FCC Control Systems Concepts:

Why it's not too early to speak about it !!!

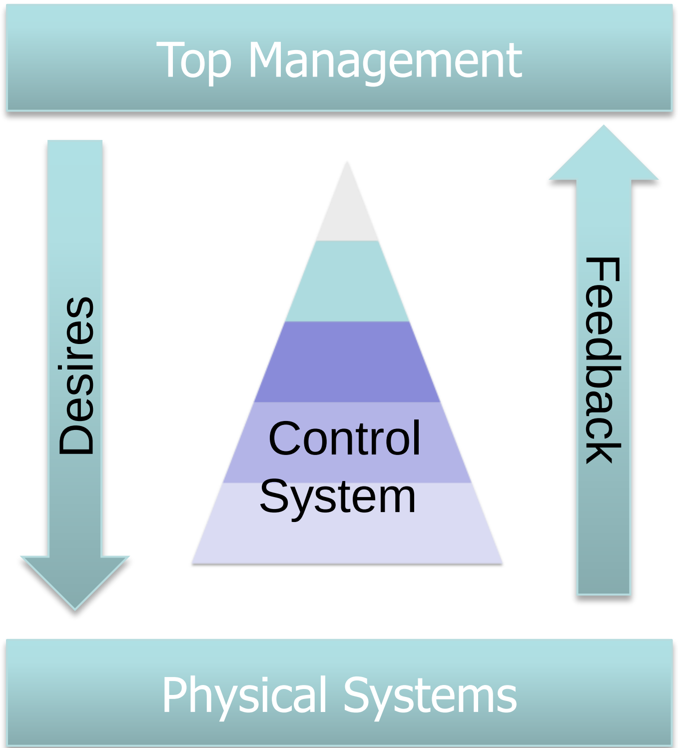
Ph. Gayet

FCC Washington Workshop
26 March 2015

Summary

- Control Systems Definitions and Model
- Specificities of Present Accelerator & Experiments Control Systems
- Identified Tracks
- Control Study Collaboration

Control System Definition

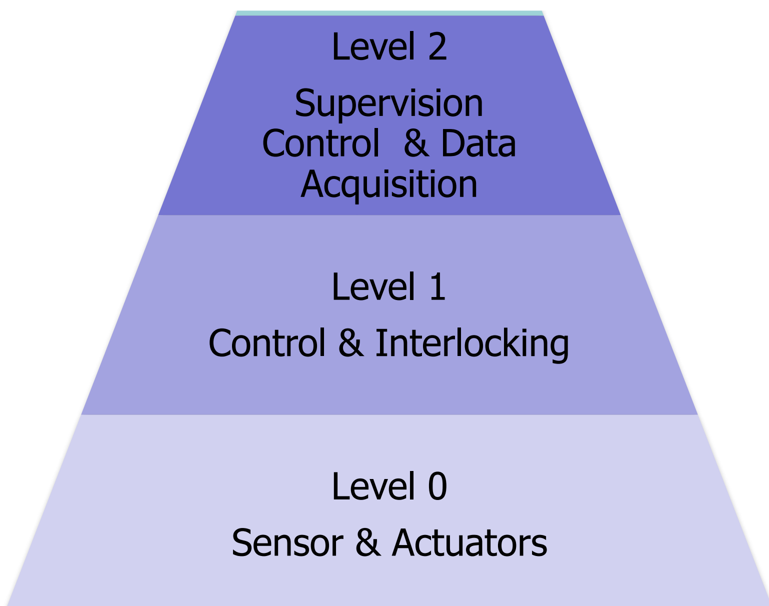


A **control system** is a set of tools to manage, command, direct or regulate the behavior of Physical Systems

Classical Control Systems Model

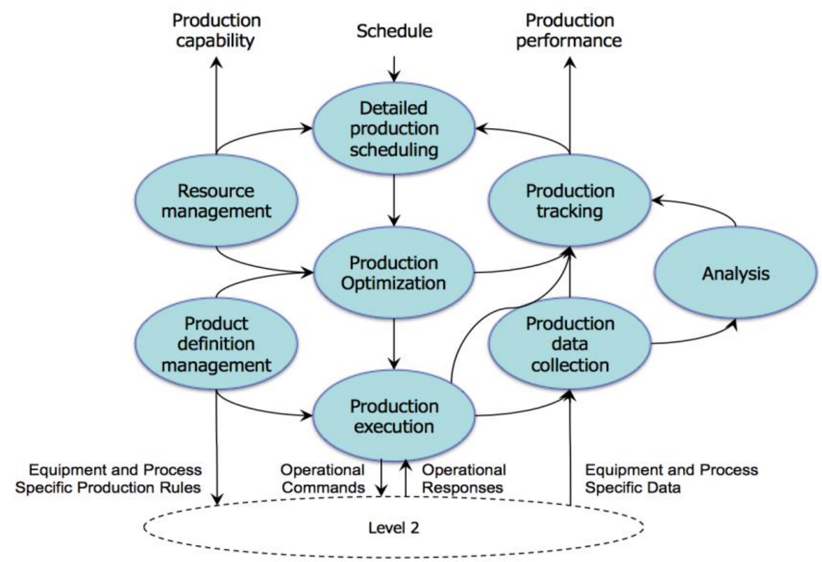
Company Overall management :

- [Enterprise Resource Planning] (ERP)
- [Product Lifecycle Management] (PLM)
- [Customer Relationship Management] (CRM)
- [Human Resource Management] (HRM)
- [Process Development Execution System] (PDES)



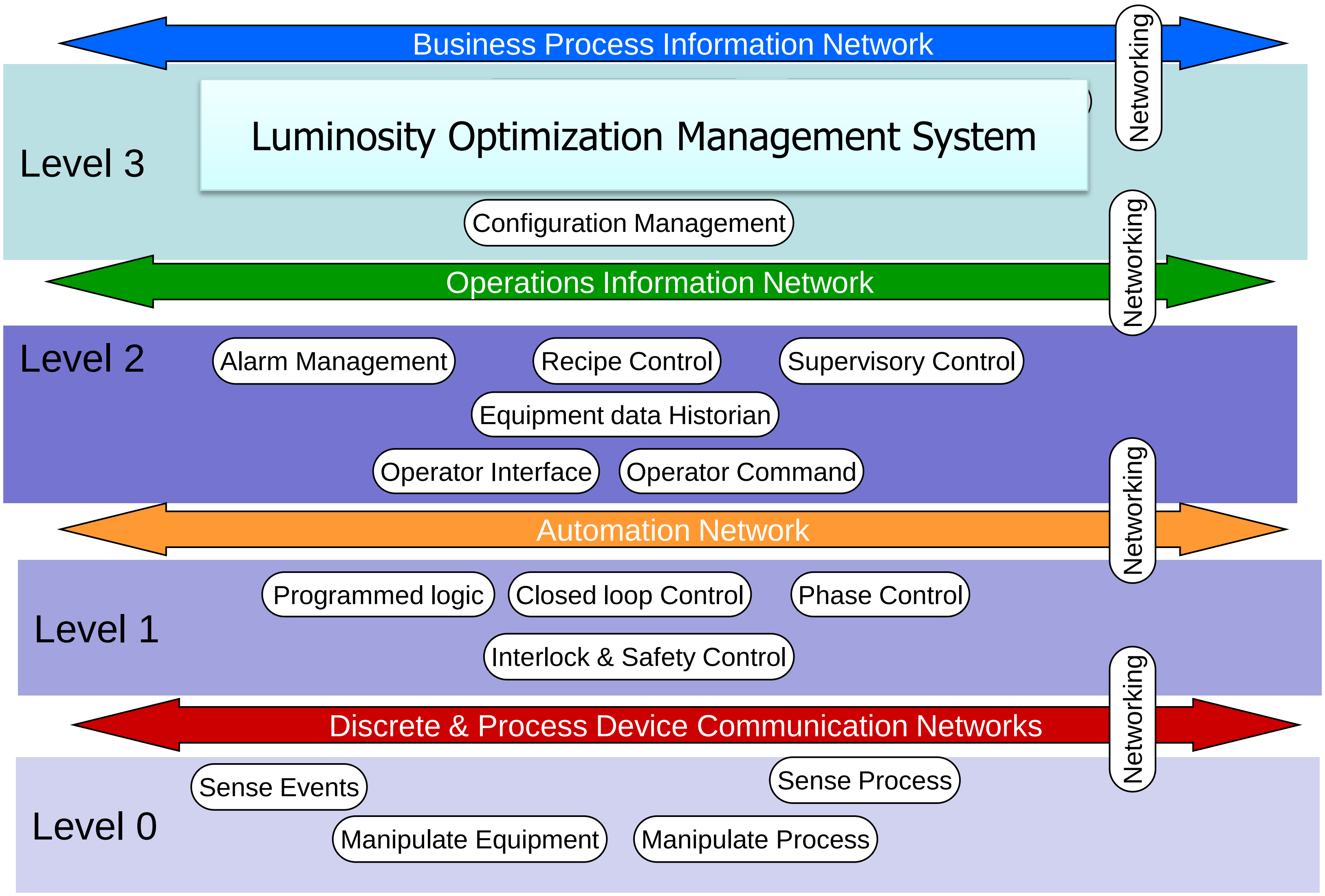
Our domain of interest

Generic Automation Pyramid from ISA 95

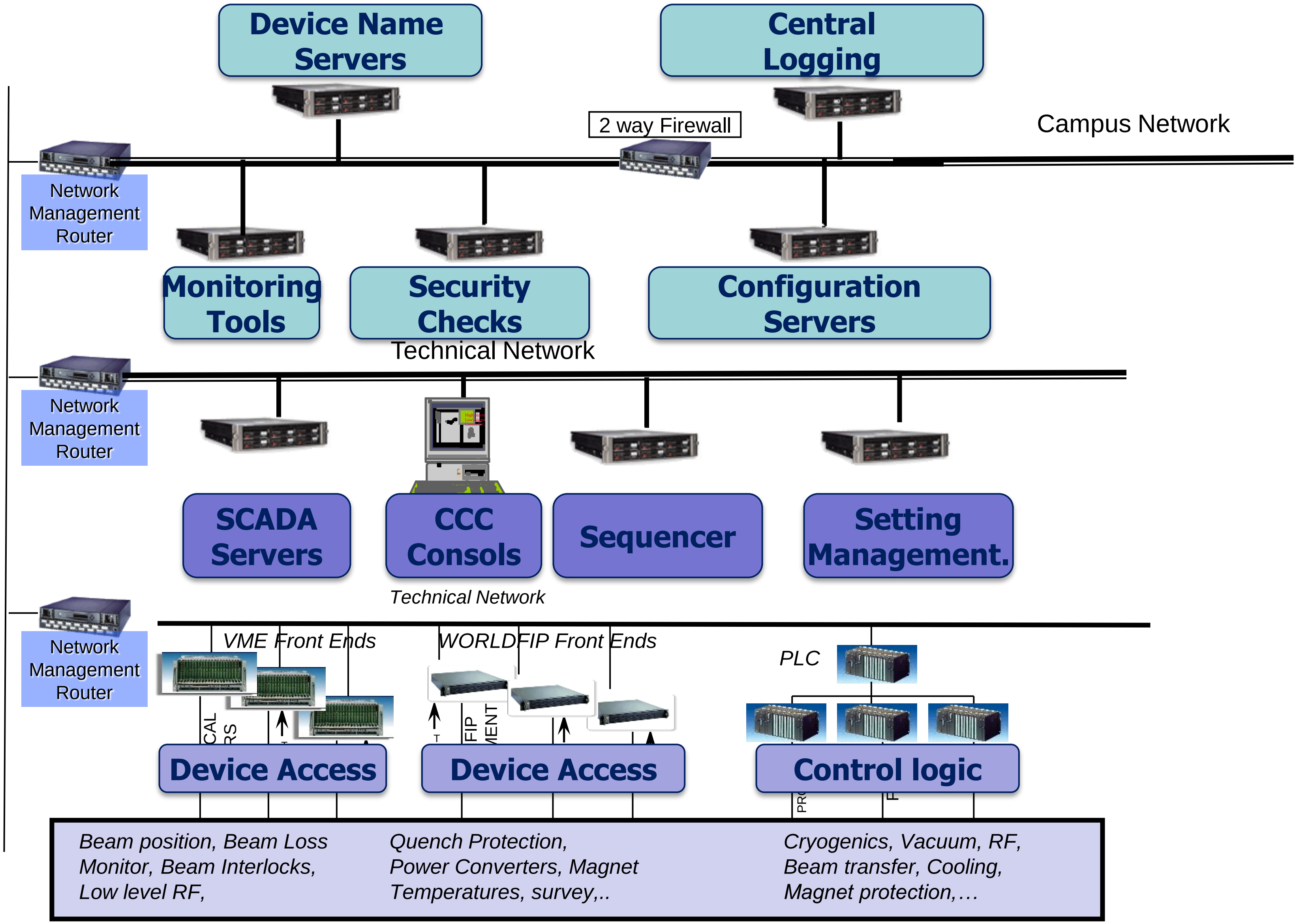


Manufacturing Operation Management Systems

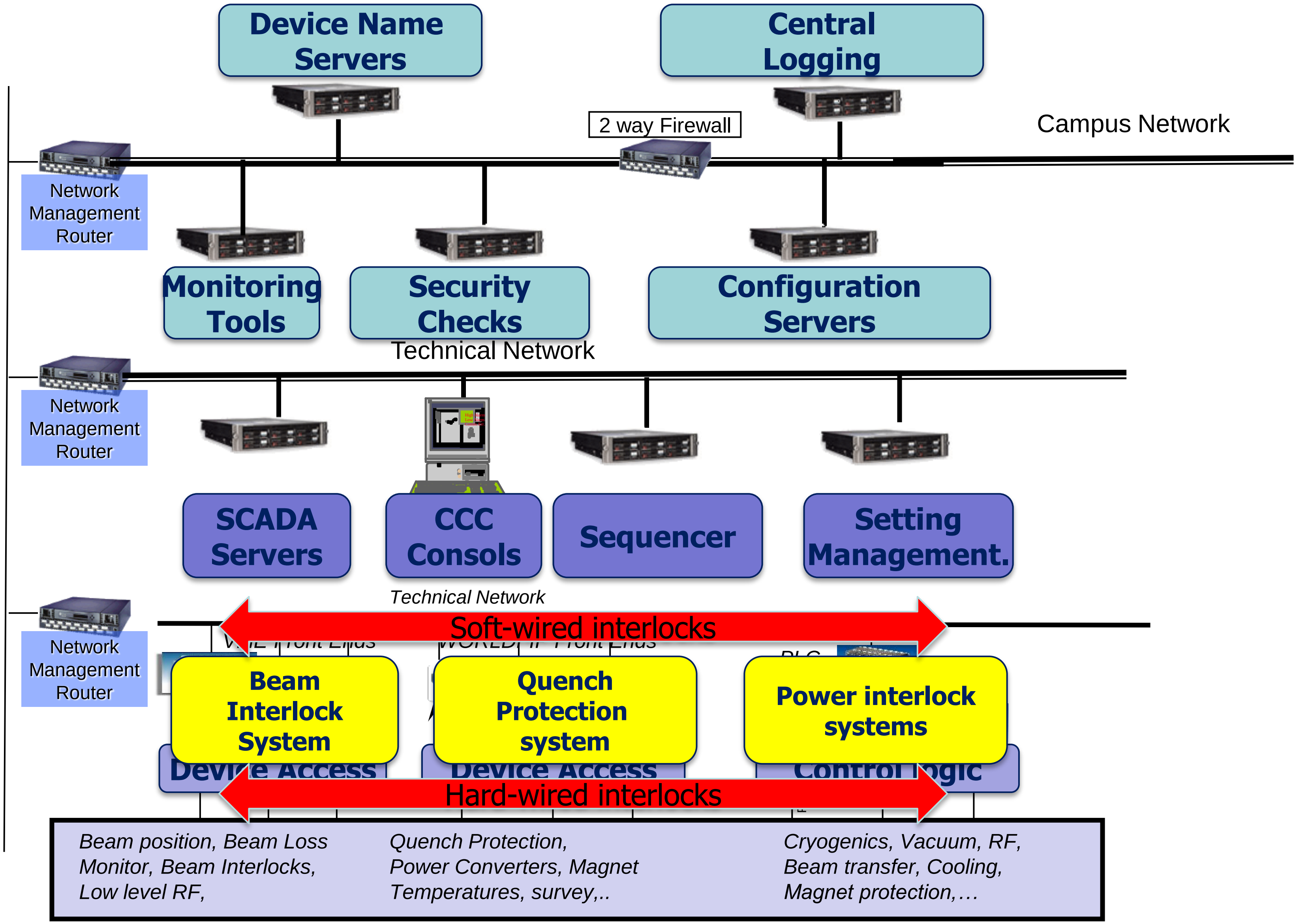
Concepts: Functional Architecture



Functional Architecture : LHC Accelerator



Functional Architecture : LHC Accelerator

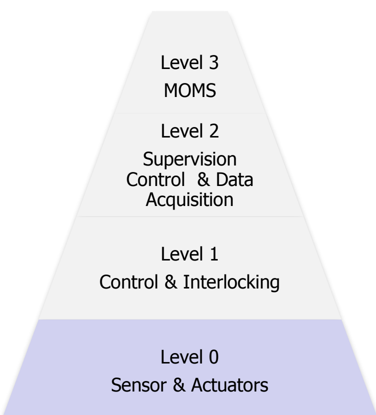


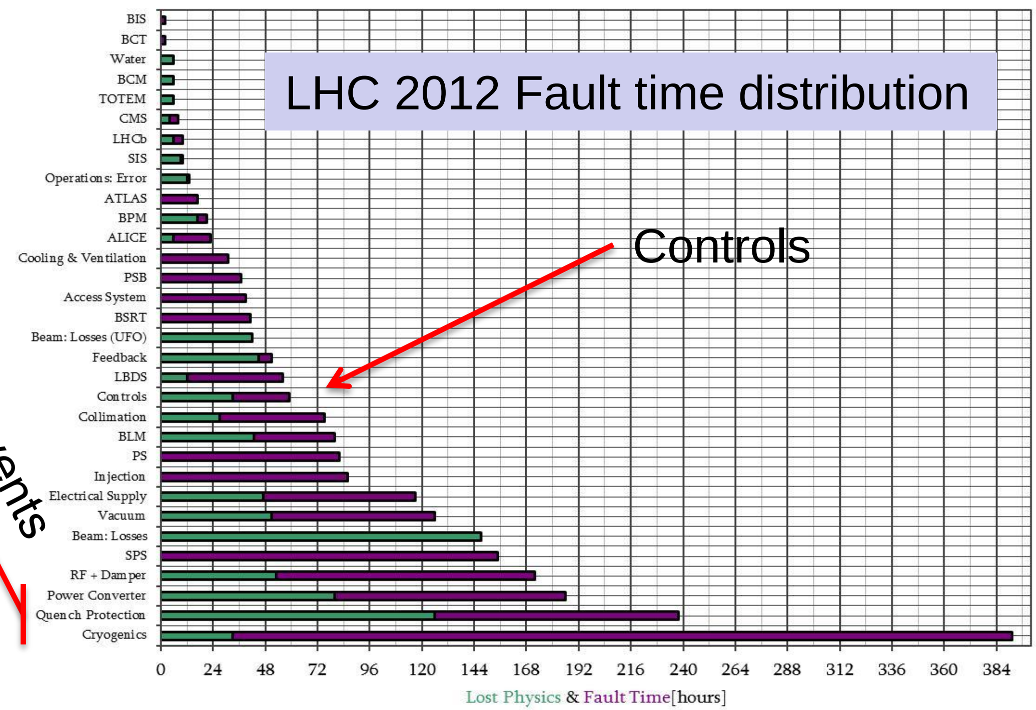
Preliminary Figures for LHC Level 0

LHC Accelerator Tunnel

Number of channels per system for one sector		DI	DO	AI Hz	AI DHz	AI Khz	AI Mhz	AO Hz	AO Hhz	Total	Scaling factor
Beam instrumentation	P2Pfiber						500			500	Lenght
Quench Protection Sysstem	Fieldbus	400		2200	1300					3900	length/ circuits
Cryogenics		700	250	2000				800		3750	Lenght
Power converter						200			100	300	Circuits
Vacuum	Cables	200	50	100						350	Lenght
Access control		30	50							80	Lenght
Magnet protection		1200	1200							2400	circuits
Ventilation		50	50			100				200	length
		2580	1600	4300	1300	300	500	800	100	11480	

Large part due to R2E related events

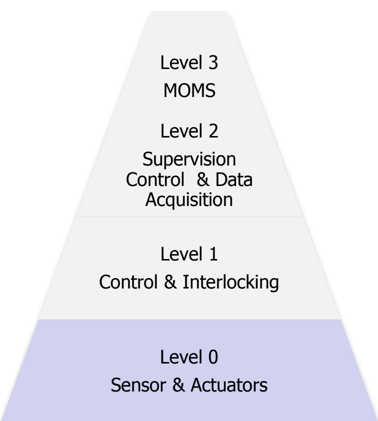


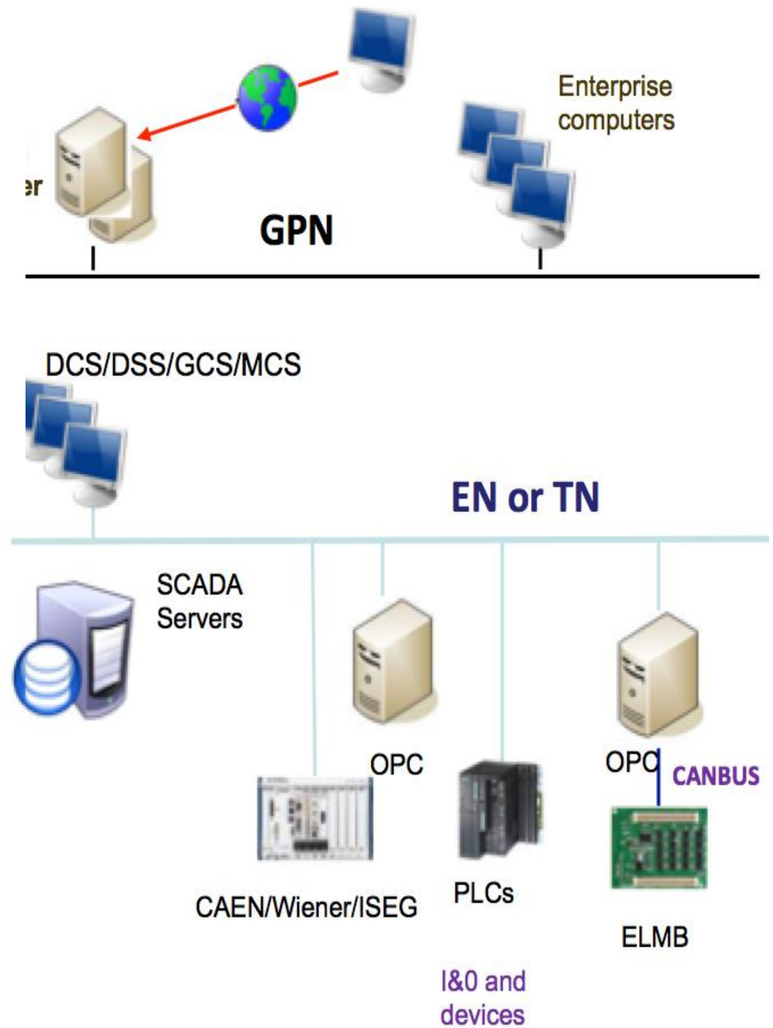


DCSs Level 0 and 1

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

Table 2.2 Summary of the most commonly used hardware in the CMS DCS.

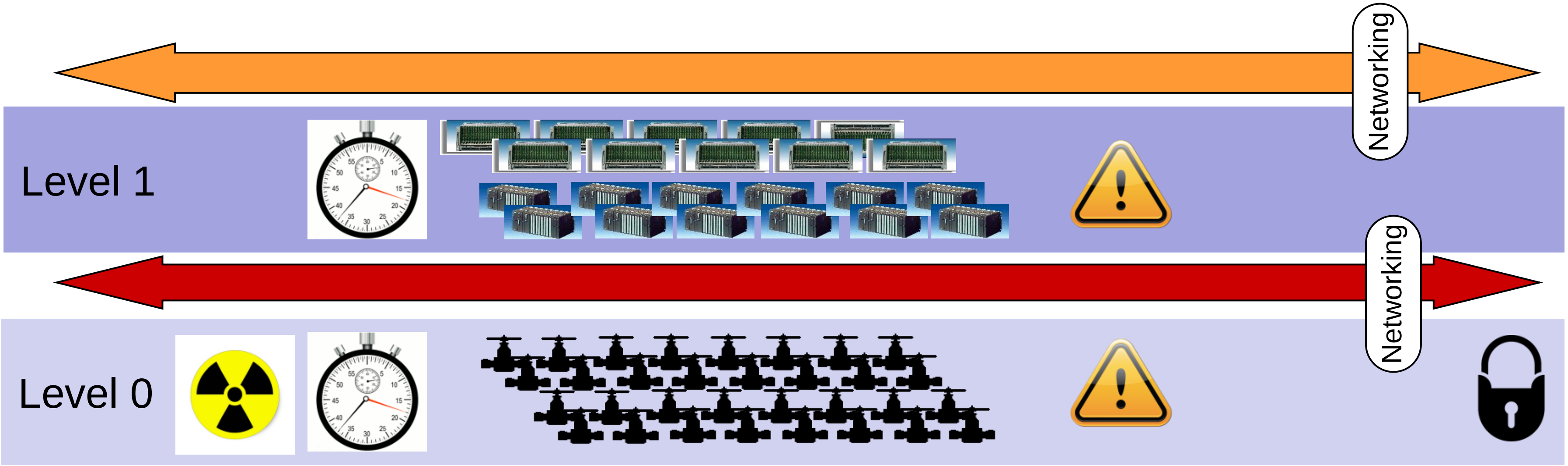




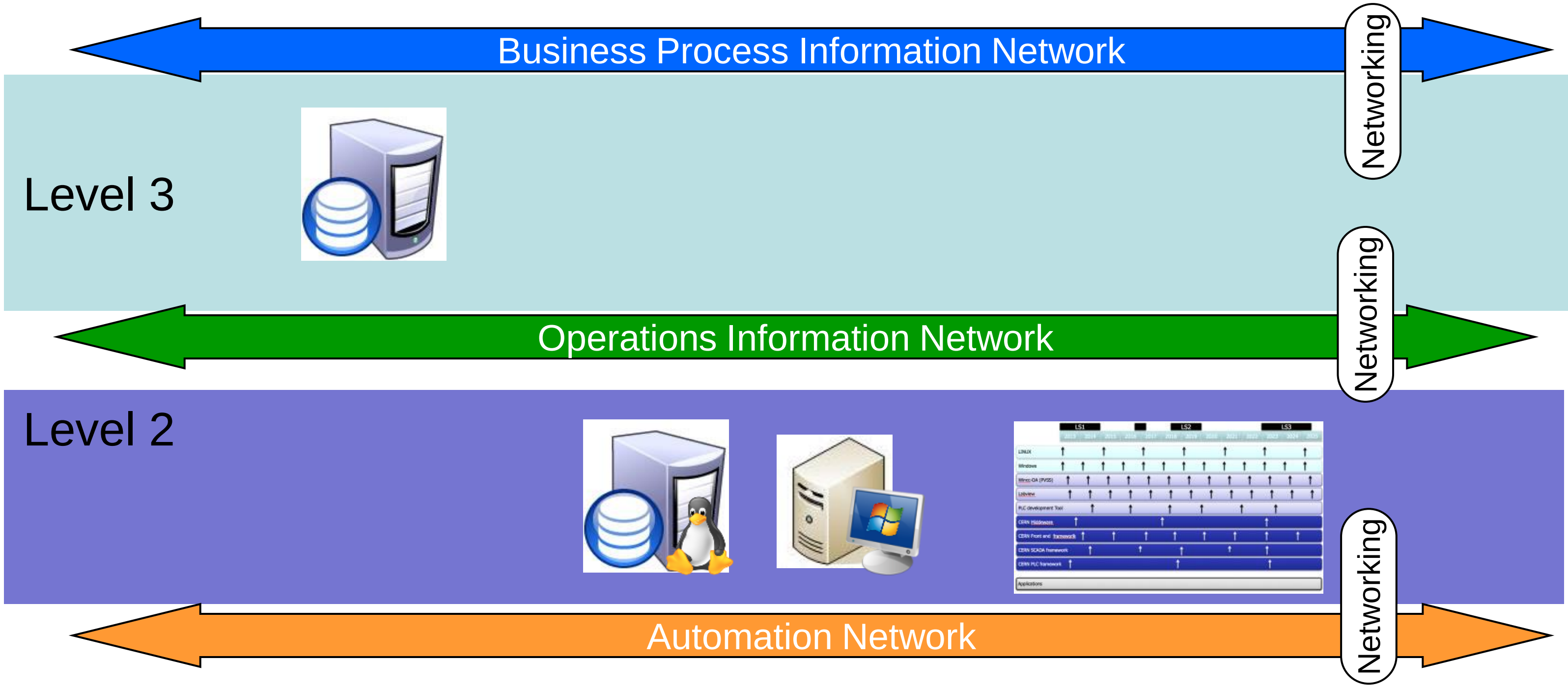
Major Constraints for Levels 0 and 1

- Access Restrictions
- Large or even enormous (experiments) amount of devices
  - First estimation for FCC: accelerator (100000 for level 0, 10000 for level 1), detectors (millions for level 0)
- High level of Radiation (premature ageing, Single Event Upset)
- Timing & Triggering distribution
- Cohabitation of very fast and slow processes
  - Different front end platforms from commercial suppliers
  - Specific hardware developments (instruments interface, I/O treatments Board,..)
- Long Lifetime
  - Level 0 solutions should ideally equivalent to the equipment one
  - Level 1 aligned to the platform lifetime (10-20 years)
- Host the safety systems

Highest Investments Costs

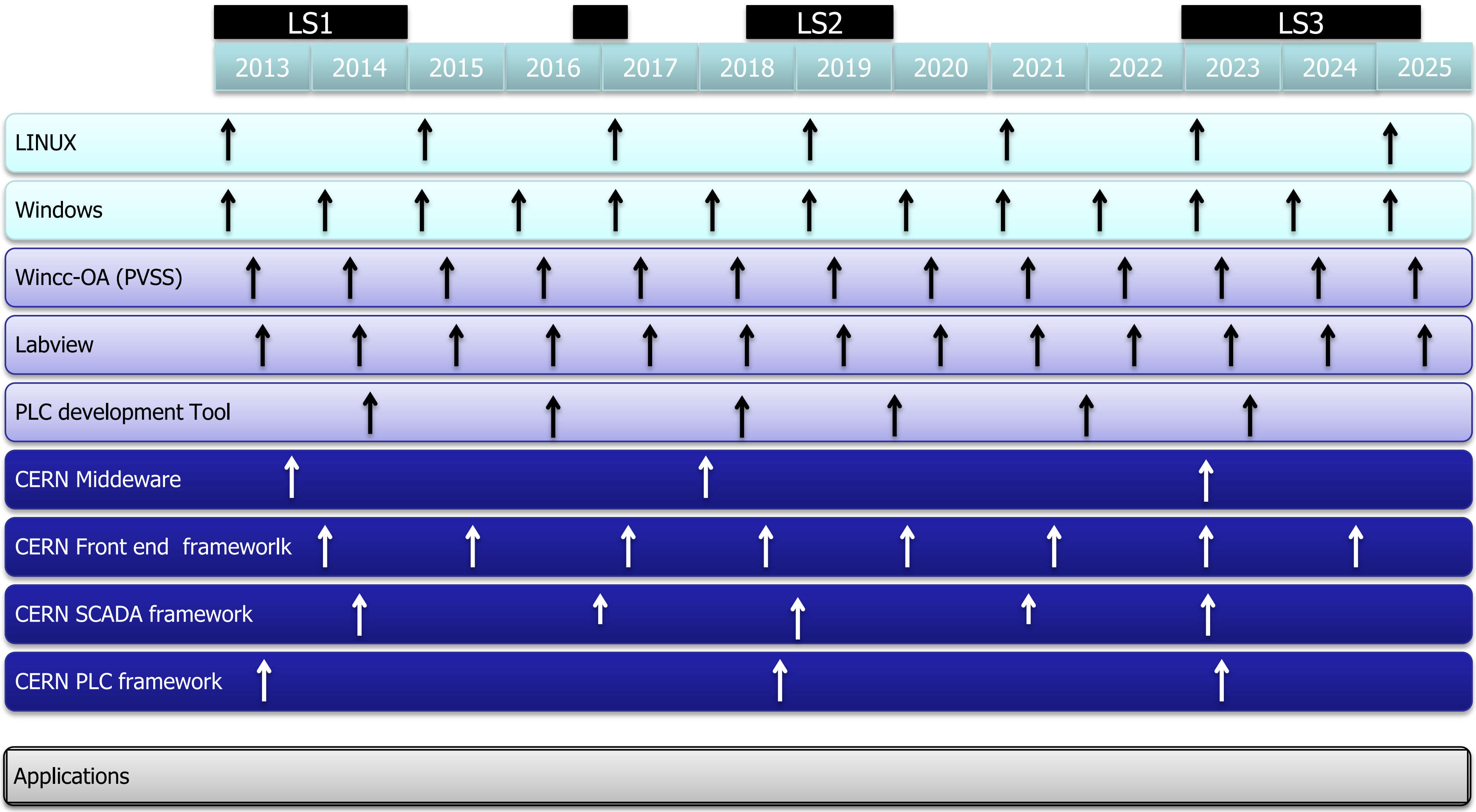


SPECIFICITIES for present Level 2 & 3

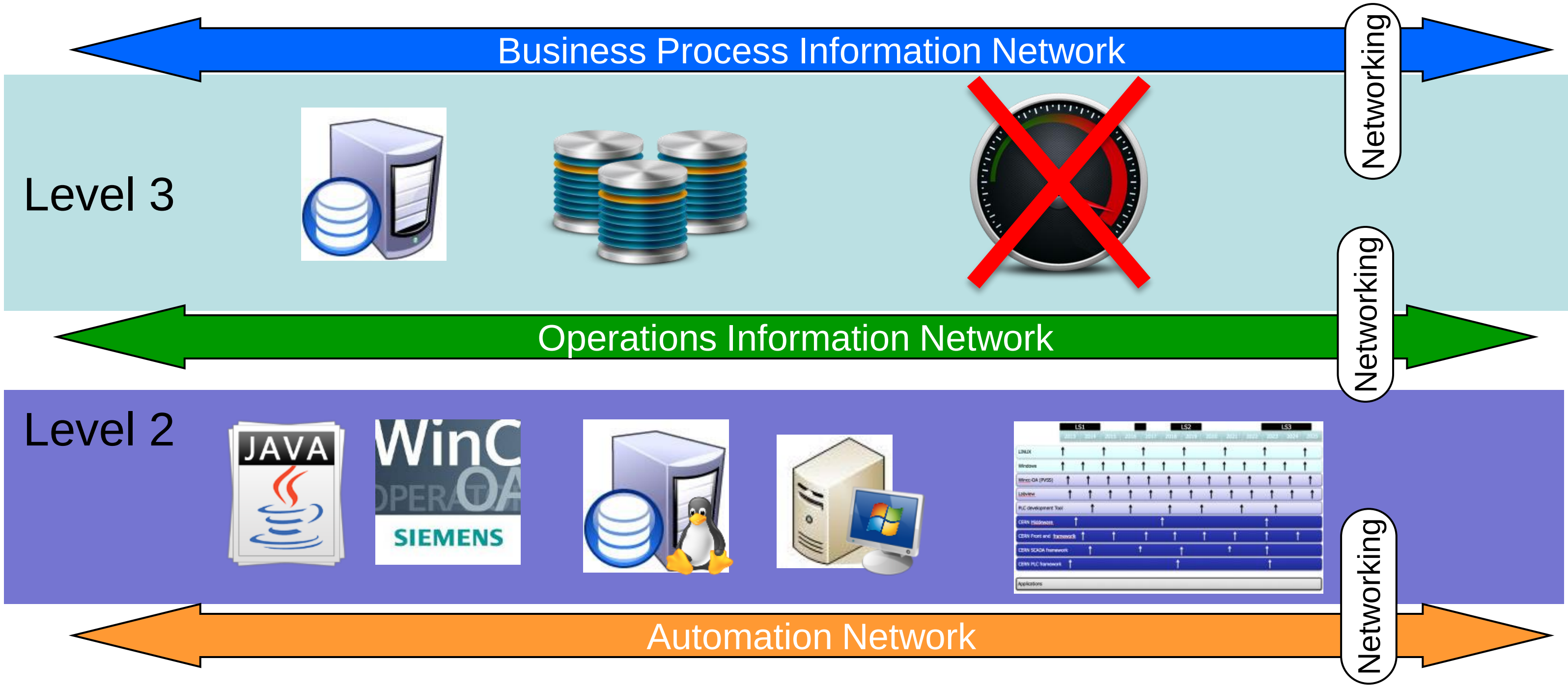


- Systematic use of standard off the shelves solutions (hard & soft)
  - Short back end platform lifetime (5 years max)
  - Complex upgrade policy related to the software ecosystem.

Impact of Software Ecosystem on Applications



Specificities for present Level 2 & 3



- Systematic use of standard off the shelves solutions (hard & soft)
  - Short back end platform lifetime (5 years max)
  - Complex upgrade policy related to the software ecosystem.
- Cohabitation of industrial or Home made supervision System
  - Beam related & utilities or infrastructure
  - DAQ & other Detector control systems
- Extensive use of data driven solution
  - Configuration, Security, Settings
- No or Embryonic Integration of "LOMS"

Highest Operation Costs

Identified Track of Studies

Level 3
- Fault pattern recognition or identification,
- Process simulation and optimization tools
- Integration of data analytics
- Integration of CMMS
- Complex event processing tools

Level 2
- Transparent Application Upgrade
- Integration of commercial and home made solutions
- …

Level 1
- Self Configuration Device
- Device virtualization
- …

Level 0
- Wireless communications for the last meters
  - Radiation tolerance
  - Real time constraints
  - Safety systems
- Self repairing or hot swappable components
- Fault tolerant HW/SW
- Compatibility with remote handling
- …

Across levels
- How can we use Model driven development
- Is it a way to produce Generic and manageable specifications for a large type of application and such a long project
- Is the new trend for control cloud concepts adapted to our infrastructure
- Can we use the distribution of High throughput computing
- What can improve the availability and the maintainability of the control systems
- How can we reduce the number of proven solutions

FCC Control Coordination

Key	Title	T	Potential participants TBC
1.1	Hadron injectors	ID	
1.1.3	Technical systems	ID	
1.1.3.5	Control system requirements	CO	P. Gayet / BE CO
1.2	Hadron collider	ID	
1.2.3	Technical systems	ID	
1.2.3.5	Control system requirements	CO	P. Gayet / BE/CO
1.4	Lepton collider	ID	
1.4.3	Technical systems	ID	
1.4.3.5	Control system requirements	CO	P. Gayet / BE-CO
2.2	Hadron collider experiments	ID	
2.2.2	Technical systems	ID	
2.2.2.12	Data acquisition, detector controls and detector safety	CO	Frank Glege; Niko Neufeld
3.2	Technical infrastructures	ID	
3.2.1	Accelerator technical infrastructures	ID	
3.2.1.5	Communications and networks	CO	
3.2.1.11	Accelerator control concepts and architectures	CO	P. Gayet / BE-CO
3.2.2	Experiment technical infrastructures	ID	
3.2.2.5	Communications and networks	CO	
3.2.4	Safety and access systems	ID	
3.2.4.1	Conventional environmental monitoring systems	CO	
3.2.4.2	Radiological monitoring system	CO	
3.2.4.3	Surveillance, Site surveillance and security systems	CO	
3.2.4.4	Access control systems	CO	
3.2.4.5	Access safety systems	CO	
3.2.4.6	Safety Alarm & Monitoring System	CO	
3.2.4.7	Emergency stop systems	CO	
3.3	Operation and energy efficiency	ID	
3.3.1	Global operation scenarios	ID	
3.3.1.6	Global reliability	CO	
3.3.1.8	Maintenance concepts	CO	
3.3.2	Hadron complex operation	ID	
3.3.2.8	Reliability and availability	CO	
3.3.3	Lepton complex operation	ID	
3.3.3.6	Reliability and availability	CO	
3.3.4	Lepton-hadron complex operation	ID	
3.3.4.7	Reliability and availability	CO	
3.5	Computing and data services	ID	
3.5.1	Computing	ID	
3.5.1.5	Accelerator complex monitoring and performance analytics	CO	
3.5.1.11	Accelerator operation control environment	CO	Philippe Gayet / BE OP
3.5.2.1	On-line networks	CO	Niko Neufeld, Pierre Van der Vyvre
3.5.4	Data Archive and Availability	ID	
3.5.4.3	Data formats	CO	
3.5.4.4	Data integrity and technology obsolescence	CO	
3.5.4.7	Accelerator data availability requirements and concepts	CO	
3.5.6	Platforms and tools	ID	
3.5.6.1	Platform technology evolution (computing, networking, stor	CO	Bernd Panzer, EN/ICE
3.5.6.2	Operating system and software environment considerations	CO	
3.5.6.3	IT Infrastructure management and provisioning ecosystem	CO	
3.5.6.5	Supervisory Control and Data Acquisition ecosystem	CO	Frank Glege and EN/ICE
3.5.6.6	Safety system platforms	CO	Johannes Gutleber
3.5.6.8	Data analytics ecosystem	CO	P. Gayet/E. Grancher **TBC**
3.5.6.9	Systems modelling and simulation infrastructures	CO	Frank Glege?, TBA
3.5.6.10	Application development tools and libraries	CO	
3.5.6.11	Data visualization	CO	
35.6.13	Control systems platforms	CO	
3.5.7	Security	ID	
3.5.7.1	On-site cyber security	CO	Stefan Lueders
3.5.7.2	Off-site cyber security	CO	Stefan Lueders
4.3	Cost estimates	ID	
4.3.2	Hadron complex estimates	ID	
4.3.2.1	Accelerator complex operation cost estimates	CO	
4.3.2.2	Collider cost estimates	CO	
4.3.2.5	Infrastructure cost estimates	CO	
4.3.2.6	Injector cost estimates	CO	
4.3.2.7	Personnel cost estimate	CO	
4.3.3.1	Accelerator complex operation cost estimates	CO	
4.3.3.2	Collider cost estimates	CO	
4.3.3.4	Infrastructure cost estimates	CO	
4.3.3.5	Injector cost estimates	CO	
4.3.3.6	Personnel cost estimate	CO	

- 47 topics have been identified in 8 main chapters Of the FCC Work package breakdown
- We have chosen to include them in the perimeter of the control coordination study
- They cover the four levels of the control system pyramid.

- Control system requirements
- Control systems concepts and architectures
- Technology evolution
- Communications and networks
- Data Acquisition needs
- Safety systems specificities
- Maintenance, Reliability and availability
- Monitoring and performance analytics
- Modeling and Simulation
- Cyber security
- Cost estimates

Control Study Collaboration

- We Want to Set up a Collaboration that :
  - Will profit of the past experience
    - In our labs or with the successful control collaboration

Control System Collaboration Success Stories

- The Physic community has a good & successful practice for control system collaboration, the most noticeable ones are :

  - EPICS (Accelerator controls)
    - Launched in 1989 !!!
    - Still very active today with more than 40 facilities worldwide
    - Base solution for ILC, ESS, and ITER CODAC
  - TANGO (Synchrotron light source)
    - Launched in 1998 at ESRF
    - Now now in version 9 With more than 25 partners WORLDWIDE
    - Very active development
  - JCOP (LHC detector control system)
    - Launched on 1998 at CERN
    - Grouping 4 LHC experiments involving dozens of Lab hundredth of developers
    - 600 applications servers
    - Now less than 50 people to maintain
    - Chosen for Fixed target experiments

Control Study Collaboration

- We Want to Set up a Collaboration that :
  - Will profit of the past experience
    - In our labs or with the successful control collaboration
  - Covers the 4 layers of the Control systems in order to include all Physical, Operational and Technical constraints and offer all necessary services.
  - Include the Experimental Physic community and the Industry in order to :
    - Federate the efforts to include the technological breakthrough and not miss any rupture that will happen
    - Take profit of the Fast pace of progress in the industry
    - Create condition for trustful and win/win collaboration
      - Keep under control the strategic domain
      - Avoid vendor lock issues
      - Knowledge transfer to industry
    - Find the balance between:
      - Open Solution
      - Solution based on open Standard
      - Off the shelves and Proprietary solution
    - …

Conclusion

- Control systems will be key components for the performances of the FCC
  - Impact on the availability
  - Impact on the operation cost
- They are connected to all equipment
- Despite the diversity of the physical systems we have to maximize the use of common solutions
- Conceptual Choices have to be made early not the technology choices
- Choices shall cope with the technological evolution
- We will use any opportunities given by HL-LHC to fuel the collaboration
- We need Help!!!