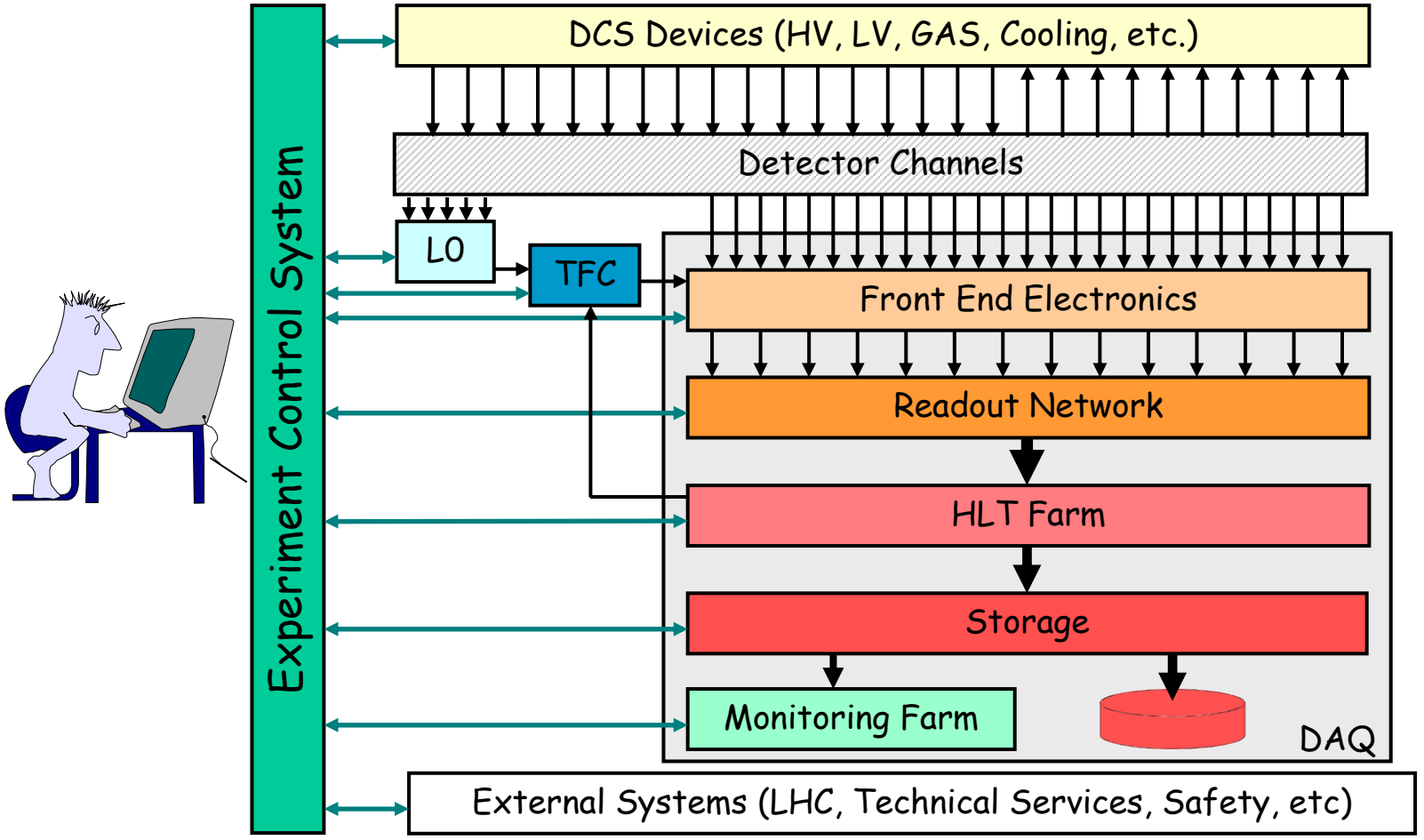
The LHCb Experiment Control System:

On the path to full automation

Clara Gaspar, October 2011

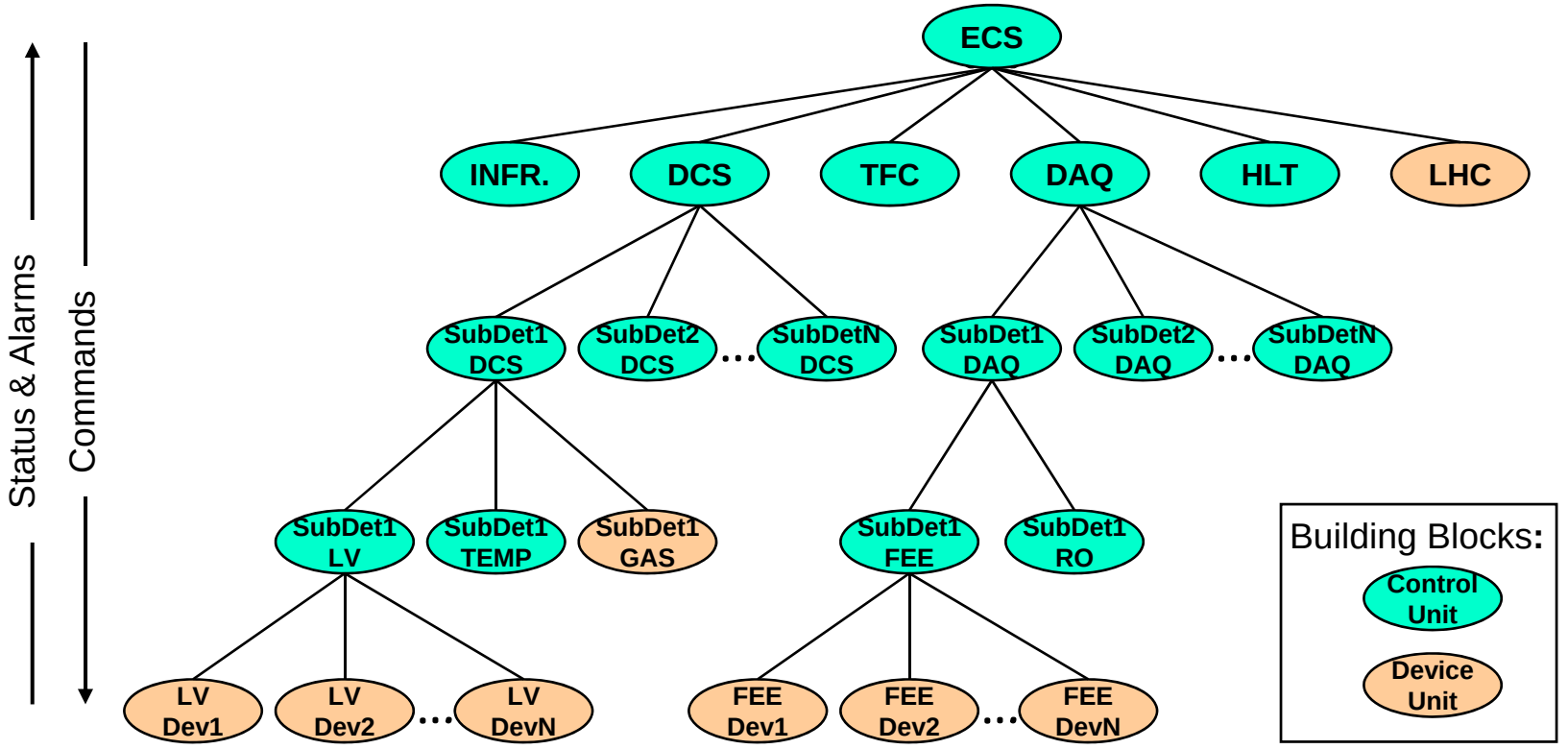
The Experiment Control System

- Is in charge of the Control and Monitoring of all areas of the experiment



Homogeneity

- Same architecture and same tools used throughout the Control System.
- Generic Architecture:



The Control Framework

- **The JCOP* Framework is based on:**
  - SCADA System - PVSSII for:
    - Device Description (Run-time Database)
    - Device Access (OPC, Profibus, drivers) +DIM
    - Alarm Handling (Generation, Filtering, Masking, etc)
    - Archiving, Logging, Scripting, Trending
    - User Interface Builder
    - Alarm Display, Access Control, etc.
  - SMI++ providing:
    - Abstract behavior modeling (Finite State Machines)
    - Automation & Error Recovery (Rule based system)

Device Units

Control Units

* - The Joint COntrols Project (between the 4 LHC exp. and the CERN Control Group)

Device Units

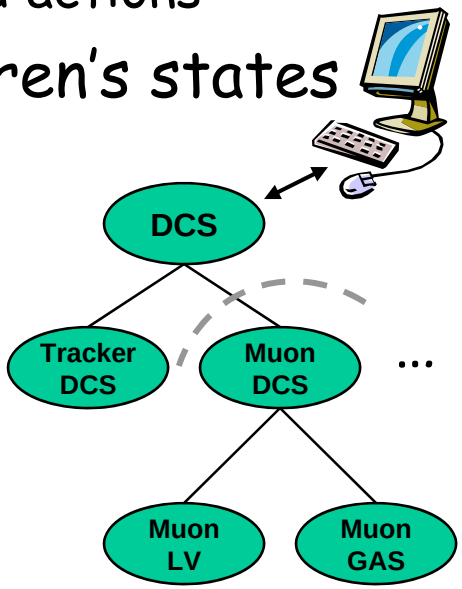
Device Unit

- **Provide access to "real" devices:**
  - The FW provides interfaces to all necessary types of devices:
    - LHCb devices: HV channels, Read Out boards, Trigger processes running in the HLT farm or Monitoring tasks for data quality, etc.
    - External devices: the LHC, a gas system, etc.
  - Each device is modeled as a Finite State Machine:
    - It's main interface to the outside world is a "State" and a (small) set of "Actions".

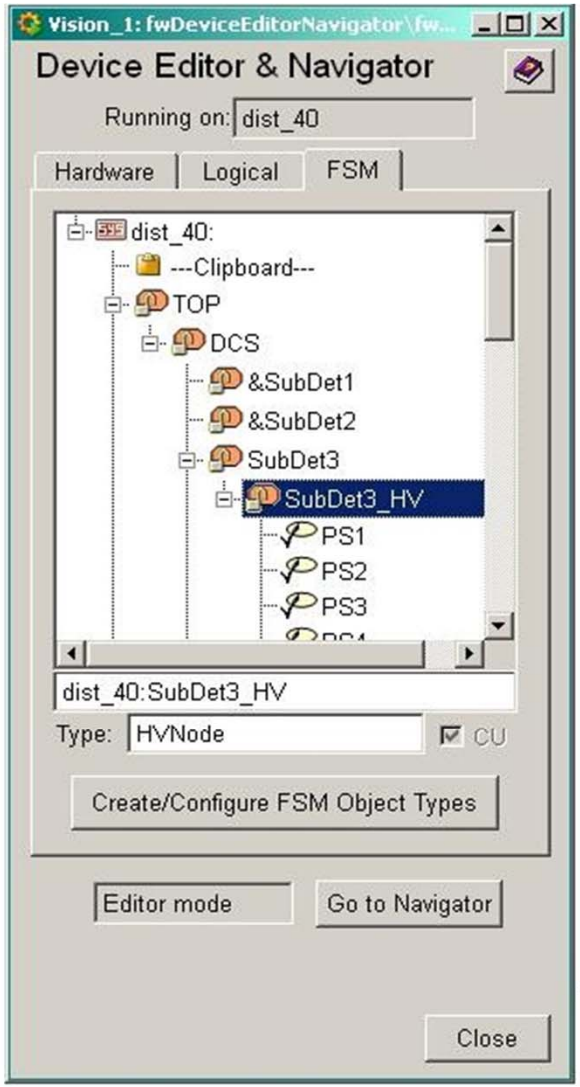
Hierarchical control

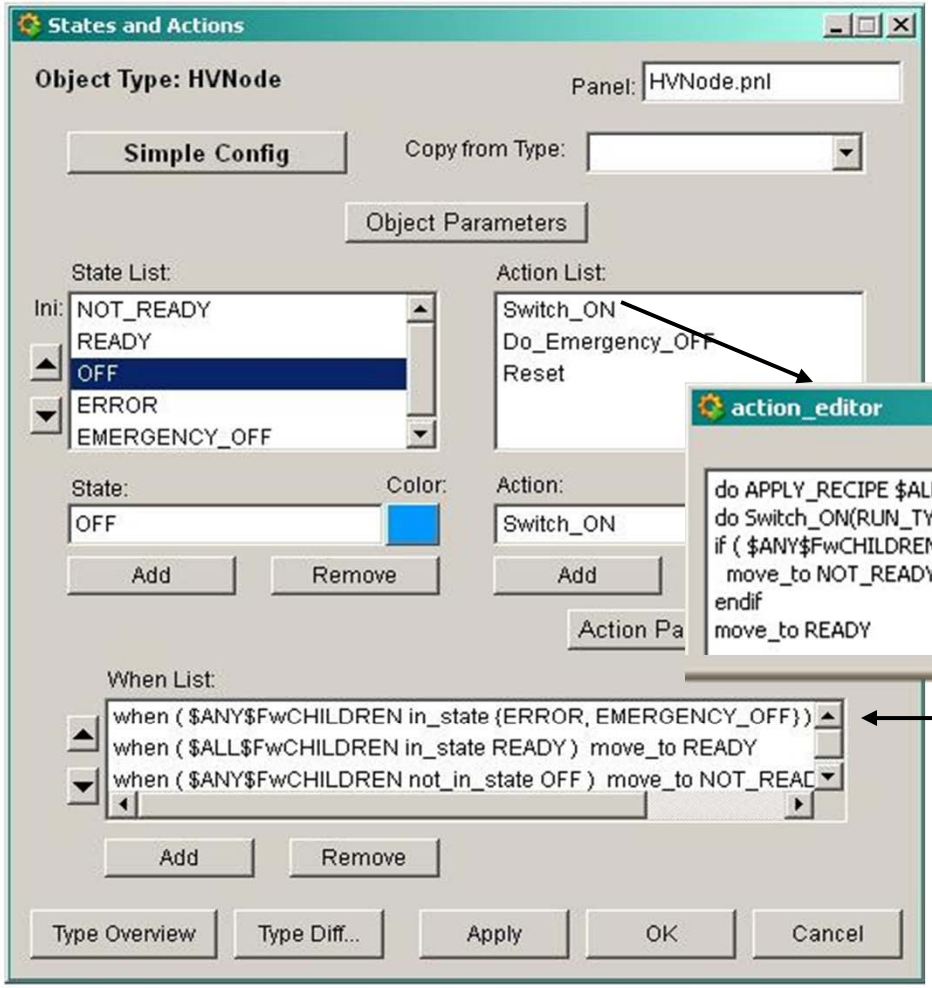
Control Unit

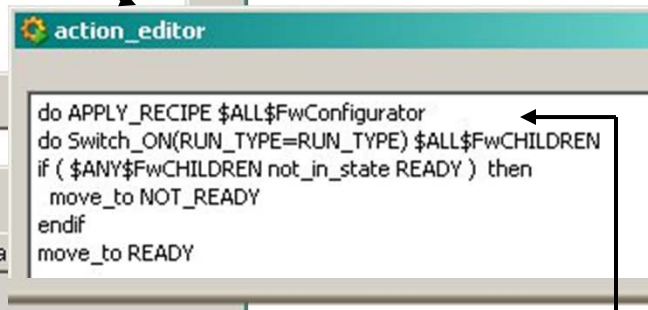
- **Each Control Unit:**
  - Is defined as one or more Finite State Machines
    - It's interface to outside is also a state and actions
  - Can implement rules based on its children's states
  - In general it is able to:
    - Include/Exclude children (Partitioning)
      - Excluded nodes can run is stand-alone
    - Implement specific behaviour & Take local decisions
      - Sequence & Automate operations
      - Recover errors
    - User Interfacing
      - Present information and receive commands



FW - Graphical Editor





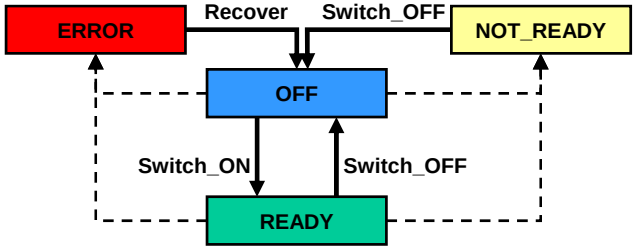


- **SMI++**
  Objects
  States &
  Actions

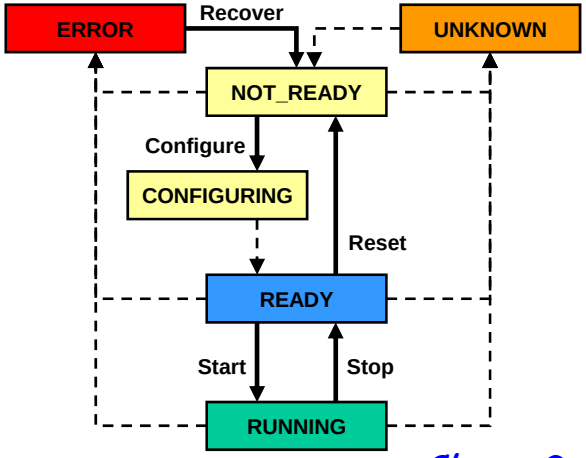
- Parallelism, Synchronization
- Asynchronous Rules

Operation Domains

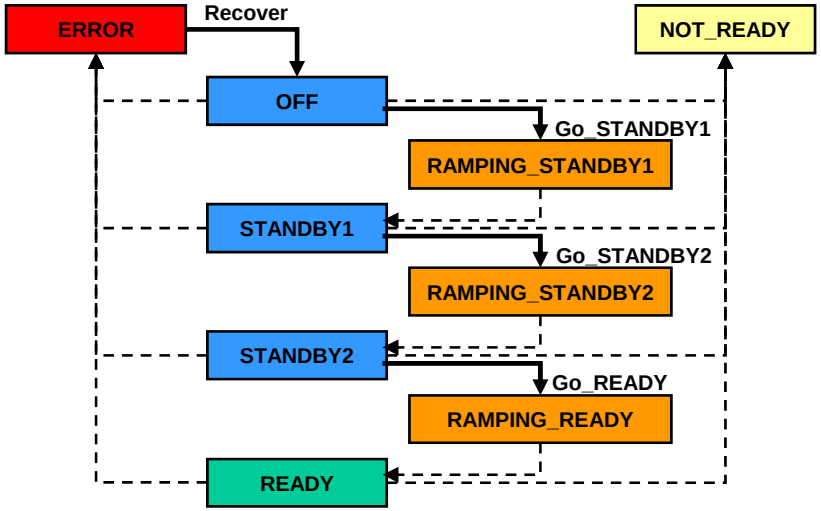
- **DCS Domain**
  Equipment operation related to a running period (Ex: GAS, Cooling)



- **DAQ Domain**
  Equipment operation related to a "RUN" (Ex: RO board, HLT process)

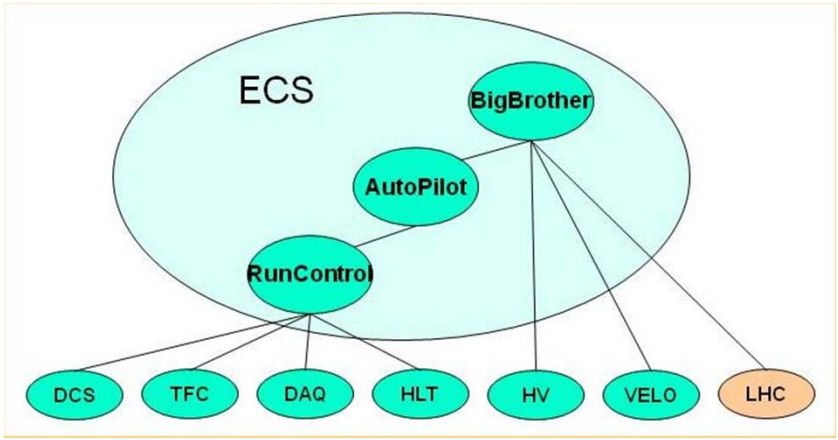


- **HV Domain**
  Equipment operation related to the LHC State (Ex: High Voltages)



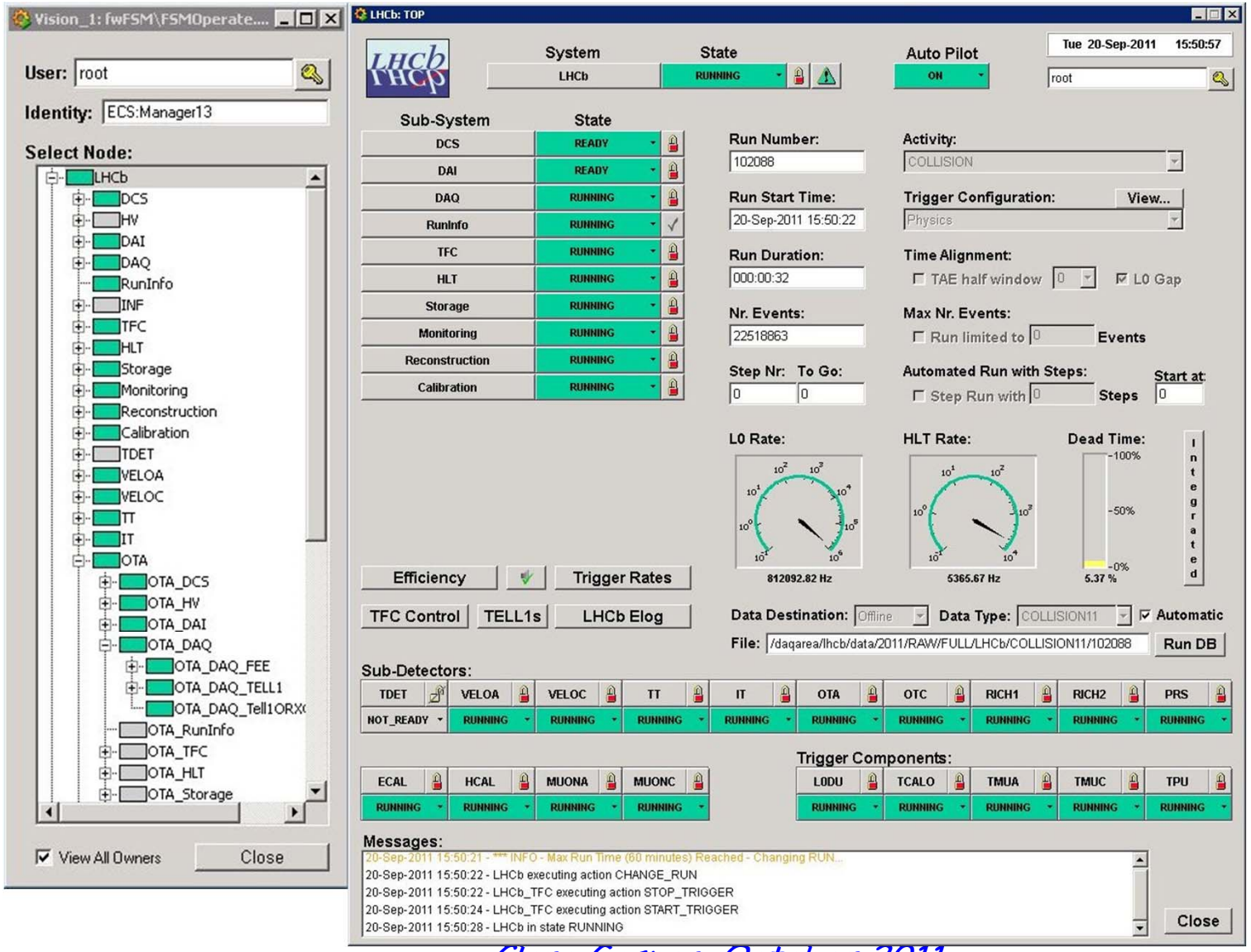
- **FSM templates distributed to all Sub-detectors**
- **All Devices and Sub-Systems have been implemented using one of these templates**

ECS - Automation



- **Some Examples:**
  - HLT Control (~1500 PCs)
    - Automatically excludes misbehaving PCs (within limits)
    - Can (re)include PCs at run-time (they get automatically configured and started)
  - RunControl
    - Automatically detects and recovers SubDetector desynchronizations
    - Can Reset SDs when problems detected by monitoring
  - AutoPilot
    - Knows how to start and keep a run going from any state.
  - BigBrother
    - Based on the LHC state:
      - Controls SD Voltages
      - VELO Closure
      - RunControl

Run Control



Matrix

Domain

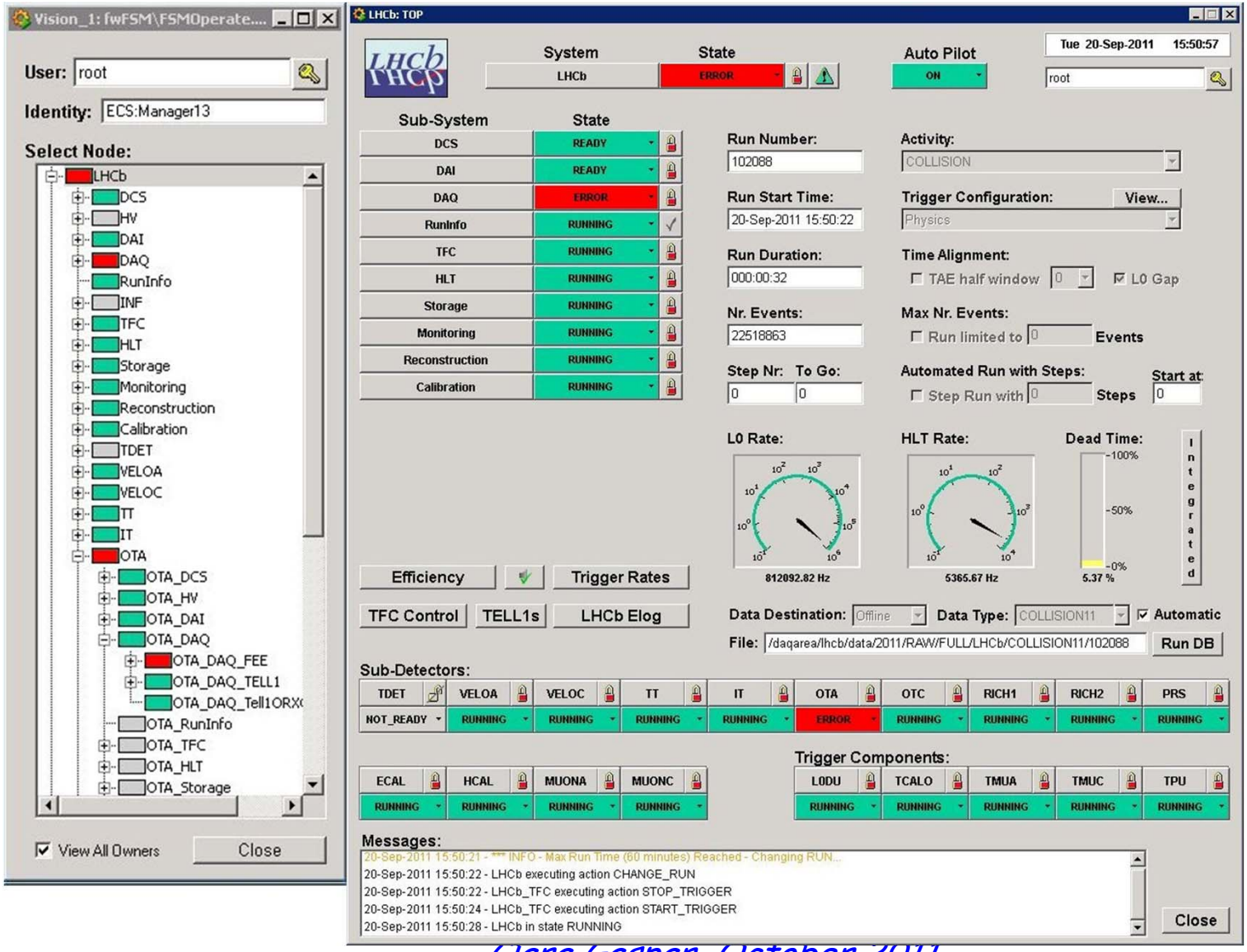
X

Sub-Detector

Activity

Used for Configuring all Sub-Systems

Run Control



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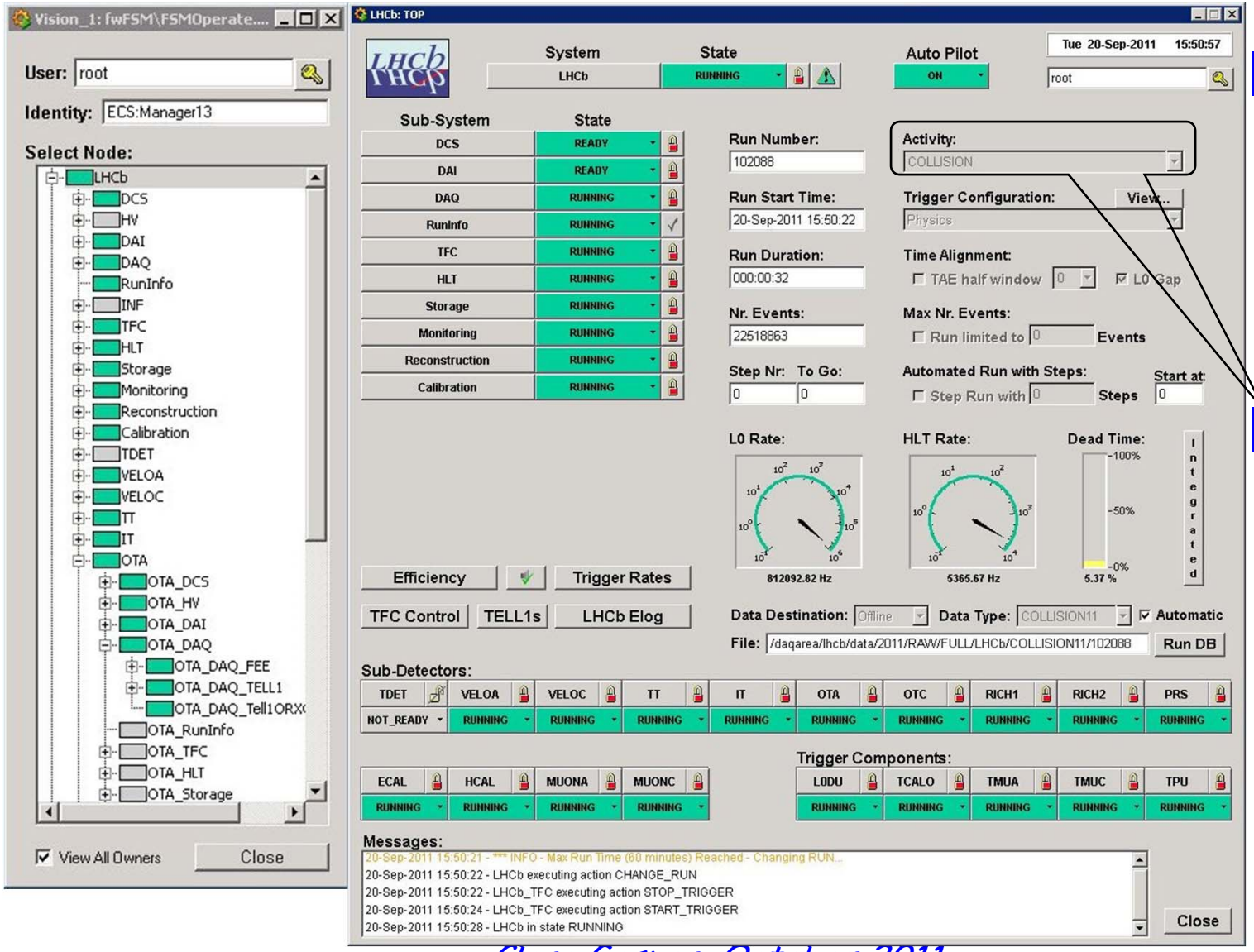

Matrix

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X

Sub-Detector

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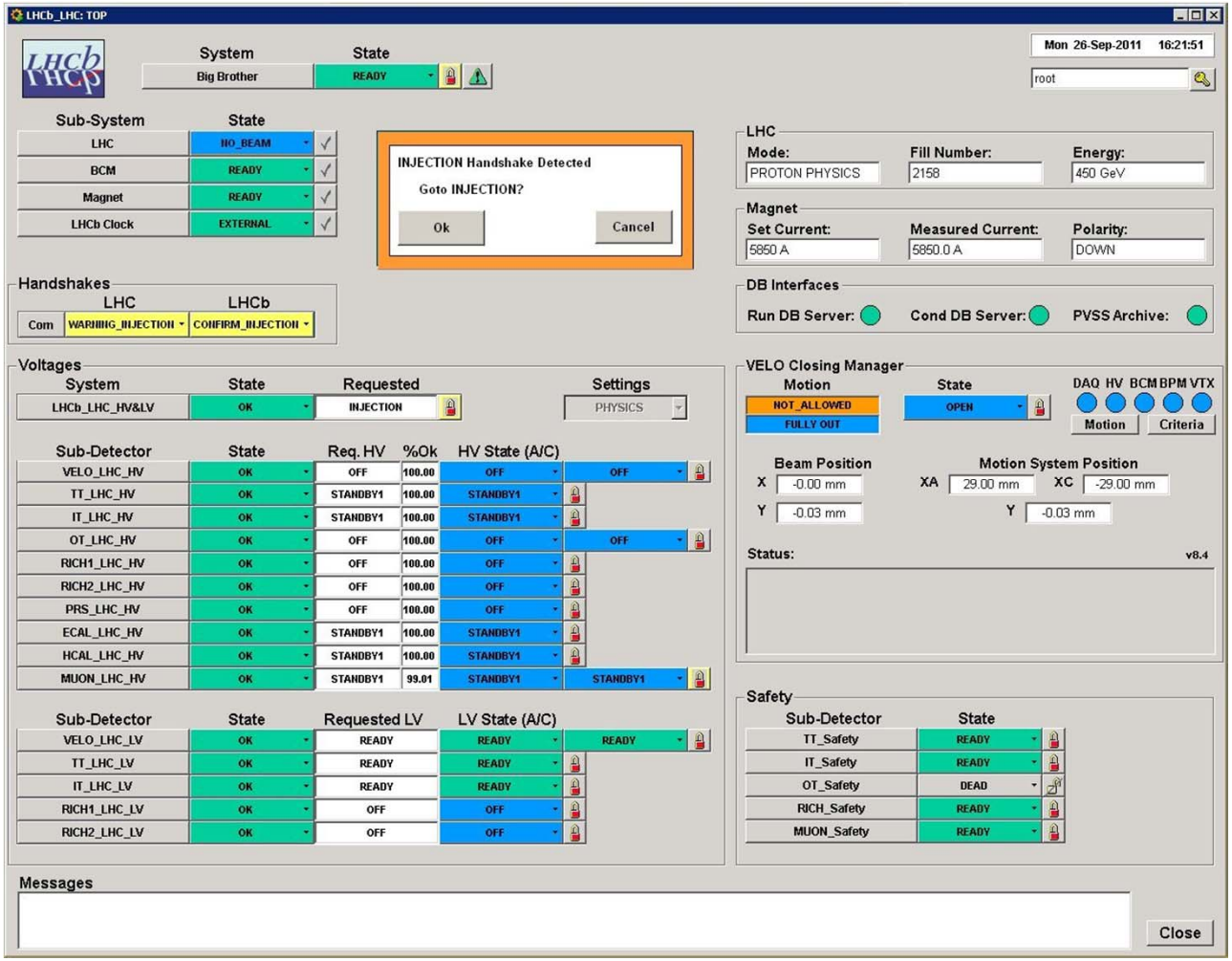
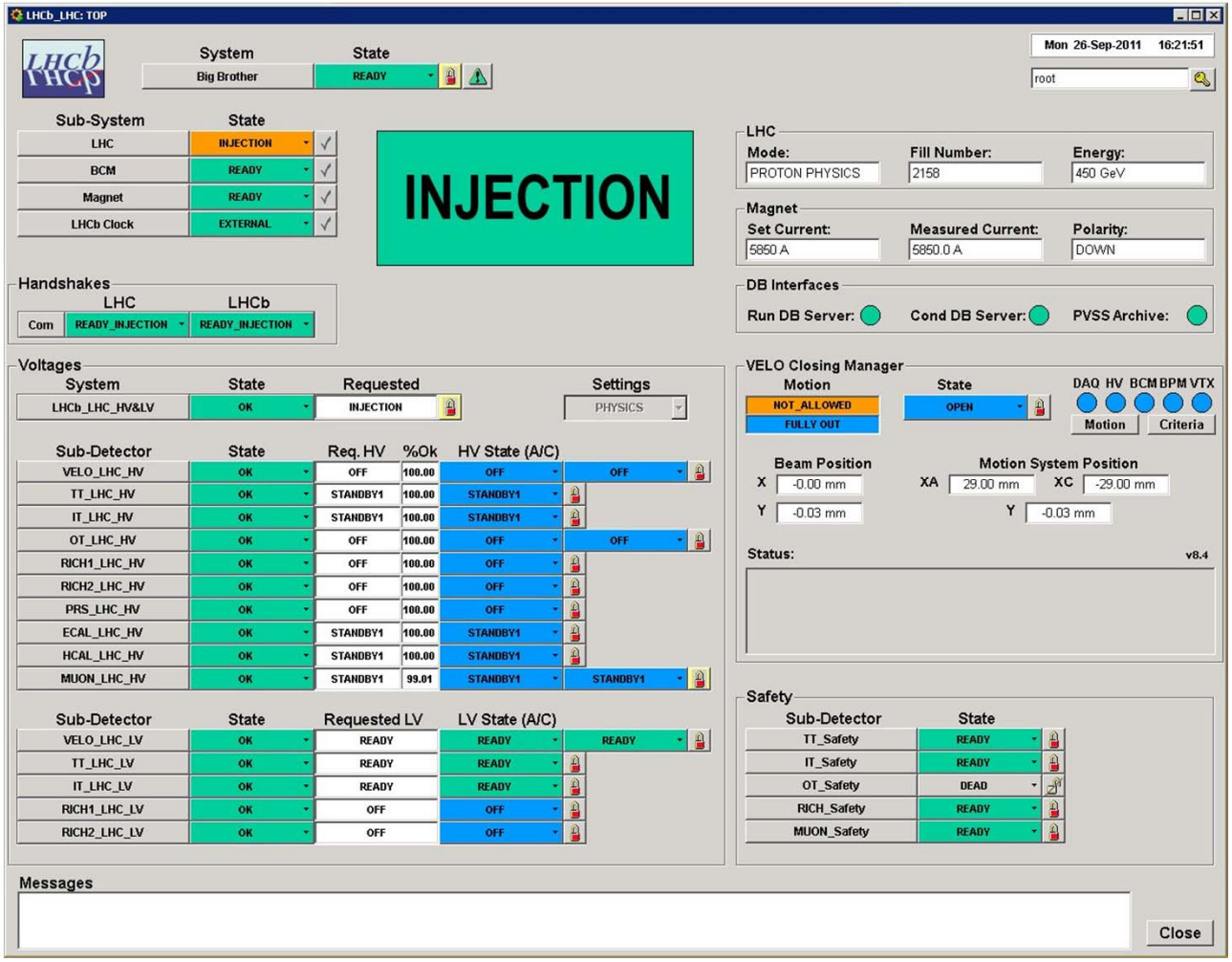
Used for Configuring all Sub-Systems

LHCb Operations



- **Two operators on shift:**
  - Data Manager
  - Shift Leader has 2 views of the System:
    - Run Control
    - Big Brother
- **Big Brother**
  - Manages LHC dependencies:
    - SubDetector Voltages
    - VELO Closing
    - Run Control

LHCb Operations



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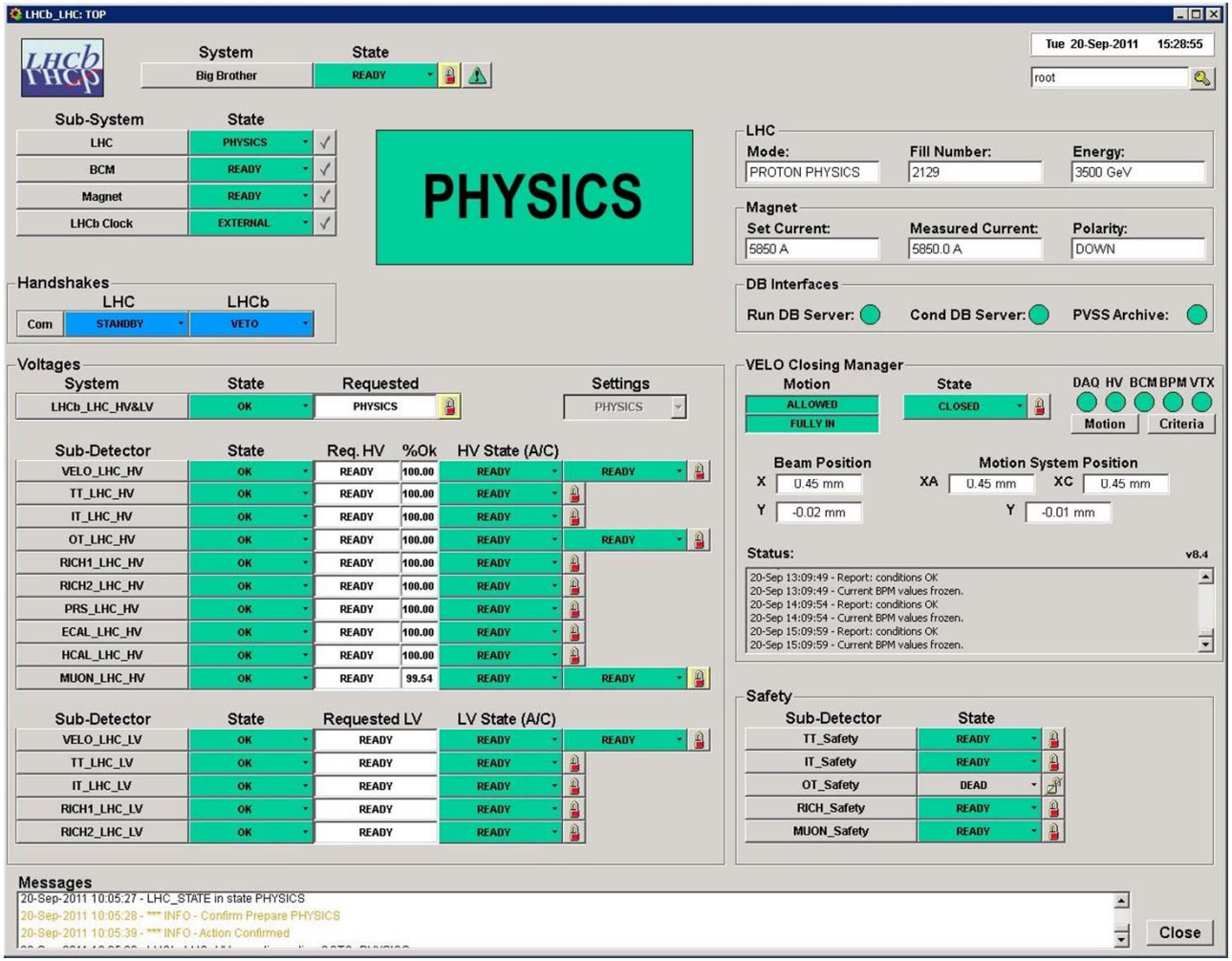

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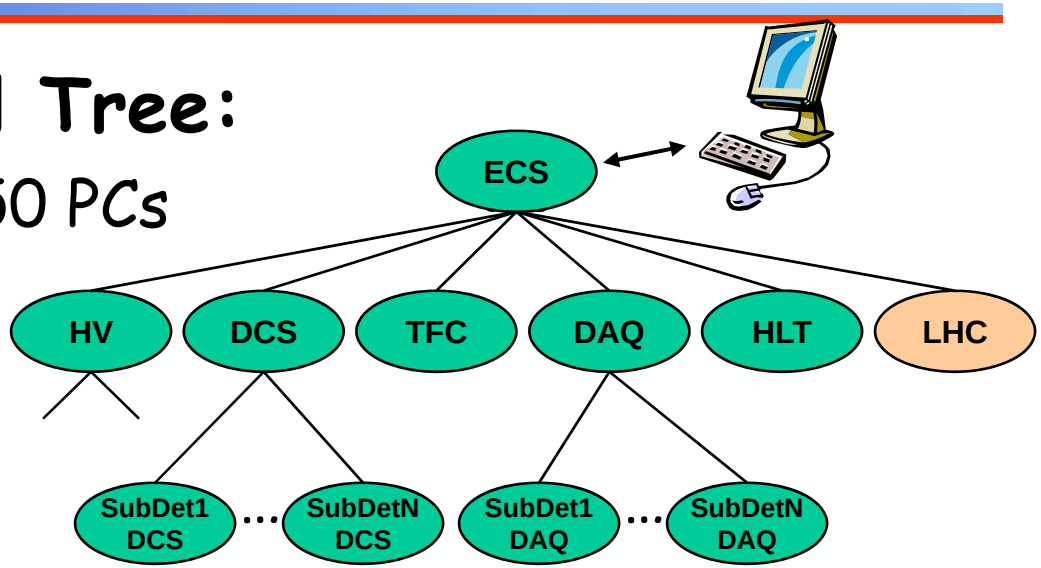
ECS: Some numbers

- **Size of the Control Tree:**
  - Distributed over ~150 PCs
    - ~100 Linux (50 for the HLT)
    - ~ 50 Windows
  - >2000 Control Units
  - >50000 Device Units



- **Run Control Timing**
  - Cold Start to Running: 4 minutes
    - Configure all Sub-detectors, Start & Configure ~40000 HLT processes (always done well before PHYSICS)
  - Stop/Start Run: 6 seconds

Conclusions

- **LHCb has designed and implemented a coherent and homogeneous control system**
- **The Experiment Control System allows to:**
  - Configure, Monitor and Operate the Full Experiment
  - Run any combination of sub-detectors in parallel in standalone
- **Some of its main features:**
  - Partitioning, Sequencing, Error recovery, Automation
  - ➡ Come from the usage of SMI++ (integrated with PVSS)
- **LHCb operations now almost completely automated**
  - Operator task is easier (basically only confirmations)
  - DAQ Efficiency improved to ~98%