The CMS ECAL Control and Safety Systems Upgrades during the CERN LHC Long Shutdown 2

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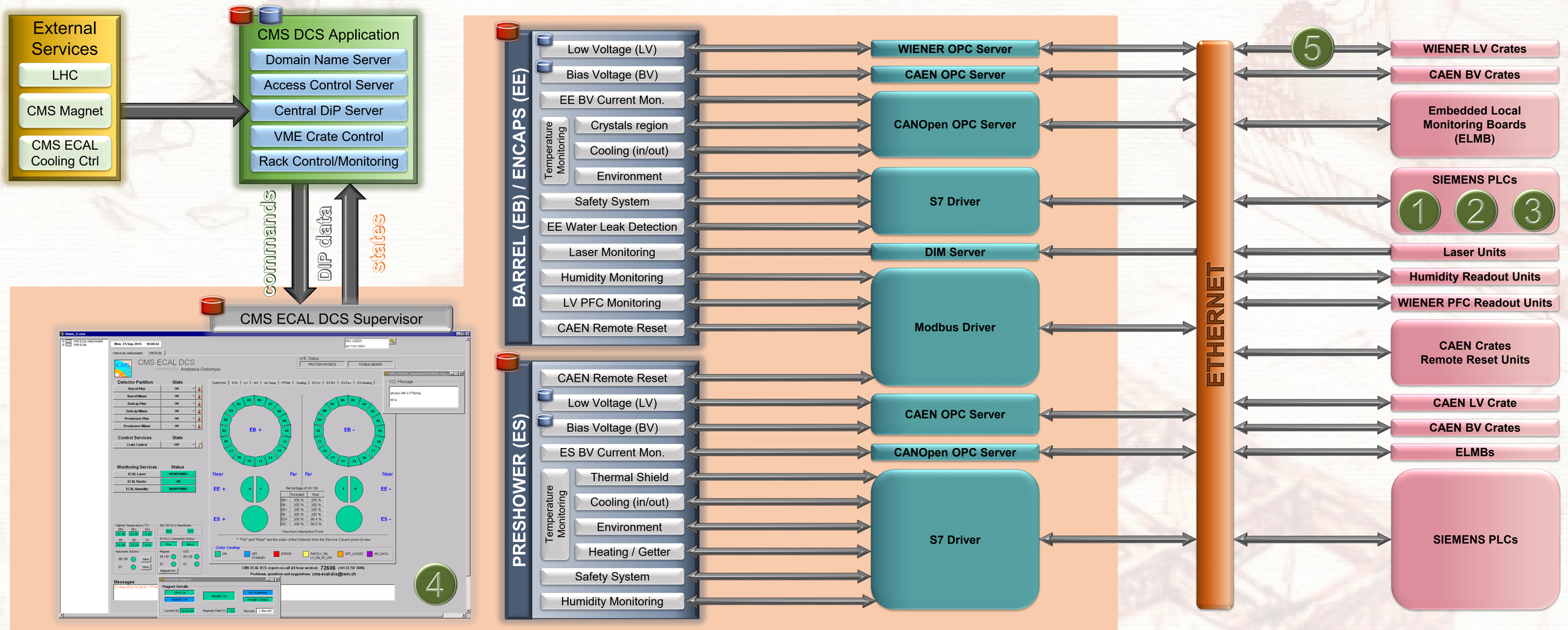
On behalf of the CMS Collaboration

The CMS ECAL Detector Control System



Redundant Windows servers running in hot standby mode

3 servers
@ CMS service cavern

- Based on the WinCC Open Architecture software package
- Uses Joint COntrols Project (JCOP) and CMS frameworks
- 3-role access control (MONITOR / OPERATOR / EXPERT)
- Applications archive / retrieve data from central databases
- Alerts and protective automatic actions at all system levels

3 servers
@ CMS data center

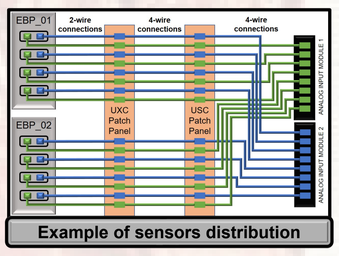
24/7 On-call Services

- Two levels: Operator / Expert (also responsible for the safety system hardware)
- Contributes to the maximum availability of the detector
- Log of failures used for further system improvements and corrections

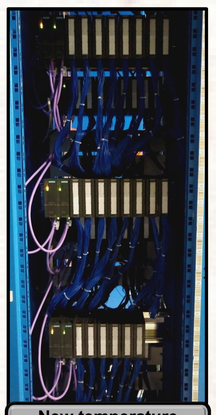
DCS software | Software interface | Use of Configuration DB
Off-detector hardware | Hardware interface | Use of Conditions DB

1 Safety System Temperature Readout System

- ✓ ***Motivation:*** *Original system presented several hardware and software issues*
- ✓ Replacement of Custom Made (CM) by Commercial-Off-The-Shelf (COTS) hardware
- ✓ 352 NTC sensors B57211V2471J060 read out by 44 SIEMENS 6ES7331-1KF02-0AB0
- ✓ Sensors' redundancy preserved with distribution among different readout modules
- ✓ Recovery of four sensors – monitoring coverage at 100%
- ✓ **Improved reliability, availability and robustness**



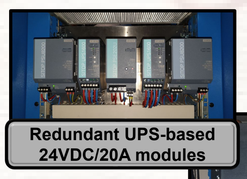
Example of sensors distribution



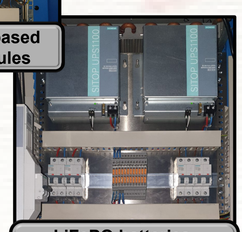
New temperature readout hardware

2 Safety System 24VDC Distribution with UPS

- ✓ ***Motivation:*** *Load increase due to the installation of new hardware*
- ✓ Fully redundant UPS-based 24VDC/20A distribution
- ✓ Based on the latest generation of SIEMENS hardware
- ✓ LiFePO batteries to be replaced every 15 years
- ✓ Batteries can support the complete system for approx. 60 min
- ✓ **Improved availability and reduced maintenance efforts**



Redundant UPS-based 24VDC/20A modules



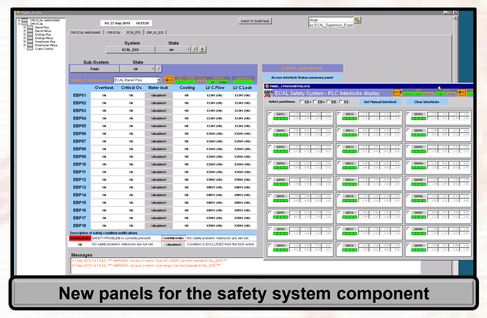
LiFePO batteries, circuit breakers and power distribution

3 Safety System PLC Code

- ✓ ***Motivation:*** *Standardization accross CMS sub-detectors safety systems*
- ✓ Based on the CMS Tracker PLC code architecture, adapted for the CMS ECAL specifications
- ✓ CPU and PROFIBUS redundancies properly implemented and validated
- ✓ Redundancy issues are logged and propagated to the detector control system for alerts
- ✓ **Improved long-term support and maintenance**

4 Control System Software

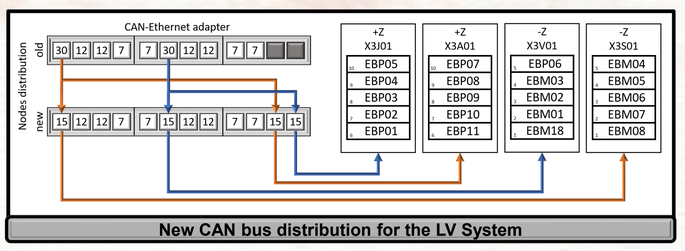
- ✓ ***Motivation:*** *Hardware/specifications changes and evolution of software platforms*
- ✓ Adapted to support all hardware changes and new functionalities
- ✓ Computing hardware to be replaced by new and more powerful servers
- ✓ Migration to Windows Server 2016 and WinCC OA 3.16
- ✓ Deployment of latest versions of the CMS DCS and JCOP frameworks
- ✓ Certification of source codes compatibility with UTF-8 (ISO-8859-1 encoding no longer supported)
- ✓ Migration from Subversion (SVN) to GitLab
- ✓ Migration to OPC Unified Architecture (UA)
- ✓ New and enhanced user interfaces
- ✓ **Improved operation and long-term support**



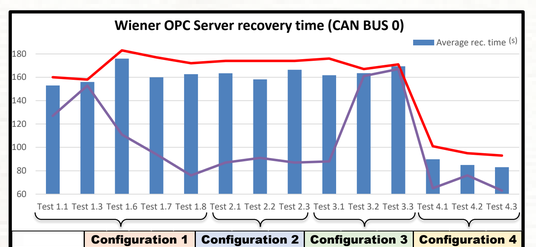
New panels for the safety system component

5 Low Voltage System Re-distribution of data buses

- ✓ ***Motivation:*** *Fix communication issues on buses running at the limit of their specifications*
- ✓ Handling of additional latency introduced by CAN-Ethernet adapters
- ✓ Two buses containing 30 nodes each were split in four buses with 15 nodes
- ✓ Optimal set of parameters introduced in the data server configuration
- ✓ General performance improvement by a factor of up to 2
- ✓ Initial tests successful and long-term validation ongoing
- ✓ **Improved reliability, availability and performance**



New CAN bus distribution for the LV System



	Configuration 1					Configuration 2			Configuration 3			Configuration 4		
Test	1.1	1.3	1.6	1.7	1.8	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3
Crates	30					30			30			15		
Latency (ms)	0					1000			1000			1000		
Retries	5					5			0			5		
Avg rec. time	153	156	176	160	163	163	158	166	162	164	169	90	85	83
Max rec. time	160	158	183	177	172	174	174	174	176	167	171	101	95	93
Min rec. time	127	153	111	94	76	87	91	87	88	161	167	65	76	63

Performance comparison between possible configurations

1) ETH Zurich – Institute for Particle Physics and Astrophysics
2) CERN
3) INFN Sezione di Pisa, Universita' di Pisa, Scuola Normale Superiore di Pisa
4) University of Wisconsin-Madison

Acknowledgements
Swiss National Science Foundation, Switzerland