Detector Control System for the AFP detector in ATLAS experiment at CERN

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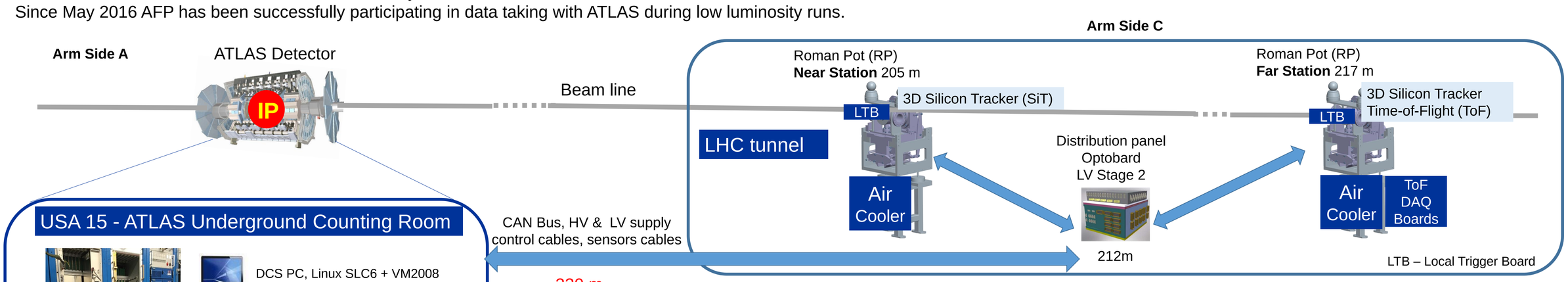
ATLAS Forward Proton (AFP) detector

The AFP detector, which aims at measuring momenta and angles of diffractively scattered protons, will consist of two Roman Pot (RP) stations located in the LHC tunnel at 205 m and 217 m from the Interaction Point (IP) and situated on each side of the ATLAS experiment. Two 3D Silicon Tracker detectors and Time-of-Flight detector will be installed on each side. This year, during the winter technical stop two Roman Pots with 3D Silicon detectors on side C were successfully installed and commissioned.
Since May 2016 AFP has been successfully participating in data taking with ATLAS during low luminosity runs.



DCS PC, Linux SLC6 + VM2008

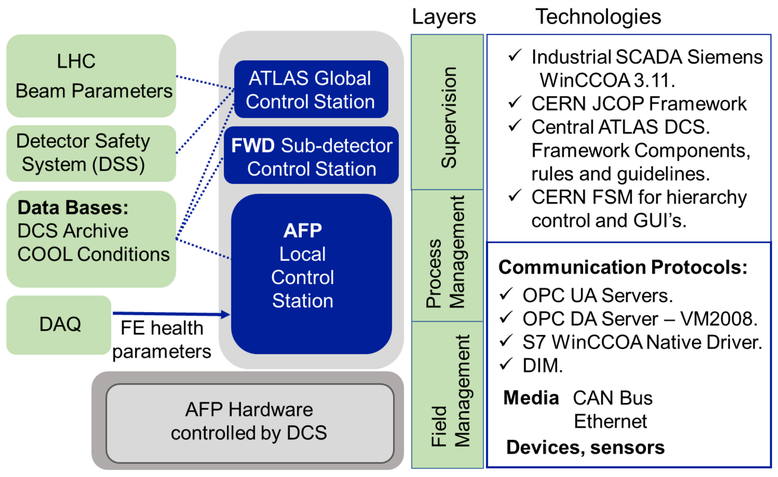
- ✓ RP movement and position monitoring
- ✓ Secondary Vacuum control
- ✓ Cooling control
- ✓ HV
- ✓ LV Stage1
- ✓ Optoboard Supply, CAN Bus Supply
- ✓ Temperature monitoring
- ✓ LV, HV Interlock system
- ✓ VME DAQ Crate

Based on radiation conditions in the tunnel, easy access and maintainability during the collider activity, only the necessary hardware, proven as radiation hard, is installed close to detector stations. All other equipment is located in the ATLAS underground counting room (USA15).
The detector infrastructure and necessary services are supervised by the Detector Control System (DCS).
Standard industrial solutions are used wherever possible, AFP DCS profits from experience of other ATLAS subdetectors: IBL and ALFA.
The main challenge is:
- ✓ A large variety of subsystems integrated within AFP DCS.
- ✓ Scattered detector hardware – distance between apparatus parts is 330 m.

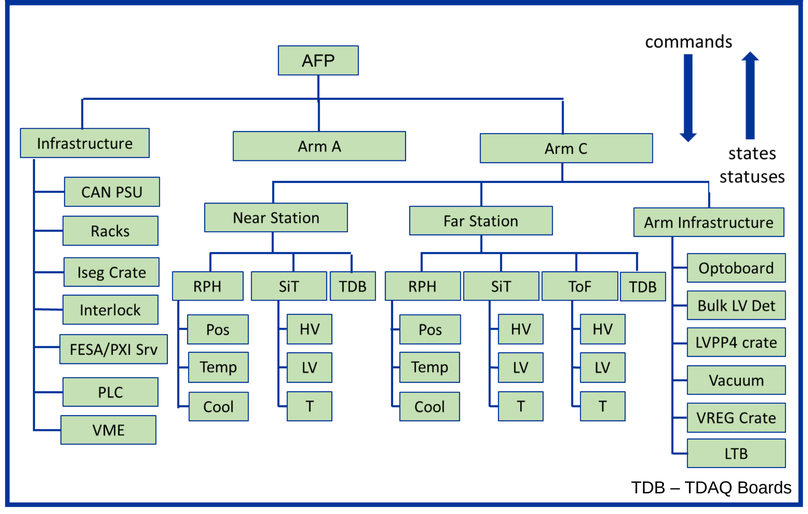
AFP Detector Control System (DCS)

DCS is responsible for coherent and safe operation of the detector:
- ✓ Provides tools for bringing the detector into desired operational state, monitors its parameters, signals any abnormal behavior and performs actions.
- ✓ Defined subset of detector parameters is stored in data bases for later inspections.
- ✓ Graphical user interfaces allow overall detector operation and visualization.

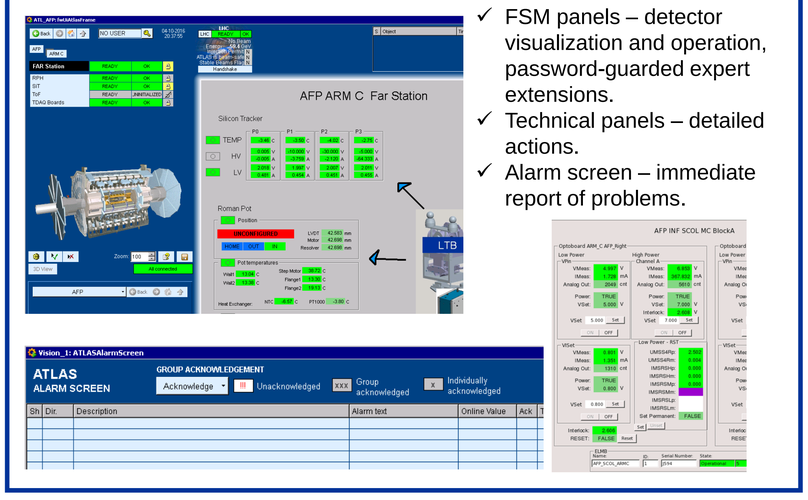
DCS Software structure and tools



AFP FSM Hierarchy



Graphical User Interfaces

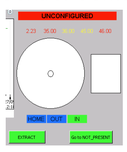


- ✓ FSM panels – detector visualization and operation, password-guarded expert extensions.
- ✓ Technical panels – detailed actions.
- ✓ Alarm screen – immediate report of problems.

AFP Hardware Subsystems

RP Positions and Movement

RP is inserted into the beam pipe only during stable beam. Movement control is done from the CERN Control Center.



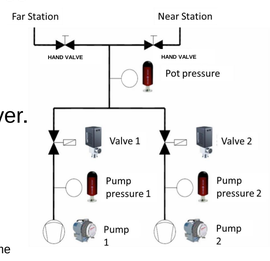
AFP DCS can only:
- ✓ Monitor RP position and status.
- ✓ Extract RP in case of emergency.
- ✓ Disable RP movement.

- ✓ PXI-FPGA NI based platform – motor operations.
- ✓ Front End Software Architecture (FESA) based. server – interface between PXI and LHC
- ✓ DIM protocol.
- ✓ No framework, FSM.

Secondary Vacuum

Reduces stress of thin RP window and prevents water condensation and icing of the detector, when temperature is below 0 degree

- ✓ Two pumps per arm.
- ✓ Control via PLC S1200.
- ✓ Ethernet based.
- ✓ S7 native WinCCOA driver.
- ✓ No framework, FSM.

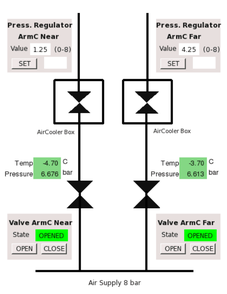


Pressure values from the pump side sensor vs time

Cooling

Vortex type air cooler:
- ✓ Precooling of input air in Air Cooler.
- ✓ Cooling with Vortex tube in RP.

- ✓ Control and monitoring with PLC S1200:
  - The same as for Vacuum.
  - Ethernet based.
- ✓ S7 native WinCCOA driver.
- ✓ No framework, FSM.



High Voltage

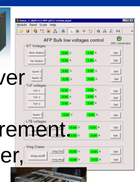
SiT: depletion voltage
ToF: photomultiplier supply

ISEG HV System:
- ✓ Crate: ECH 238
- ✓ Modules:
  - o EHS F405N.
  - o EHS F430N.

- ✓ CAN Control.
- ✓ ISEG OPC UA Server.
- ✓ JCOP Framework.
- ✓ FSM.

Low Voltage

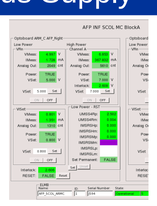
1st stage USA15:
- ✓ Wiener PL512
  Ethernet controlled, Wiener DA OPC server JCOP Framework, FSM.
- ✓ Splitting to 4 lines, precise current measurement. ELMB, CAN bus, CanOpen UA OPC server, ATLAS + AFP Framework, FSM.



2nd stage tunnel:
- ✓ Crate with radiation-hard Voltage Regulators.
- ✓ Non-standard firmware ELMB, CAN bus,
- ✓ CanOpen OPC UA server, no framework, FSM

Optobard Supply, CANbus Supply

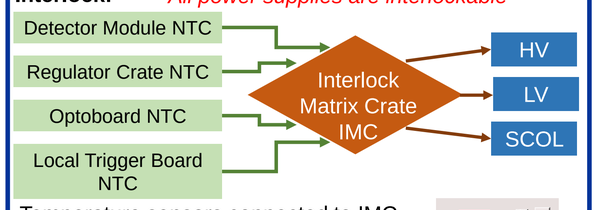
Optoboard supply (SCOL):
- ✓ 3 supply voltages
- ✓ ELMB, CAN bus,
- ✓ CanOpen OPC UA server
- ✓ ATLAS + AFP Framework, FSM



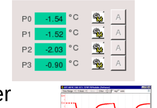
CAN bus supply:
- ✓ CAN supply of all ELMB-based devices
- ✓ ELMB, CAN bus, CanOpen UA OPC server
- ✓ ATLAS Framework, FSM

Temperature monitoring & Interlock

Interlock: *All power supplies are interlockable*

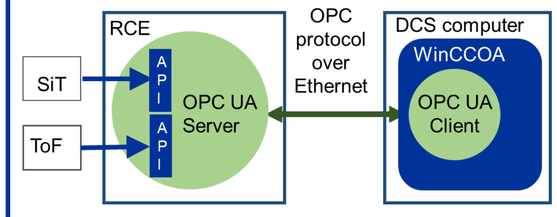


Temperature sensors connected to IMC
Crucial sensors – hardware interlock
Monitoring:
ELMB, CAN bus, CanOpen UA OPC server
ATLAS Framework, FSM



FE Health Parameters

FE chips parameters collected by DAQ and sent to DCS



OPC UA server embedded in RCE acquires health parameters via dedicated API's

ELMB – Embedded Local Monitor Board: multipurpose I/O system, widely used at CERN

AFP DCS Status, October 2016

- ✓ AFP DCS installed in January 2016 – operational during the installation in the tunnel, commissioning and first data taking
- ✓ Integrated with ATLAS DCS since June 2016
- ✓ It is growing together with the detector apparatus
- ✓ Operation of the detector with FSM and technical panels
- ✓ Crucial parameters guarded with alarms, e-mail/SMS notification for requested subset
- ✓ Hardware/software interlocks in place
- ✓ Reporting *AFP Safe for Beam* status

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Acknowledgements

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