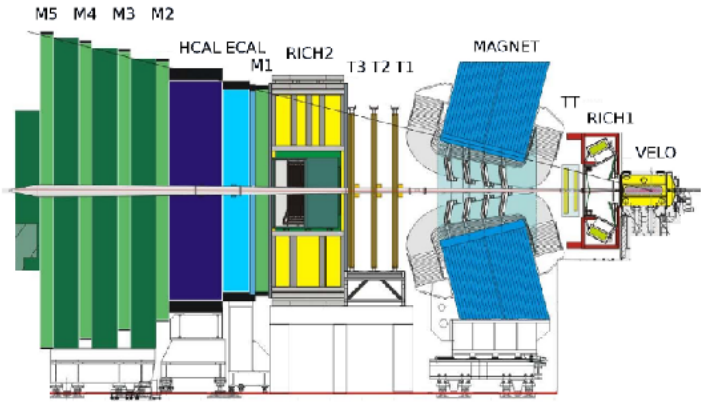


Configuring and Automating an LHC Experiment

For faster and better Physics Output

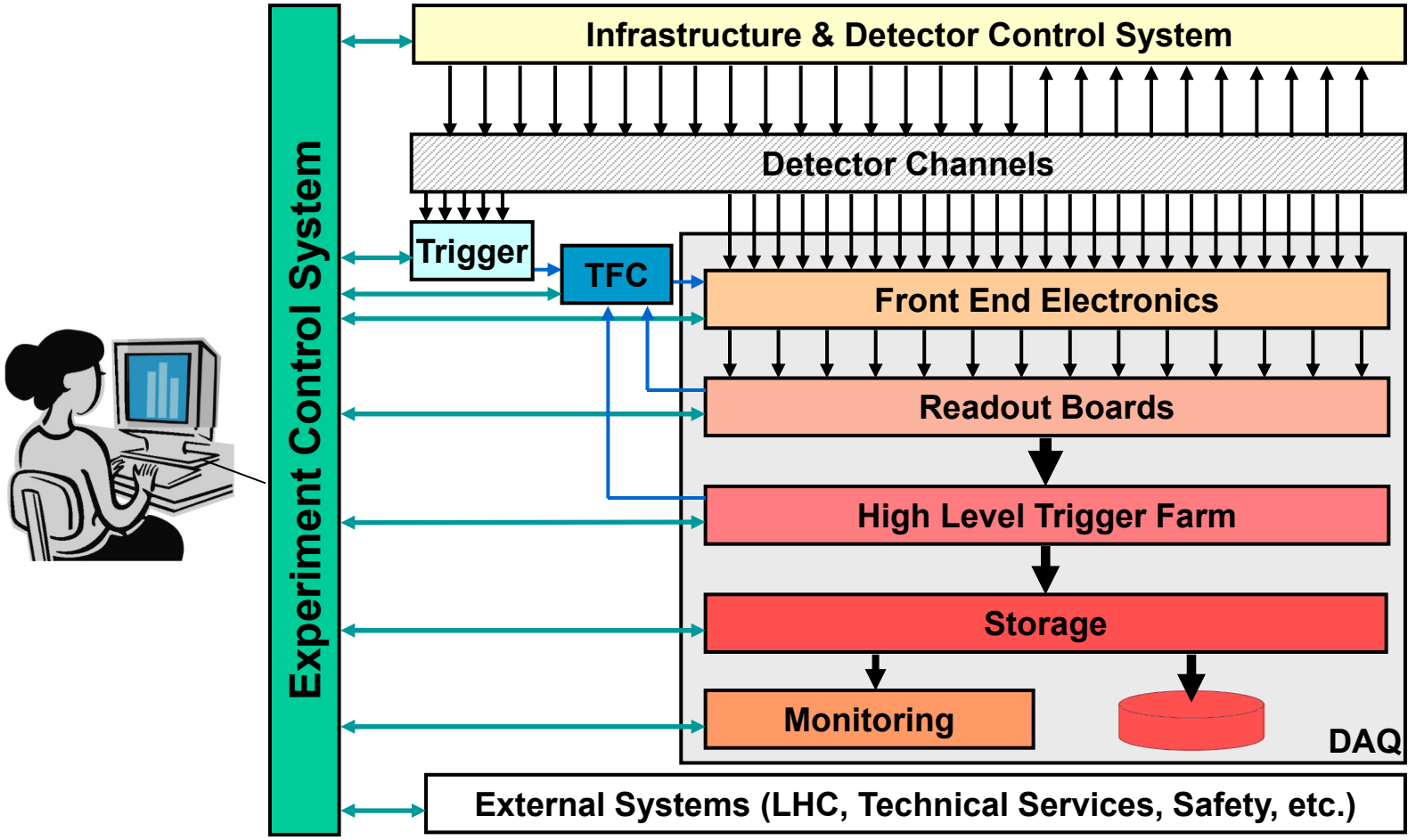
Clara Gaspar, October 2017

Introduction

- **LHCb's New Online Dataflow in Run II**
  - Introduced Prompt Calibration and Alignment
  - Aims:
    - Better Trigger Efficiency
    - Full offline-quality data directly out of the Online System -> straight to Physics Analyses
    - By Making better use of online farm resources
      - Take advantage of LHC's duty cycle and shutdown periods
- **Represented a challenge for the control system**

Experiment Control System

Scope:



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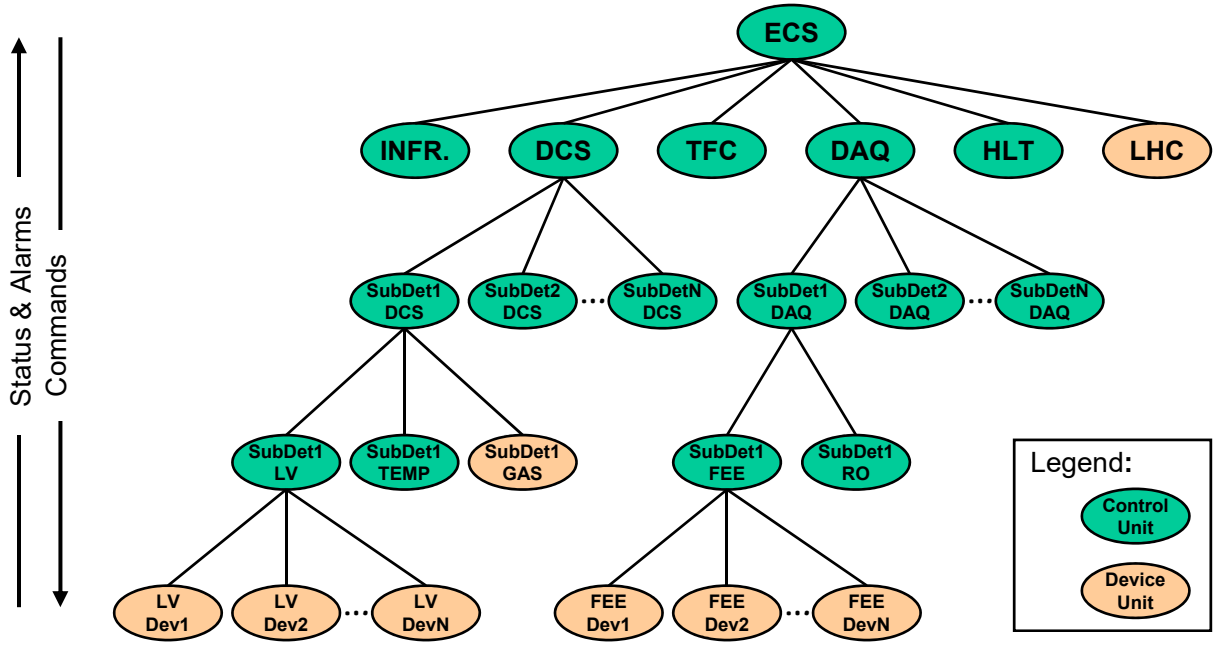
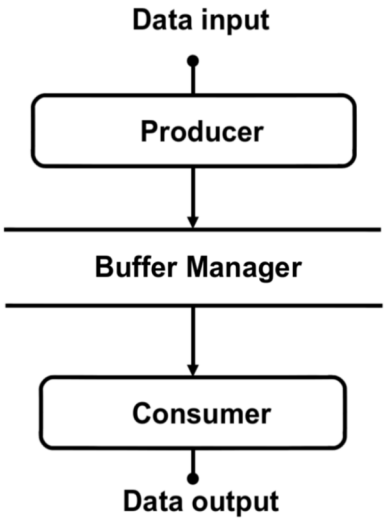


- **Implementation: (JCOP project)**
  - WinCC-OA
  - SMI++
- **Deployment:**
  - Runs distributed over ~160 PCs (Virtual Machines)

- **Control Units are logical entities:**
  - Behave as a Finite State Machine / Rule Based system:
    - Capable of Partitioning: Exclude/Include children
    - Can take local decisions: Sequence & Automate Operations or Recover Errors
- **Device Units**
  - Provide the interface to the device (hardware or software)

The High Level Trigger

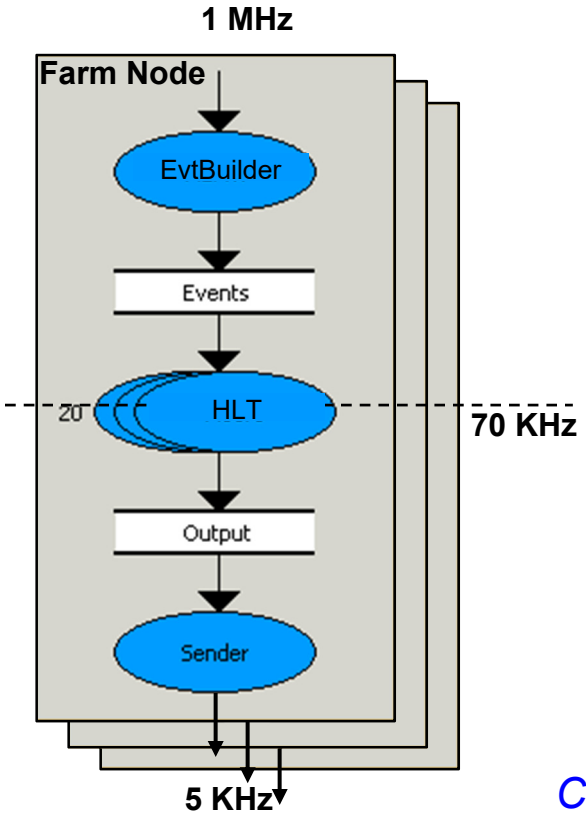
- **Selects interesting events for Physics**
- **Runs distributed on the HLT Farm**
  - **Farm Hardware**
    - ~1600 nodes, ~ 50000 cores, heterogeneous
    - Organized in 62 sub-farms, 24 to 32 nodes each
  - **Farm Software**
    - **Dataflow Pattern**
      - Buffer Manager Concept
    - **Dataflow Tasks**
      - Based on Gaudi Online
      - Integrated in Control System like any other Device via FSM states&actions



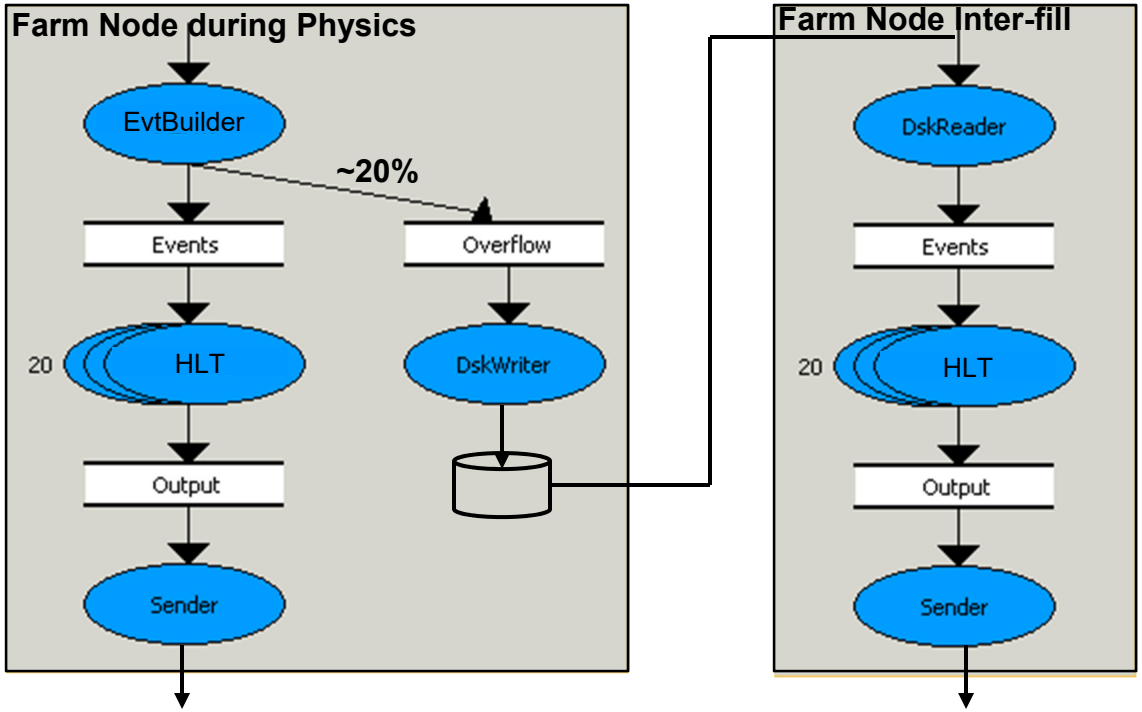
HLT Farm Evolution

- **Resource Optimization in 2012 -> Deferred HLT**
  - Idea: Buffer data to disk when HLT busy / Process in inter-fill gap
  - ➡ Reconfigure the whole farm at start/end of Physics

Standard HLT

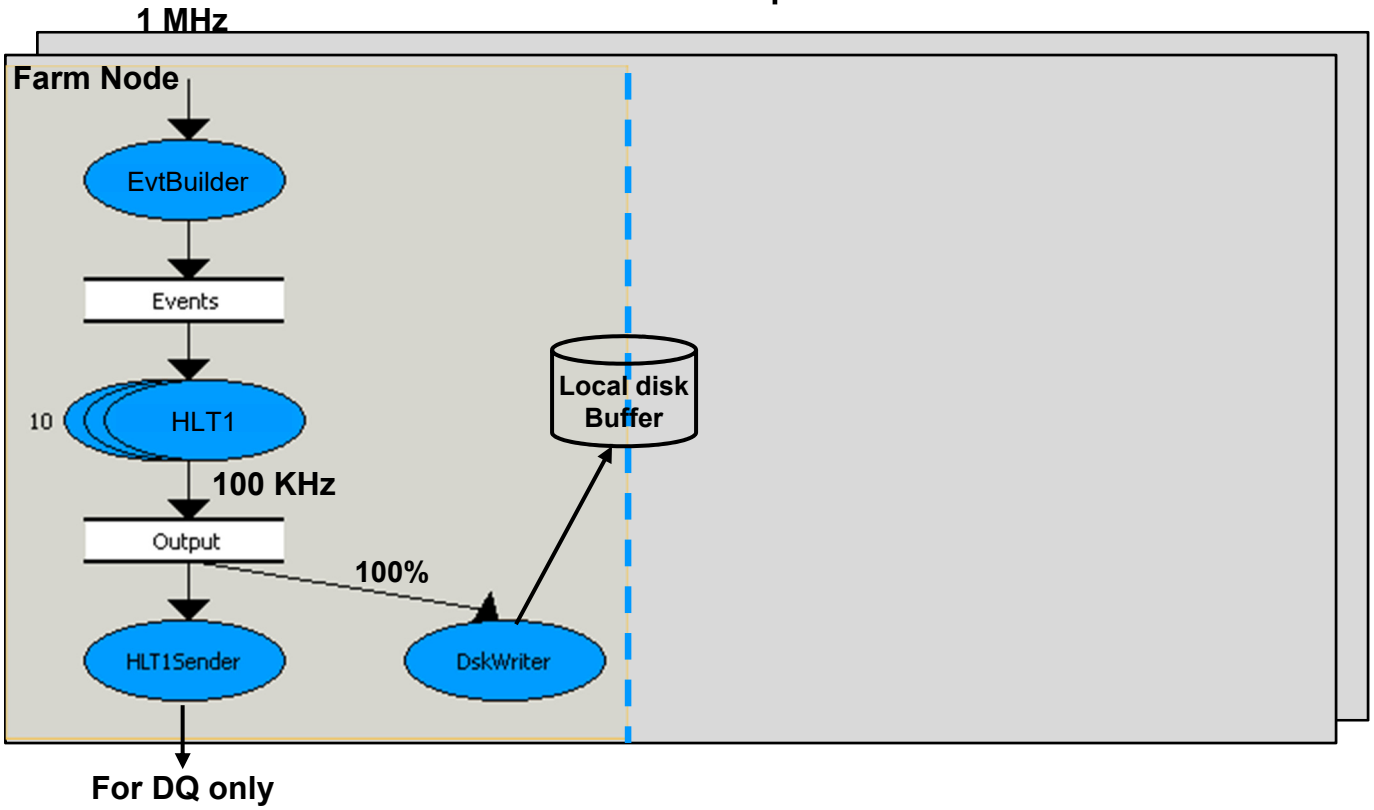


Deferred HLT



HLT Farm Now

- **Even better Resource Optimization in 2015 -> Split HLT**
  - Idea: Buffer ALL data to disk after HLT1 / Perform Calibration & Alignment / Run HLT2 permanently in background
  - ➡ Each node has 3 concurrent/independent dataflow slices



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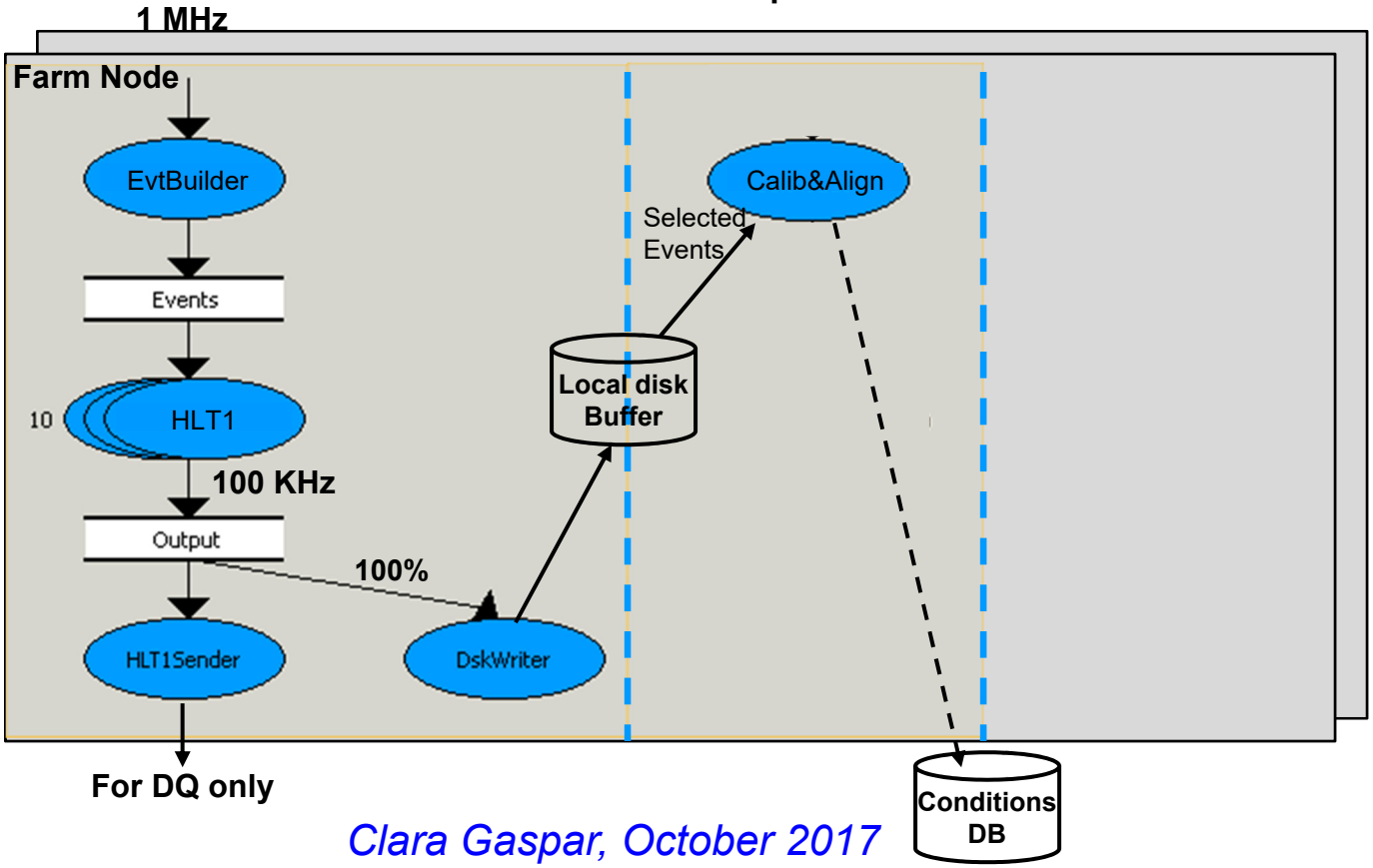

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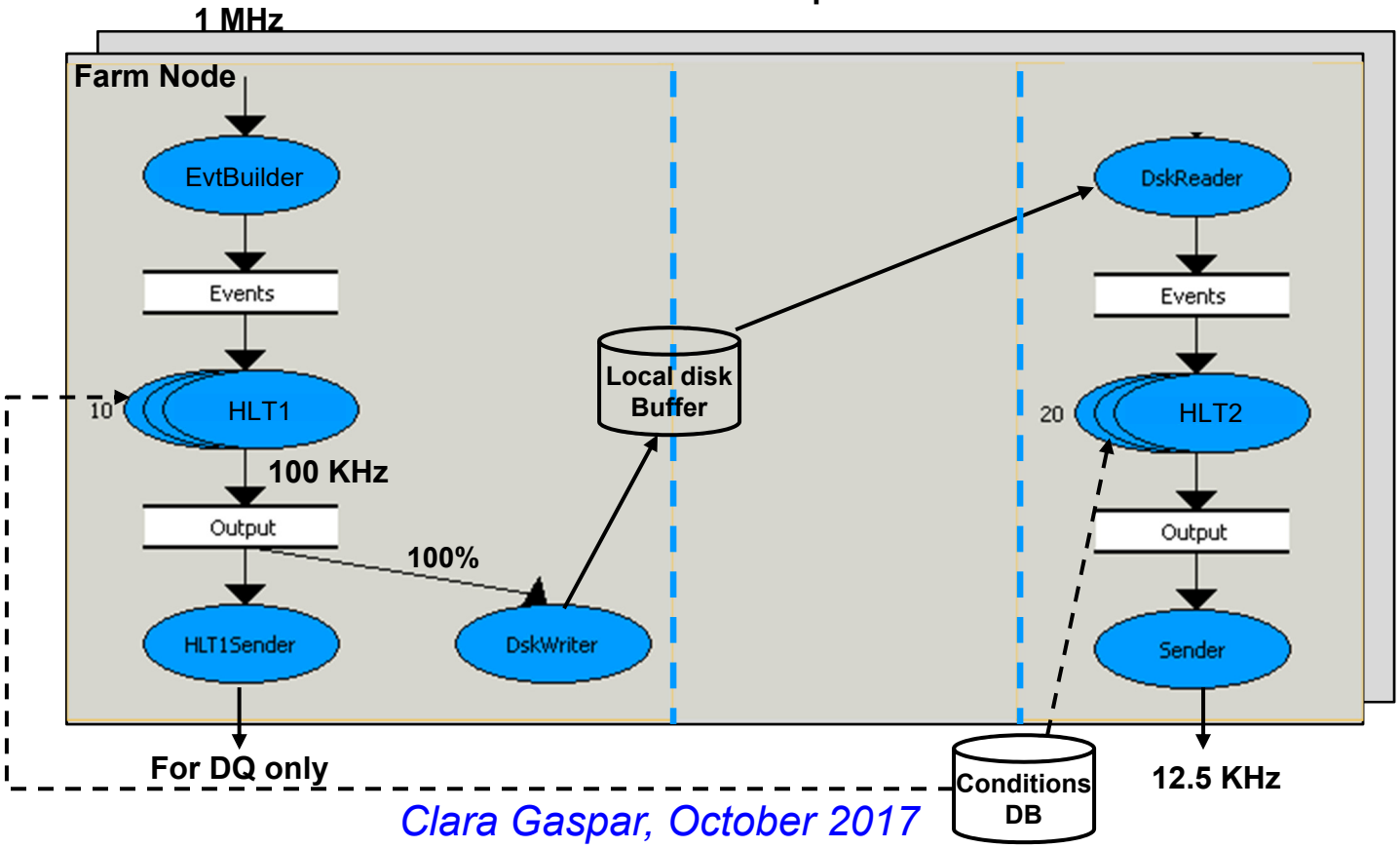

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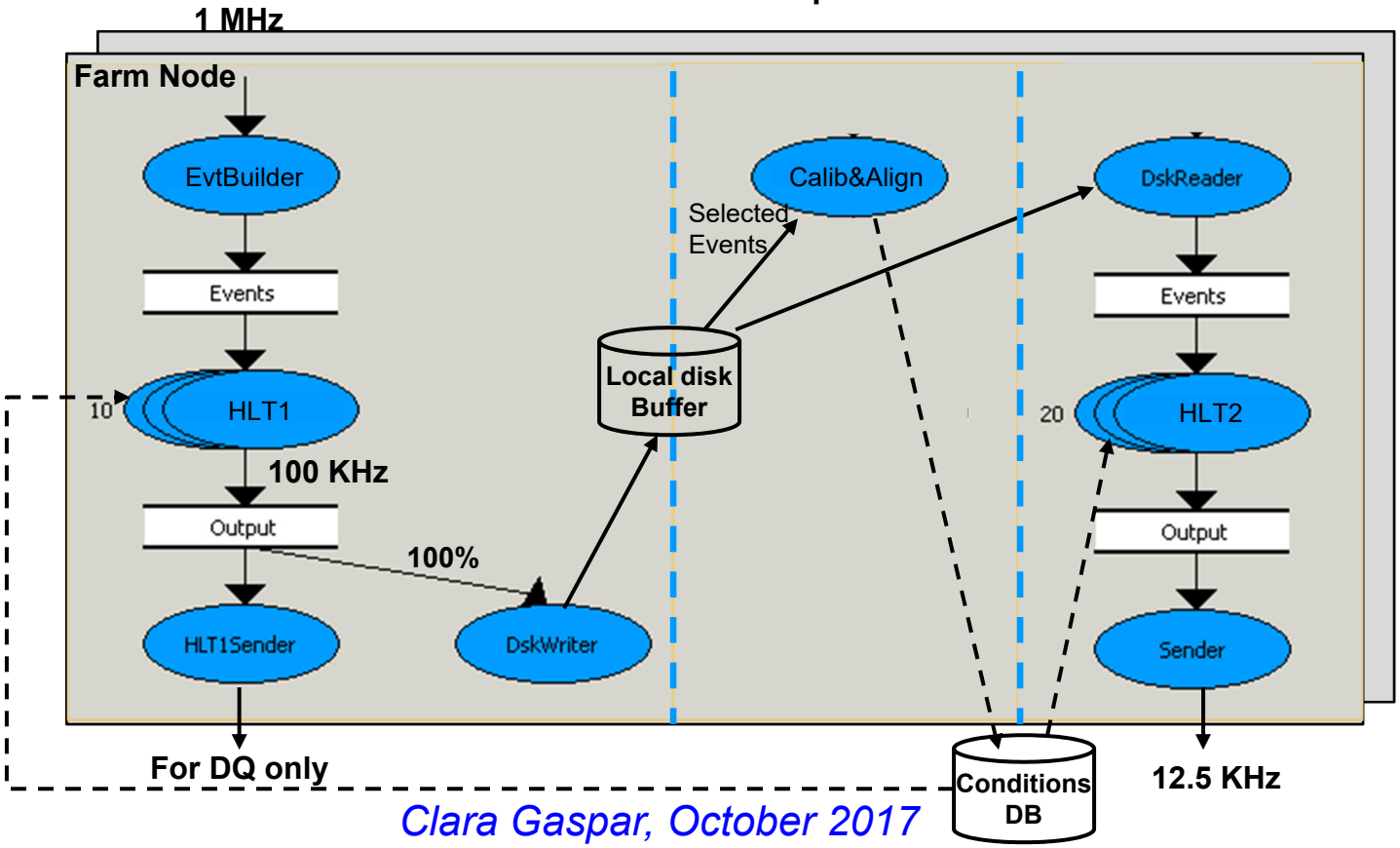
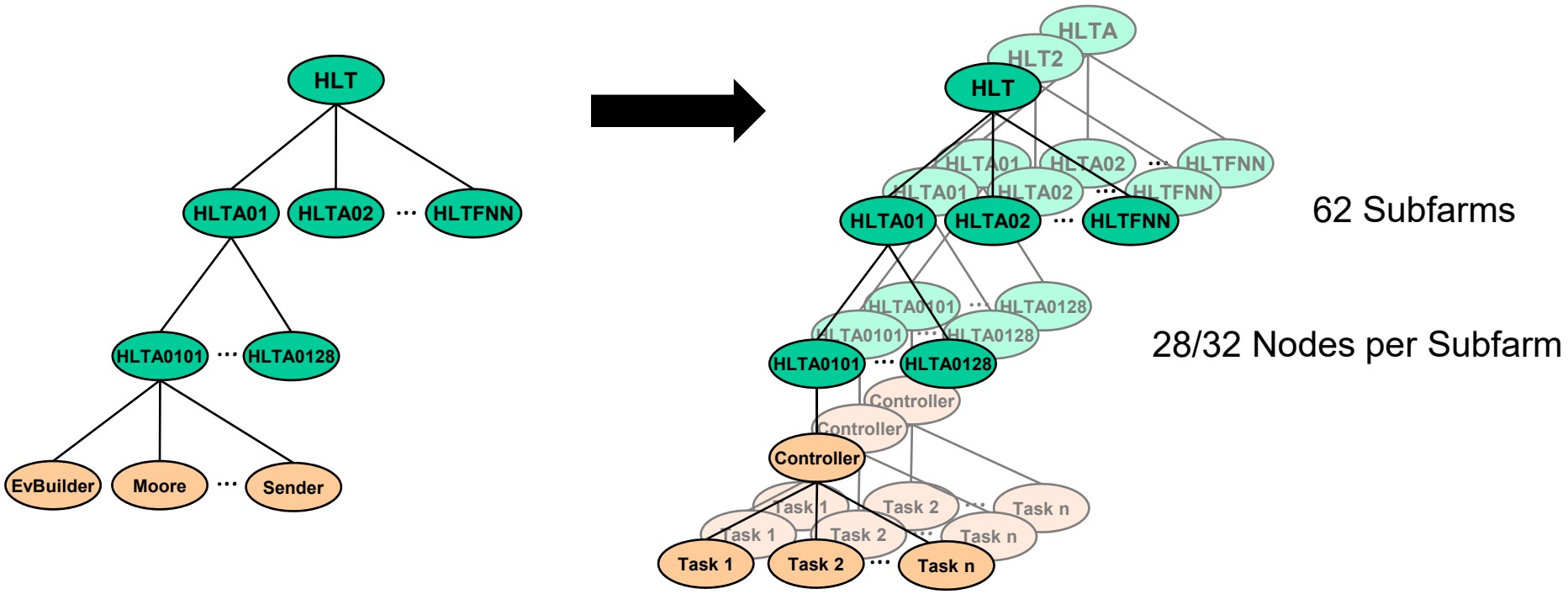


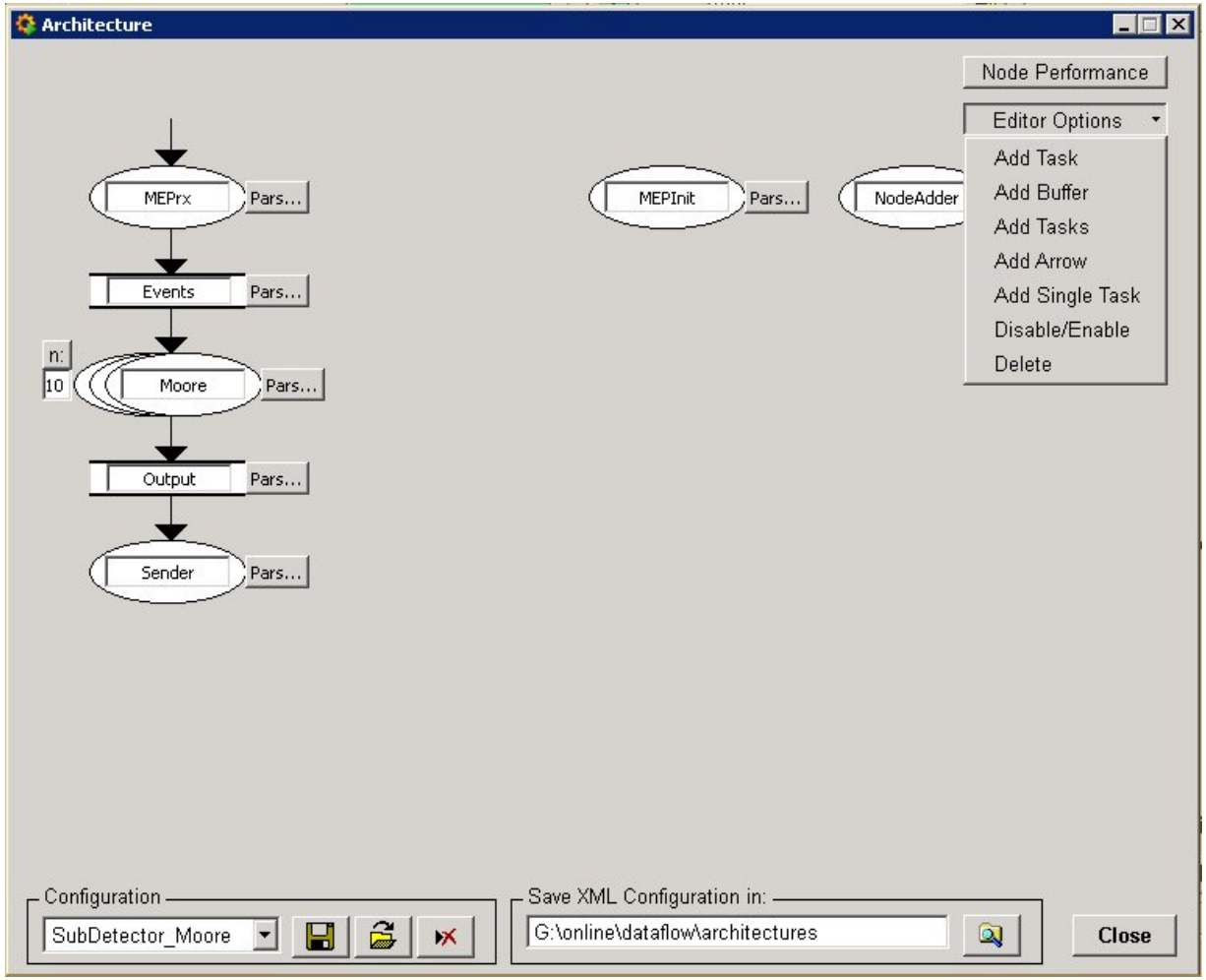
HLT Farm Control



- **Control Tree**
  - From 1 to 3 Independent Trees (actions, states and partitioning)
- **Dataflow Tasks:**
  - In the past were Hardwired in the Control Tree
  - Now Dynamic via a Controller which receives an “Architecture”

“Architecture” Concept

- **Defines the dataflow / task layout on each (farm) node**



- **Graphic Editor:**
  - **Examples:**
    - Old-style HLT
    - HLT1
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    - Calibration, Alignment, etc.
- **Graphic Used at Run Time**

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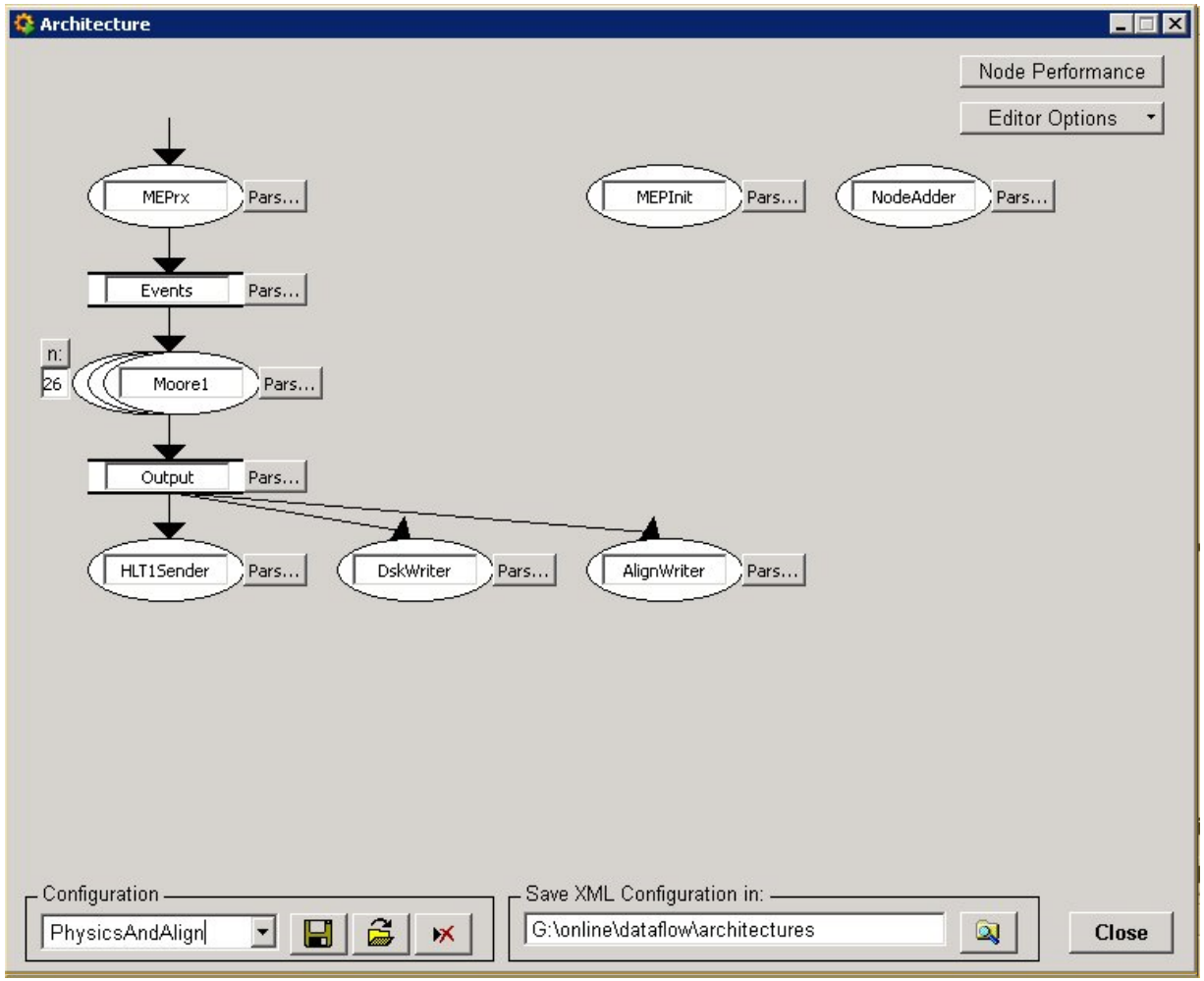

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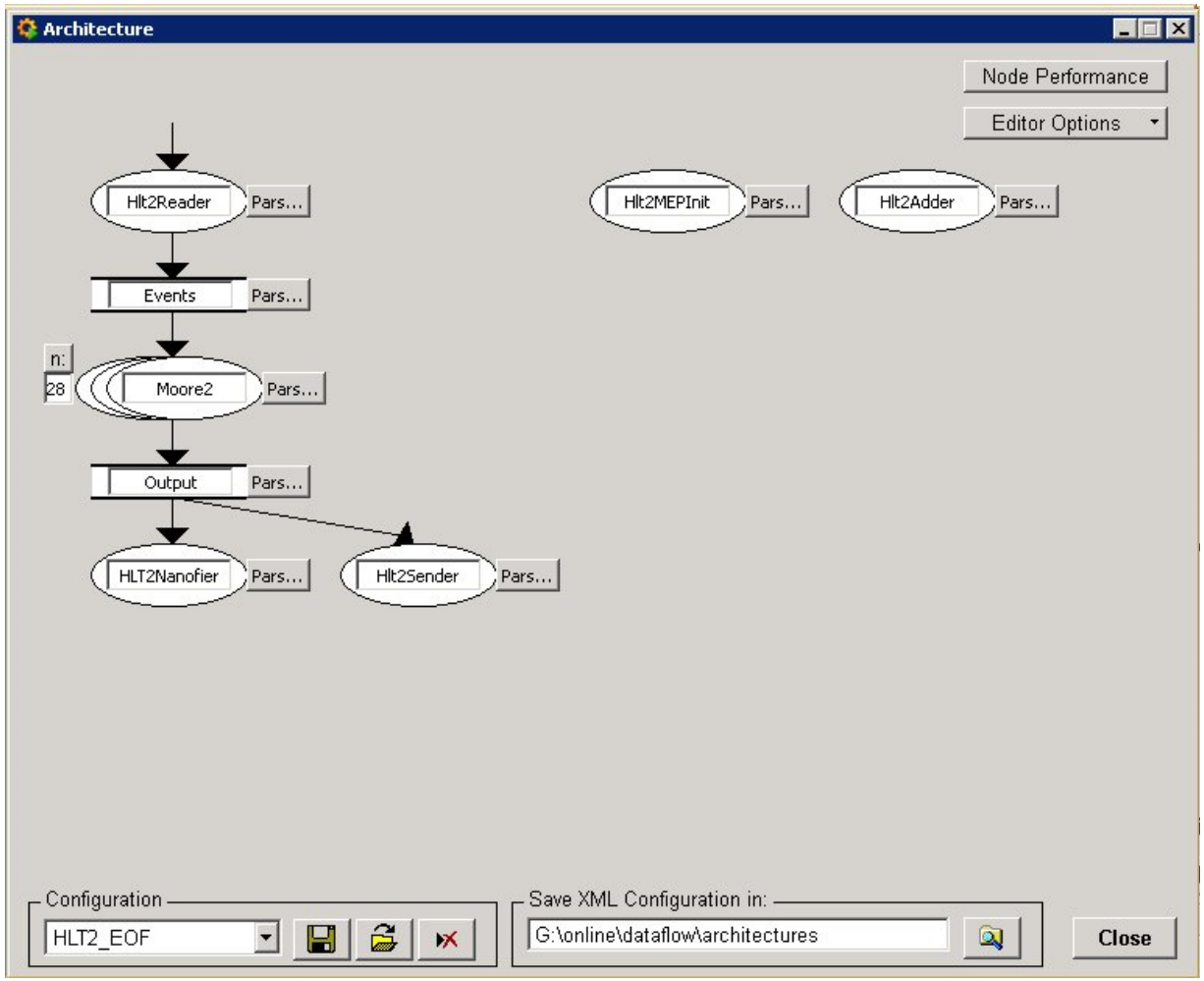

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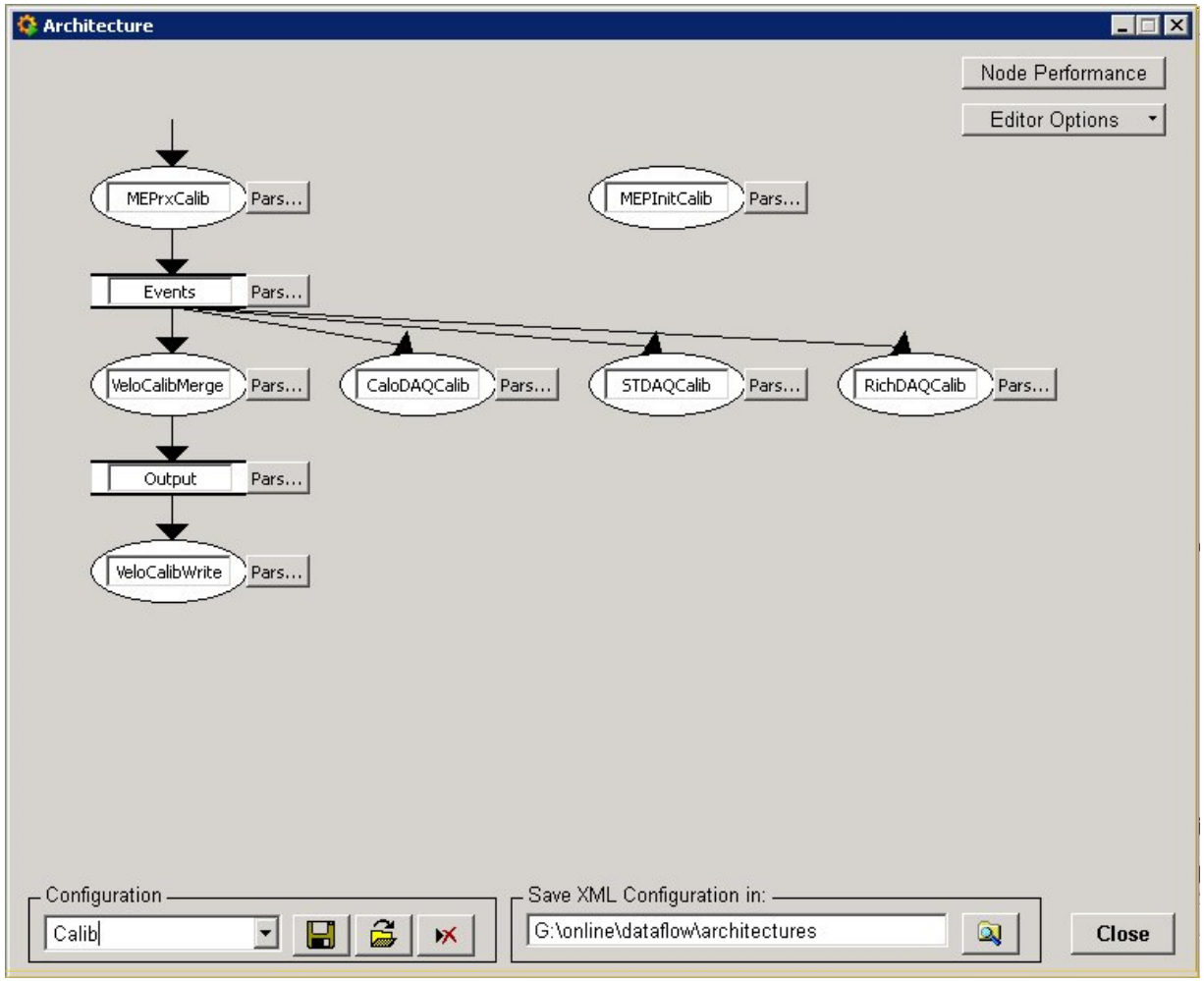

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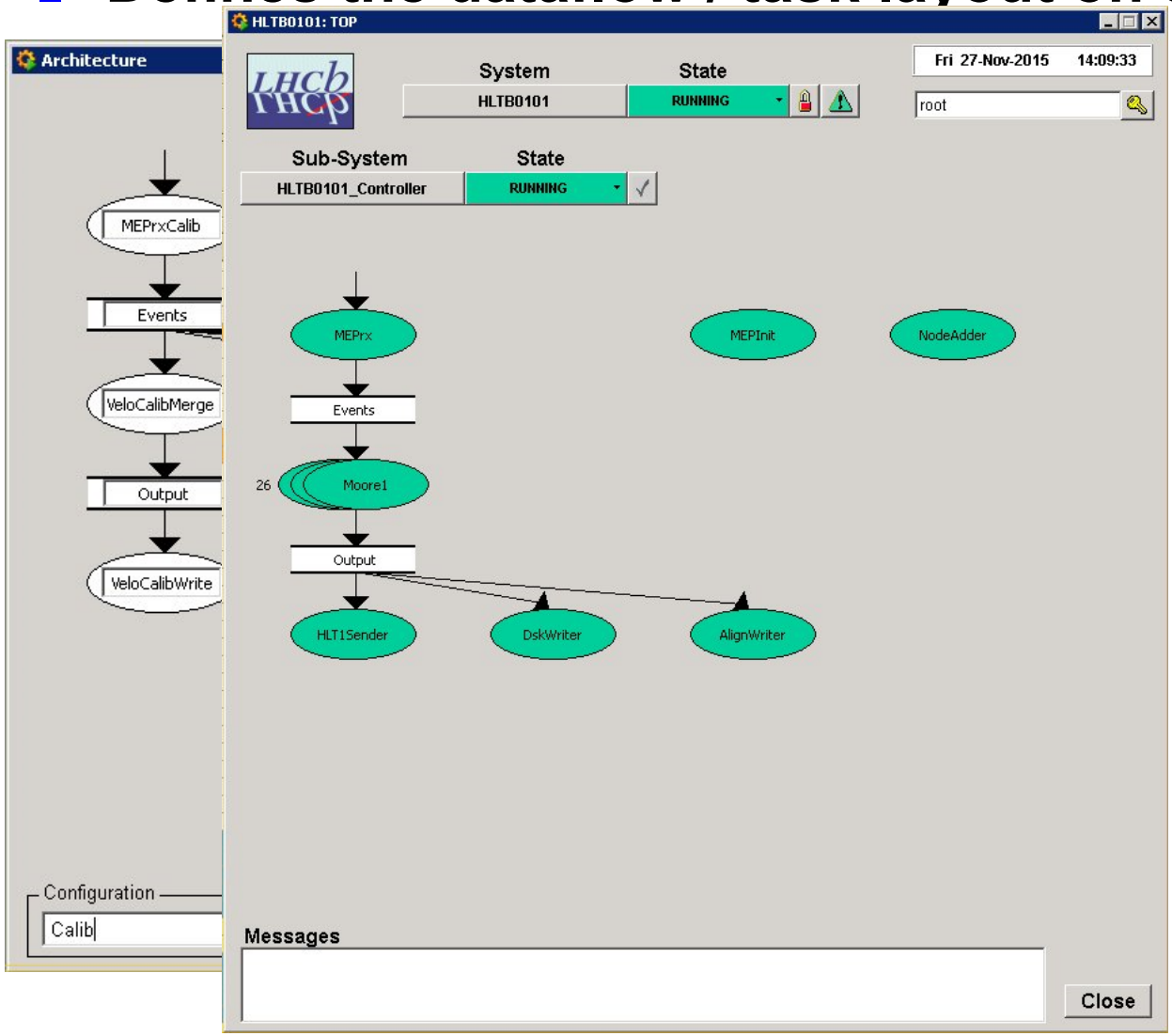

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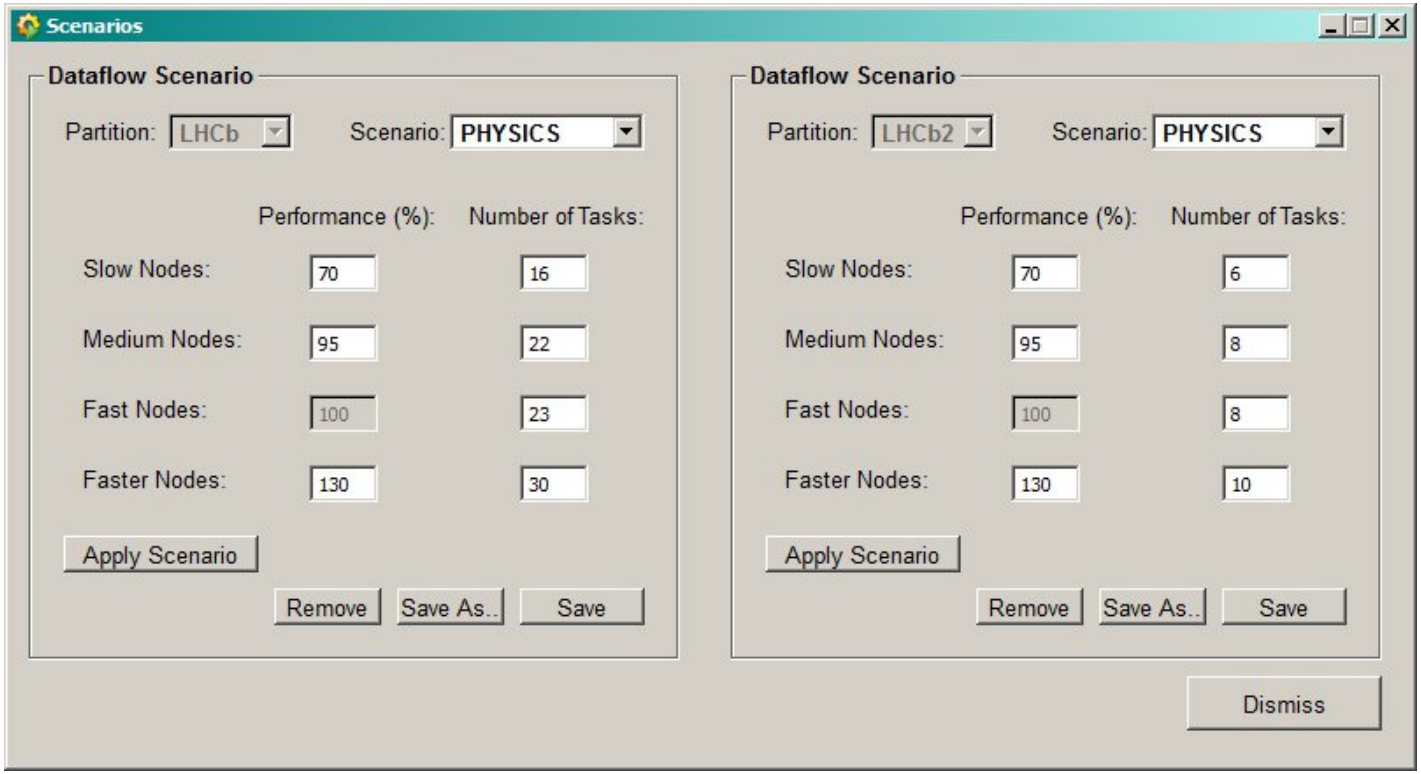
"Scenario" Concept

- **Defines number of HLT1 & HLT2 tasks for load balancing (initially hardwired in the Architecture)**
  - Depending on the LHC/LHCb State and type of node
  - Can be applied at RunTime and takes effect within a second



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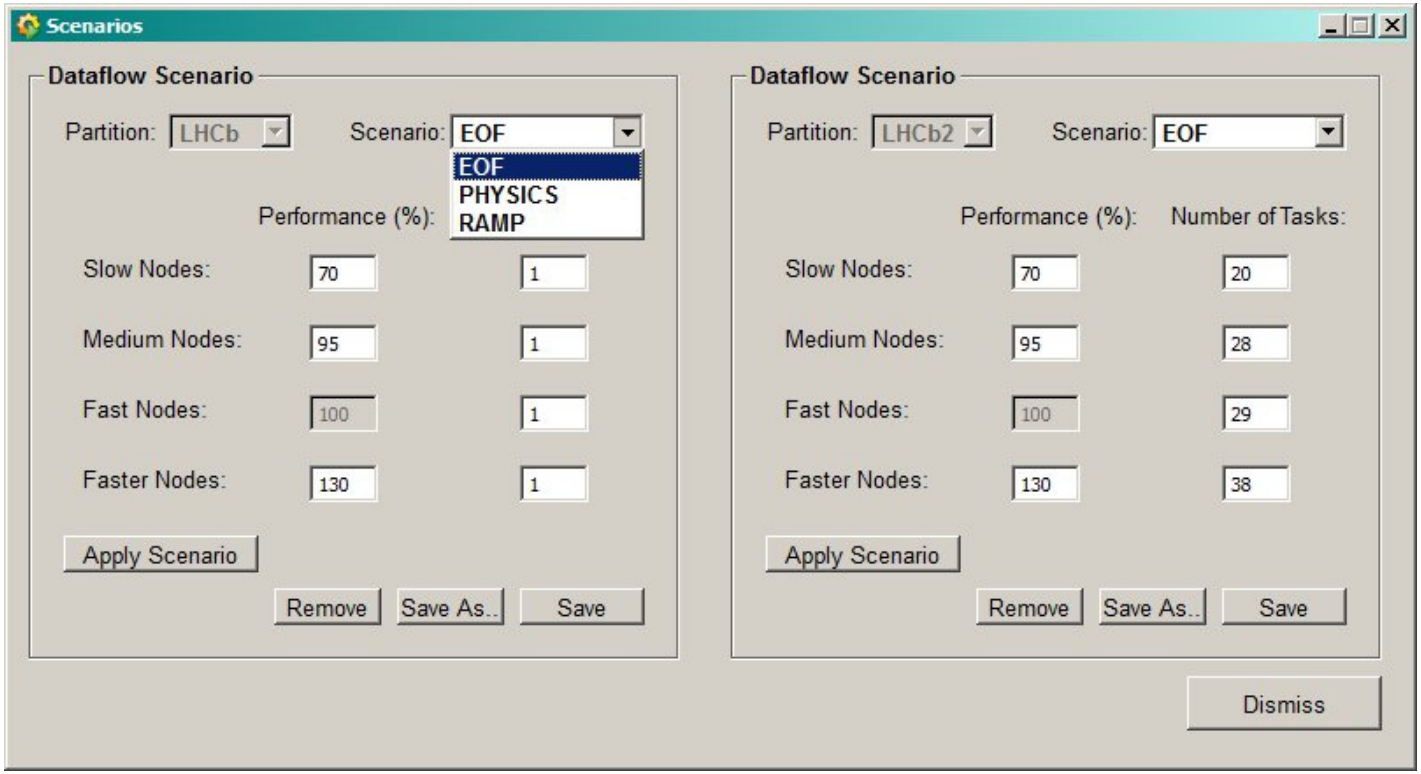
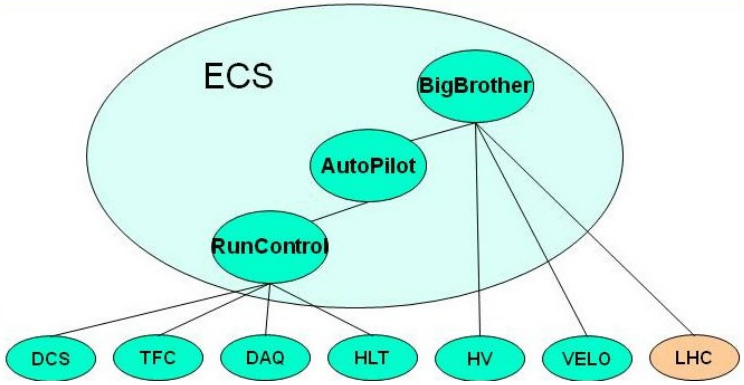
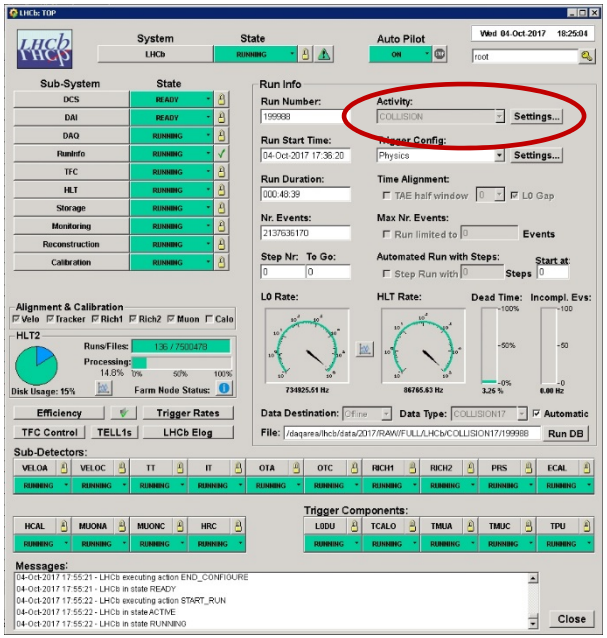


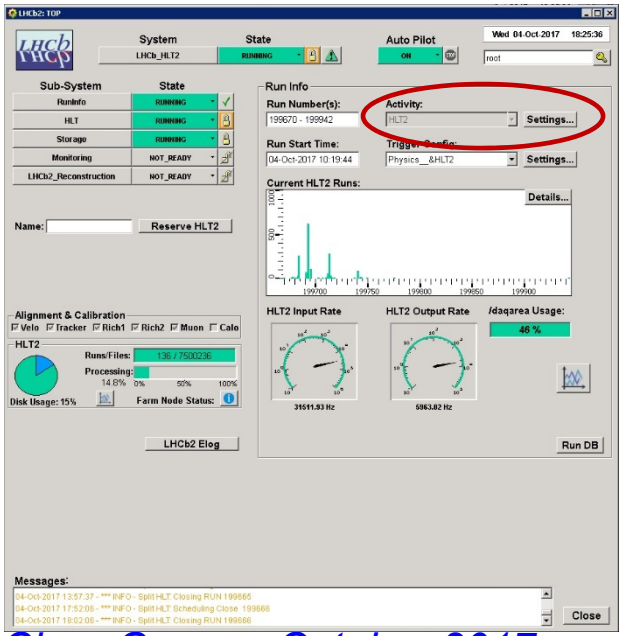
"Activity" Concept

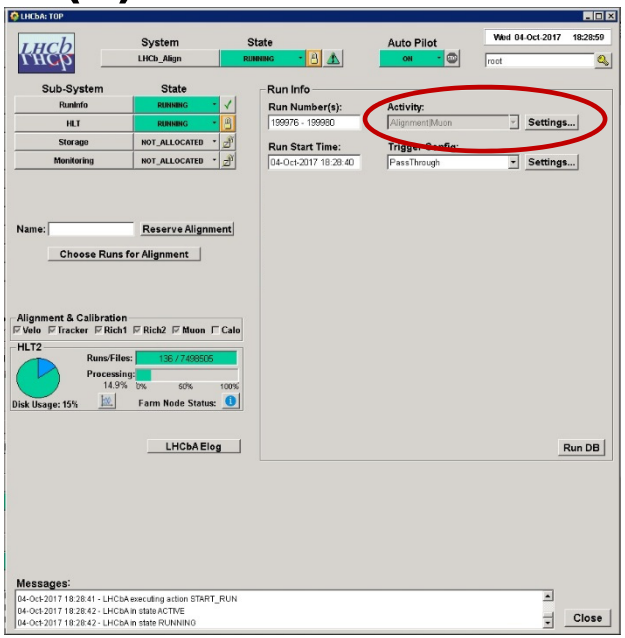


- **Run Control driven by an Activity:**
  - Defines the set of parameters ("recipe") which is applied by each sub-system.
    - Example: "PHYSICS|LEAD"
    - Contains, for example, the "Architecture"

- **Three Farm Slices -> Three Run Control(s):**







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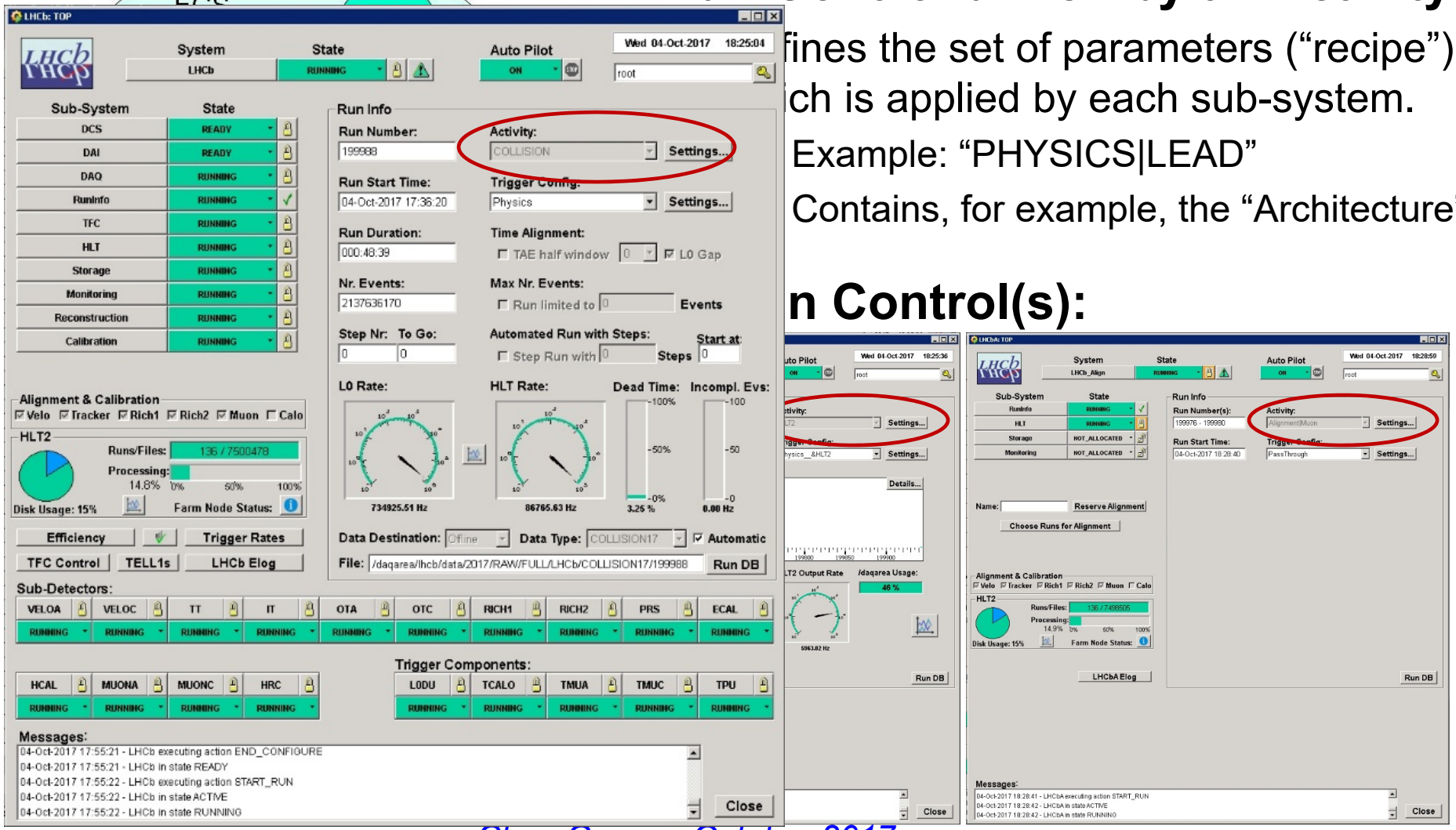

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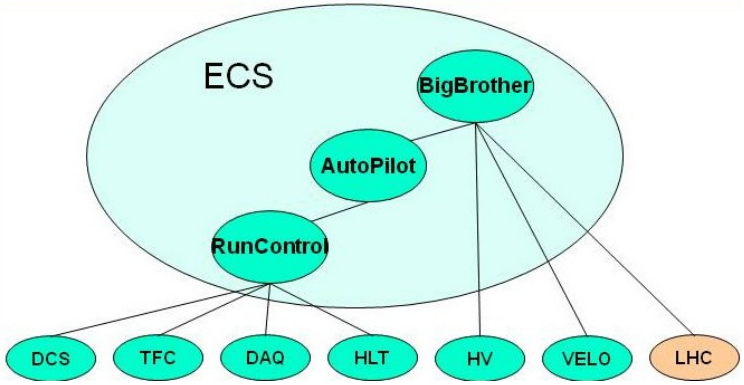

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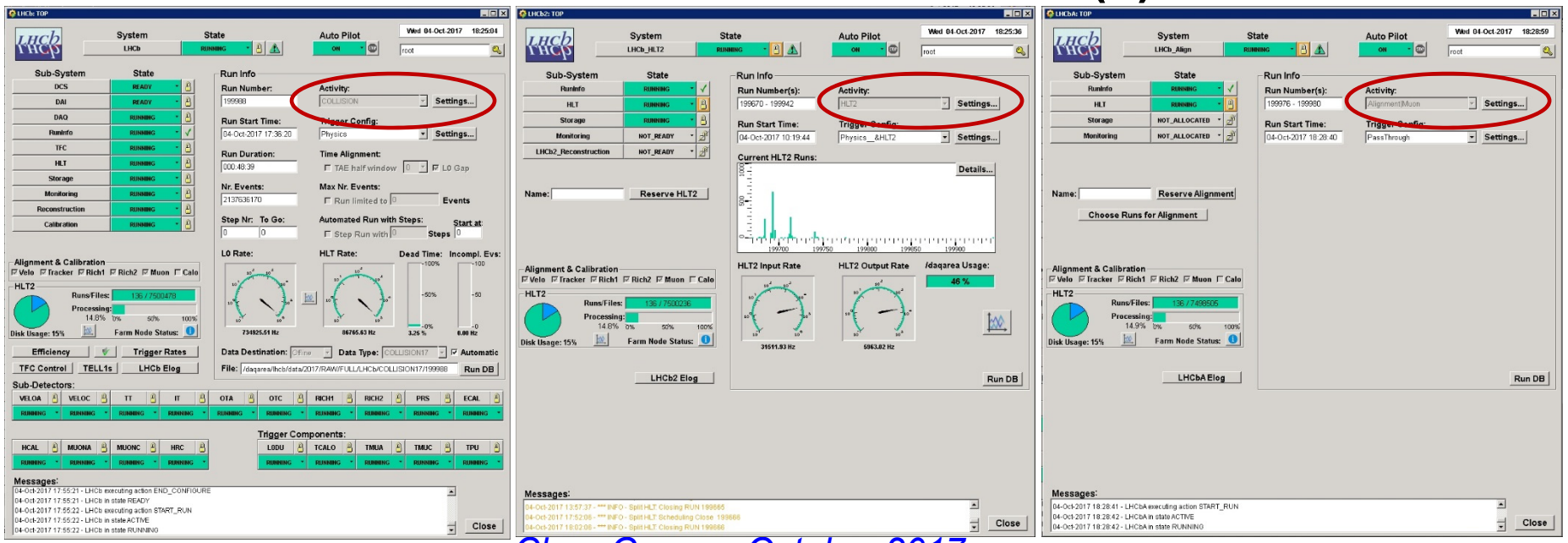
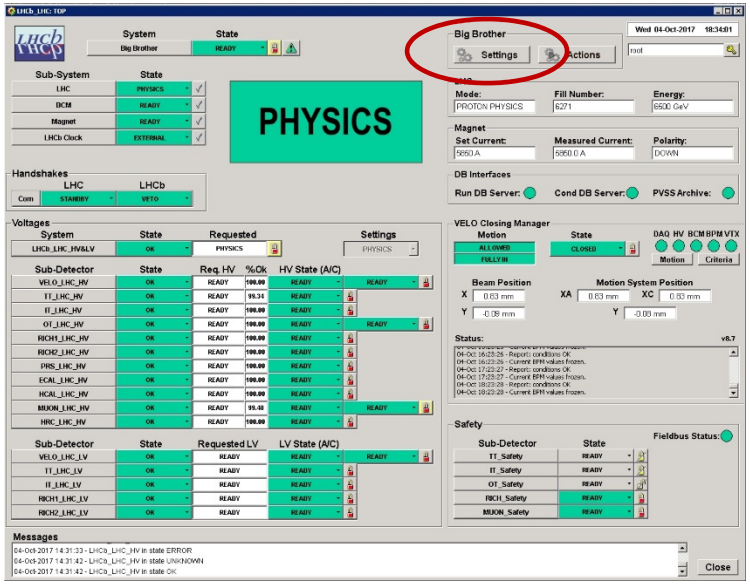
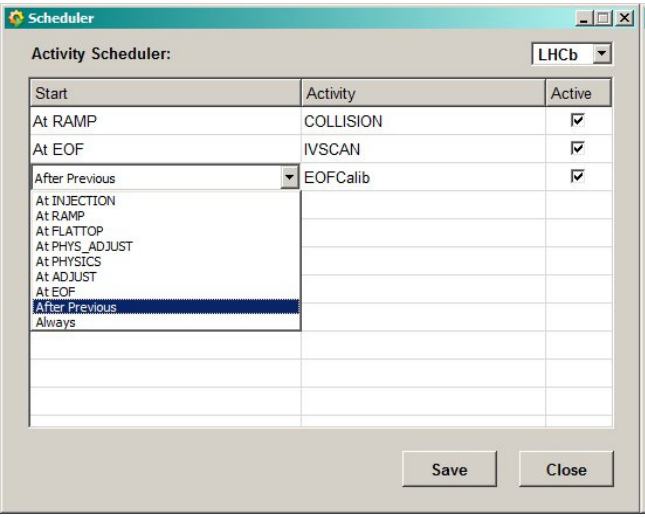
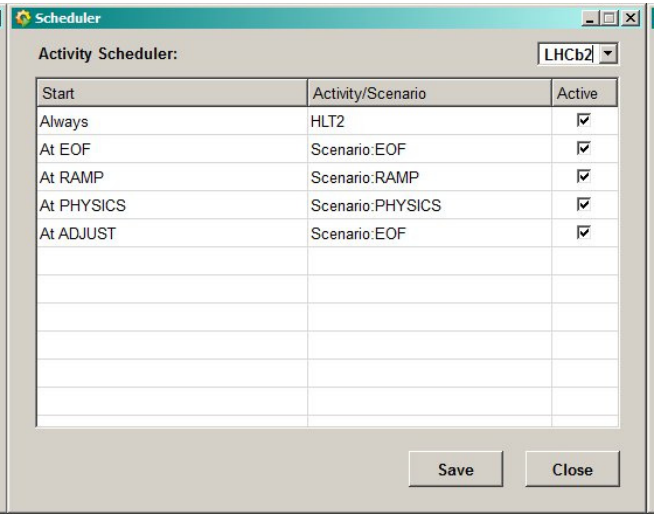


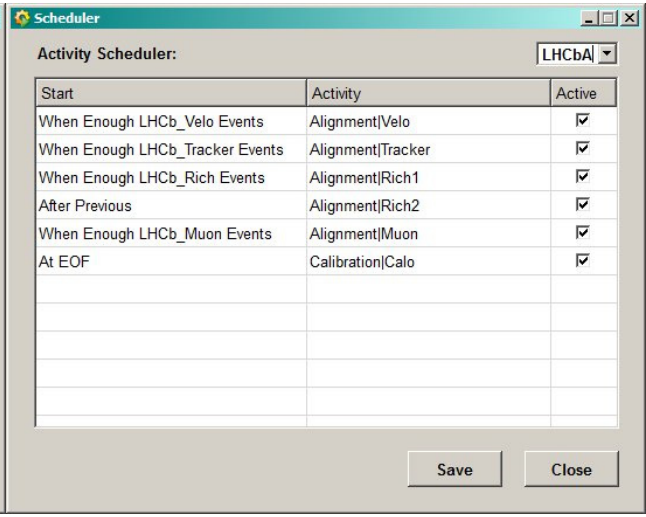
“Scheduler” Concept



- **Big Brother automates operations based on the LHC State, driven by Scheduler(s):**
  - Define sequences of Activities/Scenarios
  - Complete Automation of each Run Control with very few lines
  - 3 lines to automate main Run Control







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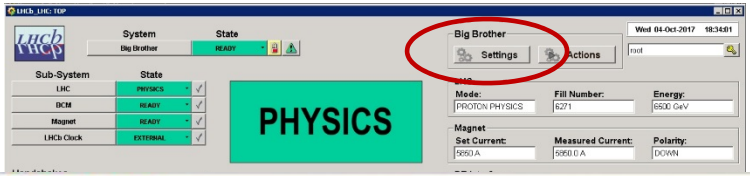

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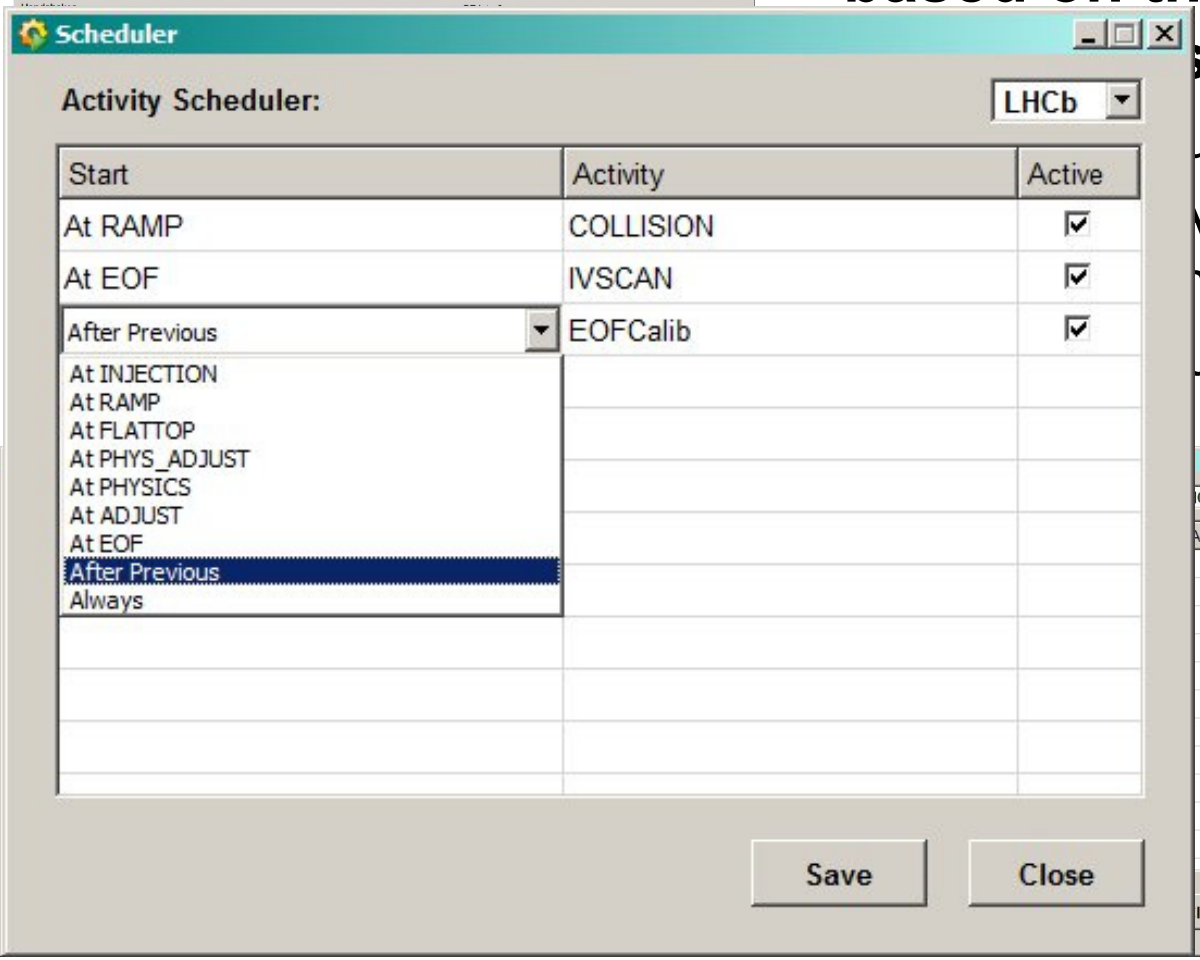

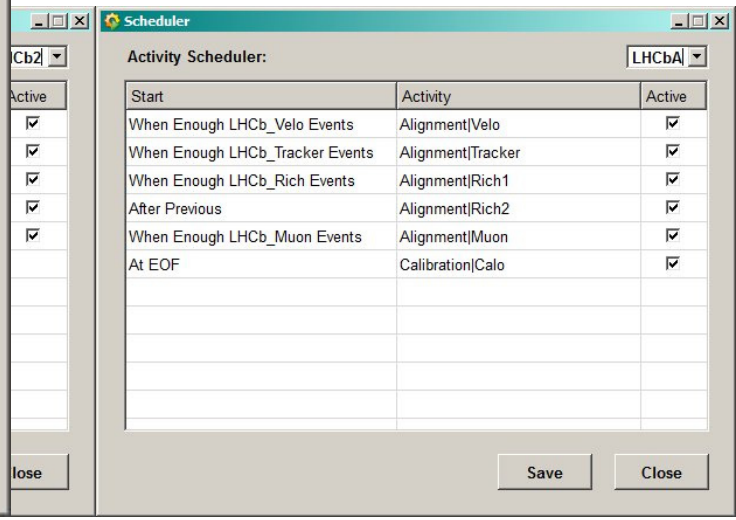

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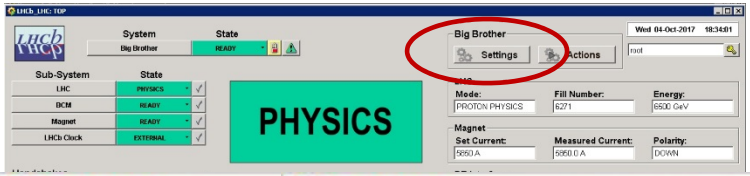

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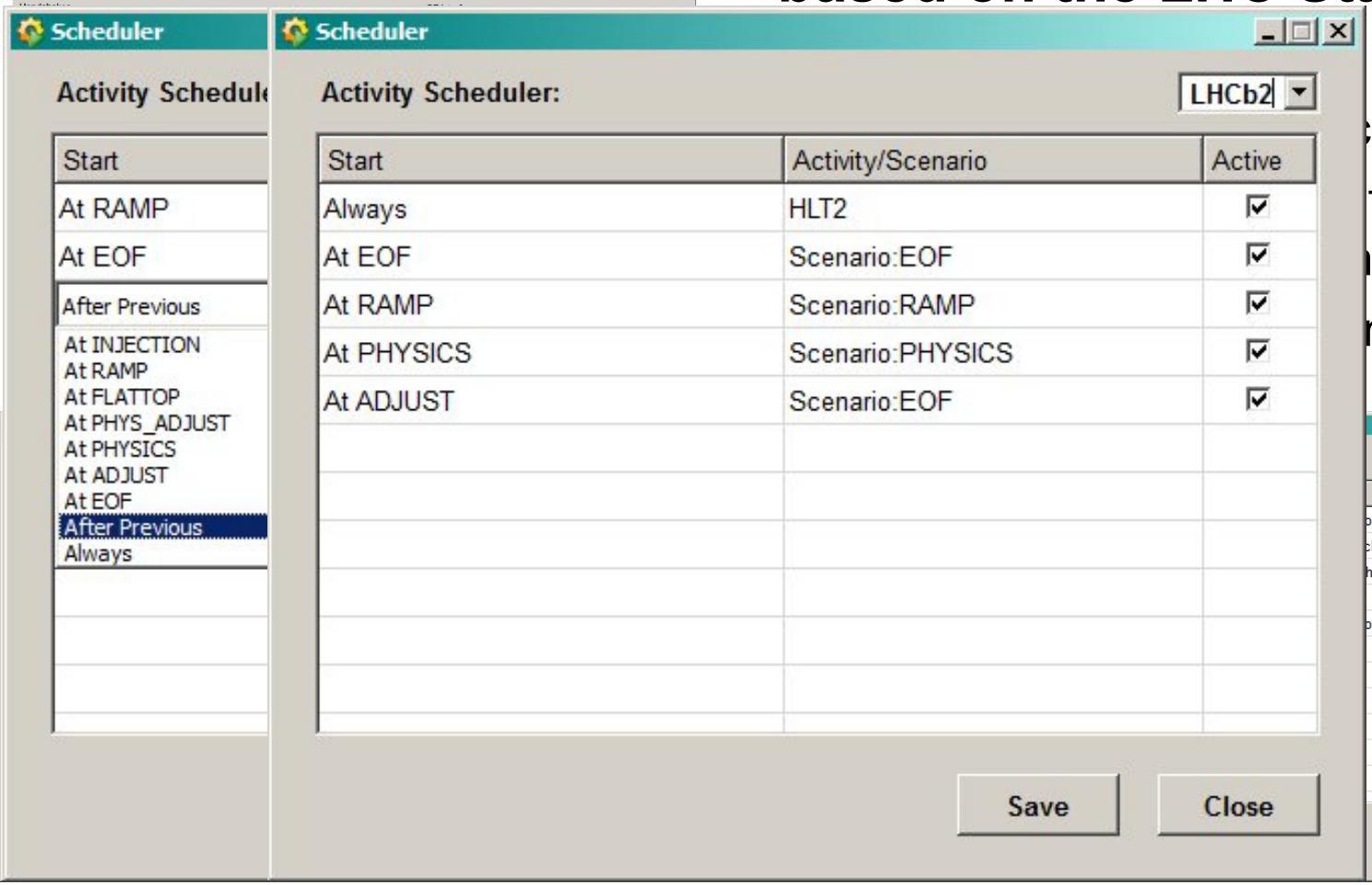

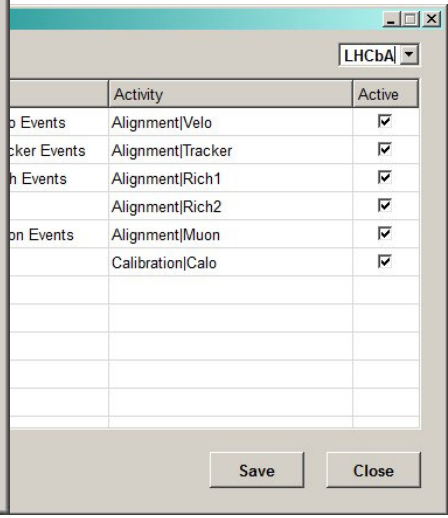

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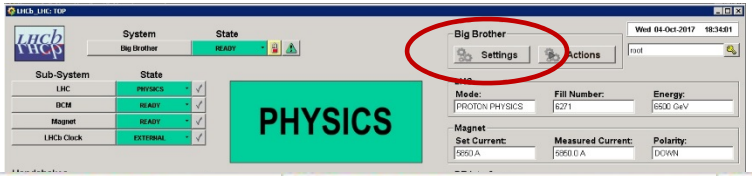


- **Big Brother automates operations based on the LHC State, driven by**

Scheduler

Activity Schedule

Start
At RAMP
At EOF
After Previous

At INJECTION
At RAMP
At FLATTOP
At PHYS_ADJUST
At PHYSICS
At ADJUST
At EOF
After Previous
Always

Scheduler

Activity Scheduler:

Start
Always
At EOF
At RAMP
At PHYSICS
At ADJUST

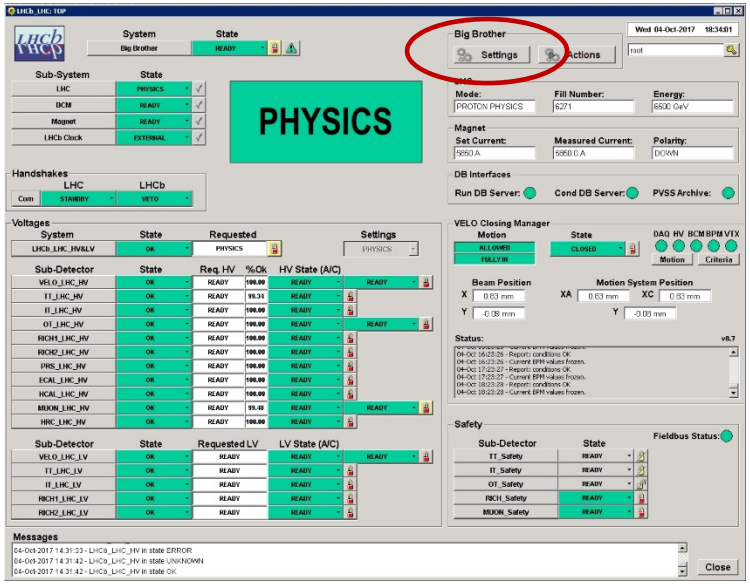
Scheduler

Activity Scheduler: LHCbA

Start	Activity	Active
When Enough LHCb_Velo Events	Alignment|Velo	☑
When Enough LHCb_Tracker Events	Alignment|Tracker	☑
When Enough LHCb_Rich Events	Alignment|Rich1	☑
After Previous	Alignment|Rich2	☑
When Enough LHCb_Muon Events	Alignment|Muon	☑
At EOF	Calibration|Calo	☑

Save Close

“Scheduler” Concept



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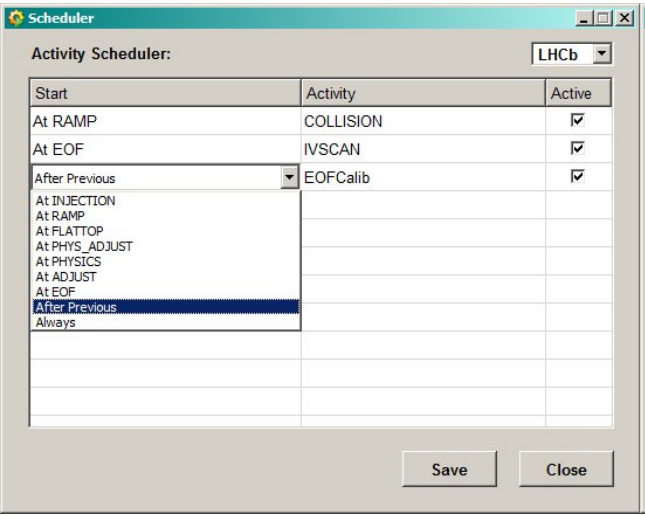

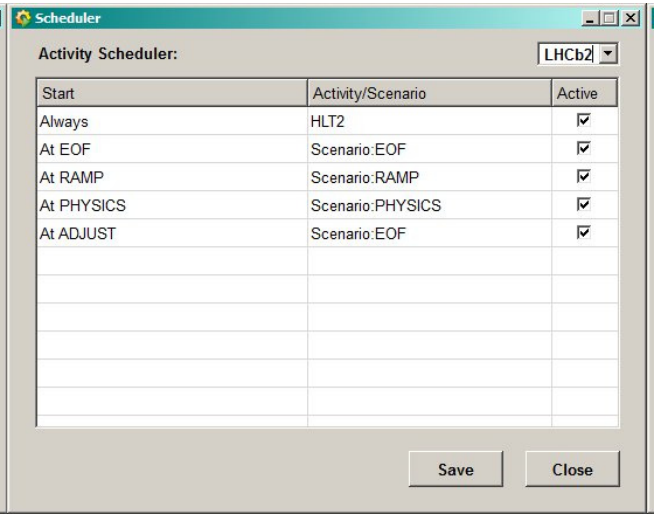

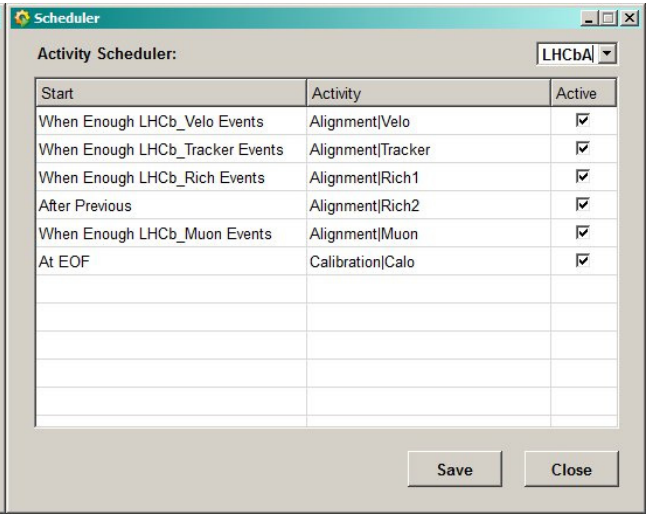

Conclusions

- **LHCb's New Online Dataflow represented an Operational challenge, but due to:**
  - The modular architecture and flexibility of the original design
  - Some new concepts (architectures, scenarios, schedulers)
- **It is now:**
  - Seamlessly Integrated
  - Completely automated
- **And the farm is kept as busy as possible**
  - Also offline simulation (concurrently) when still free resources.