

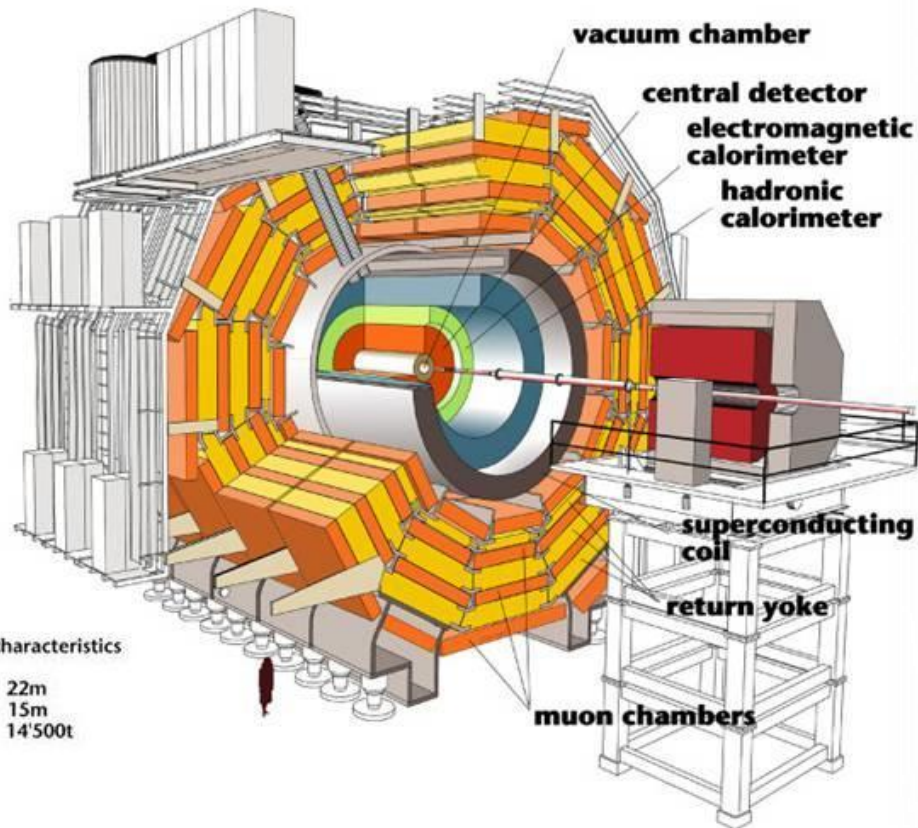
# **Status of the CMS Detector Control System**

**International Conference on Computing in High Energy and  
Nuclear Physics 2012, New York**

**Robert Gomez-Reino  
on behalf of PH-CMD CERN group**

# The Compact Muon Solenoid

A multi-purpose Large Hadron Collider experiment



#### Detector characteristics

Width: 22m  
Diameter: 15m  
Weight: 14'500t



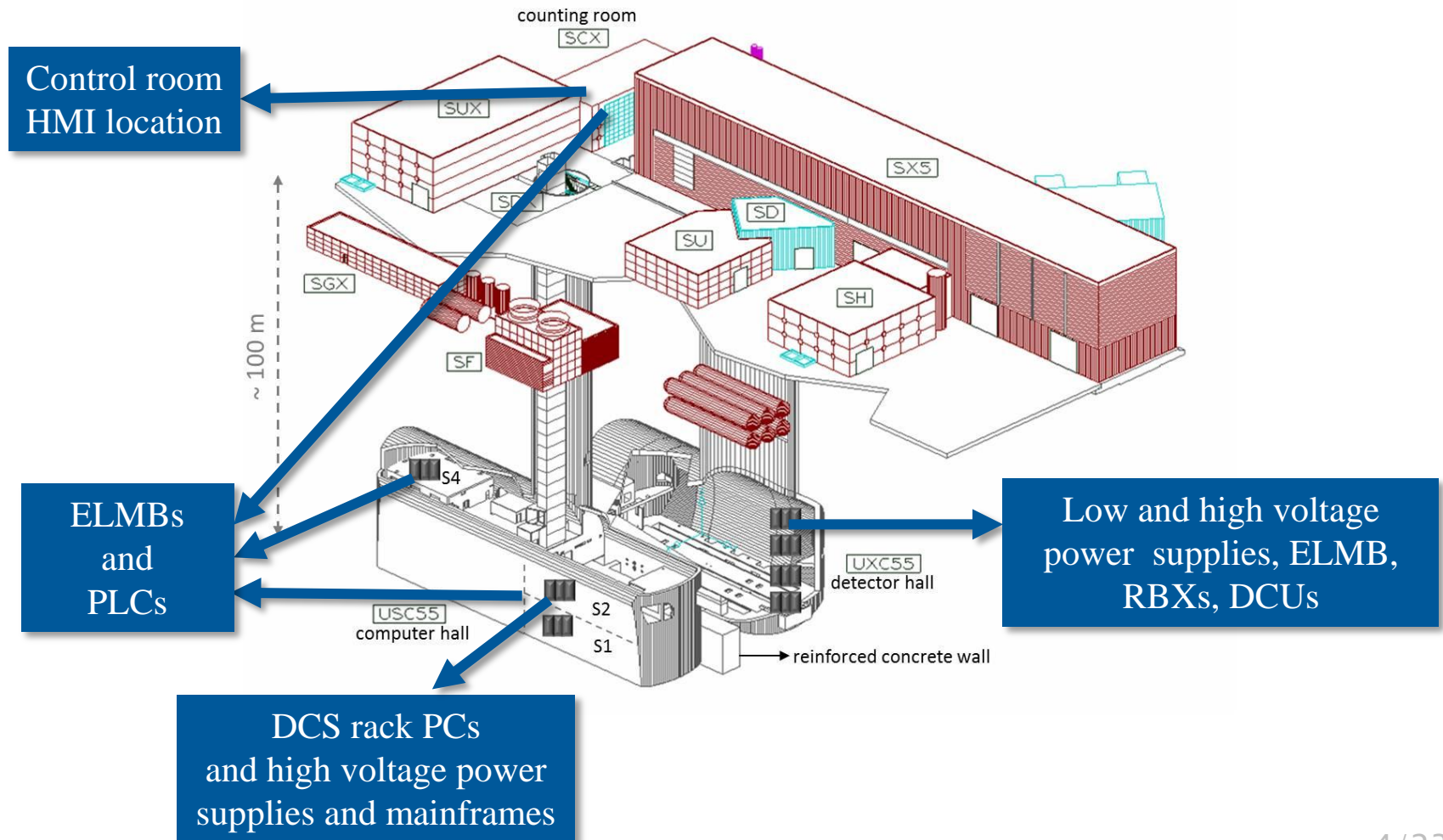
# A Quick DCS Hardware Overview

Some representative examples

Device type	Usage	Brand	Driver	Parameters
Power supply	Front end electronics and detector bias	CAEN W-IE-NE-R CMS-made	OPC/Ethernet OPC/CAN DIM	~2.5 M
Embedded Local Monitoring Board (ELMB)	Temperature, humidity and pressure monitoring Water leak detection Laser monitoring	CERN-made	OPC/CAN	~24 K
DCU, RBX	Detector monitoring	CMS-made	DIM, PSX	~0.5 M
PLC	Safety, Cooling Rack electrical distribution	Siemens Schneider	S7 Modbus/tcp	~12 K

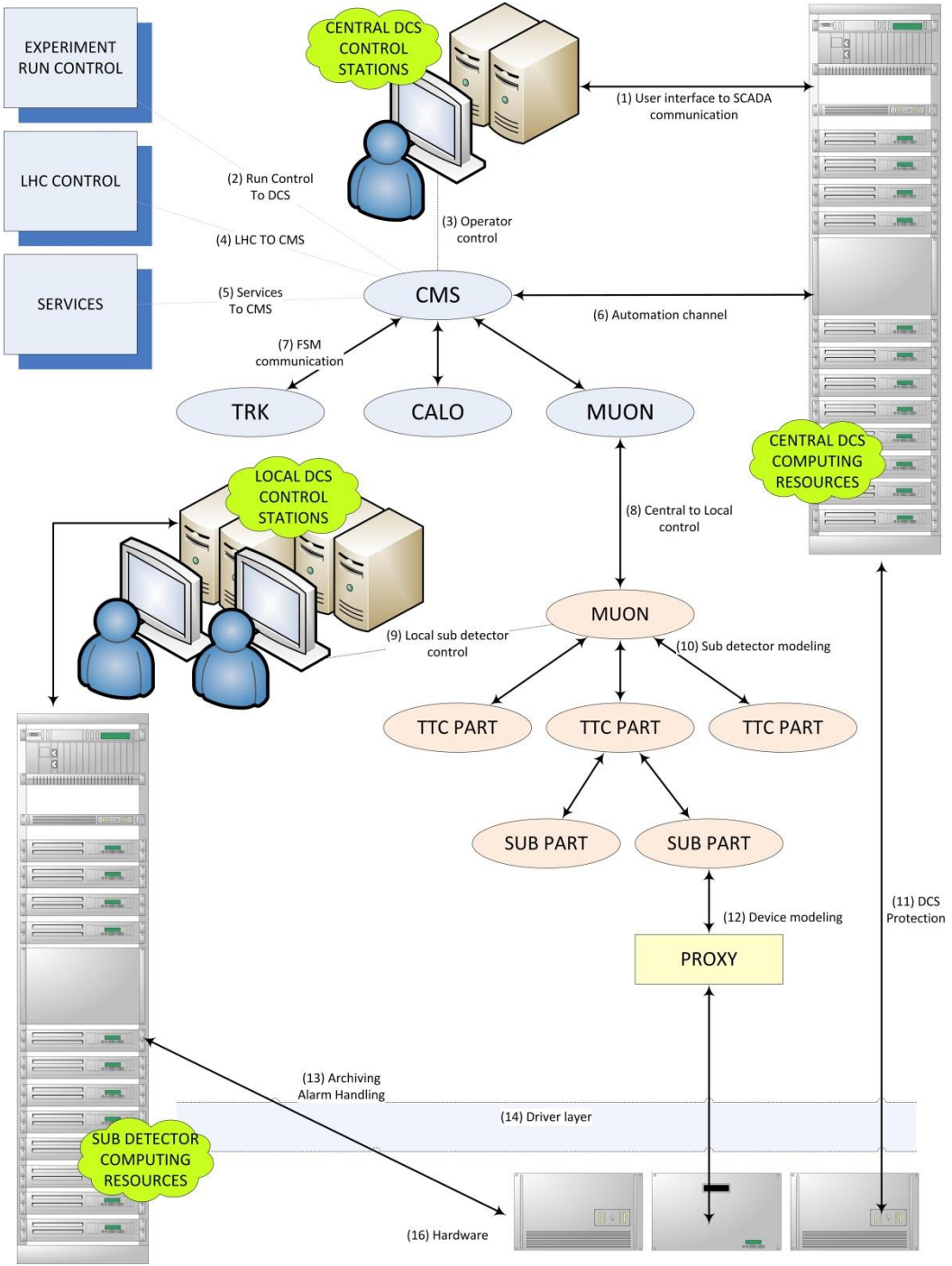
# DCS Hardware distribution

Distributed across different experiment areas



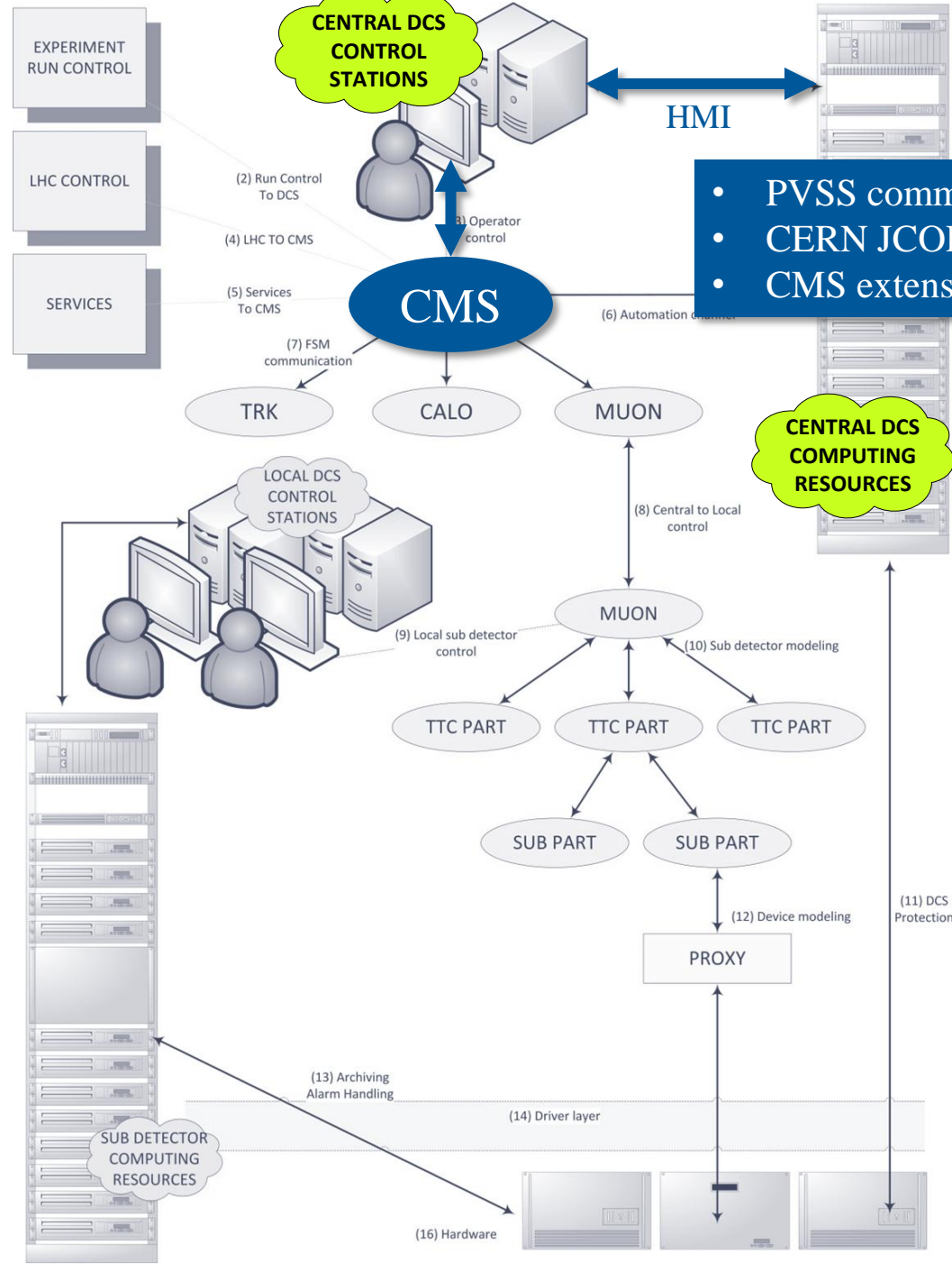


# DCS Architecture



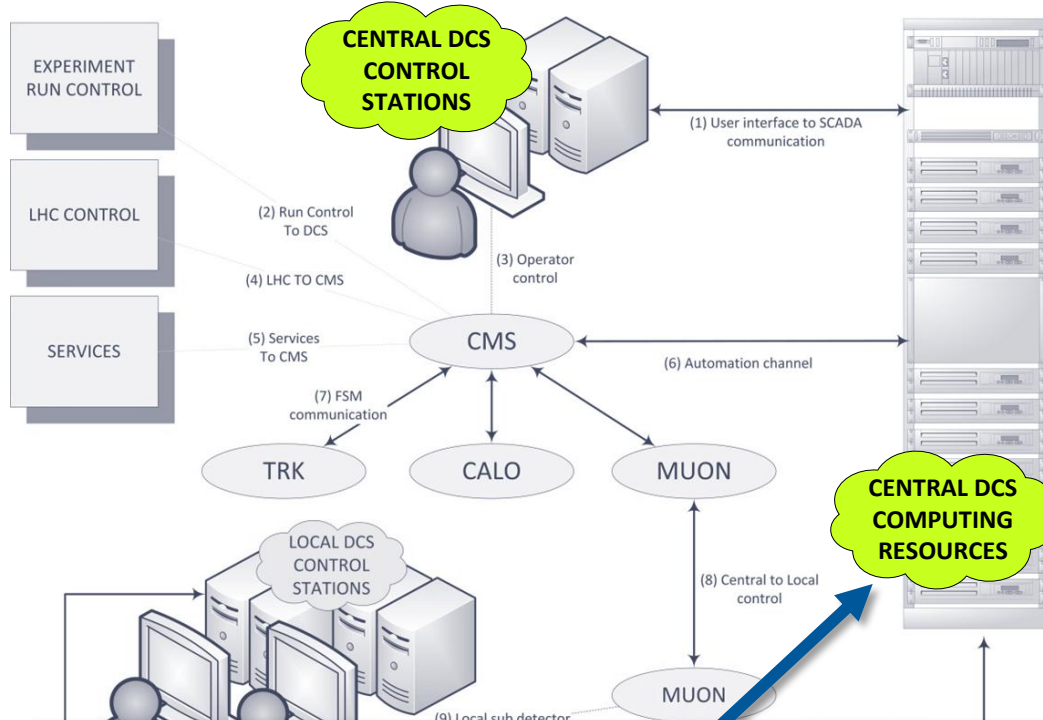


# DCS Infrastructure

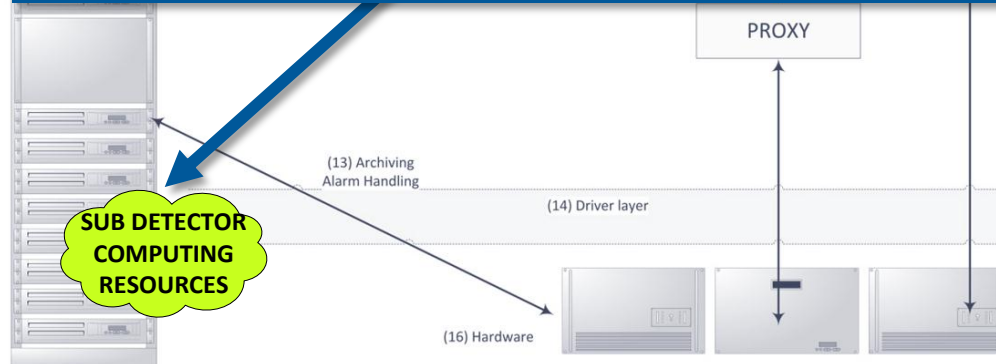


- PVSS commercial SCADA
- CERN JCOP framework
- CMS extension framework

# DCS Infrastructure

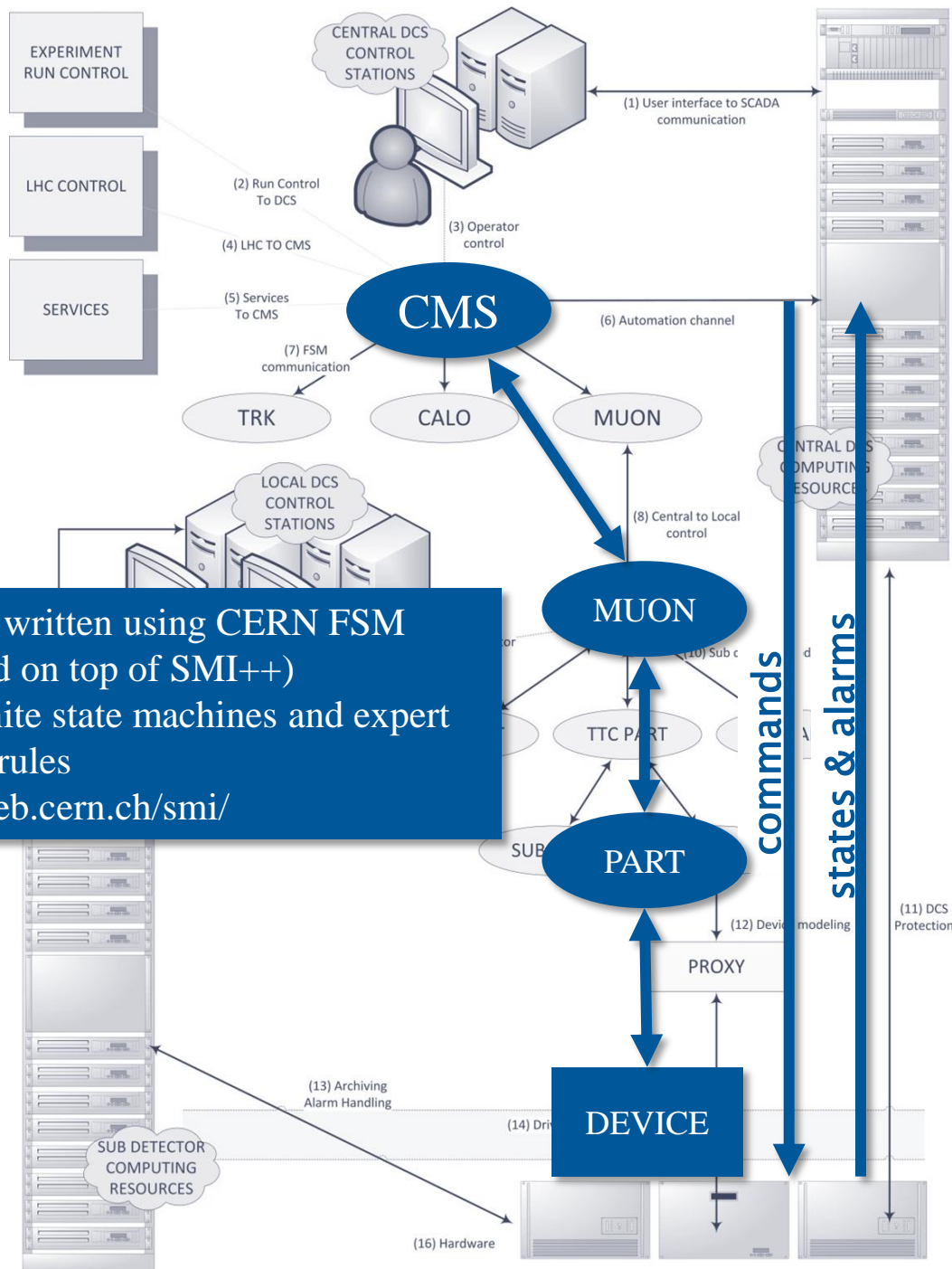


- ~100 rack mounted PCs distributed in 14 racks
- Both the supervisor and the sub-detectors PCs are centrally managed using CERN Computing Management Framework
- All PCs are running Windows XP
- DCS applications are installed using a plug-in mechanism that allows for deploying functional detector components





# DCS Control Tree



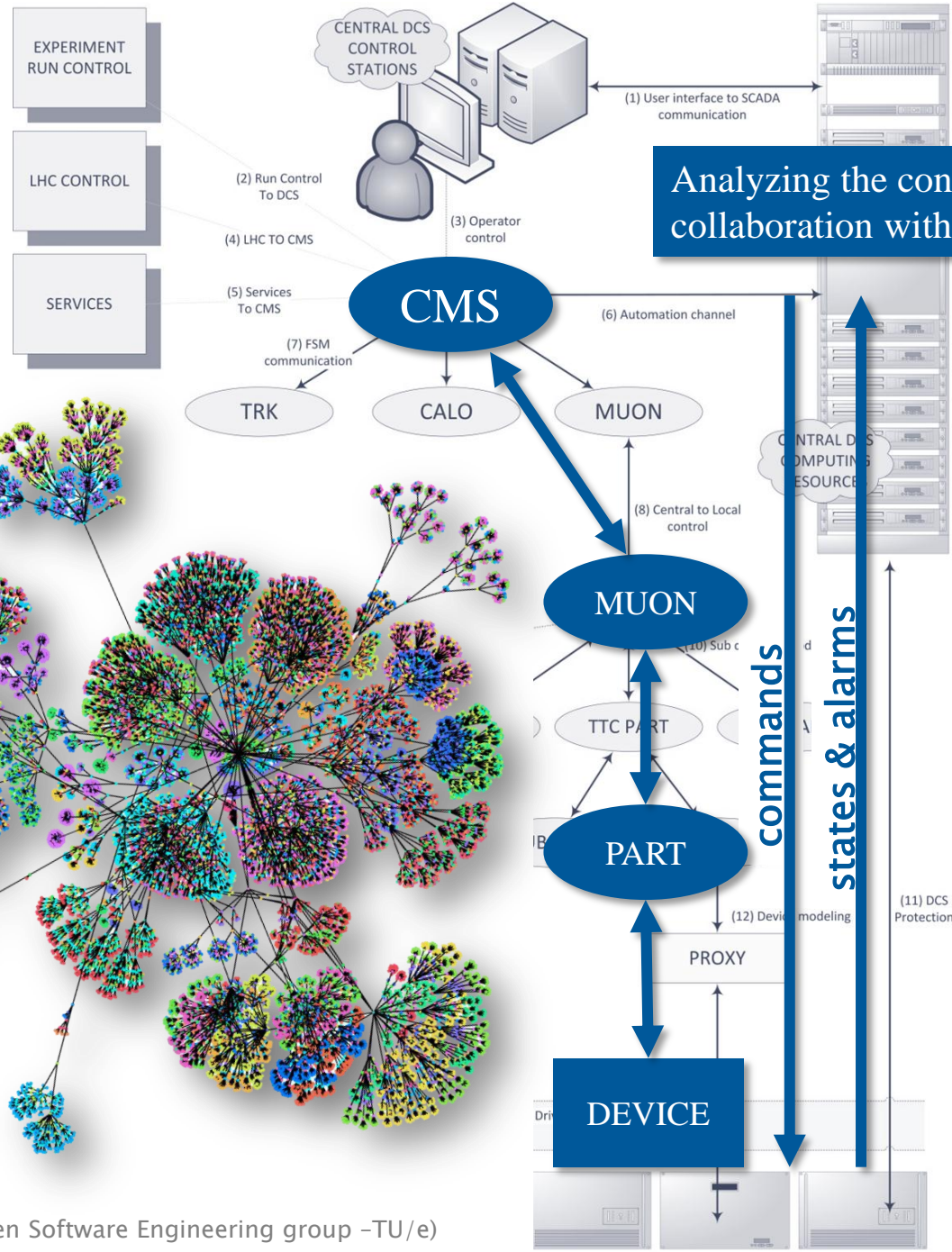
- Control tree written using CERN FSM toolkit (build on top of SMI++)
- Based on finite state machines and expert system-like rules
- <http://smi.web.cern.ch/smi/>

commands  
states & alarms

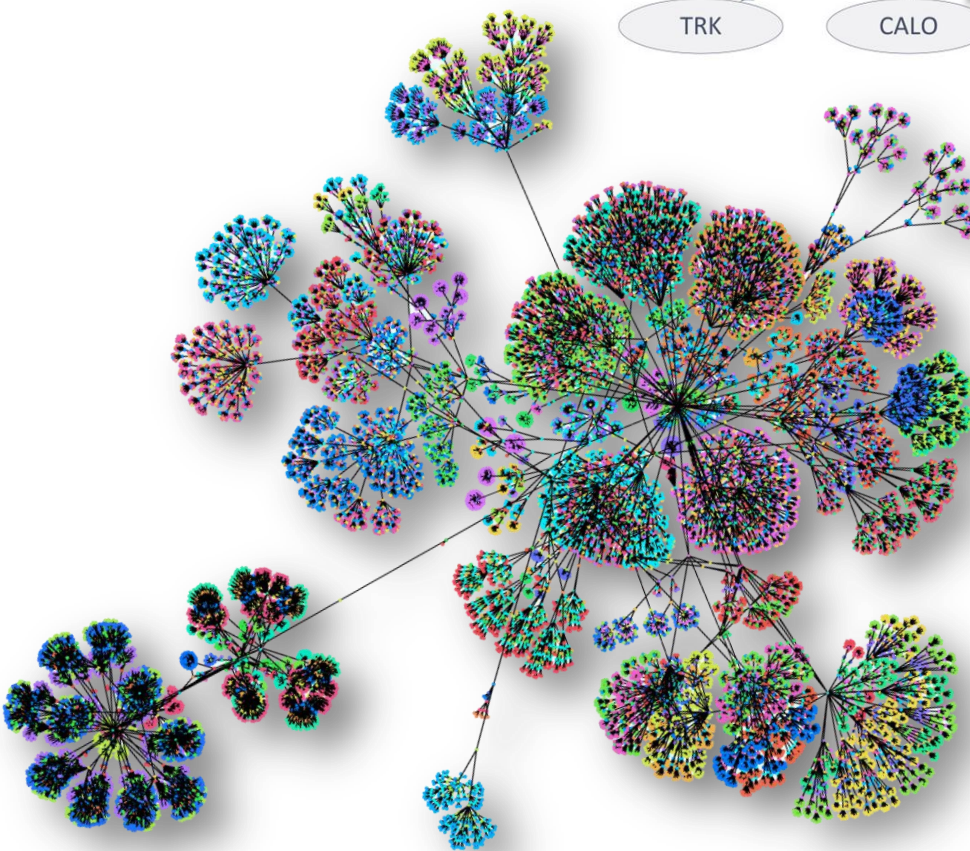




# DCS Control Tree



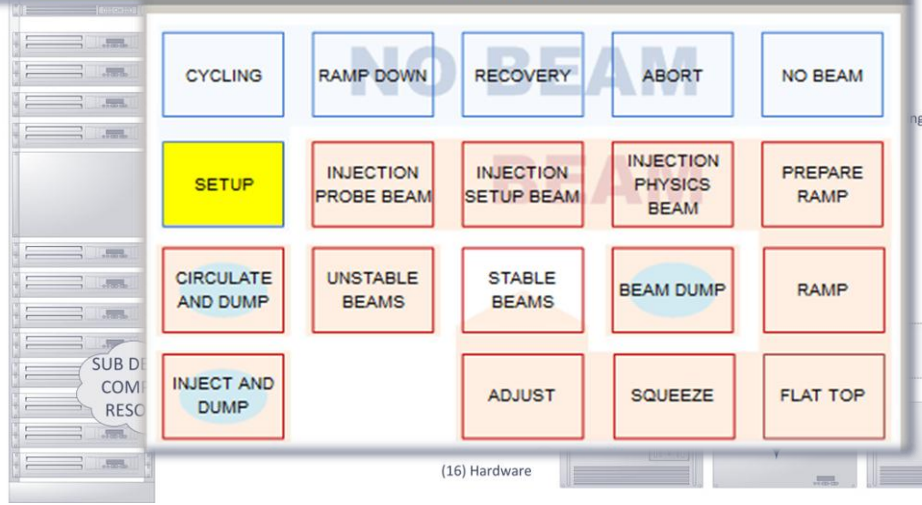
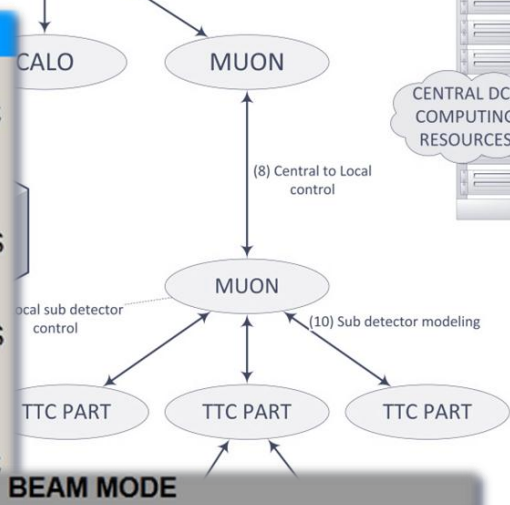
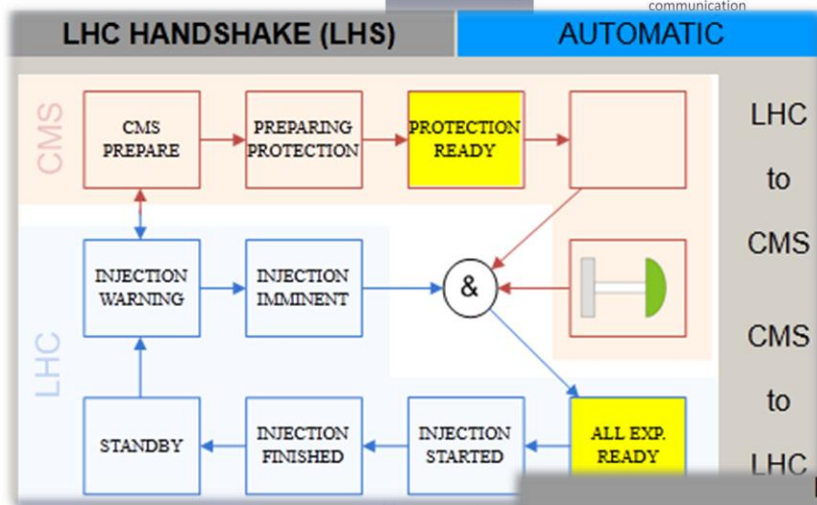
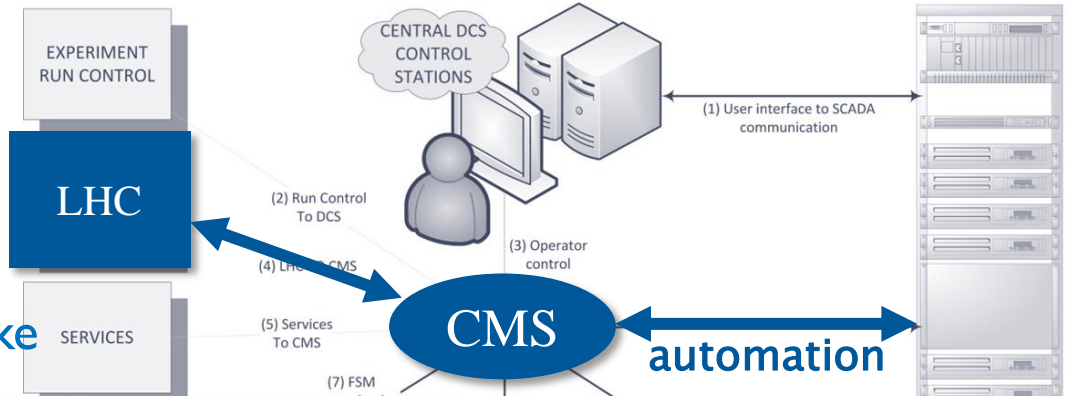
Analyzing the control Tree in collaboration with TU/e





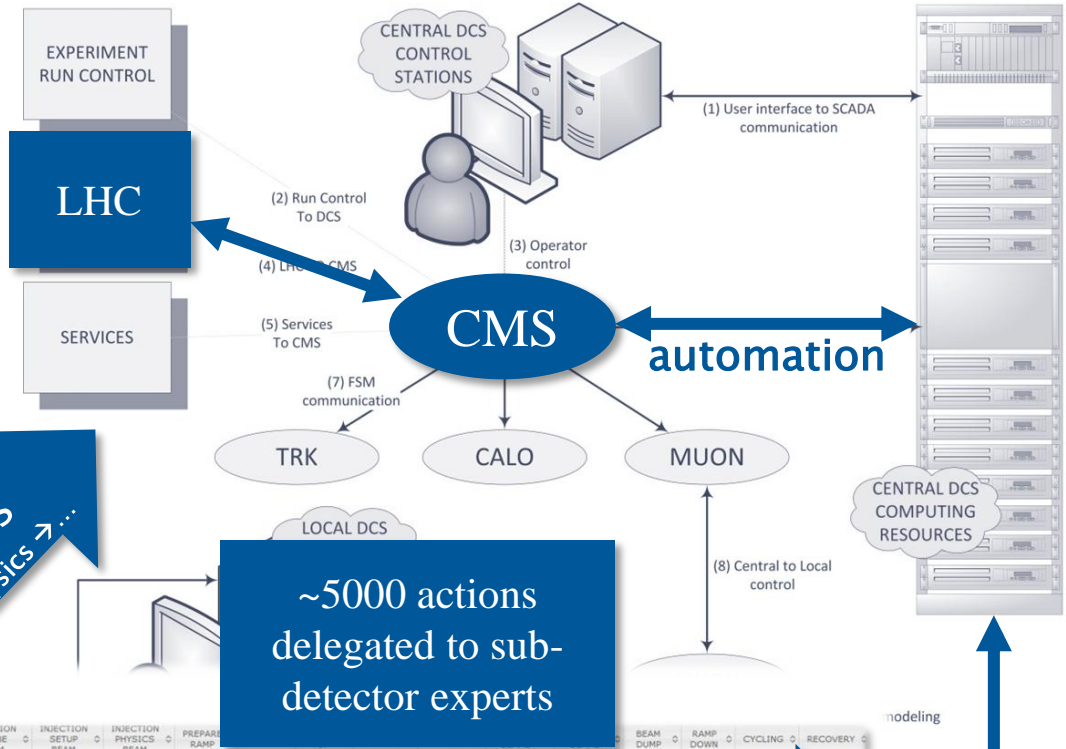
# DCS

## LHC handshake



protection

# DCS Automation



**Machine modes**  
Access → Proton physics → ...

## Beam modes

Inject beam → Ramp → Flat top → ... → Stable beams → ...

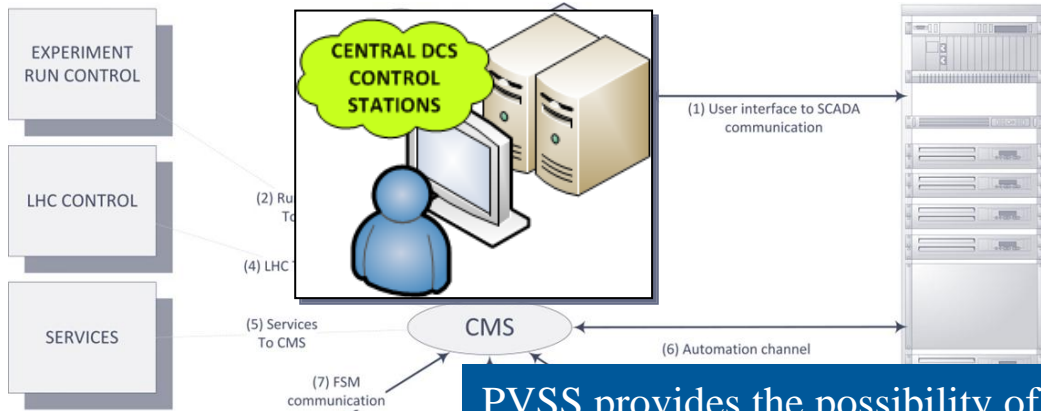
	ABORT	INJECTION PROBE BEAM	INJECTION SETUP BEAM	INJECTION PHYSICS BEAM	PREPARE RAMP	RAMP	FLAT TOP	SQUEEZE	ADJUST	STABLE BEAMS	UNSTABLE BEAMS	BEAM DUMP	RAMP DOWN	CYCLING	RECOVERY	
LOCAL BM																
LOCAL BP																
LOCAL EM																
LOCAL EP																
PIXEL		PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	GO TO PHYSICS		
TRACKER		PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	GO TO PHYSICS		
HCAL																
DT		PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	GO TO PHYSICS				GO TO PHYSICS				
CSC		GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO PHYSICS	GO TO PHYSICS	GO TO PHYSICS						
ECAL ESM	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO PHYSICS	GO TO PHYSICS	GO TO PHYSICS	GO TO PHYSICS		GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	
ECAL ESP	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	GO TO PHYSICS	GO TO PHYSICS	GO TO PHYSICS	GO TO PHYSICS		GO TO STANDBY	GO TO STANDBY	GO TO STANDBY	
KPC		PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	GO TO PHYSICS	GO TO PHYSICS	GO TO PHYSICS						
ZDC		PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	PROTECT STANDBY	GO TO STANDBY	GO TO PHYSICS	GO TO PHYSICS	GO TO PHYSICS	PROTECT STANDBY					
	GO TO PHYSICS mode=muonHV							GO TO PHYSICS mode=ppHV	GO TO PHYSICS mode=ppHV							

**Sub-detector**

**protection**



# DCS HMI



PVSS provides the possibility of running many user interfaces connecting to the same system

Drawbacks:

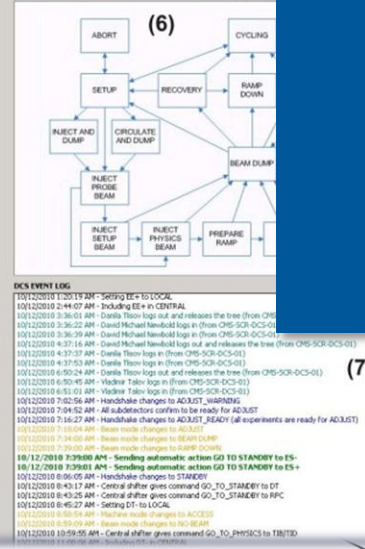
- Puts some stress on the system where the user interfaces is connecting to. It doesn't scale
- Requires partial PVSS installation where the user interface should run

Solution: web based user interfaces

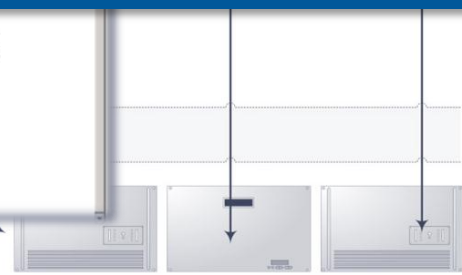
Advantages:

- It scales
- Doesn't require other than a web browser in the client side (tablets, smartphones...)

CMS	BEAM PHASES	READY	MAINTENANCE
AUTOMATIC ACTIONS	CURRENT	NEXT	PROTECTED FOR NO BEAM
ENABLED	NO BEAM	SETUP	PROTECTED FOR NO BEAM
<b>(1)</b>			
PIXEL	IN CENTRAL	STANDBY	IMPACTED
STRIPS	IN CENTRAL	NOT READY	IMPACTED
ECAL	IN CENTRAL	NOT READY	
<b>(2)</b>			
HCAL	IN CENTRAL	PHYSICS	
ZDC	IN CENTRAL	STANDBY	
CASTOR	IN CENTRAL	STANDBY	
DT	IN CENTRAL	STANDBY	
RPC	IN CENTRAL	STANDBY	
CSC	IN CENTRAL	PHYSICS	
CSC+	IN CENTRAL	PHYSICS	

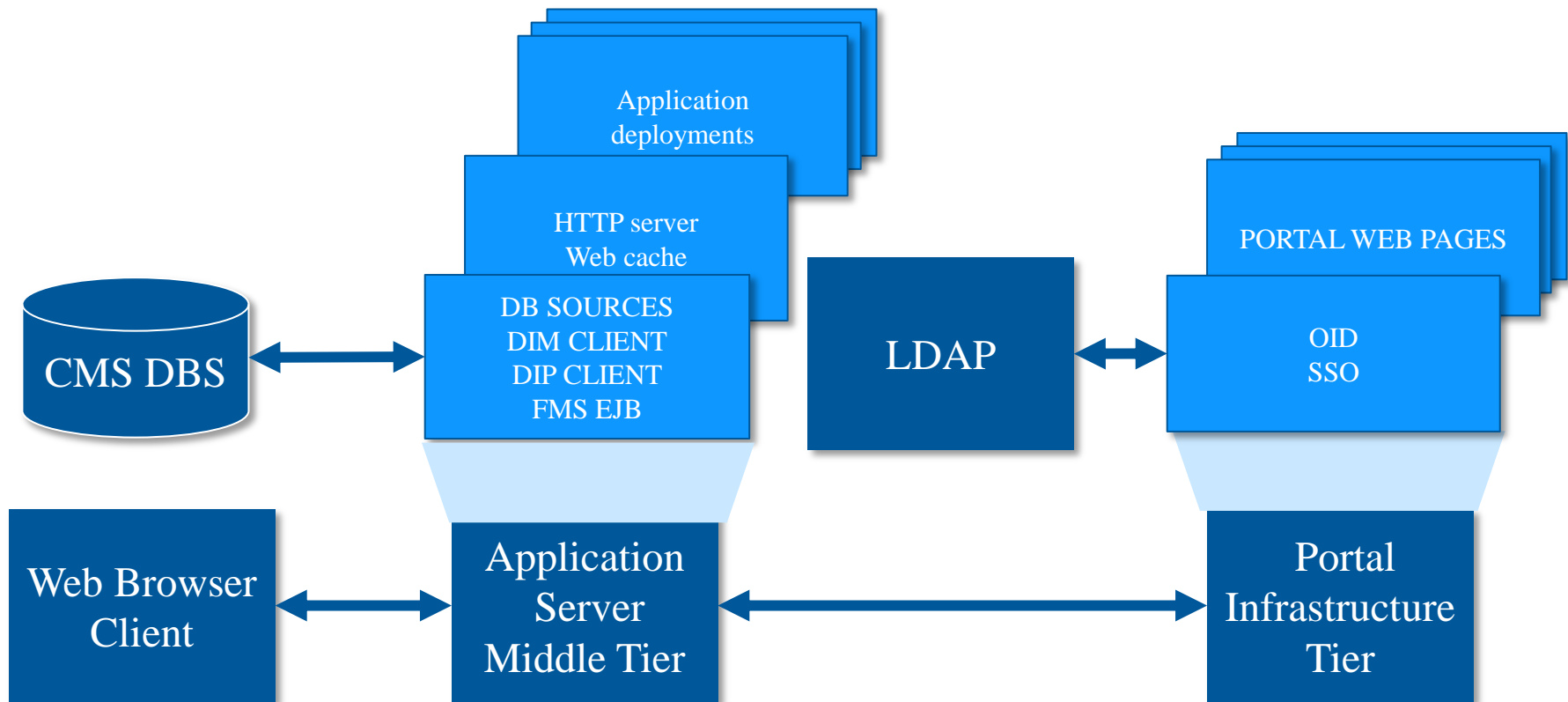


(16) Hardware



# Web monitoring

## Architecture



# DCS web applications

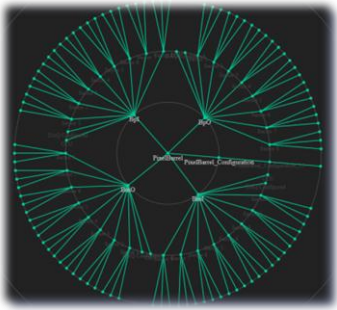
Some highlights

S2D02	ECAL	ON
22	22	0.9 0.9 31

Rack monitoring & crate control



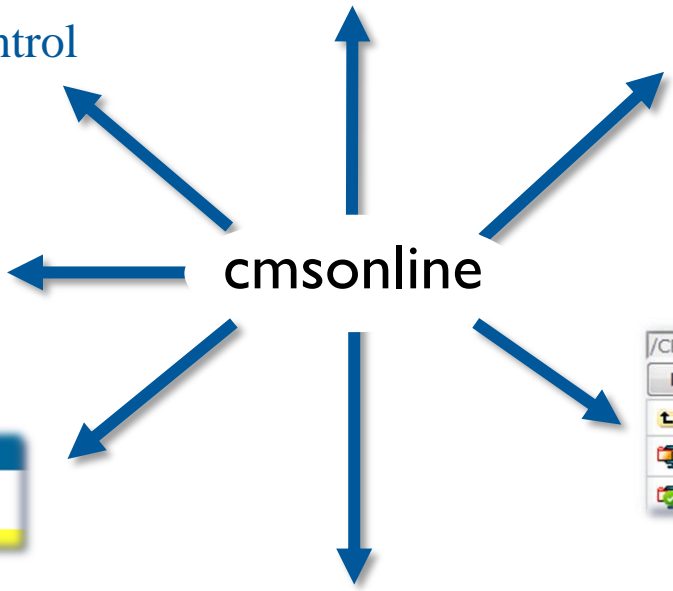
DCS operation summary



FSM monitoring



plotting online tool



TIME [Geneva Local Time]	ALIAS / DATAPOINT
Filter...	<input type="text"/>
Clear Filter	
13:26 May 02, 12	cms_heal_dcs_02.FSCNotOn.Number

DCS Alert screen

/CENT/CMSfwAlertSystem			
Import Files from SVN >>		Grant Access >>	
	Name	Version	Revision
	CMSfwAlertSystem	1.5.0	3297
	CMSfwAlertSystem	1.1.8	3151

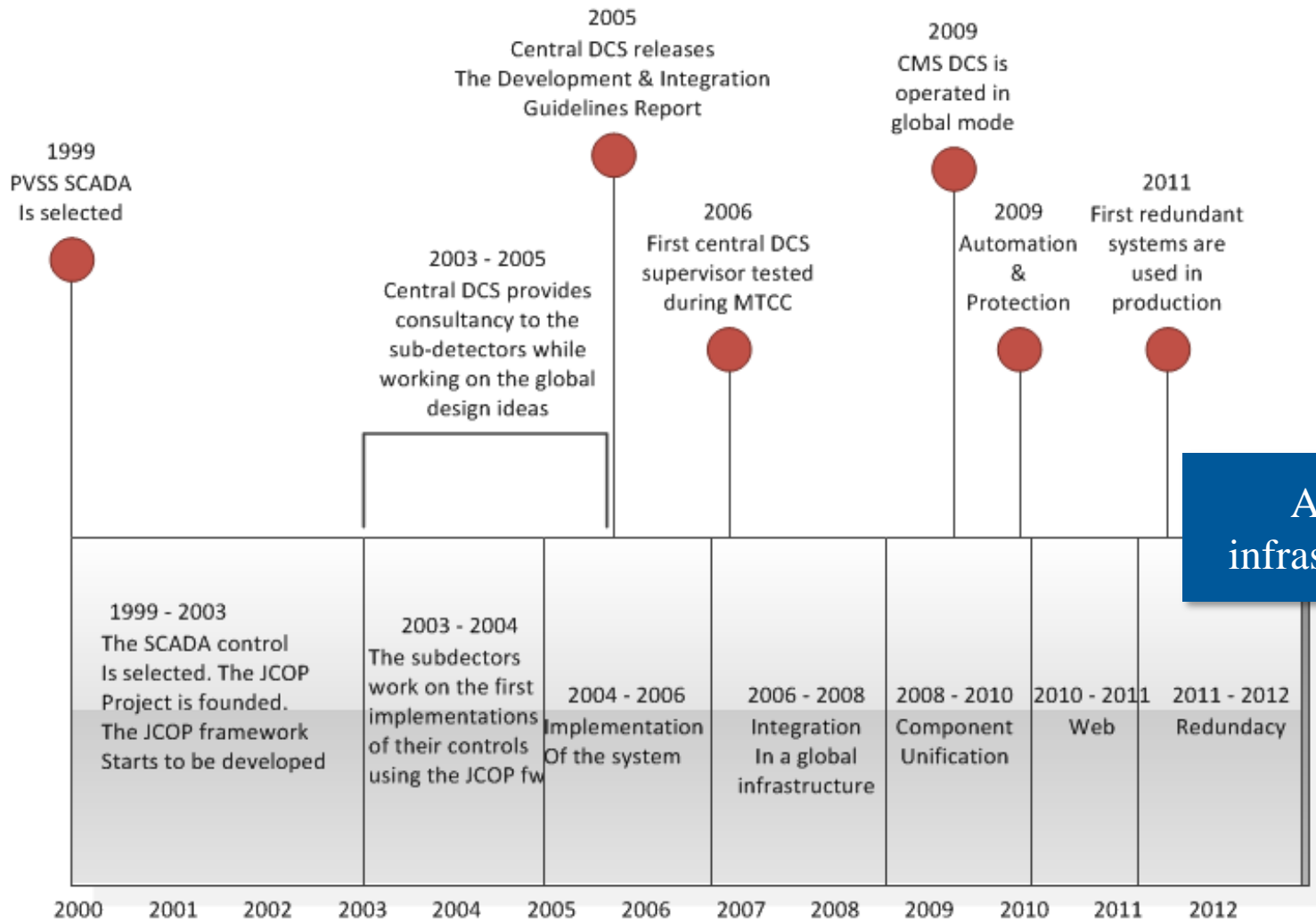
DCS component installation

infrastructure control & monitoring



(Loads of work by L. Masetti and M. Janulis)

# The DCS history



Aging  
infrastructure

# DCS upgrade

## The motivation

- ❑ The Central DCS infrastructure is confronting two concurrent issues:
  - ❑ the end of life of the operating system in use (W. XP)
  - ❑ the aging of the current computing infrastructure





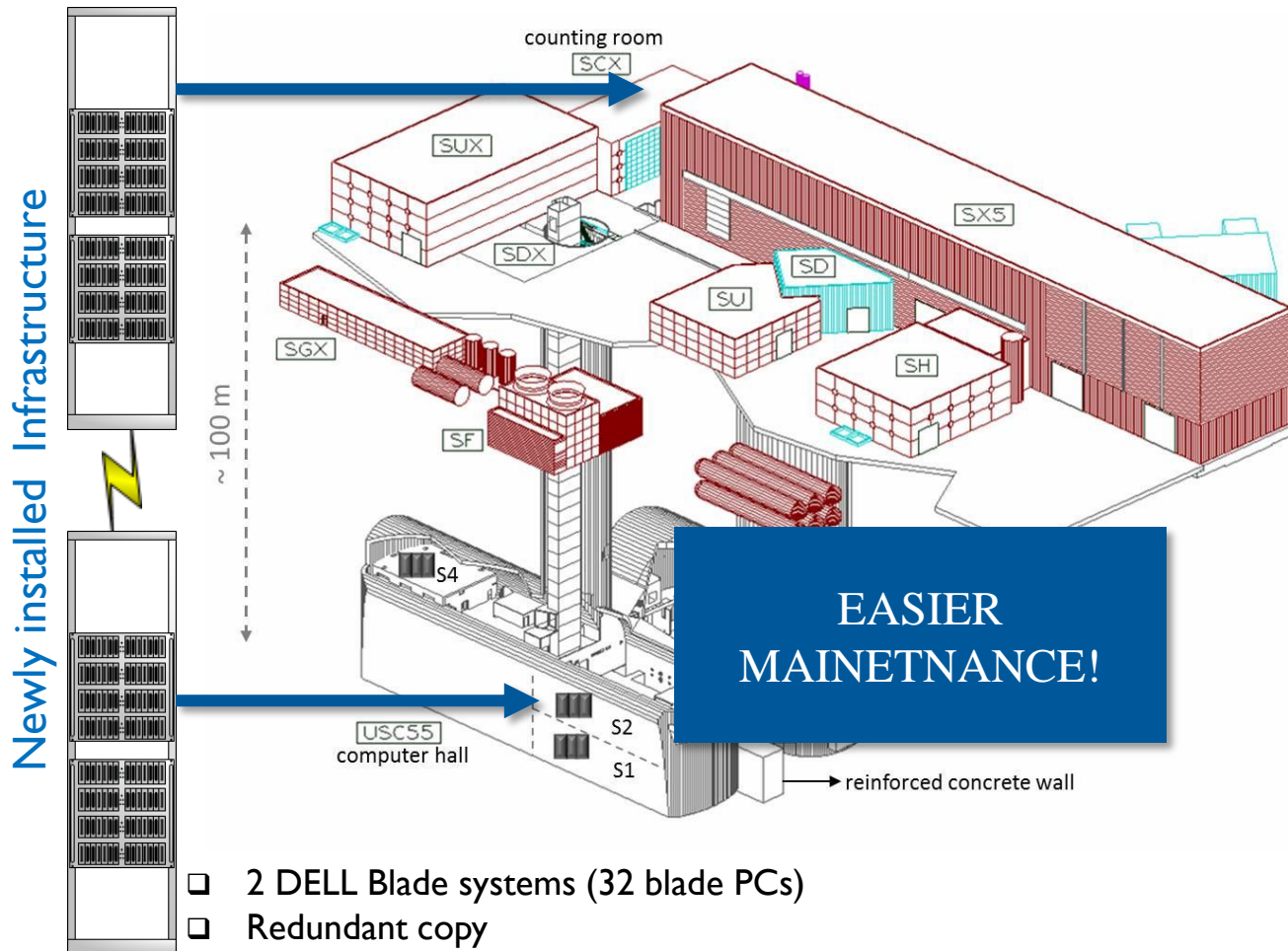
# DCS upgrade

## Hardware replacement

- ❑ One approach would have been to replace the current rack mounted PCs with newer ones
- ❑ The central DCS group has chosen instead for a high-density modular solution (DELL Blade systems) incorporating PCs and networking into a single chassis that provides shared power, cooling and management

# DCS upgrade

## New computing infrastructure location



# Upgrade ongoing work

Some system refactoring needed

- ❑ All DCS control and monitoring hardware must be Ethernet based (USB, serial and PCI based hardware was replaced or adapted to Ethernet based solutions)
  
- ❑ Approximately every 3 PVSS systems (running in individual rack PCs) will be merged in one Blade PC
  - ❑ Should make sure there are no collisions (used ports, driver limitations, naming collisions...)
  - ❑ Will make use of CMS DCS factorization capabilities

# DCS upgrade

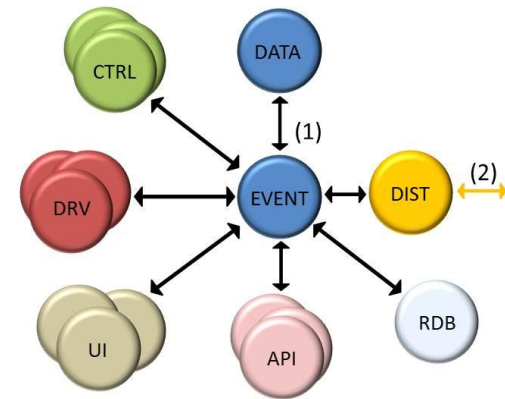
## The Operating System Upgrade

- ❑ After looking at the different possibilities CMS decided to move the Windows XP systems to Windows 7
  - ❑ Windows is still CMS controls platform (OPC)
  - ❑ Windows Server version didn't add features useful in our infrastructure
  - ❑ Window 7 64b tests on new Blades very successful in terms of performance and memory management



# DCS upgrade

One step further: redundancy



- To achieve the zero downtime the redundant partners will use a built-in SCADA (PVSS) functionality to run PVSS projects in a hot-standby mode taking over in case of failure

PVSS: system overview (cms\_cent\_dcs\_17\_18)

cms\_cent\_dcs\_01 cms\_rc\_dcs\_04

1 7 8 9

Error state: 17:20:24

Userinterface #1

Force active Force active

Redundancy Split mode

cms-cent-dcs-18

70.0% 70.0%

DM EV EV DM

Archive	CTRL and other	Driver	Dist	Dist	Driver	CTRL and other
0   ValueArchive_000	4   fwFsmSrvr	1   SIM	93   cms_rcal_	93   cms_rcal_	1   SIM	3   CMSfwRedunda
1   01) 5 minutes arc	4   API		92   cms_eecal_	92   cms_eecal_		3   API
2   02) Hour archive	5   unDistributedCo		30   cms_alig_c	30   cms_alig_c		4   fwFsmSrvr
3   03) Day archive	5   API		240   cms_hcal_v	240   cms_hcal_v		4   API
4   04) Command arc	6   unDistributedCo		98   cms_eecal_v	98   cms_eecal_v		5   unDistributedCo
5   05) State archive	6   API		211   cms_rpc_d	211   cms_rpc_d		5   API
						97   RDBA

One project is active the second one in a hot-standby passive mode

Need to review DCS components for redundancy

CMS is the only LHC experiment using redundancy

PVSS managers handle redundancy JCOP and CMS extensions need to be enabled

Poster: "High availability through full redundancy of the CMS detector controls system" Dr. Polese Thursday from 13:30 to 18:15

# Summarizing

- ❑ Fulfilled the operational, functional and environmental requirements, providing efficient automatic and safe detector operation.
- ❑ Used and contributed to the JCOP framework.
- ❑ Created CMS development guidelines to ease the integration on a common framework.
- ❑ Always working on unifying functional components.
- ❑ Extensive work performed on developing web applications.
- ❑ Year 2012 will be dedicated to improve our infrastructure making it fully redundant

# Thank you for you attention!

CMS central DCS is an small team formed by people with different backgrounds sharing their interest and passion for control systems and for technology in general.

We are always looking for ways to increase and share our technology knowledge.

Contact us: [Robert.gomez-reino@cern.ch](mailto:Robert.gomez-reino@cern.ch)