ATLAS Tile Calorimeter Cesium calibration system

Control and analysis software

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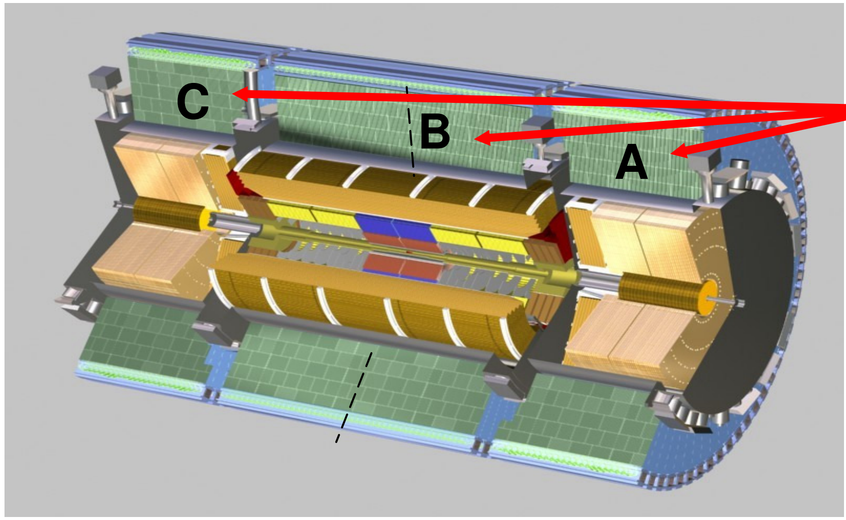
on behalf of Tile Collaboration
by Oleg Solovyanov, IHEP Protvino, Russia

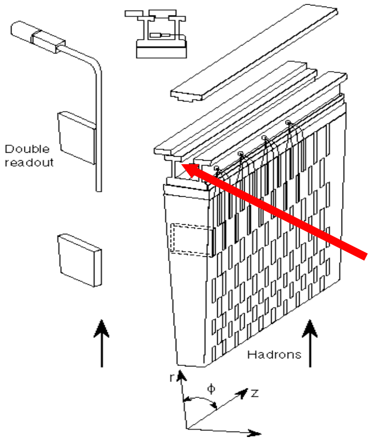
Outline

- ATLAS Tile Calorimeter
- Cesium calibration system
- Software architecture
- Operation, results and performance
- Conclusions

Tile Calorimeter

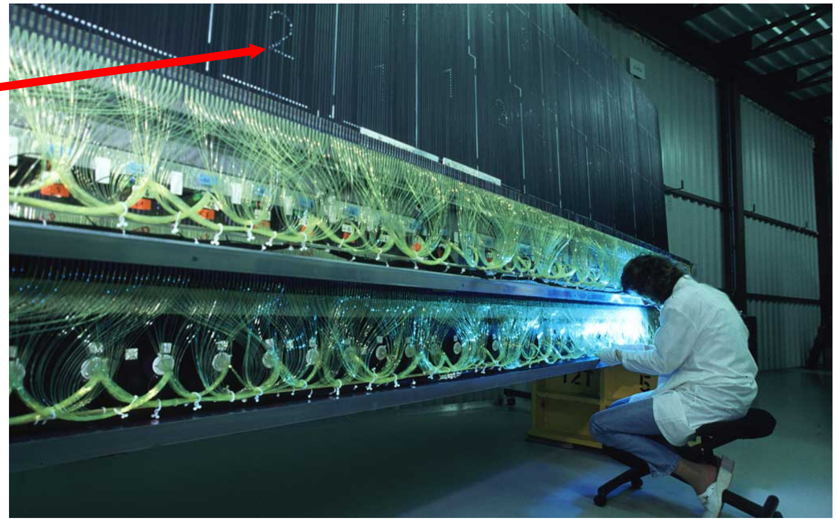


View of ATLAS[1] calorimeter system. The TileCal[2] sampling calorimeter constructed of steel plates (absorber) and scintillating plastic tiles (active material). It is designed as one barrel and two extended barrel parts. All the three sections have a cylindrical structure divided in ϕ by 64 wedges.



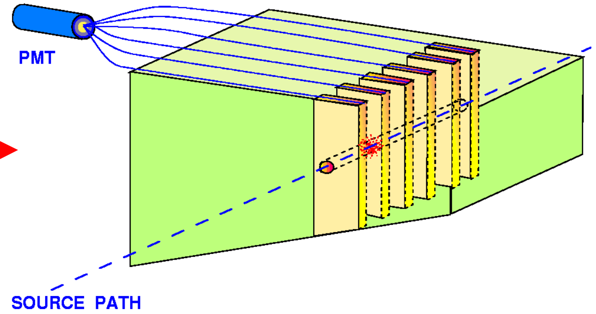
Within modules there are a number of cells corresponding to the projective geometry

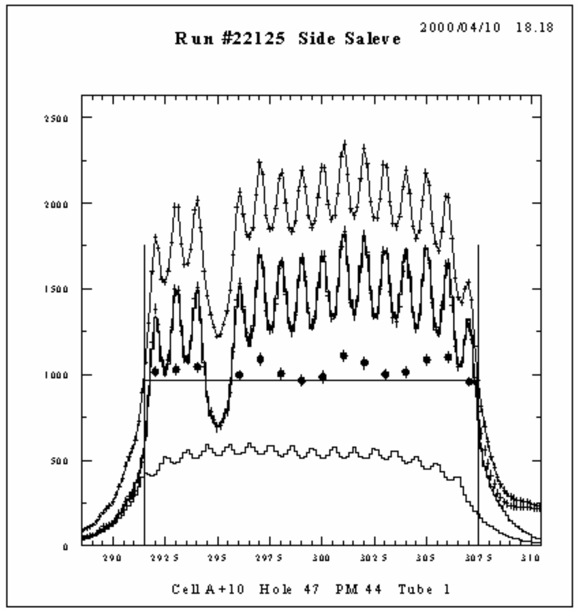
Front-end electronics [3] located inside module's girder



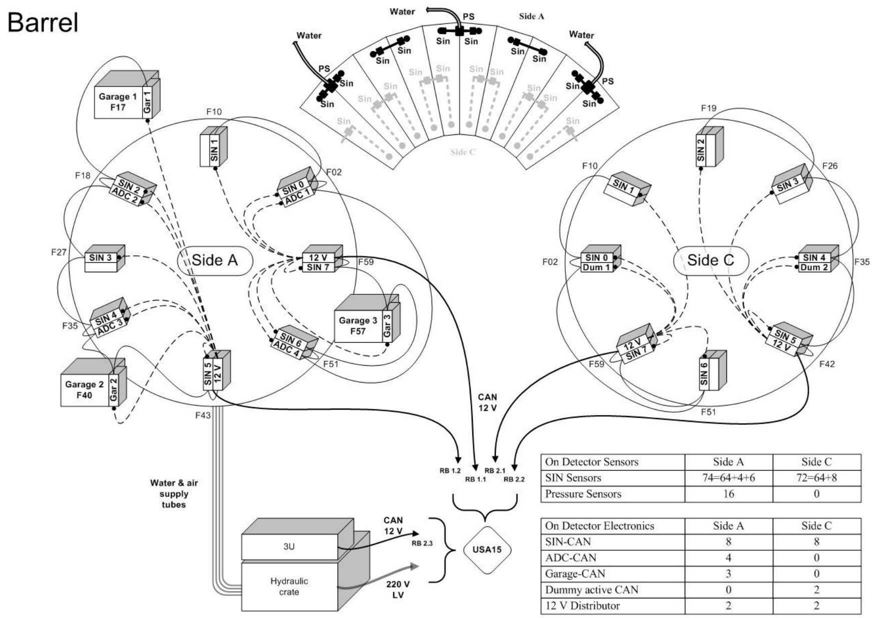
Cesium calibration system

- To calibrate and monitor the TileCal, a powerful (~10mCi) ^{137}Cs γ-source is used
- While the source moves in the detector inside calibration tubes by a flow of liquid, integrated PMT currents from front-end electronics are read out
- The use of a movable source allows to test the optical quality of the scintillators and fibers, to equalize the response of all the cells (<1%), to monitor each cell over the time and to provide the overall energy calibration [4]
- In order to transport the radioactive source in a safe and controllable way along the 10km of tubes inside the calorimeter, an elaborate source drive and monitoring system are needed [5],[6]
- An intelligent on-line software is required to perform the task of source movement and detector response analysis





Electronics layout

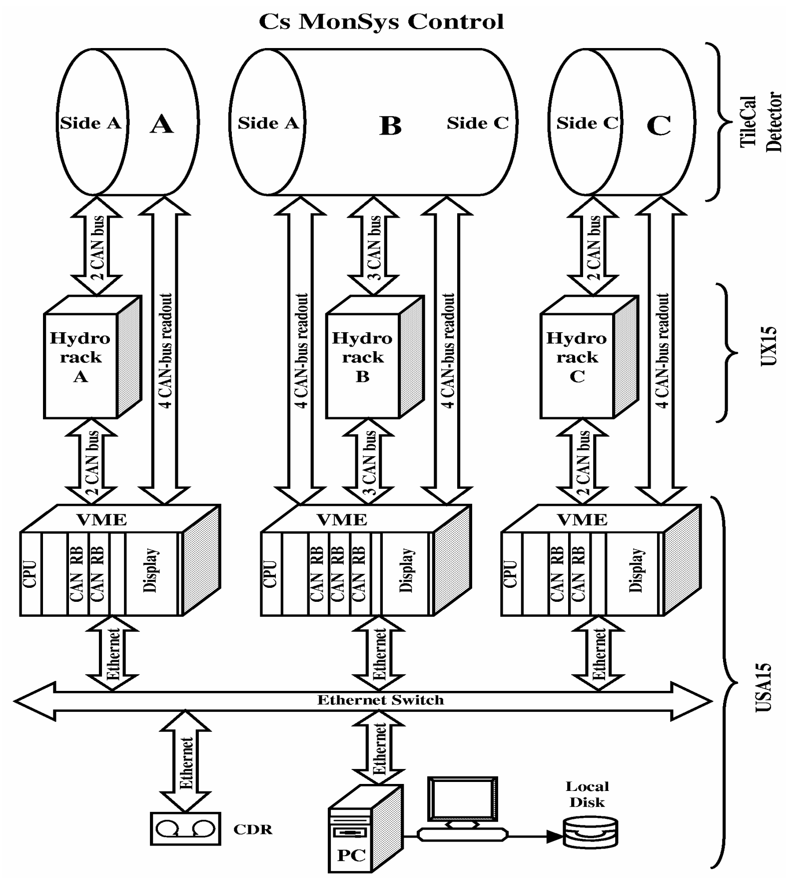


On Detector Sensors	Side A	Side C
SIN Sensors	74=64+4+6	72=64+8
Pressure Sensors	16	0

On Detector Electronics	Side A	Side C
SIN-CAN	8	8
ADC-CAN	4	0
Garage-CAN	3	0
Dummy active CAN	0	2
12 V Distributor	2	2

- Schematic view of sensors and control boards layout around the calorimeter

- Control and readout scheme



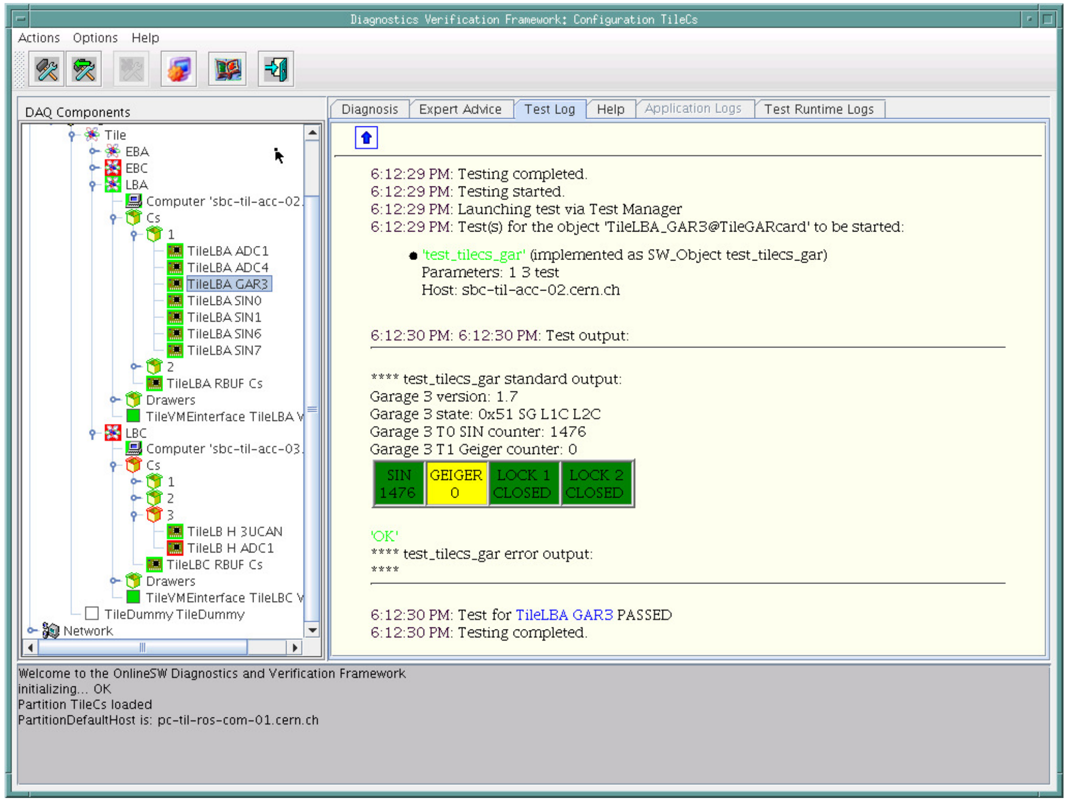
Software requirements

- Control and operate the hydraulics, electronics and run the ^{137}Cs source through the whole Tile calorimeter sensitive volume
- Read out the integrated current of the PMTs, while the source capsule moves with the designed speed, perform readout switching when capsule passes from one module to another*
- Be capable to correct/adjust the run conditions according to current system status and on-line analysis information
- Visualize results of online analysis and the position of the capsule, and the physical conditions of the run
- Store raw and reconstructed data
- Communicate with detector control system and calibration databases
- Monitor status of the hardware components, perform their tests and calibration

*readout is possible only from one module at a time

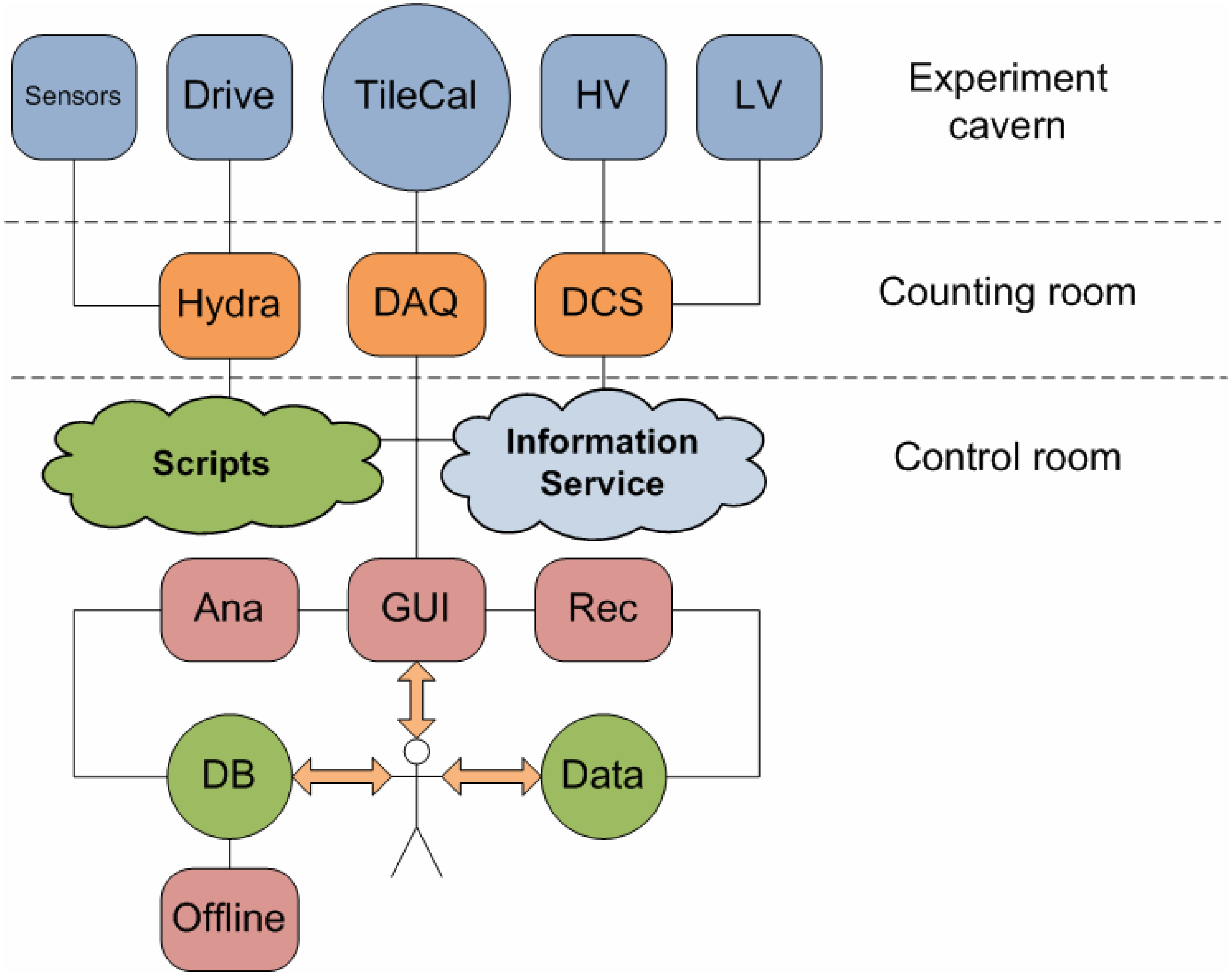
Electronics tests

To cope with system size, diversity and complexity of components, a set of tests has been developed with the help of ATLAS DVS framework [7], which allows to describe a hierarchy of components and their tests, to be executed in a sequential or parallel way, depending on the need.



- 10000 PMT channels in 256 front-end electronics “drawers”
- 500 source control sensors read out by 100 boards of 7 different types
- Electronics and their tests are described in configuration database
- Executed from command line or GUI
- Results provided in text or HTML format
- Expert system approach

Software architecture



- Readout and control processes running inside VME crates
- Information service (IS)[8],[9] as communication media between processes
- Embedded scripting facilities for program logics
- GUI, DB and other facilities for operator

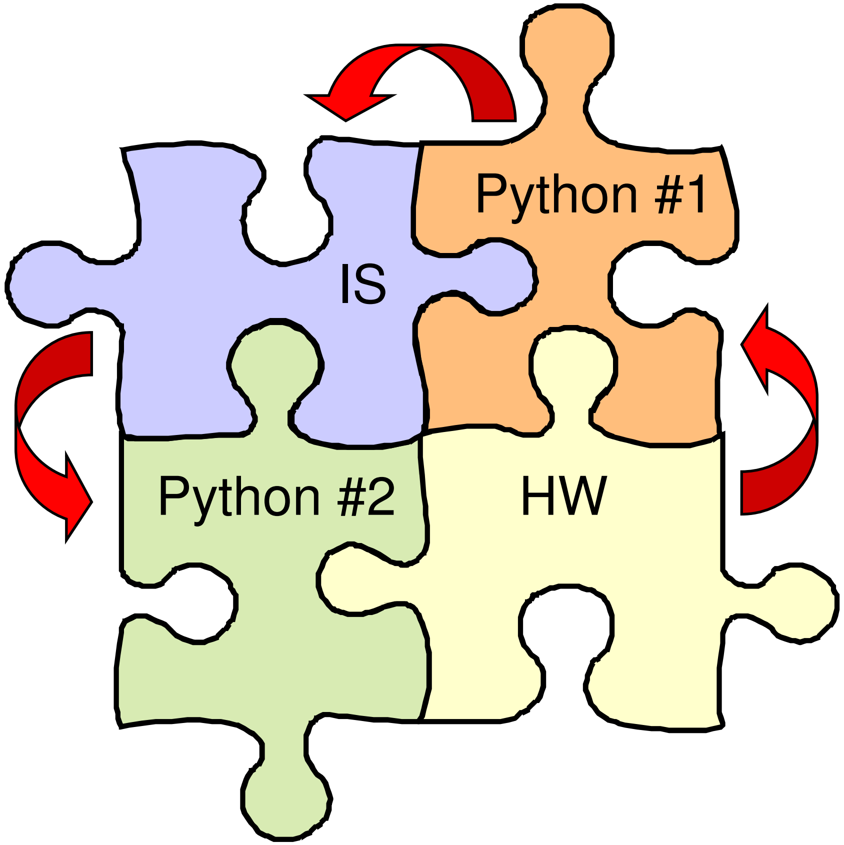
Scripts

- Scripting facilities for program flow control and configuration add flexibility and ease of use for non-experts
- Embedded Python interpreter with extention library links together hardware objects and their representation inside Information service to share data between processes
- Configuration with Python scripts helps complex descriptions of different setups
- Standard scripts for control process algorithms and runtime behavior

```
# move_source.py - move the source
import time

global sinpath, switchpos, switchneg
global base_pump_speed, finger_from, finger_to, direction
global tube_from, tube_to
global source_position

# determine contour size as number of modules between from
and to pipes
def contour_size(f,t):
    size = abs(pipes[t]-pipes[f])
    if size > 12: size = size-64
    return abs(size)

# find the last hitted sin
def find_source(since=0):
    lastsin = '00'
    lasthit = since
    for s in sinpath:
        # anticlockwise direction
        if direction>0:
            if sin[s].hit>=lasthit:
                lasthit = sin[s].hit
                lastsin = s[:2] # leave 2 digit module name
        # clockwise direction
        else:
            if sin[s].hit>lasthit:
                lasthit = sin[s].hit
                lastsin = s[:2]

    return int(lastsin)
```

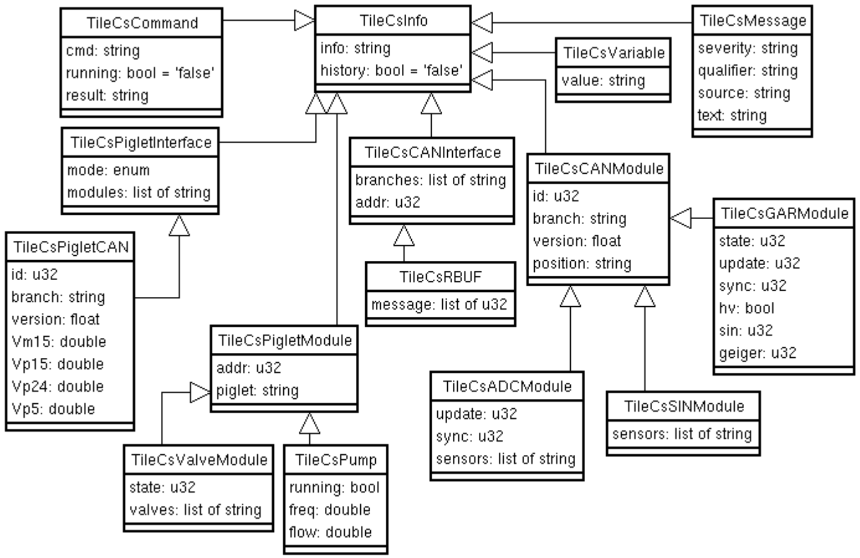
Script example

Python extention



- A set of Cs specific extention classes for Python
- Python object links together hardware component and IS representation
- Python object interacts with hardware
- Updates IS information
- Objects of Python “Info” classes, subscribed to the update, gets new state
- Information exchange between Python scripts running at different computers

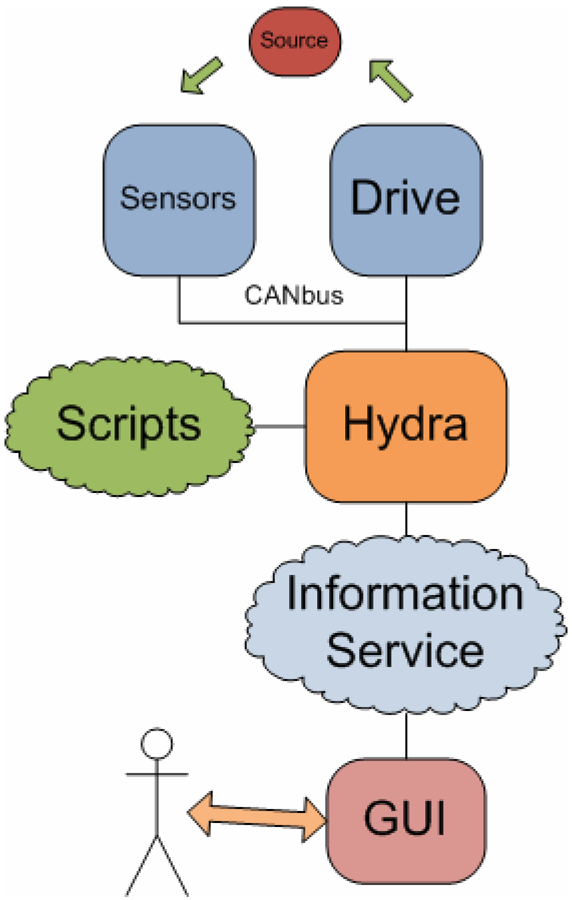
IS classes



TileCs IS schema (part)

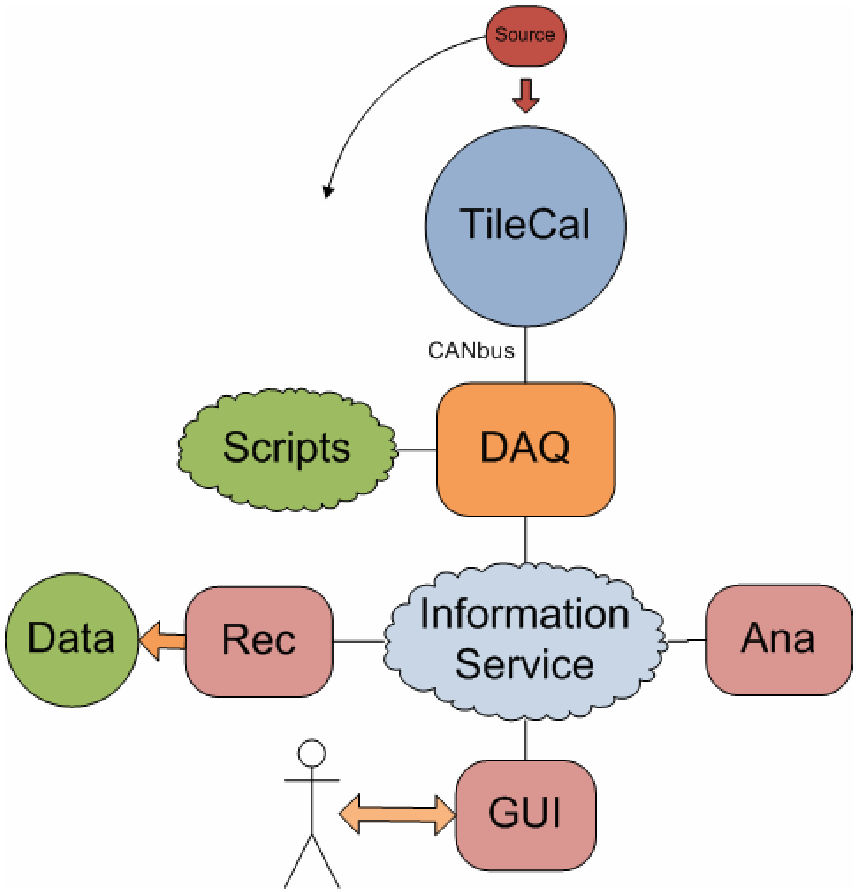
- An hierarchy of information service classes describes Cs specific hardware and software objects to share information between processes
- Many useful IS features
  - is_ls and is_monitor utilities
  - autogenerated C++ and Java bindings
  - command listener
  - server history “time machine”
  - server backup helps crash recovery

Control processes



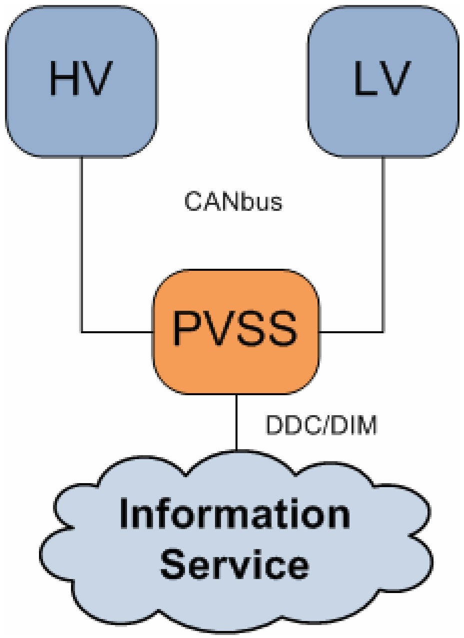
- Hydra controls the drive and sensors via CANbus
- Moves the source
- Reacts to current source position to switch drive contours
- Provides information for other processes
- Executes commands received from GUI or other processes
- Uses scripts to change configuration and control logics

DAQ



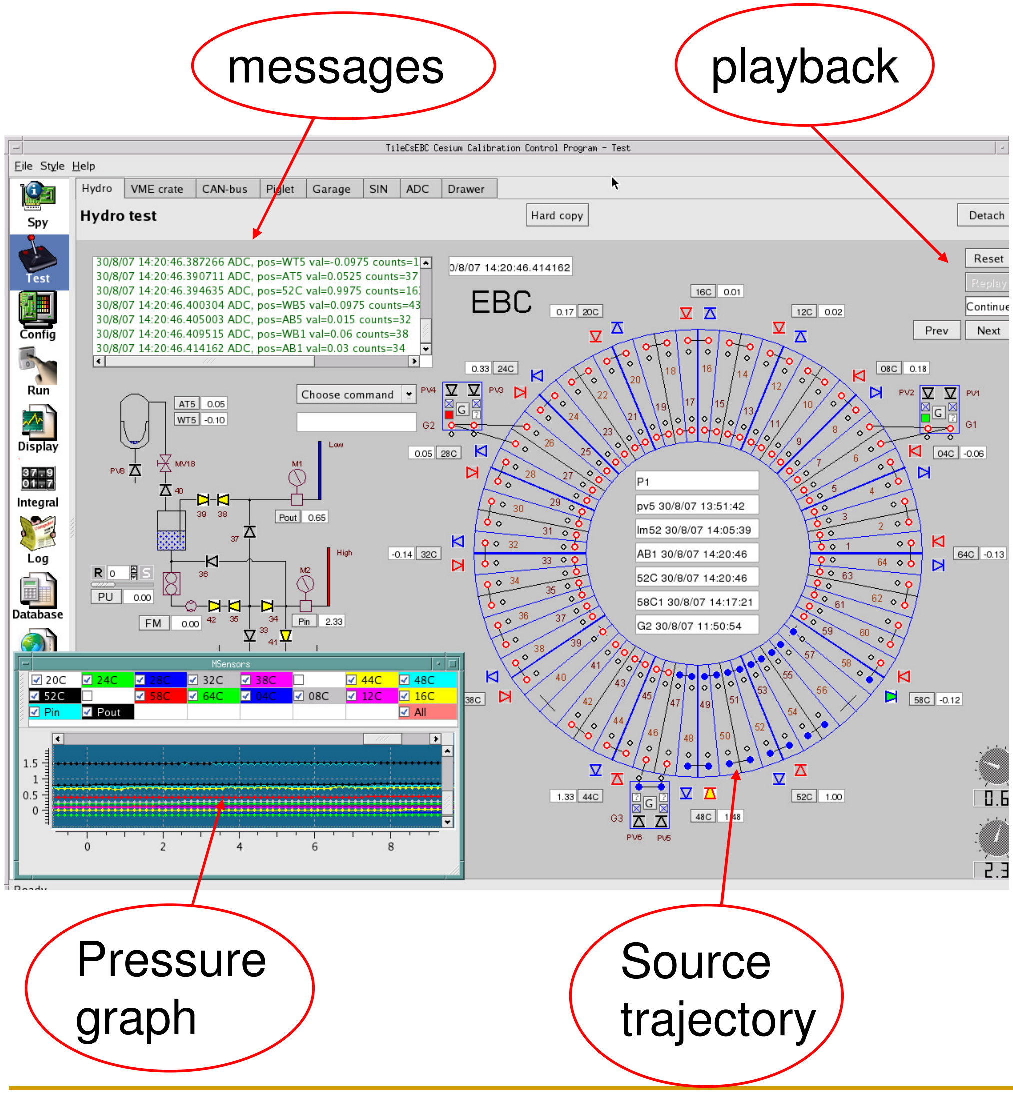
- DAQ process read out PMT responses and control front-end electronics via CANbus
- Switches front-end module readout based on current source position
- Provides data to the analysis and recording processes via IS

DCS and safety



- To fulfill the task of save and controlled operation an interface to detector control system (DCS) is required
- DDC package [10] of ATLAS TDAQ is used to retrieve and send high voltage and other important information, like temperatures, power supply status
- Source position, run status is provided for experiment operators (SLIMOS, etc.)

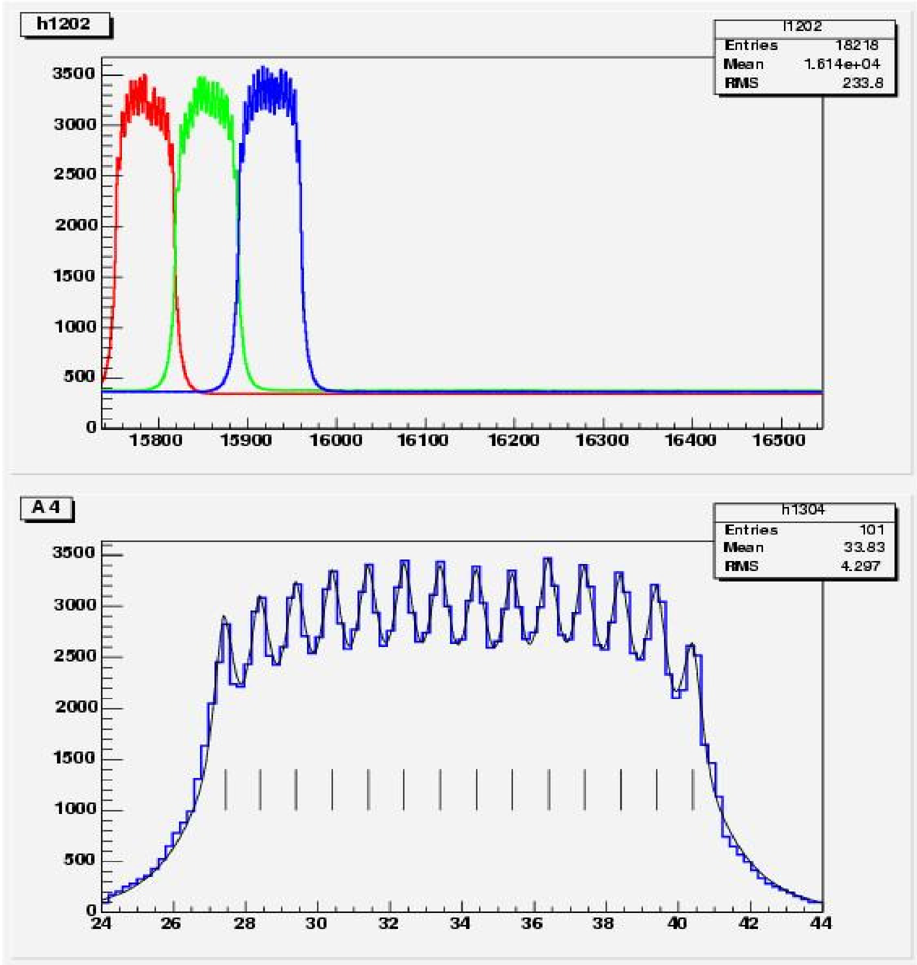
GUI



- QT application
- Allows to manipulate with any single valve as well as to send high level commands
- Receives information from all the sensors and visualize status of the system in real time
- Have important playback feature: full history can be replayed in accelerated mode

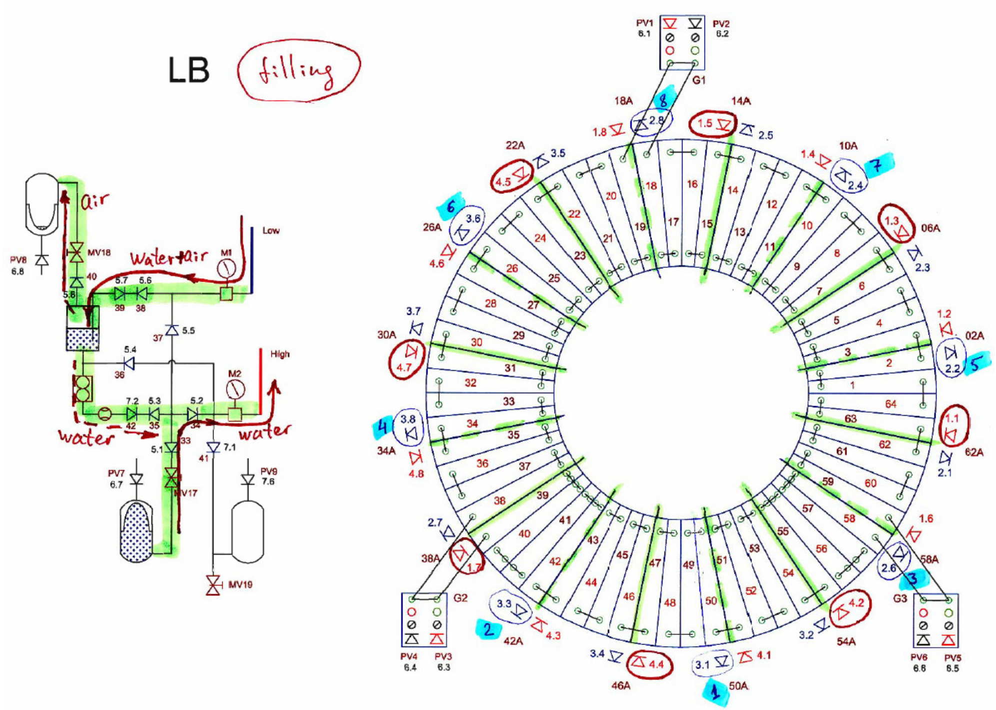
Data analysis

- Almost all TileCal modules are different, so sophisticated analysis software is required to achieve calibration with required precision
- Raw data taken during the run saved to a file in form of ROOT trees for easy access and visualization.
- Analysis can be started during the run as soon as data from one calorimeter module are available
- Response in every cell is calculated and results are used in iterative equalization procedure.
- Global data quality flag from analysis process might be taken into account by control process (e.g. to send capsule back to some particular bad module or to stop the run)
- Results are visualized in GUI and stored in the database



Cell response to the passing source

Operations



- From sketch to the program logics – scripting facilities provide a way for easy algorithm and sequence encoding by non-experts in programming
- No need for program recompilation to change logics
- Developed a set of scripts for operational steps, like water filling, run preparation, source location, etc.

RUN operation scenario

- Preparation
  - FE electronics tests: pressure sensors, SINs, garage sensors, 3U-crates etc.
  - Safety checks: locate the source, air pressure leak test
  - Functionality of the equipment: hydraulic drive, garage locks etc.
  - Control of liquid flow: pump, air pressure, detector local pressures etc.
  - Water filling: fill detector volume with liquid from the water storage tanks
- Cs RUN
  - Run the source capsule at a desired speed, keeping an eye on its current position with SIN sensors and detector response
  - Collect PMT responses and store it along with the online analysis of the correctness of the information
  - Adjust the source movement, data readout and online analysis modes according to the current run conditions (situation)
- Post run tasks
  - Water draining: pump, air pressure, detector local pressures
  - Safety checks: garages, source location, source blocking

Results

- Cesium calibration system is installed in the ATLAS experiment cavern, commissioning is ongoing
- Regular electronics tests verified the integrity and stability of the components
- Dummy source runs allowed to check system functionality and operational logic before introducing the radioactive source to the still busy environment of experiment installation

Performance

- 100Hz trigger frequency
- Data flow rate relatively small, ~20 KB/s
- The full Tile Calorimeter barrel scan normally should take about 8 hours and produce ~300 MBs of raw data
- Several runs per year are planned, after initial series of runs for optical quality verification, primary equalization and calibration effort

Conclusions

- A system to calibrate and monitor ATLAS Tile Calorimeter with a movable radioactive source, driven by liquid flow, has been installed in the ATLAS pit
- Online software has been developed, using ATLAS TDAQ components for database, information exchange, electronics tests, communication with detector control systems, etc.
- Scripting facilities allowed for quick prototyping and modification flexibility by non-experts
- GUI provided operator with clear status and control, and history mechanism for post-run problem analysis
- Data analysis software with online response
- Good performance has been achieved for data taking and online analysis, to cope with the task at the speed of source travel
- Many thanks to all Tile collaboration and ATLAS TDAQ group

References

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