The first running period of the CMS detector controls system

A success story

ICALEPS 2013

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Outline

- Introduction to CERN/CMS
- Challenges to the CMS **D**etector **C**ontrols **S**ystem
- Design concepts of the DCS

About CERN


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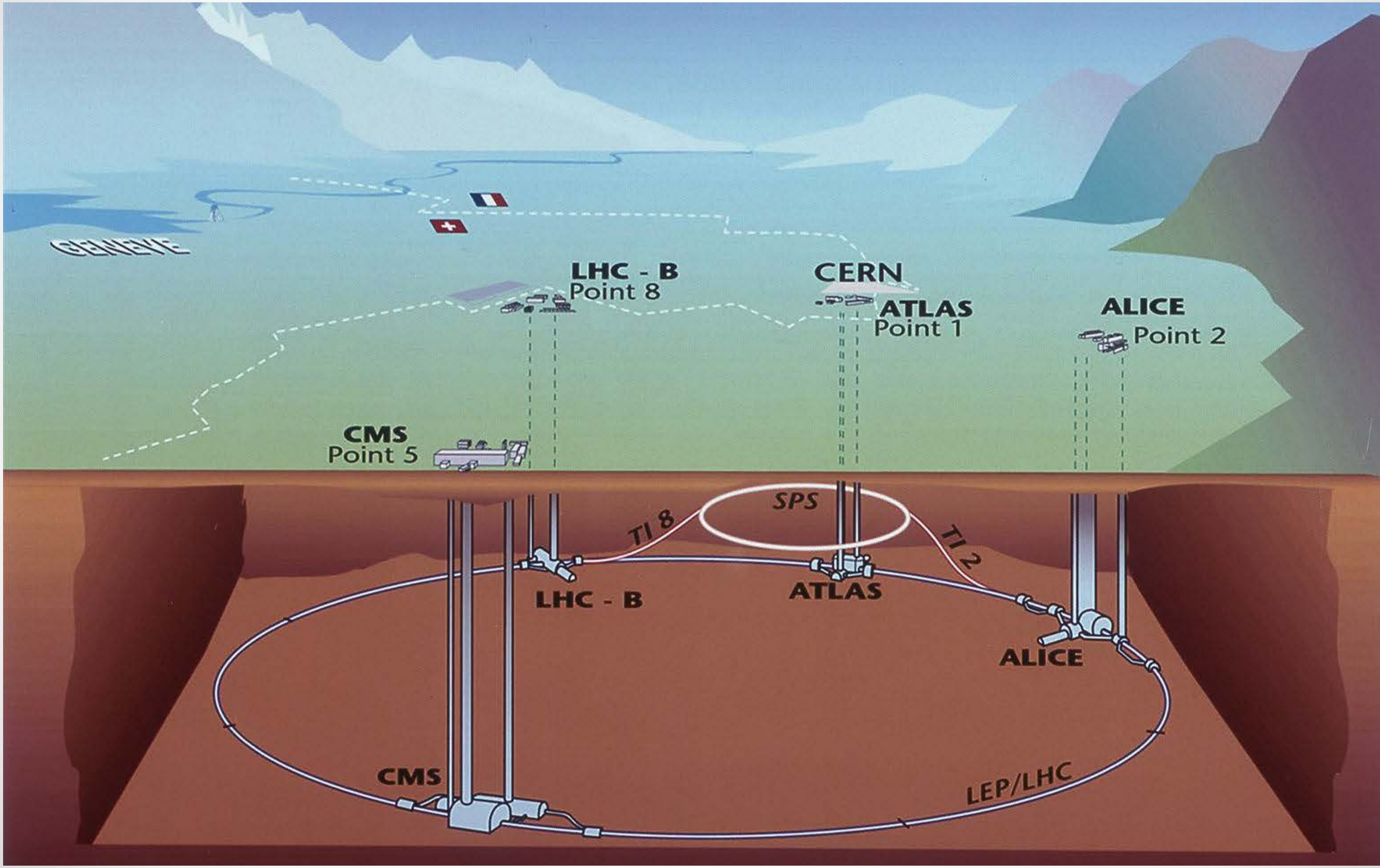
About CERN


GENEVE
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
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CMS
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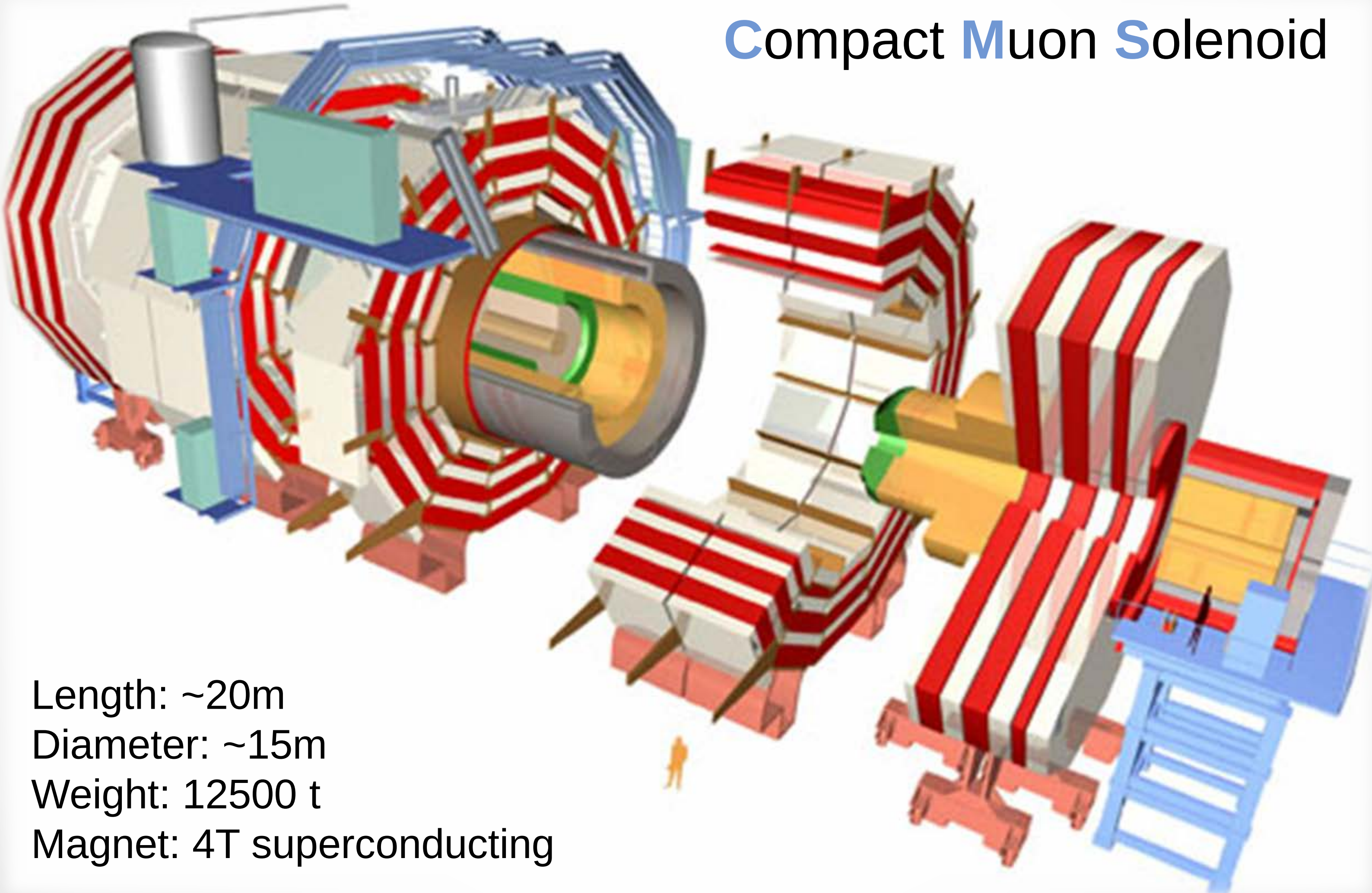
LHC - B
ATLAS
ALICE
CMS
LEP/LHC

The CMS detector



Compact Muon Solenoid

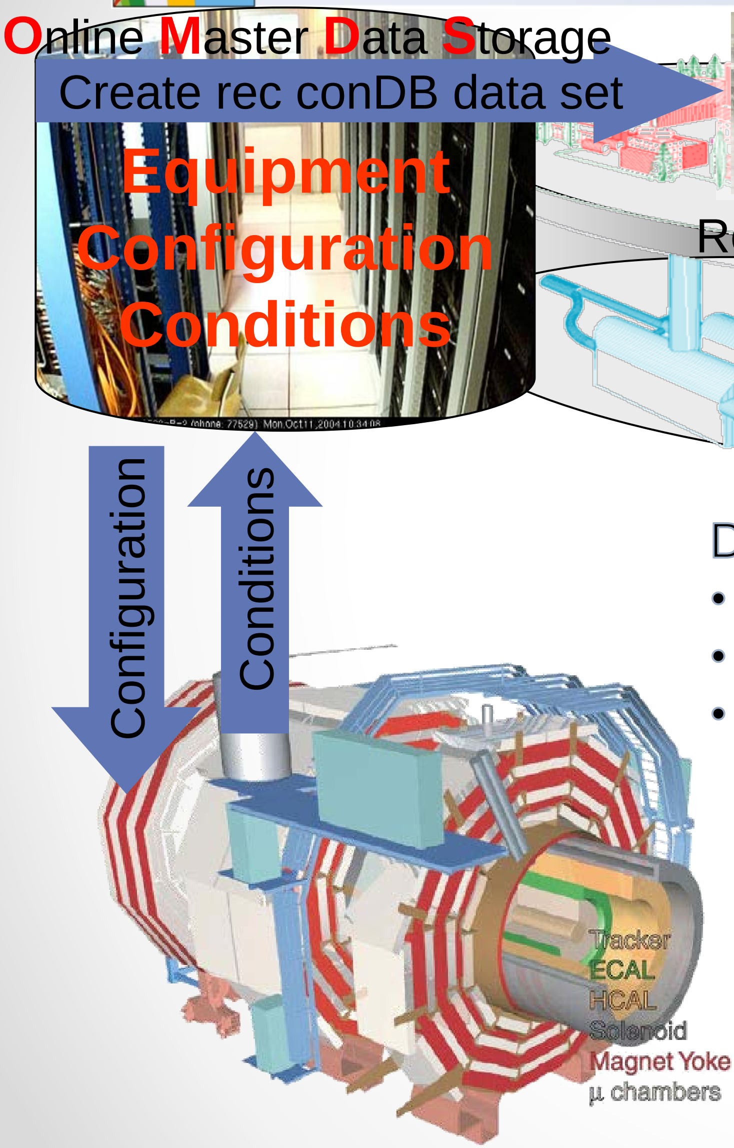
Length: ~20m
Diameter: ~15m
Weight: 12500 t
Magnet: 4T superconducting

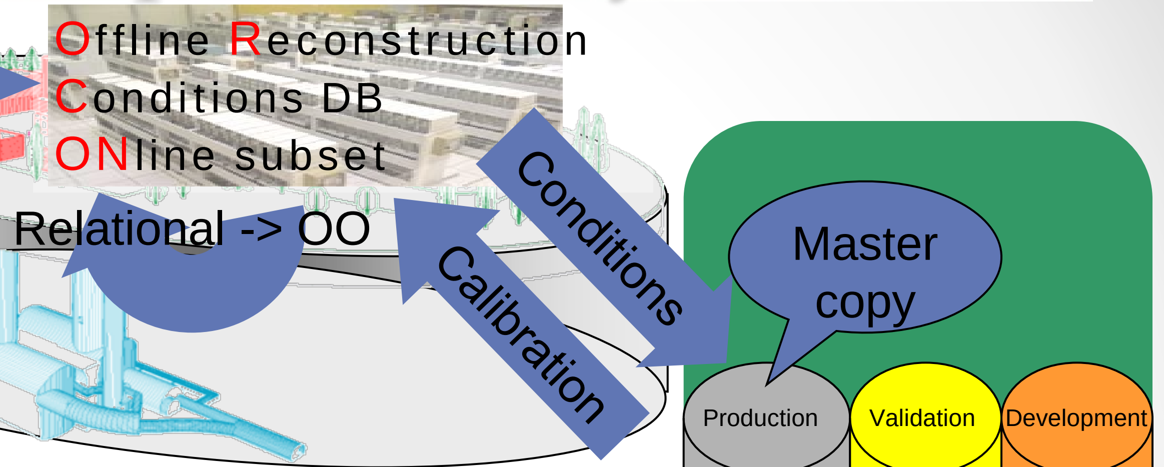
CMS DCS facts

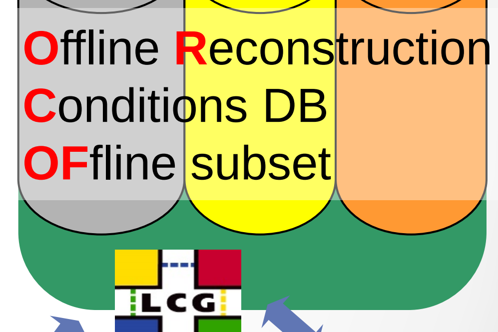
- Working since three month after LHC start up at ~100% efficiency.
- SCADA: WinCC OA developed by ETM
- ~3 million parameters
- ~700.000 lines of code
- ~35000 finite state mashine nodes
- ~70 SCADA systems
- ~70 PCs (Windows)
- ~50 DB schemas (ORACLE)
- O(TB) of data in schemas

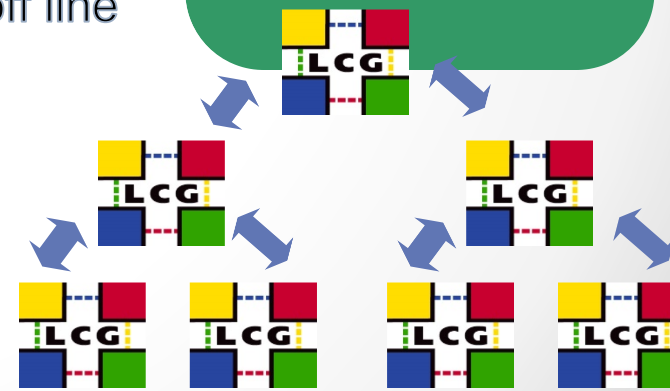
LHC: large hadron collider
SCADA: supervisory control and data acquisition

Data persistency









DCS Data has to be:

- Stored
- Kept accessible
- Made available to off line reconstruction

DCS challenges

Technical

- Unprecedented in size and complexity
- Diversity of items to control
- Multitude of required IT techniques
- Single non expert shifter for all CMS DCS
- Availability 24/7 365d/y

Managerial

- Heterogeneous developer group
- Integrate all sub detector DCS projects in one overall CMS DCS project
- Decision making only by persuasion

Starting point

From previous (smaller) experiments at CERN we knew that

- A hierarchical controls system structure is advantageous for several aspects (see next slides)
- Automation of controls helps to increase the efficiency
  - o Automatic reaction to accelerator status maximizes time available for physics data taking
  - o Automatic error recovery avoids erroneous operator actions and ensures a fast reaction

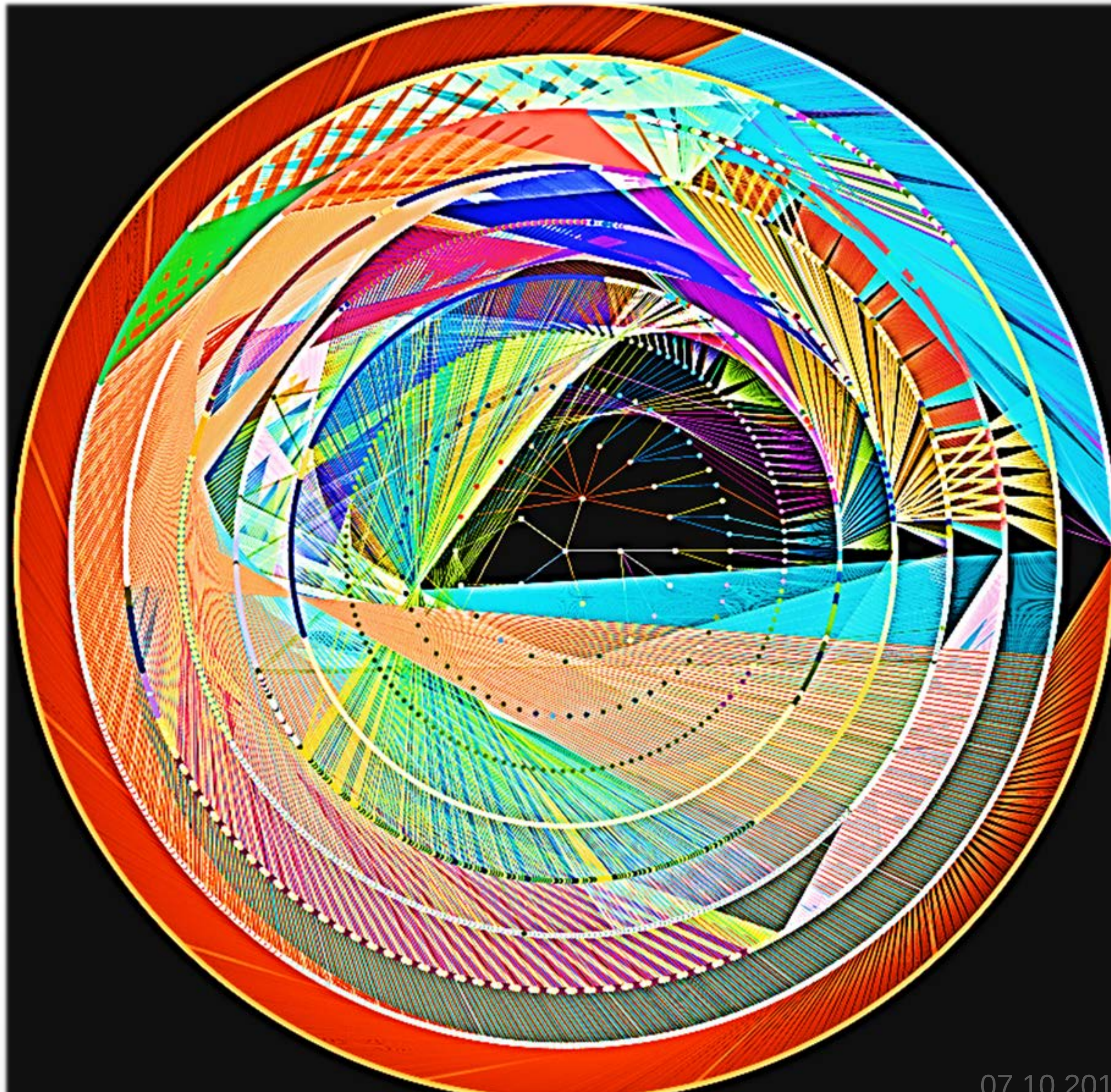
Coping with size

- The key to handling the large size of the project was factorization and templating.
- Entities of equal behavior have been identified and modeled using the SMI++ finite state machine toolkit, which has been connected to WinCC OA within the JCOP framework.
- Those entities have been organized in a hierarchical structure to provide a synthesized abstraction of the system status at each level and offer a centralized and simplified control of the whole system.

JCOP: CERNs joint controls project

Controls hierarchy

- 35000 finite state machine nodes in a hierarchical structure

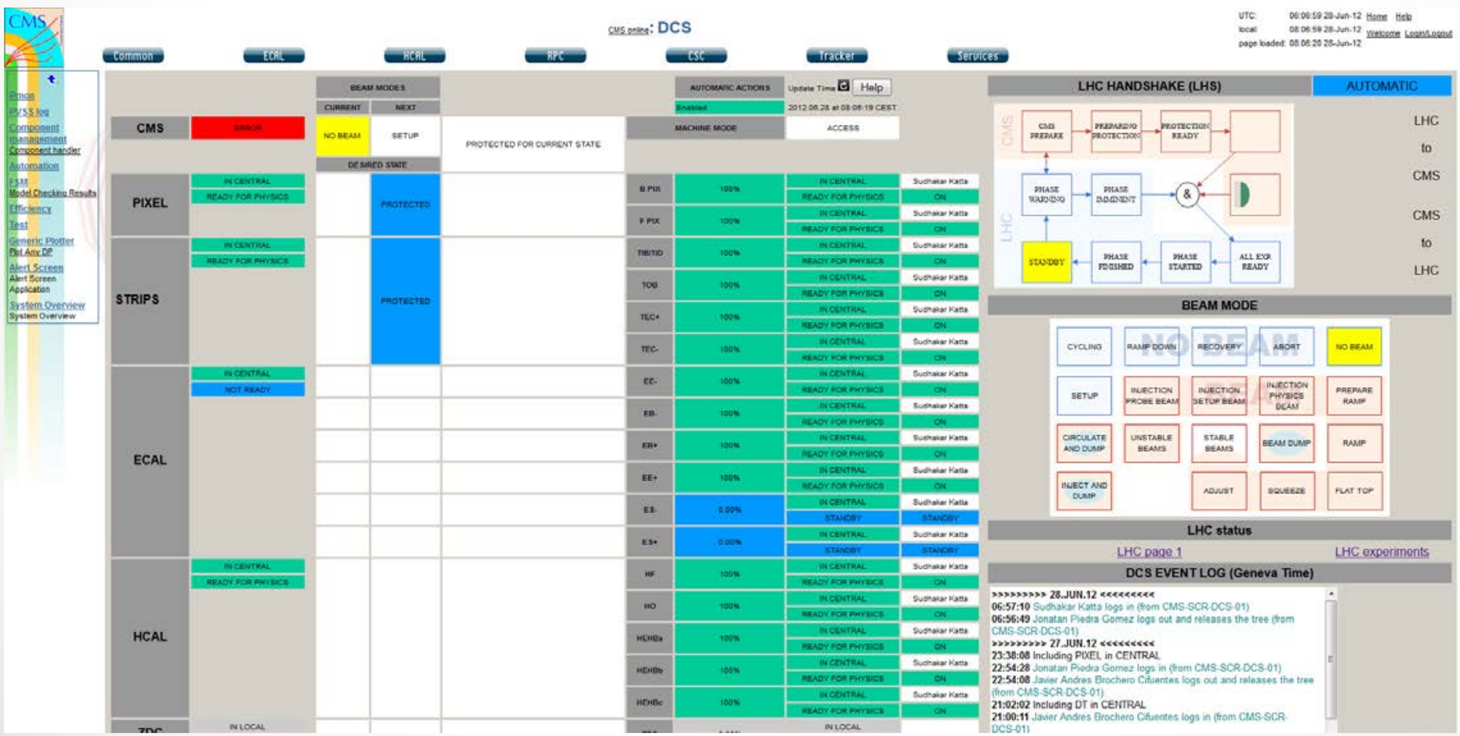


Homogenizing diversity

- The protocols for the communication with hardware have been set to be wherever possible OPC
- A concept of software components initially developed in JCOP has been re used and applied to common functionalities identified in CMS.
- A computing service like infrastructure has been set up to target SVN versions of the software components to be deployed on the DCS computing nodes
- The detector experts can monitor and control their systems through on line tools

CMS online web

- ORACLE portal web infrastructure
- ~50 web applications (ELOG, shift list, ACT…)
- 1 DB managed by the CMS DCS team
- 2 web servers



Always and never

- The CMD DCS is required to run 24/7, 365 d/y.
- System failures during data taking mostly lead to loss of physics data
- Services used by multiple DCS systems have been identified and made redundant using the WinCC OA redundancy feature
- Currently the full system is made entirely redundant:
  - Two identical set ups in distinct locations using different services
  - Ideally will require interventions only during working hours
  - Maintenance can be transparent

Less is more

- Millions of parameters can't be controlled by a human in real time.
- Experience shows that most failures are caused by human intervention whilst the system actions are mostly correct.
- The primary mean to render the large amount of data controllable is the hierarchical structure.
- Knowledge about the quality of the current state and automatic actions for remedy have been included in many nodes in the hierarchy

Less is more

- The WinCC OA alert system is used to inform the operator or the detector expert about system failures.
- A help system has been connected to the alerts to allow detector experts to pass information about the failure and its remedy to the operator

Running experience

- The CMS DCS was running ~27600 hours in central operator mode since autumn 2009. (~32400 in total up to now)
- The commissioning took ~3 month.
- The mean number of required expert interventions was ~1-2 per week.

Conclusions

- The CMS DCS represented a challenge mainly due to its unprecedented size
- The key concepts of the system are factorization in a hierarchical structure of templated instances and synthesis of status information
- Redundancy and the service like computing infrastructure ease the maintenance
- The running experience over the last running period is very positive and confirms the correctness of the system design

Other CERN presentations

- OPC Unified Architecture within the Control System of the ATLAS Experiment
  - MOPPC032
- Centralized Data Engineering for the Monitoring and Control of the CERN Electrical Network
  - MOPPC023
- New Electrical Network Supervision for CERN: Simpler, Safer, Faster, and Including New Modern Features
  - MOCOBAB01
- Reusing the knowledge from the LHC Experiments to implement the NA62 Run Control
  - TUPPC064
- Hierarchies of Alarms for Large Distributed Systems
  - TUPPC115
- High-level Functions for Modern Control Systems: A Practical Example
  - THPPC081
- An Overview of the LHC Experiments' Control Systems
  - WECOAAB01