

# The detector Control Systems for ATLAS Roman Pots

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- Detector Control System (DCS) definition
- WinCC OA – Tool to build the DCS
- ATLAS Roman Pots (ARP) detectors
- ARP DCS
  - Overview
  - Systems (HV, LV, Movement, etc)
  - Operation
  - Data and archiving
- Summary

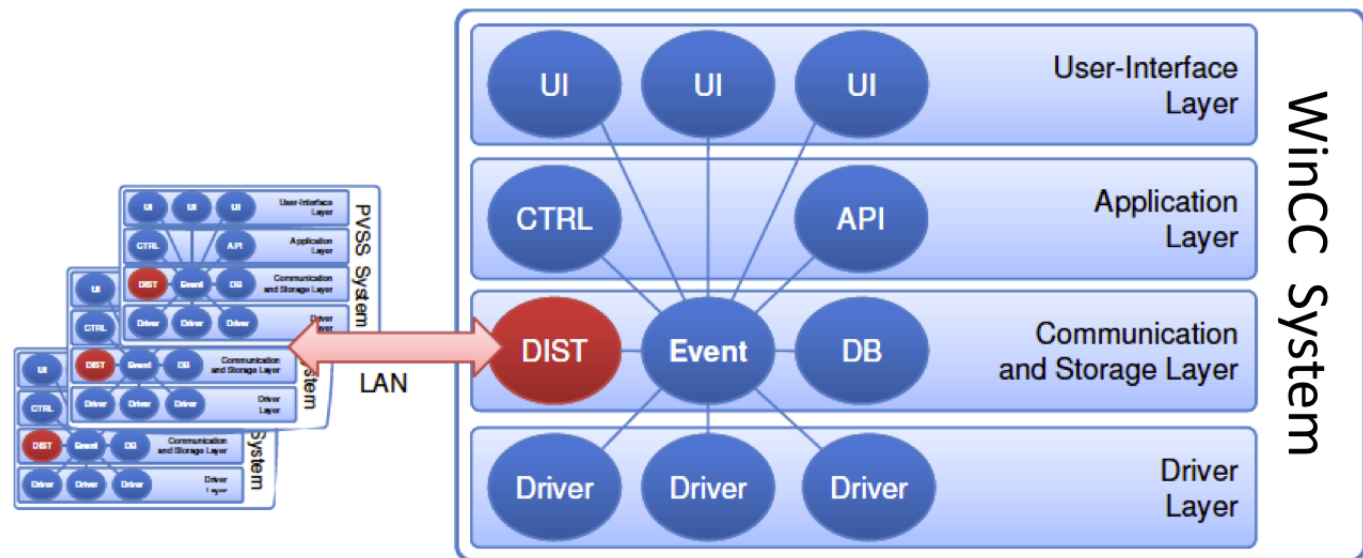
# What is the Detector Control System (DCS)?

**"Provides control and monitoring of the detector hardware and ensures the safe and reliable operation of the detector, assuring good data quality"**

- Should be able to bring the detector into any desired operational state
- Handle a large variety of equipment
- Handle an enormous number of individual channels
- Continuously monitor and archive the operational parameters
- Signal any abnormal behaviour to the operator
- Allow manual or automatic actions to be taken
- Handle the communication between the ATLAS sub-detectors
- Handle the communication to other independent systems:
  - LHC accelerator
  - CERN technical services
  - ATLAS magnets
  - Detector Safety System (DSS)
- Interface between operator and detector

# WinCC OA

- Supervisor Control and Data Acquisition (SCADA) system
- Commercial product from SIEMENS (previous PVSS)
- Tool to develop the DCS system for all LHC experiments
- Chosen by Joint Control Project (JCOP)
  - Standards for hardware components
  - Implementation policies
  - Back-End software
  - Operational aspects
- DCS software core is organized into a Project



# Console managers

## Control Manager

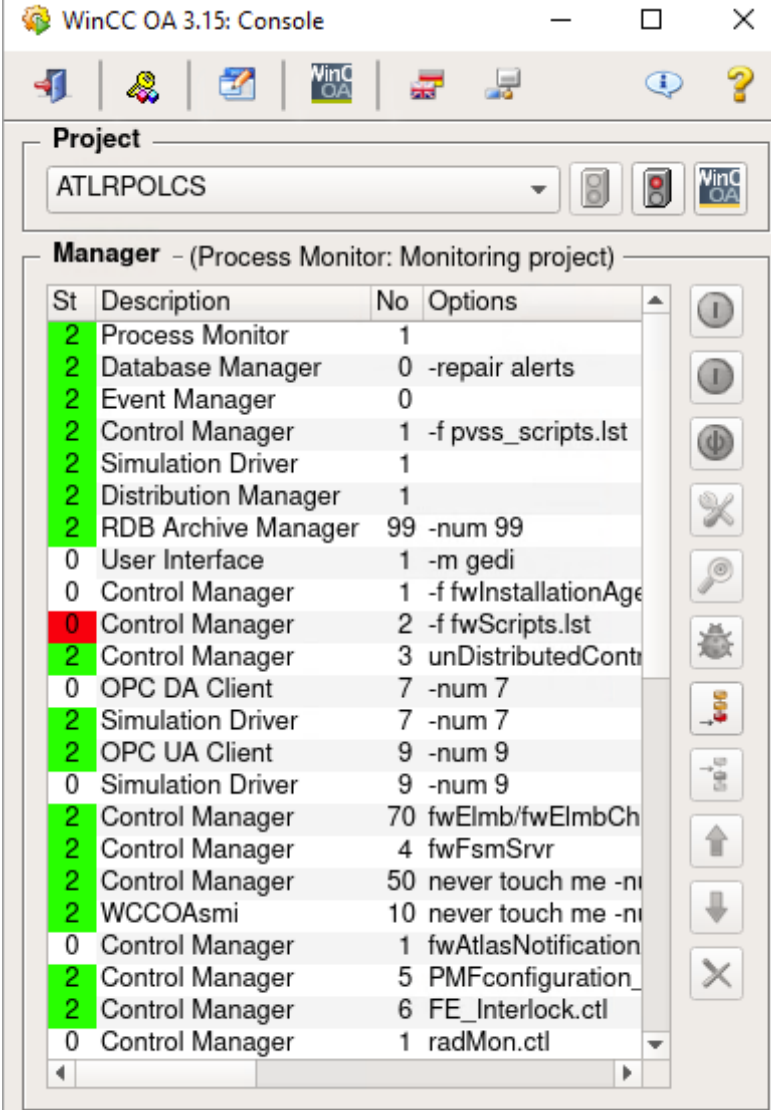
- Execute simple or complex scripts automatically
- Interpreter with syntax similar to C
- Scripts triggered on events
- Large library of functions

## API Manager

- Application Programming Interface (API)
- Allows to incorporate other compiled code
- All WinCC OA's own Managers are based on this API

## Driver Manager

- Communication protocol
- Standards Drivers
  - Open Platform Communications (OPC)
  - Distribution Information Management (DIM)
  - S7 (Programmable Logical Controller - PLC)
- Driver API for new drivers



The screenshot shows the WinCC OA 3.15: Console window. The 'Project' dropdown is set to 'ATLRPOLCS'. The 'Manager' section is titled '(Process Monitor: Monitoring project)'. It displays a table of managers with columns for 'St', 'Description', 'No', and 'Options'. The table contains 20 entries, with the first 10 rows highlighted in green and the 11th row highlighted in red.

St	Description	No	Options
2	Process Monitor	1	
2	Database Manager	0	-repair alerts
2	Event Manager	0	
2	Control Manager	1	-f pvss_scripts.lst
2	Simulation Driver	1	
2	Distribution Manager	1	
2	RDB Archive Manager	99	-num 99
0	User Interface	1	-m gedi
0	Control Manager	1	-f fwInstallationAge
0	Control Manager	2	-f fwScripts.lst
2	Control Manager	3	unDistributedCont
0	OPC DA Client	7	-num 7
2	Simulation Driver	7	-num 7
2	OPC UA Client	9	-num 9
0	Simulation Driver	9	-num 9
2	Control Manager	70	fwElmb/fwElmbCh
2	Control Manager	4	fwFsmSrvr
2	Control Manager	50	never touch me -n
2	WCCOAsmi	10	never touch me -n
0	Control Manager	1	fwAtlasNotification
2	Control Manager	5	PMFconfiguration_
2	Control Manager	6	FE_Interlock.ctl
0	Control Manager	1	radMon.ctl

# WinCC variables and alerts

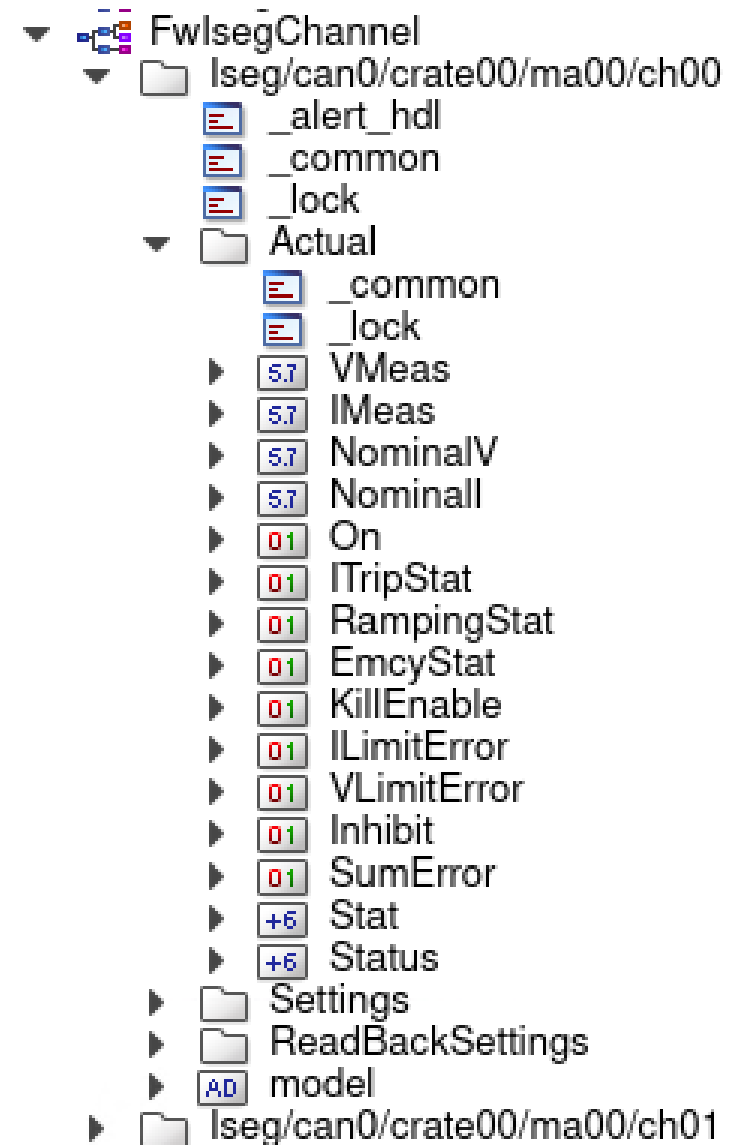
## Variables

- Variables organized in Data Points (DPs) composed of elements (DPEs):
- Emulates the hardware structure
- Configure addresses, alerts, archiving, etc

## Alerts

- Signals if a variable is outside of a predefined range or in a good range
- Represents the Status of a component
- Different levels:

- OK
- WARNING
- ERROR
- FATAL



# Graphical User Interface (panels)

- Monitor detector parameters
- Possible to execute tasks by user command
- Technical Panels:
  - Monitor/control detector sub-systems
  - Complex actions that require special monitoring
  - Additional information
  - System tests/debug
  - For expert use

**ATLAS AFP - Movement System**

FESA Alive

PXI Alive

**In Physics Flag**

ArmCfar	ArmCnear	ArmAnear	ArmAfar
NOT_IN Position	NOT_IN Position	NOT_IN Position	NOT_IN Position
Current Values Selected Position: 2.079 Range: 0.050	Current Values Selected Position: 3.326 Range: 0.050	Current Values Selected Position: 3.015 Range: 0.050	Current Values Selected Position: 2.471 Range: 0.050
New Values Position: 2.079 Range: 0.050	New Values Position: 3.326 Range: 0.050	New Values Position: 3.015 Range: 0.000	New Values Position: 2.471 Range: 0.000
Force OUT: FALSE Force IN: FALSE	Force OUT: FALSE Force IN: FALSE	Force OUT: FALSE Force IN: FALSE	Force OUT: FALSE Force IN: FALSE
Use Current Position	Use Current Position	Use Current Position	Use Current Position
Apply Position	Apply Position	Apply Position	Apply Position

ArmCfar	ArmCnear	ArmAnear	ArmAfar
WAITING FOR COMMANDS	WAITING FOR COMMANDS	WAITING FOR COMMANDS	WAITING FOR COMMANDS
LVDT: 42.826	LVDT: 42.330	LVDT: 40.585	LVDT: 41.778
Motor: 42.941	Motor: 42.314	Motor: 40.671	Motor: 41.478
Resolver: 42.941	Resolver: 42.314	Resolver: 40.671	Resolver: 41.478
IN HOME OUT	IN HOME OUT	IN HOME OUT	IN HOME OUT

**Mismatch**

Mismatch threshold	Limit	Home	Mvt	ARM A FAR	ARM A NEAR	ARM C NEAR	ARM C FAR	ALERTS
0.500	0.900	0.900		LVDT/MOTOR	LVDT/MOTOR	LVDT/MOTOR	LVDT/MOTOR	Active/Not Active
NEW threshold				RESOLVER/MOTOR	RESOLVER/MOTOR	RESOLVER/MOTOR	RESOLVER/MOTOR	

Set New

CLOSE

**ATLAS ALFA - Vacuum and ventilation Monitoring**

FAN S8-B7L1 ON

FAN S8-A7L1 ON

VAV ALIVE

Sector 8-1

RP side 14.39 mBar

MODE S8-1

- Alternate SET
- Both SET
- Pump1 SET
- Pump2 SET
- Manual SET

VALVE2 S8-1

Mode AUTO

State CLOSED

OPEN CLOSE

Pump side 1264.81 mBar

PUMP2 S8-1

Mode AUTO

State STOPPED

ON OFF

VALVE1 S8-1

Mode AUTO

State CLOSED

OPEN CLOSE

Pump side 286.51 mBar

PUMP1 S8-1

Mode AUTO

State STOPPED

ON OFF

VALVE2 S1-2

Mode AUTO

State CLOSED

OPEN CLOSE

Pump side 12.41 mBar

PUMP2 S1-2

Mode AUTO

State STOPPED

ON OFF

VALVE1 S1-2

Mode AUTO

State CLOSED

OPEN CLOSE

Pump side 1049.01 mBar

PUMP1 S1-2

Mode AUTO

State STOPPED

ON OFF

Sector 1-2

RP side 16.00 mBar

FAN S1-A7R1 ON

FAN S1-B7R1 ON

MODE S1-2

- Alternate SET
- Both SET
- Pump1 SET
- Pump2 SET
- Manual SET

VALVE2 S1-2

Mode AUTO

State CLOSED

OPEN CLOSE

Pump side 12.41 mBar

PUMP2 S1-2

Mode AUTO

State STOPPED

ON OFF

VALVE1 S1-2

Mode AUTO

State CLOSED

OPEN CLOSE

Pump side 1049.01 mBar

PUMP1 S1-2

Mode AUTO

State STOPPED

ON OFF

# Graphical User Interface (panels)

- Monitor detector parameters
- FSM Panels:
  - Display only essential information during data taking
  - No actions available/visible for non-expert

The screenshot displays a control interface for the ATLAS Roman Pot system, organized into four main sections corresponding to different stations: ARM C, AFP, ARM A, and Far Station. Each station section contains several sub-panels:

- Roman Pot:** Shows movement status (e.g., "WAITING FOR COMMANDS"), LVDT and Motor positions, Resolvers, and switches for IN, HOME, OUT, Pot Temp, and Cooling.
- Silicon Tracker:** Displays temperature (T [C]), HV [V], HV [uA], and LV [V] data for four channels (P0, P1, P2, P3).
- Time of Flight (TOF):** Shows TOF Temp, HV, and LV parameters.
- TDAQ LTB:** Displays Temperature and Power Supply status.
- Infr Arm C/A:** Shows LV Crate, VREG Crate, VLDB, LTB LV, and Vacuum status.
- Infrastructure:** Displays PLC, Racks, and DAQ Crate status.
- TDAQ LTB (bottom):** Shows Temperature and Power Supply status.

At the bottom, there are global status indicators for "Pulsar" (OFF), "Safe for beam?" (Safe for Beam), "Override KEY" (NO), and "Trigger" (TOF\_DTM).

The screenshot shows a detailed view of the ATLAS ALFA - Roman Pots Control System. It features four main Roman Pot sections: ALFA B2 (7L1), ATLAS B2 (1L1), ALFA B1 (7R1), and ATLAS B1 (1R1). Each section includes:

- Positioning Diagrams:** Shows the horizontal (H-x) and vertical (V-y) positions of the Roman Pot in micrometers (um).
- BPMs (Beam Position Monitors):** Displays H-x and V-y coordinates for ALFA and ATLAS BPMs.
- Resolution and Motor Data:** Shows Resolver and Motor values for each Roman Pot.
- LVDT and L-M Status:** Displays LVDT positions and L-M (Left-Middle) status.
- Control Elements:** Includes buttons for IN, OUT, HOME, AC, and cooling/heating indicators.

At the bottom, there are sections for "BIS" (Beam Instrument System) status, "SECTOR 8-1" and "SECTOR 1-2" Roman Pot status (e.g., RP1, RP2, RP3, RP4, RP5, RP6, RP7, RP8), "SERVERS" status (PLC, FESA, MARATHON, VME, MB Monitor, ISEG), and "INFRASTRUCTURE" status (CAN/ELMB, MarathonLV, Vac.Ventil, VMecrate, ISEGcrate). A "Movement" section shows "Motors READY".



# Graphical User Interface (panels)

### ATLAS ALFA - Roman Pots Control System

## ATLAS ALFA - Sector 8-1 Station A7L1

### RP3 (A7L1U) READY

Front-End	ON
PMF	CONFIGURED
HV	READY
Movement	HOME

### ATLAS ALFA - RP3 Motherboard parameters

MONITORING ENABLED

Monitor Alive

### RP4 (A7L1) READY

Front-End	ON
PMF	CONFIGURED
HV	READY
Movement	HOME

### RP3 HV monitoring

MAPMT MD settings  
V set 900 V  
I Trip 500 uA

MAPMT OD settings  
V set 900 V  
I Trip 500 uA

### ATLAS ALFA - RP3 PMF configuration

AlfaCarBus0/ELMB\_1 OPERATIONAL OK

### Motherboard monitoring

RP3 ON OK 6.13 V 9.57 A  
ON OK 7.56 V 1.02 A

3V3 PMF 3.12 V 1600.7 mA  
1V2 COR 1.22 V 136.2 mA

GOL 5.3 mA TTC-RX 32.0 mA

1 VCC-IO 2V5 412.0 mA  
1 VCC-IO 3V3 630.5 mA

### ATLAS ALFA - RP3

MOTHERBOARD / DETECTOR PARAMETERS

3V3 PMF	3.12 V	1600.7 mA	Row1 ALFA-R	2.46 V	525.1 mA	MAROC	3.44 V	492.2 mA	
1V2 COR	1.22 V	136.1 mA	Row2 ALFA-R	2.49 V	630.0 mA	MAROC	3.43 V	604.9 mA	
GOL	5.3 mA	TTC-RX	32.0 mA	Row3 ALFA-R	2.50 V	546.1 mA	MAROC	3.43 V	600.1 mA
1 VCC-IO 2V5	412.1 mA		Row4 ALFA-R	2.48 V	692.8 mA	MAROC	3.44 V	613.7 mA	
1 VCC-IO 3V3	630.6 mA		Row5 ALFA-R	2.49 V	714.3 mA	MAROC	3.43 V	605.9 mA	

### Layer 10V

ON STABLE  
Vmeas 900.00 V  
Imeas 358.87 uA

### Layer OD3

ON STABLE  
Vmeas 800.01 V  
Imeas 317.18 uA

### Layer 8V

ON STABLE  
Vmeas 900.01 V  
Imeas 359.90 uA

### Layer 9V

ON STABLE  
Vmeas 900.00 V  
Imeas 358.41 uA

### Layer 6V

ON STABLE  
Vmeas 899.99 V  
Imeas 358.60 uA

### Layer 7V

ON STABLE  
Vmeas 900.01 V  
Imeas 359.14 uA

### Layer 4V

ON STABLE  
Vmeas 900.00 V  
Imeas 357.82 uA

### Layer 5V

ON STABLE  
Vmeas 900.01 V  
Imeas 358.44 uA

### Layer 2V

ON STABLE  
Vmeas 900.00 V  
Imeas 358.15 uA

### Layer 3V

ON STABLE  
Vmeas 900.01 V  
Imeas 358.69 uA

### LED / Trigger

LED mode DISABLED  
Latency CONFIGURED  
Bias Step 255  
Pulse width  
Trigger Logic  
Trigger Rate 0 Hz

### PMF configuration

MD Gains EQUALIZED  
Threshold 7

Trigger 1 Gains M1 37 OL1 38  
Threshold 8

Trigger 2 Gains M2 39 OL2 40  
Threshold 8

### HIGH VOLTAGE

HV READY OK

MAPMT MD settings  
V set 900 V I Trip 500 uA

MAPMT OD settings  
V set 800 V I Trip 500 uA

Trigger PMT settings  
OL - Vset 950 V Itrip 500 uA  
MD - Vset 1100 V Itrip 500 uA

### POT MOVEMENT

DISABLED

Mvt Control HOME OK

Top 41.96 mm Bottom -42.50 mm X1 ALIVE

### BIS

User P B1 B2  
Inj. P T T  
Dev. Allow T

### SERVERS

PLC VME ALIVE

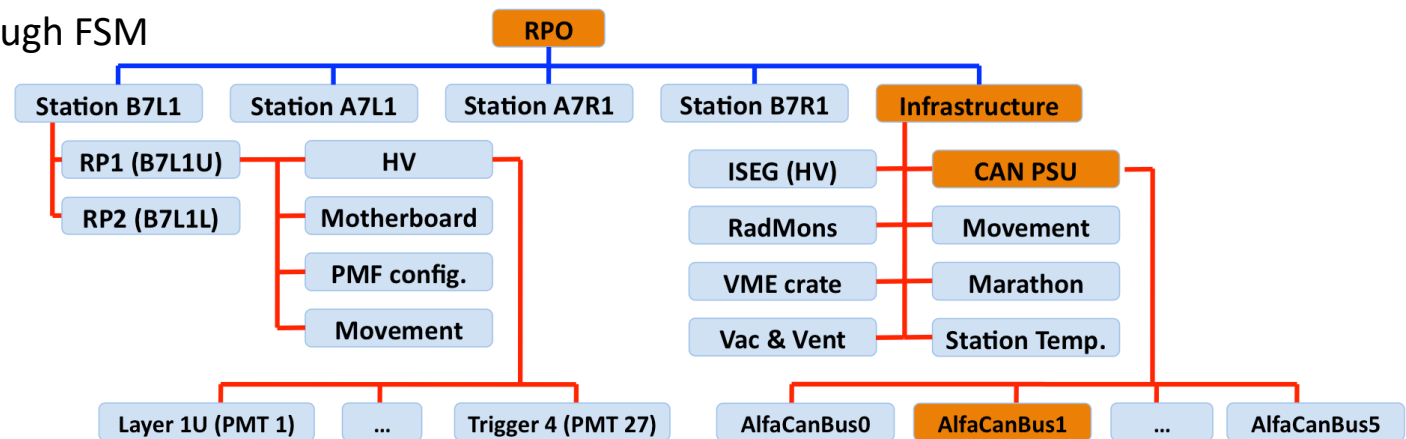
# Finite State Machine (FSM)

- Abstract representation of an experiment
- Monitor and control a huge number of parameters
- DCS Front-End (FE) correspond to FSM Device Units:
  - Calculate States based on detector components states
  - Calculate Status based on alarms
  - Commands setup for detector operation
- DCS Back-End (BE) is mapped onto a hierarchy of FSM elements (Control and Logical Units)
  - State/Status based on children's State/Status
- States and status are propagated upwards
- Commands are propagated downwards
- Main detector operation through FSM

RPO	NOT_READY	ERROR	🔒
B7L1	SHUTDOWN	ERROR	🔒
A7L1	SHUTDOWN	OK	🔒
A7R1	SHUTDOWN	OK	🔒
B7R1	SHUTDOWN	OK	🔒
Infrastructure	NOT_READY	ERROR	🔒
CONFIGS	READY	OK	✓
Physics Position	READY	OK	✓
Latency	READY	OK	✓

CAN	NOT_READY	ERROR	🔒
PSU_bus	READY	OK	🔒
AlfaCanBus0	READY	OK	🔒
AlfaCanBus1	SHUTDOWN	ERROR	🔒
AlfaCanBus2	READY	OK	🔒
AlfaCanBus3	READY	OK	🔒
AlfaCanBus4	READY	OK	🔒
AlfaCanBus5	READY	OK	🔒



# Finite State Machine (FSM)

Back Home NO USER 19-10-2022 14:33:17

**FWD**

RPO	READY	OK	🔒
B7L1	SHUTDOWN	OK	🔒
A7L1	READY	OK	🔒
A7R1	READY	OK	🔒
B7R1	READY	OK	🔒
Infrastructure	READY	OK	🔒
CONFIGS	READY	OK	✓
Physics Position	READY	OK	✓
Latency	READY	OK	✓



Zoom: 100

3D View All connected

RPO Absolute Luminosity For Atlas Detector Control System

ALFA READY OK 🔒

RP1 (B7L1U)	SHUTDOWN	OK	🔒	TRACKING	25 PMF
RP2 (B7L1L)	SHUTDOWN	OK	🔒	TRACKING	25 PMF
RP3 (A7L1U)	READY	OK	🔒	TRACKING	0 PMF
RP4 (A7L1L)	READY	OK	🔒	TRACKING	0 PMF
RP5 (A7R1U)	READY	OK	🔒	TRACKING	0 PMF
RP6 (A7R1L)	READY	OK	🔒	TRACKING	0 PMF
RP7 (B7R1U)	READY	OK	🔒	TRACKING	0 PMF
RP8 (B7R1L)	READY	OK	🔒	TRACKING	0 PMF
Infrastructure	READY	OK	🔒		

LHC READY OK AFP ALFA LUCID ZDC

Injection Probe Beam Energy 450.0 GeV Injection Permit Y ATLAS & beam-safe Stable beams flag N Go to Handshake

C OK A OK INF OK

Object Time 0

W E F D U

## ATLAS ALFA - Roman Pots Control System

ALFA B2 (7L1)



ATLAS B2 (1L1)



ALFA BPMs

H-x	12 um
V-y	24 um
H-x	35 um
V-y	-2 um

ATLAS BPMs

H-x	-152 um
V-y	-3202 um
H-x	440 um
V-y	-3335 um

ATLAS B1 (1R1)



ALFA B1 (7R1)



Range 3000 um

Resolver	41.290	R-M 0.00	Resolver	41.968	R-M 0.00	Resolver	42.073	R-M 0.00	Resolver	40.437	R-M 0.00
Motor	41.290		Motor	41.968		Motor	42.073		Motor	40.437	
LVDT	41.239	L-M -0.05	LVDT	41.959	L-M -0.01	LVDT	42.046	L-M -0.03	LVDT	40.454	L-M 0.02
44.347	43.602	36.000	45.000	45.000	35.500	45.000	45.000	35.500	45.000	45.000	35.500
35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000
35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000
RP1	OUT	HOME	RP3	OUT	HOME	RP5	OUT	HOME	RP7	OUT	HOME
IN	AC	IN	IN	AC	IN	IN	AC	IN	IN	AC	IN
35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000
36.000	36.000	36.000	35.500	35.500	35.500	35.500	35.500	35.500	35.500	35.500	35.500
42.974	42.974	42.974	45.000	45.000	45.000	45.000	45.000	45.000	45.000	45.000	45.000
LVDT	40.742	L-M -1.46	LVDT	42.504	L-M -1.54	LVDT	43.064	L-M -1.35	LVDT	43.478	L-M -1.56
Motor	39.287		Motor	40.965		Motor	41.711		Motor	41.917	
Resolver	39.155	R-M 0.13	Resolver	42.515	R-M -1.55	Resolver	42.605	R-M -0.89	Resolver	43.256	R-M -1.34

BIS

User P: F F T T Inj. P: T T Dev. Allow T

Notification

SECTOR 8-1

RP1 (B7L1U)	SHUTDOWN	OK	🔒
RP2 (B7L1L)	SHUTDOWN	OK	🔒
RP3 (A7L1U)	READY	OK	🔒
RP4 (A7L1L)	READY	OK	🔒

SECTOR 1-2

RP5 (A7R1U)	READY	OK	🔒
RP6 (A7R1L)	READY	OK	🔒
RP7 (B7R1U)	READY	OK	🔒
RP8 (B7R1L)	READY	OK	🔒

SERVERS

PLC PXI FESA MARATHON VME MB Monitor ISEG

INFRASTRUCTURE READY OK 🔒

CAN / ELMB	READY	OK	🔒
MarathonLV	READY	OK	🔒
Vac_Ventil	READY	OK	🔒
VMEcrate	READY	OK	🔒
ISEGcrate	READY	OK	🔒

Movement

Motors READY

Luis Seabra

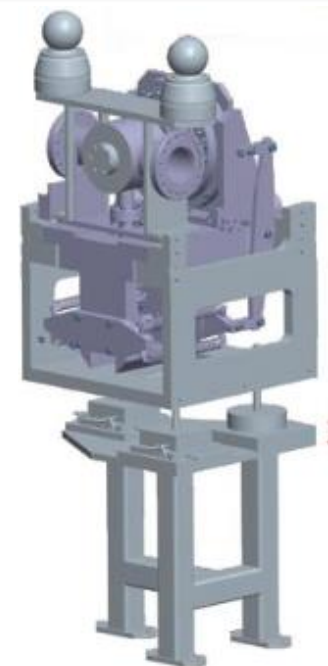
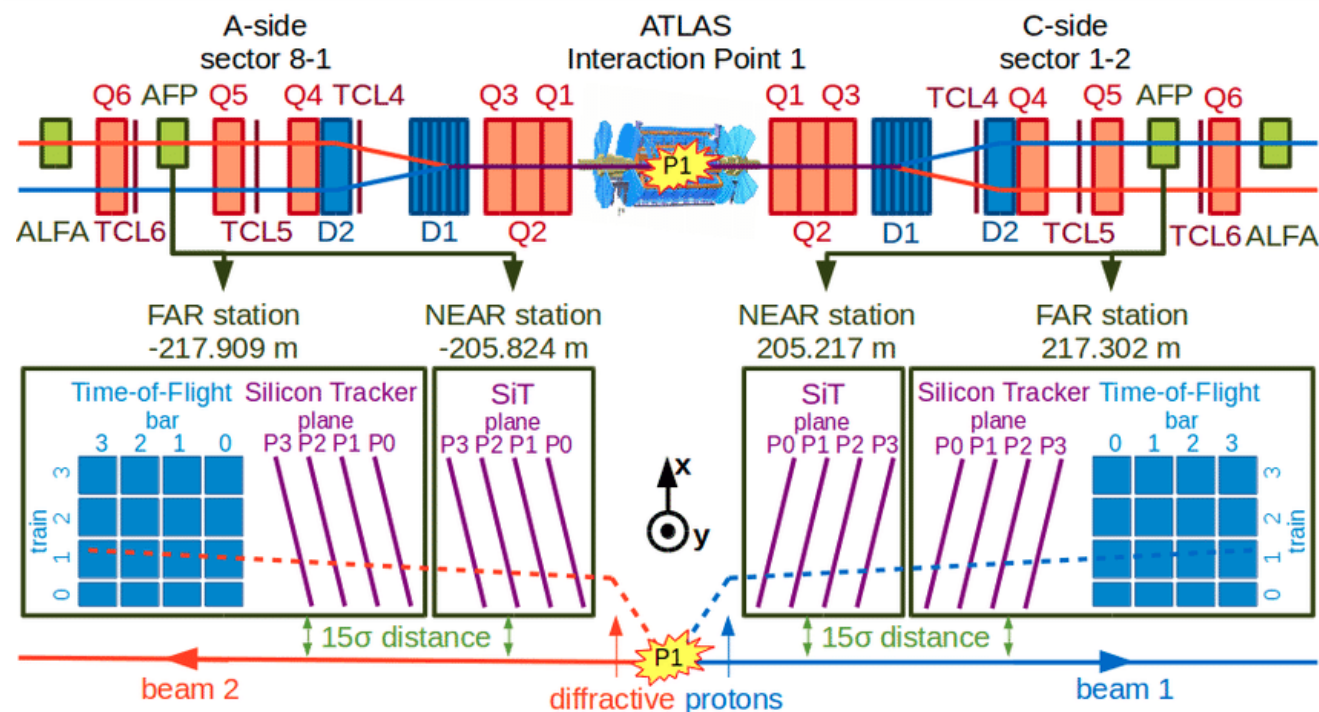
The detector Control Systems for ATLAS Roman Pots - LIP Seminar, 20<sup>th</sup> October 2022

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$$\text{ARP} = \text{ALFA} + \text{AFP}$$

- “Similar” detectors
- People working on both detectors
- LIP responsibility in Forward DCS:
  - Full responsibility in ALFA
  - Deputy in AFP (Movement, Vacuum and cooling systems)

# ATLAS Forward Protons (AFP)

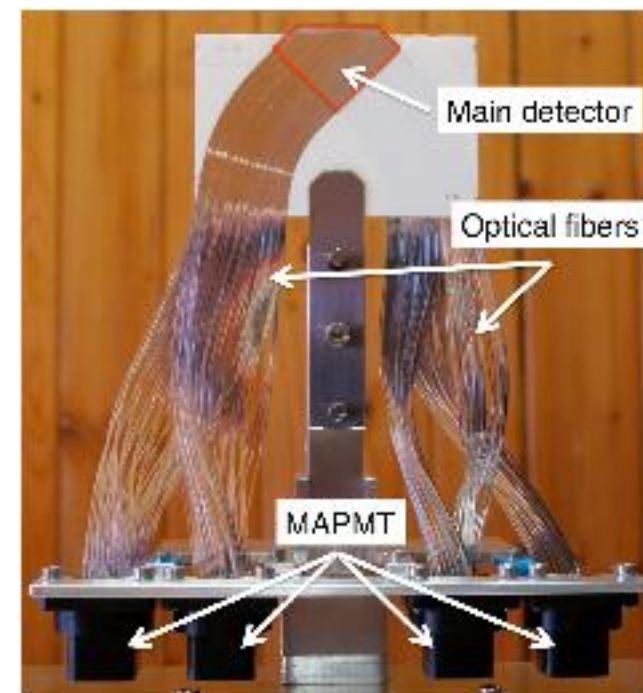
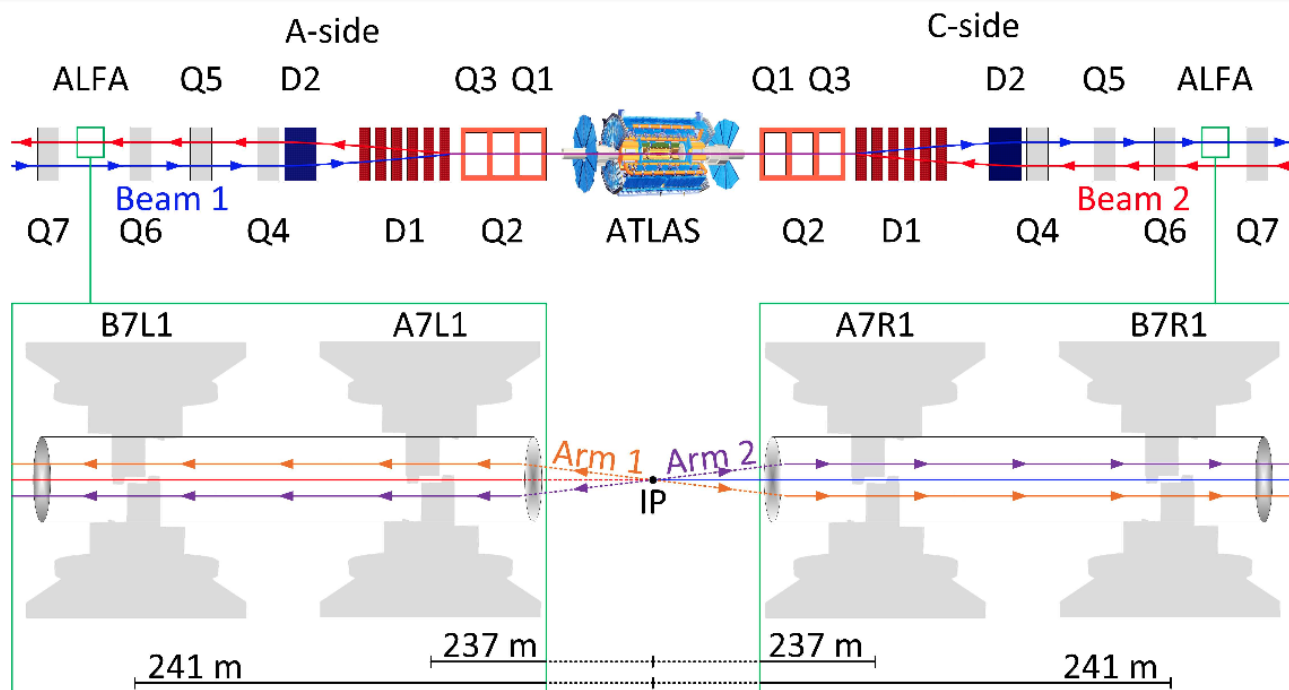


- Sub-detector of the ATLAS experiment
- Tracking (SiT) + Timing (ToF) detector
- SiT with 4 silicon sensors planes in each station
- ToF with 44 L shape Quartz bars readout by PMT in FAR stations only
- Both detectors inside a Roman Pot
- Independent horizontal movement

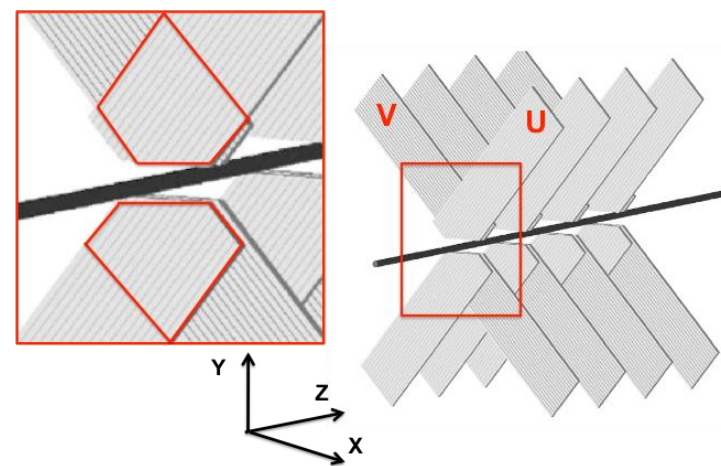




# Absolute Luminosity For ATLAS (ALFA)



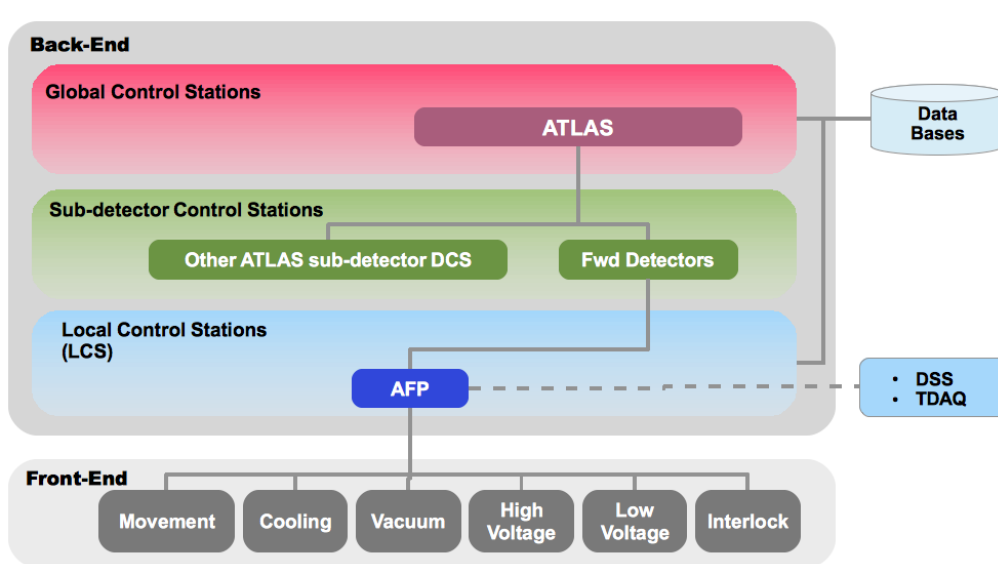
- Sub-detector of the ATLAS experiment
- Scintillating optical fibers arranged in a UV geometry
- Read-out from a multi-channel PMT (32 channels) MAPMT
- Each fibers to a single PMT channel
- Composed by Main detector and Overlap detector
- Detector inside a Roman Pot
- Independent vertical movement



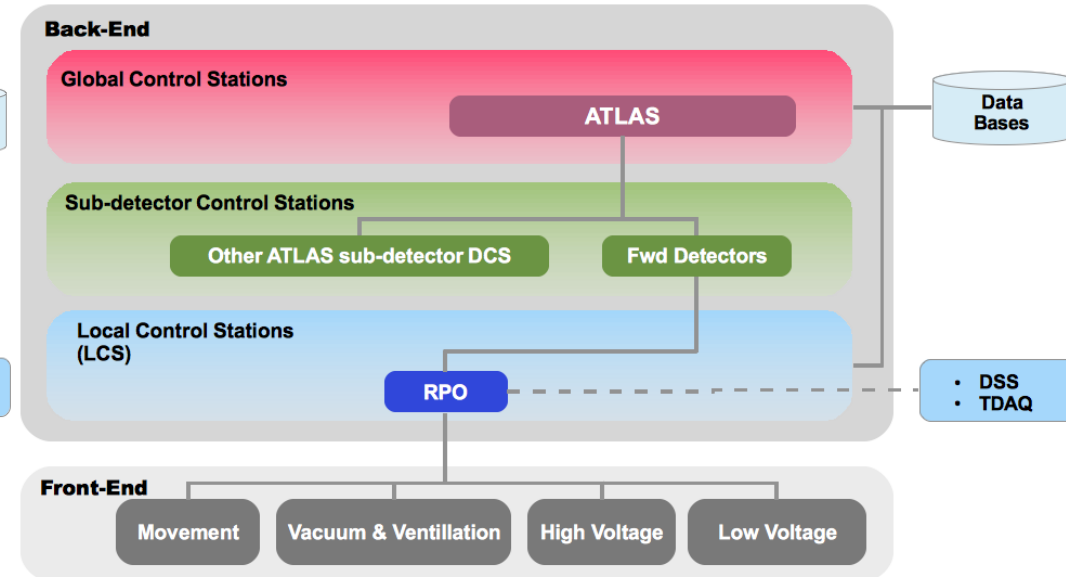
# ARP DCS Overview

- One Machine (LCS) with a single WinCC OA project
- CAN-USB interfaces (Systec + PEAK)
- Linux CC7 OS and WinCC OA 3.16
- Data from Front-End includes, voltages, currents, temperatures, states, etc
- Only a few thousands of monitoring/control channels
- **Large variety of Front-End systems**

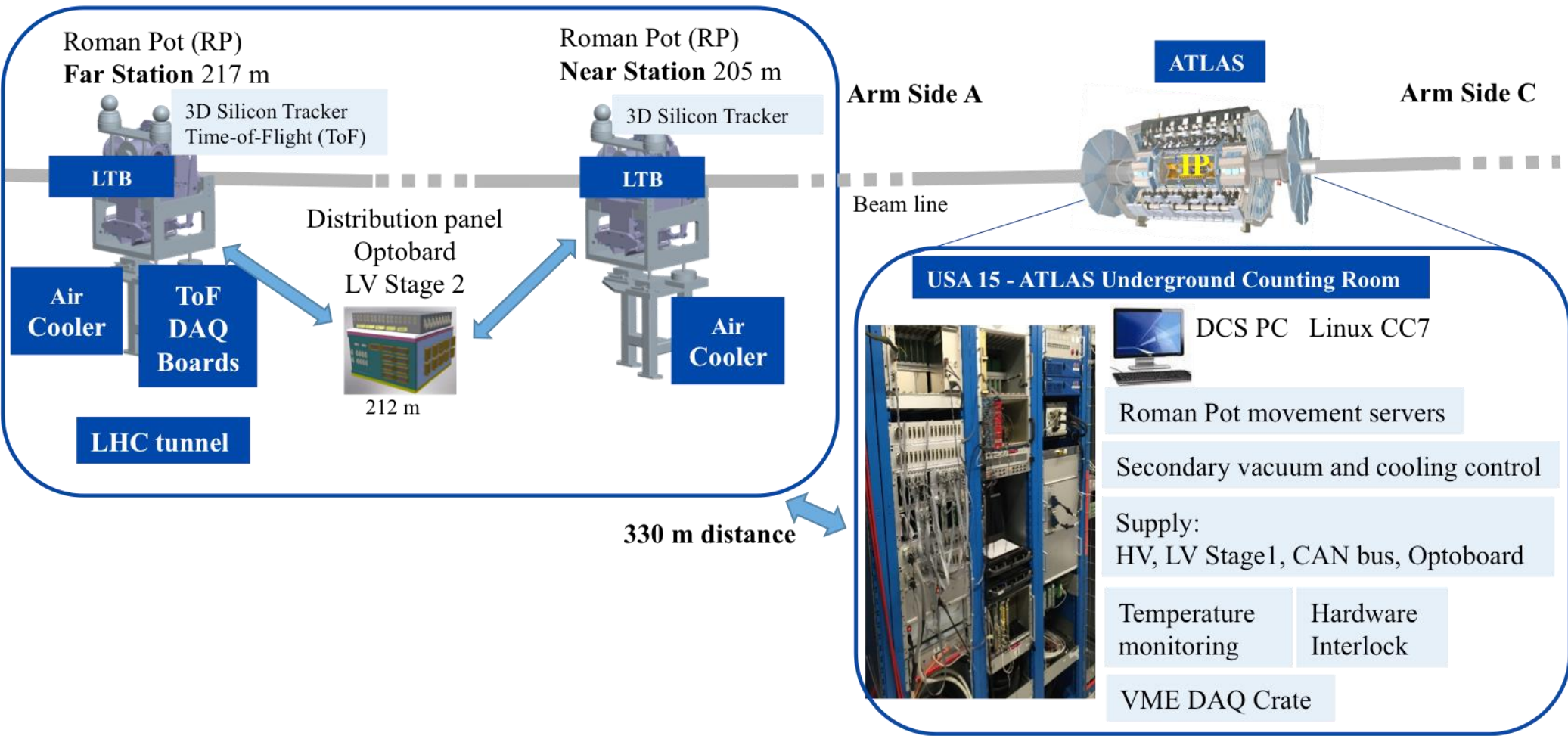
## AFP



## ALFA



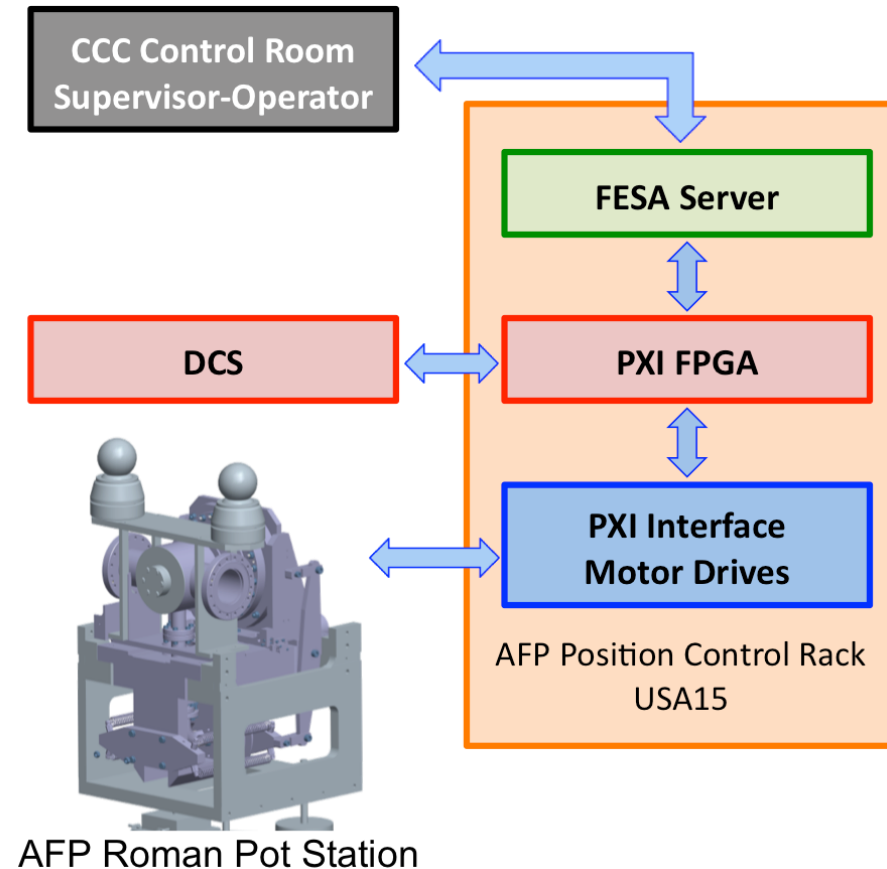
# AFP Hardware supervised by DCS





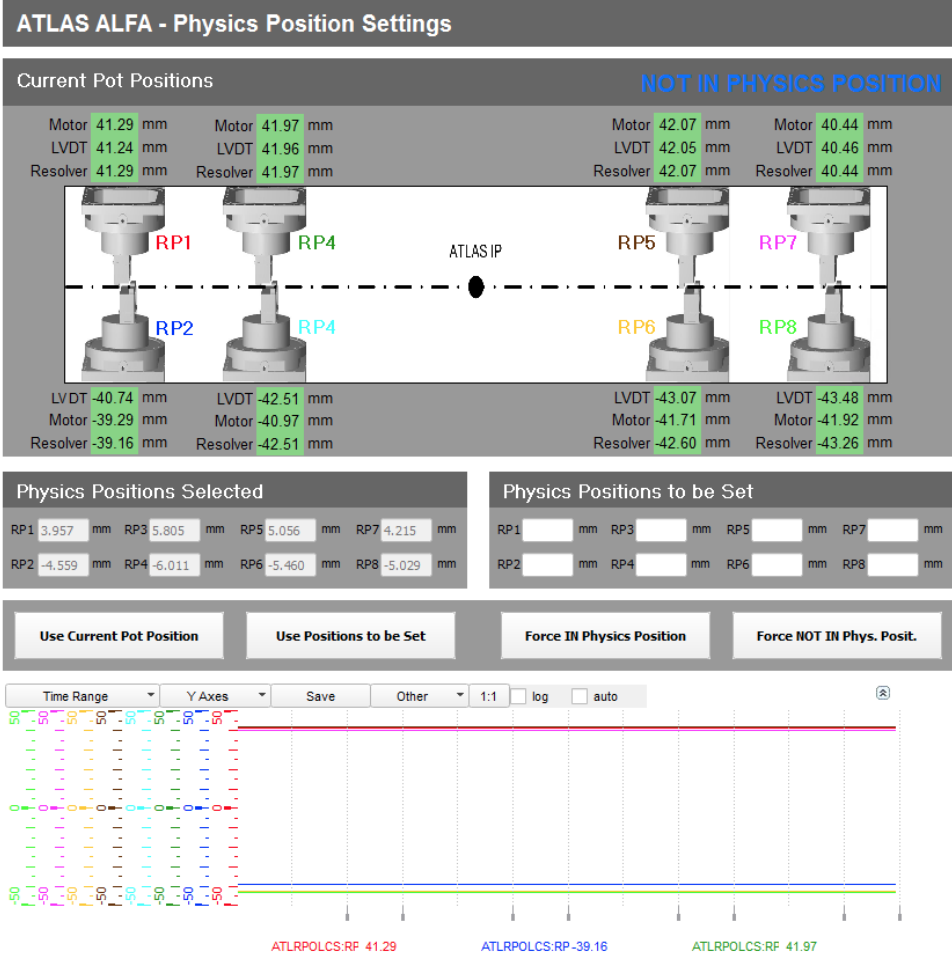
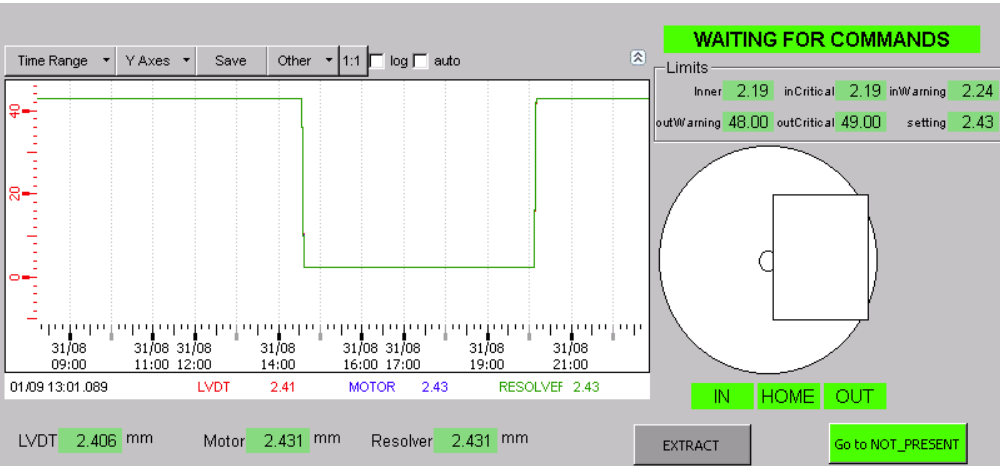
# Movement System

- DCS monitors the Roman Pots (RPs) positions inside the LHC beam pipe
- Similar for both AFP and ALFA
- Independent horizontal (AFP) and vertical (ALFA) movement of 5 micro meters step
- Toggle switches for movement range/limits and electrical stop switch for calibration
- Two systems involved:
  - National Instruments PXI for motors
  - Front-End Software Architecture (FESA) server for DIM DNS host
- DCS in the movement system:
  - Monitors RPs positions and states
  - Disables movement
  - Extracts RPs with springs in case of emergency



# Movement System

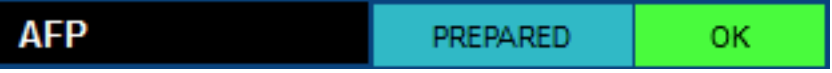
- Position information given by:
  - LVDT (Linear Variable Differential Transformer)
  - Step motor
  - Resolver
- Mismatch alarms if different readings from different measurement systems
- Good position for physics data tagged by DCS



# Movement System – State evaluation

- Movement state and switches will be used to calculate FSM state for the movement system in the DCS
- Pots movement follows a sequence
- ALFA and AFP have different state calculation
- AFP only in READY state when Pots inserted

Pots in HOME

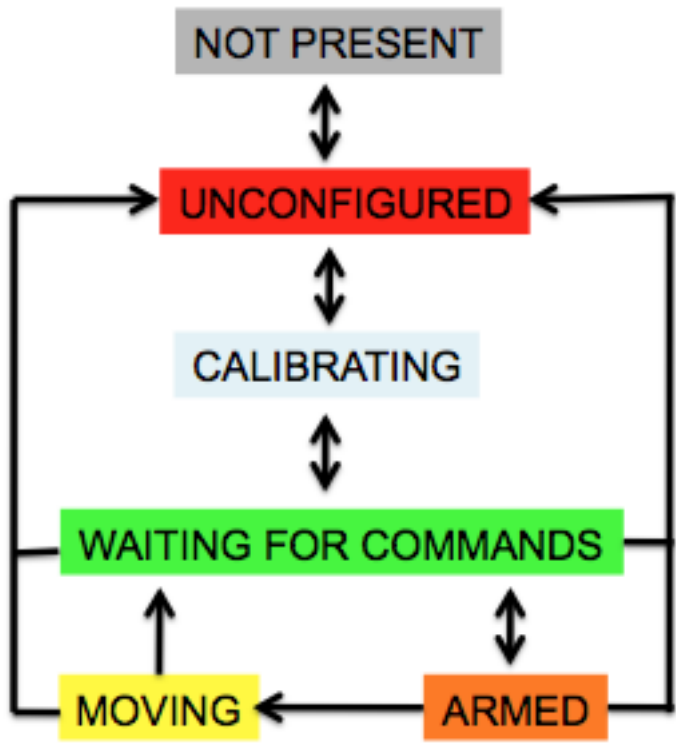


Pots IN



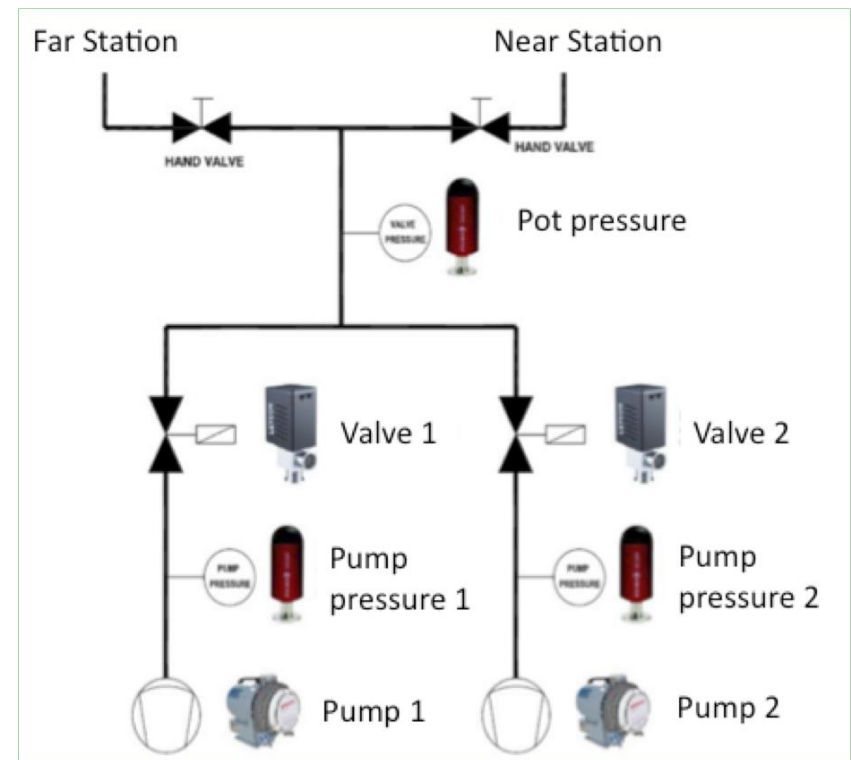
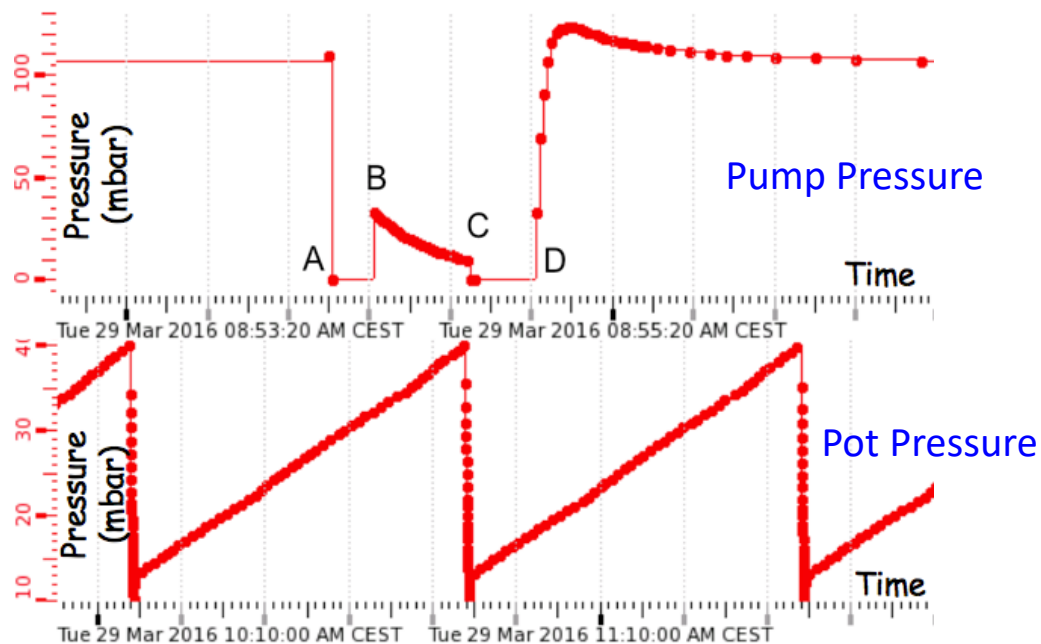
The screenshot shows the DCS interface with the following elements:

- Position:** WAITING\_HOME (cyan), OK (green), and a checkmark icon.
- Time Range:** 19/10 11:06 to 19/10 11:12.
- Limits:** Inner 3.10, inCritical 35.00, inWarning 35.50, outWarning 45.00, outCritical 45.00, setting 43.00.
- Switches:** IN (green), HOME (blue), OUT (green).
- Current Values:** LVDT 42.332 mm, Motor 42.314 mm, Resolver 42.314 mm.



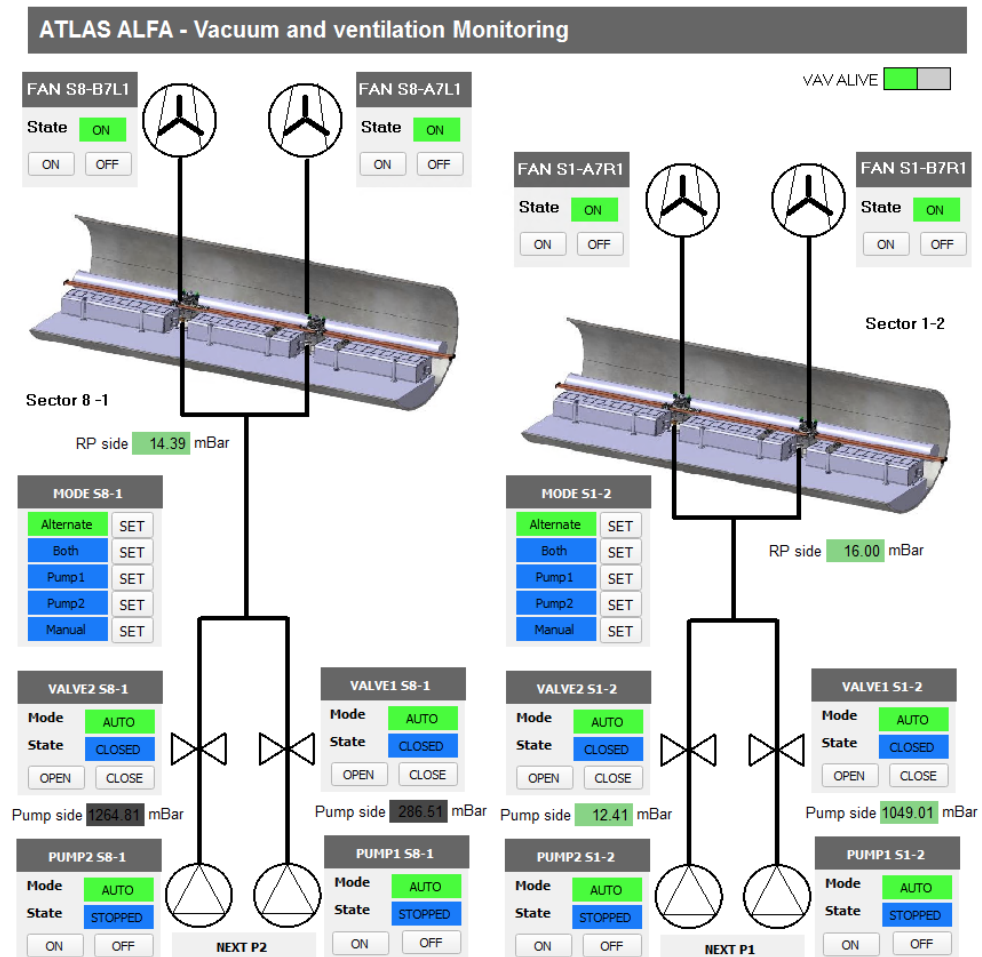
# Secondary Safety Vacuum

- Protection against the LHC high vacuum and icing inside the Roman Pot (RP)
- Similar for ALFA and AFP
- Independent vacuum in each arm: 10-40 mbar (AFP) and 10-20 mbar (ALFA)
- Redundant components to increase durability and cope with failures
- Control and Monitoring through a Programmable Logic Controller (PLC)



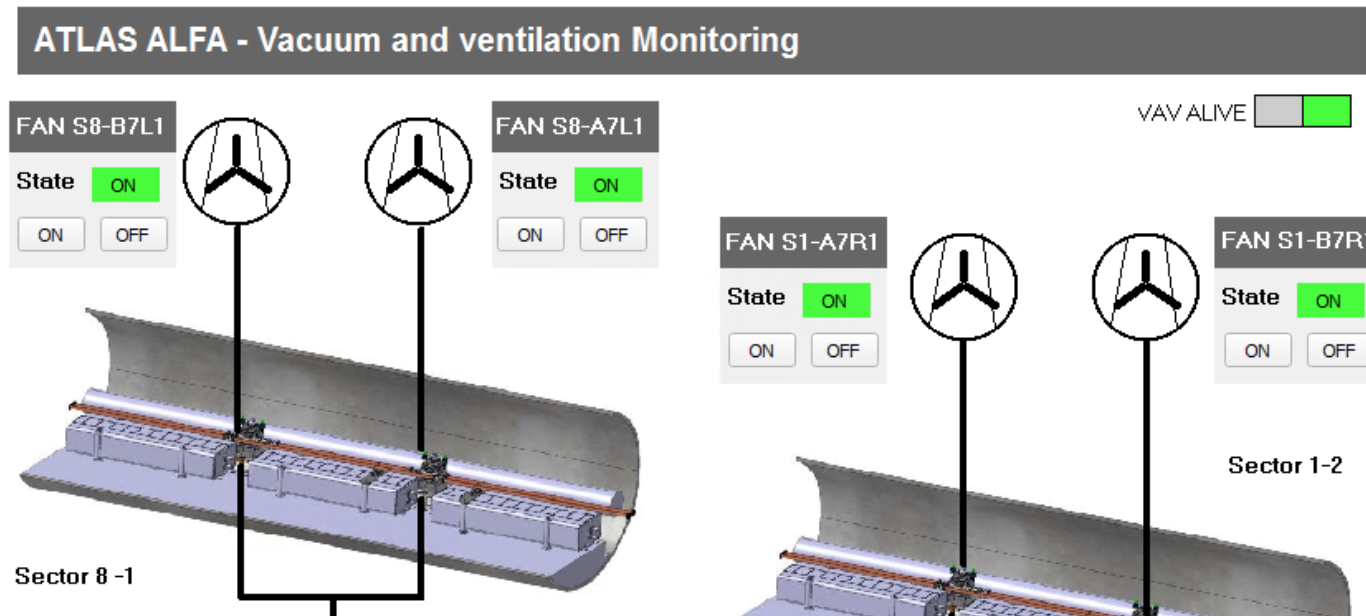
# Secondary Safety Vacuum

- AFP uses PLC S7-1200 from Siemens
  - Communication between the PLC and the DCS through the WinCC OA S7 driver via TCP/IP
- ALFA uses PLC S7-100 from Siemens (very old)
  - Communication between the PLC and the DCS through OPC DA server in a machine outside ATLAS network connected through DIP
- DCS in the secondary vacuum system:
  - Monitors pressure at Pump and RP
  - Monitors Pumps and Valves states
  - Selects the mode in which the PLC will work
  - Allows full system control if in Manual mode
- Pumping rate monitored
- Interlock system in AFP: Extract pots in case of vacuum failure
- Notification via e-mail and SMS in case of alarm



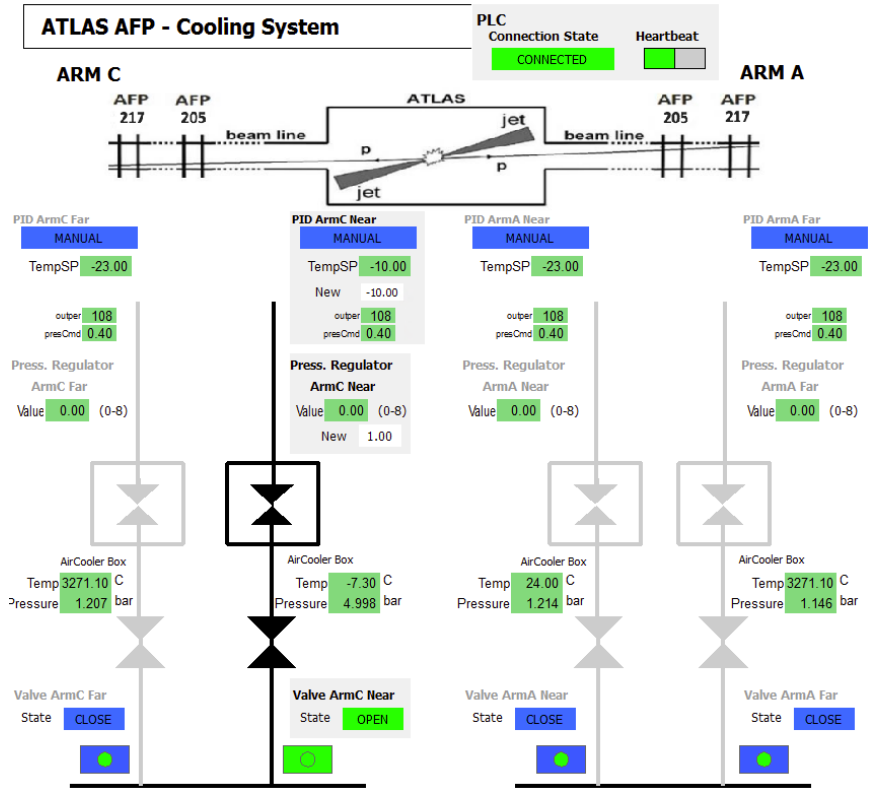
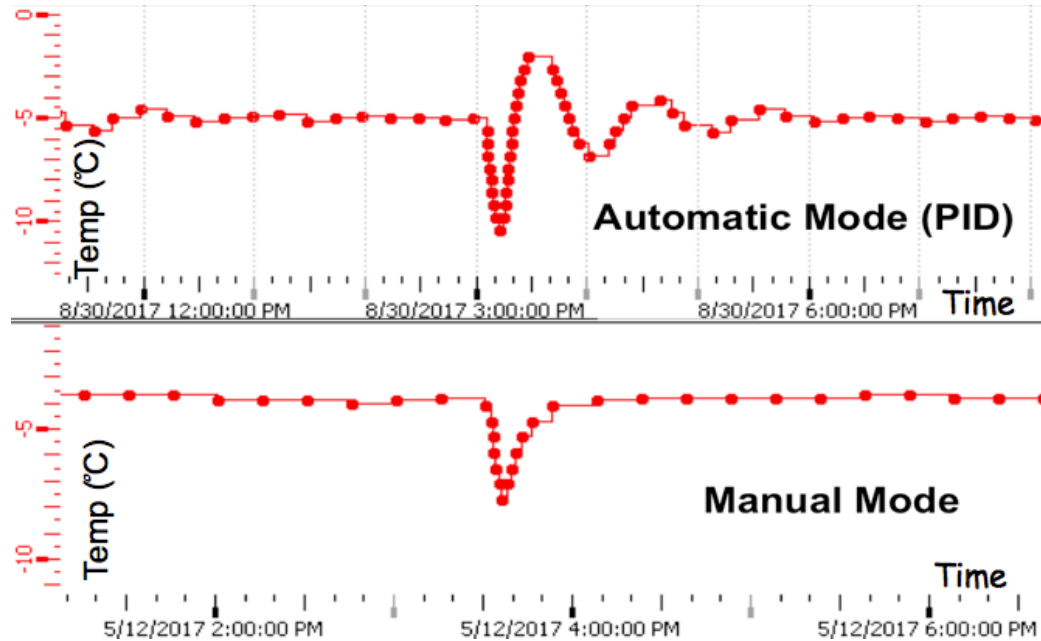
# Cooling System

- Cooling of the electronics and detectors
- Both system are controlled and monitored by PLC (same as vacuum)
- ALFA uses fans and AFP a Dry Air Vortex Cooling System (next slide)
- In ALFA no electronics is inside Roman Pot
  - Roman Pot Filler is used to conduct heat
  - Ventilation is provided to PMTs box and Motherboards



# AFP Cooling System

- Cooling of the electronics and detectors
- Heat conducted to a Heat exchanger inside the Roman Pot
- Cold air provided by Dry Air Vortex Cooling System (AirCooler) controlled and monitored through the PLC
- Manual mode: full operator control
- Automatic mode: PLC control through a PID (Proportional Integral Derivative)



- AFP DCS in the cooling system:
  - Controls and monitors electrovalves
  - Monitors temperature (PT 1000)
  - Monitors air pressure before AirCooler
  - Sets operation mode (Automatic/Manual)

# AFP Power Supply

## High Voltage (HV)

- HV to SiT sensors and ToF PMTs
- ISEG HV system:
  - ECH 238 crate
  - EHS F405n module (-500V) for SiT
  - EHS F430n module (-3000V) for ToF
- CAN-controlled with OPC UA server

## Supply Control - OptoLink (SCOL)

- For optoboard modules (3 voltages)
- In USA15 and ELMB controlled

AFP ARMA VREG Controller

Wiener MARATON OPC Server **Connected**  
CanOpen OPC Server **Connected**

CAN Bus and ELMB

CAN BUS name: ELMB/VREG\_A System port: 5  
ELMB name: ELMB/VREG\_A/afpVregArmA  
Serial Number: F208  
Hardware version: C40  
Software Version: E43  
ELMB State: **Operational**

VREG Crate afpVregArmA

8	7	6	5	4	3	2	1	0
V	T	T	T	T	S	S		
L	O	O	O	O	I	I		
D	F	F	F	F	T	T		
B	H	G	F	E	D	C	B	A

Controller Details

STATUS

Powered **TRUE**  
Connected **TRUE**  
Ready **TRUE**  
Command Execution **FALSE**  
Alive **ALIVE**  
Routine **RUNNING**

Detail information on installed boards

Activated Boards **1ab0000**  
Readout Boards **1ab**  
Kill Boards **0**  
Kill All **5f**  
General Uninhibit **0**

HV Operation ARM C NEAR Station

OPC Iseg Server **Connected**

	ch	Power	V Actual	Vset	I Actual	I Trip limit
Plane P0 HV	00	<b>ON</b>	<b>-20.00</b> V	20.00 V	<b>-7.61</b> uA	100.00 uA
Plane P1 HV	01	<b>ON</b>	<b>-20.00</b> V	20.00 V	<b>-22.46</b> uA	100.00 uA
Plane P2 HV	02	<b>ON</b>	<b>-20.00</b> V	20.00 V	<b>-23.10</b> uA	100.00 uA
Plane P3 HV	03	<b>ON</b>	<b>-20.00</b> V	20.00 V	<b>-29.49</b> uA	100.00 uA

Module ma00 General Information

RampSpeed **0.90** %Vn  
Software ID **6.49**  
Bit Rate **125000** Kb/s  
HV V Limit **102.74** %Vn  
HV I Limit **102.70** %In  
Temperature **33.25** C  
Supply24V **24.57** V  
Supply5V **4.95** V

Module ma00 Error Status

General Alarm **0**  
Hw Limit too Low **0**  
I Limit Error **0**  
I Trip Error **0**  
Module Temp Error **0**  
Safety Loop Error **0**  
V Limit Error **0**  
Volt Supplies Error **0**

Module is Alive **ON**  
Module is Stable **ON**

## Low Voltage (LV)

- 1<sup>st</sup> stage: Wiener PL512 power supply + LVPP4 crate located in USA15 (12 X 4 channels)
  - Ethernet controlled with OPC UA server
  - Current measurement with ELMB
- 2<sup>nd</sup> stage: Low Voltage Regulator (VREG) Crate + VREG Controller located on the tunnel
  - CANbus controlled through ELMB



# ALFA Power Supply

## High Voltage (HV)

- HV to 23 MAPMT + 4 Trigger PMTs
- ISEG HV system:
  - ECH 238 crate
  - 8 X EDS 20 module (3000V)
- CAN-controlled with OPC UA server

**HIGH VOLTAGE**

HV SHUTDOWN OK

**MAPMT MD settings**  
V set 900 V I Trip 500  $\mu$ A

**MAPMT OD settings**  
V set 800 V I Trip 500  $\mu$ A

**Trigger PMT settings**  
OL - Vset 950 V Itrip 500  $\mu$ A  
MD - Vset 1100 V Itrip 500  $\mu$ A

## Low Voltage (LV)

- 2 front-end crates provide the (5V and 7V) to the front-end electronics (motherboards)
- 2 rectifiers (PFC, one per side) provide regulated input voltage to the front-end crates
- 2 controllers in the VME crate allow remote control and monitoring of the front-end crates
- Ethernet-controlled with OPC UA server

**SECTOR 8-1** Crate RCM\_1 State **POWER ON**

**RP1**

Ch. 4 (5V) OFF  
0.03 V 0.25 A  
OK T max OK V min  
OK I max OK P max  
OK V max OK Timeo

Ch. 5 (7V) OFF  
0.03 V 0.26 A  
OK T max OK V min  
OK I max OK P max  
OK V max OK Timeo

**RP2**

Ch. 6 (5V) OFF  
0.04 V 0.25 A  
OK T max OK V min  
OK I max OK P max  
OK V max OK Timeo

Ch. 7 (7V) OFF  
0.05 V 0.29 A  
OK T max OK V min  
OK I max OK P max  
OK V max OK Timeo

# AFP Temperature monitoring and Interlock Matrix Crate

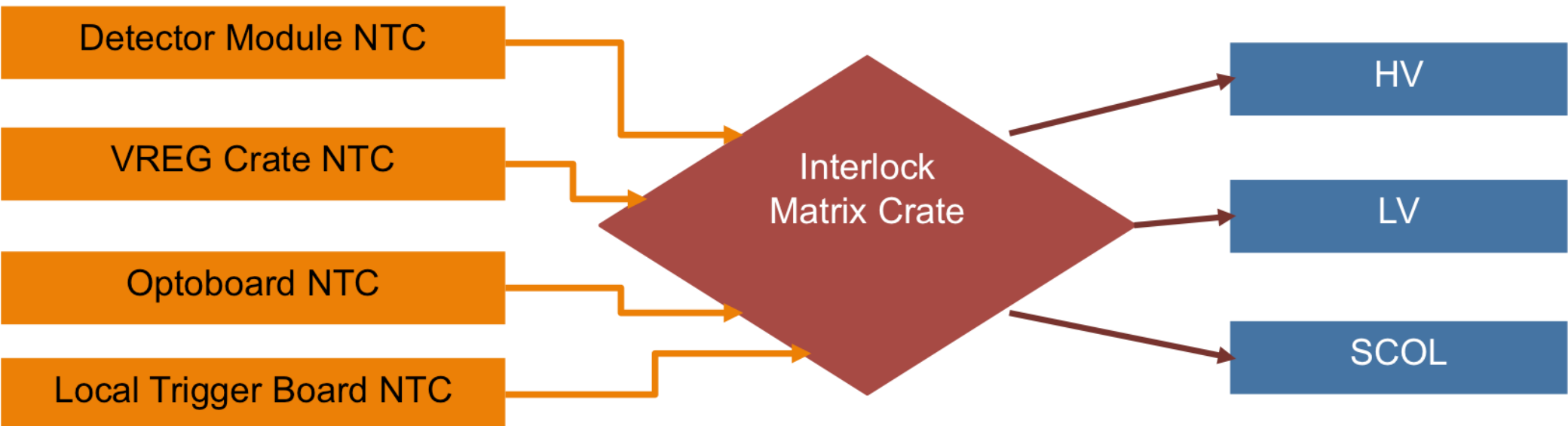
## Temperature monitoring

- Temperature sensors (NTC's):
  - Inside the pots (wall, SiT planes, heat exchanger, ...)
  - Station (Stepper motor and Local Trigger Board)
  - Air Cooler, Optoboard, VREG
- CANbus monitored through ELMB

## Interlock Matrix Crate

- Interlock system for the LV Wiener PL512 and HV lseg
- Triggered if a temperature exceeds a threshold value
- CANbus controlled through ELMB

*All power supplies are interlockable*



# ALFA Temperature monitoring and RadMons

## Temperature monitoring

- Temperature sensors (PT100 ):
  - Inside the pots (wall and detector)
  - Station (PMT box, Motherboard, etc)
  - Beam pipe
- CANbus monitored through ELMB

ATLAS ALFA - Temperature monitoring of stations

Top Detector	B7L1	A7L1	A7R1	B7R1
Detector Sensor1	26.2	20.9	23.2	21.8 oC
Detector Sensor2	15.1	20.9	23.1	21.8 oC
BlackBox PMF1	14.9	19.9	29.3	28.7 oC
BlackBox PMF19	14.8	20.0	26.7	26.5 oC
BlackBox PMF23	1.9	20.4	26.8	26.6 oC
BlackBox AirIn	19.6	23.3	21.5 oC	
BlackBox AirOut	14.9	19.6	22.4	22.2 oC
Detector Outside baseplate	15.4	20.5	24.6	23.4 oC
Roman Pot1	15.6	21.0	23.4	22.3 oC
Roman Pot2	15.6	21.1	23.3	22.3 oC
Roman Pot3	15.7	21.0	23.3	22.2 oC
Roman Pot4	15.5	21.0	24.6	22.3 oC
Roman Pot5	15.7	20.9	23.3	22.0 oC
Roman Pot6	15.5	20.9	23.4	23.4 oC
Roman Pot Outside flange	15.7	20.7	22.5	21.1 oC

Tunnel	B7L1	A7L1	A7R1	B7R1
Air	14.7	20.5	21.1	19.6 oC

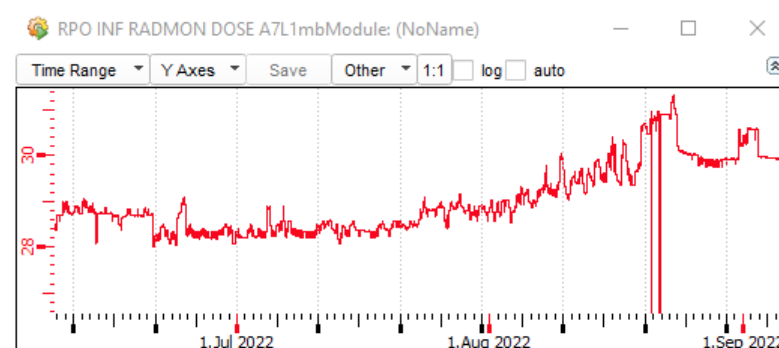
  

Cross	B7L1	A7L1	A7R1	B7R1
	15.5	20.5	22.0	21.0 oC

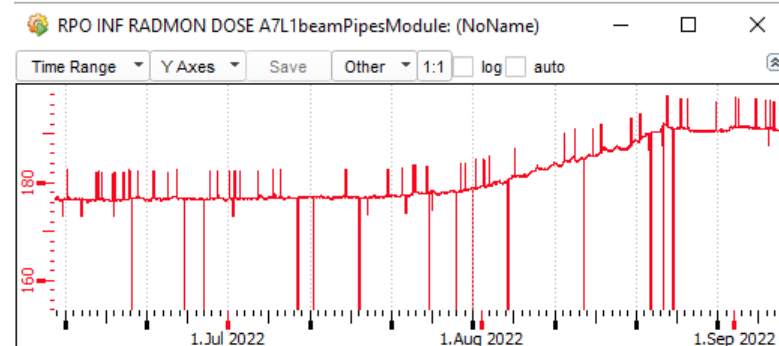
Bottom Detector	B7L1	A7L1	A7R1	B7R1
Detector Sensor1	15.8	21.1	23.9	22.8 oC
Detector Sensor2	15.7	21.0	22.8	22.8 oC
BlackBox PMF1	16.1	20.3	28.3	26.9 oC
BlackBox PMF19	16.1	20.4	32.5	28.2 oC
BlackBox PMF23	16.2	20.6	38.0	32.2 oC
BlackBox AirIn	16.6	20.2	22.7	21.1 oC
BlackBox AirOut	19.9	23.2	22.1 oC	
Detector Outside baseplate	15.9	20.9	23.3	21.9 oC
Roman Pot1	15.8	20.8	22.7	21.5 oC
Roman Pot2	15.8	20.9	22.6	21.4 oC
Roman Pot3	-7.0	20.9	22.7	21.4 oC
Roman Pot4	-10.9	20.8	22.6	21.5 oC
Roman Pot5	15.9	20.9	22.6	21.4 oC
Roman Pot6	16.0	20.8	22.6	21.4 oC
Roman Pot Outside flange	15.3	20.8	22.7	21.3 oC

## RadMons

- In one side (both stations and beam pipe)
- Readout every hour by a control script
- CANbus monitored through ELMB

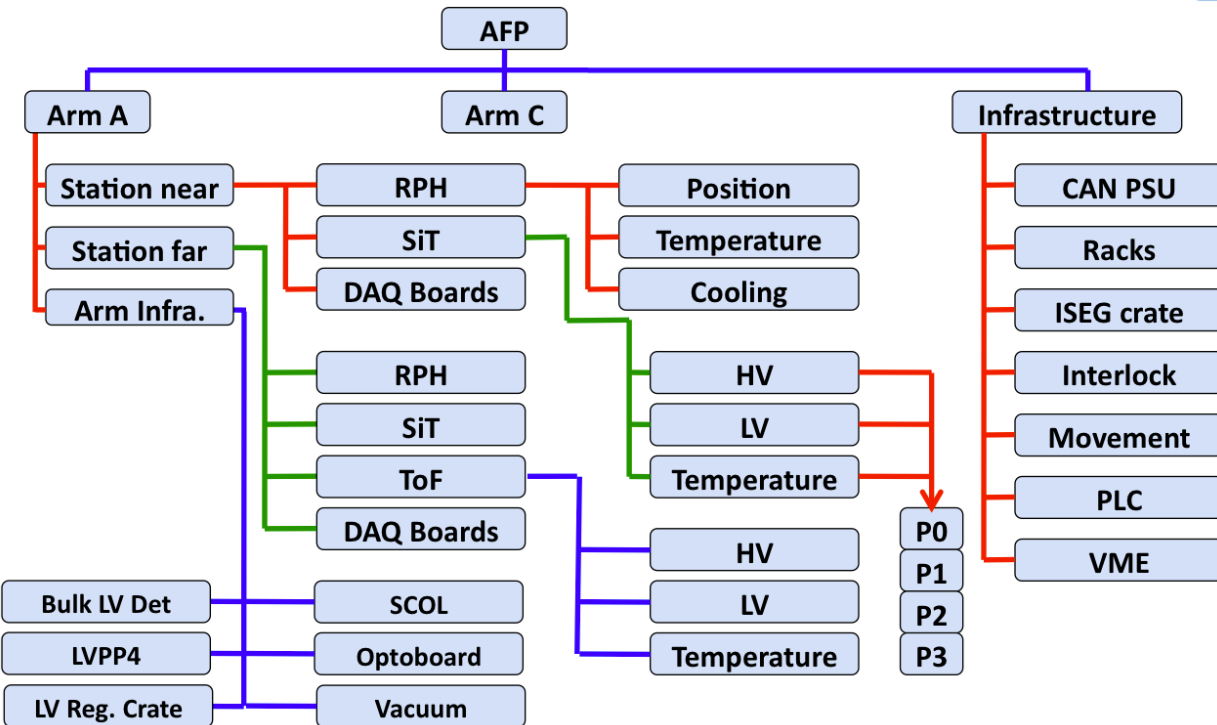
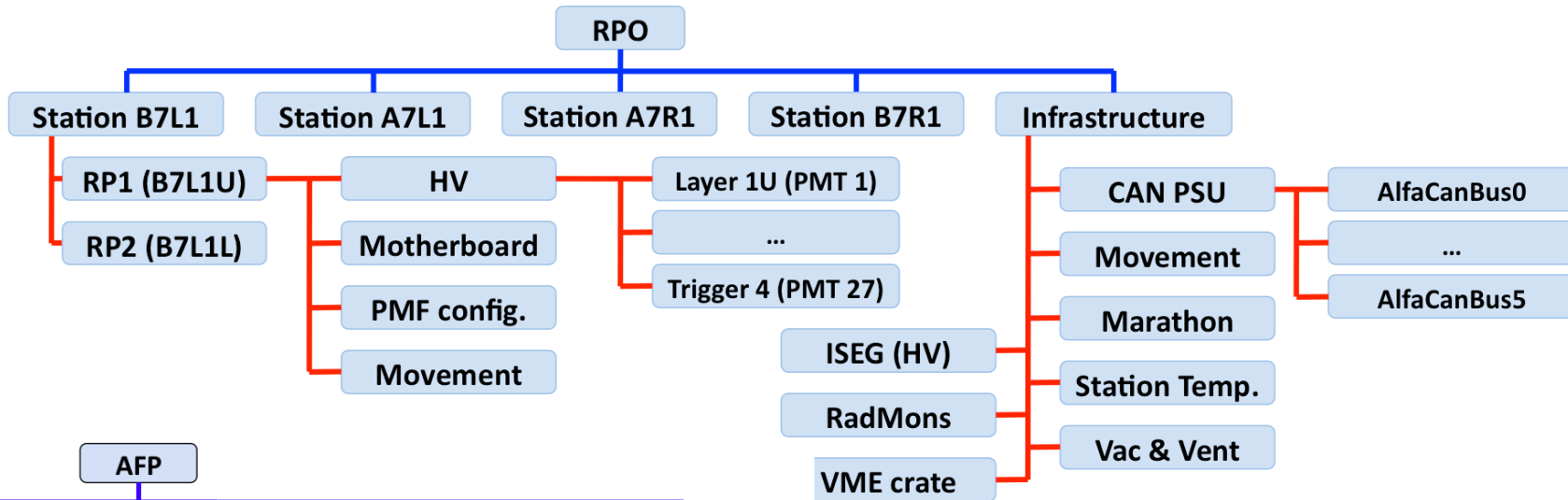


9/7/2022 8:20:26 PM (097)  
ATLRPOLCS:AlfaCanBus4\_ELMB63\_r1 29.87



9/7/2022 8:20:37 PM (253)  
ATLRPOLCS:AlfaCanBus4\_ELMB63\_r1 191.42

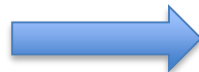
# ALFA and AFP FSM



# ALFA Operation

- AFP runs continuously when ATLAS is taking data and when inserted
- ALFA runs in low luminosity runs (mostly OFF during the year)
- ALFA goes through a power ON procedure which takes several minutes
  - Switch Motherboards ON (LV)
  - PMF (PMT Front-End) configuration
  - Power ON to the PMTs (HV)
- Each powering ON/OFF set corresponds to a different FSM state

RPO	READY	OK	🔒
B7L1	SHUTDOWN	OK	📈
A7L1	SHUTDOWN	OK	🔒
A7R1	SHUTDOWN	OK	🔒
B7R1	SHUTDOWN	OK	🔒
Infrastructure	READY	OK	🔒
CONFIGS	READY	OK	✓
Physics Position	READY	OK	✓
Latency	READY	OK	✓



RPO	FE_ON	OK	🔒
B7L1	FE_ON	OK	📈
A7L1	FE_ON	OK	🔒
A7R1	FE_ON	OK	🔒
B7R1	FE_ON	OK	🔒
Infrastructure	READY	OK	🔒
CONFIGS	READY	OK	✓
Physics Position	READY	OK	✓
Latency	READY	OK	✓



RPO	READY	OK	🔒
B7L1	READY	OK	📈
A7L1	READY	OK	🔒
A7R1	READY	OK	🔒
B7R1	READY	OK	🔒
Infrastructure	READY	OK	🔒
CONFIGS	READY	OK	✓
Physics Position	READY	OK	✓
Latency	READY	OK	✓



RPO	FE_READY	OK	🔒
B7L1	FE_READY	OK	📈
A7L1	FE_READY	OK	🔒
A7R1	FE_READY	OK	🔒
B7R1	FE_READY	OK	🔒
Infrastructure	READY	OK	🔒
CONFIGS	READY	OK	✓
Physics Position	READY	OK	✓
Latency	READY	OK	✓

# ALFA Front-End Handling - PMF configuration

- Configuration of 23 FPGAs (one for each PMF) and two FPGAs in the trigger mezzanine
- Dedicated user interface (progress and check failures)
- Data sent to the FPGAs
  - PMF (gains, thresholds and control bits for each PMF)
  - Trigger (pattern, rate and latencies)
  - LED configuration (pulse width, voltage and mode)
- Configured through the serial peripheral interface of the ELMBs
  - Exchange of 16 bits words between ELMB and FPGA
- ReadBack test
- Motherboard readout and PMF configuration share the same CANbus so no MB monitoring during PMF configuration

ATLAS ALFA - RP3 PMF configuration

Read-back config:  NORMAL  ALL  NONE

LED / Trigger:  CONFIGURED  
 Latency:  CONFIGURED

LED mode:  DISABLED  LED 1  
 Bias Step:  Pulse width:  ns

Trigger Logic:        
 Trigger Rate:  Hz

PMF configuration

MD: Gains: EQUALIZED | 0  
 Threshold: 7 | 0 | 17

Trigger 1: Gains: M1: 37 | OL1: 38  
 Threshold: 8 | 0 | 20

Trigger 2: Gains: M2: 39 | OL2: 40  
 Threshold: 8 | 0 | 20

PMF_1	PMF_2	PMF_3	PMF_4	TR_1
				TR_2
PMF_5	PMF_6	PMF_7	PMF_8	PMF_9
PMF_10	PMF_11		PMF_12	PMF_13
PMF_14	PMF_15	PMF_16	PMF_17	PMF_18
PMF_19	PMF_20	PMF_21	PMF_22	PMF_23

Configured  
  Not Configured  
  Disabled  
  Read back failed  
  Transition

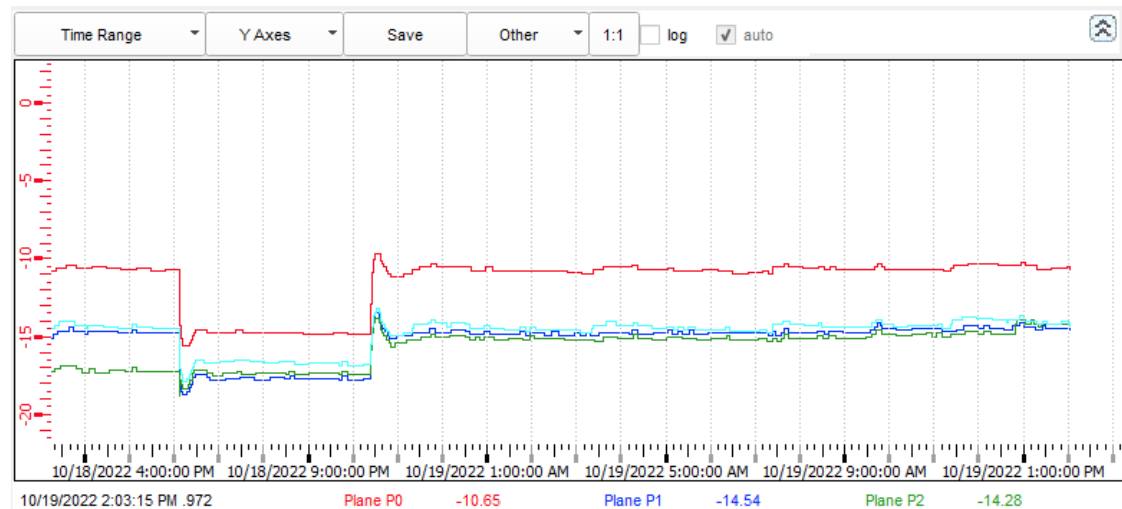
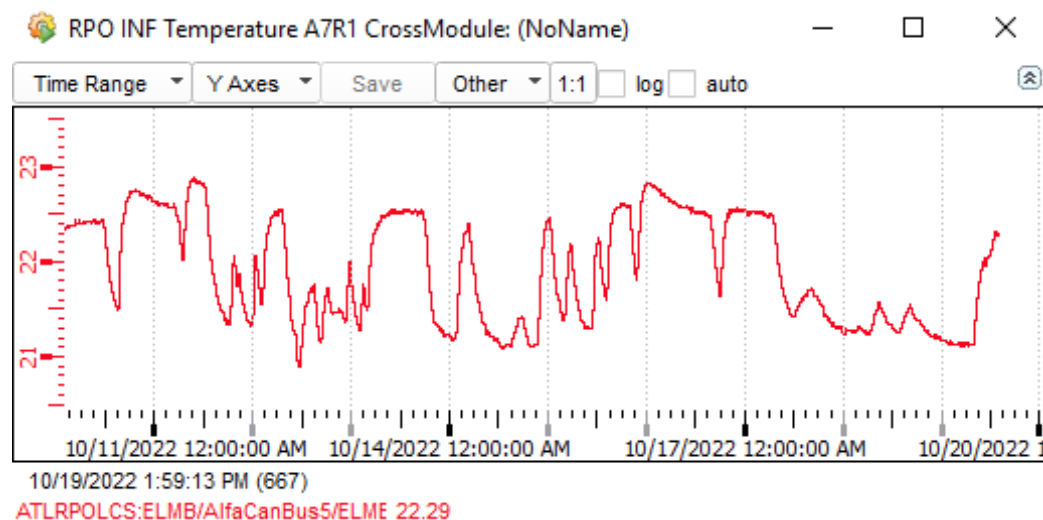
# Archiving and notification

## Data Archiving

- Relevant data related with the detector operation (voltage, currents, etc)
- Smoothing mechanism based on value and/or timestamps
- Online database - Oracle
  - Available inside ATLAS technical network
  - Online monitoring
- Offline database - COOL
  - Available outside ATLAS technical network
  - Physics analysis and data quality
- DCS Data Viewer (DDV)

## Notification

- Provides e-mail or SMS notification
- Based in triggered alarms from critical systems



# DCS data for analysis

- DCS data is stored mainly for hardware debugging
- Other studies can be performed:
  - Relation between pressure (secondary vacuum) and showers
    - In the simulation we assume that pot bottom (thin window) is flat. However, this is only an approximation. Operational pressure of 5(10)-30(40) mbar results in bulging the window. In principle this may change the cross section (as the interaction area changes in shape and effective width) for having showers induced from station
  - Relation between pot temperature and showers
    - Similar to above, the heat may change the length of pot moving its bottom closer to the beam. In such case probability to have shower may increase
  - Impact of temperature on SiT efficiency
    - SiTs are actively cooled (PID algorithm), but the temperature is not perfectly stable. It would be interesting to check if there is a correlation between hit multiplicity in a given plane and temperature on module.
  - Impact of HV on SiT efficiency
    - When in the run, HV in one plane (out of 4) may be varied. Analysis should reveal the efficiency (wrt other 3 planes) as a function of HV.



# Summary and final remarks

- WinCC OA provides the tools to build the ARP DCS
  - Variables (DPEs) configuration: alarms, archiving, etc
  - Control scripts, APIs, drivers, etc
  - Graphical Users Interface and FSM
- ARP DCS is:
  - Able to monitor and control a large variety of systems
  - Fully integrated in ATLAS DCS
  - Operating continuously without any big issue
  - Coping with ATLAS upgrade in terms of software improvements and maintenance
  - Attending wishes and new requirements
- DCS support is always available

Thanks for your attention