Trigger in the service cavern. The θ-view of the trigger, that so far only used R-φ primitives, was implemented, and tested during the CRAFT09 run.

The online monitoring, error reporting and the DQM have also improved: summary information of the complete status of the detector is available to the shifters in a comprehensible way, together with performance indicators (efficiency, synchronization, data integrity, etc.). The calibration workflow has been streamlined and calibration quality information is published in the off-line DQM, which has become the core of the Data Certification process.

The DT chamber performance for tagging a muon and reconstructing its track and for generating a trigger primitive has been studied in detail using the CRAFT08 data. In particular we have studied the sensitivity of the DT system to the muon track bending (and thus to transverse momentum p_T) in the yoke magnetic field.

A good understanding of the detector and trigger performance has been achieved, the calibration workflow is well under control, and the software procedures are now such that prompt calibration of time offsets has been validated in the data reconstruction workflow at the end of CRAFT09.

Resistive Plate Chambers (Barrel RB and Endcap RE): After the 2008-09 shutdown activities, the full RPC system has been operated during the CRAFT09 run. Satisfactory results have been achieved and the two main sources of concern as discussed in the last April report (coherent noise producing high Level-1 trigger rate, and unexpected increase of current in few RE chambers) have been resolved. The RPC Level-1 trigger rate has been almost constant with very rare spikes, while RE currents have also shown a constant and stable behaviour.

Extensive improvements have been achieved in system monitoring capability. New tools in the DCS software enable monitoring and correlating chamber temperature, humidity and current, gas humidity, and cooling system performance, in order to promptly spot improper operating conditions and set alarms.

Some additional work is still needed to refine the configuration procedures at the run start up and the detector control protocols during the run. The group is now fully engaged to have all the needed tools fully tested by the LHC start-up.

Alignment:

All alignment shutdown interventions have been completed successfully. The most critical was the adjustment of the –z Link Disk which will allow the Link system to perform reconstruction in the -z half of CMS. Several MABs were fixed, removed, recalibrated and reinstalled, and new photogrammetry of all reinstalled components and of all wheels is being performed.

The main progress of the muon alignment since April has been a refinement of both the track-based alignment for the DTs and the hardware-based alignment for the CSCs. The first reconstruction of the entire barrel from the hardware alignment is available.

For DT track-based alignment, there has been significant improvement in the internal alignment of the superlayers inside the DTs. In particular, the distance between superlayers is now corrected, eliminating the residual dependence on track impact angles, and good agreement is found between survey and track-based corrections. The alignment of DTs with respect to the tracker using global tracks has also improved significantly, through use of the latest B-field map, better run selection criteria, and optimized momentum cuts. An alignment is now obtained for all six degrees of freedom (three spatial coordinates and three rotations) of the aligned DTs. A validation procedure using independent, stand alone muon tracks to cross-check the results is well close to completion.

In the endcaps, new alignment results are available for CSC chambers. The main improvements are that ME±1/3 and ME±2,3,4 CSCs are aligned in global-z and local phi_x, and that photogrammetry information has been incorporated into the reconstruction analysis.

The alignment groups aim to provide track-based alignment constants from CRAFT09 data, and for the first time hardware-based alignment constants for DTs. Both hardware and track-based alignment procedures should be in place for LHC data. Studies of detector stability and reproducibility under magnet cycles and after opening and closing of the detector are ongoing.

Trigger and Data Acquisition

Status
Level-1 Trigger:

The trigger system has been in use in cosmic and commissioning data-taking periods. All foreseen algorithms in the L1 Trigger Menu are operational. During CRAFT09 running the trigger delivered more than 300 million muon and calorimeter triggers to CMS. Timing and configuration of the muon triggers appropriate for collisions running was also used; despite the low muon trigger rate in these conditions, about 10 million muon events were collected. Several long runs of about 10 hours were taken with high rate random triggers (> 70 kHz) on top of physics triggers; the system has performed stably and reliably.

Various improvements in the trigger firmware suggested by previous running have been implemented and were validated in CMS global runs. An improved version of the tau-jet algorithm has also been deployed.

The L1 trigger software tools were improved based on the CRAFT experience. Priority was given to the conclusion of the scheme for transferring from online to offline (O2O) the trigger configuration data, including masks of noisy and dead channels, now fully implemented. A revision of the L1 Trigger menu for start-up was done, following guidance from the reviews of the Trigger Tables.

The analysis of the trigger performance in CRAFT08 was concluded. Results on rates, resolution and efficiency were produced for the three muon trigger systems and for the calorimeter triggers (electron/gamma and jets), which show a good trigger performance matching the requirements.

Trigger Coordination:

The Trigger Studies Group collaborated with the Physics groups to refine a series of "lean" trigger menus that are easier to manage, monitor and maintain. In addition, Primary Datasets and Express Selection bits have been defined that address the detector commissioning, Data Quality Monitoring (DQM) and physics needs for the first LHC runs. The CPU time of the new menu is more than 50% shorter than the original HLT menus presented as part of the HLT exercise, while the efficiency for physics signals has been improved. The online operation has made effective use of a special commissioning HLT farm to pretest menus before deployment.

A series of trigger performance reviews was conducted in collaboration with the Physics groups to assess the new trigger menu suitability for physics data. The reviews established the benchmark plots (e.g., turn-on curves and occupancies) and examined the existing software used for trigger evaluation and monitoring. Dedicated alignment, calibration and monitoring streams have been tested during CRAFT09.

DAQ:

The 50 kHz DAQ system consists of the full detector readout, 8 DAQ slices with a 1 Tbit/s event building capacity, an event filter to run the HLT comprising 720 8-core PCs, and a 16-node storage manager system allowing a writing rate up to 2 GByte/s and a total capacity of 300 TB. The problems with the PCs and infrastructure of the event filter farm which revealed during 2008 when stress testing were followed up with the manufacturers and have been resolved. An additional 30 PC racks with water cooling have been installed to allow expansion to a 100 kHz DAQ system.

The 50 kHz DAQ system has been commissioned and has been put into service for global cosmics and commissioning data taking. During CRAFT09, data were taken with ~1 kHz cosmic trigger rate. Often an additional 80 kHz of random triggers were mixed, which were pre-scaled for storage.

Releases of the online software, including framework and services, run control and central DAQ applications have been made. These addressed bug fixes, performance improvements, and functionality enhancements. The procedure for releases and deployment has been improved. Porting of the software to the SLC5 platform has started. The re-factorization of the storage manager software has been completed and is in production since June 2009.

The central Detector Control System (DCS) has been operational 24/7, supervising the infrastructure and providing services to the sub-detector DCS systems.

A setup for testing and validating the central DAQ has been installed in SCX5. It is scaled down in size compared to the full DAQ production system, but consists of the same hardware and software components.

Offline Software

Status

A workshop took place in April in order to define the tasks to be completed in order to bring CMS offline software into stable operation in readiness for data-taking with colliding beams. In the intervening period the main activity has involved integrating and validating a wide range of new features from all subsystems in a major new release cycle (CMSSW_3_1_x). Attention was also given to optimization of the code and of the data formats in order to keep the CPU time, memory footprint, and data storage requirements within budget.

Following the adoption of the latest version of the Geant4 toolkit, the simulation group made a final validation of the chosen physics list, the EML variant of the QGSP_BERT model. This physics list offers an improvement of ~20% in computing performance in the electromagnetic sector. Information on noise and dead channels can now be read from the detector database so as to allow a better description of the real detector and its performance. Further optimization of the code used to simulate pile-up has resulted in significant improvements in the memory footprint resulting in savings of >0.5 GB for the low luminosity pile-up scenario. Work is progressing on commissioning the code used to mix events from multiple sources, such as minimum bias, cosmics and beam-halo events, for use in the production infrastructure. The workflow for the standard production of simulated samples mixed with real data is also undergoing production tests. Progress is also being made on the integration and testing of the forward detector simulation code.

A large number of improvements have also been introduced in all components of the reconstruction software in order to better handle a realistic detector. Features have been added to handle dead and noisy channels in the local reconstruction of many detectors. Changes in tracking algorithms have improved the efficiency for the reconstruction of displaced tracks and of tracks with low momentum. The description of the magnetic field was improved to allow phi asymmetries and scaling factors to match with measured data. Particle Flow is now better integrated with electron reconstruction and it has been tuned to benefit from most recent improvements in iterative tracking. The new version of the Physics Analysis Toolkit has been made simpler and more user friendly.

The first production release of this new cycle (CMSSW_3_1_0) was deployed at the beginning of July for use in a large scale Monte Carlo production. Release validation procedures have been improved in order to certify the entire software chain, including application sequences, detector conditions, and software configuration settings. Pre-production samples were made for each channel (typically 10k – 1M events per channel) using final software workflow configurations and these were used to validate the software before launching full production. The newly formed Physics Validation Team had responsibility for analysing these samples and ensuring that the software achieved the required functionality and performance needed to accomplish the physics programme. Validation was achieved after two rounds of pre-production and full production started at the end of July using CMSSW_3_1_2. Progress with production was very impressive such that by end of August >300M events had been produced and transferred to custodial storage.

The CRAFT09 run has been extremely useful for exercising and validating offline software and for gaining operational experience.

Work on testing and commissioning the Tier 0 production system has continued during data-taking runs. During CRAFT09, production of skims used in alignment and calibration workflows (AlCaReco) was exercised as part of express processing for the first time. They were used as input to prompt calibration workflows running at the CAF, whilst bulk data were buffered at the Tier-0 for 48 hours. New constants were then fed via the Conditions DB into the prompt reconstruction of the same runs that were used to calculate the constants.

Full scale testing of the Tier-0/CAF production systems is continuing in September using samples of Monte Carlo events in order to look at system performance under realistic conditions in terms of event size and reconstruction time. The usage of CrabServer for analysis continues to increase.

The Data Quality Monitoring infrastructure has been further consolidated and attention focused on the commissioning of the data certification system. Central DQM shifts have been routinely performed at P5 and at the CMS Centre on the Meyrin site during all data taking campaigns.

A new procedure for managing software releases that is better adapted to the data-taking phase of the experiment is being adopted. As the LHC turns on, we expect that there will be pressure for both release stability and for prompt deployment of a number of new developments critical to the physics performance of CMS. The new model has fairly short release preparation cycles, lasting only 6 weeks, each cycle consisting of approximately 3-4 pre-releases followed by 2-3 weeks of validation.

Computing

Status

The most important activities during the past months were the combined Scale Testing for the Experimental Program (STEP'09), the regular Cosmics data taking (CRAFT09) and the large Monte Carlo production preparing for the first data analysis with LHC data. Regular computing shifts started together with CRAFT in July; they monitor the distributed computing infrastructure and the workflows. User Support has organized several training courses. In June the Analysis Operation task started to monitor the performance of the infrastructure and to support analysis activities.

STEP'09 was a multi-VO exercise in the context of WLCG focused on combined tests of critical functions of the WLCG infrastructure at full scale by all four LHC experiments. The required CMS tapes system performance could be demonstrated at CERN and at most Tier-1 sites. Tests were repeated at some Tier-1 sites in September when the final configuration at the site became available. Processing with data transfers in parallel were successfully tested at Tier-1 centers during STEP'09. Analysis at Tier-2 centers was performed at an unprecedented scale using more that 50% of all available resources. An end-to-end functionality test for processing steps at Tier-0, Tier-1, and analysis access including luminosity and conditions information, was performed in September.

The reliability and availability of all Tier-1 and Tier-2 centers is continually monitored in CMS, performing regular data transfers and submitting short production and analysis test jobs together with tests of critical grid services. The performance is reviewed regularly and failures are reported and fixed immediately. This has improved several additional sites to become productive for Monte Carlo production and analysis.

For the CRAFT cosmics running the operational procedures for LHC data taking at the Tier-0 were put in place: the handling of the physics express stream and the procedures for regular calibration and alignment activities. A realistic test of the procedures to handle different primary dataset streams at full scale was performed in September.

A very large Monte Carlo production of more that 500M fully simulated events started in July with the final CMS software release for start of data taking. These data samples will be used for the analysis of first LHC data. More than 12.000 CPU slots at Tier-2 sites could be used very reliably. Several new sites could join the production due to the successful commissioning of their resources as a result of targeted effort by the Facility Operation team.

The comprehensive training course on "Using Physics Analysis Toolkit (PAT) in your analysis" was organized in an intense one-week format in June and repeated in September. Several other training courses on Grid usage, C++, Statistics and courses on CMS software for summer students were held during the summer.

Physics

Status

The CMS Physics groups are continuing preparations for the initial LHC beams, strengthening and improving several key aspects of the analysis methodologies and associated tools. The last six months have marked the successful startup of a dedicated Physics Validation Team. About 50 new physics studies have passed the CMS approval procedure and have been submitted to the main summer 2009 conferences. The Physics Analysis and Physics Objects Groups are preparing their specific offline selection procedures, for an efficient data analysis when collisions start.

An important pre-requisite of physics analyses is the validation of the offline datasets. The physics groups, together with the offline team, have joined their efforts and set up a dedicated Physics Validation Team. The task of the team is the prompt physics-validation of real data and Monte Carlo productions. The team validates the production output, catching possible new unexpected features and defects, and ensuring a high-quality physics production. The first validation campaign, during which the validation procedures were tested, took place in July 2009. This occurred in association with the start of a large Monte Carlo production which is based on the reconstruction software to be used for the forthcoming LHC data taking.

The preparation of specific physics measurements has progressed well. A benchmark centre-of-mass energy of 10 TeV was used in all these studies. The corresponding internal (Analysis Notes) and public (Physics Analysis Summary) documents have been written and passed the CMS approval procedure. A particular effort was invested in minimizing the dependence of the physics results from simulation, by developing “data-driven” approaches.

The Physics Analysis and Physics Objects Groups have considerably progressed in developing specific data-skimming and data-reduction procedures, which are necessary steps for an efficient and flexible usage of the computing resources at Tier2 centers. The selections are largely based on common CMS tools and integrated with the Physics Analysis Toolkit (PAT). A general test of the physics groups’ dataflows will take place in October 09, prior to the first LHC beams.

Meanwhile, the Physics Objects Groups have actively contributed to the analysis of the cosmic-ray data collected at the end of 2008, and took part to the preparation and prompt analysis of the recent cosmic data-taking, August 09. This experience is precious in view of the forthcoming LHC collisions.

Before LHC collisions, the physics groups are going to revisit their main physics studies, focusing on the very initial measurements, using large samples of simulated events based on the same version of the reconstruction software and trigger tables to be used for the forthcoming LHC data-taking [and generated at a center-of-mass energy of 7 TeV]. These samples where recently produced, and validated by the Physics Validation Team. In October 09 a general test of the skimming and data-reduction procedures, involving the specific physics groups’ resources at Tier2’s, will take place.

Conclusion

After completion of the shutdown maintenance and repairs, the CMS detector was closed in mid-July, and CRAFT09 was successfully run in August. First results indicate a performance equal to, or better than, that in CRAFT08. However, some improvements in data-taking efficiency still need to be made. Much was learnt from CRAFT08, with over 20 papers to be sent for publication at the beginning of November. The software and computing systems have been exercised by generating and distributing MC samples (500 M fully simulated events) to update 10 TeV physics analyses and soon 7 TeV physics analyses, and to become familiar with the latest version of CMS software (CMSSW_3). The “October” exercise is scheduled to test/reaffirm our analysis readiness.

CMS is ready for beam.

CMS Financial Information

The RRB is reminded that the foreseen deficit for CMS Construction was presented at the RRB23 meeting in October 2006. A request to cover this deficit in 3 steps was also presented. A plan (see Table 1 taken from CERN-RRB-2006-105) in three steps was proposed.

- The first priority is to complete the low luminosity detector requiring 17.5 MCHF.
- The second priority is to complete the DAQ. For this 8.4 MCHF are needed.
- The third priority is to upscope to design-luminosity detector needing a sum of 16.6 MCHF.

The restoration of the forward RPC (RE) system was also proposed.

There is no change to report, with respect to the report in April 2009, on these activities except to reaffirm that some of the activities covered by Step 3 funds shall start later this year or early next year, notably the construction of the staged RE system.

Surface Infrastructure

Plans for long and sustained periods of running and for upgrades were mentioned in the April 2009 RRB. During the last few months work has been done to give form to these plans.

The required facilities can be separated into three distinct parts: the CMS Operation Support Center (OSC) at Point 5, the Engineering Integration Center (ENIC), and the Electronic Integration Center (ELIC), the latter two in Bldg. 904 on the Prevessin site. These are partly new projects as well as the continuation of existing ones with the aim of concentrating necessary services for the operation of the CMS detector in only a few locations. The detailed justification for these facilities is given below.

The CMS Operation Support Center (OSC) is to be mainly built in the surface building (SX5) where previously the surface assembly of the detector was performed. The SX5 will host Swiss Class C radiation laboratories for maintenance/repair of affected detector components, a semi-clean area for the gas-ionization chambers of the muon system, serve as a buffer zone for temporary storage of equipment removed from UXC during shutdowns and an area for logistics, transport and arrivals. Finally, as part of the outreach activities, a visitor center overlooking the SX5 areas will be built. The creation of the CMS Operation Support Center will extend over several years in four phases. In phase 1, in 2010, the basic facilities will be completed. In phase 2, the subsystem laboratories will be constructed in SX5. In phase 3, the offices, the conference rooms, and subsystem control-rooms, and the visitor center will be installed in the two barracks. In phase 4 detector-specific shielding working areas and handling tooling for activated objects will be installed. The funding of the CMS Operation Support Center is split between contributions from CERN, from the M&O-A budget, and from the M&O-B budget. The total costs over 4 years are about 2'900 kCHF. CERN is expected to contribute 1'425 kCHF, the M&O-A budget 1'164 kCHF, and the M&O-B budget 310 kCHF.

The Engineering Integration Center (ENIC) exists already in Bldg. 904 on the Prevessin site. Its operation was funded in the past as part of the Cost to Completion. From 2010, it is requested that its operation be partly supported from the M&O-A budget. Its future tasks will be: the assistance of the CMS Technical Coordination Team for maintenance, consolidation, and upgrade projects; ensuring the coherence with Electronic and Electrical Integration; provision of support and advice for short and medium term visiting engineers; maintenance and documentation of the as-built CAD model of CMS as well as consolidation and upgrade activities; interfacing technical information from collaborators with the CATIA CAD package used and required by CERN; distribution of the as-built model in several standard CAD formats; maintenance and development of the Equipment Management Database (EMD), in particular the tracking of all equipment in UCX which have been exposed to beam and require radiological screening. The total cost is shared between CERN, collaborating institutes, upgrade funds, and M&O Cat. A. The sum of the proposed funds from M&O Cat. A for the next four years amount to 1'008 kCHF.

The Electronic and Electrical Integration Center (ELIC) complements the Engineering Integration Center and will also be located in Bldg. 904. It provides test-beds for burn-in of equipment to be installed or re-installed at Point 5. A Trigger/DAQ facility is needed to validate Trigger or DAQ chain modifications before installation at Point 5. This facility needs a 5% of the whole chain. Major parts of the facility can be provided from units recuperated from Point 5 as a result of the regular replacement program. The total cost for this project is expected to be shared between CERN, M&O Cat. A, and M&O Cat. C contributions. The M&O Cat. A contribution for the next four years amounts to 948 kCHF.

The costs of these facilities were presented to the RRB-Scrutiny Group.

CMS Upscopes and Upgrades

CMS planning for the Upgrades will be updated in a dedicated workshop to be held between 28-30 October 2009 in Fermilab taking account of the LHC schedule.

As has previously been indicated two phases of the Upgrades are planned; Phase 1 will take the peak luminosity around a few times the design luminosity of 10^{34} cm^{-2} s^{-1} and the Phase 2 up to 10^{35} cm^{-2} s^{-1}.

During the Phase 1, CMS will be upscoping or upgrading the following items: forward RPC system, ME4/2, items of infrastructure (e.g. YE4, etc), replacement of the pixels system, changes deemed necessary after first running (these could include e.g. some transducers in the HCAL system). These items have previously been brought to the attention of the RRB. Planning and costs of some of the above items are known whilst more time, and experience from first runs, are needed for the others.

The preparations for Phase 2 Upgrades necessarily require R&D, which has to be conducted in parallel with data-taking and work for Phase 1.

Status of Requests for Additional Funding

CMS is very grateful to the Funding Agencies that have already made commitments to the above-mentioned steps and to those that have made further progress towards completing their commitments since the April 2009 RRB. The current situation is outlined in Tables 2 and 3.

To cover the deficits mentioned above, and the strategy that we are following requires all of the Funding Agencies to fulfill their obligations, at least for Steps 1 and 2.

In order to balance the income with the expenditure for the low luminosity detector, CMS again urgently requests all the Funding Agencies that have not yet made the full commitments with respect to the October 2006 Global Financial Plan to do so, at least for the Steps 1 and 2 and to the restoration of the first phase of the RE system (eta < 1.6).

Table 1: Completing the Design Luminosity CMS detector in three steps (kCHF).

From October 2006 RRB (CERN-RRB-2006-105)

	PhDs	MoU Funding 2002	CTC1 RRB15 Oct02	CTC2 RRB20 Apr05	Constr. Funding 2006	Low Lumi Constr.	DAQ 4 slices PhD	Low Lumi + DAQ	Upscope Rest PhD	Total Design Lumi	
Austria	11	3,900	600	275	4,775	211	45	256	171	427	
Belgium	27	5,000	870	300	6,170	272	111	384	420	803	
Brazil	9				0	0	37	37	140	177	
Bulgaria	5	600	0	0	600	26	21	47	78	125	
CERN	72	85,200	13,500	4,800	103,500	4,569	297	4,865	1,119	5,984	
China	13	4,315	500	300	5,115					*in kind RPC*	
Croatia	7	280	49	20	349	15	29	44	109	153	
Cyprus	3	600	106	43	706	31	12	44	47	90	
Estonia	2	90	16	6	112	5	8	13	31	44	
Finland	12	5,000	870	300	6,170	272	49	322	187	508	
France CEA	14	5,600	1,687	445	7,732	341	58	399	218	617	
France IN2P3	38	19,700	2,000	2,000	23,700		*2,000*	*2,000*	*0*	*2,000*	*Pledged*
Germany BMBF	41	17,000	2,709	1,100	20,809	919	169	1,087	637	1,725	
Germany DESY	5				0	0	*2,000*	*2,000*	*0*	*2,000*	*New Collab.*
Greece	17	5,000		0	5,000	221	70	291	264	555	
Hungary	6	1,000	58	0	1,058	47	25	71	93	165	
India	26	4,400	300	500	5,200					*in kind RPC*	
Iran	3	510	700	0	1,210					*in kind RPC*	
Ireland	1				0	0	4	4	16	20	
Italy	181	55,000	8,927	4,000	67,927	2,998	746	3,744	2,813	6,557	
Korea	14	1,315	500	147	1,962					*in kind RPC*	
Mexico	5				0	0	21	21	78	98	
New Zealand	3				0	0	12	12	47	59	
Pakistan	3	2,445	230	149	2,824					*in kind RPC*	
Poland	12	3,000		0	3,000	132	49	182	187	368	
Portugal	5	2,000	300	140	2,440	108	21	128	78	206	
RDMS	72	18,862	2,211	1,657	22,730	1,003	297	1,300	1,119	2,419	
Serbia	3		450	0	450	20	12	32	47	79	
Spain	34	6,000	1,350	450	7,800	344	140	484	528	1,013	
Switzerland	30	86,500		200	86,700	0	124	124	466	590	
Taipei	11	2,330	410	0	2,740	121	45	166	171	337	
Turkey	18	1,000	58	0	1,058	47	74	121	280	401	
UK	49	9,100	918	3,000	13,018	575	202	777	762	1,538	
USA	418	104,320	12,800	1,868	118,988	5,252	1,722	6,974	6,497	13,471	
Sum	**1170**	**450,067**	**52,119**	**21,700**	**523,843**	**17,530**	**8,400**	**25,930**	**16,600**	**42,530**	
Requested			**63,000**	**32,000**							

Table 2: Status of Pledged or Paid Additional Funding (kCHF)

	Step 1	Step 2	Step 3	Comment
Austria	211	45	171	
Belgium-FNRS	136	56	311	
Belgium-FWO	136	56	109	
Brazil	n.a.	37		
Bulgaria				Awaiting response
CERN	4,569	297	1,119	
China	Endcap RPC	Endcap RPC	Endcap RPC	
Croatia	15	29	109	
Cyprus	31	12	47	
Estonia	5	8	31	
Finland	272	49		
France-CEA	341	58	218	
France-IN2P3	n.a.	2,000	n.a.	
Germany BMBF	919	169	637	
Germany DESY	n.a.	2,000	n.a.	
Greece				
Hungary				Discussing
India	Endcap RPC	Endcap RPC	Endcap RPC	
Iran	Endcap RPC	Endcap RPC	Endcap RPC	Discussing
Ireland	n.a.	4	16	
Italy	**1,750**			
Korea	Endcap RPC	Endcap RPC	**171**	
Mexico	n.a.			Awaiting Response
New Zealand	n.a.	12		Discussing Step 3
Pakistan	Endcap RPC	Endcap RPC	Endcap RPC	
Poland	132	49		
Portugal	108	21		
RDMS-DMS				Discussing
RDMS-Russia		**300**		Discussing
Serbia	20	12		
Spain	344	140		
Switzerland	n.a.	*141*	466	
Taipei	121	45		
Turkey	47	74	280	
U.K.	575	202	762	
USA-DoE/NSF	5,252	1,722		
Sum	**14,984**	**7,538**	**4,447**	
Requested	**17,530**	**8,400**	**16,600**	
% covered	**85%**	**90%**	**27%**	

Bold: Input since April 2009 RRB

Table 3: The state of funding of the restoration of the forward RPC system.

FUNDING Countries	**Contributions kCHF**	**Comments**
Belgium	420	Likely to use its Step 3 funds for RPC system
China	**500**	
India	800	In final stages of approval
Iran		Discussing. Requesting 800 kCHF
Korea	405	In Cash
Pakistan	1250	