Towards the Final ATLAS Pixel Detector Control System

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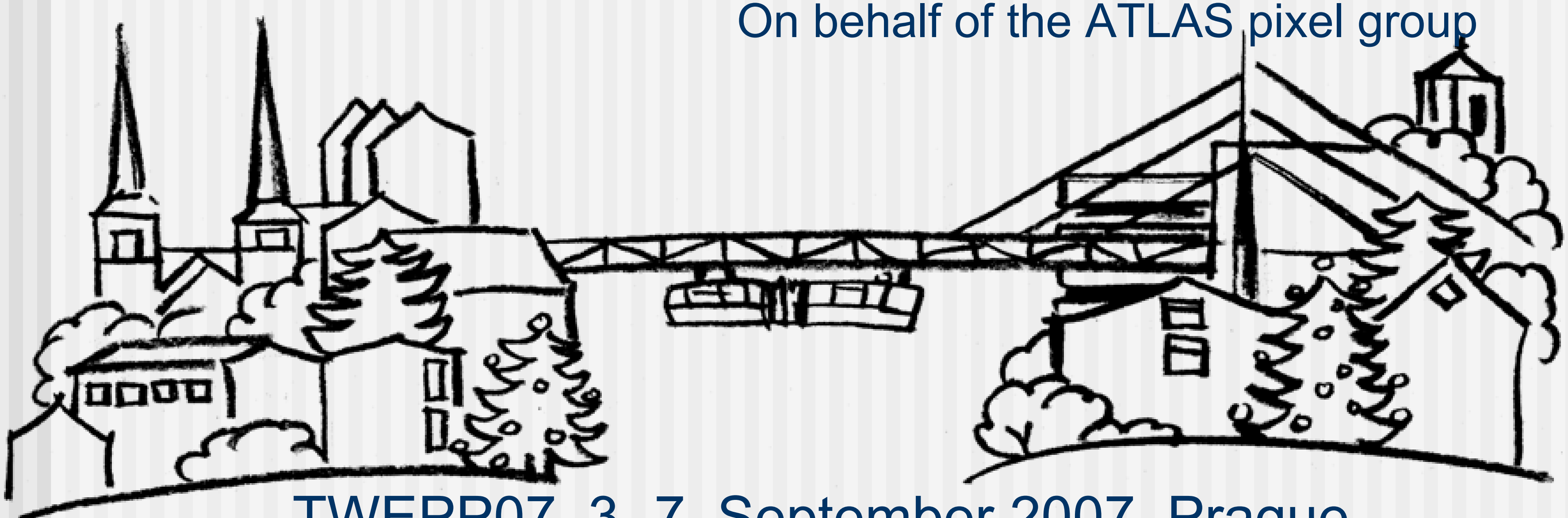
On behalf of the ATLAS pixel group

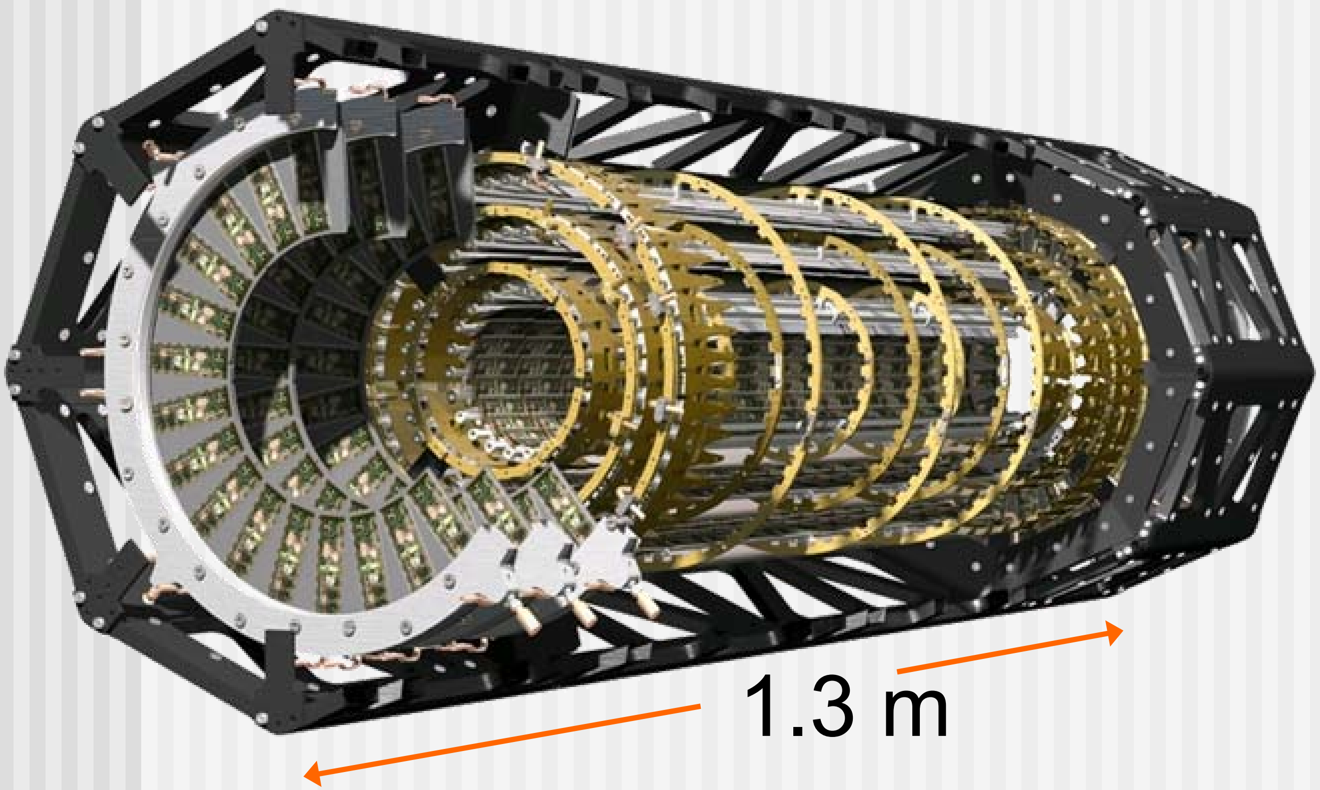


TWEPP07, 3.-7. September 2007, Prague

Overview

- The ATLAS Pixel Detector
  - Readout units
  - Parameters to be controlled
- Detector Control System Hardware
- 10% Setup at CERN
- Structure of the detector control software and gained experience:
  - **FIT**: Front-end Integration Tool
  - **SIT**: System Integration Tool
  - **FSM**: Finite State Machine
  - **DB**: Data Base Interfaces
  - **DDC**: DAQ (Data Acquisition) DCS (Detector control system) Communication
- Summary and Outlook

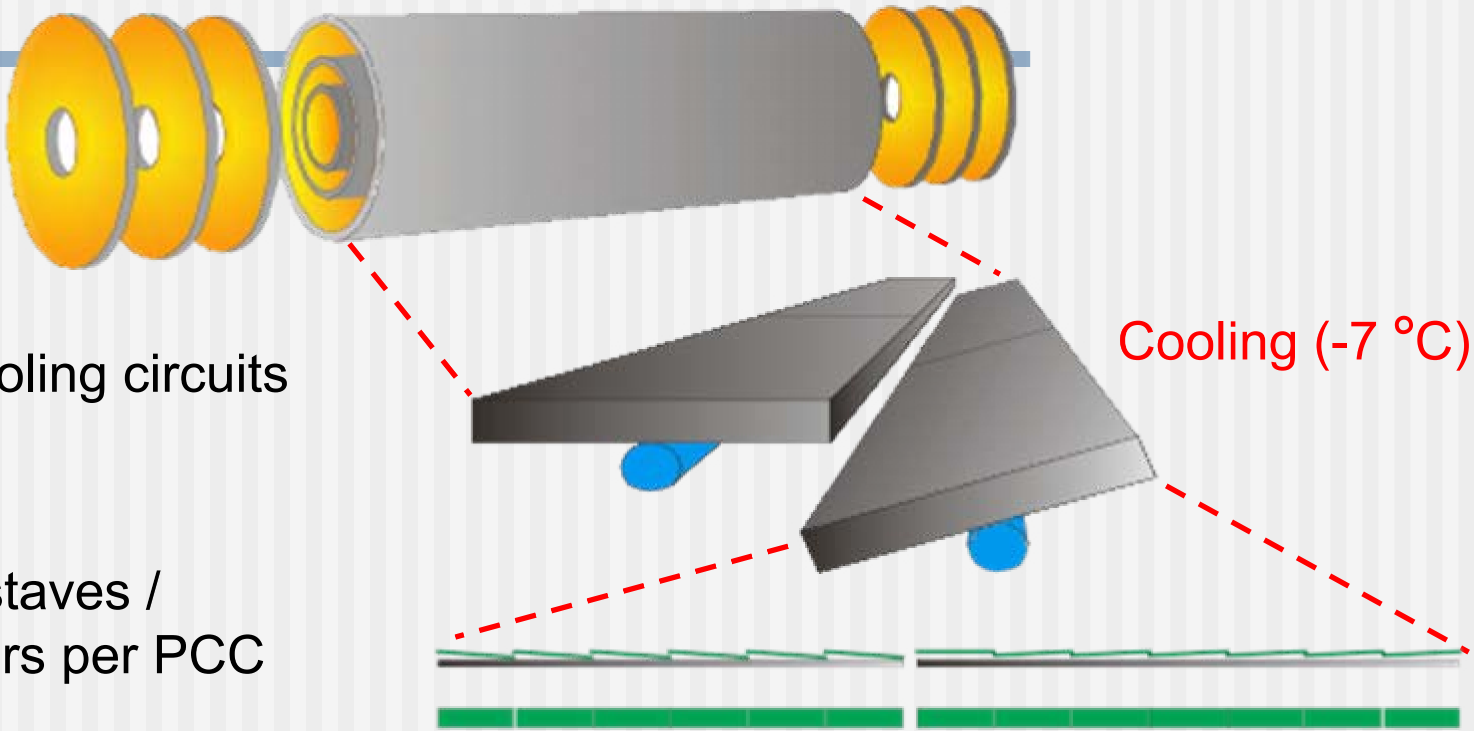
The ATLAS Pixel Detector



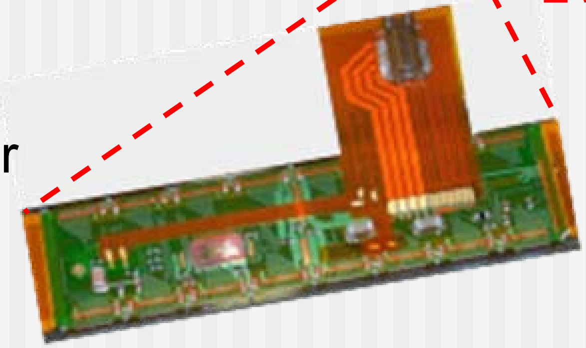
- 1744 detector modules
- 3 layers in the barrel (consist of staves)
- 3 disks on each end (consist of sectors)
- 80 million readout channels (~90% ATLAS)
- main task: vertex-reconstruction
- 3 space points for $|\eta|<2.5$
- Optical communication used for command and data transfer

Pixel Detector Geography

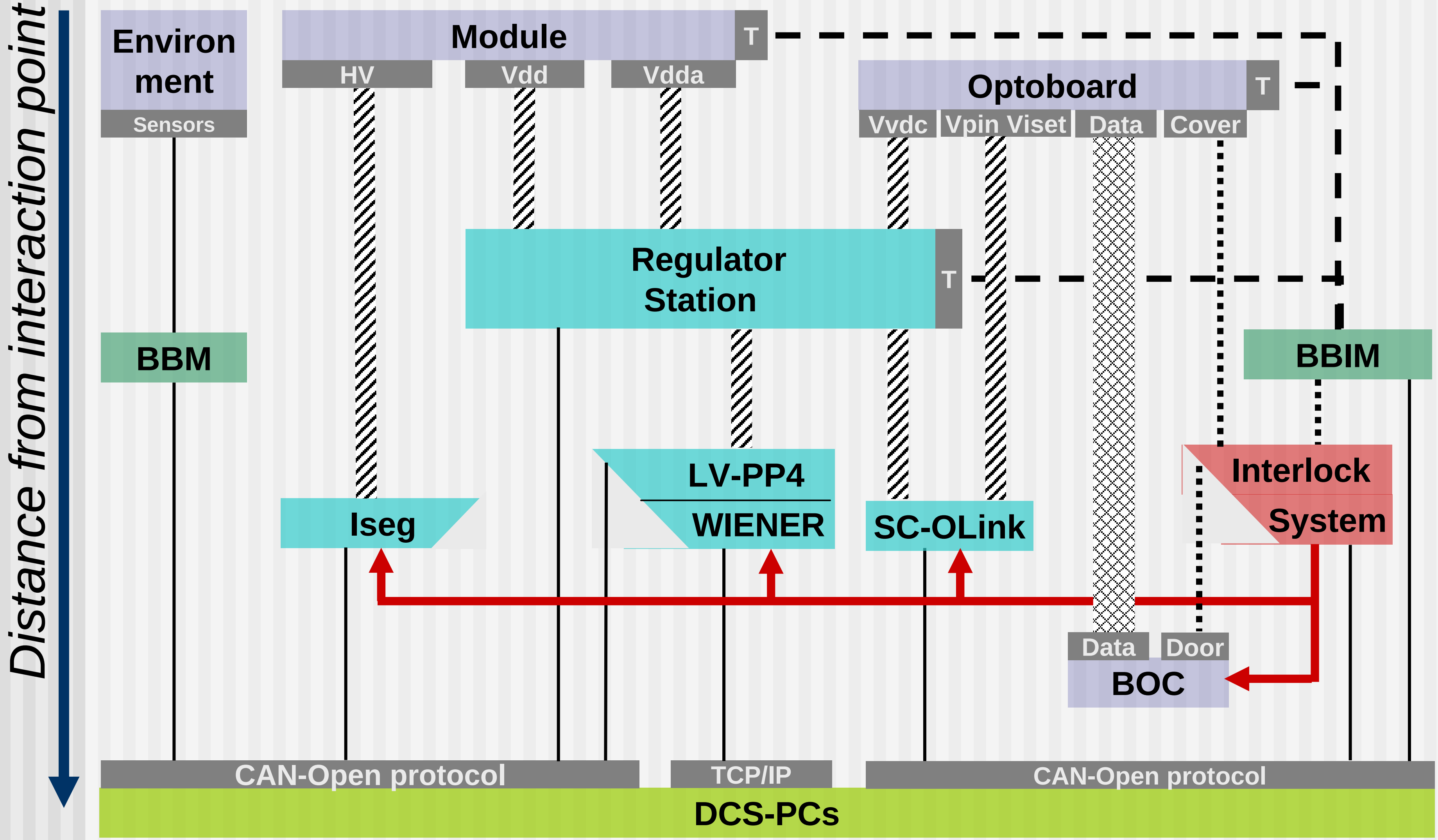
- 6 Disks
- 3 Layers
  - Parallel cooling circuits (PCCs)
    - 4 half-staves / 2 sectors per PCC



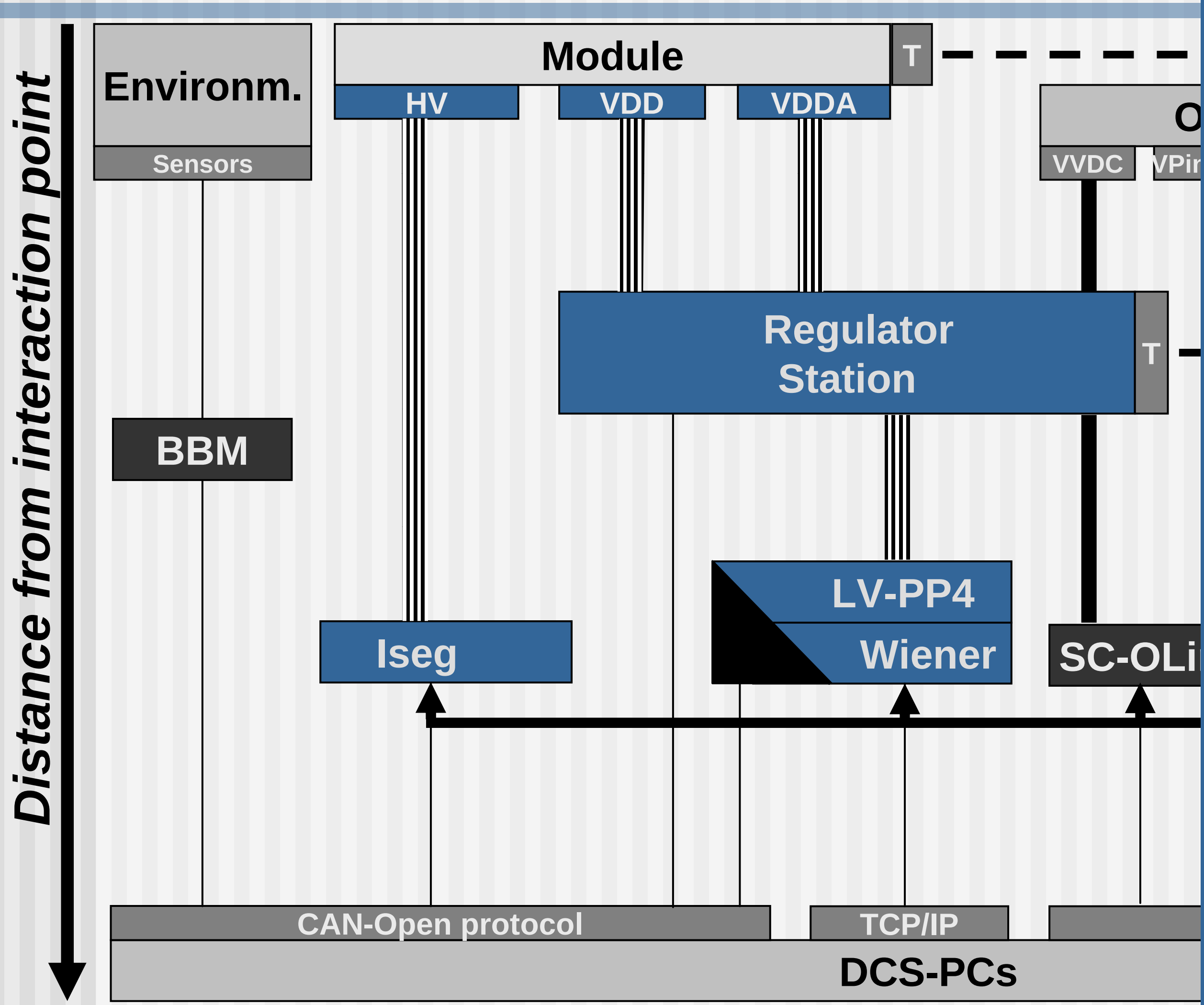
- 6 / 7 modules per half-stave or sector building a **Readout Unit**



DCS Hardware



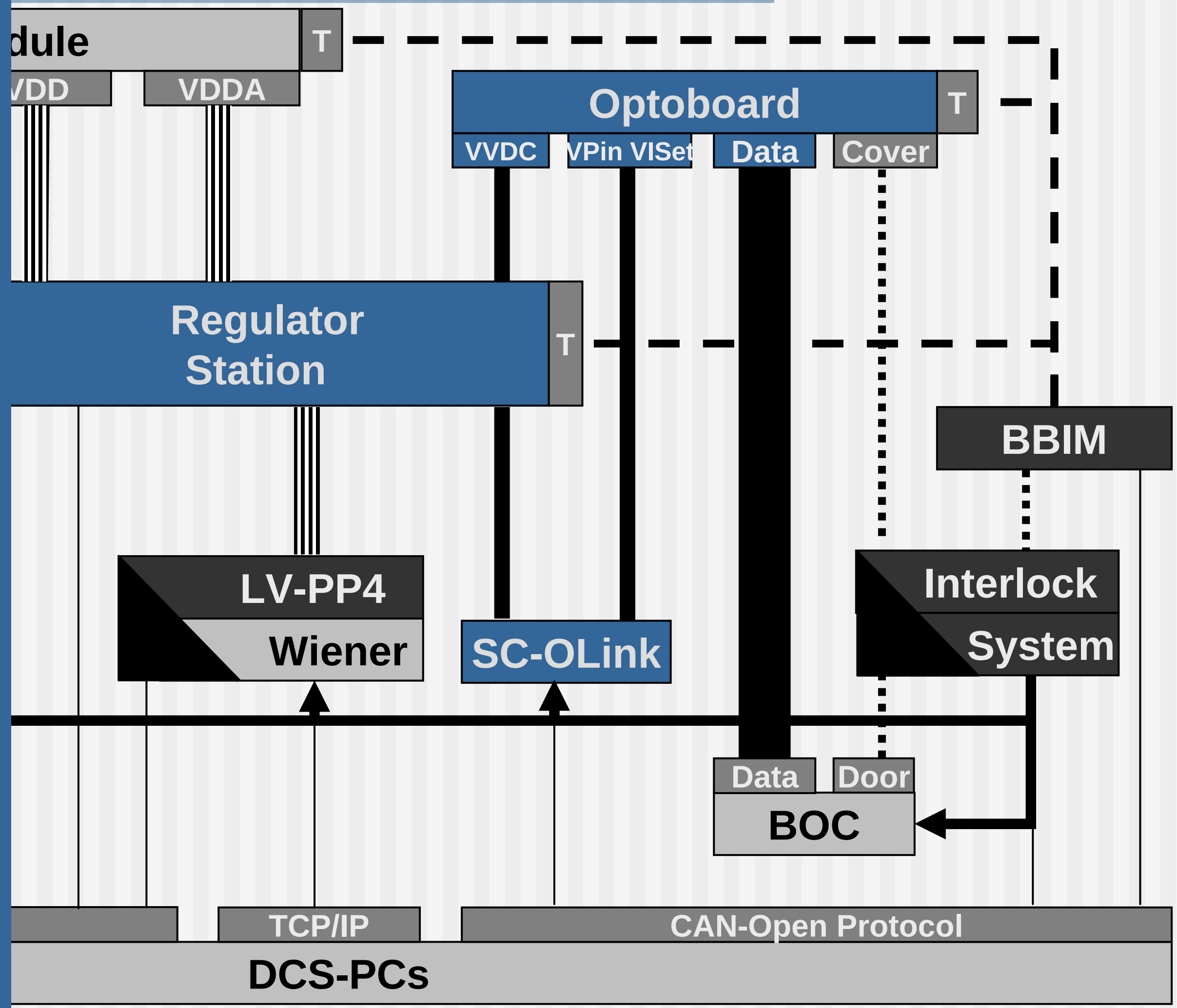
DCS Hardware: Modules



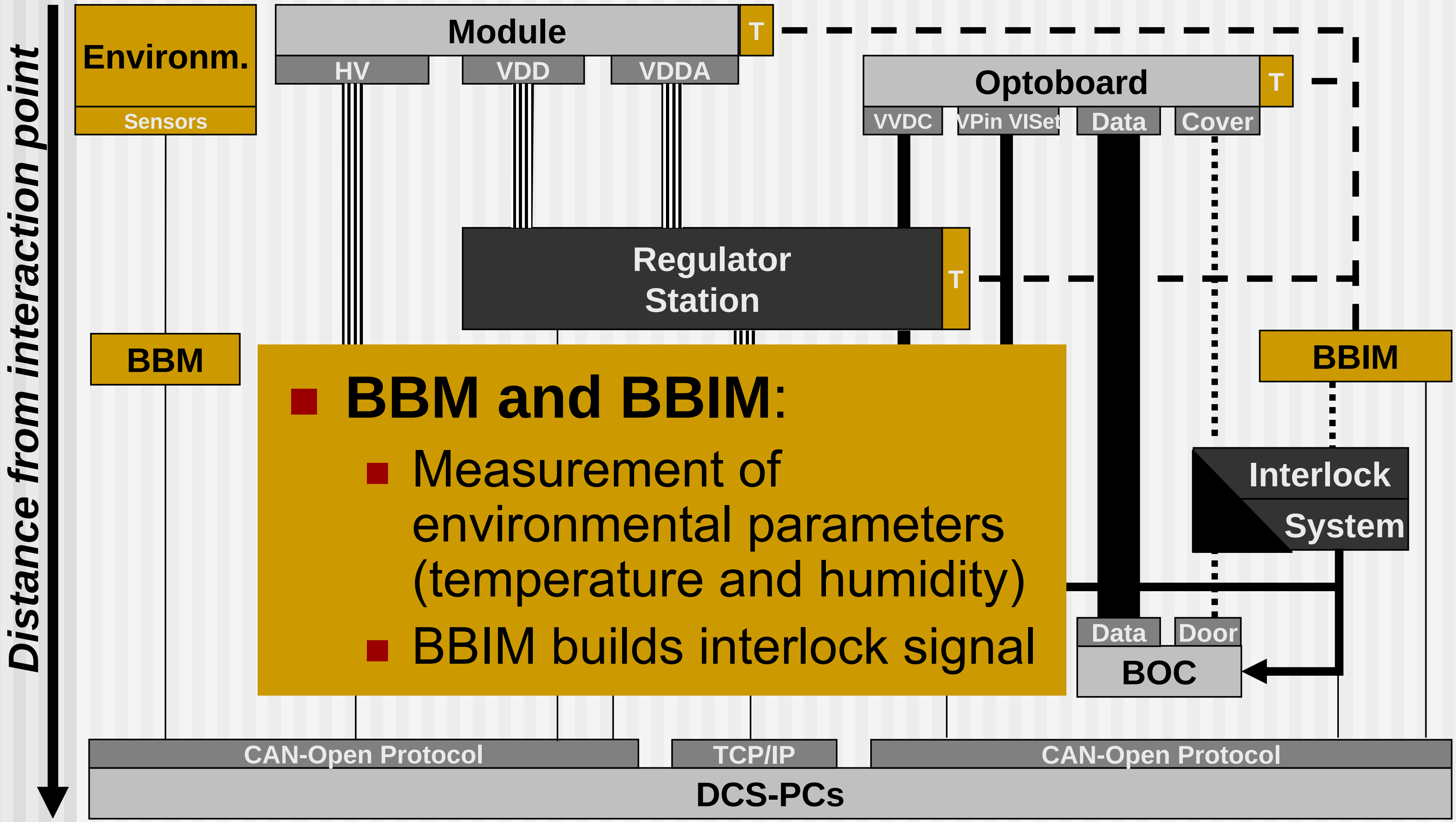
- **Wiener:**
  - Low voltage for analog and digital circuits of the modules
- **LV-PP4:**
  - Distribution and measurement of currents
- **Regulator Station:**
  - Adopt and regulate voltages inside the detector volume
  - Individual switching
  - measurement
- **ISEG:**
  - sensor bias voltage

DCS Hardware: Optoboard

- **Supply and Control for the Opto Link (SC-OLink):**
  - Vvdc: 0..10 V, 800mA
  - Vpin: 0..20 V, 20 mA
  - Viset: 0..5V, 20 mA
  - RST_Opto
- **Regulator Station:**
  - Voltage adoption and regulation for Vvdc inside detector volume
  - switching
  - Voltage and current measurement

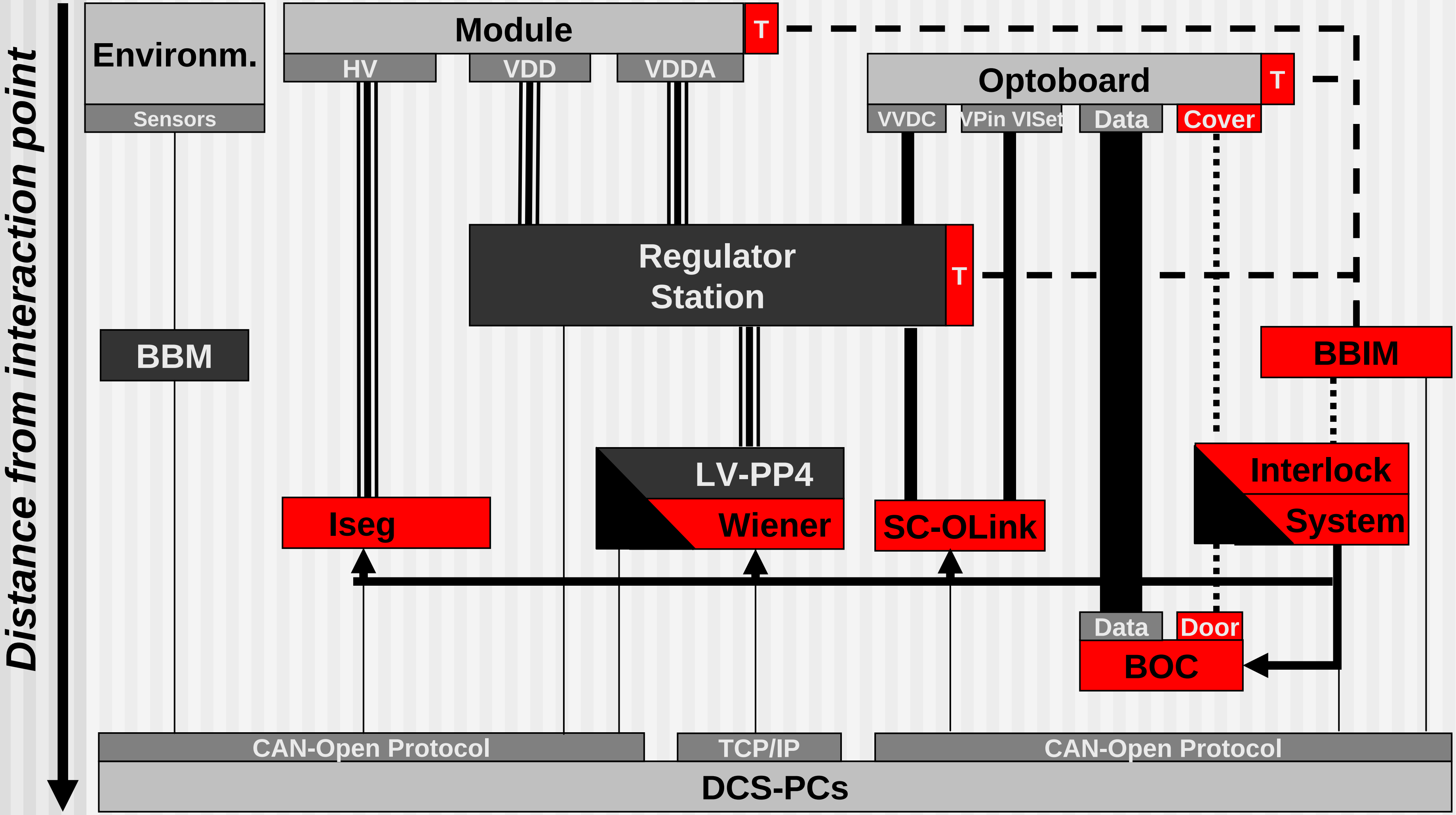


DCS Hardware: Environment



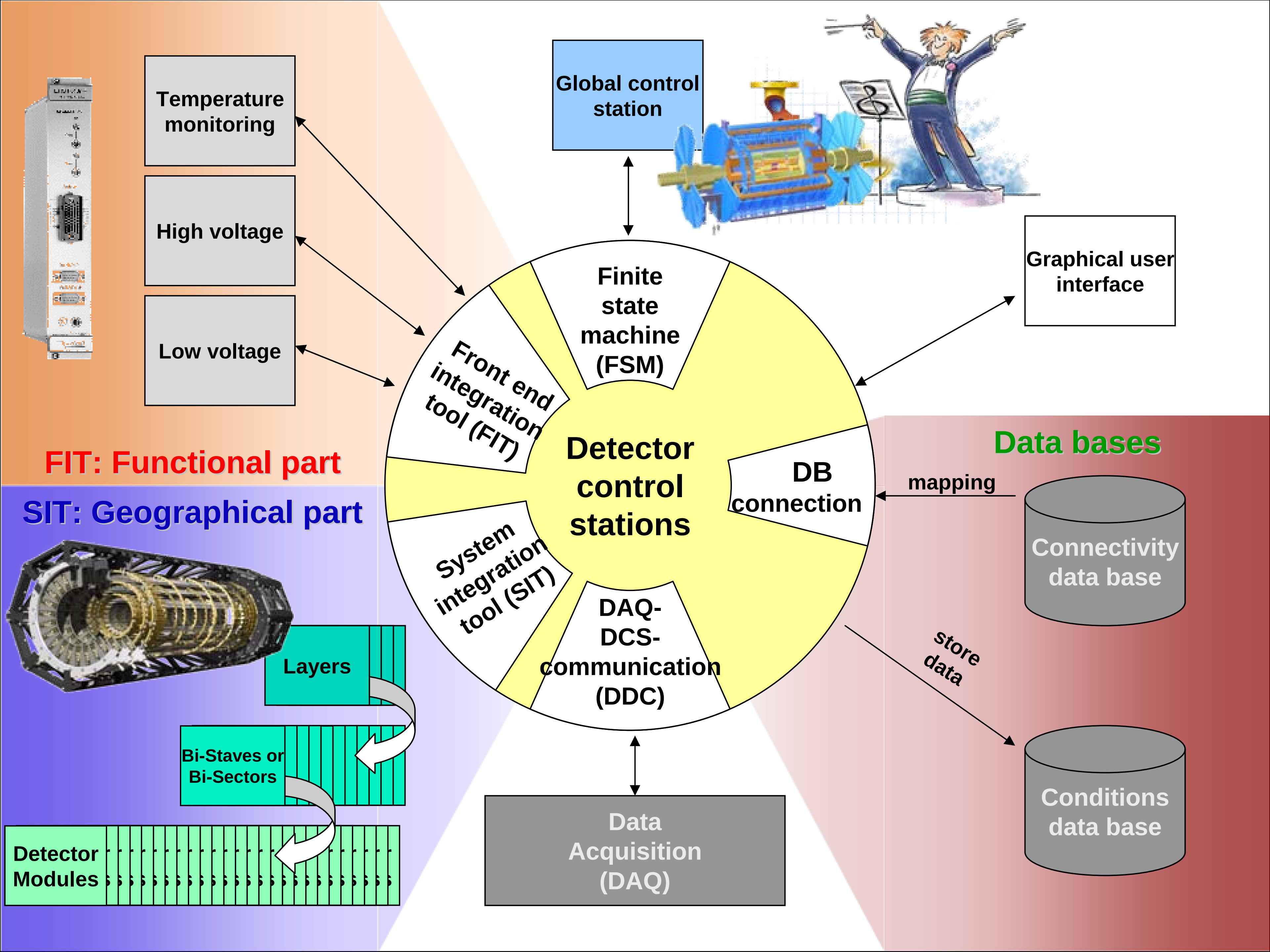
- **BBM and BBIM:**
  - Measurement of environmental parameters (temperature and humidity)
  - BBIM builds interlock signal

DCS Hardware: Interlock System



A 10% Setup

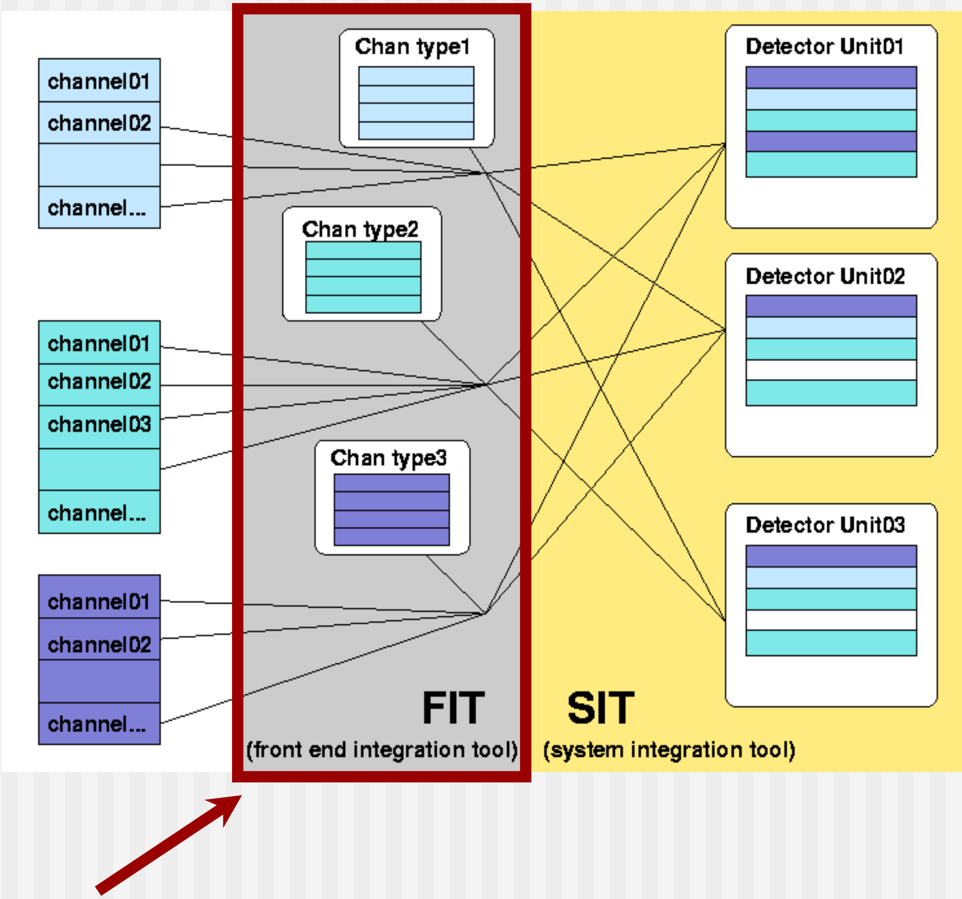
- At CERN a test setup was built to operate 10% of the final detector components in parallel.
- Setup was used over more than 8 months (incl. system extensions).
  - System-test to check compatibility of final components
  - Stepwise connectivity test of the full pixel detector
- All DCS components have been integrated into this setup.
- The control mechanism for the setup was identical to what will be used in the final detector.


Temperature monitoring
High voltage
Low voltage
FIT: Functional part
Global control station
Graphical user interface
Finite state machine (FSM)
Front end integration tool (FIT)
Detector control stations
DB connection
System integration tool (SIT)
DAQ-DCS-communication (DDC)
Data bases
mapping
Connectivity data base
store data
Conditions data base
SIT: Geographical part
Layers
Bi-Staves or Bi-Sectors
Detector Modules
Data Acquisition (DAQ)

FIT: Front-end Integration Tool

Integration, control and monitoring of the DCS hardware

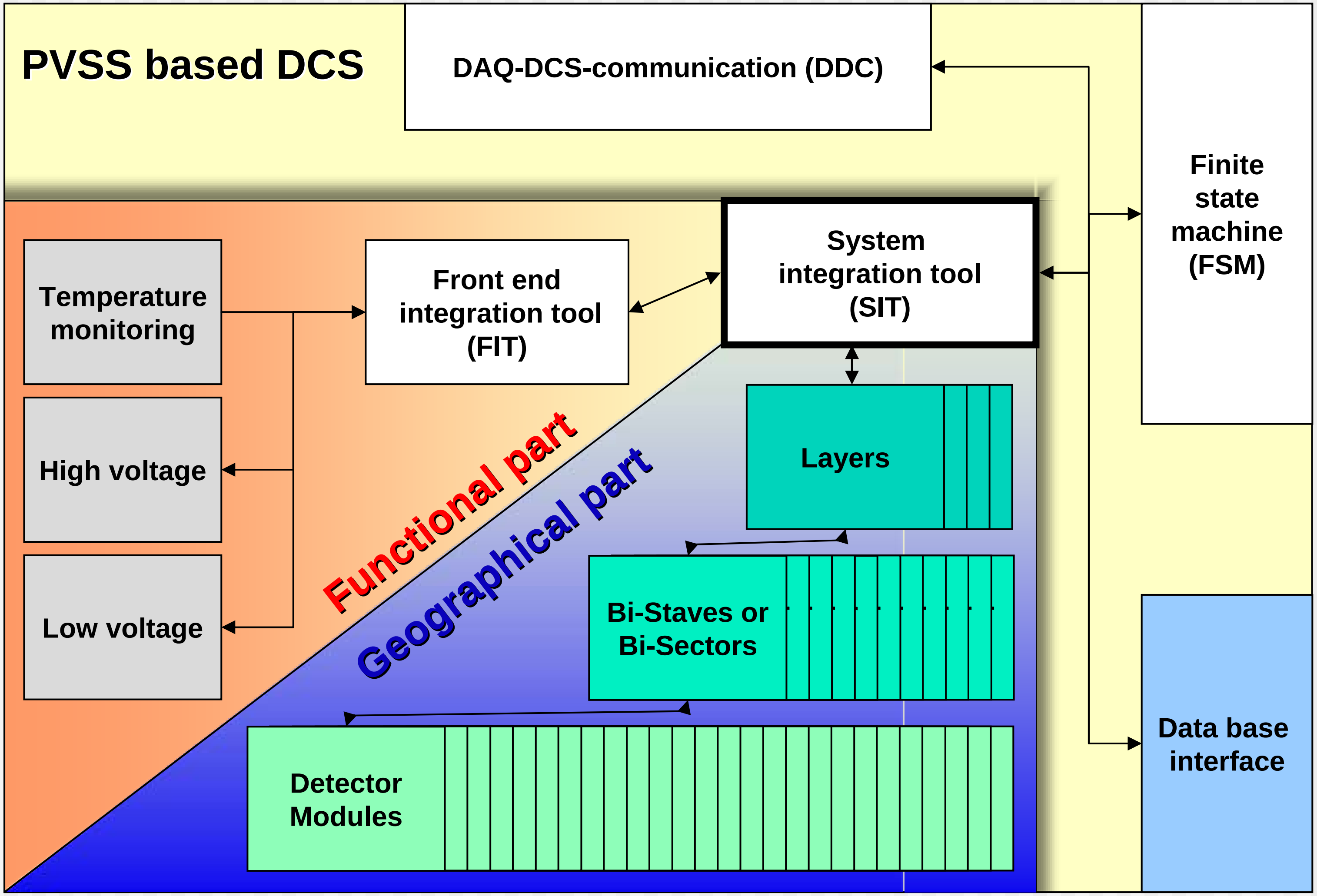
- Central management and administration of the hardware instances
- Creates data structure reflecting the different hardware
- Measurement of parameters of the hardware
- Offers special GUIs for administration and error handling



FIT: Experience

- 3 FITs exist:
  - Wiener power supplies
  - Iseg power supplies
  - ELMB (embedded local monitoring board)
    - Serving: BBIM, SC-Olink, Regulators, TBOC, and LV_PP4
- All DCS hardware can be integrated and managed for the complete system by the FITs
- The tools work safe and reliably
- The FITs have been used in the 10% setup intensively to integrate the hardware control into the DCS software package without problems. All hardware access is handled by the FIT.

SIT: System Integration Tool



SIT: Experience

- Virtual cabling of the detector inside the control software
  - The SIT loads the connectivity from the database which was frequently required during the connectivity tests and worked reliably
  - The data structure generated by the FIT (hardware data) is managed using “Aliases” (avoids data copies)
- The SIT offers GUIs where the user can monitor the different detector parts (and not the different power supplies, temperature sensors, etc.)
- The detector like structure of the aliases is the basis for the FSM (as control instance) and for the communication between the DAQ system and DCS (DDC).

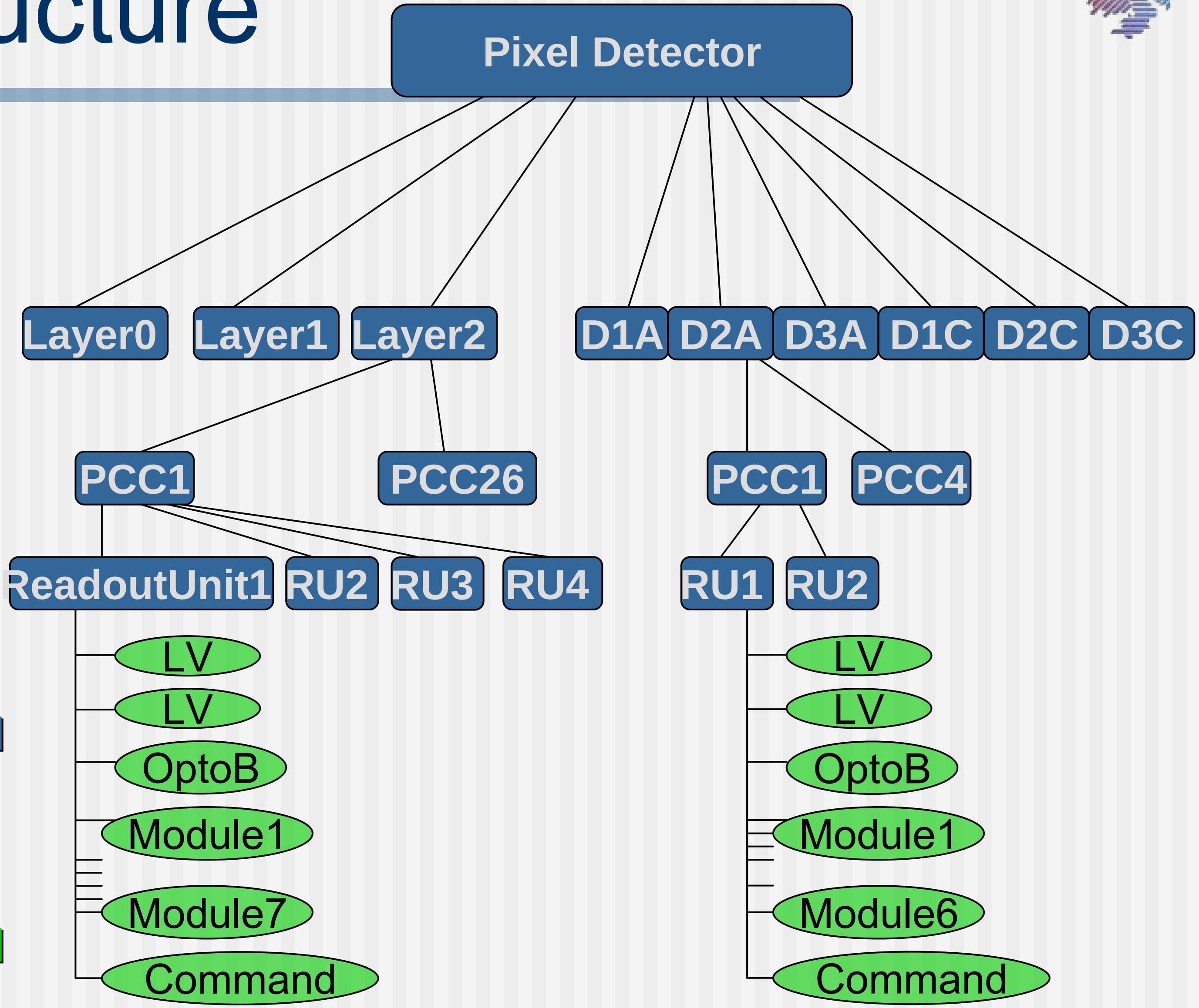
FSM: Finite State Machine

- To build an FSM one needs:
  - Objects
  - States
  - Commands
- Implementation of the hierarchical structure of the detector
  - Summarizes and evaluates the status of the detector
  - Allows for partitioning
  - Clear depiction
  - Simple handling
- STATEs used for the 10% setup:

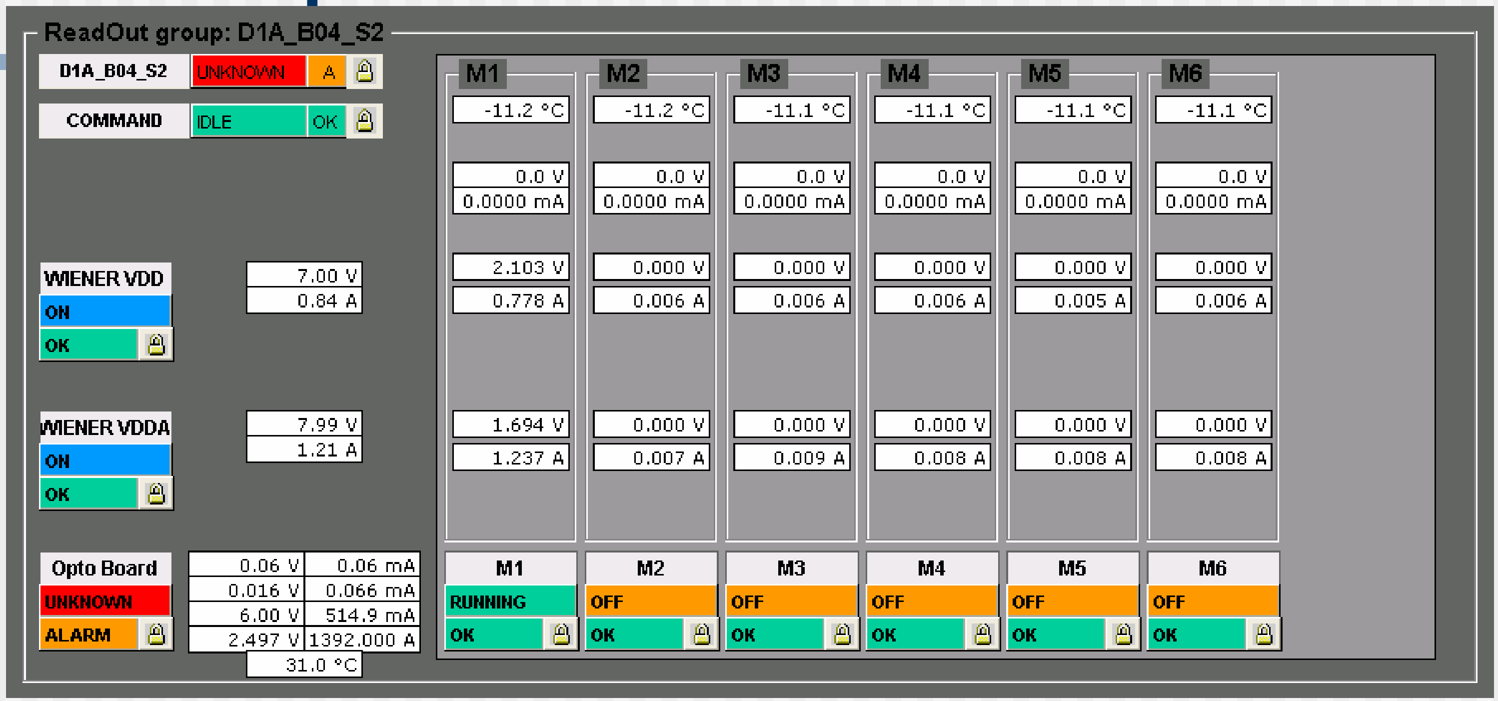
RUNNING	**READY / ON**	**NOT_READY**	**OFF**	**UNKNOWN**

FSM: Structure

- Control Units (CU) as dividing element
- Broken down into a detector like structure
- CU contain furthers CUs or Device Units (DU)
- Control Units: state is generated from states of children
- Device Units: state is generated from values



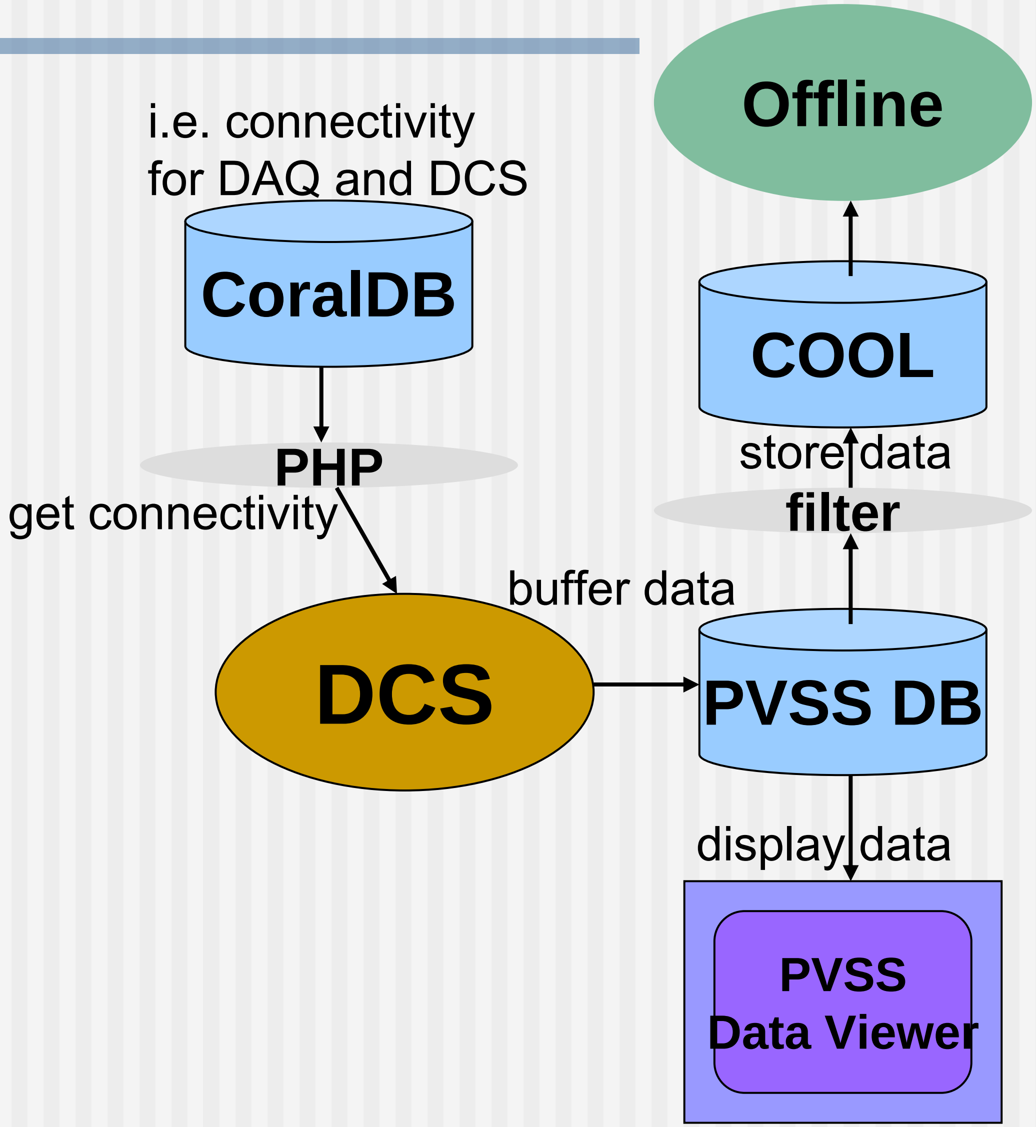
FSM: Experience



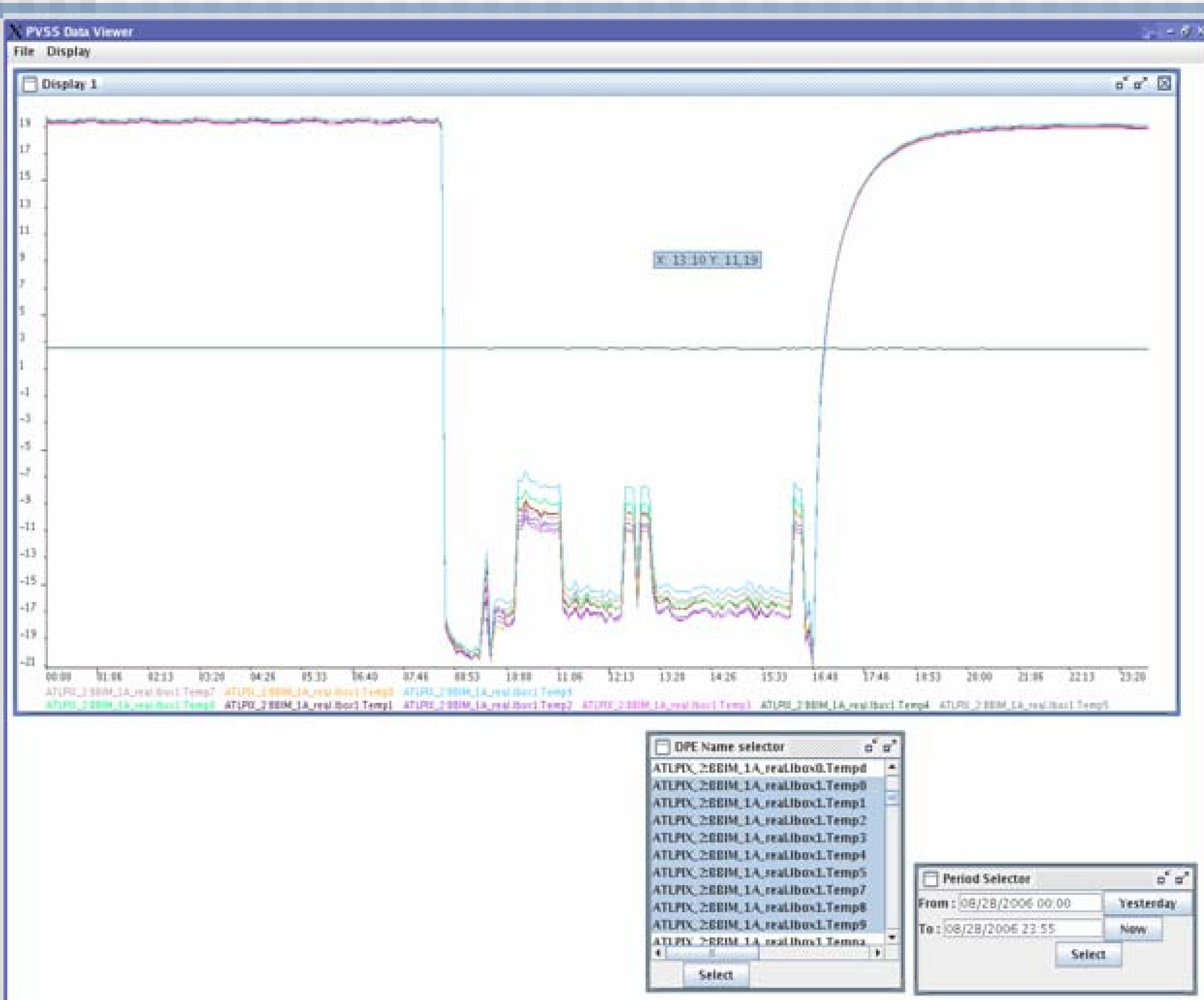
- The CPU load caused by the FSM was acceptable
- Experience in hardware control was gained (i.e. order of device switching): Device Unit “command” was introduced for this
- guarantees well-defined procedure
  - Avoids dangerous states of detector (Readout Group)
  - Avoids confusing situations for the operators

DB: Overview

- Oracle databases
- Used for connectivity data and for logging measured data
- Connectivity data is extracted using PHP program
- DCS measures values periodically and stores them into the PVSS DB
- These values are filtered into the offline DB (COOL) and can be accessed using a PVSS Data Viewer directly



DB: Data Viewer



- General purpose PVSS Data Viewer for displaying of condition data has been developed
- Extracts data
- Display and analysis
- Export in various formats
- Can access online and offline DB

DDC: **D**AQ **D**CS **C**ommunication

- Motivation:
  - DAQ needs to send commands to the DCS FSM
  - Tuning procedures for the optical link need interaction between DAQ and DCS
- As communication protocol DDC provided by ATLAS TDAQ is used

DDC: Overview

Detector Control System

Monitoring and Operation of Hardware

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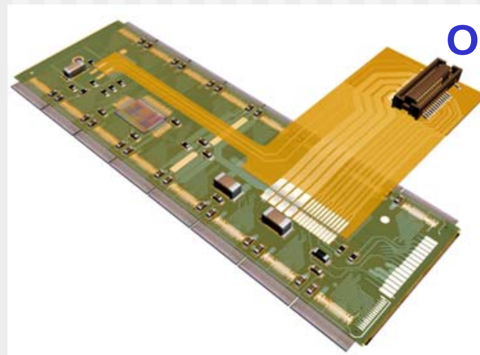
Voltages
Currents

Temperatures
Interlock



Data
Optical link

Data Aquisition

Interface

...

...

DDC: DCS-DAQ-Communication

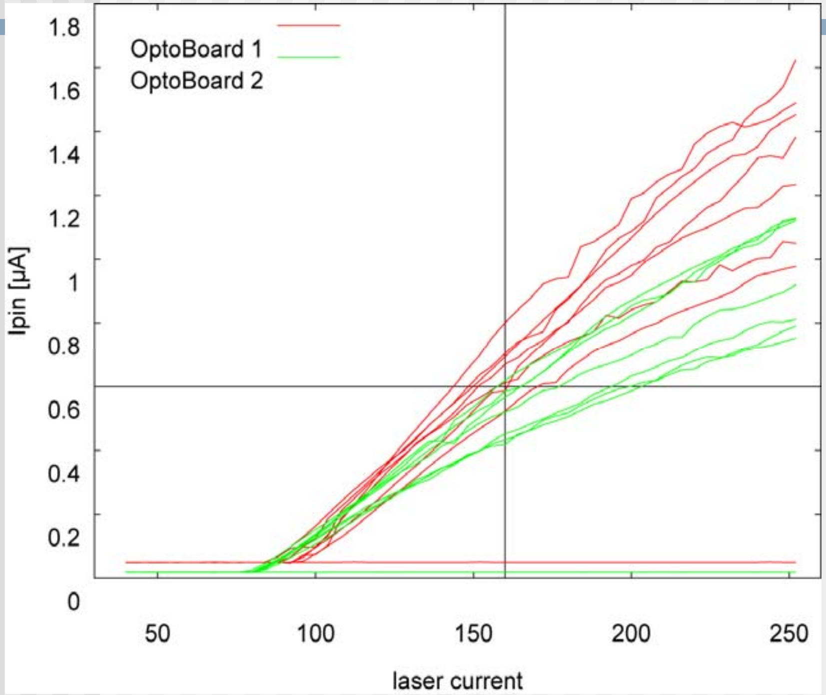
DDC (DCS)

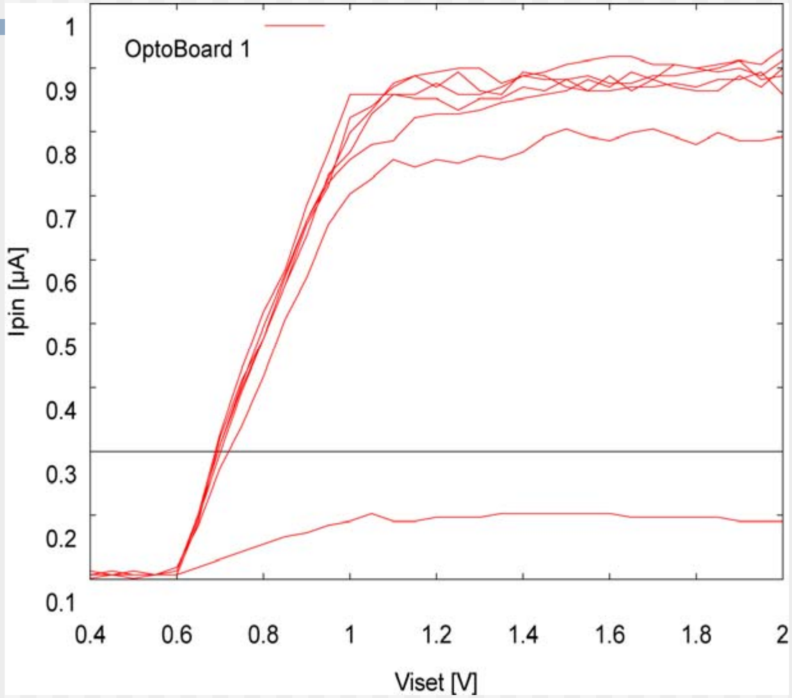
Commands: switch on, switch off
Set voltages, currents

Info: hardware status,
temperatures, currents, ...

DDC (DAQ)

DDC: Experience





- DDC realized the command transfer from DAQ to the DCS-FSM in the 10% setup successfully
- Optolink tuning and monitoring worked using DDC
- DDC on DCS side is capable of receiving 4000 commands per second

Summary

- The **D**etector **C**ontrol **S**ystem hardware and software were tested intensively in a 10% setup over more than 8 months
- **FIT** and **SIT** were proven to be solid tools for managing the hardware
- **FSM** was built according to the setup needs. It was intensively used by the shift crews. Useful experience for the FSM in ATLAS was gained
- Interfaces to the conditions and connectivity DB are close to the final versions and a Data Viewer has been developed
- **DDC** makes FSM commands and therefore detector operation available on DAQ side. Tuning algorithms for the optical link work using DDC.

Outlook

- Experience gained in 10% test finds its way into the design of the final system
- Hardware installation is to be finished
- FSM adoption to detector needs and structure is ongoing
- DDC performance studies for complete system have to prove the capabilities of this protocol for the final detector