LHC @ FNAL Remote Operations Center

LHC@FNAL – a new Remote Operations Center at Fermilab

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Abstract

- Commissioning the LHC accelerator and experiments will be a vital part of the worldwide high-energy physics program beginning in 2008. A remote operations center, LHC@FNAL, has been built at Fermilab to make it easier for accelerator scientists and experimentalists working in North America to help commission and participate in operations of the LHC and experiments. Evolution of this center from concept through construction and early use will be presented as will details of its controls system, management, and expected future use.

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- Concept
- Design
- Construction
- Details/Special Features
- Early Use
- Future Plans
- Summary & Acknowledgements

What is LHC@FNAL?

- **A Place**
  - Where members of the LHC community can participate remotely in CMS and LHC activities
  - That provides access to information similar to what is available in control rooms at CERN
  - With the amenities of a formal control room
- **A Communications Conduit**
  - Between CERN and members of the North American LHC community
- **An Outreach tool**
  - Visitors will be able to see current LHC activities
  - Visitors will be able to see how future international projects in particle physics can benefit from active participation in projects at remote locations.

What is LHC@FNAL?

- **Facilitate communication and help members of the LHC community in North America contribute their expertise**
  - **LHC is a large part of the US and Fermilab program**
  - **Major US colliders shut down in 1-2 years**
  - **HEP trend is fewer but larger and more complex facilities**
  - **Widely distributed expertise, not always at CERN**
- **CMS**
  - **One of several dedicated operations and monitoring centers:**
    - a traditional “Control Room” located at Point 5 in Cessy, France
    - a “CMS Centre” for up to fifty people located in Meyrin, Switzerland
    - remote centers such as the LHC@FNAL at Fermilab.
- **LHC**
  - **An extension of the CERN Control Centre (CCC).**
  - **Provide remote monitoring for LHC accelerator components (magnets+instrumentation) developed and built in the U.S.**
  - **Development of software for the LHC controls system**
- **Development of tools for efficient remote access**
- **A unique opportunity to have detector and accelerator experts in close proximity to each other solving problems together.**

How did the Concept Evolve?

Fermilab

- Contributed to construction of several major CMS components
- Hosts the LHC Physics Center (LPC) for US-CMS
- Is a Tier-1 grid computing center for CMS and is also involved in offline software development
- Designed and fabricated LHC machine components
- Is part of the US LHC Accelerator Research Program (LARP)
- Is involved in software development for the LHC control system through a collaboration agreement with CERN called LHC@FNAL Software (LAFS).

The LPC had always planned for remote data quality monitoring of CMS during operations. Could we expand this role to include remote shifts?

LARP was interested in providing support for US-built components, training people before going to CERN, and remote participation in LHC studies.

We saw an opportunity for US accelerator scientists and engineers to work together with detector experts to contribute their combined expertise to LHC & CMS commissioning.

The idea of joint remote operations center at FNAL emerged (LHC@FNAL).

Remote operations for LHC and LARP

LHC remote operations:
- training prior to stays at CERN
- remote participation in studies
- 'service after the sale': to support accelerator components built in the U.S.
- access to monitoring information
- software development for LHC controls system (LAFS)

LARP: The US LHC Accelerator Research Program (LARP) consists of four US laboratories, BNL, FNAL, LBNL and SLAC, who collaborate with CERN on the LHC.

The LARP program enables U.S. accelerator specialists to take an active and important role in the LHC accelerator during its commissioning and operations, and to be a major collaborator in LHC performance upgrades.

CCC at CERN

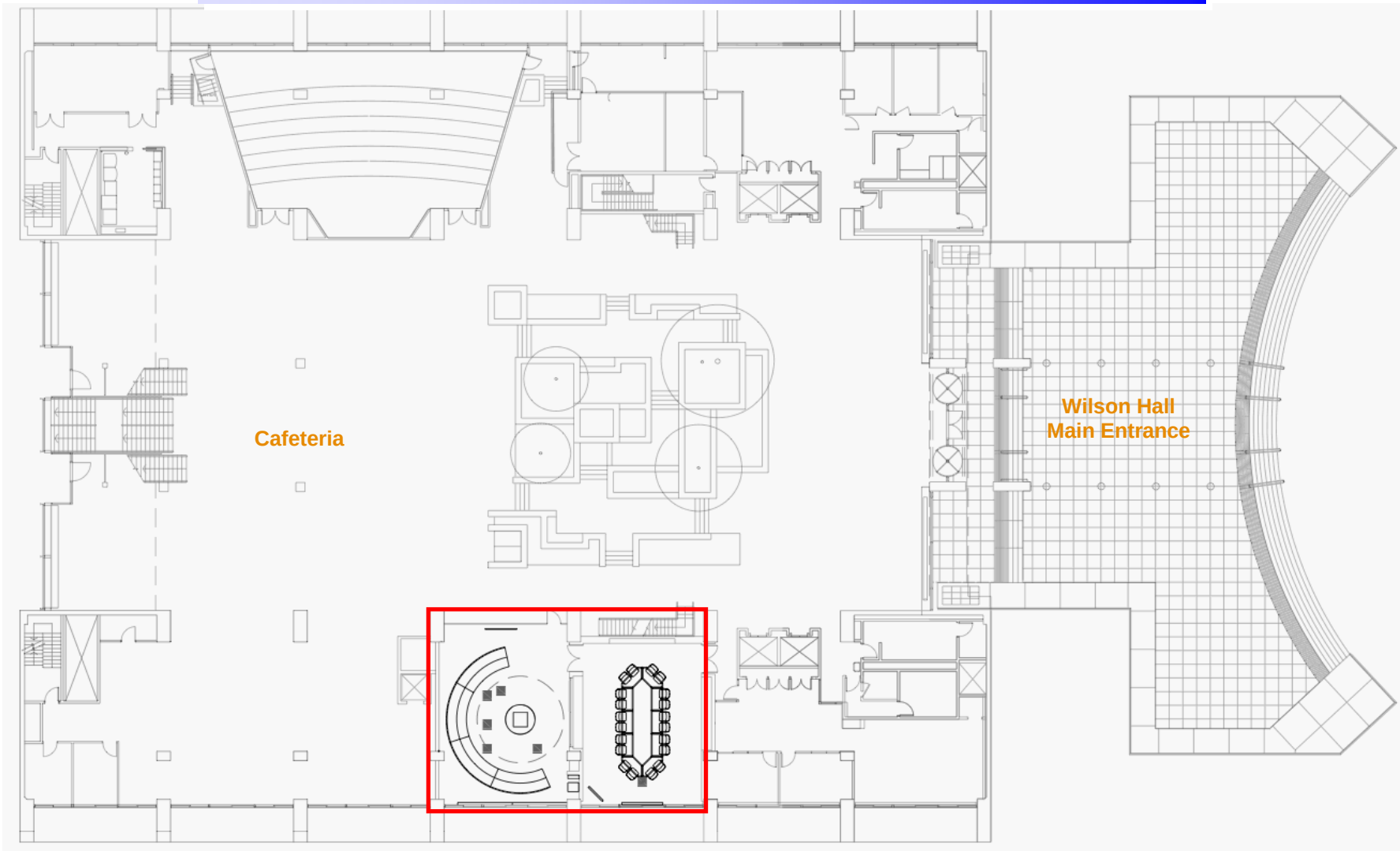
Concept Evolution

- Some proof of principle work done by LHC/LARP personnel
  - Thanks to AB/OP colleagues at CERN
- CMS Remote Operations Center
  - Hadron Calorimeter Test Beam, Magnet Test and Cosmic Challenge
- Unified Task Force formed at request of FNAL Director
  - First meeting 4 May 2005
  - Close-out 19 October 2006
- Requirements document created and reviewed
  - CMS
  - LHC
  - CMS/LHC combined
  - Constraints
  - 63 total requirements
  - Review 21 July 2005
- Visits to other major facilities in fall 2005
  - JLAB, Hubble Space Telescope, SNS, APS, National Ignition Facility, ESO, …
- Proposal to Directorate and constituents
  - Construction Authorization and Engineering May 2006
  - Construction initiated September 2006

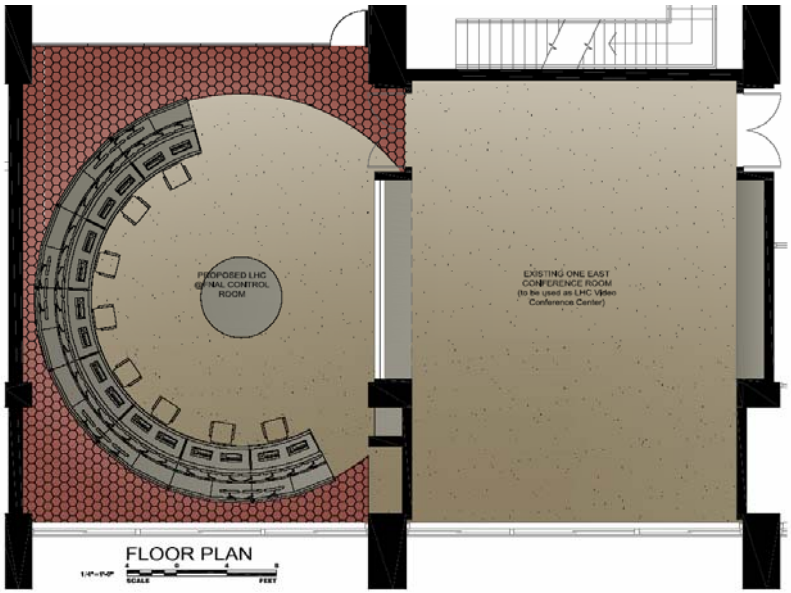
Design

- Variation of CERN Control Centre (CCC) design
- Design work done in-house
- High Visibility location preferred
  - Laboratory Director
  - Adjacent to meeting and office areas
  - Provide Security
  - Maintain Privacy when required
- Special Features
  - Storefront/mullion-free glass
  - Projection Wall & Screens
  - Privacy glass between center and adjacent conference room
  - Programmable lighting
  - Standalone HVAC system
  - Window treatment - morning glare

Location



Renderings

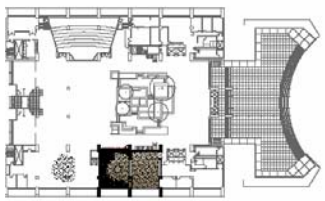


View of proposed control room – looking east from Atrium

View of existing conditions

View with projection on wall

View with projection on glass



Atrium level key plan

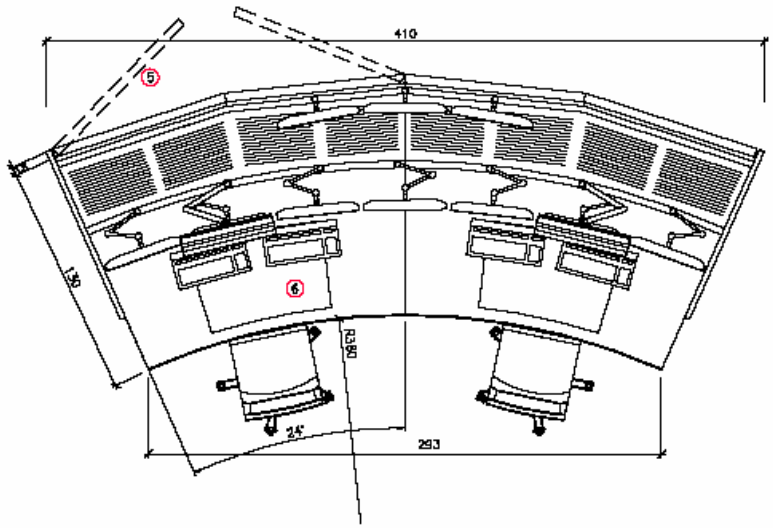
LHC @ FNAL
OPERATIONS CENTER

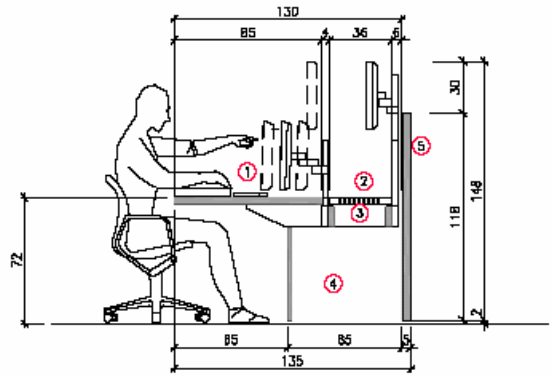
ATRIUM LEVEL PROPOSAL
April 25, 2006
FESS / Engineering

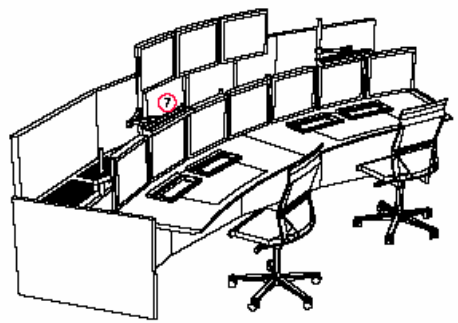
Isometric view of proposed control room

Consoles

- **Three Bids submitted**
- **Consider Cost & Specifications**
- **Same Vendor as for CCC selected**

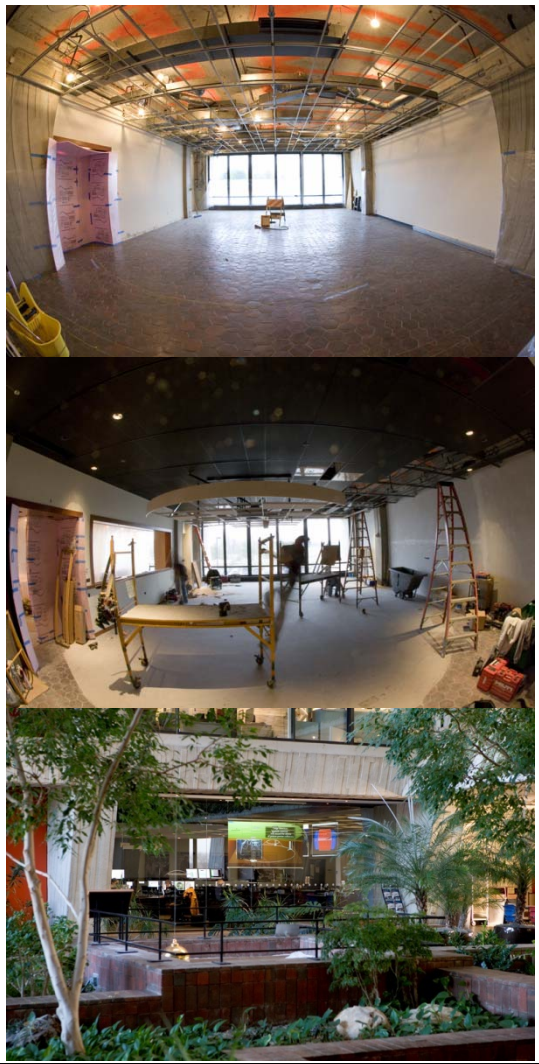






① Work top
② Monitor top
③ Cable channel
④ Installation room
⑤ Acoustic screen doors
⑥ Insert
⑦ Light–top

Construction Slide Show



Construction Summary

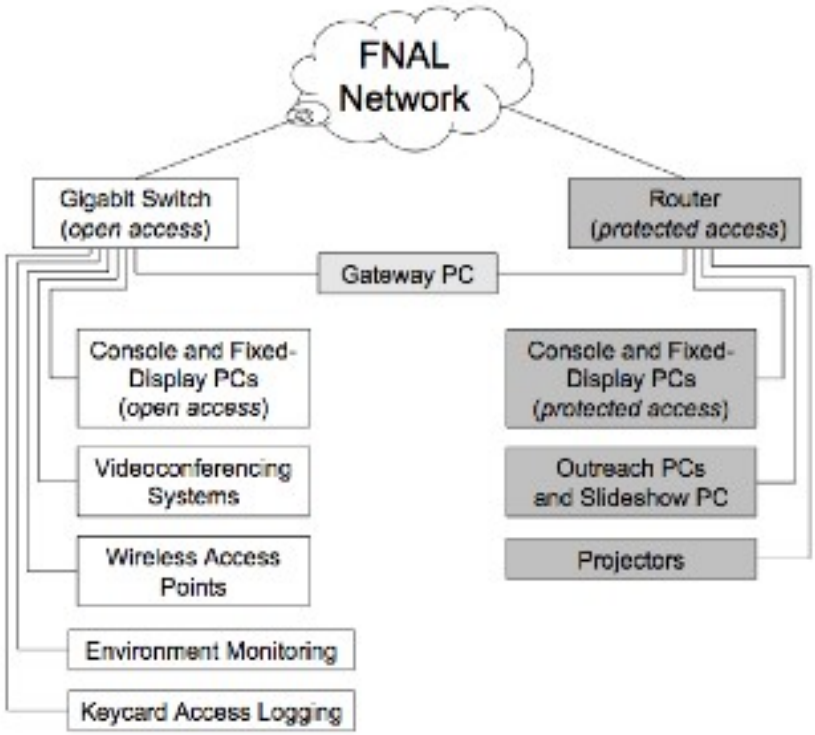
Noteworthy Features

Features that are currently available:

- CERN-style consoles with 8 workstations shared by CMS & LHC
- Videoconferencing installed for 2 consoles
- Webcams for remote viewing
- Secure keycard access to LHC@FNAL
- Secure network for console PCs
  - Dedicated subnet, router with restricted access
- 12-minute video essay displayed on the large “Public Display”
  - Used to explain the LHC and CMS to tour groups visiting Fermilab
- High Definition (HD) videoconferencing system for conference room
- HD viewing of LHC@FNAL, and HD display capabilities in the centre
- Secure group login capability for consoles, with persistent console sessions

Computing

- **Separate Computing Systems/Platforms for**
  - **Consoles**
  - **Outreach**
  - **Videoconferencing**
  - **Projectors**
  - **Gateway**
  - **Server**
- **Protected access as appropriate**



Type	Operating System	Quantity
Console PC	Scientific Linux	8
Fixed-display PC	Scientific Linux	4
Gateway PC	Scientific Linux	1
FCC Server	Scientific Linux	1
Outreach Mac	Mac OS X	2
Presentation PC	Windows	1
EVO/VRVS PC	Windows	1

Early Use

- Current Organization
  - Engineering Working Group
    - Operations Support Team
  - CMS Working Group
  - LHC Working Group
  - Outreach Working Group
- LARP
  - SPS Beam Study period
  - LHC Hardware Commissioning
- LHC@FNAL Software (LAFS)
  - Applications development

CMS Usage

- **Tier 1 Computing Operations**
  - **Responsible for FNAL Tier-1 Computing**
  - **~50% of USCMS computing**
  - **Central support for university based Tier-2 centers**
- **CMS Tracking Integration Test**
  - **Full operational test of 18% of CMS Silicon Tracker located at CERN**
  - **US involved in detector construction**
  - **Shifts ran between February and June, 2007**
  - **About 15 people from FNAL and several other institutions participated**
  - **Remote Monitoring (detector control restricted to CERN)**
    - Data Quality
    - Event Display
    - Detector Control System (detector voltage, currents, temperature,…)
    - Data transfer to FNAL and associated bookkeeping
- **CMS Global Runs**
  - **Integration tests at the end of every month**

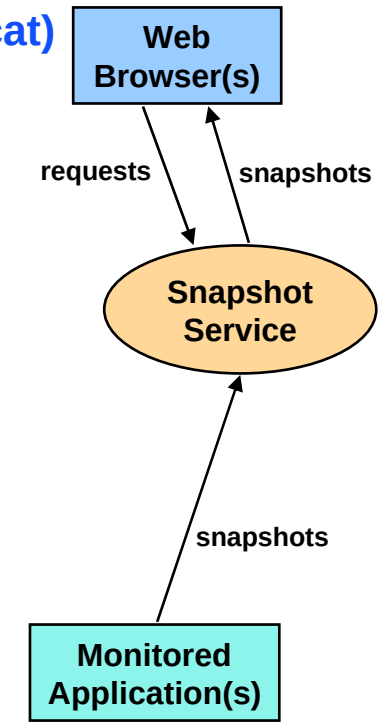
Role Based Access (RBAC)

- An approach to restrict system access to authorized users
  - For the LHC control system
- A ROLE is some job function
  - Examples are LHC operator, RF expert, Developer, etc.
  - Control system users are assigned one or more roles
- Device/property access may be restricted to authenticated users with certain roles
  - Read
  - Monitor
  - Write/Set
- Crucial for remote access
  - Permissions can be set up to allow remote users to access certain devices safely
- Developed as a collaboration between CERN&FNAL (LAFS)
- Deployed in June 2007

See Posters TPPA04, TPPA12, WPPB08

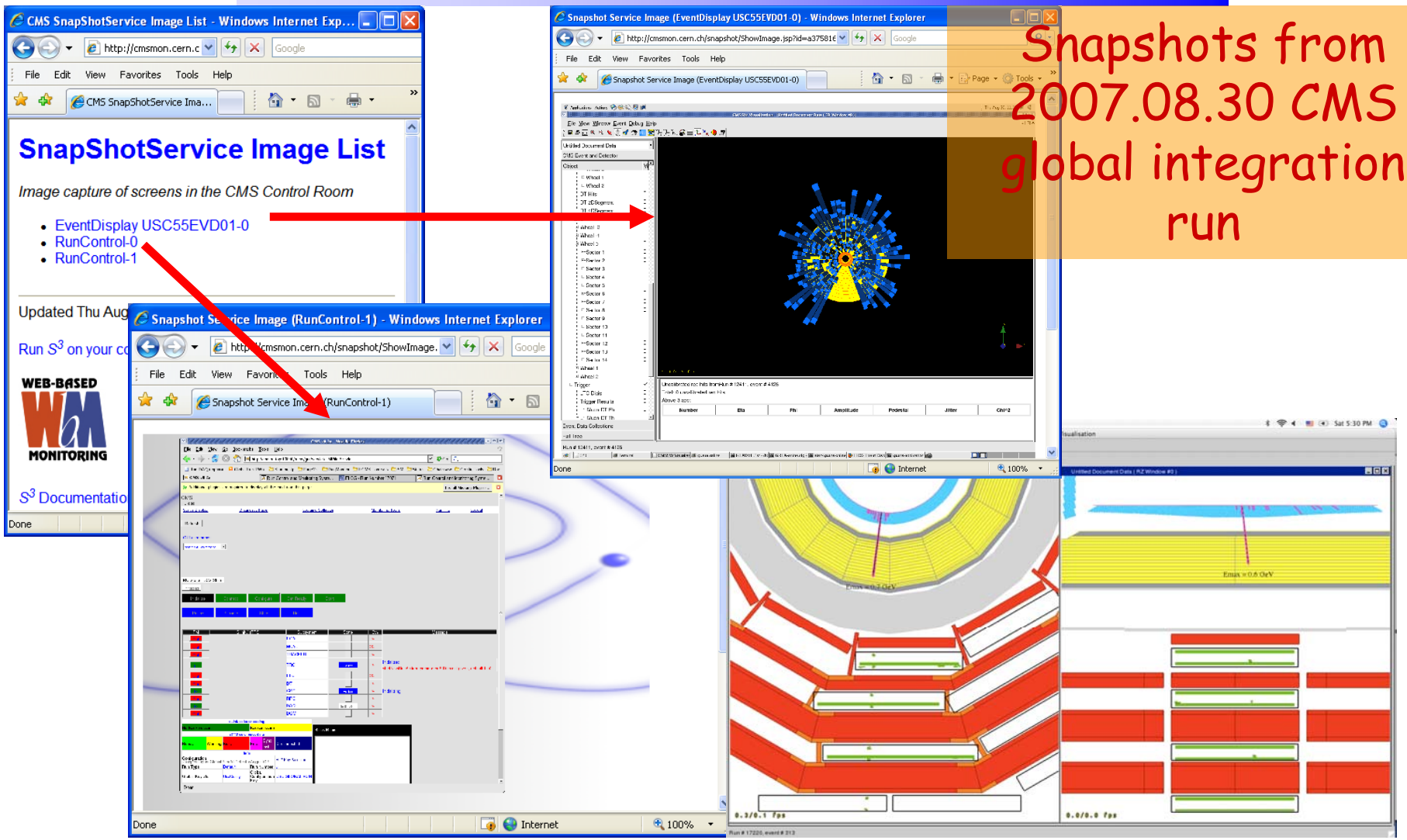
Screen Snapshot Service (SSS)

- **Provide snapshots of a graphical console to remote users**
  - Read only images
  - Using only web-based technologies (Java, JSP, Tomcat)
  - No possibility of control
  - No client software installation
  - Simple, single server installation per facility
  - No extra firewall rules beyond web server access
- **Service**
  - Receives snapshots from monitored applications
  - Caches for a short period of time
  - Serves to requesting authorized users
- **Monitored Applications**
  - Java webstart application continually captures desktop and sends to service
- **Used by CMS for tracker integration test**



More information at: http://home.fnal.gov/~biery/snapshot/

Screen Snapshot Service Example



Snapshots from 2007.08.30 CMS global integration run

Web Based Monitoring (WBM)

- Considerable information saved by online monitoring processes into the CMS database
  - Trigger rates, cross sections, runs taken, beam conditions, temperatures, voltages, environmental conditions, etc.
  - Varying schemas, but can be presented as value vs time
- Web Based Monitoring reads data and makes available in a variety of formats
  - HTML, XML, text, graphics, ROOT TTree object
  - Generic database query + many custom web pages
  - Value vs time, also correlation plots between values
- Web based ROOT browser developed to look at histograms produced by the Data Quality Monitor (DQM) system

CMS Run Summary Pages

CMS RunSummary - Netscape Browser

File Edit View Go Bookmarks Tools Help

http://cmsdaq.cern.ch/cmsmon/cmsdb/servlet/RunSummary

CMS RunSummary

Rows: 1 Data: root | text | xml | query

RUNNUMBER	USERNAME	SEQUENCE	BOOKINGTIME	RUN_MODE	START_TIME	STOP_TIME	TRIGGERS	EVENTS
2241	toppro	CESSY_DAQ	2006.08.10 13:40:46	null	2006.08.10 15:40:46	2006.08.10 16:25:15	50222	50222

Rows: 3 Data: root | text | xml | query

COMPONENT	AVERAGE_RATE_HZ	AVERAGE_SIZE	AVERAGE_SIZE_RMS	N
BU_PERFORMANCE	8.559	262492.814	127.999	96
EVM_PERFORMANCE	19.201	72.000	0E0	43
RU_PERFORMANCE	18.756	87469.880	31.728	129

LTC_CONTROL Configuration

Trigger	Name	Enable
0	DT	1
1	CSC	0
2	RBC1	0
3	RBC2	0
4	RPCTB	0
5	na	0

LTC_CONTROL Rates, *n=44*

AVERAGEDEFFICIENCY	1.000
AVERAGEDL1ARATE	19.131
AVERAGEDRAWL1ARATE	19.131
BLOCKEDTRIGGERS	0E0
EFFICIENCY	0.977
L1ARATE	18.523
RAWL1ARATE	18.523

MagnetStatus

Temperature, °K	5.034 *n=243*	2006.08.10 16:25:13
Current, A	566.056 *n=178*	2006.08.10 16:25:13
MAGNET_CURRENT, A	588.172	2006.08.10 16:25:14
VACCUUM, bar	1.665118E-6 *n=0* *	2006.08.10 15:09:09

* no values during run; last value before run is shown

FED Enable Masks

Component	Id	Status	OK?
ECAL	818	0x1b	Good
HCAL	700	0x3	Good
HCAL	701	0x3	Good
HCAL	702	0x3	Good

Done — Spyware Protection Not Effective

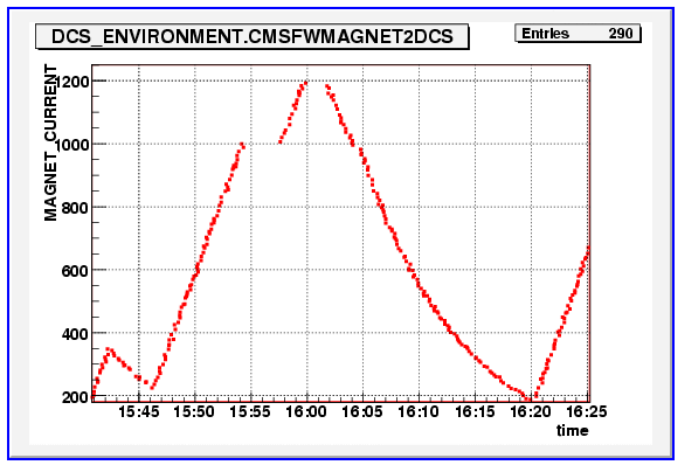
CMS RunSummary - Netscape Browser

File Edit View Go Bookmarks Tools Help

CMS RunSummary

Column	min	max	clear
CHANGE_DATE	2006.08.10_15:40:46	2006.08.10_16:25:15	☐
MAGNET_CURRENT	178.6	1251.6	☐

Submit



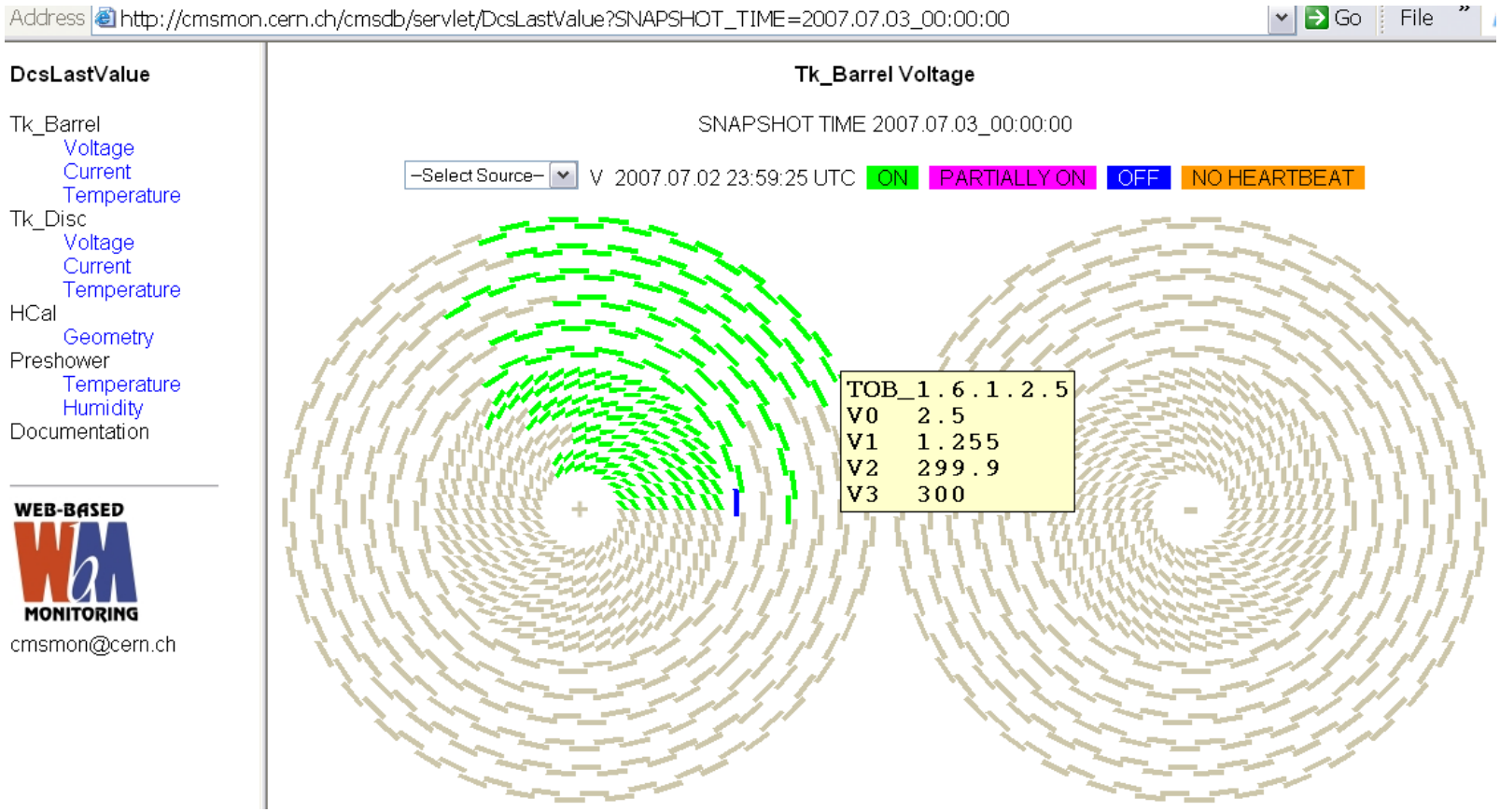
[eps]

Rows: 290 Data: root | text | xml | query

CHANGE_DATE	MAGNET_CURRENT
2006.08.10 15:40:49	196.000
2006.08.10 15:40:52	202.000

http://cmsdaq.cern.ch/cmsmon/cmsdb/servlet/GenericQu... — Spyware Protection Not Effective

CMS Tracker Detector Status



Future Plans

- **Ramp up CMS shifts**
  - Detector Commissioning
  - Global Runs
  - Computing Software and Analysis Challenge (CSA07)
- **LHC Hardware Commissioning**
  - Keep LHC Project Associates engaged after return
  - US/LARP deliverable monitoring
- **LAFS**
  - Continue applications development
- **LHC Beam Participation**
  - SPS and other Injector Beam Studies
  - LARP Instrumentation
  - LHC Commissioning and Beam Studies (especially for luminosity upgrades)

Summary

- Remote operations is the next step to enable collaborators to participate in operations from anywhere in the world. Goals are:
  - Secure access to data, devices, logbooks, monitoring information, etc.
  - Safeguards so actions do not jeopardize or interfere with operations
  - Collaborative tools for effective remote participation in shift activities
- Fermilab has built the LHC@FNAL Remote Operations Center
  - Shared by scientists and engineers working on the LHC and CMS.
  - Collaborative Design
  - Built rapidly
- Provides a means to participate remotely in LHC studies, access monitoring information, a training facility, and supports development of software for the LHC control system.
- For CMS it provides a location for CMS remote commissioning and operations shifts, and Tier-1 grid monitoring shifts.
- Already a popular stop for visitors and dignitaries.

http://cd-amr.fnal.gov/remop/remop.html

Acknowledgements

- LHC@FNAL Task Force
  - Especially Elvin Harms (the original speaker) and Erik Gottschalk from whom many slides were taken
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  - Tom Prosapio
- CERN AB/OP
  - Especially Djanko Manglunki
- Staff of Sites Visited
- Users of Facility