National Technical University of Athens
School of Applied Mathematical and
Physical Sciences

ATLAS ITk

Environmental Monitoring for the ATLAS ITk Barrel Integration

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HEP2026

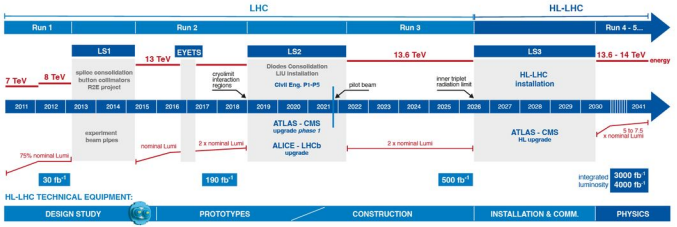
Outline

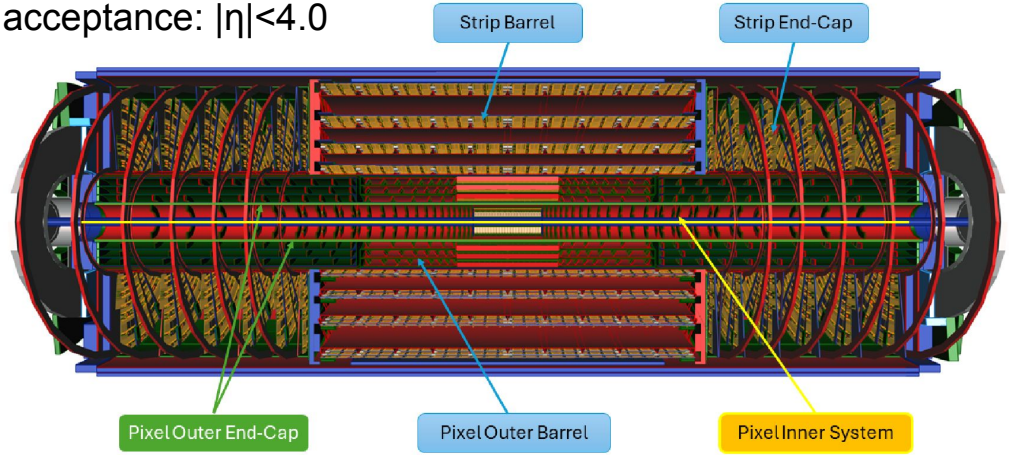
- **Introduction ITK upgrade**
- **Environmental safety system**
  - Motivation and Context
  - System overview
  - System infrastructure
  - Software and FSM
  - Dry-Down studies
- **Itk barrel leak rate test**
  - Measurement setup
  - Results
- **Conclusions**

ATLAS - Inner Tracker

Inner tracker detector (ITK)

- **All-silicon tracker**: pixel and strip detectors
  - ~178m^2 of silicon sensor (168m^2 strips and 13m^2 pixels)
- **Higher radiation tolerance**
- **Finer granularity** up to 5 billion readout channels
- Extended tracking acceptance: |η|<4.0

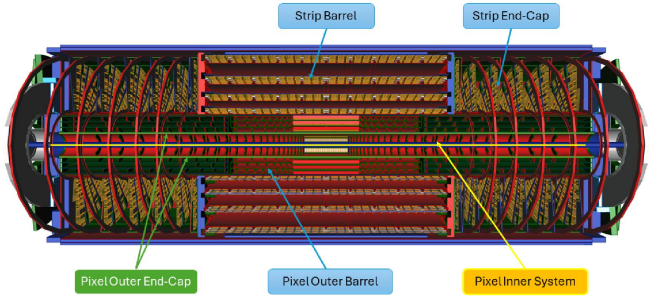


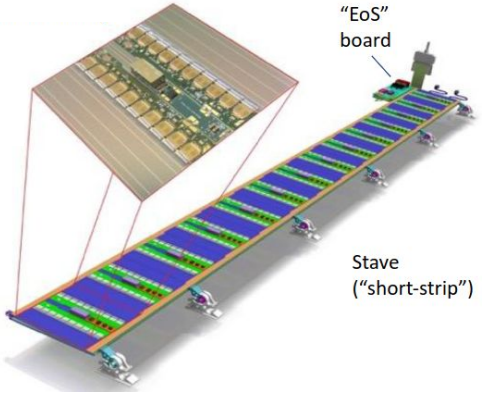


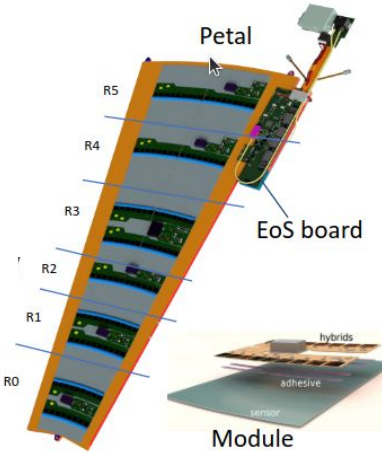
ATLAS - Inner Tracker

Inner tracker strip detector

- Building block of **itk strip barrel** detector: **Stave**
  - total number of staves: 392
  - A stave has 28 silicon modules (14 each side)
  - 2 types: Short-Strips, Long-Strips
- Building block of **itk strip end-cap**: **Petal**
  - total number of petals: 384
  - 18 module per petal





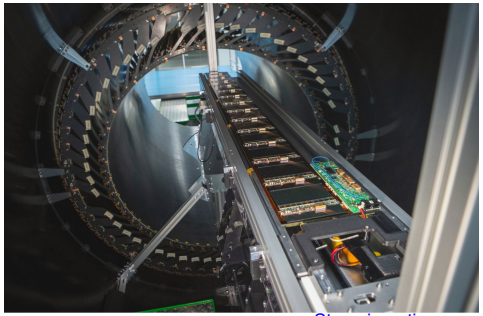


Environmental Safety System

Motivation and Context

- Integration of the ITk Strip Barrel at CERN
  - Outer cylinder located in clean room
  - Production staves have begun arriving at CERN.

- Cold tests will be performed during barrel strip integration.
  - **Powering and testing of staves at −35°C**
- **Cooling plant malfunction** can result in temperatures **down to −55°C**
- **Dew point must remain below -60 °C** before any cold operation otherwise warm operation.



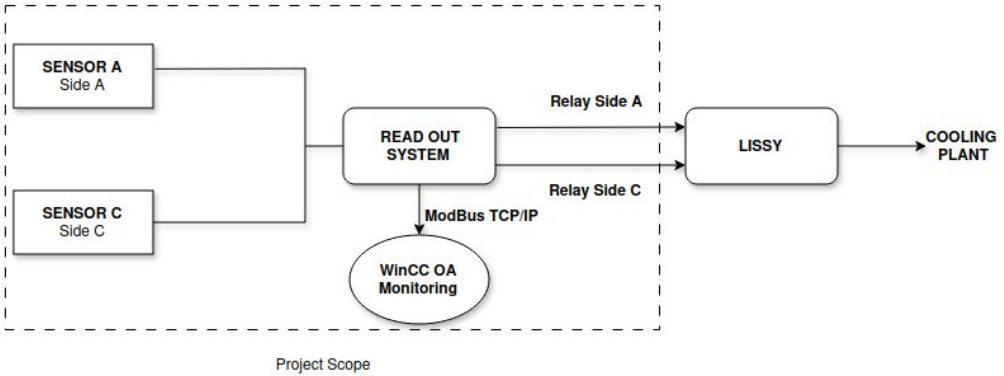
Stave insertion

Dew-point monitoring and safety system during the integration phase is needed

System Overview

This system provides environmental protection for the ITk Barrel during integration.

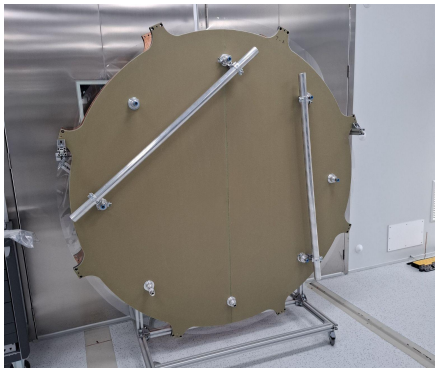
- **Two DMP8 sensors (Side A & Side C)** connected to a **single Vaisala transmitter**
- **Dew-point-based relays** providing **the interlock to the cooling plant** via **LISSY**(**L**ocal **I**nterlock **S**afety **Sy**stem)
- **Continuous monitoring and supervision via WinCC OA**:
  - Barrel temperature, Humidity & dew point
  - Probes status
  - Transmitter Relays



System infrastructure

- **Vaisala Indigo 520 Transmitter**, installed in the Clean Room
  - Reads up to two probes
  - Provides 4 configurable analog outputs and 2 relays.
  - Modbus TCP/IP server
  - Plugged into UPS

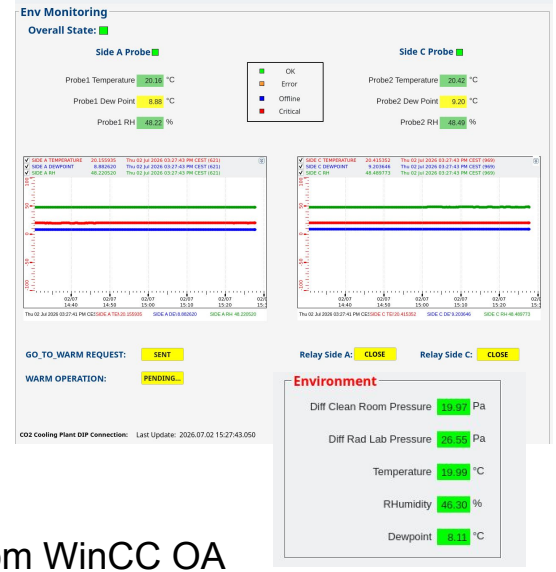
- **Two DMP8 probes**, measuring dew point, temperature, relative humidity.
  - Measurement range for continuous use -70 … +45 °C T_dew
  - Accuracy ± 2-3°C T_dew
  - Mounted on the **dummy structural bulkheads** during operation.



Software implementation

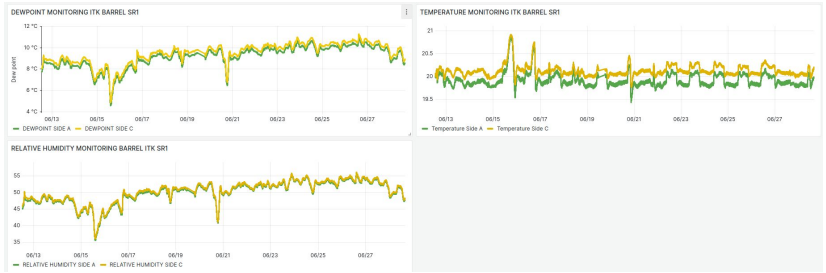
WinCC OA

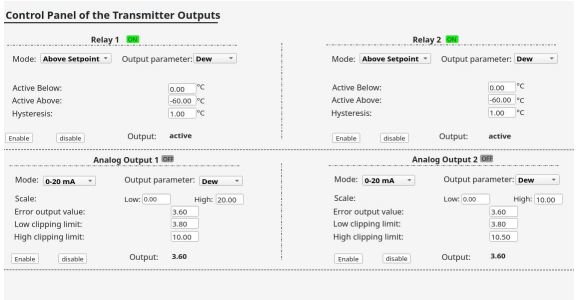
- monitoring + hardware alarm handling + historical archiving.
- DIP subscription to cooling plant and clean room ventilation system
  - access to DSS safety states of the cooling plant
  - access to environmental conditions of the clean room



Grafana

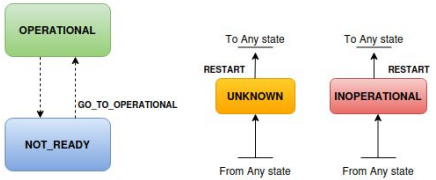
- More convenient way for the dry down(no need for alarm handling)
- Monitoring dewpoint, RH, temperature.
- Getting the parameters from Influx database configured and set up from WinCC OA

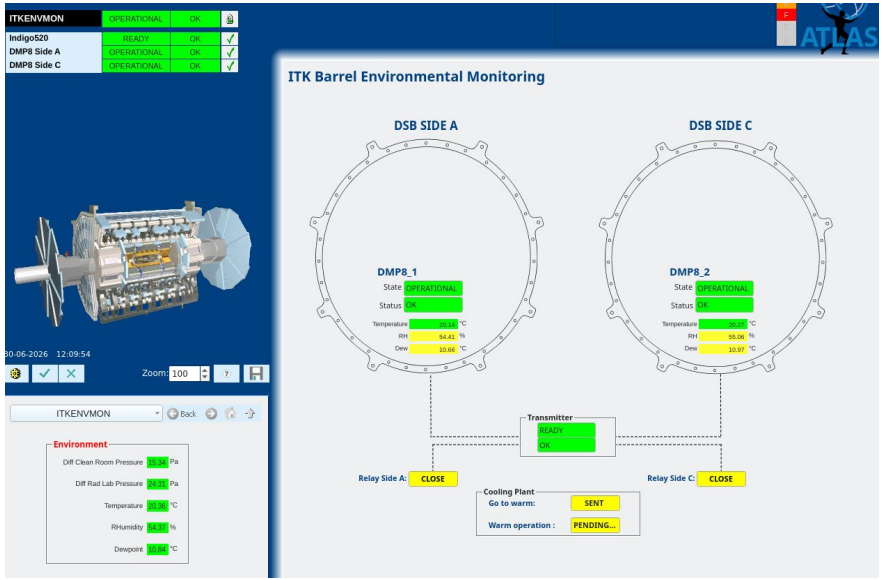


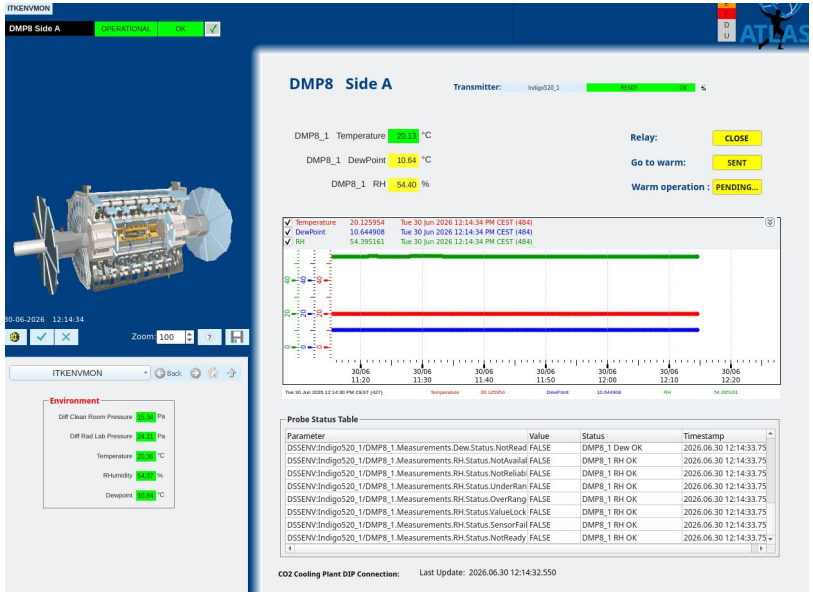


WinCC OA + FSM

- **Finite State Machine (FSM),** Tree-like hierarchy of states :
  - One node for each Device (1 Transmitter, 2 Sensors)
- Will be integrated into the barrel strips integration FSM





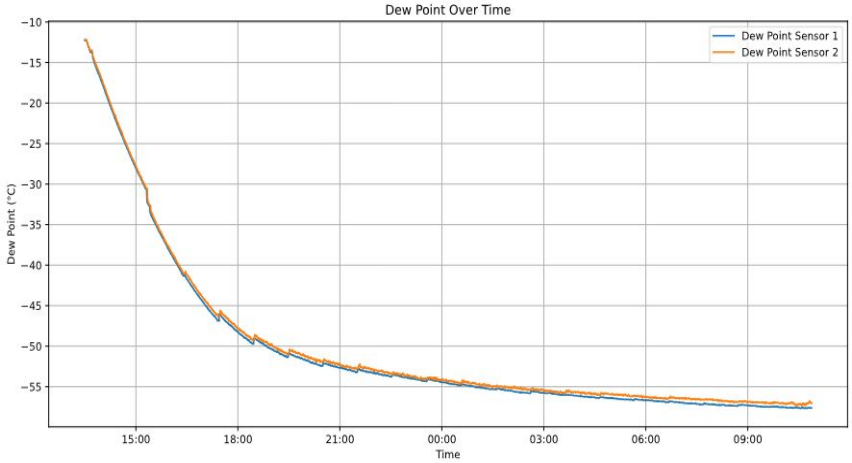


Dry down objectives

Motivation from the 2025

Previous dry down (Summer 2025): limited duration – several objectives could not be evaluated

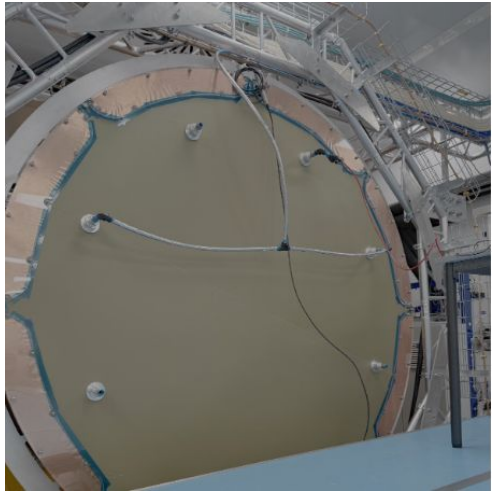
- Determine time to reach -60°C
- Determine minimum achievable dew point
- Evaluate dew point recovery
- Simulate dryer failure scenario

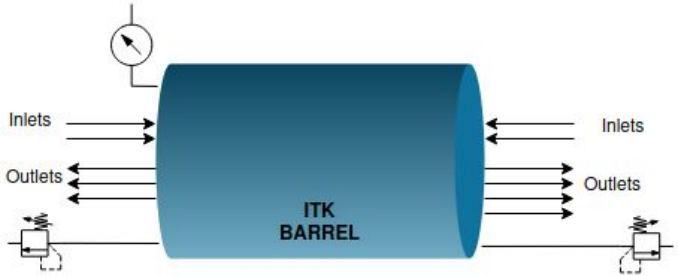


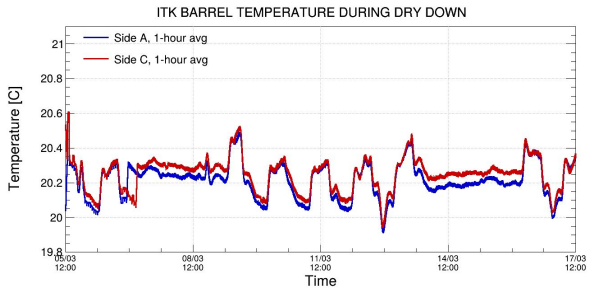
https://indico.cern.ch/event/1529721/contributions/6532090/attachments/3077641/5453304/2025_06_04_ITk_Strips_ColdTests.pdf

Dry Down Configuration

- Barrel closed with bulkheads equipped with pressure-relief valves (>5 mbar)
- Two dry-air inlets per side, 10 Nm³/h per side
  - at -80℃ Dewpoint
  - ~1 volume exchange per hour
- Overpressure <1mbar
- Stable temperature (~ 20-21℃)
- Dew-point sensor accuracy : ±2-3℃







Dry Down Dew Point Measurement

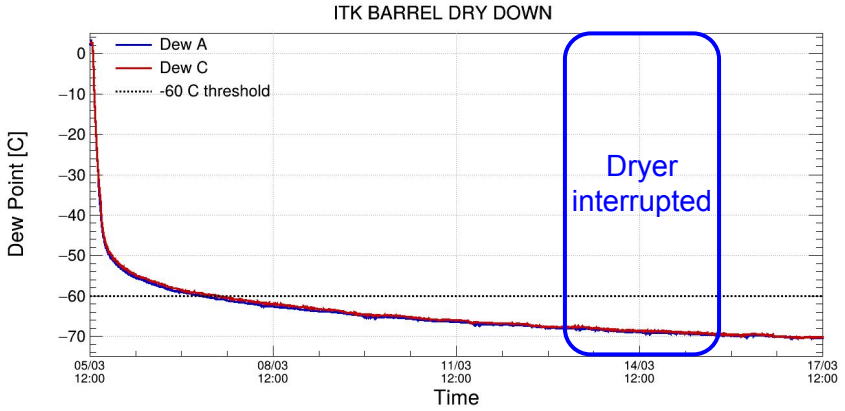
Dry Down

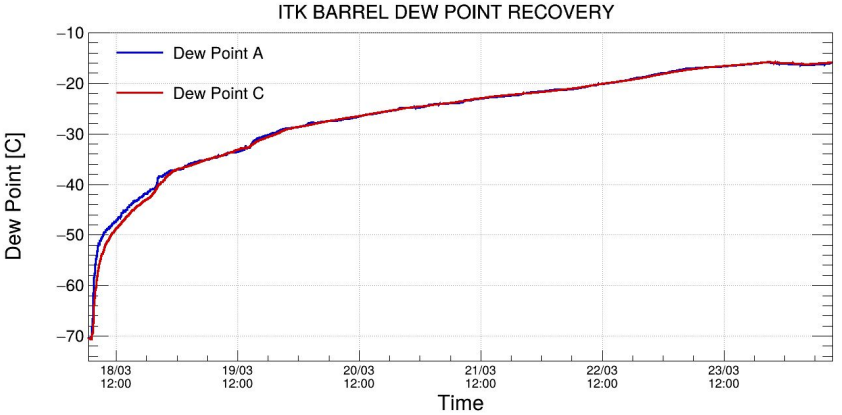
- Reached at -70 °C (DMP8 limit)
- Reached −60 °C after approximately two days
- Dry-air supply interrupted for ~ 2 days
  - Backup supply took over

Recovery

- ~ 2 h from -70 °C to -55 °C
  - Safe reaction margin
- Approximately one day to recover to −35 °C.
- Then slowly increases.

The barrel had no thermal load during this test, different behaviour is expected during operation.

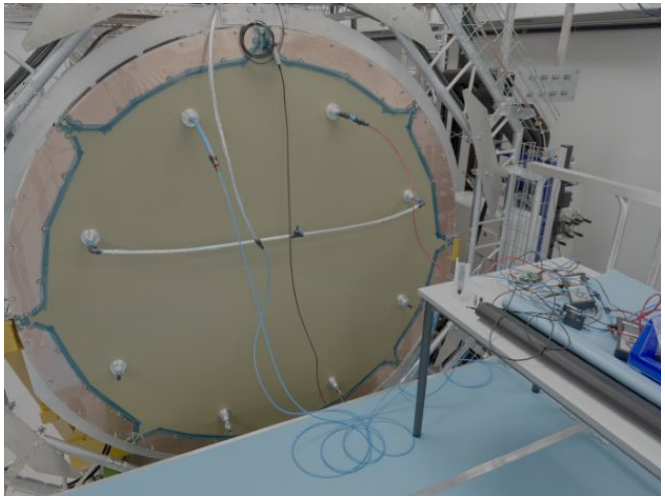


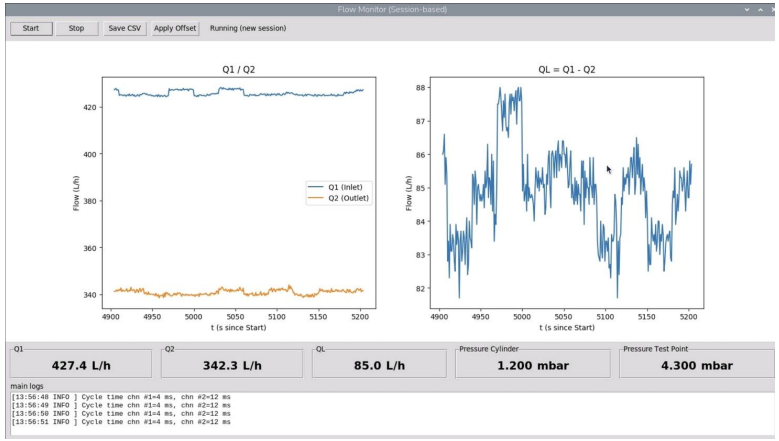


ITk Barrel Leak Rate Test

Gas Leak Rate Measurement Setup

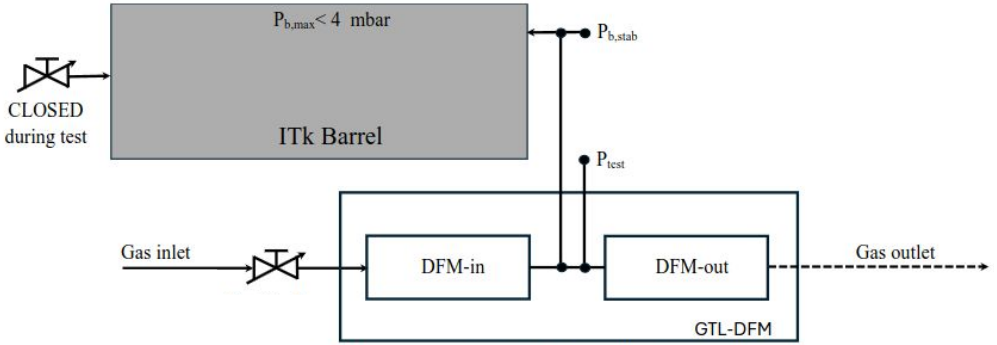
- Flow Rate Loss (FRL) method
- Two Festos SFAH-10B Digital Flowmeters
  - Bidirectional, capable of reading from -600 to 600 L/h
  - supporting IO-Link protocol
- Raspberry pi 4B + IO-Link hat
- Two Differential Manometers
- Data taking software and UI has been created.

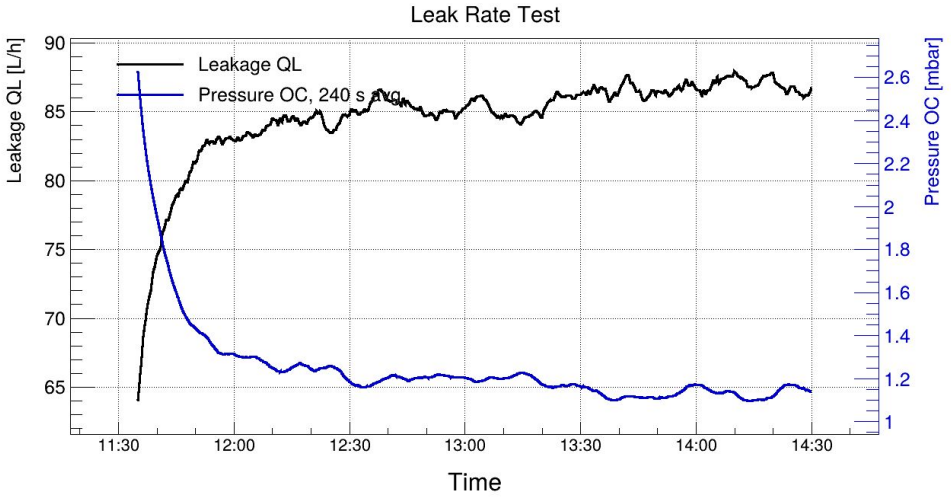




Open Outlet Configuration

- Standard FRL method with the outlet kept open
- Inlet flow fixed at 420 L/h
- System stabilized at ~1.1mbar overpressure
- Measured leak rate: ~86 L/h
- **Higher pressures could not be achieved**





Conclusions

- Developed an environmental monitoring and protection system for the ITk Strip Barrel integration.
- Successfully validated the dry-down procedure and demonstrated that the required dew-point conditions can be achieved.
- An FSM has been developed that later will be included into the main FSM of the Strips Barrel.
- First gas leak rate test was performed on the Outer Cylinder of the ITK barrel

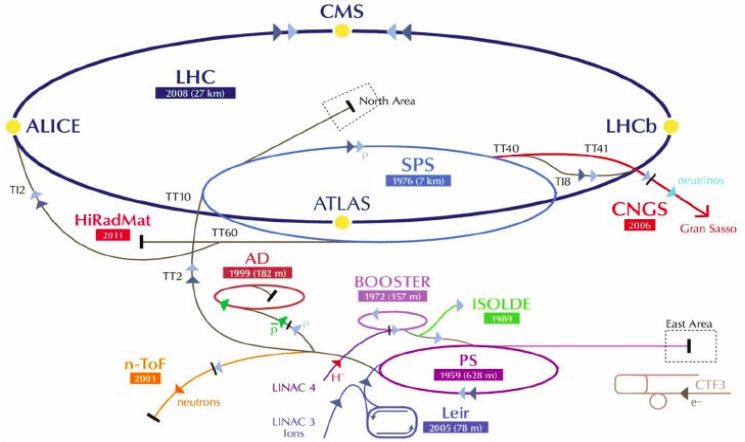
Thank you!

BACK UP

CERN: The LHC and ATLAS

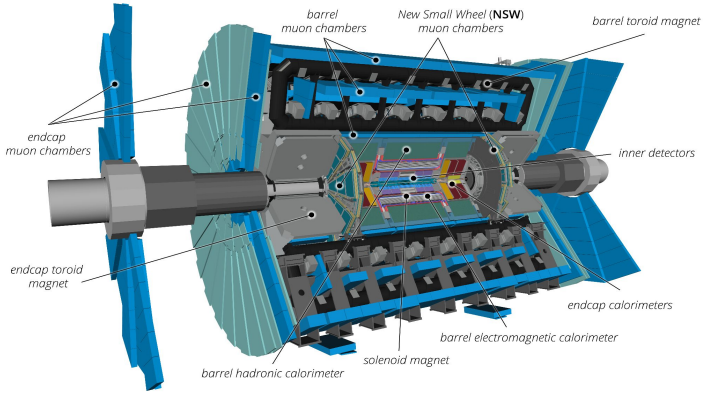
Large Handron Collider

- Circumference: 27 km
- Located ~100 m underground
- proton-proton collisions
- C.M energy 13.6 TeV



A Toroidal LHC ApparatuS

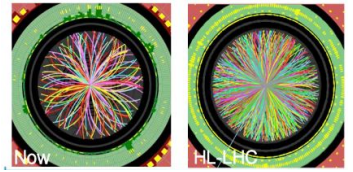
- General-purpose detector
- Mass: ~7000 tonnes
- Size: 44 x 25 m
- Discovery + precision physics

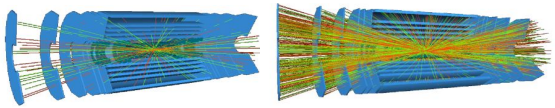


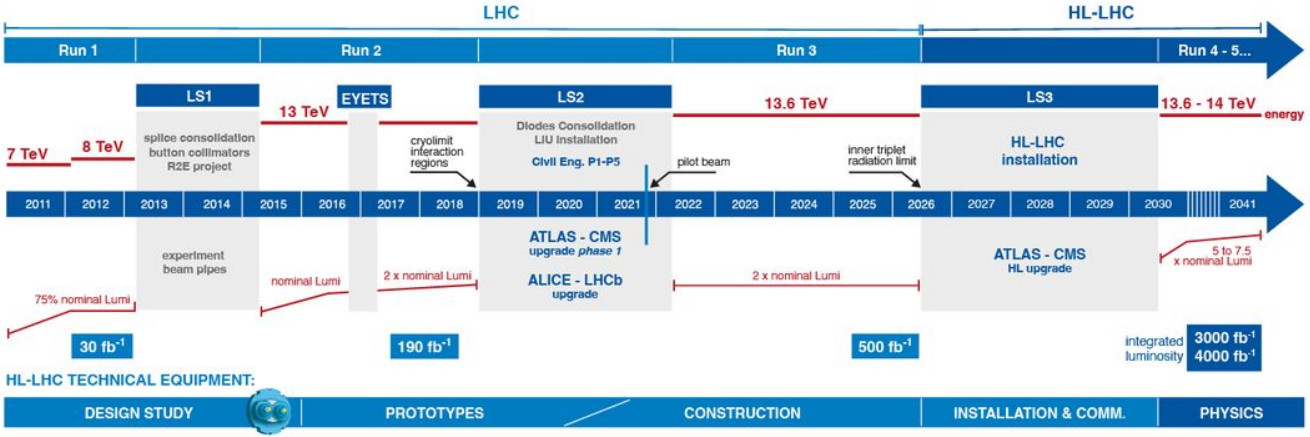
HiLumi LHC

The **HL-LHC** will increase the complexity of **LHC** collisions

- Integrated luminosity increased by a factor of 10
- Number of collisions from ~45 to 200 per bunch crossing (pileup)
- Much higher radiation levels and detector occupancy
- Harsh operating conditions: **ATLAS needs to be upgraded!**

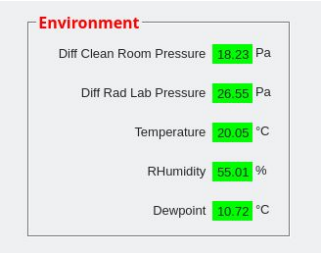


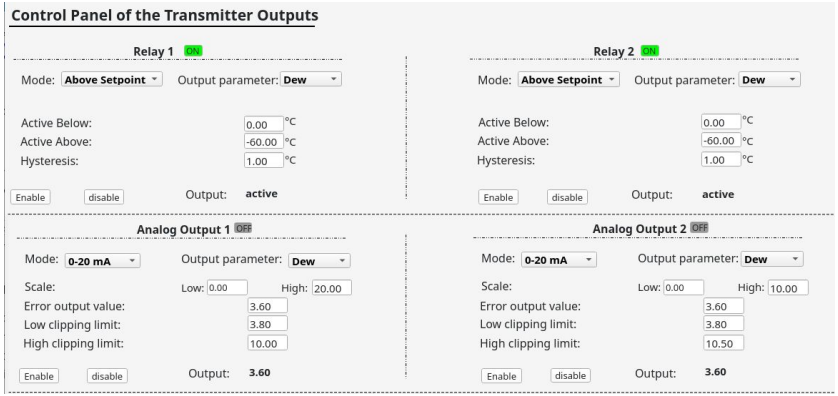


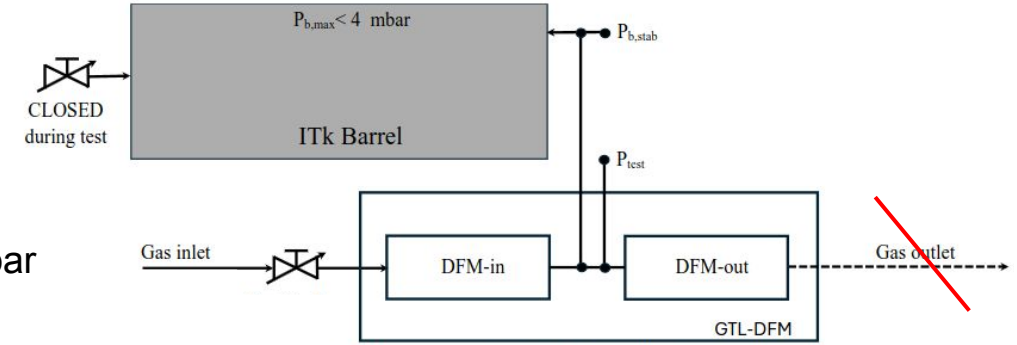
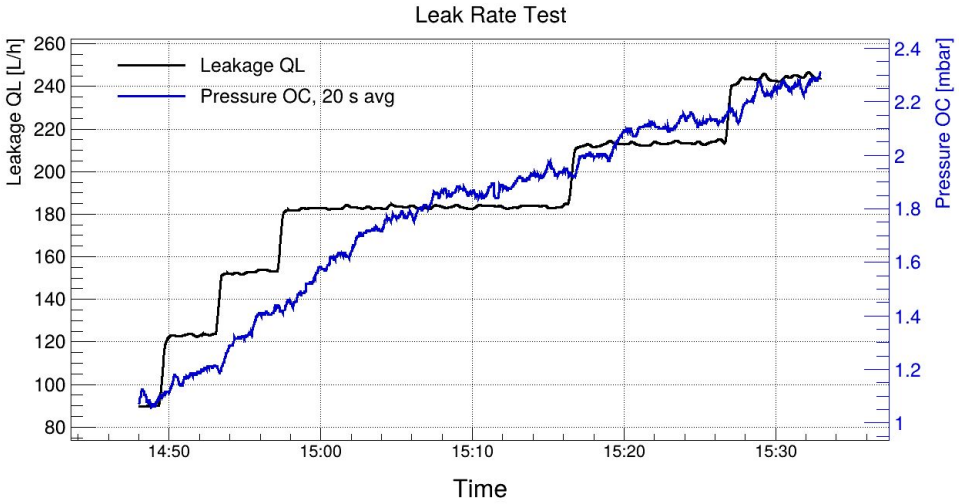


WinCC OA Implementation

- Creating Data Point Types for Transmitter + DMP8 probes.
- **Modbus TCP/IP Client** getting the data from the Transmitter.
- Monitoring + Hardware Alarm Handling + Historical Archiving.
- DIP Subscription to the Cooling Control System, access to Cooling plant DSS Alarms.
- DIP Subscription to the Ventilation System access to Environmental Conditions of the Clean Room.
- Panel for controlling Transmitter two Relays and Analog Outputs.
- Panels to populate the FSM Tree.





Closed Outlet Configuration

- Outlet closed to increase the barrel overpressure
- Inlet flow increased in discrete steps
- Pressure reached ~2.3 mbar
- No time to complete the measurement at 3 mbar
- Clear indication that there is high leakage