Status of CMS

Progress Summary Report for April 2010 RRB30

Since the last progress report in October 2009, the CMS detector has been tested in LHC beams at 0.9, 2.3 and most recently 7.0 TeV and has demonstrated exceptional performance. First physics results have been published. A potentially critical problem of faulty bushings in cooling lines has been addressed. All subsystems have achieved substantial improvements in performance and robustness. Physics now drives the CMS schedule. An ambitious but achievable plan has been laid out for physics results in the coming year.

Infrastructure and Magnet

The infrastructure was in good shape for the start of the 2009 pilot run. Water leaks due to faulty bushings in Endcap Yoke (YE) water cooling circuits became a serious concern during the run after a second leaky circuit appeared. In December, the CMS management board decided to open up CMS in the winter shutdown and replace the bushings on the innermost yokes. The CERN management agreed to the request for additional time.

CMS achieved a full opening of both sets of endcap yoke disks in 10.5 days and showed that a full scale maintenance of 6 disks and 2 wheel faces could be done in 6 weeks. Faulty bushings were replaced not only on YE±1 but on all YEs. The effects of the leaks on other subsystems were studied. No damage was found and cleaning of corrosion and residues was performed. Fortunately the full "assembly-phase" mechanical and field coordinator crews and some specialist crews were available. Technical Coordination relies heavily on workflow planning of the EN-MEF Experiment Area Management team.

This was the first shutdown requiring full Radiation Protection procedures. In general it went well, but required constant on-site shepherding. Several tasks for BRM, CASTOR, HF, T2, and installation of cameras, leak detectors, instrumentation of the N_2 leak-search and TOTEM T1 truss installation, survey and alignment etc. were also performed. There were many minor problems that were solved on the spot without schedule penalty thanks to a highly experienced and committed field crew. The most serious incident occurred in respect to HF-raising in which a beam pipe support lever arm was out of place and resulted in displacement of one end of the beam pipe by several centimeters without damage. The event was treated as a Technical Incident, reviewed, and procedures modified. Additional monitors have been added.

For the Solenoid, the field was cycled to check magnet operation, pre-compress yoke elements, and adjust HF's to nominal z positions. A survey confirmed all major elements within 1mm of nominal positions. On the 10^{th} of February, the field was ramped to 3.0 T, continuing to 3.8 T the next day. Final position of HF at 3.8 T was identical to previous ramps but once again the route taken was different! There was a sudden HF movement in the last 100A. Plots show a continued "creep" during pauses at 3.0T and 3.5T. Waiting for such movements to finish in future could reduce the range of a sudden correction. After the experience of this shutdown and following the recommendations of the LHC Committee it was decided to set-up a task force to review all engineering aspects of the forward region of the experiment.

Commissioning

The last few months were quite exciting for all Detector Performance Groups (DPG). The first ever pp collision events collected at the end of 2009 have been used extensively by all subsystems to test, optimize and tune detector behavior, offline reconstruction chain and trigger performance. A first π^0 peak was reported within less than 24 hours of start of collisions. The 'rediscovery' of standard, low-mass resonances were regularly reported at the 8:30 accelerator meetings. Alignment and calibration infrastructure were well-prepared. Dedicated AlCaReco skims went smoothly, and a first set of conditions updates were approved for reprocessing of the full dataset over Christmas.

A debriefing workshop on operations in the 2009 run was held on Jan. 15 and produced a list of improvements and their priorities. Commissioning did not restart until late January due to detector maintenance. Weekly exercises were then used to deploy, debug, and validate improvements in firmware and software. Objectives defined in the debriefing workshop have been achieved. As of the second week of February continuous operation was started. One goal was the collection of enough Cosmics to verify alignment and readout timing after changes to the firmware/hardware. We recorded 1.3 M tracks before LHC requested our magnet be turned off to recommission the accelerator with beam.

We were ready for beam splashes when beams first circulated at the end of February. The LHC schedule consisted mainly of machine development for the first four weeks during which CMS established a mode of operation consisting in full shift crews during daytime and reduced shift crews at night. Circulating beams in daytime were used to check trigger timing, log halo particles for forward muon system alignment studies. Halo and cosmic events were collected over night with only a few interested detectors included in the trigger and data acquisition. So far we have had very few disturbances in the overall data flow despite frequent changes in configurations, proving that the data chain downstream of IP5 is also very robust. As indications of the improvements since 2009; the first 7 TeV event was recorded at 12:58:43, selected, reconstructed, visualized, approved and posted for public view by 13:01 while a π^0 peak was available < 1 hour later.

Tracker

During 2009 pp collisions the Tracker operated stably and with excellent performance. A large sample of tracks was collected and many nice results appeared quickly. A paper describing Tracker performance, tracking algorithms and first reconstructed resonances is in an advanced state of preparation for publication. During operation in 2009, 98.4% of channels were operational in the pixel sub-detector, and 97.2% in the strip sub-detector. The fraction of operational strips increased to 98.1% during the shutdown. Operational channels have measured efficiencies well above 99% in all layers. Tracker power and cooling, was flawless during operation with beams. A crude timing scan of the Strips and Pixel detectors was possible in the 2009 pilot run. Results were analyzed online via the DQM system and optimized delay settings were quickly brought online. A fine timing scan was carried out with collisions in 2010 to compensate for the remaining module to module timing differences and to optimize the spatial resolution of the detector.

During the 2009 data taking events were observed with a specific pattern of high multiplicity pixel clusters related to the beam background. They do not consist a problem for data taking and analysis but will be monitored further when the beam intensity increases. An appropriate task force has been appointed to understand and monitor all details of the problem.

The focus of the tracker during the shutdown was on performance, robustness and reliability. The Online Software team scrutinized tracker code and firmware in detail and deployed changes. Improvements are visible in the reduction of DAQ configuration time and enhanced robustness. The High Voltage transition from STAND-BY to ON at start of run has been optimized for data taking. Following extensive work on the DCS and power systems, a full check of the integrity of the software interlocks was performed. Maintenance of the cooling system during the technical stop was also performed and entailed draining of the plants. The Tracker is performing magnificently in 2010 and evidence for the known resonances like K0's and Λ's were observed in the first days.

Electromagnetic Calorimeter

After CRAFT09, which included all ECAL sub-systems, important modifications were made to prepare for LHC running. These included stabilization of the LED system and improved timing relative to the LHC clock in the endcap trigger. New firmware was also installed, improving stability at nominal readout rates (around 100kHz).

At the start of the 2009 pilot the newly installed Preshower was the first CMS sub-system to witness the effects of the "splash" events. The central rings of the ECAL barrel detector were used to trigger CMS for these events and data were analyzed in order to improve the relative timing of the readout channels, especially in the endcap calorimeters (crystals and Preshower) where cosmic ray data are sparse. As a result, all systems were operational for 0.9 and 2.36 TeV collisions. The ECAL groups produced the first π^0 and η distributions as noted above. Masses match simulation up to a fully-understood 1.7% energy scale difference which was reduced below 0.5% by the start of 7 TeV data-taking.

Collision data in 2009 revealed events with anomalously high-energy signals in single crystals in the barrel ECAL. They are due to energy depositions in the avalanche photodiodes that detect scintillation light in the barrel. A special task force, called ASC-TF (ASC stands for Anomalous Signals in Calorimeters) was appointed to understand in detail the origin of the problem and to propose the appropriate procedures to mitigate its impact on trigger and physics.

During the shutdown, minor repairs were carried out, increasing the fraction of working channels to more than 99%. Trigger card firmware upgrades also enable the endcap ECAL to be used in the Level-1 trigger. Steady improvements to ECAL stability have been seen in the past months. The ECAL DPG has focused on software developments for physics running that include better signal reconstruction and tools to tag and monitor the anomalous single-crystal signals in the HLT via the Strip Fine Grain Veto Bit. The energy scale in the barrel calorimeter has been increased by 1.7% to account for the temperature difference relative to the test beam environment (0.5%); definition of scale in the simulation (0.9%); and shower containment with field on (0.3%). The π^0 and η peaks show better match of simulation to data. The readout phases of all ECAL components are now set to ~0 ns to optimize signal reconstruction efficiency. The Pre-Shower detector is now fully integrated with ECAL. Analysis tools for prompt data qualification as developed for CRAFT have been updated for collision data. The noise model for both the barrel and endcap ECAL is complete and will be integrated into CMSSW in the near future.

Hadron Calorimeter

HCAL recorded the beam-on-collimator (splash) and first collision data in November and December 2009, and provided triggers to CMS with HF. All HCAL detectors, including ZDC and CASTOR, took collisions data. Splash events were used to improve the energy inter-calibration of the HB and HE under the assumption that the energy deposited by the large flux of muons was a smooth function in η and ϕ. The new calibration coefficients were applied prior to collision data taking. For HO, a similar analysis has been finalized. Splash events were also used to determine the relative timing between channels in HB and HE. New delay settings were calculated based on splash events from one beam, applied and verified with the splash events from the other beam. Timing information from HF, though not optimized, allowed discrimination between collisions and single-beam-related events, and HF also provided the data to extract the CMS luminosity measurement. A full timing scan has been performed in 2010 data-taking.

HCAL trigger primitives (TPs) identify the beam crossing (BX) of the interaction and the energies in the calorimeter towers. After the 2009 pilot run the algorithm was made more robust against imperfectly timed signals, which previously led to a significant fraction of lost energy. The HCAL TPs now benefit from full energy efficiency in pp collisions.

The HCAL frontend readout boxes are equipped with persistent memory (FRAM), which can store configuration parameters that can be downloaded to the electronics with a single command. Use of these memories was recently commissioned. This saves configuration time and reduces both communication traffic and configuration errors.

Anomalous and noise events previously studied in cosmic running are now being studied with the collision data. There are several types of HPD noise producing spurious signals ranging from below 20 GeV to several hundred GeV that are understood and very low rate. In HF, interactions in the PMT windows can produce anomalous signals of order 100 GeV but these events can also been identified. Filter algorithms, using the fact that window interactions affect only a single PMT, are being tuned with first data. The study of these events are part of the efforts of the ASC-TF previously described.

The two ZDCs took data for both splash and collision running, and analysis is ongoing to determine the neutron energy spectra for both minimum bias events and the subclass of events where there is a hard collision. Because the ZDCs are so far away from CMS the Monte Carlo simulation requires special tools to transport particles through the beam magnets. This software is now integrated into CMSSW. ZDC is now fully integrated in HCAL operations. CASTOR has been in the CMS data stream since November. CASTOR data are presently being analyzed. Slow controls and data monitoring for CASTOR are fully integrated into HCAL operations.

Muon Detectors

Endcap Cathode Strip Chambers (CSC): The most important development for the CSCs was the successful replacement of all 396 fault-prone cooling water bushings discussed earlier. After replacement, the bushings were tested with high-pressure gas and then water. Minor leaks were found and promptly fixed. The CSCs performed very well in 2009 and 97% of chambers are operating properly in 2010. Improvements have been made to CSC DCS to allow for central control of the system. Slight adjustments to timing early in autumn 2009 based on analysis of beam halo events resulted in very high efficiency for identifying the correct bunch crossing with the CSC trigger in collision events. Data analysis has led to improvements in local reconstruction performance. Minimum bias events collected in December provided the first small sample of muons, mostly from π/K decays in flight as shown by good agreement between data and simulated minimum bias events at 0.9 and 2.36 TeV. Low luminosities pushed development of reconstruction and triggering at lower transverse momenta than those for which the CMS Muon System was designed but the system still works well, particularly by making use of tracks from the Silicon Tracker by matching them with a segment in the muon detectors. Offline reconstruction of timing of cathode strip data has attained the level expected from test beam via new front-end firmware and better timing corrections.

Barrel Drift Tubes (DT): The DT system was ready for the 2010 run. Detector hardware, control and safety, and the software for calibration and monitoring are all in excellent condition. Disconnected HV channels are ~0.1% of the total. The loss in detector acceptance because of failures in the Read-Out and Trigger electronics is ~0.5%.

In October 2009, with CMS closed, the DT system suffered a significant water leak in the top part of YE+1 that generated HV trips in eighteen chambers going transversely down from the top sector in YB+2 to the bottom sector in YB-2. All chambers recovered and all associated minicrates with Level 1 readout and trigger electronics were functional but long-term damage to some minicrates could not be completely ruled out since they were not accessible to be checked until after the 2009 LHC run when the end-caps were opened. The result of the inspection after the opening of the experiment was positive. There was no evidence of water penetration in the minicrates in YB±2. The central barrel yoke will be checked in a future opening of CMS wheels.

Power connectors associated with the CAEN low voltage power supplies had faulty mating that was observed to cause overheating. All 670 connectors were replaced.

There have been many improvements to the DAQ and monitoring software. Extensive use of the database enables all operating conditions and configuration parameters to be fully traceable. The Trigger Supervisor, with tools for coarse and fine synchronization, has been deployed and tested. A few unstable Opto-Rx boards were identified and replaced. Web-based interfaces were developed that allow efficient remote monitoring.

Resistive Plate Chambers (RB and RE): During the winter shutdown the RPC group revalidated the RE chambers and cured known problems of connectivity (HV, LV and signal cables) and gas system integrity. A few chambers with HV problems were recovered and additional temperature sensors were installed in cooling pipes. The hardware is now in very good shape with below 1% dead/masked channels. New trigger supervisor software enables configuration in a very short time and some automatic diagnostic and recovery protocols from communication errors have been introduced. The main monitoring tools are robust and efficient. The RPC DCS has been running smoothly for months and all protocols for central operation and the LHC handshake acknowledgment have been implemented and tested. The DQM has also been greatly improved by adding additional controls and simplifying the user interface. Offline, work is underway to have automatic evaluation of efficiency and history plots for important parameters.

The cosmic Technical Trigger (TTU) is fully commissioned and now in operation. This trigger has proved to be an important tool for fast evaluation of RPC operating voltages. It is also important for central tracker studies and alignment.

For the barrel RPCs extensive studies of the CRAFT09 cosmic events yielded a fine- tuned synchronization and chamber-by-chamber efficiency map. For the forward RPCs, splash events data have enabled significantly improved synchronization. Forward chambers efficiencies are however obtained from muon beam halo samples. The RPC DPG is now focused on prompt data feedback and run-by-run data quality certification.

Muon Alignment:

The barrel optical alignment system has progressively evolved from reconstruction of single active planes to super-planes to full barrel reconstruction. Initial validation studies comparing this full barrel alignment at 0T with photogrammetric data provide promising results. In addition, the method has been applied to CRAFT09 data, and the resulting alignment at 3.8 Tesla yields residuals from extrapolated tracker tracks that indicate good internal barrel alignment, albeit with a small overall offset with respect to the tracker. This improvement allows the optical system to provide alignment for startup in 2010.

A new, improved internal DT alignment has been implemented. It now includes alignment of the theta layer and corner-block to wire information that allows optically reconstructed corner blocks to be translated into DT layer positions.

The end-cap optical alignment showed much progress in analysis of transfer line data. The next set of CSC alignment constants will include alignment in X and Y directions perpendicular to the beam line, which is most relevant for muon reconstruction.

Unfortunately, around the 3rd of February during an inspection of the beam pipe, the Link Disk supported by the YE-1 was accidentally misaligned in a way that compromises its optical connection to the Alignment Ring sitting on the Tracker. Its 6 Laser beams miss their targets in 17 out of 18 impact points at 3.8T. It will be realigned in the November 2010 access at the latest. Detailed algorithms have been developed to relate the muon hardware alignment to the tracker (by means of the link system). Studies indicate that very good alignment can be achieved with 20 pb^{-1} of data.

Trigger and Data Acquisition

Level-1 Trigger: All foreseen algorithms in the L1 Trigger Menu are operational. During CRAFT09 the trigger delivered more than 300 million muon and calorimeter triggers. The L1 Trigger operated stably during the 2009 pilot run. A set of minimum and zero-bias triggers provided the main triggers in first collisions. Timing of calorimeter triggers was optimized using splash events and also collision data. The fine synchronization of the muon trigger system required more statistics as obtained in 2010.

The L1 tools automating several tasks and making the interface to trigger shifters more user friendly were improved based on early running experience. Minor revisions of L1 menus for 7 TeV were implemented. Trigger menus for various luminosities are ready.

Trigger Coordination: The Trigger Studies Group (TSG) took data from beam splashes, circulating beams and pp collisions at 0.9, 2.3 and 7 TeV. Trigger menus, streams, datasets and monitoring tools quickly adapted to different beam timing conditions, an evolving L1 trigger system and unusual detector configurations. In all cases, the trigger performed remarkably well. Offline trigger shifts complement online DQM activities. Joint trigger-physics reviews have evaluated the 2009 trigger performance and planned for improvements. Trigger validation software was reviewed to ensure readiness for 2010 collisions.

The TSG is taking data with collisions at 7 TeV. Improvements have been made in the manner in which the HLT configuration can be accessed from within analysis jobs. Finally, the TSG has defined the evolution of the trigger menus as luminosity rises in close collaboration with the Physics Datasets Working Group and Physics Coordination.

DAQ: The DAQ system serviced global cosmic and commissioning data taking. Typically data were taken with ~1 kHz cosmics trigger rate and raw event size of ~500 kByte. Often an additional ~100 kHz of random triggers were mixed in and prescaled for storage to stress test the overall system.

The online cluster, the production online Oracle database, and the central Detector Control System (DCS) have been operational 24/7. The performance of the cooling infrastructure of the online data center in SCX5 has been studied by operating all equipment to generate a heat load of about 570kW. After tuning the settings of the water flow and air conditioning system a safe working point with some contingency has been established. A study to upgrade the cooling capabilities to 1MW has been launched. This additional capacity is needed for the extension of the DAQ-HLT (High Level Trigger).

A number of releases and updates 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. A number of XDAQ framework versions are in production. Release-10 has been produced which supports in addition to the SLC4-32bit platform, the SLC5 platform (64-bit OS, 32-bit applications with the alternate gcc434 compiler). The SLC5 platform is initially targeted for the HLT nodes, motivated by the requirement of having the same HLT environment running online and offline. The cluster nodes running HLT, Storage Manager, and online DQM have been migrated to SLC5. The Level-1 and HLT scalers have been commissioned. These scalers count the (post-deadtime) level-1 trigger bits and the HLT paths per Luminosity Section (LS). They are stored in the Run-Info database.

Central run control has been enhanced to take into account the status of the DCS and LHC. This significantly simplifies the duties of the Central, DAQ and Trigger shifters, since many steps of the complex procedure to start a run have now been automated. The control of the DAQ during the phases of an LHC fill includes configuration of the DAQ when there's a stable clock, suppression of payload of the silicon strip detector when not at full voltage, reduction of the gain of the pixel detector when not in stable beam and switching on and flagging of the events when LHC is in stable beam phase.

Offline Software

The Offline operations model proved successful in 2009 LHC data taking. At the same time, new developments have been realized in all areas. During and after the 2009 pilot Run, offline components have been heavily stressed. The Tier0 system was able to process the stream of cosmic and collision data steadily using the CMSSW_3_3_X release series. These data have been used for the first physics paper on charged track multiplicity and the commissioning of the detector. Both required a series of complete reprocessings of data and associated MC. The first complete reprocessing was on December 14th followed by a second one on December 19th. Together with the full sample, various skims were made available such as "Beam Halo" and "Interesting Events" skims among others. "AlcaReco" samples were also produced for commissioning. For the first time all samples were processed twice; once with the 33X version compiled for the SLC4 architecture, and once with 34X compiled for the SLC5 architecture. This allowed the final validation of the releases under the new architecture which is now the default at CERN and all Tier1/2/3s. After the winter shutdown a new reprocessing was made with 33X on Jan 23 and with 34X on Feb 9. These are the most recent versions of the 2009 data samples. The procedure for deployment of bug fixes through patch releases, on a timescale of less than an hour, was validated in these reprocessing runs. Currently the whole system (HLT, Tier0 and Tier1/2/3s) has moved to the CMSSW_3_5_X release series, which has already been validated on all 2009 data and 2010 beam splashes. Further refinement of this release is underway with 7 TeV collisions. All collected data are quickly distributed to Tier2 sites all over the world and accessed via CMS Remote Analysis Batch (CRAB) jobs.

The Visualization system, currently comprising two different products (iSpy and FireWorks), is heavily used online and is critical to our understanding of the detector and beam conditions. The event displays have produced beautiful pictures seen in the news media in the second half of December and again at the end of March. Starting from this solid base, a task force was created to assure all CMS needs are covered. A call for all users' wishes resulted in a very complete requirements document. A technical Workshop was held in San Diego in February and produced a comprehensive plan. The two event displays will be merged, incorporating features of both into a single product to ease future maintenance and reduce duplication of effort. Until the new product is tested and deployable, both iSpy and Fireworks will be maintained and kept functional.

The DQM infrastructure group is continuing its certification and commissioning efforts. DQM shifts occur at CERN, Fermilab and DESY. DQM results are evaluated in the weekly PVT (Physics Validation Team) meetings. Data certification is now possible at the luminosity block level (i.e. in 23 s intervals). New constants from a better calibration and understanding of the detectors are being prepared daily, and inserted in Global Tags, which are used for further tests and reprocessings. The AlcaReco team is preparing the prompt calibration loop for calibrations from data to be used in Prompt Reconstruction. Beam Spot calibration is being automated to provide quick feedback to LHC operators.

The Generator team, with help from the Data Management group, is prototyping an interface to request production of new samples to avoid having to rely on Twiki pages. The Simulation team is rapidly inserting in the code base all the lessons learned during data taking, such as the response of the electronics to real data. Overall, the current match between simulated and real data is very promising in all sub-detectors. The Simulation team is also working to include the CASTOR shower library simulation in CMSSW.

The Reconstruction team is reviewing and improving the code and physics performance of the reconstruction objects contained in the various processing Tiers (RECO, AOD). The team has also been involved in frenetic activities during early data taking to insure preparation of reconstructed data even when detector conditions are not optimal.

The Analysis Tools team has been able to provide the first Physics Analysis Toolkit (PAT) files within hours of the appearance of first reconstructed collision data. They are actively working on a general mechanism to upload high level analysis constants such as reconstruction efficiencies, rates, etc. to the database. Starting in October, specific CMSSW releases targeted for analysis were built and are the subject of intensive training courses. The Fast Simulation group has continued to focus on feature improvements motivated by studies comparing directly to the pp collisions data.

The WMDM (Workload Management and Data Management) group is continuing its large effort to rework the processing systems that were used for Monte Carlo in previous years. This complete change in error handling prompted the successful Tier0 project whose state tracking infrastructure is now being used in the next generation processing infrastructure called WMAgent. The work of the past 6 months has been to implement a Tier1 reprocessing system based on this WMAgent infrastructure. The new system is now being beta tested at FNAL for both re-reconstruction and skimming. The developer's goal is to shift the underlying infrastructure of the CRAB server to WMAgent.

A Webtools group was formed to complete the work on the core environment used in hosting web tools within the Offline project, to further develop the architecture of the security infrastructure, and to provide sufficient documentation, training and hands on support for Offline developers providing web interfaces to offline provided services.

Computing

The CMS distributed computing system performed well during the initial 2009 run and basic functionality was achieved for all computing tiers. The Tier-0 infrastructure was able to repack and promptly reconstruct collision and cosmic events collected in 2009 running. The events were successfully archived on tape at CERN and transferred to Tier-1 centers for custodial storage. While the total rate of collision events and the luminosity were smaller than anticipated, the online system was able to deliver a wide dynamic range of incoming rates and the Tier-0 handled the load. The smaller total volume of data allowed CMS to multiply subscribe the most interesting samples to several Tier-1s, which improved the speed at which samples arrived into the hands of analysis users.

The 2009 samples delivered to Tier-1 centers were reconstructed frequently. CMS reprocessed collected data every 5 to 6 days during the run and has performed several complete passes in 2010. The low volume of data allowed the Tier-1s to reprocess the data in less than 2 days - dominated by setup and bookkeeping. The readiness of the Tier-1 centers during the 2009 period was excellent with CMS averaging 7 of 7 Tier-1 sites passing the readiness tests during the period of running.

The Tier-2 centers were well utilized for analysis of the early data. The analysis operations team subscribed just over 1PB of samples to Tier-2 centers, which was a combination of new collision samples and existing simulated event samples. Currently around 300 individuals submit analysis jobs to the Tier-2 centers during a given week. In addition to the analysis access, 1.7 billion simulated events were produced during 2009 using predominantly Tier-2 resources.

The 2009 preparation activities contributed directly to the successful start-up at the end of the year. In the late spring there were scaling tests with the WLCG, STEP-09, early in the year helped demonstrate the ability to replicate data and to submit analysis jobs. The large scale reprocessing of the 2008 cosmic run helped to exercise the processing system and the Tier-1 facilities. The fall had the October Analysis Exercise, which helped to train new users and to demonstrate new functionality on the Tier-2s. The Tier-0 had dedicated functionality tests and the 2009 cosmic run.

Additionally the operational aspects of the Computing system are maturing. We have 3 shifts per day of Computing Shift Persons (CSP). We have sufficient remote shifting centers that we can satisfy most of the shift needs with people working in a locally convenient time. The CSPs are complemented by the Computing Run Coordinator (CRC) who serves on-call at CERN for a week at a time. The infrastructure to support shifts and the shifters themselves is maturing and improving.

Physics

The last six months have marked the successful startup of the commissioning with collision data. Quite a lot has been accomplished in a very short time. Although the delivered luminosity was small in 2009, CMS has: completed and posted five Physics Analysis Summaries on the performance on tracking, photons and electrons, particle flow, jets and missing transverse energy for a total of more than 100 pages; published the first CMS physics paper on soft QCD; started five other analyses on low pt QCD that will produce five papers in the next month or so. One remarkable outcome of the 0.9, 2.36 and 7.0 TeV collision data has been the amazing out-of-the-box agreement of data with simulation at low energies so early in the commissioning of the experiment with beams. In particular the missing transverse energy, generally appreciated as a challenging experimental observable, was demonstrated to be well under control. Online luminosity determination is operational for the collision runs. In addition, the large sample of 300 million cosmic ray triggers collected during 2008 has been analyzed to measure the ratio between the positive and negative muon yields at high p_T.

To facilitate the efficient exchange of information during the collision period, physics ran a series of operations meetings in addition to the Physics Validation Team (PVT) meetings. The structure used for the October Exercise was efficiently transferred to a "Physics Operation" model by transforming the Monte-Carlo exercises into real data analysis activities. The DPGs were included and given the prominent role of detector studies with the first collisions. The DQM and PVT groups were essential to first certify runs for analyses and to provide important prescriptions for treating subtleties in the data.

The first CMS physics paper, (Transverse Momentum and Pseudorapidity Distributions of Charged Hadrons in pp Collisions at sqrt(s)=0.9 and 2.36 TeV), was delivered by a task force in order to assure the timely completion and the highest standards of scientific quality. This task force integrated people from operations and in particular from the tracker and pixels community to work with the physics groups to understand the data and associated systematics. This model proved to be effective for the commissioning of the physics objects and for the integration of the different communities. Following this successful example, the plan for the first 1 pb^{-1} and the following 10 pb^{-1} at 7 TeV has been constructed around five task forces covering; quarkonia and b-physics with muons, jet physics, and high pt lepton (W/Z/top) physics. These task forces will perform the commissioning of the relevant physics objects and will deliver a number of early papers. The physics objects commissioned by these task forces will then be used in many other analyses.

The low-pt muon trigger, which can be run with low threshold, has been improved in order to increase substantially the yield of recorded decays of the J/psi into muon pairs. This trigger will permit recording of a very large sample useful for commissioning and for a large number of physics measurements in QCD and the B sector. A sample of high threshold muon and electron triggers will accommodate efficient turn-around for the commissioning of high momentum leptons. The distribution of the datasets to the analyses groups has been defined taking into account the rapidly changing conditions, and a complete plan for the analyses up to 10 pb^{-1} of integrated luminosity has been prepared.

Conclusion

The CMS detector was ready for, and performed extremely well in the 2009 pp data-taking run at 0.9 and 2.36 TeV. Data from these runs have been extensively analyzed to improve detector performance and to obtain first physics results. During the winter shutdown, a crucial operation was carried out to replace all potentially faulty bushings in the muon system water cooling lines and to improve all subsystems for more robust operation in 2010. The 2010 data-taking run at 7 TeV is off to a successful start. All systems have demonstrated significant improvements and plans exist for still more improvements in the coming year.

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 was to complete the low luminosity detector requiring 17.5 MCHF.
- The second priority was to complete the DAQ. For this 8.4 MCHF are needed.
- The third priority was 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.

End of Construction

There have been no changes in the end of construction deficits with respect to the October 2008 RRB report (cf. CERN-RRB-2008-095), totaling 22.266 MCHF.

Once all Step 1 and Step 2 funds will be received, they will be used in priority to cover the deficit, leaving some 3.7 MCHF available for the DAQ completion.

CMS Up-scopes and Upgrades

CMS planning for the Upgrades will be updated in June to cope with the new plans for LHC as developed in the Chamonix Meeting at the end of January 2010.

LHC is definitely moving toward a new operations scheme based on 2-3 years of running interleaved by major shutdown periods. The first shutdown will be needed to raise the energy and it is actually foreseen in 2012; a second major shutdown is expected around 2015-16 to raise the luminosity to the design value of 10^{34} cm^{-2} s^{-1}. Later in the decade a further increase in the luminosity is foreseen to match the goal of delivering to experiments ~300fb^{-1} of integrated luminosity per year.

CMS will use the first two LHC shutdowns to maintain and increase the physics potential of the experiment. In particular CMS plans to up-scope or upgrade in the next 5 years the following items: forward RPC system, ME4/2, items of infrastructure (e.g. YE4, etc), the pixels system. In addition we plan to implement the changes deemed necessary after the experience of the first running period; these include new photo-detectors for the hadronic calorimeters (HO, HF, HB, HE) and could include part of the trigger system. These items have previously been brought to the attention of the RRB. Planning and costs of some of the above items are known since a while, whilst more time and experience from first runs, are needed for the others.

The preparations for the second phase of the upgrades for the high luminosity running of LHC, will require R&D, which has to be conducted in parallel with data-taking and with the construction and installation work necessary for the first part of the upgrade.

A detailed description of the new plan for the Up-scope and Upgrade of CMS will be presented to the October RRB.

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 October 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.

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**							

Notes:

Korea has pledged to participate with a cash contribution of 405 kCHF to the rescope of the Forward RPC.

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

Sum of Amount	Type	Reason		
		Paid Or Pledged		
FA	Step 1	Step 2	Step 3	Comments
Austria	211	45	171	
Belgium-FNRS	136	56	311	
Belgium-FWO	136	56	109	
Brazil		37		
Bulgaria				Awaiting response
CERN	4,569	297	1,119	
China				In Kind RPC
Croatia	15	29	109	
Cyprus	31	12	47	
Estonia	5	8	31	
Finland	272	49		
France-CEA	341	58	218	
France-IN2P3		2,000		
Germany-BMBF	919	169	637	
Germany-DESY		2,000		
Greece	221	70		
Hungary				Discussing
India				In Kind RPC
Iran				Discussing Step3
Ireland		4	16	
Italy	1,750			
Korea			405	
Mexico				Discussing
New Zealand		12		Discussing Step3
Pakistan				In Kind RPC
Poland	132	49		
Portugal	108	21		
RDMS		300		Discussing
Serbia	20	12		
Spain	344	140		
Switzerland		141	466	
Taipei	121	45	171	
Turkey	47	74	280	
UK	575	202	762	
USA	5,252	1,722		
Grand Total	15,205	7,607	4,852	
Requested	17,530	8,400	16,600	
% covered	87%	91%	29%	

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

FUNDING Countries	**Contributions kCHF**	**Comments**
Belgium	420	In Cash, 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	