INTERLOCK AND SAFETY SYSTEMS FOR ITK SYSTEM TEST

Matteo Durando

Supervisors: Dr. Jan-Hendrik Arling
Maximilian Felix Caspar
Konstantin Mauer

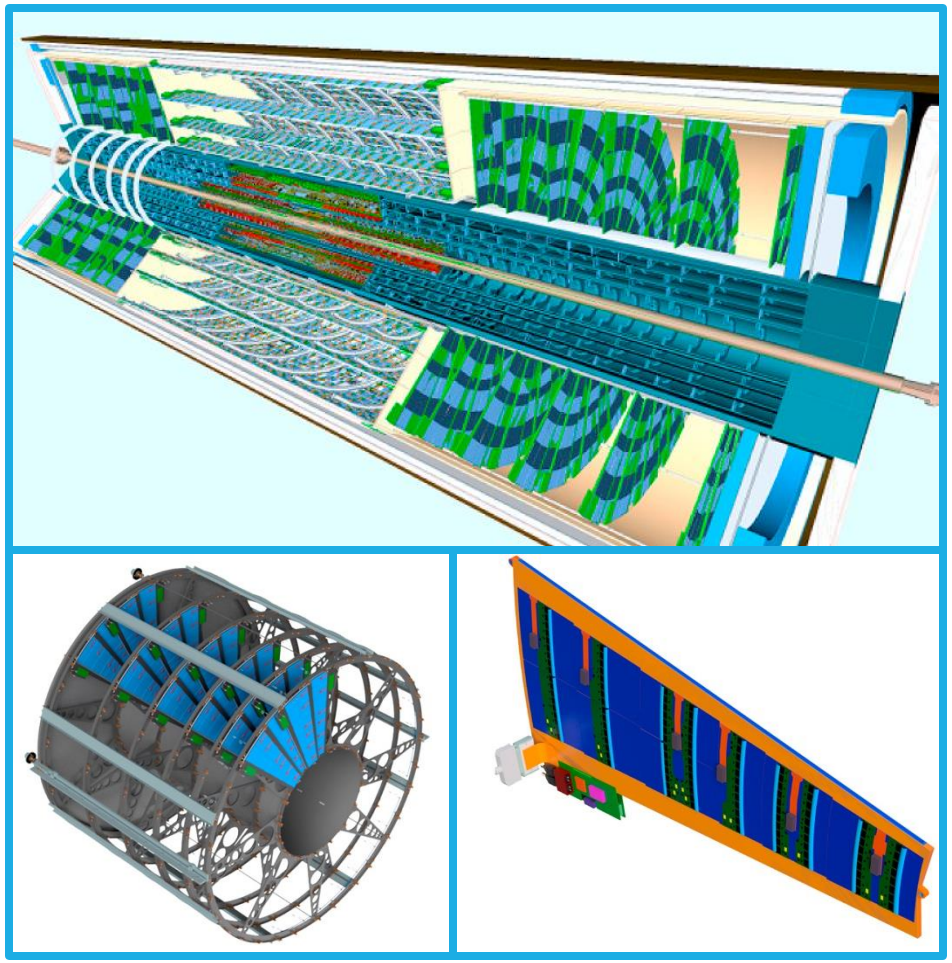
DESY Summer Student Programme 2024

ATLAS ITk Strip End-Cap

ATLAS Inner Detector will be upgraded for HL-LHC with a new all-silicon tracking detector called “ATLAS Inner Tracker” during LS3

Strip End-Cap characteristics

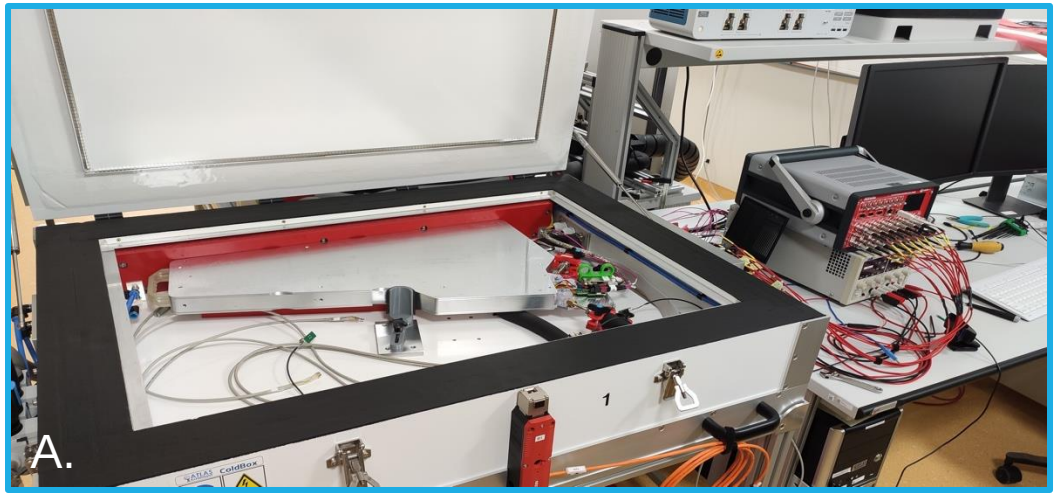
- 6 tracking layers
- 32 petals for each disc
- 6 modules for each petal
- Strip sensors with wire-bonded hybrid readout
- In-built CO2 pipes for cooling

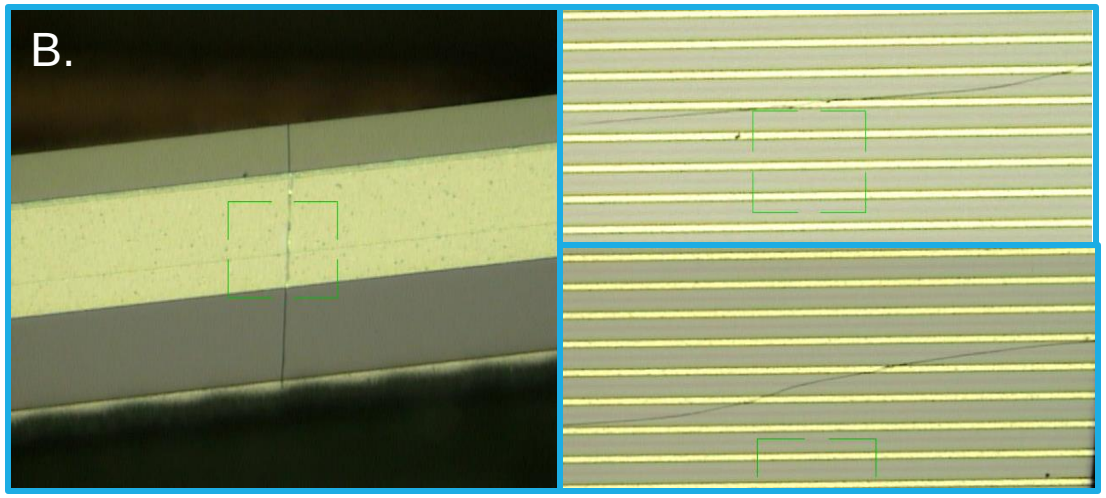


ITk Petal & System Test

Main activities

A. Petal testing at different temperatures
B. Silicon inspection for crackings
C. Preparing ITk integration



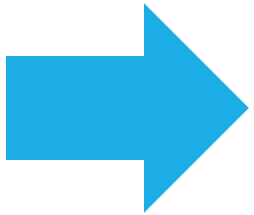


Interlock and Safety systems

Requirements

Need to protect both the objects and the people operating with them

- ✓ Detect possible issues
  - ➢ Electrical issues
  - ➢ Cooling failure
- ✓ Minimise human control over enabling/disabling systems
- ✓ Enable DAQ only with optimal conditions



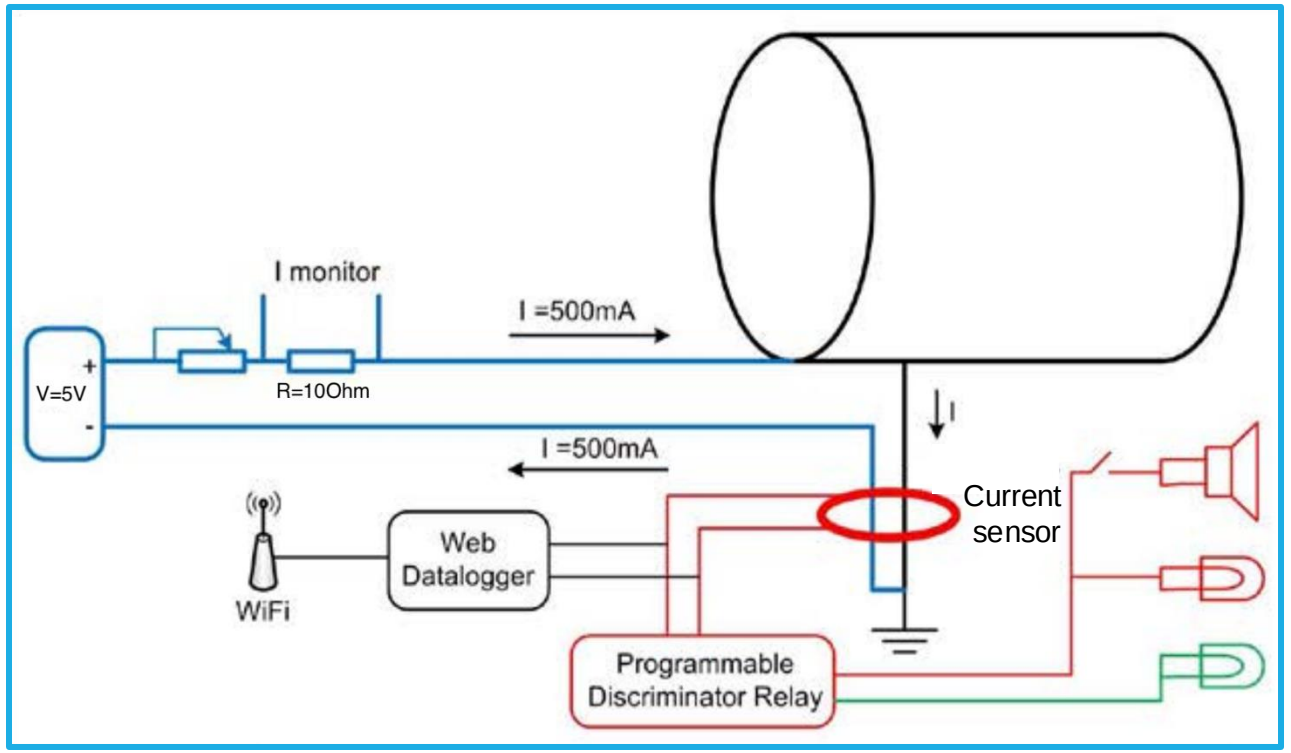
Examples

- Detector Control System (DCS)
  - ➢ Monitor the condition of the entire detector while running
- Ground Fault Monitor (GFM)
  - ➢ Monitor ground connections during petal insertion
- InterlockBoard
  - ➢ Monitor and control coldbox setup during petal testing

Ground Fault Monitor

Specifications

- Real-time monitor for unwanted earth connection
- Measure unbalance in current flowing through an induction coil
- Flowing current of 500mA
- Sensitivity of 1mA unbalance
- Maximum expected GF detection for R = O(kΩ)



Useful relations:

$$R_{GF}^{MAX} = R_{Bk} \cdot \frac{I_{Bk}}{|I_{Bk} - I_{Bl}|}$$

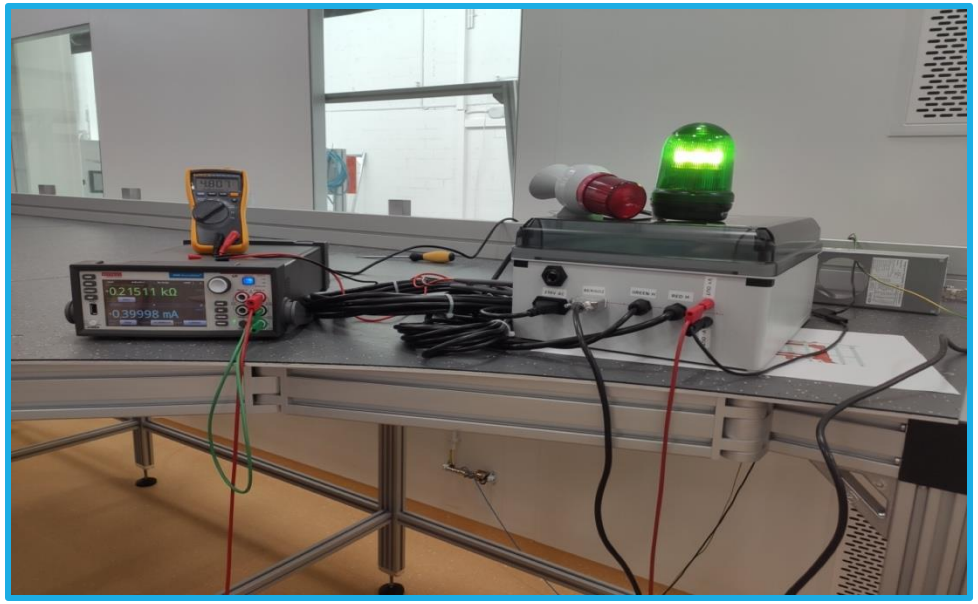
$$V_{Det} = R_{Bk} \cdot I_{Bk}$$

$$\frac{I_{Bk}}{|I_{Bk} - I_{Bl}|} \in [500,1000]$$

GFM – Lab testing

Measurements

- Testing with different cables and resistances
- Increased Bergoz sensitivity by tuning the parameters
- Measured possible GF sources on the assembly platform



Issues:

- ❖ Maximum detectable GF is significantly lower compared to what expected
- ❖ Device not able to detect accidental disconnections
- ❖ Possible problems with German guidelines for the construction of 230V devices

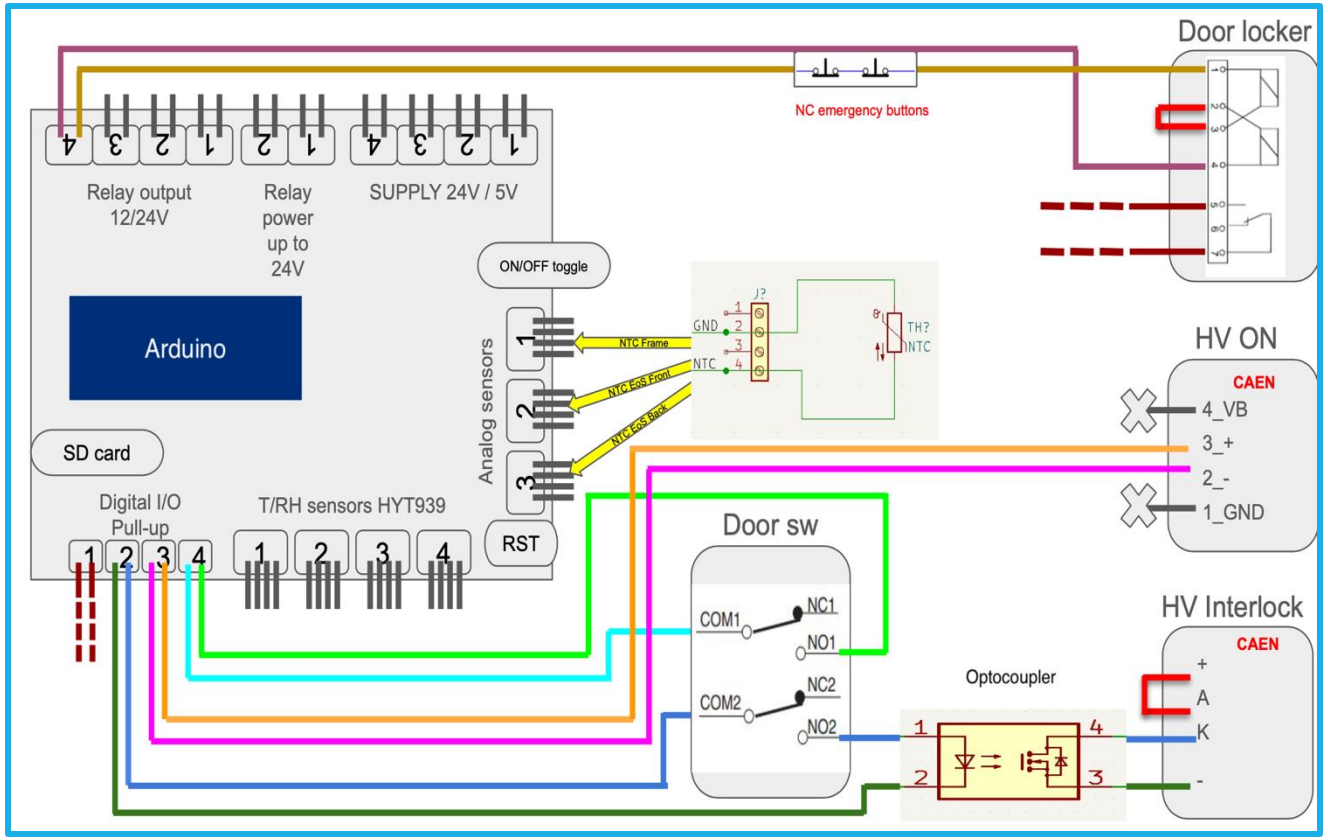
Future improvements:

- ✓ Define the resistance of detector – ground connection
  - Define expected values for GF connections
  - Define maximum voltage to apply to the detector
- ✓ Test with more realistic configuration

InterlockBoard

Objectives

- ✓ Monitoring coldbox environment and petal temperature
- ✓ Enabling PSUs (HV / LV) for petal testing
- ✓ Steering the magnetic door lock
- ✓ Upload real-time status to Grafana dashboard



Components:

1. Arduino-based microcontroller
2. Sentuino Board (designed by IFIC – Valencia)
3. Python interface for data pipeline Arduino –> PC –> Grafana

IB – Arduino characteristics

Advantages

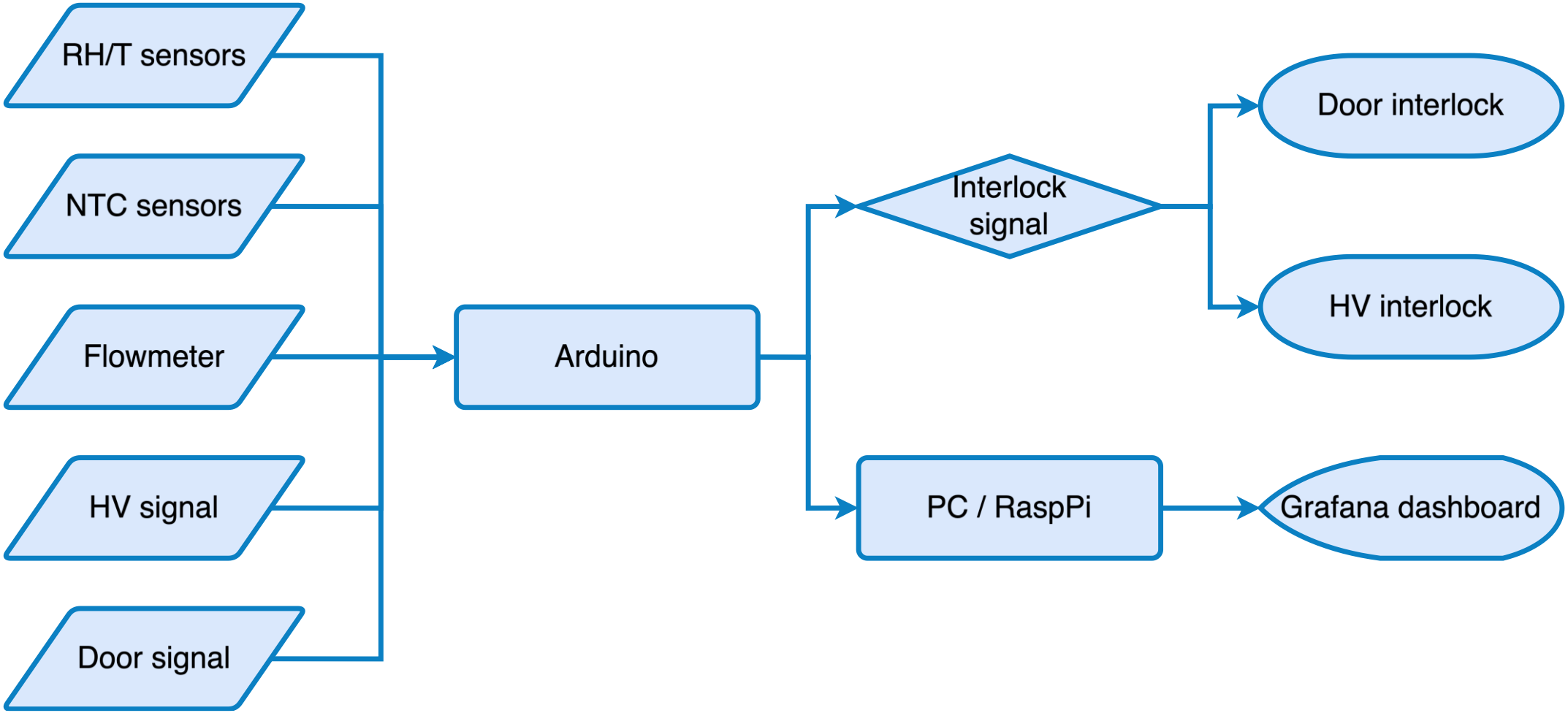
- ✓ Analog signal interface without external ADC/DAC
- ✓ Low power consumption
- ✓ High reliability for long term operation
- ✓ Low cost for the material
- ✓ Lots of documentation for different projects

Disadvantages

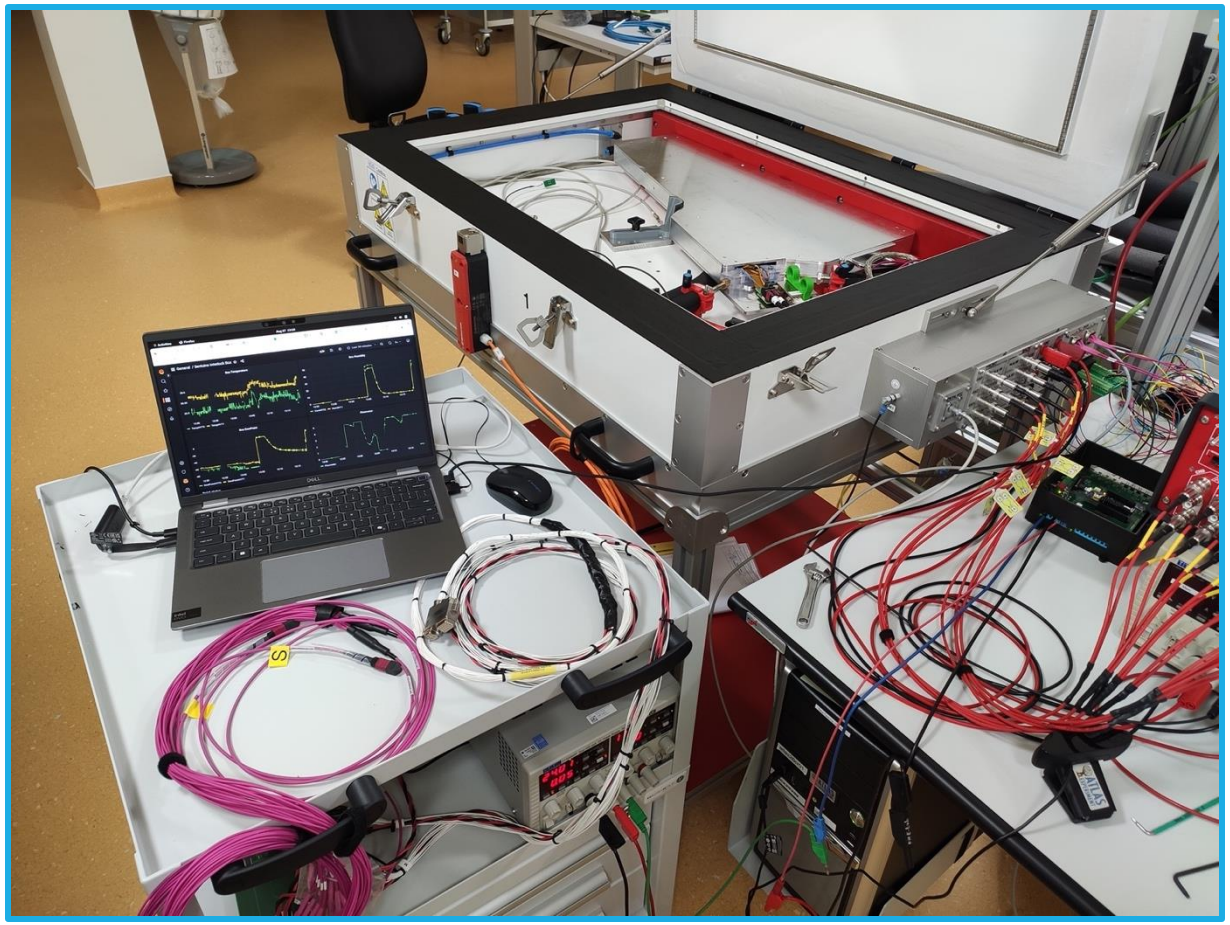
- ❖ Limited computational power
- ❖ Absence of a file system
- ❖ C++ compatible only
- ❖ Limited communication bandwidth
- ❖ Issues regarding network connection

→ Another device (PC/RaspPi) is required to send data through the network

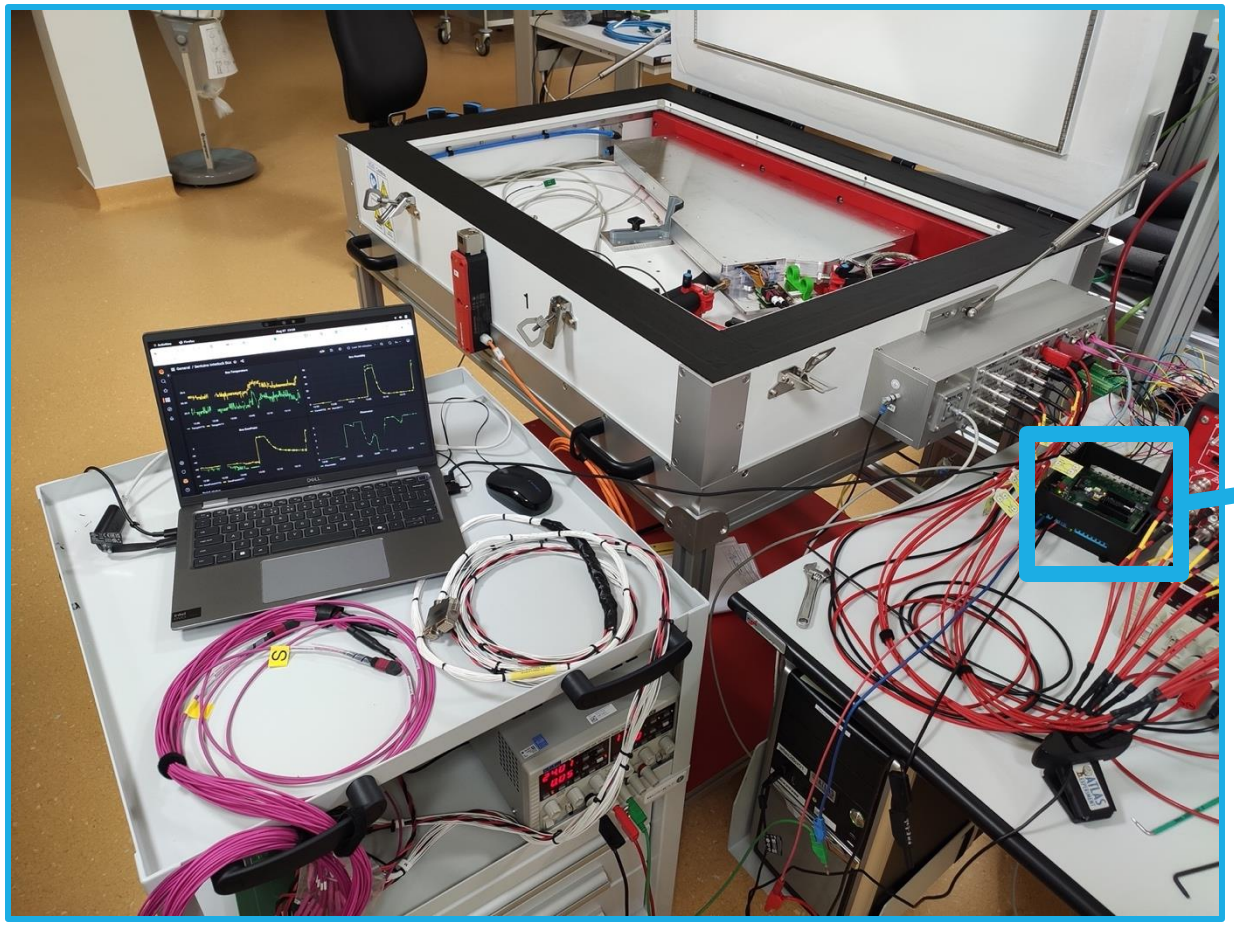
IB – Data & signal pipeline



IB – Setup



IB – Setup

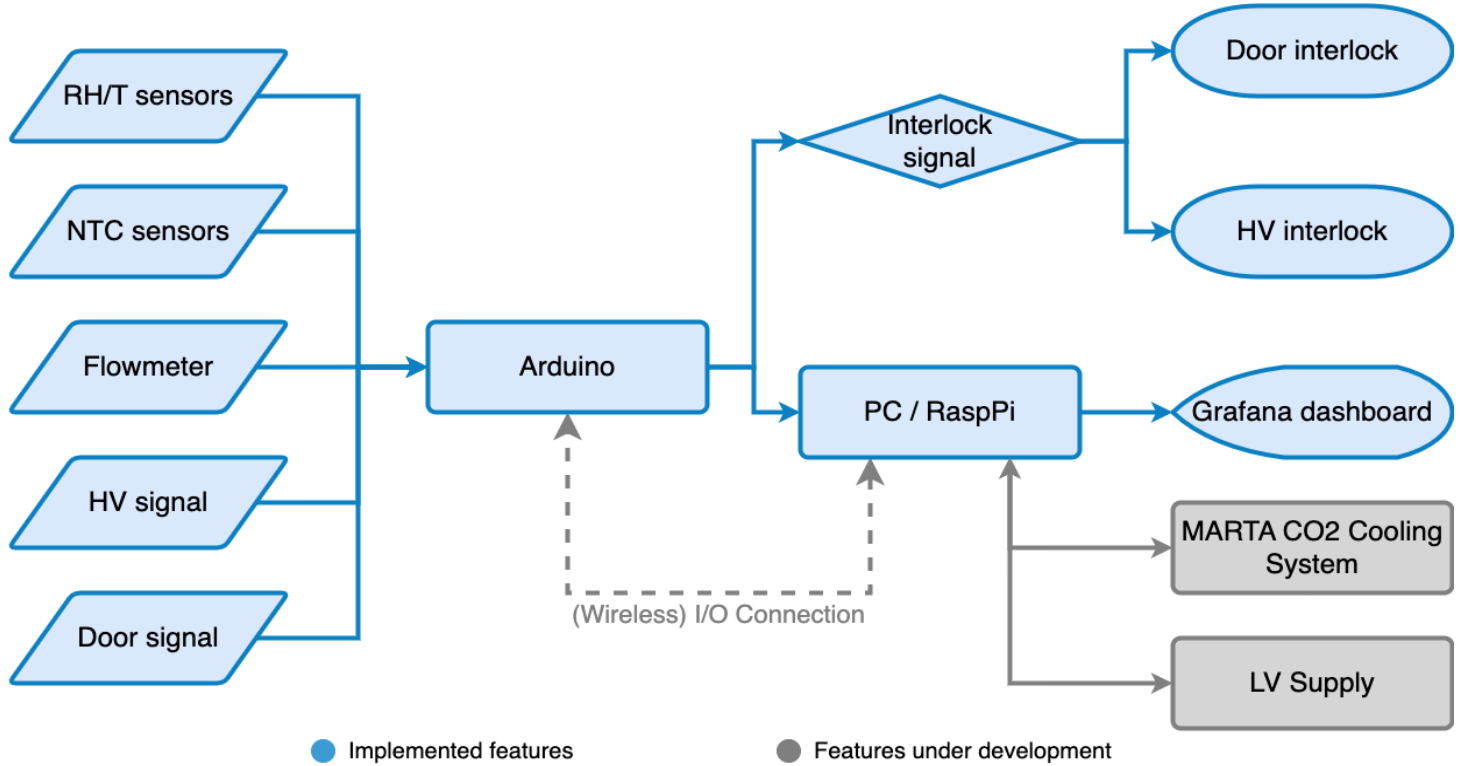


IB – Setup


General / Sentuino Interlock Box
2024-08-27 13:00:00 to 2024-08-27 14:30:00
Environment status
Box Temperature
20.7
20.65
20.6
20.55
20.5
20.45
13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20 14:3
TempHYT0 TempHYT1
Box Humidity
50
40
30
20
10
0
13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20 14:3
HumHYT0 HumHYT1
Box DewPoint
0
-20
-40
-60
-80
13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20 14:3
DewPointHYT0 DewPointHYT1
Flowmeter
5
4
3
2
1
0
13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20 14:3
Flowmeter

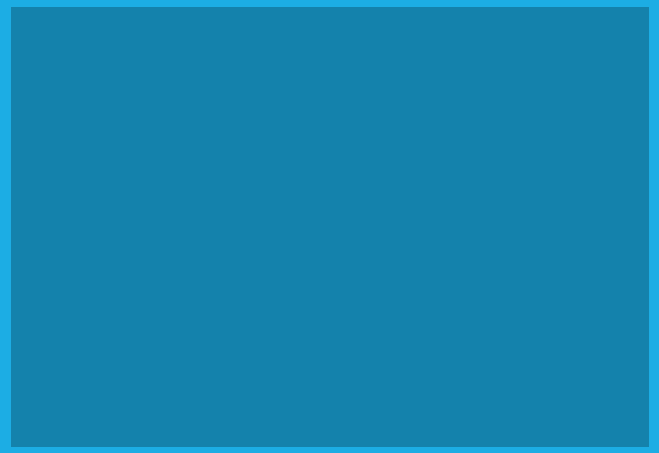
IB – Further developments

- Add integration for MARTA CO2 cooling system (I/O)
- Add I/O signals for LV power supply
- Enable wireless connectivity for sending data and OTA update



Summary

- The system test for ATLAS ITk has the objective to define and verify the operating conditions of the detector and all the external services related to its operation
- Interlock and safety systems are required to operate the detector to decrease significantly the risks for both the detector itself and the people working on it
- Tests with the GFM have put in evidence some criticalities that will be rediscussed and fixed before the start of insertion and integration phases.
- The InterlockBox will give the opportunity to operate the coldbox with a more reliable and expandable system for the monitor & control part



THANK YOU

Acknowledgments:

Jan-Hendrik Arling
Maximilian Felix Caspar
Konstantin Mauer