CMS Centres for Control, Monitoring, Offline Operations and Prompt Analysis

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Abstract. The CMS experiment is about to embark on its first physics run at the LHC. To maximize the effectiveness of physicists and technical experts at CERN and worldwide and to facilitate their communications, CMS has established several dedicated and inter-connected operations and monitoring centres. These include a traditional "Control Room" at the CMS site in France, a "CMS Centre" for up to fifty people on the CERN main site in Switzerland, and remote operations centres, such as the "LHC@FNAL" centre at Fermilab. We describe how this system of centres coherently supports the following activities: (1) CMS data quality monitoring, prompt sub-detector calibrations, and time-critical data analysis of express-line and calibration streams; and (2) operation of the CMS computing systems for processing, storage and distribution of real CMS data and simulated data, both at CERN and at offsite centres. We describe the physical infrastructure that has been established, the computing and software systems, the operations model, and the communications systems that are necessary to make such a distributed system coherent and effective.

1. Introduction

At the CHEP 2004 conference in Interlaken, Fabiola Gianotti of ATLAS clearly identified some of the human difficulties we will face at the LHC: "O(1000) physicists in panic-mode using and modifying the software and accessing the database, GRID …" and "…at the beginning they will be confronted with most atypical (and stressful) situations, for which a lot of flexibility will be needed". This paper describes how CMS Centres will address this situation in a number of ways: by co-locating sub-detector offline experts at CERN, Fermilab and other locations; by hosting CMS computing operations teams; by giving all 3000 CMS collaborators live access to monitoring information; and by ensuring that communications systems are effective.

"CMS Centres" are large rooms for CMS physicists and support staff working on offline operations and monitoring activities[1]. They contain desks, computers, monitoring screens, communications systems, and are located in or close to major CMS office buildings and meeting rooms. Ongoing activities in CMS offline computing, online operations and data quality monitoring have led to the establishment of several interim CMS Centres which were highly successful in the recent Magnet Test

[1] They are not to be confused with the Tier-0, -1, and -2 Computing Centres (CERN/IT, FNAL, etc.).

and Cosmic Challenge (MTCC) [1] and the offline Computing, Software and Analysis (CSA06) challenge[2]. To prepare for LHC data-taking, these facilities will be replaced in 2007 by:

- a new purpose-built "CMS Control Room" at the LHC interaction point 5 (P5) in Cessy;
- a "CMS Centre" on the CERN Meyrin site in the former PS-MCR[2];
- an "LHC@FNAL" centre at Fermilab;
- and possibly other such centres at Tier-1 or Tier-2 centres and in CMS Institutes.

In January to March 2006 a Requirements and Technical Assessment Group (RTAG) assessed the functions and requirements for the "CMS Centre" in Meyrin [3], as summarized in the next section.

2. Functions and Requirements of the CMS Centre

The main CMS Centre on the CERN main site in Meyrin should provide effective facilities to support the following two mission-critical activities:

1. Monitoring, Calibrations, and Data Analysis Operations, including tasks such as data quality monitoring (DQM), prompt sub-detector calibrations, and time-critical data analysis of express-line and calibration streams; and
2. Offline Computing Operations for coordinating the processing, storage and distribution of real CMS data and simulated data at CERN and together with collaborating offsite centres.

The co-location in the CMS Centre of expert teams from the trigger, HLT, sub-detector and offline computing groups will enhance communications and enable cross-system solutions to be developed and implemented rapidly.

In addition to the core functions of the CMS Centre, there are related activities in the neighbourhood of the CMS Centre, which have implied needs. These include: office space for physicists; offices for offline computing personnel; large shared offices for specific working groups; and meeting rooms with professional phone- and video-conference equipment.

2.1. Monitoring, Calibrations, and Data Analysis Tasks

The first key role of the CMS Centre in Meyrin is to support data quality monitoring, calibrations, and rapid data analysis. The CMS Centre will host dedicated trigger and sub-detector offline software experts who will communicate closely with their counterparts in the CMS Control Room. They will develop coherent solutions to offline problems and benefit greatly from the co-location in the CMS Centre of experts from the other trigger and sub-detector groups.

The shift personnel in the CMS Control Room are responsible for ensuring the integrity of data for each sub-detector and for top-level global data quality monitoring. Although many experts will work at P5 during data-taking, the majority of CERN-based CMS personnel will be on the Meyrin site. The CMS Centre should therefore enable physicists to follow the status of CMS data-taking by mirroring the main Control Room displays, for example by exporting screen snapshots that are updated as frequently as once every few seconds on a Web server. There will be dedicated DQM shifts in the CMS Centre, with help from similar offsite centres, notably the LHC@FNAL. This is critical at LHC start-up when the machine, trigger and detector conditions are evolving quickly.

The CMS Centre will host teams doing systematic data quality monitoring of very recent CMS data for all sub-detectors, using information from the online as well as processes running offline on the CMS Analysis Facility (CAF) and the Tier-0 centre. These activities will provide rapid feedback to the Control Room. Each sub-detector group in the CMS Centre will have an area with monitoring screens, as above, and PCs for working on DQM activities. Offline experts will work in the CMS Centre to diagnose and fix problems that arise during data-taking, working closely with people in the Control Room. The CMS Centre will reduce congestion in the P5 Control Room and the time wasted traveling between Meyrin and Cessy.

As far as it is possible, all monitoring applications will be location independent (e.g. Web-based) so that experts may monitor their quantities of interest from wherever they are, be they in the CMS

[2] PS-MCR denotes the Proton Synchrotron Main (or Meyrin) Control Room.

Control Room, the CMS Centre, an offsite centre (e.g. LHC@FNAL), in their office, or at home. The CMS Control Room at P5 is responsible for controlling the operations of CMS data-taking. For certain applications, such as access to monitoring data, it may be useful for the Control Room to be able to give an expert in the CMS Centre temporary control of an application running at P5 to help debug a problem.

The CMS Centre should provide a focal point for offline detector experts to work on calibrations, alignments, good/bad run lists, and rapid (express-line) analysis. They will use offline computing resources, in particular the CMS Analysis Facility (CAF) and the Tier-0 centre at CERN. The rapid provision of updated constants is required for subsequent processing of events, notably the Tier-0 offline reconstruction, as well to provide feedback to the online operations, such as the higher level triggers. This work is a key factor in making CMS competitive and will include both routine daily tasks and rapid responses to unforeseen problems. The co-location of experts from each sub-detector in the CMS Centre will greatly facilitate work on calibrations which involve several sub-detectors. The details of the calibration, alignment and analysis tasks are still being refined for startup. Even after startup these needs will continually evolve. Therefore the CMS Centre should provide generic facilities that can meet a broad range of changing needs.

2.2. Offline Computing Tasks

The second main function of the CMS Centre is support for offline computing operations. The majority of the CERN-based team is already established in a dedicated operations room in Building 8 near the CMS Centre, and a second team is being established at Fermilab. These teams will work closely with the physicists in the CMS Centre and the LHC@FNAL as well as with the CMS Control Room, the CERN Tier-0 centre, the large Tier-1 computing centres, and the smaller and more numerous Tier-2 centres.

The CMS Centre will provide monitoring screens to display the status of the offline computing operations (e.g. data storage, processing, movement, heartbeats of centres and systems, etc.). Each group of monitoring screens will have an associated working area with PCs and several screens, which are distinct from the dedicated monitoring screens.

The data operations teams are responsible for coordinating the storage and distribution of CMS data and simulated Monte-Carlo (MC) data. The CERN team is responsible for the receipt of event data and slow-control as well as calibration data from online systems, storage of data at CERN, and distribution of data to Tier-1 centres. The data operations teams also coordinate the processing of CMS data and simulated data. This includes the quasi-real time processing at the Tier-0, re-processing at Tier-1 centres, and the simulation and reconstruction of MC samples at Tier-1 and Tier-2 centres.

The CMS Centre will be the focal point for many offline software activities, both for the sub-detector software experts, as discussed above, and for core services such as software testing, release management, software distribution, and database administration. CMS also requires a number of user support services such as a user support helpdesk, user registration, and administration of virtual organizations. The user support staff also coordinates the computing and offline documentation and training activities.

2.3. Division of Responsibilities

Table 1 summarizes the roles of the CMS Control room on the one hand and the CMS Centre and the Remote Operations Centres (ROCs), such as the LHC@FNAL, on the other hand. The tasks for each sub-detector will depend on specific needs therefore the sub-detector tasks in the table are indicative only. The number of personnel involved per sub-detector can be significant, for example, the ECAL expects to need about ten people at or near the CMS Control Room and about six people at the CMS Centre.

CMS Group	CMS Operations Responsibilities by Location	
	CMS Control Room (Cessy)	CMS Centre at CERN (with LHC@FNAL,...)
Run Control / DAQ	Tasks / responsibilities include: ▪ Operate/control CMS detector ▪ Liaise with LHC operations ▪ Acquire data from detectors ▪ Operate filter farm ▪ Write events to local storage ▪ Transfer data to CERN / IT ▪ Manage online databases	
Trigger / HLT	Tasks / responsibilities include: ▪ Operate L1 trigger and HLT ▪ Set trigger conditions according to policy of Trigger Coordinator	Tasks / responsibilities include: ▪ Monitor L1 and HLT together with offsite centres / experts and give feedback to Control Room ▪ Prepare and test new trigger configurations ▪ Trouble-shoot problems (e.g. using the CAF)
Offline / Computing	Tasks / responsibilities include: ▪ Software installations for HLT ▪ Deploy tools for global DQM, histograms, event display	Tasks / responsibilities include: ▪ Store CMS data at CERN ▪ Operate Tier-0 reconstruction ▪ Run CAF operations for calibration, alignment and rapid analysis - schedule and prioritise CAF work ▪ Manage offline databases and monitor DB services ▪ Operate and monitor data productions at CERN and remote centres, together with offsite centres ▪ Operate and monitor data transfers to Tier-1 centres
Sub-detector	Tasks / responsibilities for a typical sub-detector include: ▪ Ensure safe operation of sub-detector and monitor hardware ▪ Take calibration data (e.g. pre-fill pedestal runs) ▪ Provide constants to HLT ▪ Check real-time DQM for the specific sub-detector	Tasks / responsibilities for a typical sub -detector include: ▪ Coordinate sub-detector offline operations ▪ Detailed sub-detector DQM together with offsite remote centres / experts ▪ Liaise with counterpart in Control Room ▪ Run dedicated jobs on express-line and calibration streams (e.g. in CAF) ▪ Provide updated constants for HLT and Tier-0 processing of event data
Global run / data quality monitoring	▪ Monitor trigger / detector status ▪ Monitor online DQM results (e.g. histograms and event displays) ▪ Communicate issues of data quality to other shift personnel in Control Room ▪ Liaison with CMS Centre person (e.g. to request further studies of specific problems)	▪ Real-time monitoring of trigger / detector status and DQM results from Control Room (e.g. mirrored displays) ▪ Monitor global DQM histograms & event displays from offline processes running in CAF and Tier-0 ▪ Collate run quality information from all detectors ▪ Coordinate preparation of global good/bad run lists ▪ Coordinate (with computing operations) the scheduling of Tier-0 bulk processing of events ▪ Check data quality after Tier-0 bulk processing ▪ Liaise with offsite remote centres / experts
Global calibration / alignment		▪ Monitor content and quality of AlcaReco stream(s) ▪ Coordinate with sub-detector groups the processing of AlcaReco data (e.g. for full tracker alignment) ▪ Coordinate offline database updates ▪ Provide updated constants to HLT ▪ Liaise with offsite remote centres / experts

Table 1 Respective responsibilities of the CMS Control Room and the CMS Centre and offsite centres, particularly the LHC@FNAL.

3. CMS Centre Design

This section describes the technical parameters, design and construction status of the CMS Centre at CERN.

3.1. Building Space

The CMS Centre is located in the former main control room of the CERN Proton Synchrotron (PS). The main room, shown in Figure 1, is almost 300 sq. m in area and will contain 22 consoles (desks with several flat screens) arranged in the shape of a racetrack, and three tables for discussions and overflow work. The main room is surrounded by meeting/breakout working rooms that will be professionally equipped for phone and video-conferencing with the CMS control room at Point 5 and offsite centres, notably the LHC@FNAL. There is a small room for printers, faxes, and storage space for office supplies, spares, tools, documentation, etc. and a rest area with modest kitchen facilities for use by shift-takers. Dedicated space of about 30 sq. m is required for outreach displays.

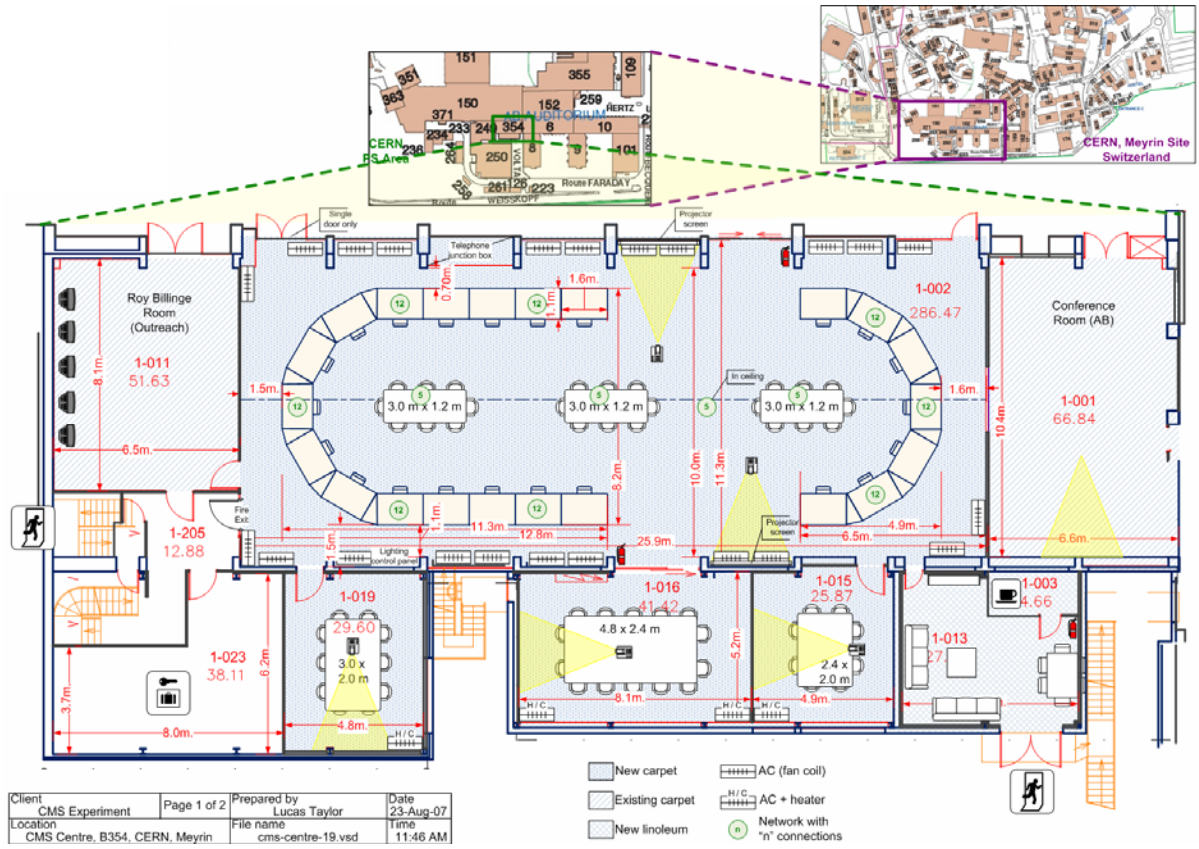

Figure 1 Floor plan for the CMS Centre in the former PS main control room, building 354, CERN Meyrin site.

Networks, telephones, electrical power, and iced-water for air-conditioning are located under a tiled false floor and dedicated cable trays in the consoles. High quality camera views will be displayed in the CMS Centre, showing the CMS Control Room and major offsite centres (initially the LHC@FNAL centre, with possibly others later). These should be accompanied with an audio-conferencing capability.

CMS needs 1600 sq. m (~250 people) of new offices from CERN near the CMS Centre to accommodate computing operators, offline developers, and physicist users of the CMS Centre. Shared

visitor space will be provided with desks, good wireless network for laptops, a few fixed terminals, and other services such as lockers and provisions for receiving mail.

3.2. Computing Equipment and Furnishings

The consoles in the main room are very similar to those in the CERN Control Centre (CCC) and the LHC@FNAL centre. Each comprises a desk with several screens for interactive work, several raised screens for monitoring displays, and cabinets for housing associated PCs and cables. Various standard desktop tools will be deployed throughout the various centres, such as Web-based monitoring tools, a platform-independent chat system, shared desktops to enable experts to perform tasks remotely, and desktop video-conferencing. Figure 2 shows the consoles in the CCC, which are very similar to those being installed in the CMS Centre.

Three large tables are located along the major axis of the room for work-related discussions and overflow work of experts. Each seats 8-10 persons and is equipped with power, telephones, and network sockets. Several large computer displays, or projectors with screens, will display the top-level status of CMS online and offline operations. One large display in a prominent location is foreseen for outreach purposes, for example showing an automatically updating live event display.

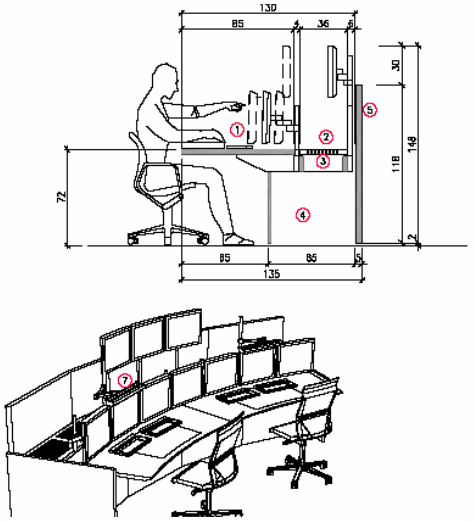

Figure 2 Schematic design of consoles.

3.3. Technical Services

3.3.1. Heating, Ventilation and Air-Conditioning

The main room and the adjoining auxiliary rooms of the CMS Centre all require a controlled heating, ventilation and air-conditioning (HVAC) system due to the large quantities of computing equipment and the significant numbers of people. The HVAC system will be able to maintain a reasonable working temperature of 21– 24 degrees Celsius depending on the time of year. For the main room, the air conditioning capacity will be sufficient to cope with the electrical power consumption (estimated below), and a typical occupancy of 25-50 persons.

The cooling system uses an iced-water supply which is connected through steel lagged pipes under the false floor to 25 fan-coil units on the edges of the rooms.

Applicable regulations for shift and other workers regarding natural and artificial lighting need to be considered. The lights should have dimmer switches to enable the luminosity of each of the various zones to be adjusted.

In total, the power required for all IT equipment in the main room is about 40 kW, calculated as follows. The power budget for each PC is assumed to be 0.5 kW. This allows for fast CPU(s), several modern graphics cards each potentially driving multiple screens, and miscellaneous other peripheral devices. A single console is estimated to require 1.5 kW (2 PCs at 0.5 kW each and 6 screens at about 80W each). The power for 22 consoles is therefore about 33 kW. In addition, power is required for up to about 40 laptops, which implies a total need of 2 kW for all laptops (assuming 50 W per laptop). A modest amount of power is needed for several printers, projectors, and wall-mounted display screens.

To ensure continued operation of critical monitoring consoles in the event of power outages, it is assumed that a minimum of about 10% of this power is on a secure supply (UPS). In addition to the consoles' needs, power is required for other services for the main room, notably lighting and air-conditioning. Neighboring rooms (meeting room, rest-area / kitchen, etc.) require power for general equipment roughly consistent with normal office usage.

Some noise reduction measures are required due to the large number of people and equipment in the room. The background noise sources and the intrinsic acoustic frequency response of the room were professionally measured. Acoustic measures were then proposed based on these measurements and simulations of the room response. These include acoustic carpet tiles and fibre-glass insulation in the false ceiling. The PCs will be housed in acoustically insulated cabinets that reduce the noise from their fans without restricting the flow of cooling air. The refurbishment of the ventilation systems also reduced the ambient noise.

Although the room will generally remain open during normal working hours a system of controlled access at other times should be in place, based on the CERN access card.

3.4. Networks and Telephones

The CMS Centre requires excellent connectivity to the general CERN / IT network, to the CMS Control Room, and to offsite CMS centres (notably FNAL and possibly others). The rather similar LHC@FNAL has a 1 Gbps link for 12 PCs and has seen sustained rates of about 30% of this capacity already, even before data taking has started. Scaling this to the CMS Centre which has about 50 PCs implies the required network capacity is 4 Gbps for all the consoles. Each console needs two connections for fixed PCs and one DHCP connection, making 75 connections for the consoles. An additional 25 sockets are needed for outlets on the meeting tables and for peripherals such as printers and projector systems. Wireless networking is required throughout the CMS Centre for up to about 50 laptops for the whole CMS Centre area (total wireless capacity of about 1 Gbps). All network equipment should be on a secure electrical supply (UPS). All network connections use Cat-6 fibre.

The CMS Centre has one analogue telephone line (supporting international calls) per console with a hands-free (speaker) phone which also has a headset. The main room and all meeting rooms are equipped with conference phones.

3.5. Summary of CMS Centre Technical Parameters

The CMS Centre technical requirements are summarized in the table 2. Further details are given in reference [1].

3.6. Status of the CMS Centre

The construction of the CMS Centre at CERN is nearing completion. The engineering work included upgrading the electrical power, refurbishing the lighting systems, installation of iced-water cooling system, new network and telephone cabling, relaying the floor, acoustic insulation of the ceiling, as well as re-decoration and numerous repairs. The carpet and consoles will be installed in November 2007 and PCs and screens will be installed starting in December 2007. The CMS Centre will be commissioned in the first three months of 2008, a process which involves the installation of the various software applications and the establishment of the communications systems, including video-conferencing. The CMS Centre will be ready for use by the end of March 2008, in line with the original schedule.

4. LHC@FNAL Remote Operations Centre at Fermilab

LHC@FNAL is a Remote Operations Centre (ROC) at Fermilab, located on the ground floor of the Wilson Hall high-rise building. In many respects it is similar to the CERN Control Centre (CCC) for the LHC and the CMS Centre. The purpose of the LHC@FNAL is to help scientists and engineers working on the LHC and on CMS to participate in commissioning and operations activities at CERN. LHC@FNAL has three primary functions: to provide a physical location with remote access to information that is available in control rooms and operations centres at CERN, to serve as a communications conduit between CERN and members of the LHC community located in North America, and to serve as a focal point for LHC and CMS outreach at Fermilab.

CMS Centre Requirements (RTAG)		Description / Values
Delivery Date	**Basic CMS Centre**	**Nov 2007** : with technical infrastructure complete.
	Full CMS Centre	**Mar 2008** : for LHC turn-on, with IT systems complete.
Building Space Requirements	**Office Space near the CMS Centre**	1600 sq. m of offices for ~ 250 people. Need shared rooms for visiting physicists, detector groups, and parking nearby.
	Main Room of the CMS Centre	300 sq. m (25 occupants typically; maximum 50)
	Auxiliary rooms adjoining the Main Room of the CMS Centre	Dedicated Meeting Room: 40 sq. m; equipment room: 20 sq. m; rest area / kitchen: 30 sq. m; outreach Space: 30 sq. m.
	Meeting Rooms near the CMS Centre	1 auditorium (~100-200 people); several rooms for ~50-100 people; several for 20-50 people; several for 5 - 20 people.
Computing Equipment and Furnishings	**Consoles in the Main Room**	25 Consoles each comprising: 1 Desk (~1.6m wide), 1 lamp, 1 phone (headset) 1 PC for working and 1 PC for monitor. 6 screens
	Miscellaneous Equipment and Furnishings	Main room: 25 chairs operators and 25 for visitors. Meeting tables for ~20 people. Shelves. Cupboards. Lockers. Kitchen / rest area: small dining table, 4 dining chairs, 3 easy chairs, coffee table, coffee machine, fridge, microwave, sink.
	Collaborative Working Tools	Phone- / Video-conferencing systems in all meeting rooms.
Technical Services	**Air conditioning**	Capacity to maintain 21 – 24 degrees in main room to cool equipment (40kW) plus up to 50 people.
	Lighting	Details to be determined
	Electrical Power	Main room: 40 kW for consoles plus power needs of lighting and HVAC, etc. (includes 4 kW of UPS power). Other rooms: power consistent with general office use Meeting rooms: one power socket per seat (for laptops)
	Acoustics	Acoustic measures in Main Room of CMS Centre and meeting rooms (floor / walls / ceiling as needed).
Networks and Telephones	**Networks in the Main Room**	4 Gbps for fixed network (100 outlets) 1 Gbps wireless capacity (50 connections)
	Networks in Meeting Rooms	For each meeting room require: Minimum of 100 Mbps for video equipment 1 wireless connection per occupant
	Telephones in the Main Room	30 telephone lines. 1 headset telephone per console. 1 conference phone.
	Telephones in Meeting Rooms	1 telephone and 1 conference phone per room.

Table 2 Summary of the technical requirements for the CMS Centre at CERN.

One of the primary reasons for establishing LHC@FNAL is to provide remote monitoring capabilities for LHC accelerator components developed and built in the U.S., and to provide capabilities for remote participation in LHC commissioning and beam studies. Developers of the LHC@FNAL centre have worked with members of the U.S. LHC Accelerator Research Program (LARP) to develop requirements, and have contributed to the development of software for the LHC controls system.

For CMS the goal is to maximize the effectiveness of remote physicists and technical experts working in close collaboration with the CMS Centre at CERN. The main CMS tasks at the LHC@FNAL are: (1) CMS data quality monitoring, prompt sub-detector calibrations, and time-critical data analysis of express-line and calibration streams; and (2) operation of CMS computing systems for processing, storage and distribution of real CMS data and simulated data, both at CERN and at offsite centres.

Construction of the LHC@FNAL was completed in February 2007. It consists of the ROC main room, shown in figure 2, and an adjoining conference room equipped with high-definition videoconferencing. The ROC is equipped with four CERN-style consoles (8 workstations), with 40

screens and several projected displays. There are remotely-controllable Webcams for remote viewing of the room and two consoles are equipped for video-conferencing. For security, the room has a controlled access system, and the network allows the possibility of establishing a secure tunnel to a CERN network if this feature should be needed in the future. A Screen Snapshot Service (SSS) has been developed to export the contents of arbitrary screens (e.g. a monitoring screen at CERN) to a Web browser displayed on a console at Fermilab.

Figure 2 The LHC@FNAL remote operations centre.

The LHC@FNAL is used by members of the Fermilab Tier-1 operations team who keep the CMS workflows and data management systems running smoothly at Fermilab and who provide support for seven US Tier-2 centres (primarily located at universities). The LHC@FNAL has also been used by CMS detector groups. For example, members of the silicon tracker group operated remote shifts in the ROC from February to June 2007, helping with the data quality monitoring tasks of the Tracker Integration Facility at CERN. The ROC is presently being used for CMS global commissioning runs and CMS data operations, such as the current "CSA07" computing challenge. The LHC@FNAL is increasingly used by machine experts at Fermilab who collaborate with their counterparts at CERN. An important aspect of the ROC is that accelerator experts and experimenters will be in close proximity, enabling them to share their insights on commissioning and operations.

Outreach has been an important aspect of the LHC@FNAL ROC since its inception; this was the primary reason for its location beside the main atrium of Wilson Hall. With accelerator and experiment consoles that replicate systems at CERN and users of the ROC actively engaged in LHC and CMS activities, visitors to Fermilab will be able to learn first-hand how research is performed at CERN.

5. CMS Offline Operations at the CMS Centre and the LHC@FNAL

The CMS Centre and the LHC@FNAL will each host computing operations teams who will ensure that the CMS data processing workflows function on a 24 hours/day, 7 days/week basis. These teams will work closely with each other and the operators at major computing centres to: operate CMS data processing at the Tier-0 and Tier-1 centres; to manage data transfer, placement and removal; and to monitor these operations. The control and monitoring systems, which are making increasing use of web tools, are described in references [2, 4−7].

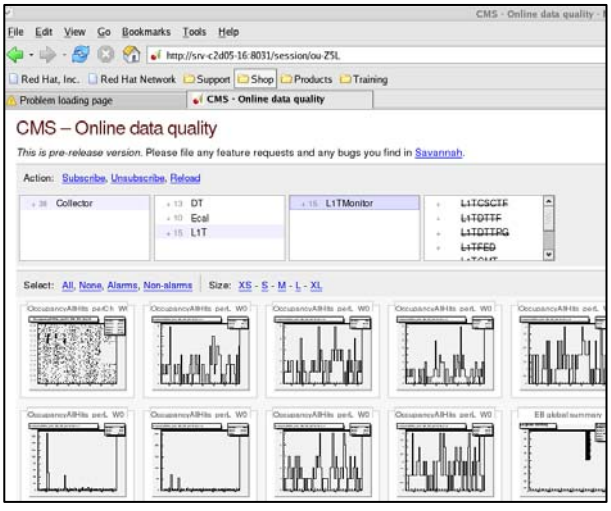

Figure 3 Web-based DQM graphical user interface.

The sub-detector data quality monitoring (DQM) teams working in the CMS Centre and the LHC@FNAL will use a web-based DQM system (figure 3) to offer access to information which enables them to monitor the quality of the CMS event data and slow control data. The tools give access to live shifter views, canned summary plots, and expert access to a repository of

thousands of detailed histograms, together with reference histograms for comparison. These tools may also be used by individuals through a web browser, irrespective of their location. More details may be found in references [8-12].

A "Screen Snapshot Service" (SSS) will be used for exporting arbitrary screen displays to the Web. The SSS system, which enables outside experts to view monitoring screens from a web browser, is already used by CDF and CMS, and is under consideration for LHC monitoring.

Effective communications between the Control Room, the CMS Centre, the LHC@FNAL, and other CMS institutes is crucial. In addition to the monitoring systems and SSS display mirrors described above, the centres will be equipped with: headset telephones (one per console); videoconferencing in the main room and in adjacent meeting room(s); WebCams to maintain a sense of proximity; as well as desktop applications such as Email and chat.

6. Summary

CMS is establishing major operations centres including: a "Control Room" at P5; a "CMS Centre" on the CERN Meyrin site; the "LHC@FNAL" centre at Fermilab; and possibly other such centres at Tier-1 or Tier-2 centres and in CMS Institutes. These centres will enhance communication and access to information, thereby helping all 3000 CMS collaborators to play their part in commissioning CMS, in monitoring the data quality monitoring, performing detector calibrations, and running express-line analysis. These centres will significantly enhance CMS competitiveness when we start taking LHC data in July 2008 at an exciting new energy frontier.

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