Status of CMS

Progress Summary Report for October 2010 RRB31

Since the last progress report in April 2010, the CMS detector has been steadily accumulating data for pp collisions at 7.0 TeV and has produced a wide array of new physics results including rediscovery of Standard Model all the way up to Top quark pairs, searches for new physics that extend beyond Tevatron limits in some cases, and even the observation of a potentially new phenomenon in very high multiplicity events. The detector, trigger, DAQ, computing and offline continued to operate extremely well even as instantaneous luminosity increased more than 4 orders of magnitude in a period of less than 6 months. Several problems arose and were addressed very effectively. Physics continues to drive the CMS schedule. Thus far, we are managing to maintain our goals of producing a broad array of physics results in a timely manner.

Infrastructure and Magnet

During the period since the last RRB report, infrastructure and magnet were generally in very good condition. Some of the problems that arose include clogging of filters on the magnet cryogenic lines, an overheated pump motor for the SS1 (Silicon-Strip-1) tracker cooling plant and failures of a number of rack turbines at P5. All of these problems were caught early and remedied before they could become serious. Elsewhere, a review of Totem T1 installation has been concluded and discussions and preparations are under way for an installation of both T1 arms during the upcoming winter shutdown.

Commissioning

After the successful start of LHC at 7 TeV in March, the goal has been to collect good quality data as efficiently as possible. The LHC has been delivering exponentially increasing instantaneous luminosities. In the first few weeks at low luminosities we collected essentially all the interactions that the LHC delivered. As collision rates started to exceed our offline data processing capabilities (300-500 Hz), we still kept the L1 trigger open (triggering on all interactions) and tasked the High Level Trigger (HLT) to select the most interesting events until the interaction rate exceeded ~50 KHz (i.e. beginning to approach saturation of the HLT). The trigger group contended very well with rapidly rising trigger rates and this has allowed CMS to maximize the data collection for both high p_T physics (W, Z, $t\bar{t}$…) and low p_T (J/ψ, Υ, inclusive b…).

The time required to produce first results was unprecedented and owes much to the fact that the alignment and calibration conditions of the detector were already very refined in extensive cosmic ray data taking the two prior years. A large number of analyses were presented in ICHEP at the end of July and many of these used data collected less than a week before the conference. By the end of August, CMS had collected 3.2 pb^{-1} of data from pp collisions.

In June an extensive operational review of each subsystem was carried out in collaboration with technical coordination to assess whether a central shift crew (composed of 5 members led by a Shift leader) could operate the subsystem safely with beam. All systems have passed their reviews and CMS has been operating with only the central shift crew since August. The shift allocation strategy has been to share the central shift and expert on-call load amongst CMS institutes in proportion to the corresponding number of signatories.

The overall performance of CMS has been exceptional as indicated by percentages of fully functional channels in the subsystems (>98%). Since the beginning of the 2010 run we have maintained data taking efficiency in excess of 88% (94% in the most recent month). Down time has been predominantly incurred by choice. For instance, we used beam time at the beginning of LHC operation to calibrate and time-in the various sub-detectors with beam. Later we dedicated beam time to debug problems related to the front-end data flow that first appeared with high L1 trigger rates. Despite these early downtime periods we have succeeded in maintaining data taking efficiency above 90%.

Tracker

The Tracker has demonstrated excellent performance and stability since April. The fractions of operational channels for Pixel and Strip systems are both very high (>98%) and stable. Operations have been generally very smooth. A persistent Pixel DAQ problem associated with beam-gas collisions in which particles generate very large clusters in the barrel modules has been solved. In some cases, when these events initiated a trigger the FEDs would overflow and then timeout. Modifications to the pixel FED firmware solved the problem. Central shift crews have operated the Pixel and Strip Systems since late June. Operation and monitoring are carried out by a combination of the central shift crew and on-call Tracker experts. Data quality and detector performance monitoring is covered by central and tracker DQM shifts and Tracker offline shifts.

The Tracker infrastructure continues to perform very well. The cooling system continues to run stably, with no significant unplanned downtimes so far in 2010. There has been a small increment in the leak rate of the SS2 (Silicon-Strip-2) system. Investigations are underway to assess the contributions from specific parts of the system.

Overall, the Tracker is performing magnificently in 2010 and there are no major outstanding issues. The performance of Alignment, Tracking and b- tagging are impressive at this early stage of the experiment. The preparation for Tracker operation with the Heavy Ion collisions is also advancing well and there are no concerns.

Electromagnetic Calorimeter

All components of the CMS Electromagnetic Calorimeter (ECAL); barrel, endcaps and preshower, have been operational and have functioned well throughout 2010 data-taking. There have been a few minor changes to firmware of the Data and Trigger Concentrator Cards (DCC and TCC) to protect against minor instabilities in data collection.

Data taken with a special HLT π^0 trigger stream was used to calculate inter-calibration constants. This has allowed us to significantly improve inter-calibration of the barrel crystals. Work is underway for the endcaps. Z decays to e^+e^- have been used to improve the overall energy scale and to improve alignment in all regions.

The study of Anomalous Calorimeter Signals (ACS) in the barrel due to highly ionizing particles in the Avalanche Photo-Diodes (APD) has led to two independent and very effective tests for ACS events in the data. One is based on the signal timing and the other on the topology of the energy deposition in neighboring crystals. We have also incorporated the APD into the Monte Carlo in detail and the simulation reproduces the anomalous signals. The events have also been observed in beam tests in the H2 beamline. The anomalous calorimeter signals could potentially limit the L1-trigger above an instantaneous luminosity of ~10^{33} cm^{-2}s^{-1}. To prepare to counter this we have modified the front-end readout to tag energy deposits with ACS like topologies at L1.

Hadron Calorimeter

The HCAL detectors participated in physics running with 99% of channels fully operational with the exception of HO Ring 2, which was turned off to preserve the HPDs for long-term operational needs. In order to operate in the fringe field at Ring 2, these HPDs had been operated at reduced gain and would contribute little to physics capability at the present LHC energy and the luminosities expected through 2011.

By August the CMS datasets were large enough to allow precise timing from collision events. All channels are now aligned to within about 1-2 ns. Similarly, the larger dataset enabled a better calibration of the energy calculated in the HCAL trigger firmware. The trigger energy scale was adjusted by 5-8% (depending on η).

The HCAL Detector Performance Group (DPG) optimized the algorithms used to identify anomalous signals in HF, using isolation and pulse shape and timing information. Improvements for the HB and HE noise algorithms are under development. A technique was developed for calibrating Castor using muons from beam scraping that looks promising. Specific triggers were implemented to collect data during machine study periods.

The control functions for the two readout boxes with SiPM photo-detectors in HO were fully integrated into operations, including their precise temperature control.

There were two Engineering Change Reviews (ECR) held since the last RRB report. One reviewed progress of the project to replace HO HPDs with SiPMs, with a proposal to increase the scope to include Ring 0 as well as Rings 1 and 2. The other reviewed a proposal to replace the PMTs in HF in order to reduce the rate of anomalous signals. Both proposals were endorsed. A proposal to add Ring 0 to the SiPM project will be presented to the MB in November.

Muon Detectors

Endcap Cathode Strip Chambers (CSC): The CSC system has continuously performed well despite many orders of magnitude increase in luminosity. The system is 98.5% operational. A low rate of electronics and HV failures extrapolates to 97% operational channels at the end of 2011. Early problems with the filling of readout buffers were fixed in firmware and software. There is now very little CMS downtime caused by CSC problems. Advances in offline reconstruction allow muon timing to be known at the level of 4ns per chamber and 2ns per muon (RMS) using either CSC cathode or anode hits.

With improvements in reliability and DCS monitoring/control software, the system has transitioned to operation by central shift crews. Daily CSC monitoring shifts are run, usually remotely, to examine the state of the system in detail.

Barrel Drift Tubes (DT): The DTs have worked reliably with over 99% of the system active in 2010. The muon rate was dominated by cosmics at the beginning of the run but this changed in August when the luminosity reached a level at which muons were cleanly seen at reasonable rates in the muon barrels. The detector is operating under CMS central control since June. There were a few non-critical interventions in UXC for repairs.

The start-up calibration and synchronization from 2009 cosmics data proved to be very good, resulting in good L1 trigger efficiency and HLT reconstruction. A full calibration was done with the first pb^{-1} of LHC data. Synchronization has undergone several iterations and the system is now very well timed-in with 95% of trigger primitives delivered at the correct BX. The DT Trigger has a sharp turn that levels out at p_T=5 GeV/c.

Resistive Plate Chambers (RB and RE): The RPC has also run at high efficiency in 2010 with ~98.5% live channels and very low noise rate. Roughly 98 % of chambers have noise rate below 1 Hz/cm^2. Average efficiency in the Barrel is 94%and 93.7% in the Endcap. The efficiency in the RE was 87% before a HV adjustment in RE in August from 9.4kV to 9.5 kV. There has been excellent improvement in RPC synchronization. Five iterations of fine tunings since April resulted in more than 99% of RB+RE hits in the correct bunch crossing. Dead time due to the RPC was 0.27 % of the CMS total since April and there has been no downtime due to RPC hardware failures. Since the beginning of June the RPC has been under central shift control and RPC data was certified as good in all collision runs since April.

Muon Alignment: The global position of the muon system with respect to the tracker is obtained to high precision using the track-based, Millipede alignment algorithm. The DTs are aligned using both tracking and an optical alignment system. Agreement within wheels is at the level of 1 mm. The CSCs are also aligned using a combination of optical and track-based methods. The optical system measures disk deformation and compression (along z) due to the magnetic field, and overlapping tracks from beam halo provide alignment in the r-ϕ plane and rotations around the axis perpendicular to the chambers. The two alignments are consistent to ~650 μm. Data taking is almost completely automated for the optical alignments used in all subsystems. Improvements are foreseen for picking up twists and to link different regions.

Trigger and Data Acquisition

L1 Trigger and DAQ: The L1 trigger showed very good running efficiency in physics data taking. During the first month of LHC operation only zero-bias and minimum-bias L1 triggers were activated and used to validate the performance of the object-based triggers (electrons, muon, jets, etc.). A small fraction of beam time was used to perform timing scans that allowed fine adjustments of the trigger synchronization. After this phase, all L1 triggers were enabled in collision runs. The final synchronization of the muon triggers was achieved using the first 100 nb^{-1} of muon data. The synchronization precision at L1 is now ~1 ns and the fraction of out-of-time triggers is a few per mil. The trigger efficiency of the calorimeter triggers (e/γ, jets, etc.) is very high (>99%) and the threshold turn-on-curves match simulation. The efficiency of the muon triggers (RPC, DT, CSC) for $p_T > 5$ GeV was initially 90% and has increased to 95% after timing adjustments and tuning of the trigger configuration with the first 300 nb^{-1} of data. Periodic adjustments of the L1 and HLT trigger prescales were used to keep up with the steep LHC luminosity time profile. The Trigger and DAQ have also recently been tested for data taking under expected Heavy-Ion conditions without front-end zero-suppression.

Trigger Coordination: The Trigger Studies Group (TSG) developed and deployed 10 trigger menus covering a range of luminosity from ~10^{27} to 3.6×10^{31} cm^{-2} s^{-1}. The operation of the trigger has been very smooth. Additional menus for 6×10^{31} and beyond are being prepared as is the configuration for Heavy Ion running. The predicted rates for triggers in new menus are produced by extrapolating from recent data and are accurate to within 10% of the subsequently observed rates. With the L1 trigger running at ~70 kHz, the HLT output rates have typically been 200 – 400 Hz with cpu times averaging ~40 ms - well within the capability of the DAQ and filter farm. The triggers have sharp turn-on curves and efficiencies generally plateau above 90%. Preparations for the 2011 run are underway with a planned series of reviews of the trigger needs of the Physics Analysis groups (PAGs) and the proposals from the Physics Object Groups (POGs), who will formulate the input to the new menus to be produced by the TSG for next year.

Offline Software

Since the last RRB report the CMS offline software has been running smoothly and keeping pace with the evolution of the luminosity delivered by LHC. Most of the analyses produced for ICHEP used data collected and analyzed with the 3_6_X software release used at Tier0 from June to early September. CMSSW_3_7_X was used for a limited reprocessing for those analyses requiring cutting edge reconstruction algorithms. The Physics Validation Team (PVT) produced good run and luminosity-section lists very quickly in order to have the maximum luminosity available for results presented at the conference. Some presentations used data collected 36 hours earlier.

Since ICHEP we have moved to the 3_8_X release online and offline. It contains all of the new developments from the April-July period including Framework I/O improvements, beam spot determination per luminosity section, event cleaning algorithms, a new Analysis Object Data (AOD) definition, new generator tunings, new simulation features like the APD simulation and updated geometry descriptions. It is also the first release that can run the prompt calibration loop at the Tier0. This will improve the efficiency of offline processing and lead to a higher quality level for the prompt reconstruction.

The automation of our validation procedures (including that of the code and the calibration constants used in the HLT) has been implemented over the summer. As of mid-September, a roughly 4 month long Monte Carlo campaign is underway with 3_8_X to produce more than 1 Billion events for use in the next phase of physics results.

The offline group is currently finalizing the development effort for the new CMSSW_3_9_X release cycle, with a first version due by mid-October. The main targets of this release are the Heavy Ions data taking in November and a complete 2010 Data and Monte Carlo reprocessing with end-of-run calibration constants.

All the areas of the Offline project had important developments in the last 6 months. The Visualization system consolidation, as described in the last RRB report, took place as planned. The two previous products, iSpy and Fireworks, were merged into a revamped Fireworks package that retains the functionalities of both and has been in use since the summer both online and offline.

DQM shifts have continued with around the clock coverage when there is beam. The shifts are shared between CERN, DESY and FNAL. The PVT certifies new data and reprocessings weekly. New features have been added to reconstruction, such as a much better cleaning of noise and a more precise treatment of ECAL spikes. The Analysis Tools group has stabilized the Physics Analysis Toolkit (PAT) for the whole 2010 Run. The Database (DB) Group has performed a major review of the DB code, whilst the Fast Simulation group is continuing efforts to match the data coming from the detector. The AlcaReco team is finishing the validation of the prompt calibration loop, where prompt reconstruction is delayed to make sure data are processed with optimal constants delivered within 48 hours of when the data being reconstructed was recorded. The first use case (BeamSpot determination) is in final stages of preparation.

A Data and Workload Management Workshop was held in FNAL at the beginning of May. Discussions were focused on the definition of a timeline and a series of milestones toward the deployment of next generation tools. CRAB2 development has been mostly frozen (apart from a few features considered to be vital to analysis), and all effort has been focused on development of a CRAB3 prototype by yearend. The same holds for ProdAgent, which will be replaced soon by the new WMAgent-based tool. Other important discussions were on DAS, RunRegistry and on the possibility to produce run-dependent MC samples. During summer time the first successful steps were taken toward the deployment of the new reprocessing system at Tier1s. Longer-term plans for the start of 2011 data taking are currently being discussed.

Computing

The CMS distributed computing system has performed well during the 2010 run. All the computing center tiers performed their expected functionalities. The Tier-0 infrastructure was able to repack and promptly reconstruct collision data. The total integrated luminosity collected so far is lower than initially planned, but the instantaneous rates and trigger levels are at the expected levels. The Tier-0 met targets for reconstructing the express stream within an hour, and promptly reconstructing, storing, and transferring physics data. Tier-0 was able to smoothly accommodate temporary increases above design in the incoming trigger rates to facilitate trigger menu transitions.

The Tier-1s generally functioned well throughout the run. Transfers from CERN to the Tier-1s for the second custodial copy were smooth and reliable. The peak rates achieved are within computing model expectations. During the first several months of running CMS had frequent software and calibration updates and many small-scale reprocessing passes were made. The Tier-1s performed these quickly.

The Tier-1s have efficiently served data to Tier-2s for analysis. The data rate from Tier-1s is much higher than the rate into Tier-1s. The analysis operations team has subscribed more than 2PB of analysis data samples centrally, and the physics groups are actively managing group space.

The Tier-2 centers were well utilized for analysis and simulation during 2010. The 2PB of samples subscribed to Tier-2 centers were a combination of new collision samples and existing simulated event samples. Currently around 350 individuals submit analysis jobs to the Tier-2 centers during a given week. The peak before ICHEP reached 500 individuals. These numbers of submitters and jobs on the grid are as anticipated.

Physics

A remarkable amount of physics progress has taken place in the last 6 months. The first major milestone was the delivery of comprehensive physics results to the ICHEP international conference held in Paris this July, where a broad spectrum of results was shown. CMS prepared 15 Physics Analysis Summaries on physics objects and 22 Summaries on new and interesting physics measurements that exploited to a maximum extent the luminosity collected efficiently with the CMS detector. The challenge was incorporating the largest batch of luminosity that was delivered only in the weeks and days before the conference (300 nb^{-1} total). The physics from this initial running period spans hadron production measurements, jet production and properties, electroweak vector boson production, and even glimpses of the top quark. Since these first analyses from CMS took place simultaneously with the commissioning of the experiment, dedicated task forces were formed for the flagship analyses in order to ensure good communication amongst all experts on the detector, physics objects, and analyses.

The topics covered on the performance of the CMS detector with LHC collisions include tracking efficiency and resolution, primary vertex reconstruction, calibration of the electromagnetic calorimeter (the overall energy scale is known to 1% in the barrel), and the imaging of the material distribution inside the tracking volume by using converted photons and nuclear interactions. Physics object performance includes that for electrons, photons, and muons as well as several algorithms for the reconstruction of jets, where the uncertainty on the energy scale has been determined to be less than 10% for calorimeter-only jets and 5% for jets using tracks. Excellent performance was also achieved with more sophisticated algorithms such as b-tagging and particle flow (which optimally combines calorimeter and tracking information to better reconstruct the kinematics of the hard collision). The overall scale of momentum measurements was checked and calibrated using decays of known resonances.

The luminosity measurement is a key component to cross section measurements, and the technique of using the forward hadron (HF) calorimeter to measure the luminosity was calibrated with dedicated LHC beam scans to a precision of 11%, dominated mainly by the uncertainty on the measured beam currents.

In the high p_T QCD sector, comprehensive jet measurements have been made on the inclusive jet cross section, the 3-jet to 2-jet ratio, jet transverse structure, event shapes, and dijet azimuthal decorrelation and angular distributions. At low p_T, measurements of the charged particle multiplicity distributions, the underlying event, and strange particle (K^0, Λ, Ξ) production yields have been performed.

Topics in B-physics included the first cross section measurements of quarkonia production at the LHC (J/Psi and Upsilon, where the latter utilized the full data sample collected by the start of ICHEP of 280 nb^{-1}), and the inclusive production of b-quarks and b-jets as tagged by muons and secondary vertices, respectively.

Approximately 800 W bosons and 70 Z bosons were selected in each of the electron and muon decay channels using 200 nb-1 of data analyzed for ICHEP, allowing for the first measurements of the cross sections and cross section ratios for electroweak vector boson production at the LHC (already systematically limited for W production). The results are in very good agreement with NNLO predictions. A first measurement of the inclusive jet multiplicity distribution for W decays also was obtained.

Rather remarkably, the amount of data collected from the LHC by ICHEP was large enough to set competitive limits on some new physics models. By examining the dijet mass distribution limits on new particle resonances such as "string resonances" could be made. Furthermore, additional limits were obtained on possible new heavy quasi-stable particles by searching for anomalous energy deposition in the tracking volume (large dE/dx) as well as on particles that stop in the detector and decay after some delay (making use of a dedicated out-of-time trigger to collect candidate events). While for minimal Supersymmetry models the amount of data collected so far is still too small to set competitive search limits, a comprehensive set of data-driven approaches to measure Standard Model backgrounds was presented at ICHEP.

An impressive highlight of the ICHEP conference was the first evidence for top quark production at LHC, where the first candidate events in the dilepton and lepton+jet topologies were shown (a total of 9 events in 250 nb^{-1}) as well as the first distributions with b-tagging.

Since ICHEP four additional Analysis Summaries were published on searches for leptoquarks, an update on the dijet resonance search, missing transverse energy in electroweak boson events, and charged particle transverse momentum spectra. Moreover, an interesting paper was published by CMS on two-particle correlations in high multiplicity LHC proton collisions. This study, which looks for the likelihood of a particle to be coincident with another anywhere in the detector, exhibits a "ridge" structure in the correlation that has so far not been observed in proton collisions but that resembles a similar structure seen in heavy ion collisions at other accelerators. While there is not yet a definitive explanation for the cause of this effect, it is a reminder that the LHC really is operating in uncharted waters, and may have many more surprises in store for us.

The focus of the physics program has now shifted to what can be achieved with the full 2010 dataset, expected to be about 30 pb-1, or 100 times larger than the ICHEP sample. Naturally, the highest priority is on the search for new physics from Supersymmetry as well as from the plethora of exotic physics models. But wherever possible, CMS will perform new or improved Standard Model measurements (precision EWK, QCD, and Top measurements). Additionally, we must prepare for the heavy ion physics program later this year. Finally, we must lay the groundwork for the Higgs search program next year, when the delivered integrated luminosity should allow for Higgs searches competitive with, and in many places even exceeding, the reach of the Tevatron.

Heavy Ions

CMS is preparing for the heavy ion program that will last about 3-4 weeks starting around the 10^{th} of November. The initial luminosity will be low, so the first measurements will likely focus on determination of global properties of heavy ion collisions, (e.g. particle multiplicity, momentum distributions, azimuthal asymmetry and jets). If accelerator works well, CMS will be able to measure quarkonia and Z^0 boson production. The planned first analyses were exercised recently by using Monte Carlo samples. The heavy ion group is organized around five Physics Interest Groups, each responsible for at least one critical publication from the first run.

We are preparing special configurations of the sub-detectors, trigger and data acquisition. For instance, we will operate with non-zero suppressed (NZS) readout of the Si Strip tracker, ECAL and HCAL to allow detailed studies of detector behavior in high multiplicity environments. A dedicated trigger menu will collect mainly Minimum Bias data. The data acquisition will be tuned to maximize bandwidth for writing of the NZS data. Data Quality Monitoring, Calibrations and Alignment procedures will be adjusted to the conditions of HI running. Computing Resources are being prepared to handle the large data volumes that could be accumulated if the accelerator operates well.

Upgrades

CERN has now established a long-range plan for the LHC in which there will be no machine operation in 2012, 2016 and 2020 to allow for machine upgrades. In view of this, CMS has begun preparations for planning modifications and upgrades to the detector to assure that the high level of performance described above can be maintained throughout this period in which instantaneous luminosity will rise considerably. The shorter-term upgrades plans include completion of the forward muon system: Muon Endcap 4 (ME4), Endcap RPCs (RE) and Endcap Yoke 4 (YE4) shielding. A replacement of the HF photomultipliers will also happen in the first LHC shutdown in 2012 to overcome some of the issues connected to the appearance of anomalous energy release in the calorimetry. In the intermediate term the hadron calorimeter hybrid photo diodes (HPD), which have had some problems with operating in magnetic fields, have shown a low, but not negligible, rate of failure, and which are no longer manufactured will need to be replaced with alternative sensors such as Silicon Photomultipliers. Also in the shutdown in 2016 it will be important to replace the Si Pixels system that will otherwise show potentially severely degraded performance ahead of the 2020 shutdown period. All of these, and other necessary maintenance and upgrades issues, are being described in detail in a CMS Technical Report that will be presented soon to the LHCC and RRB.

Conclusion

The CMS detector is now a veteran of 7 TeV pp collisions. The 2010 run was very challenging due to the rapid increases in instantaneous luminosity that required nearly continuous changes to trigger menus and other adaptations in our operations. Nevertheless, CMS performed extremely well, collecting extremely high quality data with very high efficiency in all systems. CMS also produced its first major wave of physics results at a new energy scale for pp collisions. The Standard Model was "rediscovered" all the up to the observation of top quark pair production and we have made some incursions into new territory in searches for new physics. We also have the first new and unexpected result for the LHC in the study of two-particle long-range, near-side correlations. Looking forward, CMS is preparing for first Heavy Ion running at the end of the year, and a new wave of important physics results from the 2010 run. A Technical Proposal for the upgrade with an updated financial plan will be preliminarily presented to this RRB.

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 (cf. 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 and various in-kind contributions.

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

Some of the activities covered by Step 3 funds has started this year at a very low level for 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.

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 2010 RRB. The current situation is outlined in Table 1.

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: Status of Pledged or Paid Additional Funding (kCHF)

kCHF	Type	Reason	
	Paid or Pledged		
FA	Step 1	Step 2	Step 3
Austria	211	45	171
Belgium-FNRS	136	56	311
Belgium-FWO	136	56	109
Brazil		37	
CERN	4569	297	1120
China			500
Croatia	15	29	109
Cyprus	31	12	47
Estonia	5	8	31
Finland	272	49	
France-CEA	341	58	218
France-IN2P3		2000	
Germany-BMBF	919	169	637
Germany-DESY		2000	
Greece	221	70	
India			800
Ireland		4	16
Italy	3000		
Korea			405
New Zealand		12	
Pakistan			1146
Portugal	108	21	
RDMS		300	
Serbia	20	12	
Spain	344	140	
Switzerland		124	466
Taipei	121	45	171
Turkey	47	74	280
UK	575	202	762
USA	5252	1706	
Grand Total	16323	7525	7299
Requested	17530	8400	17746
% covered	93%	90%	41%

CMS Up-scopes and Upgrades

CMS planning for the Upgrades has now been prepared, leading to a Technical Proposal that has been presented to the LHCC referees.

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 2016 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 parts of the trigger and DAQ system. These items have previously been brought to the attention of the RRB. Planning and costs of some of the above items are quite well known since some time, whilst the others are more uncertain and will be finalized in the next few months.

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.

Table 2 below summarizes our current understanding of the costs of the first phase of the upgrade.

Table 2: Upgrade Phase I Costs (kCHF)

kCHF

L1	Name	Total
1.	Magnet power and cryo	1,330
2.	Pixel Tracker	17,350
4.	HCAL	5,817
	HF - Phototubes	1,990
5.	Muon CSC	5,570
	Muon DT	2,200
	Muon RPC	4,220
6.	DAQ	6,700
	Trigger	4,600
8.	Beam Instrumentation	1,540
	Infrastructure	6,315
	Test Beam Facilities Upgrade	610
	Safety systems upgrade	964
	Electronics Integration	1,575
	Engineering Integration	3,666
Grand Total		64,447
10% of which, Common Fund		6,445

A small fraction of the upgrade cost (some 10%) would be required to be paid in cash into an Upgrade Common Fund.

The Step 3 upscope plan is a subset of the upgrade plan above. We suggest to fold the Step 3 upscope plan into the upgrade plan and to consider the funds already paid by the Funding Agencies towards Step 3 as paid towards the CMS first phase upgrade.

The CMS Collaboration will ask the Funding Agencies to discuss in the coming months with the CMS contact persons a possible level of contribution to the project. We expect to have by the April 2011 RRB a preliminary money matrix for the upgrade as well as an upgrade spending profile up to the 2017 run.

We thank the Funding Agencies for their support. In particular we would like to thank the Funding Agencies that have participated to the Step 3 effort.