ATLAS Detector Commissioning

Oslo EPF group aspect

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[1]Introduction. Detector Constrol System

[2]Data flow & Data Aquisition System

[3]Data Quality Online Monitoring

[4]Offline Monitoring

04.April'08 / EPF Seminar, University of Oslo

Outline

- ATLAS detector

1. Detector Control System

ATLAS detector

- The LHC at CERN extends the frontiers of particle physics to unprecedented high energy and luminosity:
  - $(\sqrt{s})_{pp} = 14\ TeV$
  - $\mathcal{L} = 10^{34}\ cm^{-2}s^{-1}$ (design)
  - Bunch crossing-rate 40 MHz

  $\Rightarrow$ New standards for the particle detectors!
- A Toroidal LHC ApparatuS (**ATLAS**) is a general purpose detector built to probe pp and AA collisions at LHC, following the requirements of:
  - Large acceptance & Radiation hard sensing and readout
  - Excellent charged particle ε_{reco} and $\frac{\Delta p_T}{p_T}$
  - Excellent electromagnetic calorimetry for $e^{\pm}$ and γ identification
  - Excellent μ identification and $(\frac{\Delta p_T}{p_T})_{\mu}$ over wide momenta range
  - Efficient trigger system to achieve an acceptable rate for physics processes of interest (`Higgs(es), (new) heavy gauge bosons, (super)symmetries ...`)

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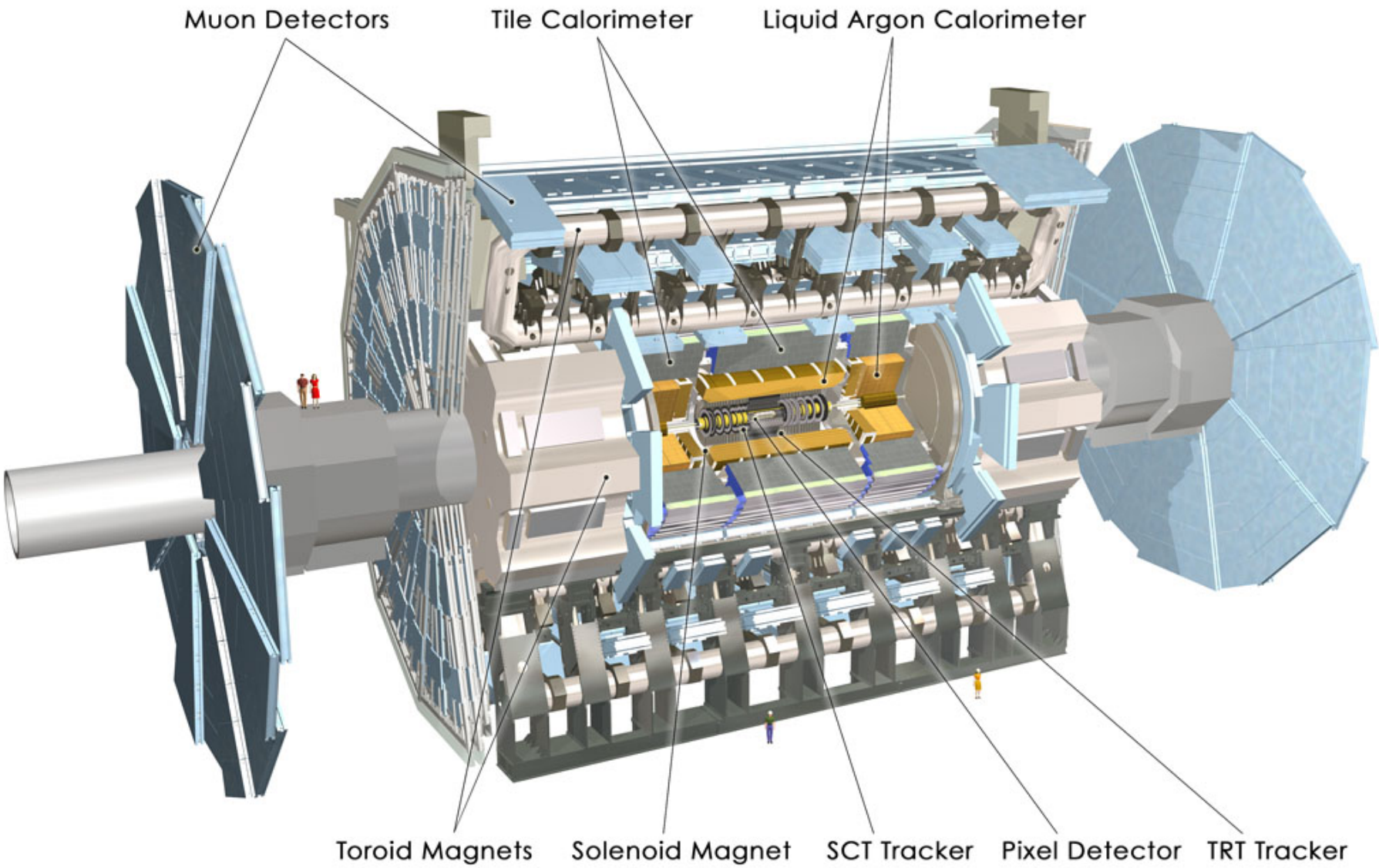
ATLAS detector



ATLAS detector

- ATLAS detector comprises:
  - Tracking: *Pixel, SCT & TRT*
  - Calorimetry:
    - `EM`: *LAr*
    - `Hadronic`: *Tile (Barrel), HEC (Endcaps), FCal (Forward)*
  - Muon system

Detector component	**Required resolution**	η **coverage**	
		Measurement	Trigger
Tracking	$\sigma_{p_T}/p_T = 0.05\%\ p_T \oplus 1\%$	± 2.5	
EM calorimetry	$\sigma_E/E = 10\%/\sqrt{E} \oplus 0.7\%$	± 3.2	± 2.5
Hadronic calorimetry (jets)			
barrel and end-cap	$\sigma_E/E = 50\%/\sqrt{E} \oplus 3\%$	± 3.2	± 3.2
forward	$\sigma_E/E = 100\%/\sqrt{E} \oplus 10\%$	$3.1 < \lvert\eta\rvert < 4.9$	$3.1 < \lvert\eta\rvert < 4.9$
Muon spectrometer	σ_{p_T}/p_T=10% at p_T = 1 TeV	± 2.7	± 2.4

- Installation is about to be completed - work of a large collaboration of several thousand people (physicists, engineers, technicians and students) over $\sim$15 years of design, development, fabrication and installation!

From installation to operation

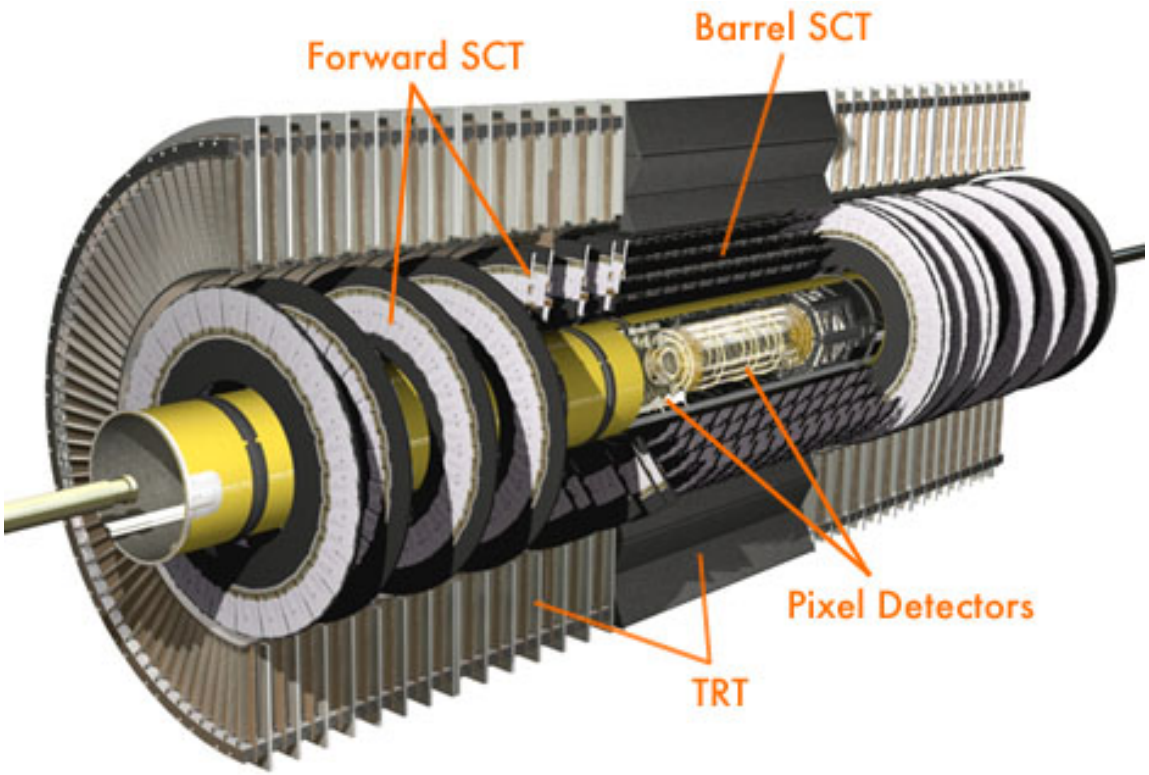
- The experiences from earlier experiments suggest that bringing an experiment from the end of the installation to the ready-to-take-good-data stage is a difficult and painful task, which usually takes more time than foreseen.
- Therefore an efficient, timely and well organized commissioning program, aimed to understand and fix as much as possible as early as possible, is mandatory

Detector Commissioning

The ATLAS commissioning has been

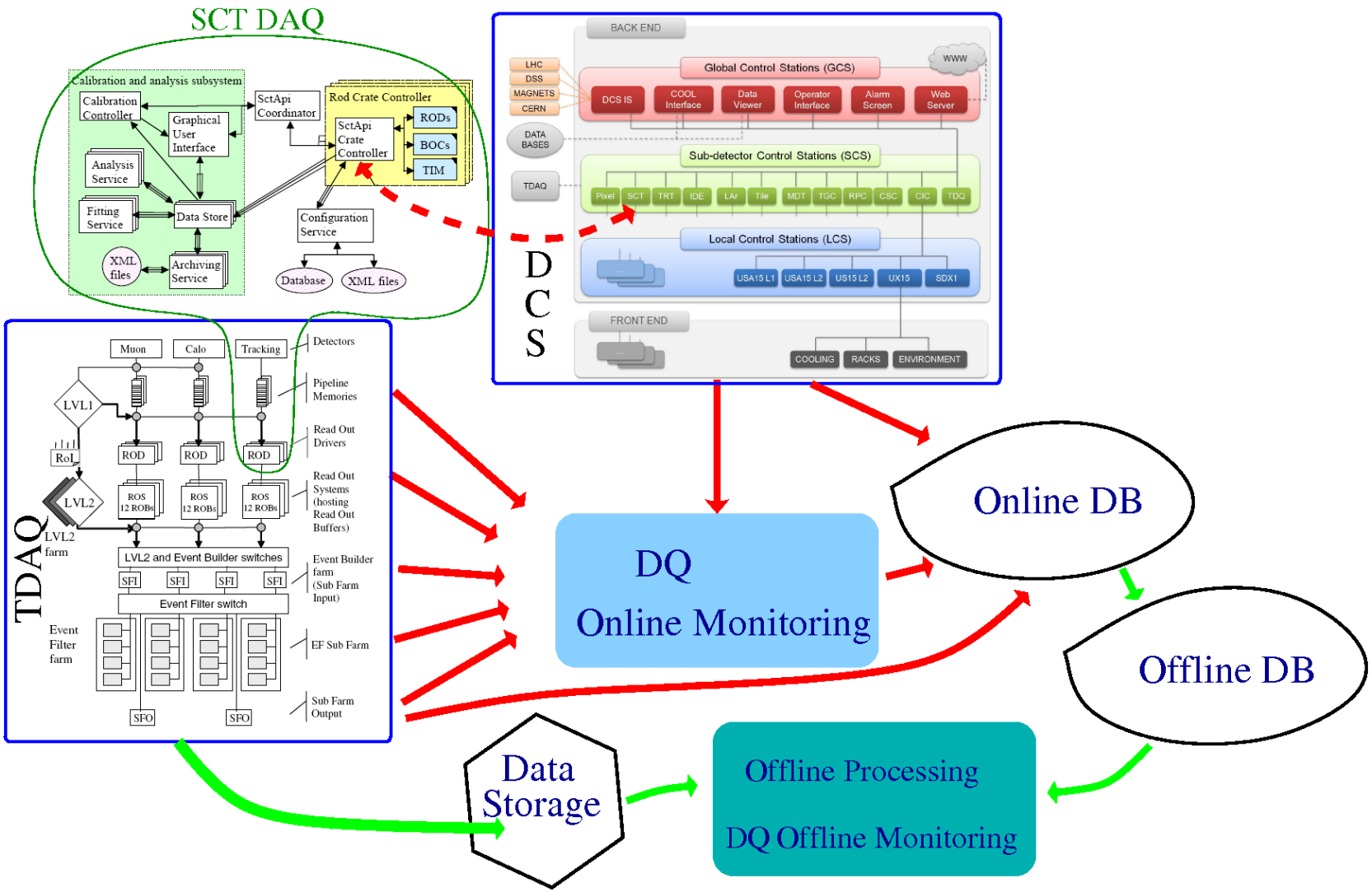
- started from the the commissioning at the sub-detector level, based on hardware tools (e.g. electronic calibration).
- continued by commissioning of the whole ATLAS detector using available "physics data":
  - `COSMIC MUONS`
  - beam gas interactions during the single-beam period.
  - pp collisions data (physics commissioning)

ATLAS Detector Commissioning

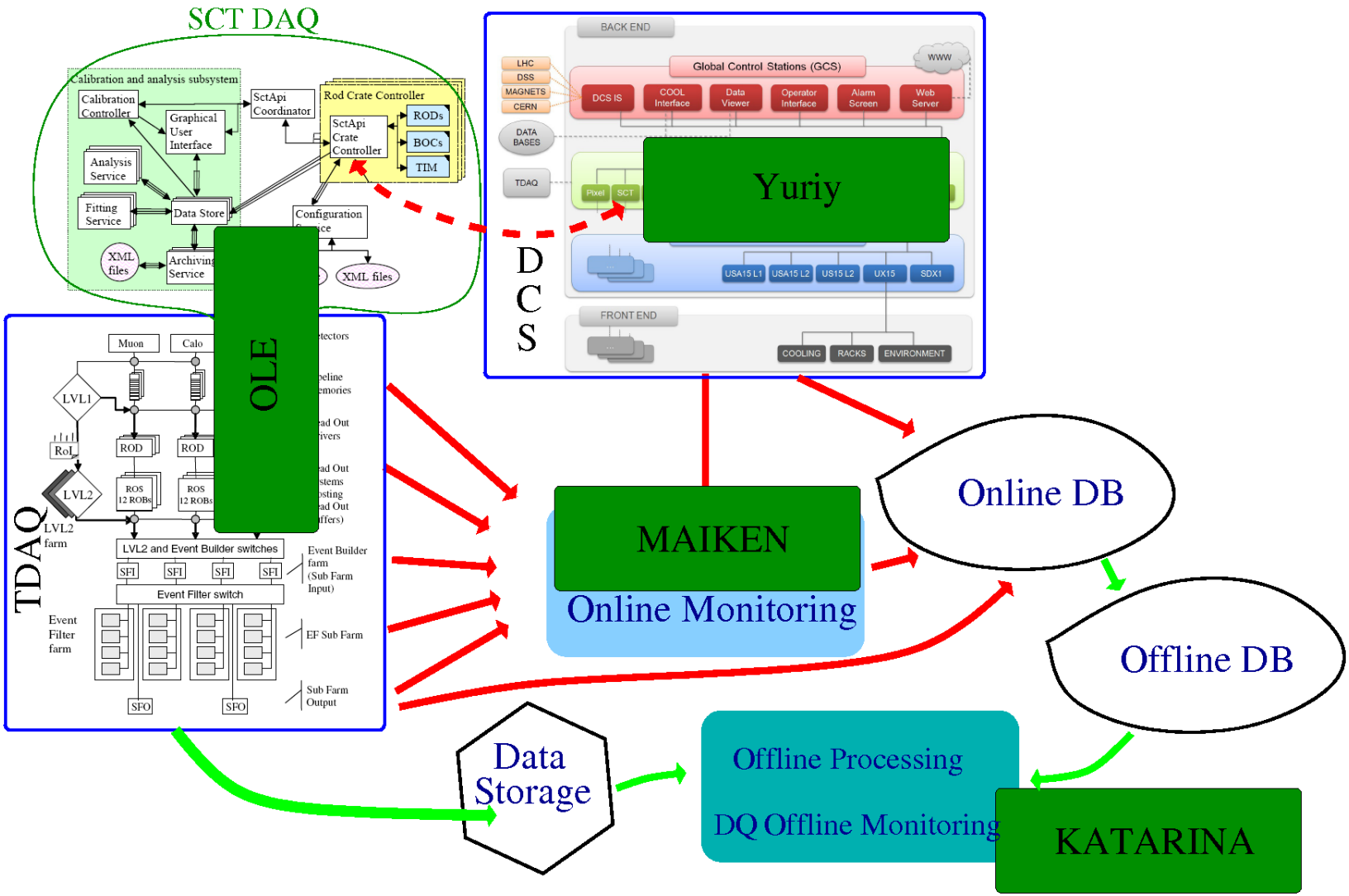


- Since long we are involved in the ATLAS Semi-Conductor Tracker (SCT, part of the central Inner Detector) project: Construction, Installation, Commissioning at earlier phases
- Following the trend, our Comsic Ray (CR) commissioning efforts also targeted on the ID SCT

ATLAS Data flow in CR tests



Oslo Flavor Of ATLAS Commissioning With CR



Oslo Flavor Of ATLAS Commissioning With CR

- ID / SCT Detector control system (DCS)
- SCT DAQ: manages the physics running of the SCT
  - read-out calibration and monitoring system. It measures the SCT performance parameters for each of the 6.3×10^6 channels in the SCT, identifies defects and problematic modules and writes them to an offline database for access from Athena, the ATLAS offline software framework.
  - has been developed and tested during commissioning of the detector with cosmics.

  $\Rightarrow$ `OLE will provide details in two weeks`
- Online Data Quality Monitoring (DQ).

  $\Rightarrow$ `MAIKEN in about 1/2 h`
- Offline Data Quality Monitoring:
  - Technical implementation (T0, grid, condition DB issues)
  - Experience from M6 week, conclusions and outlooks.

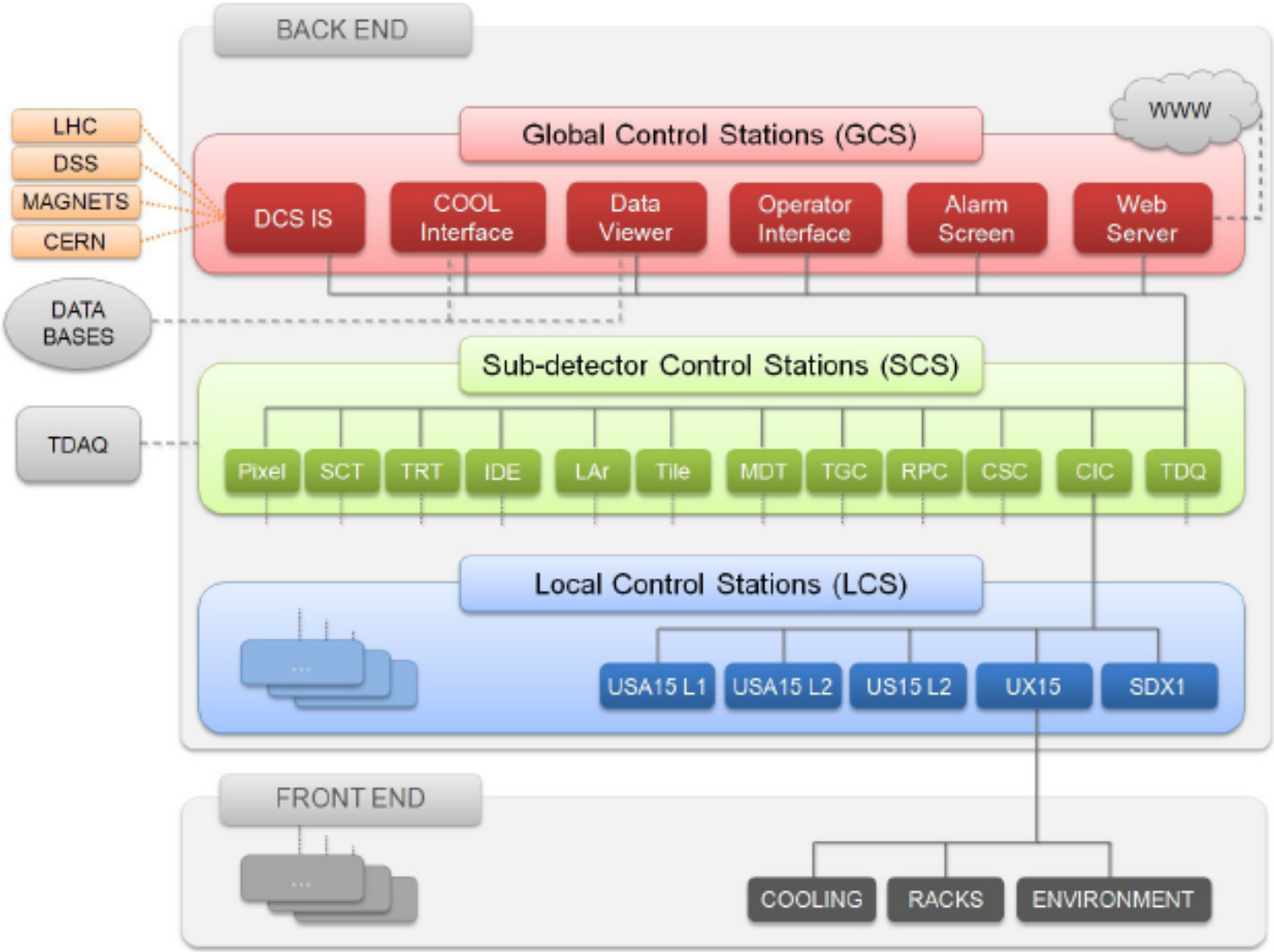
  $\Rightarrow$ `KATARINA's summary in two weeks from now`

Outline

Detector Control System

- DCS Ensures the safe and reliable operation of the detector
- PVSS is the main DCS tool for ATLAS.
- The ATLAS DCS is represented by means of Finite State Machine (FSM) hierarchy
  The detector is broken down into FSM units that are hierarchically controlled by other FSMs. These units can represent device entities, like a pump or a high-voltage crate, or logical groups of such devices, like a sub-detector or a gas system. Each unit reacts on changes of the internal status of the individual device or groups of devices it is representing and allow simplified control, error handling and interaction with other detector components in the hierarchy.
  The Device Units (DU) are the smallest entities to which commands can be sent from levels above

ATLAS DCS



ATLAS DCS hierarchy (picked up form ATLAS DCS web)

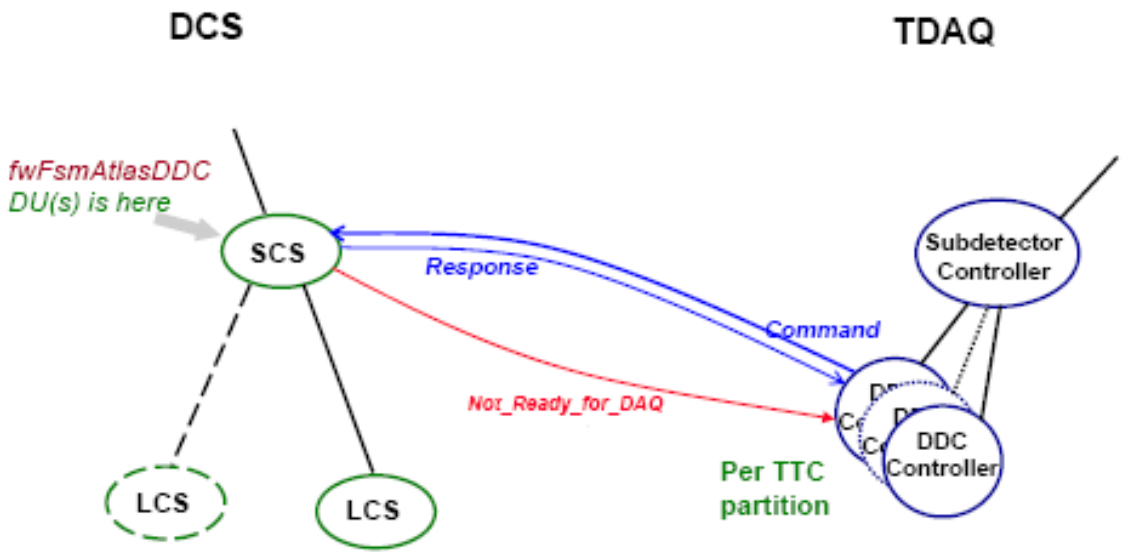
Operator Interface

- FSM operator screen: serves as primary user interface and provides detector control to the hierarchy of finite state machines
- Alarm screen: detailed list of all alerts raised inside the control system, highly configurable via pre- and user-defined filter settings
- Event log: shows a log of FSM events, performed control actions, and other software related events
- `Data viewer: accepts queries for AtlasDcs data and provides basic plotting functionality for online problem diagnostics`

Sub-detector Control Stations (SCSs)

- SCS (e.g. SCT, IDE) allows the full local operation of the sub-detector.
- At SCS level the connection with the Data AcQuisition (DAQ) system takes place in order to ensure that detector operation and physics data taking are synchronized.

  At the SCS, the sub-detector is divided into partitions which are based on the DAQ TTC (Timing, Trigger and Control) zones. The FSM reports the DCS state of the TTC zones to DAQ and it executes commands received from DAQ.



Operational Model

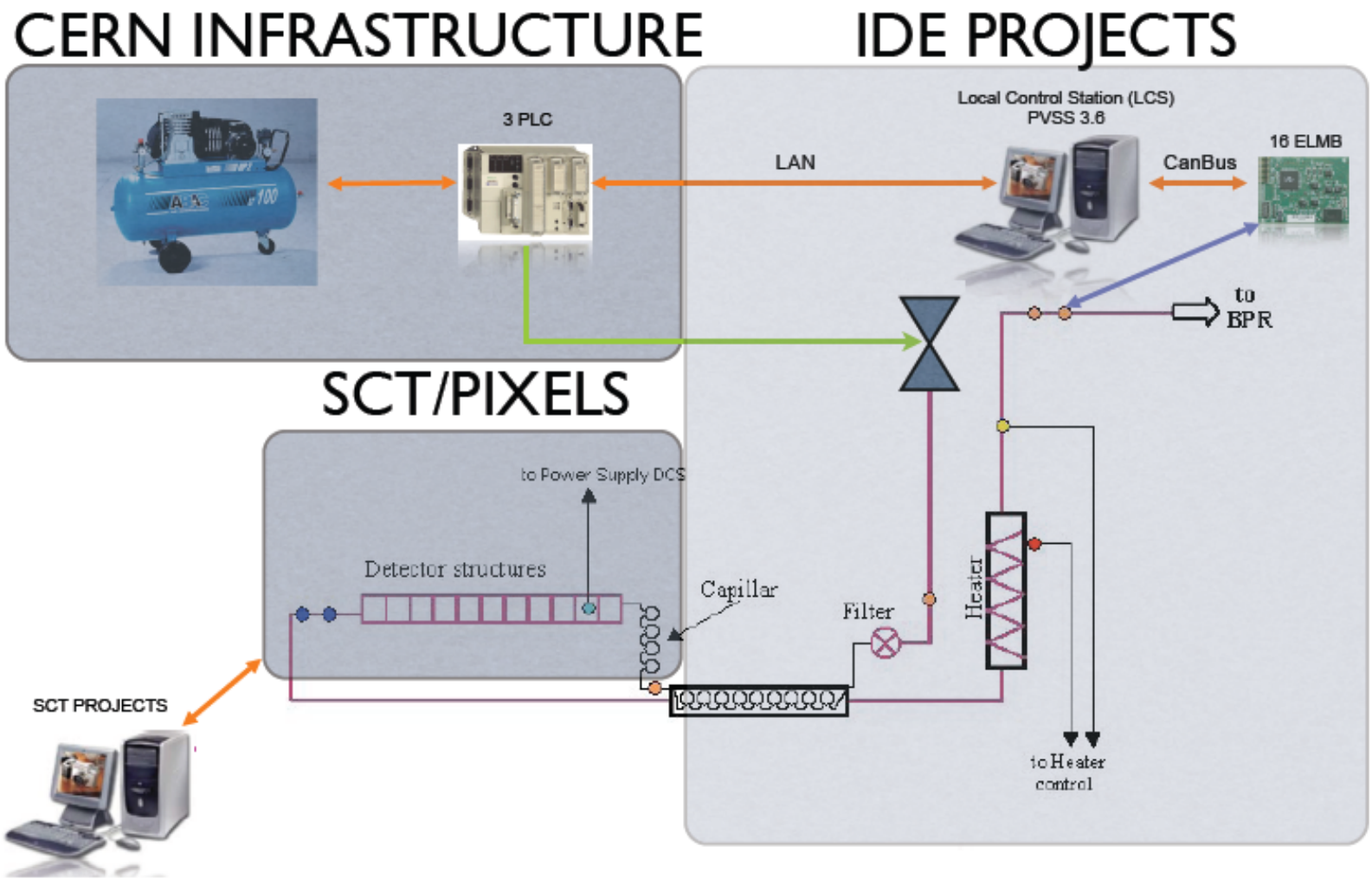
PS

- GOTO_INITIAL
  - For all cooled loops
  - Monitor temperatures
- GOTO_STARTING
- GOTO_STANDBY
  - LV at operational values
- Corrective actions
  - Reset, power cycle etc
  - Requested by DAQ using DDC
- GOTO_ON
  - Detector bias to operational values

DAQ

- **BOOT**
- **CONFIGURE**
  - Next PS operation may fail if modules not clocked
- Configure Modules
  - Send configuration packets
- Probe modules
  - Send L1A and trap events
- Corrective Actions
  - Re-send configuration etc.
- **START**
- **READY FOR PHYSICS!**

SCT operation: IDE + SCT



Tandem operation: ID Cooling and SCT DCS

IDE Cooling and ENV Projects

Main tools for Cooling Shifter

- Cooling
  - control and monitor the Cooling Loop state (ON, OFF, STANDBY, LOCKED)
  - control and monitor the Cooling Flow
  - control and monitor the Cooling Temperature
- Environmental
  - monitor cooling loop temperature
  - monitor service temperature
  - monitor humidity in the ID volumes

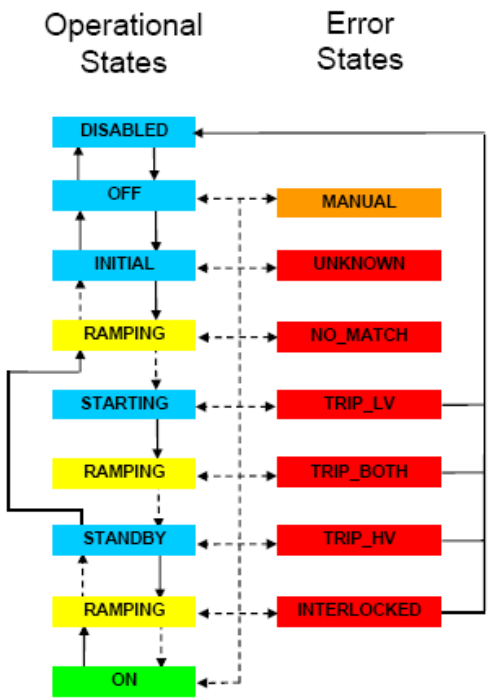
SCT Projects

- The SCT DCS comprises several PVSS projects
- each of which either falls into the category "environment" or "power supplies".
- As the operational state of the cooling plant is closely coupled with the SCT systems the cooling project is linked into SCT FSM at many levels.

SCT Power Supply Project

- provides all voltages and control signals needed for the operation of the SCT modules.
- LV and HV cards are integrated at the level of the PS crate: *LV and HV cards serving a total of 48 Detector Modules are housed in a common crate, serviced by a common crate controller, common crate power supply and crate control software*.

FSM: PS Channel DU States



The main operational states:

- OFF
  - LV hardware OFF
  - HV hardware OFF
    - Cannot read module temp
- INITIAL
  - LV OFF (0V / 0V)
  - HV OFF (5V)
    - Can read module tempera
- STARTING
  - LV STB (2.5V / 3.0V)
  - HV STB (50V)
    - Reduces probability of ove trips (Icc, Idd) during powe
- STANDBY
  - LV ON (3.5V / 4.0V)
  - HV STB (50V)
    - Reduced detector bias: us during (moderately) unstal conditions
- ON
  - LV ON (3.5V / 4.0V)
  - HV ON (150V)
    - "OK FOR PHYSICS"

SCT environmental monitoring

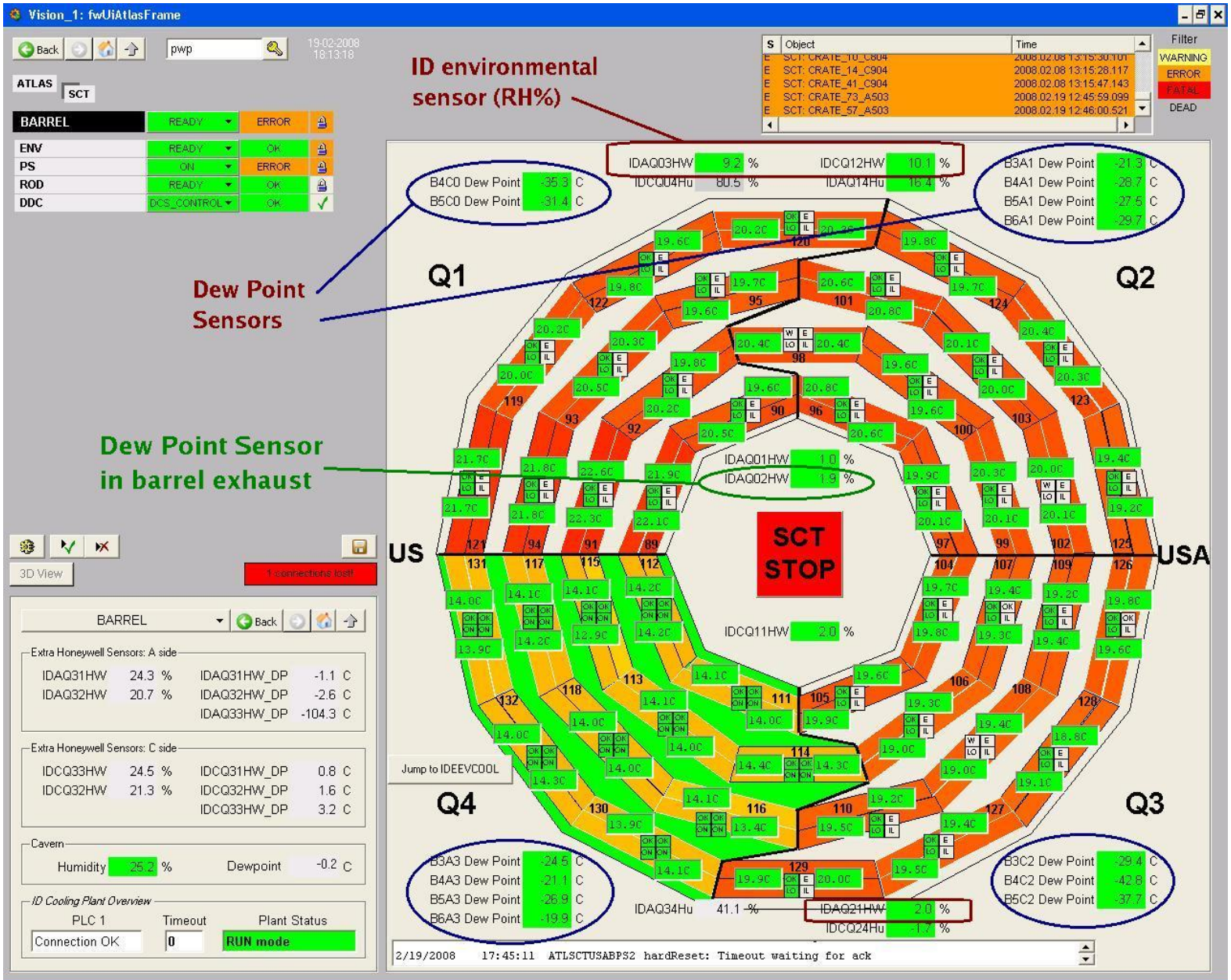
For supervising the running conditions for the SCT.

- The Environmental Monitoring measures T and RH throughout the detector and use them to calculate dew points.
- `mechanical T` of the carbon-fiber structure
- `air/N2 T`
- `cooling loop T` used in the Interlock system: their signal used to switch off the modules on the appropriate cooling loop when the temperature goes above a hardware-set threshold.
- `NTC`, `HMX` and `Xeritron` sensors

DCS watcher steps

- Checks before start:
  - DCS communication to the `SCT Power Supply & IDEEVCOOL FSM`
  - Air/N_2 flow, dew points, relative humidity
- Checks while cooling is running and before SCT modules are started
  - Reverify dry air/N_2 flow into enclosure
  - Reverify environmental conditions and dew points
  - At the start of cooling wait for the cooling pipe temperature to stabilize.
  - Verify that on SCT FSM the SCT interlock is automatically removed on PS cards when the cooling temperature of the corresponding loop falls below a threshold temperature
  - As soon as the PS are no longer in Interlocked state, mask on the SCT PS through FSM by setting *Go* to *Initial* state.
  - Check the module hybrid temperature on all SCT modules on cooled loops

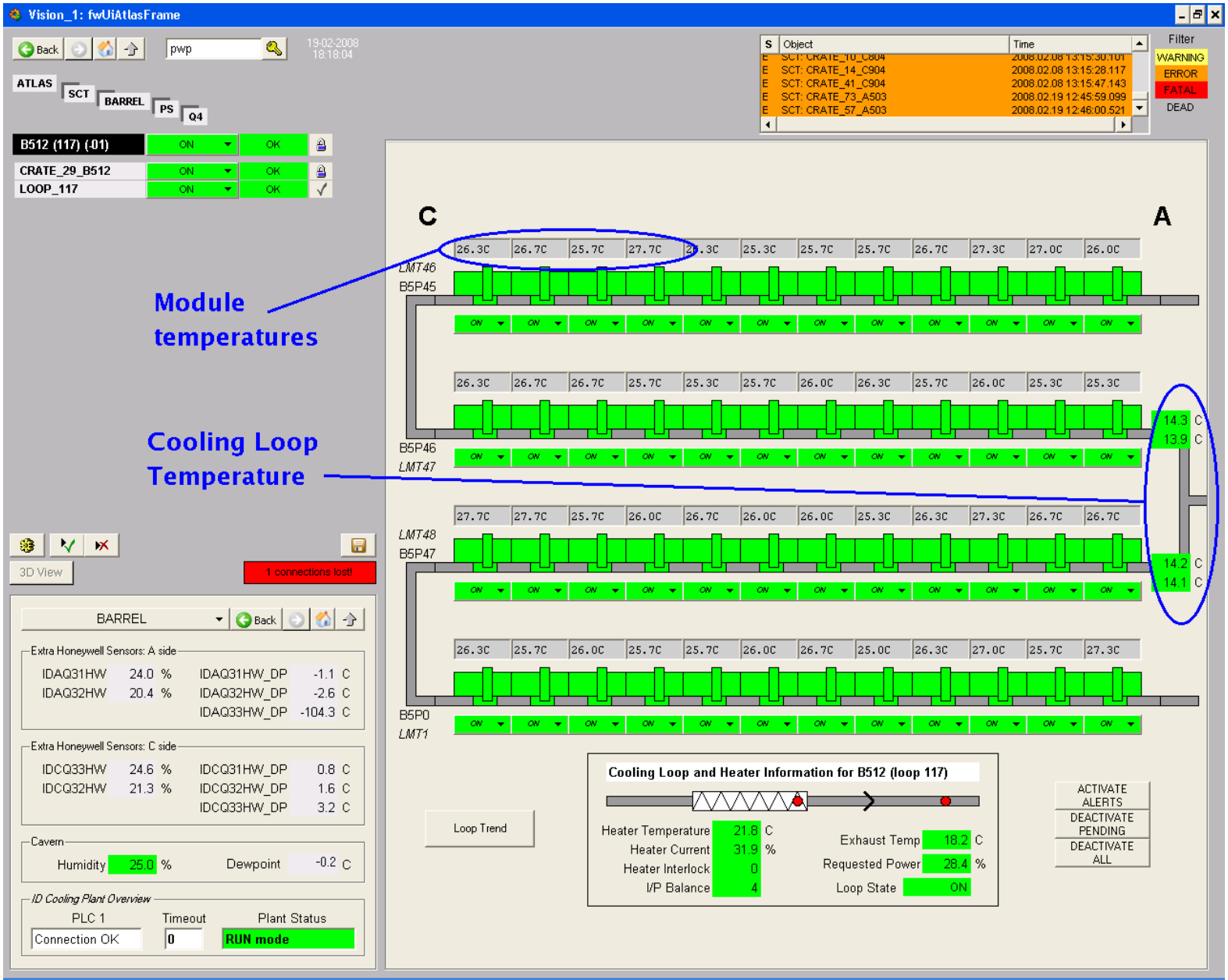
DCS watcher steps



DCS watcher steps

- SCT start: cooling is running stable and SCT may be started
  - In the Cooling-Startup the PS were set on *Go Initial* State. Now you have to set them on, going through the following steps in succession: `Starting, Standby, On`
  - If some modules trip off recover it. If this does not work call an expert.
- Routinely check while cooling and SCT are running and stable
  - Dew Point and Relative Humidity
  - Check in the cooling loops: temperature of all modules and temperature of the cooling pipe
  - Compare dew points in barrel/endcaps with the cooling temperatures
  - check rack temperatures for all SCT PS and ROD racks.

DCS watcher steps



Software Interlocks between SCT PS and ID Cooling

- The following software interlock mechanisms are implemented
  - turn off all module power IMMEDIATELY if distributed connection to IDEEVCOOL down for more than 2 minutes
  - turn off all module power IMMEDIATELY if cooling plant status anything other than `RUN - OK` or `RUN - WARNING`
  - turn off power to all modules of an individual loop if loop status anything other than `ON - OK` or `ON - WARNING`
  - do not allow power on if connection to IDEEVCOOL is down
  - do not allow power on if plant not in `RUN - OK` or `RUN - WARNING`
  - do not allow power on if loop not `ON-OK` or `ON - WARNING`

Summary

- This was a brief and very general SCT DCS aspects from M's (learned while hanging around ACR and IDSCR for various purposes)
- Good sign: there has been no major failures in the recent time (even cooling heaters worked)
- But is does not means that there are no problems, unfortunately.
- Nevertheless, from this point of view the detector looks promising.

- The closely related ongoing activity:
  - Inventory of the humidity measurements in the ID volumes
  - Installation of new sensors and related infrastructure
  - Developing a PVSS project for new dew point measurements
  - ... and (e.g. N2 system issues)

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