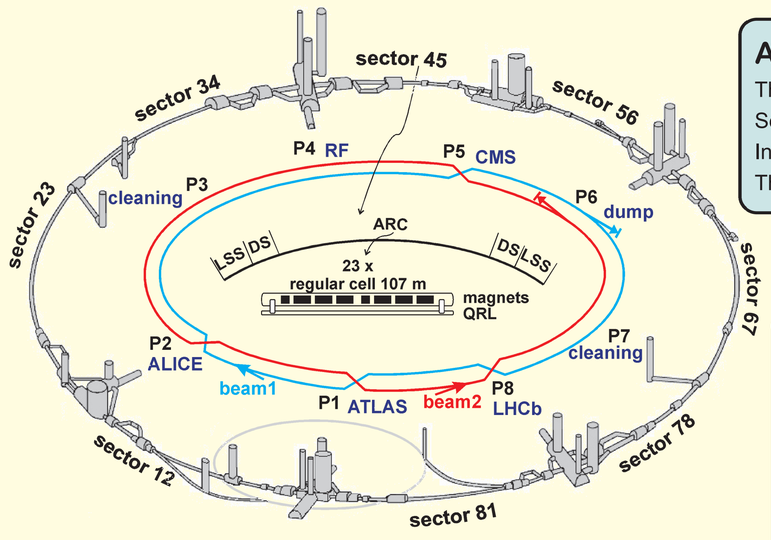
# THE CONTROL SYSTEM FOR THE CRYOGENICS IN THE LHC TUNNEL
## [ FIRST EXPERIENCE AND IMPROVEMENTS ]

P. Gomes, E. Blanco, J. Casas, C. Fluder, E. Fortescue, P. Le Roux, G. Penacoba, M. Pezzetti, M. Soubiran, A. Tovar, L. Zwalinski; CERN, Geneva, Switzerland





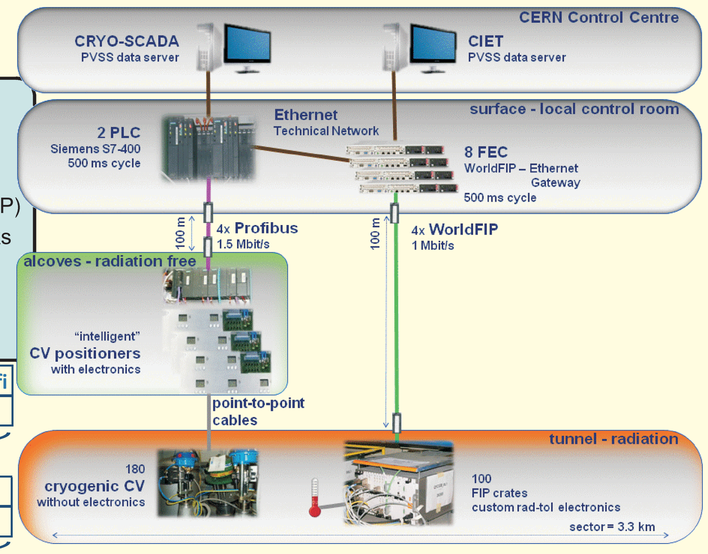
## Abstract

The Large Hadron Collider (LHC) was commissioned at CERN and started operation with beams in 2008
Several months of operation in nominal cryogenic conditions have triggered an optimisation of the process functional analysis
In order to enhance safety, availability and operability of LHC cryogenics, a major rebuild of the logic and several hardware modifications were implemented
The databases, containing instruments & controls information, are being rationalized; the automatic generator of specifications for the control software is being simplified


## Architecture

27 km proton collider, 100 m underground, 8 sectors, each with:
- 2 long straight sections (LSS); a curved part (ARC) with 23 regular cells of 107 m
- 2 000 instruments distributed over 3 300 m; industrial field networks (Profibus & WorldFIP)
- 2 PLC Siemens S7-416-2DP, each running 250 control loops & 500 alarms and interlocks
- 8 Front End Computers: gateway FIP - PLC

man-machine interface based on a SCADA built on PVSS
control software conforms to the UNICOS framework of CERN




| TT | CV | PV/QV | PT | LT | EH | FT | DI FIP | DI Profi |
|---|---|---|---|---|---|---|---|---|
| 9 599 | 2 662 | 700 | 897 | 474 | 2 429 | 2 | 521 | 1 291 |

| electrical | cables |
|---|---|
| 14 657 | 6 656 |

| physical | derived | spare | virtual |
|---|---|---|---|
| 18 575 | 8 624 | 5 702 | 1 820 |

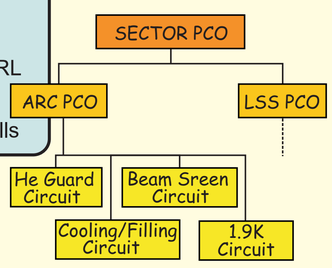
| in DB | 16 291 |
|---|---|
| 56 034 | |

| in control sys |
|---|
| 32 437 |

## Operability - PCO structure

Process logic is supervised by a hierarchy of Process Control Objects (PCO)
Below master sector-PCO, 1 for ARC and 1 for LSS
- under these, there was originally 1 for each cryogenic cell

Cells are usually operated together, because simultaneously fed from the QRL
- all individual cell PCOs replaced by only 4
- associated to the different hydraulic circuits, which are common to all cells



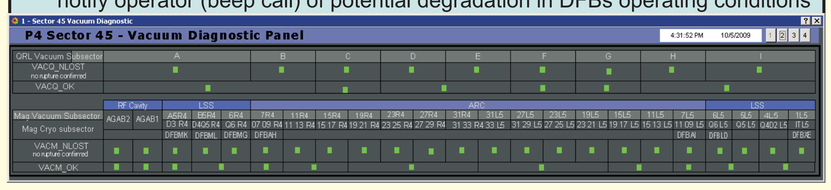

## Safety - quench valves & DFB

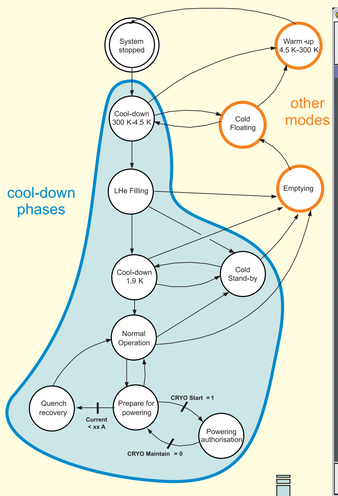
In case of damage of the magnets' helium enclosure, when the machine is filled
- to avoid or minimise helium release into the tunnel

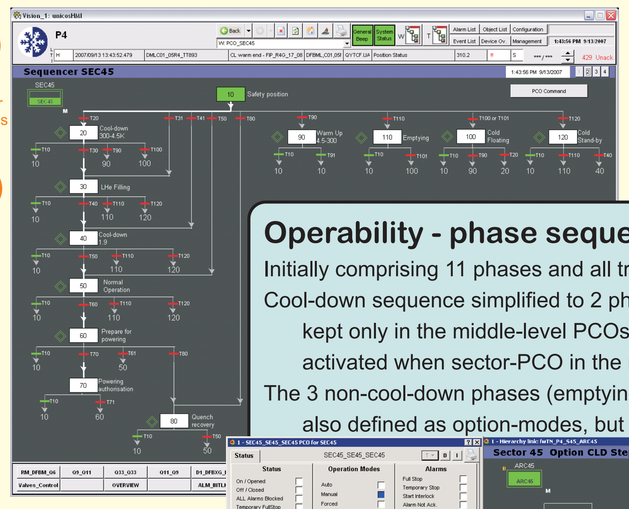
New logic for quench protection valves
- to automatically discharge into the QRL
- independently of their mechanical threshold being reached

New & more detailed hard-wired vacuum-quality signals
- combined with cryogenic signals (like pressure measurement),
- can trigger the opening of corresponding quench valves

New Thermal Switches & Pressures Switches
- notify operator (beep call) of potential degradation in DFBs operating conditions



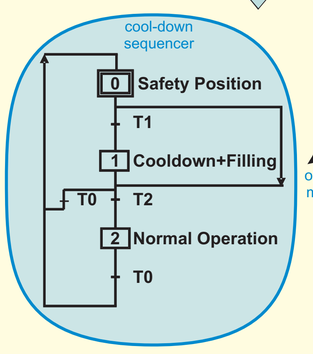



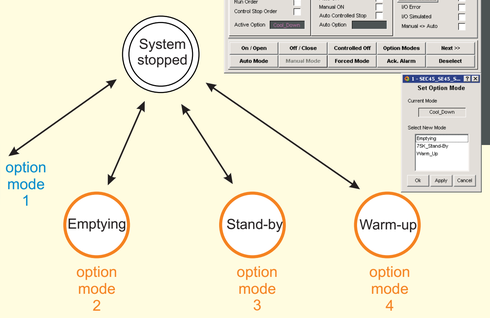




## Operability - phase sequencer

Initially comprising 11 phases and all transitions & replicated at all levels of PCOs
Cool-down sequence simplified to 2 phases
- kept only in the middle-level PCOs; removed from the other levels
- activated when sector-PCO in the new option-mode 'cool-down'

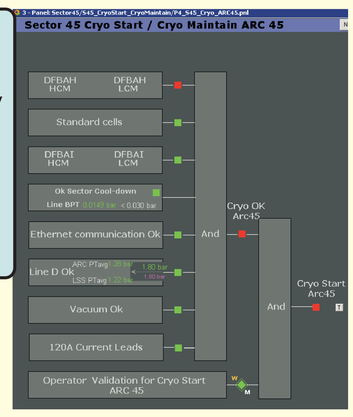
The 3 non-cool-down phases (emptying, stand-by, warm-up)
- also defined as option-modes, but without any sequencer



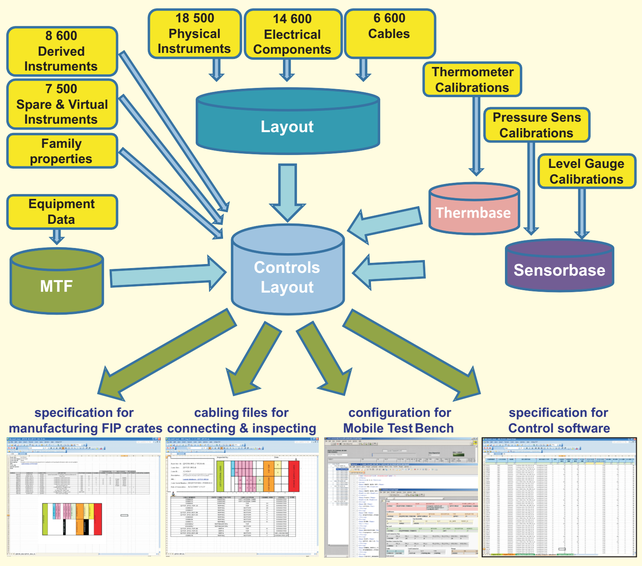

## Availability - nominal conditions

To limit down-time of magnet powering
the availability in nominal conditions expected to improved by
- median filters on all sensors, to aoid spikes
- low-pass filter for input of the control loops
- new LT object with more accurate parameterisation
- control loops reviewd and optimised
- interlocks list fully reviewd




## Software production

The modifications on PCO structure, sequencer, control loops, interlocks,
and a new version of the UNICOS programming environment
- implied significant rebuild of
  - logic templates used by the code generators
  - generic functions with for objects families
  - tools for automatic generation & automatic validation
  - SCADA panels

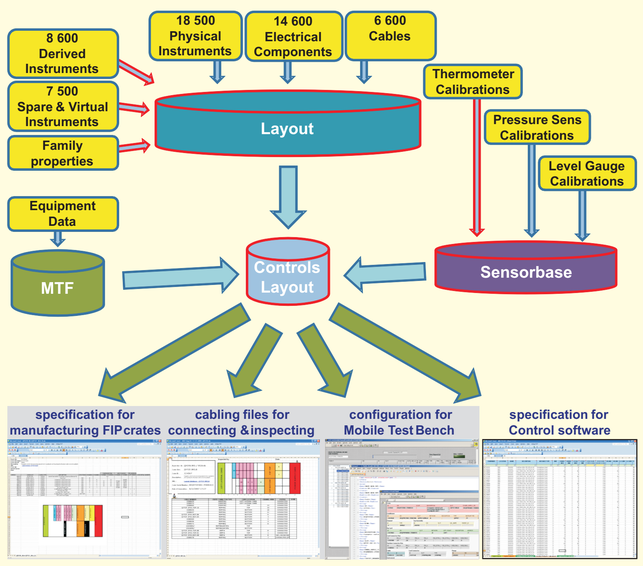



## Databases - rationalisation

The scope of the original Layout data model was broadened
with only minor modifications, it accommodates a wider range of objects and properties
- became possible a coherent treatment to physical and conceptual objects

Grouping as much data as possible in the Layout
- & treating all types of instrumentation channels the same way

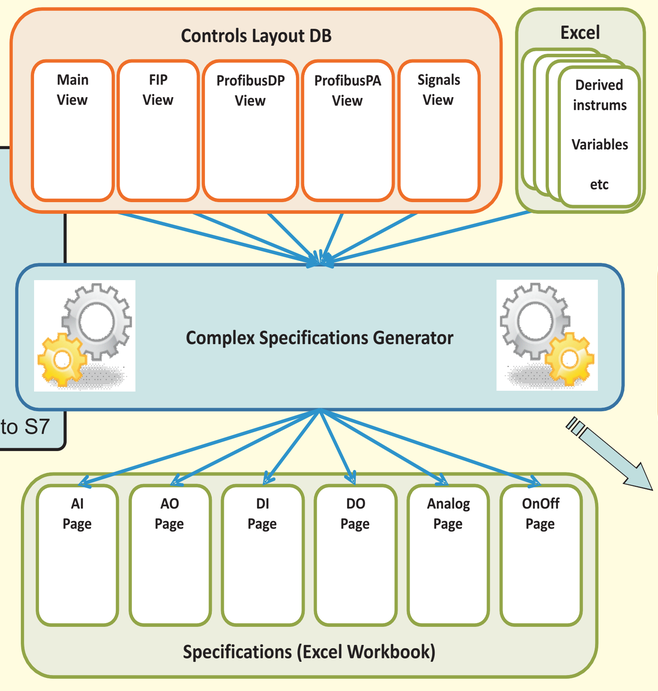
The views for the controls specifications become less complex
Not necessary to maintain distinct codes to retrieve each category of instrument
Layout DB web interface can be used to easily browse data,
- and follow relationships between all types of instruments

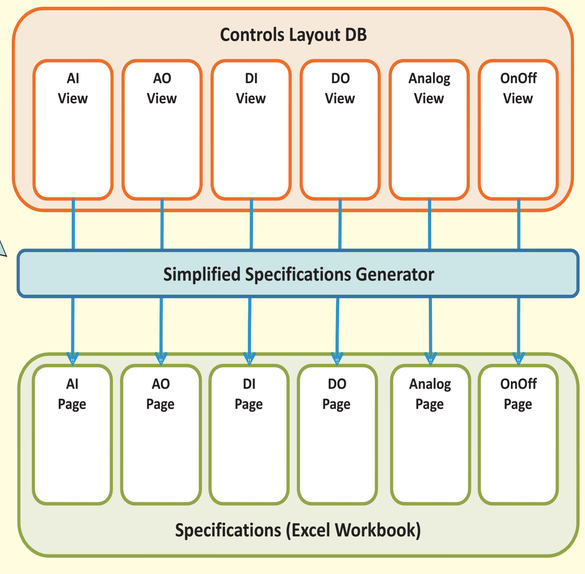



## Specifications Generator - simplification

Extracts data from several DB views & from external spreadsheets
- applies a set of rules and calculations
- to derive parameter values, relationships and secondary objects

Once the databases are completed and coherently structured
- a set of views will replicate each page of the specifications
  - the maintenance of generator & database will be much simplified
- also a view with the PLC hardware configuration directly importable into S7




## Conclusions

Database work is well advanced but not finished
- effort in maintaining old views, to minimise modifications to Specs Generator, if needed

Also updating electrical and fieldbus diagrams
- their correctness is vital for maintenance and for efficient support to operation.

Evolved towards simplicity
- in process control, databases, and generator of specifications

Combined patches and eliminated original features intended for the machine start-up
The control system is now more reliable & user friendly and adapted to regular operation