LHC@FNAL: A REMOTE ACCESS CENTER FOR LHC AND CMS AT FERMILAB

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Abstract

A facility, LHC@FNAL, is being constructed at Fermilab to help people contribute remotely to the Large Hadron Collider (LHC) effort at CERN.

As a facility, LHC@FNAL has three primary functions:

1. To provide access to information in a manner that is similar to what is available in control rooms at CERN, and to enable members of the LHC community to participate remotely in LHC and CMS [1] activities.
2. To serve as a communications conduit between CERN and members of the LHC community located in North America.
3. To allow visitors to Fermilab to see firsthand how research is progressing at the LHC. Visitors will be able to see current LHC activities, and to see how future international projects in particle physics can benefit from active participation from remote locations.

INTRODUCTION

In this paper, we first discuss the requirements for LHC@FNAL. In particular, we discuss the ways in which we anticipate interfacing with the CMS experiments and with the LHC accelerator complex. Following this we discuss the progress on the construction of the facility and the design of the consoles. Research into the remote collaborative aspects of this facility is underway.

Construction of LHC@FNAL begins this summer at Fermilab. This facility is located in the Atrium of the main building at Fermilab, Wilson Hall, and is expected to open before the end of 2006, see Figures 1 and 2. From this time on we will liaise with the CMS experiment and the CERN Control Centre (CCC) in France from where the LHC is operated.

REQUIREMENTS

A task force composed of people from Fermilab and CERN established the requirements for LHC@FNAL [2]. The document elucidating these requirements was reviewed in July of 2005; subsequent recommendations were included in the document. Based on these requirements, the specifications for LHC@FNAL have been developed, and construction of the facility is expected to begin soon.

Background

To develop requirements for LHC@FNAL, the task force concentrated on two main activities: visiting existing major scientific and engineering control rooms around the world and developing scenarios of how we anticipate this facility will be used.

The LHC@FNAL task force visited several modern controls rooms, some of which involve remote operations capabilities. We visited the following sites: remote control room for the Gemini Observatory, control room for Jefferson Lab, Space Telescope Science Institute and NASA's Goddard Space Flight Center with control rooms for the Hubble Space Telescope, National Ignition Facility, General Atomics, Spallation Neutron Source, Advanced Photon Source, and the European Space Operations Center.

The requirements were derived largely from scenarios that define the operation of LHC@FNAL, but recognize that flexibility is needed. For CMS these scenarios describe test beam activities, the Magnet Test Cosmic Challenge, detector commissioning, operations and data monitoring. For LHC, scenarios include training for accelerator physicists so they are familiar with the control system before traveling to CERN, and remote participation in hardware commissioning for U.S. deliverables, LHC beam commissioning, and post-commissioning activities. Post-commissioning activities include remote participation in LHC machine studies; support of U.S. provided deliverables, including continued support from the designers of beam-related equipment during LHC operations; and work on luminosity upgrades.

From these visits and scenarios, we have developed two types of requirements: those that address physical aspects of an operations center, and those that pertain to agreements and policies that need to be addressed by CERN, Fermilab, CMS, and the US-LHC Accelerator Research Program (LARP) [3] management. Requirements fall into four categories. The first two pertain exclusively to CMS and LHC, respectively. The third category addresses re-

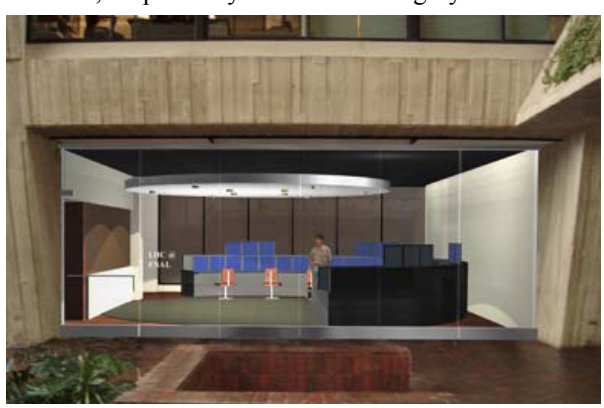

Figure 1, 3D rendering of the LHC@FNAL facility in the Wilson Hall Atrium at Fermilab

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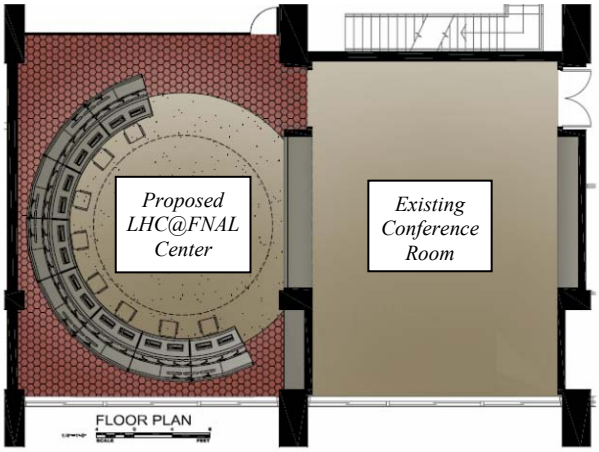

Figure 2, Floor plan of the LHC@FNAL facility at Fermilab

quirements that are common to CMS and LHC. Requirements that are derived from constraints such as safety, security, and software development issues are the fourth category.

A preliminary requirements document was submitted to Fermilab's Director at the end of July, 2005 and the final document was completed in March, 2006.

The Requirements

A total of 66 specific requirements have been delineated, under the categories of CMS Requirements, LHC Accelerator Requirements, CMS/LHC Combined Requirements and Constraints. The requirements address general capabilities: access to LHC and CMS data, meetings and other types of information; software and software development; the LHC@FNAL operational environment; and computing, networking, software development, security and safety constraints. Space does not allow us to present all of these requirements [2]. Here is a sampling from each of the categories.

- CMS Confidentiality: Data, results, conclusions, and problem reports for CMS shall be kept confidential by all LHC@FNAL users according to CMS collaboration guidelines. (This requirement is stated also in the LHC category.)
- CMS Video/Audio Monitoring: LHC@FNAL shall have access to monitoring that can be provided by video/audio hardware. Video images shall be accompanied by location, date and time information.
- CCC Software: LHC@FNAL shall have the same LHC accelerator software installed as the CCC.
- Beam Study Proposals: LHC@FNAL personnel shall be able to submit beam-study proposals to LHC management and be notified of their status.
- LHC@FNAL Safeguards: LHC@FNAL shall have safeguards such that actions do not jeopardize or interfere with the quality of data recorded by CMS, and do not jeopardize or interfere with LHC operations.
- LHC@FNAL Display Sharing: To facilitate communication between CMS and LHC, LHC@FNAL consoles shall have the capability of displaying both CMS and LHC data.
- LHC@FNAL Space Security: LHC@FNAL space shall be designed such that it can be secured and have access limited to authorized personnel.

An important aspect of LHC@FNAL is that accelerator and detector experts will be next to each other while participating remotely in activities at CERN. Individuals working together on LHC and CMS activities can use the same resources in their work while sharing their insights on the commissioning and operation of the LHC accelerator and CMS experiment.

INTERFACING WITH CMS

We are working on a range of activities for CMS operations at LHC@FNAL, including: web-based monitoring, data-quality monitoring, data cataloging, data serving, and several useful monitoring tools, such as an event display.

We are planning to have LHC@FNAL provide a general portal to all the available data about CMS that may be relevant to experts and shift personnel at Fermilab. Since these data are behind firewalls at CERN, much of the data will be accessed through web-based database queries. The development of general-purpose web based monitoring tools has begun at FNAL, with the goal of providing basic functionality for the CMS MTCC [4].

Timely access to data and data quality summaries is critical for success. We expect data summary objects, such as histograms, to be available shortly after they are produced at CERN. We envision that events from a fast event stream will be sent to Fermilab with a latency of a few hours for additional data-quality monitoring and software development.

Since Fermilab is a Tier 1 center, a large fraction of CMS event data will be sent to Fermilab. From there, the data will be catalogued and made available to Tier 2 centers and to LHC@FNAL for access and/or analysis. Furthermore LHC@FNAL can access a small selected sample of the event data with small latency (less than one minute), for example for an event display, via either the Storage Manager that is running at CERN or through an intermediate consumer application.

An important aspect of processing event data and moving data from Tier 0 to Tier-n centers is the monitoring that will be needed to ensure that the entire event handling system works reliably. We expect that LHC@FNAL will be involved in monitoring CMS event processing that is done at CERN and on grid computing resources around the world, as well as monitoring data movement through the tiered computing infrastructure.

INTERFACING WITH LHC

The basic activities that are relevant to the CERN accelerator complex include prompt access to accelerator data, communication with personnel in the CCC, the ability to participate remotely in various activities in the accelerators at CERN and the ability to monitor and assist in the maintenance of instruments supplied by LARP.

LHC@FNAL will have appropriate access to LHC accelerator data, including:

- Logged machine and fault data
- Online measurement repository
- Timely data from non-LARP instruments and all data from LARP-supplied instruments
- Machine lattice and other configuration information

The ways in which LHC@FNAL will access these data are under development at this time.

CONSTRUCTION

The location and design of the operations center has been under discussion since early 2006. Since a primary function of the center is outreach to the Fermilab community and to the general public, it was determined that it should be located in a high visibility area of Fermilab. So the main floor atrium of Wilson Hall has been chosen. This facility duplicates the layout of the CCC, see Figure 3. While allowing a closed area for security needs, onlookers will feel like they are a part of LHC@FNAL through its integrated design, large mullion-free windows, and integrated floor.

Both a conceptual design and lab-wide review of the facility have been completed. Funding has been released from the Department of Energy and bids for construction are being solicited. It is expected that construction will start by August 1, 2006 with an expected 3-month construction period. Members of the LHC@FNAL task force are part of the design and construction team.

CONSOLES

One of the primary functions of LHC@FNAL is to provide the means to access and display information as though one were located in an LHC or CMS control room at CERN. The importance of this functionality is echoed in the requirements:

- LHC@FNAL Hardware and Software Consistency: To minimize the impact on CERN resources, LHC@FNAL shall maximize consistency in hardware and software with CERN and obtain software licenses as needed.
- LHC@FNAL Consoles: LHC@FNAL shall have the same or equivalent consoles installed as the CCC.

Thus, we are installing the same consoles that were custom built for the CCC. This versatile furniture allows us to accommodate any future modifications to the CCC consoles, and to install as many PCs and monitors per console station as at CERN.

LHC@FNAL can accommodate comfortably up to eight people, each with their own console PC and three LCD screens. These screens are located at eye level on the lower tier of a two-tier monitor-mounting system. Located on the upper tier, and centered between each pair of console stations, are three displays attached to a PC that is used to display data and information providing an overall status of the LHC accelerator and/or CMS experiment. Between each pair of console stations is one more screen located on the lower tier and attached to a PC

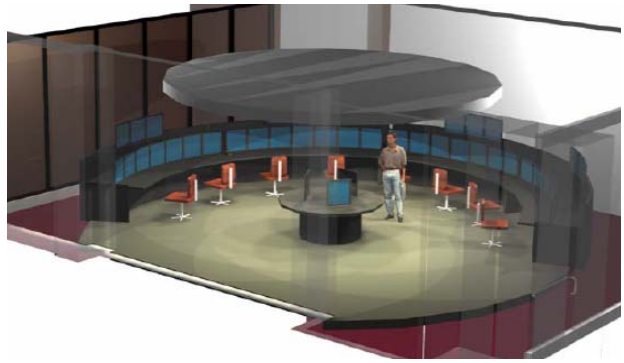

Figure 3, Isometric view of the console layout

that can be used for access to personal email and video-conferencing. The entire console configuration encompasses 16 PCs and 40 LCD screens, and can easily be upgraded to double the number of PCs and/or add additional LCD screens.

Another feature of LHC@FNAL that is being designed is a collaborative display system between LHC@FNAL and CERN. This system will facilitate the sharing of information with shift workers at CERN and colleagues working remotely at other institutions. Our design effort benefits from other efforts aimed at improving collaborative tools, most notably the design of a collaborative display for the tokamak control room [5] by the National Fusion Collaboratory Project. To contribute to the development of collaborative tools for high-energy physics we are partnering with members of the fusion-energy sciences community, who face similar challenges of working on projects from remote locations. Together we have submitted a joint proposal to the Department of Energy for a SciDAC [6] grant to significantly enhance scientific collaborations.

CONCLUSIONS

After extensive research and discussion, the requirements for a remote access facility for LHC in North America, LHC@FNAL, have been established. This facility is under construction at Fermilab. LHC@FNAL will help the LHC and CMS communities in North America contribute to the LHC effort at CERN. From this facility we will be able to assist with the commissioning of the LHC and of CMS and participate remotely in the scientific and engineering efforts there. Scientists and engineers interested in CMS and in the LHC itself will work side-by-side in this unique facility.

REFERENCES

[1] The Compact Muon Solenoid, http://cms.cern.ch.
[2] http://docdb.fnal.gov/CMS-public/DocDB/ShowDocument?docid=165.
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