CMS Online Web-Based Monitoring and Remote Operations

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for the CMS Collaboration, including

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❖ **CMS Online Web-Based Monitoring**

➢ Remote Operations
- ✓ Justification
- ✓ Physical installation, use of web services

➢ Online Web Services
- ✓ Database as source; need for meta-data descriptors
- ✓ Browsing, plotting, & dynamic time correlation plots
- ✓ CMS RunSummary example servlet
- ✓ Screen Snapshot Service S^3 desktop image display
- ✓ Environmental trends over time & real time status
- ✓ Web-Based *Root* browser; data quality monitoring

➢ Demonstrate experience during data taking
- ✓ Cosmic Ray runs, Global test runs

➢ Conclusions

CMS Endcap lowering into collision hall
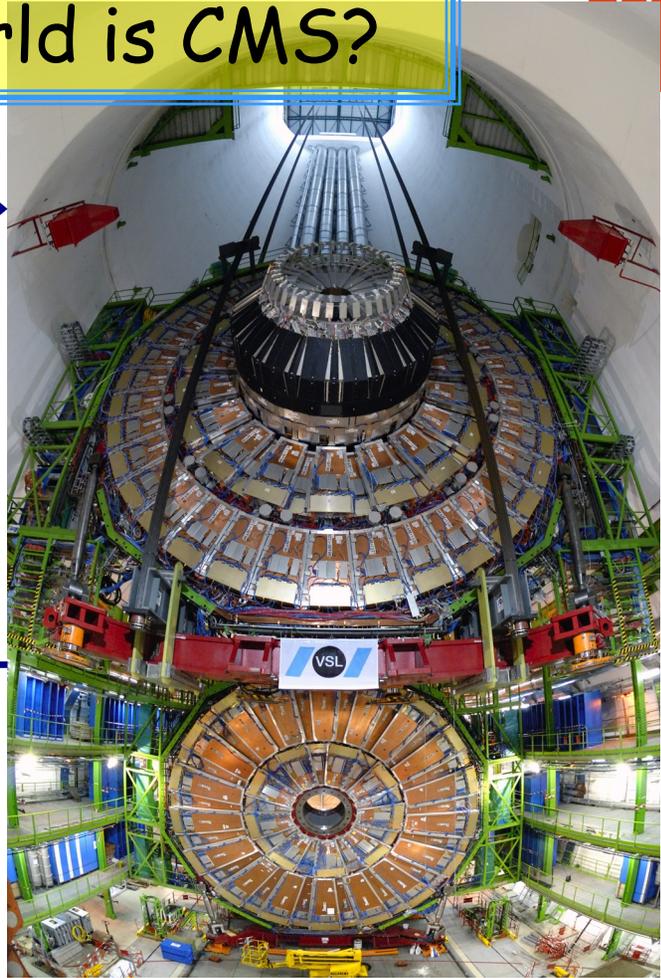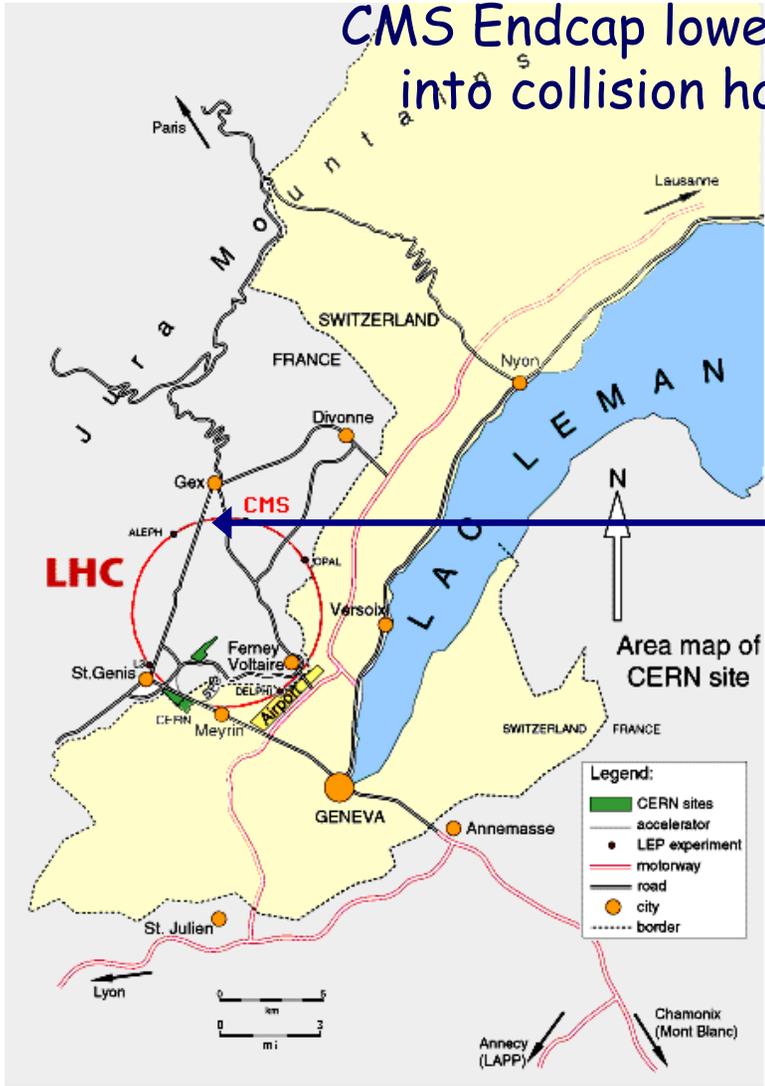
100m below Cessy, France
Large Hadron Collider (LHC) √s=14TeV
Detects proton-proton collisions

The Really Big CMS
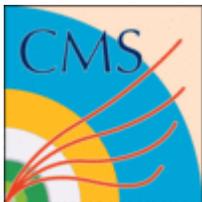
- 2/3 in collision hall
- Services to central piece of barrel
- Preparing for silicon tracker install
- December Cosmics with Magnet
- Summer 2008 collisions
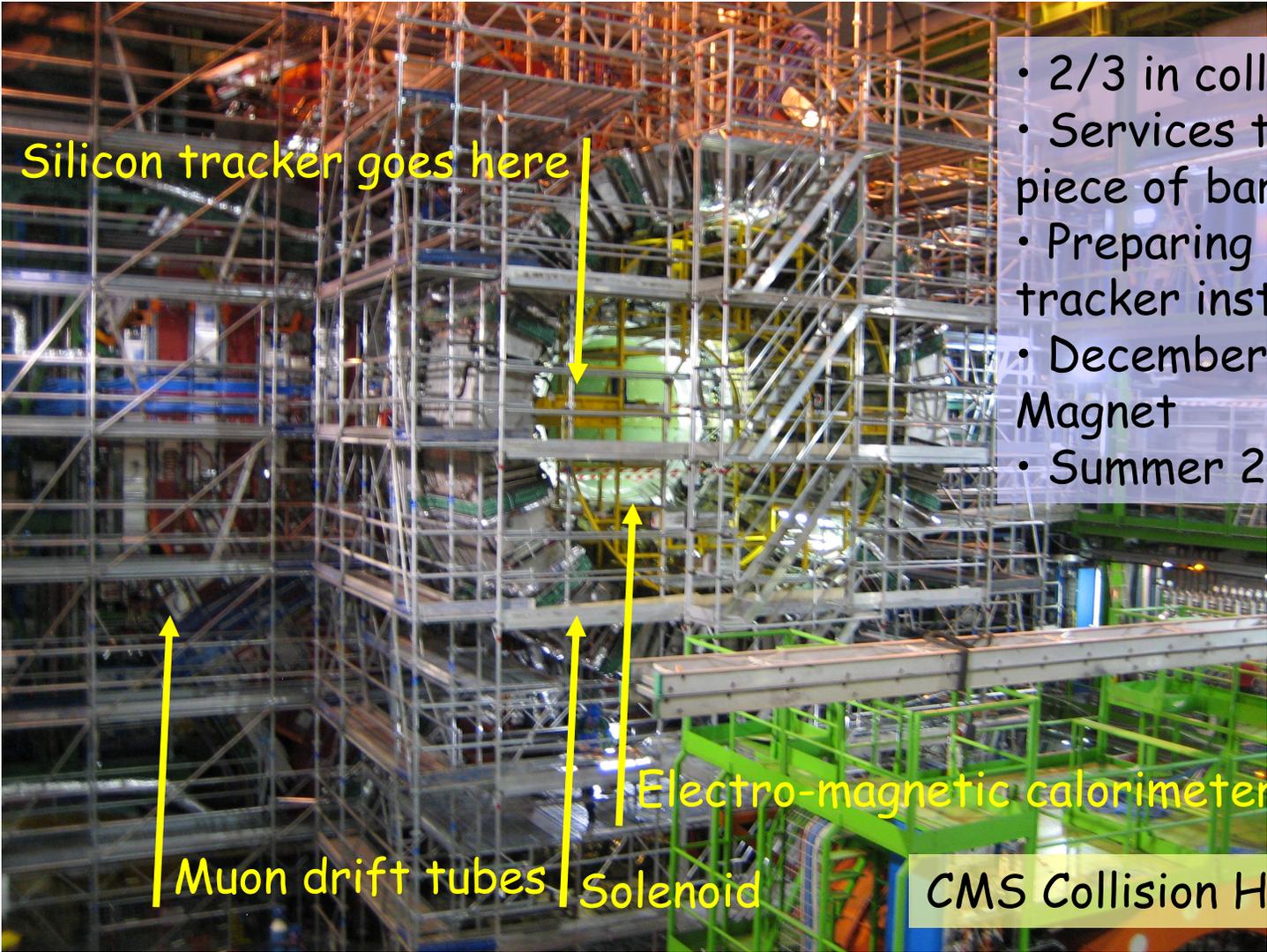
Silicon tracker goes here

Electro-magnetic calorimeter

Muon drift tubes | Solenoid

CMS Collision Hall 2007.08.30

The Really Big CMS World

CMS Institution Country

CMS Interest

2007.08.21
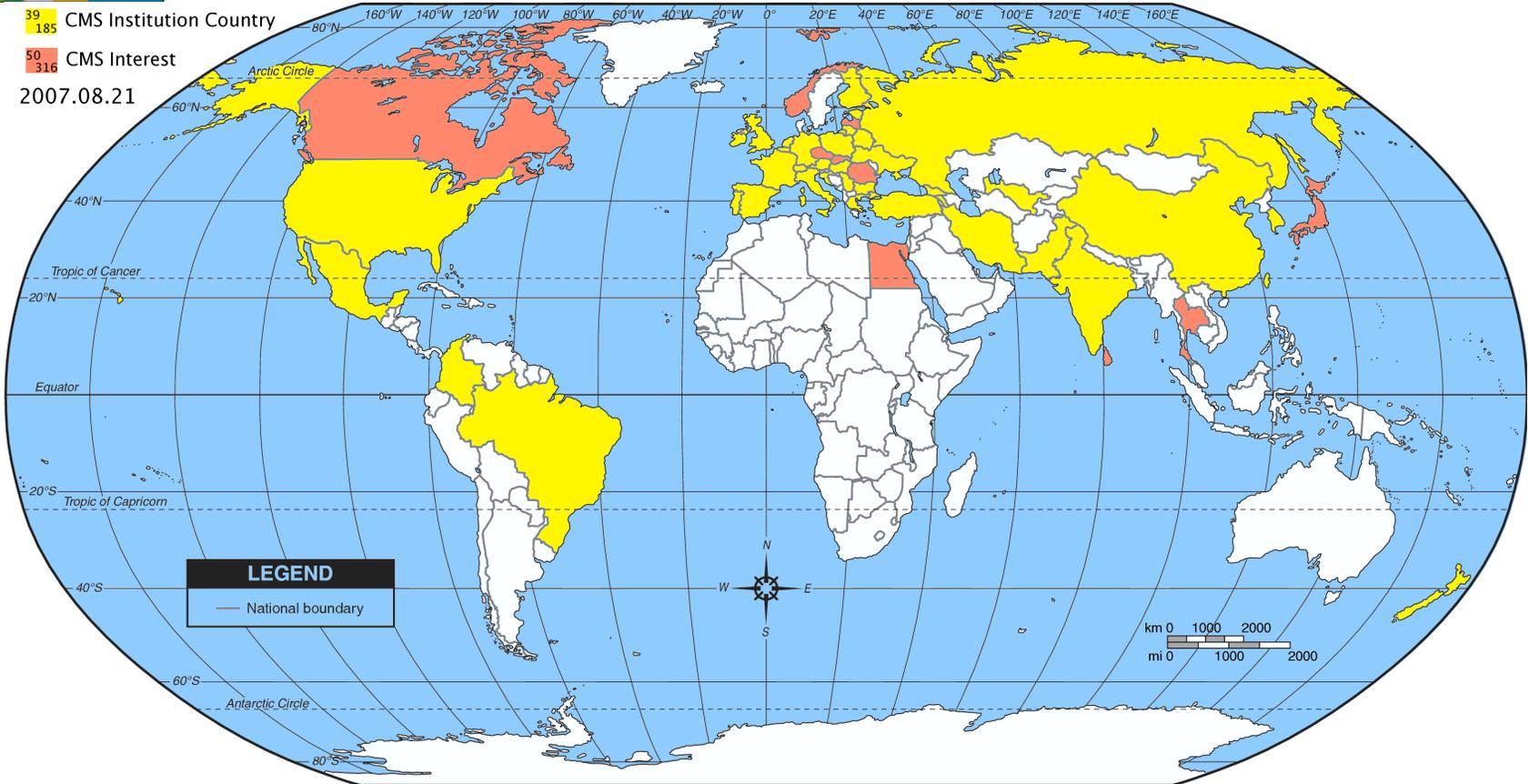
Don't you remember the <u>original purpose</u> of the WorldWideWeb?

The need to disseminate HEP data world-wide grows even more important with huge collaborations spanning the globe

Why Remote Operations?

- Thousands of collaborators located all over the world
- Most of them not resident at CERN
- Collider H.E.P. has never before been so concentrated in one location
- Need to disperse and disseminate

R.I.P.
- HERA June 2007
- CESR 2008
- PEP II 2008
- Tevatron October 2009…

Future
- ILC – 2020? 2120? Ever?
- Are we the last HEP collider experiment?
- Must be clever to survive

Remote Operations

Fermilab Remote Operations Center
LHC@FNAL

CMS Underground Control Room
2007.08.30 Global Integration Run

FNAL

CERN

- Tools needed for remote status display
- Must be easy to use, flexible, drillable
- Coöperative with firewall, security
- Must survive trans-Atlantic crossing
- Also see Lucas Taylor's talk,
"CMS Centers for Control, Monitoring, Offline Operations and Analysis"
Thursday, 14:00, DD-6, contribution 260

Web-Based Monitoring

- **Wealth of information in database**
  - Trigger rates, event rates, cross sections, beam conditions, temperatures, voltages, environmental conditions, etc. …
  - Database is preferred locale for configuration and monitoring data persistency
  - Oracle 10 located at CMS site; replicated to offline world
  - Has current and historical status data
    - ✓ Latency ~ < 1 second to ~1 minute
    - ✓ Behind firewall for security reasons
- **Need a portal to gain access**
  - Provide display of contents
  - And provide access control
- **Typical data present, "Value vs. Time"**
  - Needs tools to access, plot, download, correlate
- **Complex, heterogeneous database**
  - Many schemas, many designers
  - Already have <u>140</u> schemas just in the online database & not nearly done
- **Central description needed**
  - Correlate across subsystems
  - Typical monitoring is "Value vs. Time"
    - ✓ *Global* meta-data descriptive tables

Meta Data Tables

- Consider "value, time" pairs (x, t_x)
  - Time: Timestamp, Run Number, Luminosity Subsection
  - Entries in meta-data tables specify value, time, units, type of data, subchannels, …
  - Allows general purpose retrieval from central tables
- Conversion: HTML, Text, XML, Root formats
  - Root TTree n-tuple object with multiple values per time (x, y, z, t)
  - Optional caching of results
  - ?FORMAT=TEXT|XML|HTML|Root|GRAPHICS
  - Dynamic inline embedding of graphics
    - ✓ Other pages can access plots automatically
  - Available via HTML display page links or via direct download with *curl* or *wget* :
    - ✓ curl "http://cmsmon.cern.ch/cmsdb/servlet/GenericQuery?..."

DatabaseBrowser and GenericQuery

DatabaseBrowser - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back · · · · Address http://cmsmon.cern.ch/cmsdb/servle ▾ Go

JavaScript Tree Menu
- DatabaseBrowser omds 2007.08.13 22:21:37
  - AD_PORTAL_TEST
  - CDAQ_MONITOR
    - INDEX
    - TABLE
      - **BU_EVENT_NUMBER_DATABASE**
      - BU_OCCUPANCY_DATABASE
      - BU_PERFORMANCE_DATABASE
      - BU_STATUS_DATABASE
      - EVM_EVENT_NUMBER_DATABASE
      - EVM_OCCUPANCY_DATABASE
      - EVM_PERFORMANCE_DATABASE
      - EVM_STATUS_DATABASE
      - FBO_DATABASE
      - FMMCONTROLLER_FMMINPUT
      - FMMCONTROLLER_STATUS_DATABASE
      - FRLCONTROLLER_CARD_DATABASE
      - FRLCONTROLLER_LINK_DATABASE
      - FRLCONTROLLER_STATUS_DATABASE
      - FU_PERFORMANCE_DATABASE
      - FU_RATE_DATABASE
      - FU_STATUS_DATABASE
      - LTCCONTROL_DATABASE
      - LTC_CONTROL

TABLE CDAQ_MONITOR.BU_EVENT_NUMBER_DATABASE contents

Columns for table CDAQ_MONITOR.BU_EVENT_NUMBER_DATABASE

Set: ☐   Clear: ☐

ColumnName	DataType	Select	Plot	Order	Not Null	Equals	LowBound	HighBound
CLASS	VARCHAR2(1000)	☐	☐		☐			
EVENTNUMBERFROMEVM	NUMBER(22,10)	☐	☐		☐			
EVENTNUMBERFROMRUS	NUMBER(22,10)	☐	☐		☐			
EVENTNUMBERTOFUS	NUMBER(22,10)	☐	☐		☐			
HOSTNAME	VARCHAR2(1000)	☐	☐		☐			
INSTANCE	NUMBER(22,10)	☐	☐		☐			
RUNNUMBER	NUMBER(22,10)	☐	☐		☐			
TIMESTAMP	VARCHAR2(1000)	☐	☐		☐			

SubmitQuery

Detailed information for TABLE CDAQ_MONITOR.BU_EVENT_NUMBER_DATABASE

OWNER	CDAQ_MONITOR
TABLE_NAME	BU_EVENT_NUMBER_DATABASE
TABLESPACE_NAME	CMSOMDS_DAQ

Internet

- Peruse database definitions
- Dynamic query definition
  - ✓ Data download, plots

DatabaseBrowser and GenericQuery Java/Tomcat servlets are focal point and parents of tools
- Primarily expert starting point
- General user pages inherit (Java) from browser
  - ✓ Specific use cases, easier to use

RunSummary query

RunSummary query page an example of these monitoring and browsing tools

Select by:
• Run range
• Time range
• Component status
• Run duration, event
• Trigger type
… more to come

RunSummary pages

- Clickable measurements
  - ➢ Drill-down capability
- Plot creation
 - ➢ Provides Root TTree and histogram object in file
 - ➢ Resizeable on resubmit

Time Correlation Plots

ntuple

x	t_x
....	....
....	....
....	....
....	....
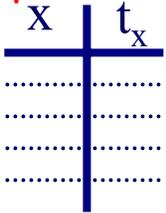
Must choose independent variable as basis for correlation

ntuple

w	t_w
....	....
....	....
....	....
....	....
....	....
....	....
....	....

$(x, t_x) \times (y, t_y)$

ntuple

y	t_y
....	....
....	....
....	....
....	....
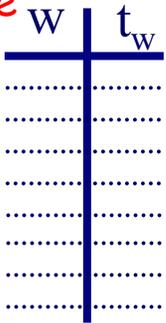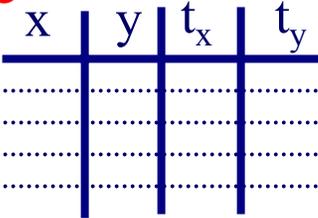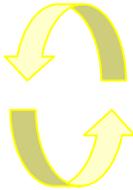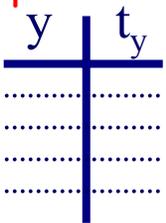
collate

$w = x, y$
$t_w = t_x, t_y$

sort and pair nearest neighbors by time
TTreeIndex

ntuple

x	y	t_x	t_y
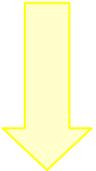
plot

TH2D
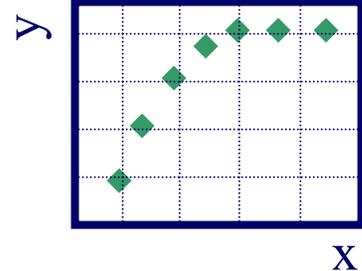
Time range must be identical: $\Delta T_x = \Delta T_y$

Time sampling period similar: $\Delta t_x \sim \Delta t_y$

Heterogeneous environment, with no a priori correlation necessary

Time Correlation Example

WEB-BASED WBM MONITORING
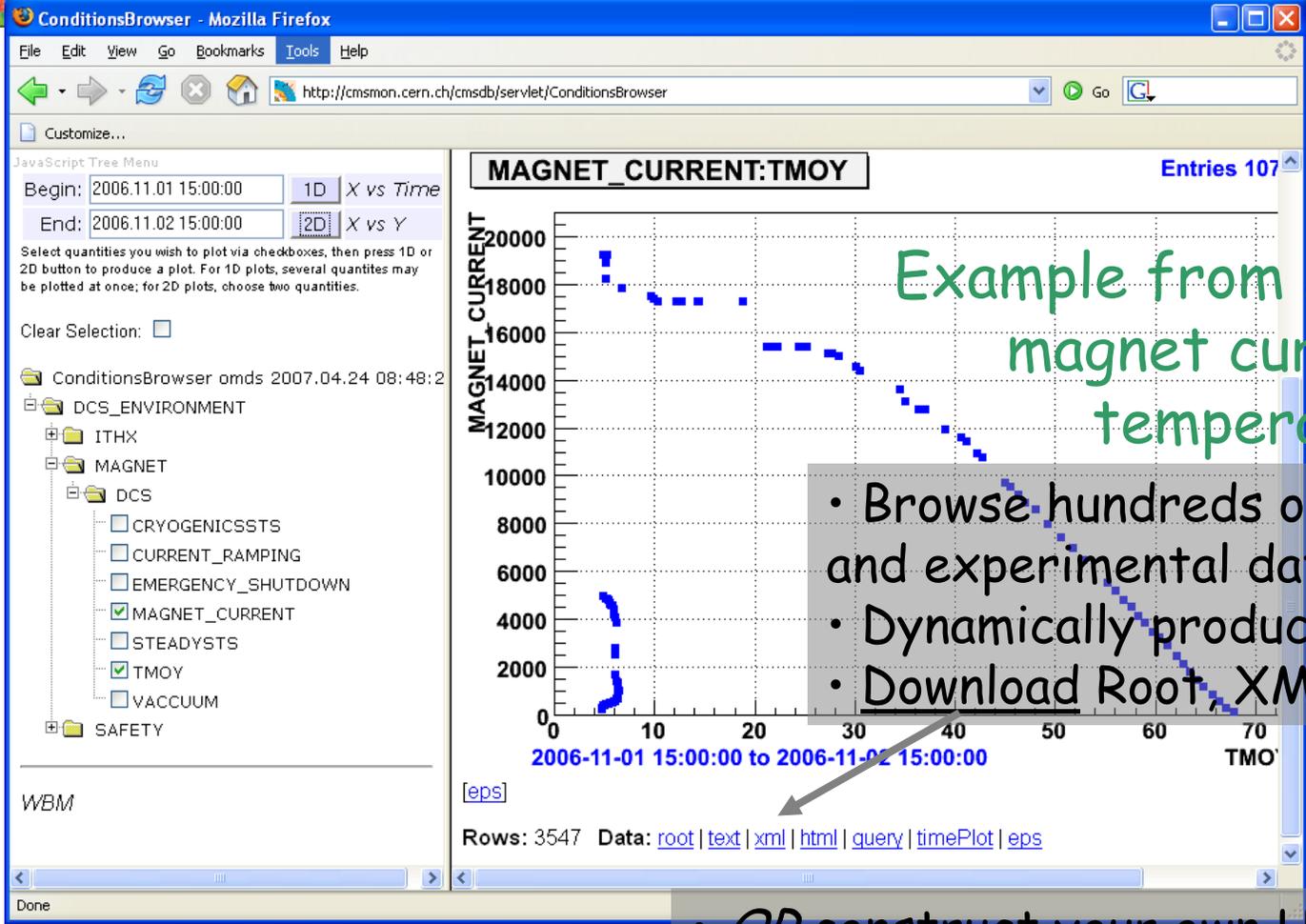
Example from MTCC* data magnet current vs. temperature

- Browse hundreds of environmental and experimental data samples
- Dynamically produce plot
- <u>Download</u> Root, XML, text, HTML

- *OR* construct your own URL for in-line linking or non-interactive "wget" access

*Magnet Test Cosmic Challenge, November 2006
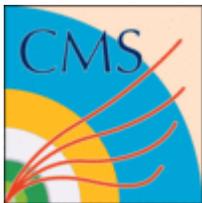
Trend over Time Plots

- Search for performance anomalies
- Interactive, historical, downloadable
- Selection of type of data
- Zoom in on problems
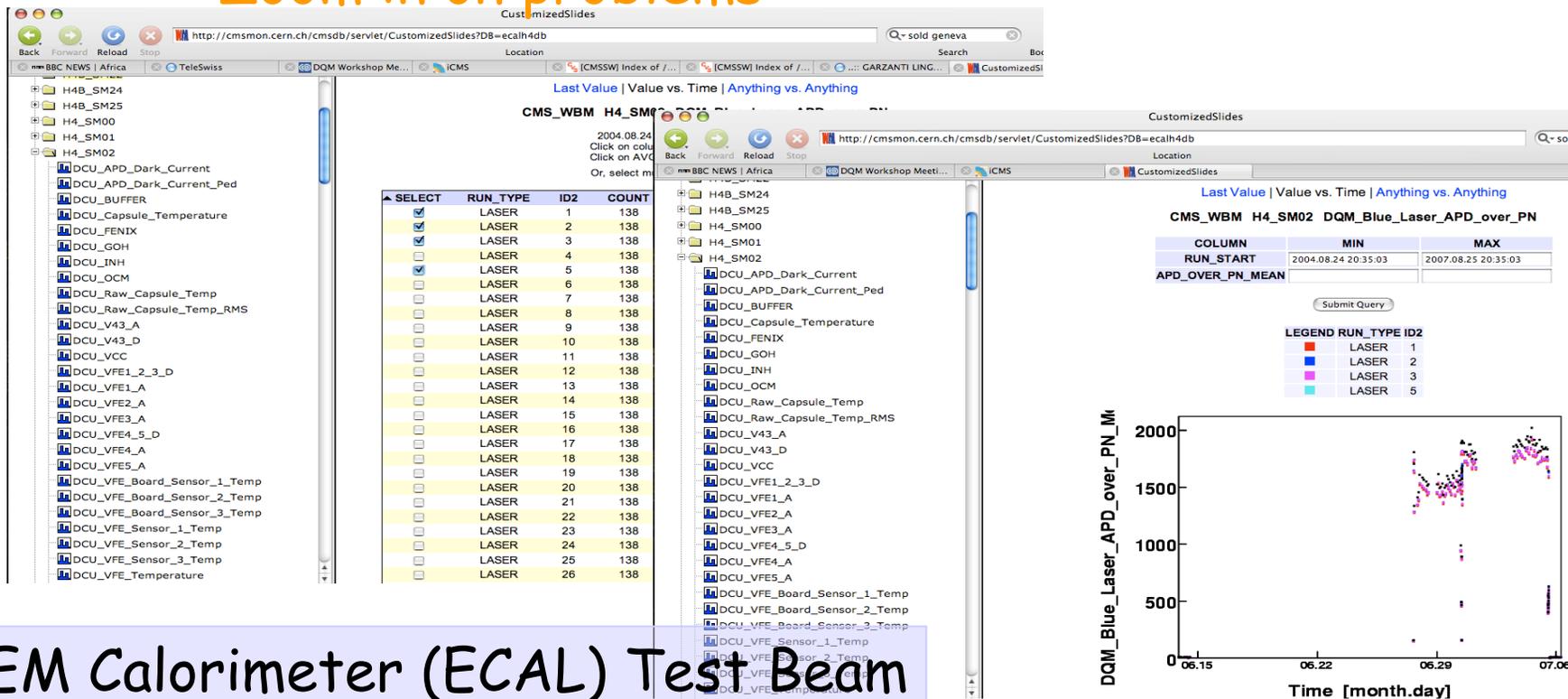
EM Calorimeter (ECAL) Test Beam

Environmental – Slow Control

- Access to current "right-now" conditions
- ...and historical settings and trends...

Silicon Tracker Integration Facility
Cosmic Ray Runs

(Zongrun Wan)

http://cmsmon.cern.ch/cmsdb/servlet/DcsLastValue

RootBrowser

- Need light-weight method to browse plethora of Root output – e.g. data quality monitoring (DQM)
  - ➢ Some DQM > 100,000 histograms CSC (!)
  - ➢ Display Root Folder tree dynamically
  - ➢ Selective display of objects implementing the Draw() method
- Implement browser for Root <u>files</u>
  - ➢ Latency ~ 30 seconds to 5 minutes
  - ➢ Transfer minimal data needed for display
    - ✓ Dynamic TFolder opening and dynamic TObject display
    - ✓ Optional single object download
  - ➢ No dependency on data structure of Root objects
  - ➢ No special web client software needed
  - ➢ Javascript on display (client) side, Java/Tomcat plus Root on server
    - ✓ A la Ajax
- Also developing sophisticated detector-specific display
  - ➢ User-defined markups and arrangement, with tools
  - ➢ Network protocol data transfer – latency < 1 s
  - ➢ Lassi Tuura

DQM / RootBrowser

Dynamic JavaScript displays with Tomcat/Java backend

Silicon Tracker Integration Facility Cosmic Ray Run

Hadron Calorimeter (HCAL)
Global Integration / Cosmic Ray Run
New DQM GUI with user markup

(Lassi Tuura)

Screen Snapshot Service S^3

- Remote Operations need Remote Knowledge
  - Operations screens, e.g. RunControl, HV Control, EventDisplay valuable for remote users to know what is going on
  - But normally have tight restrictions on access to nodes
- What is the Screen Snapshot Service?
  - A way to provide periodic, read-only copies of display images (snapshots) for remote viewing
  - Similar to products like VNC, pcAnywhere, and VGA2WEB but without the cost or danger of accidental remote control
  - Can be used to make private-network displays viewable on the public internet (useful for remote monitoring)
  - Uses commonly available technologies for portability and ease of use: Java, JSP, Tomcat

(Kurt Biery)

Screen Snapshot Service Mechanism

WEB-BASED WM MONITORING

Provides real time images of monitor displays to remote sites

Snapshot Producer *1*
Java web start app

⋮

Snapshot Producer *n*
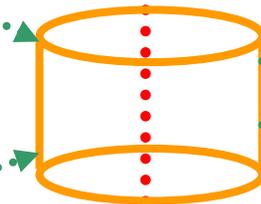
Web Service Disk Cache

Web Client *1*
Remote Ops

Web Client *2*

⋮

Web Client *m*

Periodic HTTP Web POST with image payload

Normal HTTP Request
Web page, no special config

```
S^3
File   Help

Pause            Snapshot creation interval: 60  ▾
12:52:18         Display name: GroundControl cmsmon.cms
Active           Show statistics
<< Less          Java version at runtime = 1.6.0_02

Enabled displays: ☑ 0
```
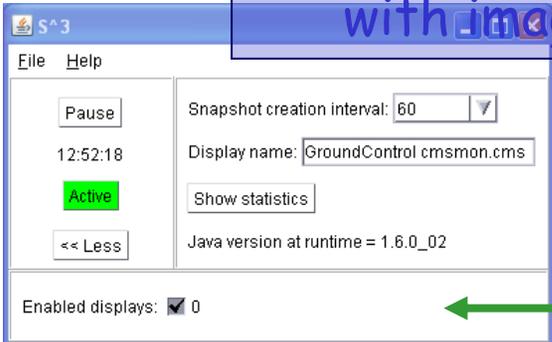
Private net
Firewall →

Public net

control widget

(Kurt Biery)

Screen Snapshot Service Example

CMS EventDisplay

Actual snapshots from 2007.08.30 CMS global integration run
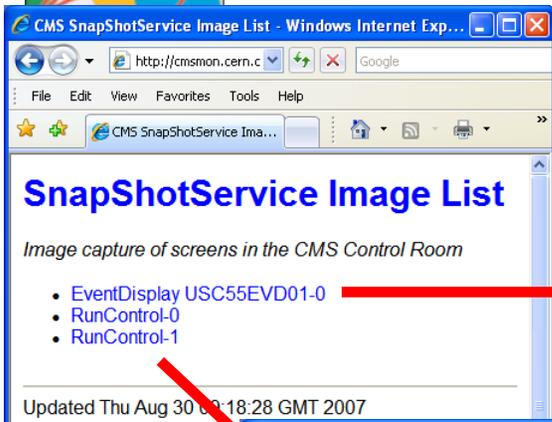
(Ianna Osborne)

S^3
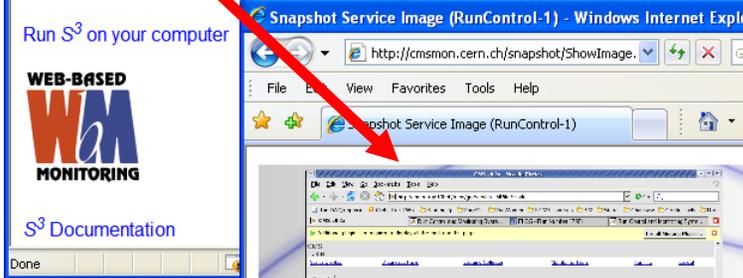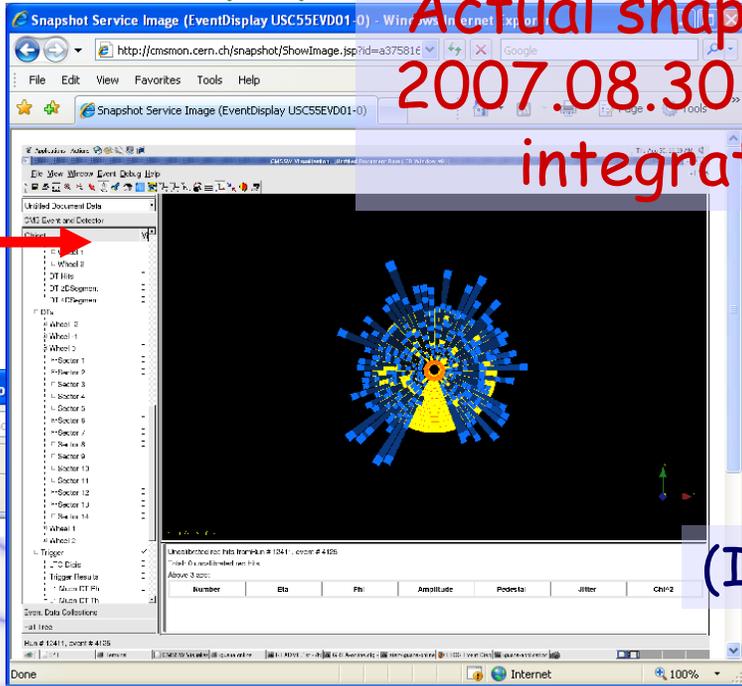
CMS RunControl
(see Alex Oh, CHEP'07 279)
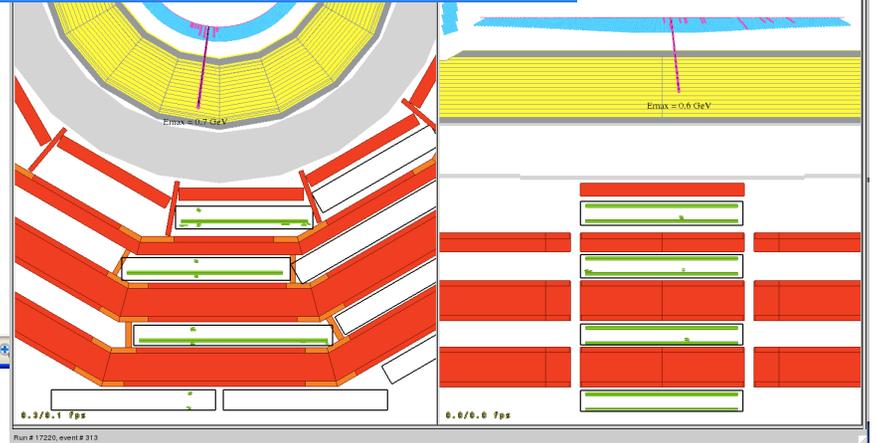
More Run Monitor Tools

CMS "Page 1" top level status display, simplicity for even the most naïve user (Oracle Portal)

(S.Murray)

CMS Fermilab Data File Process Summary Page
Files copied to FNAL Tier 1 site and status of processing
(jsp)

(F.Yumiceva, D.Mason)

Conclusions

- LHC plans first collisions in 2008
- Remote Operation will be an important part of CMS data taking
- Tools have been developed for remote operations
  - ➢ Actively used in Cosmic Runs, Test Beam, Global Integration Runs, late 2006 through 2007
  - ➢ Remote Operations Center or Individual Users and Experts
  - ➢ Continued development in preparation for collisions
  - ➢ Accessible at http://cmsmon.cern.ch

Backup Slides

HomePage

cmsmon home page
• http://cmsmon.cern.ch
• Links to servlets and documentation
• Visit me

cmsmon Activity

Usage Statistics for cmsmon.cern.ch

Summary Period: Last 12 Months
Generated 03-Sep-2007 17:30 GMT
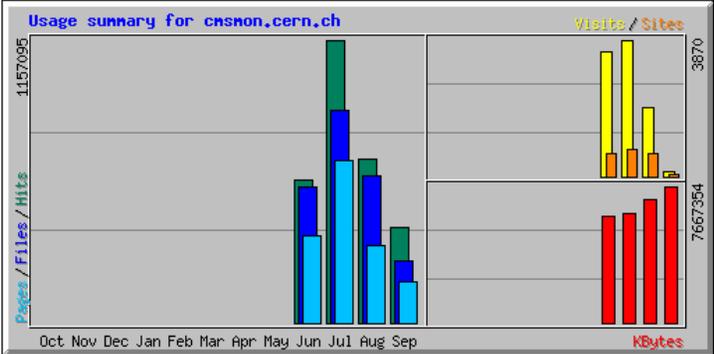
cmsmon.cern.ch server access ra
>36,000 hits July 2007
...before experiment has begun

Month	Daily Avg					Monthly Totals				
	Hits	Files	Pages	Visits	Sites	KBytes	Visits	Pages	Files	Hits
Sep 2007	130609	84841	55104	51	63	7667354	155	165314	254525	391828
Aug 2007	21523	19432	10242	62	665	6888814	1945	317531	602421	667227
Jul 2007	37325	28063	21494	124	785	6124828	3870	666316	869957	1157095
Jun 2007	36390	34566	22152	221	642	5973835	3545	354446	553062	582248
Totals						26654831	9515	1503607	2279965	2798398

Generated by Webalizer Version 2.01

Example URL Plot Query

```
<IMG SRC= http://cmsmon.cern.ch/cmsdb/servlet/GenericQuery
    ?DB=omds
    &OWNER=DCS_ENVIRONMENT
    &TABLE=FWMAGNETCMS
    &SELECT_MAGNET_CURRENT=1
    &PLOT_MAGNET_CURRENT=1
    &NOTNULL_MAGNET_CURRENT=1
    &SELECT_CHANGE_DATE=1
    &TIME_CHANGE_DATE=1
    &PLOT_CHANGE_DATE=1
    &LOW_CHANGE_DATE=2006.11.01_13:40:40
    &HIGH_CHANGE_DATE=2006.11.02_13:40:40
    &MIN_CHANGE_DATE=2006.11.01_13:40:40
    &MAX_CHANGE_DATE=2006.11.02_13:40:40
    &FORMAT=GRAPHICS>
```

Location of Data in DB

Which columns to plot, which column is time

Time and plot ranges
or
LAST_CHANGE_DATE=*seconds*

Payload returned will be purely PNG graphics

Example Multiple Time Plot

Plotting current, temperature and magnet current from November 2006
Downloadable Root file contains composite TTree ntuple for all three