THPV048

NOVEL CONTROL SYSTEM FOR THE LHCb SCINTILLATING FIBRE TRACKER DETECTOR INFRASTRUCTURE

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SCIFI TRACKER

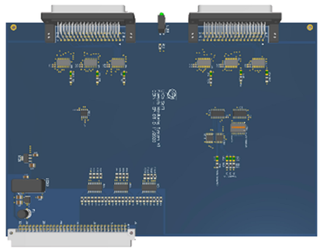
During the Long Shutdown 2 of the LHC at CERN, the LHCb detector is upgraded to cope with higher instantaneous luminosities. The largest of the new trackers is based on the scintillating fibres (SciFi) read out by SIlicon PhotoMultipliers (SiPMs). The SiPMs will be cooled down to -40°C to minimize noise. For performance and integration compatibility, the cooling lines are **vacuum** insulated. Ionizing radiation requires detaching and displacing the readout electronics from Pirani gauges to a lower radiation area. To avoid condensation inside the SiPM boxes, the atmosphere inside must have a dew point of at most -45°C. The low dew point will be achieved by flushing a dry gas through the box. 576 **flowmeters** devices will be installed to monitor the gas flow continuously. A **Condensation Prevention System** (CPS) has been implemented as condensation was observed in previous detector operation tests. The CPS powers heating wires installed around the SiPM boxes and the vacuum bellows isolating the cooling lines. The CPS also includes 672 temperature sensors to monitor that all parts are warmer than the cavern dew point. The temperature readout systems are based on radiation tolerant multiplexing technology at the the front-end and a PLC in the back-end.

VACUUM SYSTEM

- 2 vacuum subsystems
- **4** Turbomolecular pumps in the magnetic field
- 48 vacuum lines
- **48** Pirani sensors with remote electronic

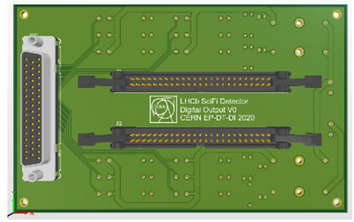
FLOWCELLS DAQ SYSTEM

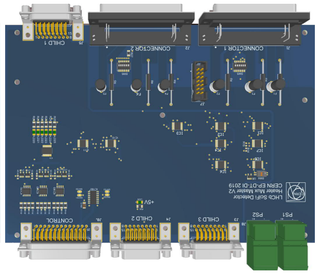
- **576** flow sensors
- 24 signal cables
- 12 multiplexers
- **12** analog inputs
- 6 digital outputs



CONDENSATION PREVENTION SYSTEM

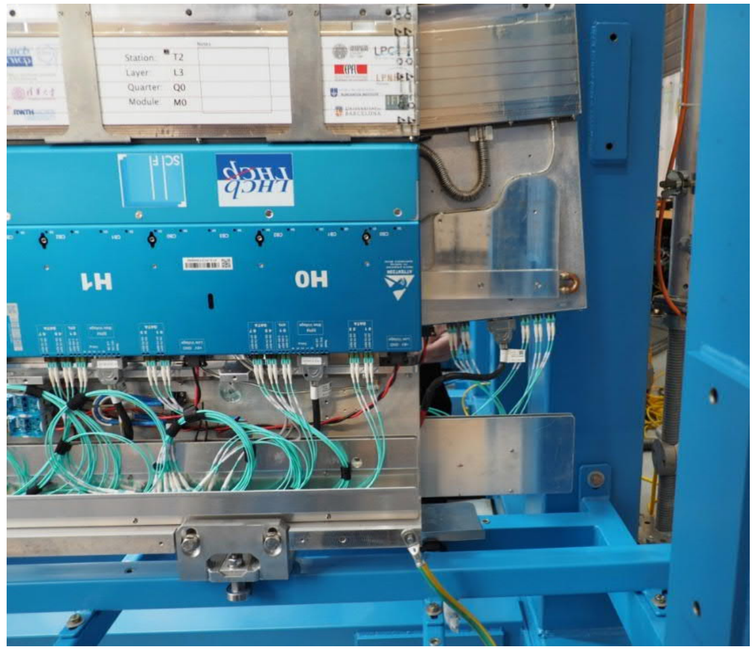
- **672** Pt100 sensors
- 288 heating wires power distribution
- **288** heaters current measurement
- 48 multiplexing boards
- **4** control cables between the service and experimental caverns



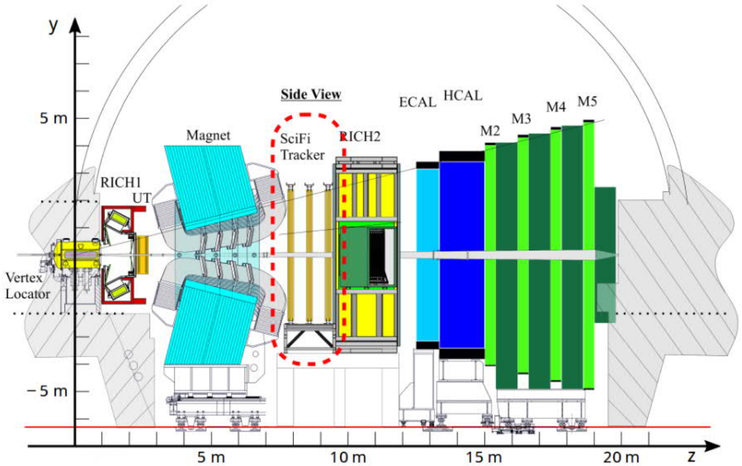


SciFi

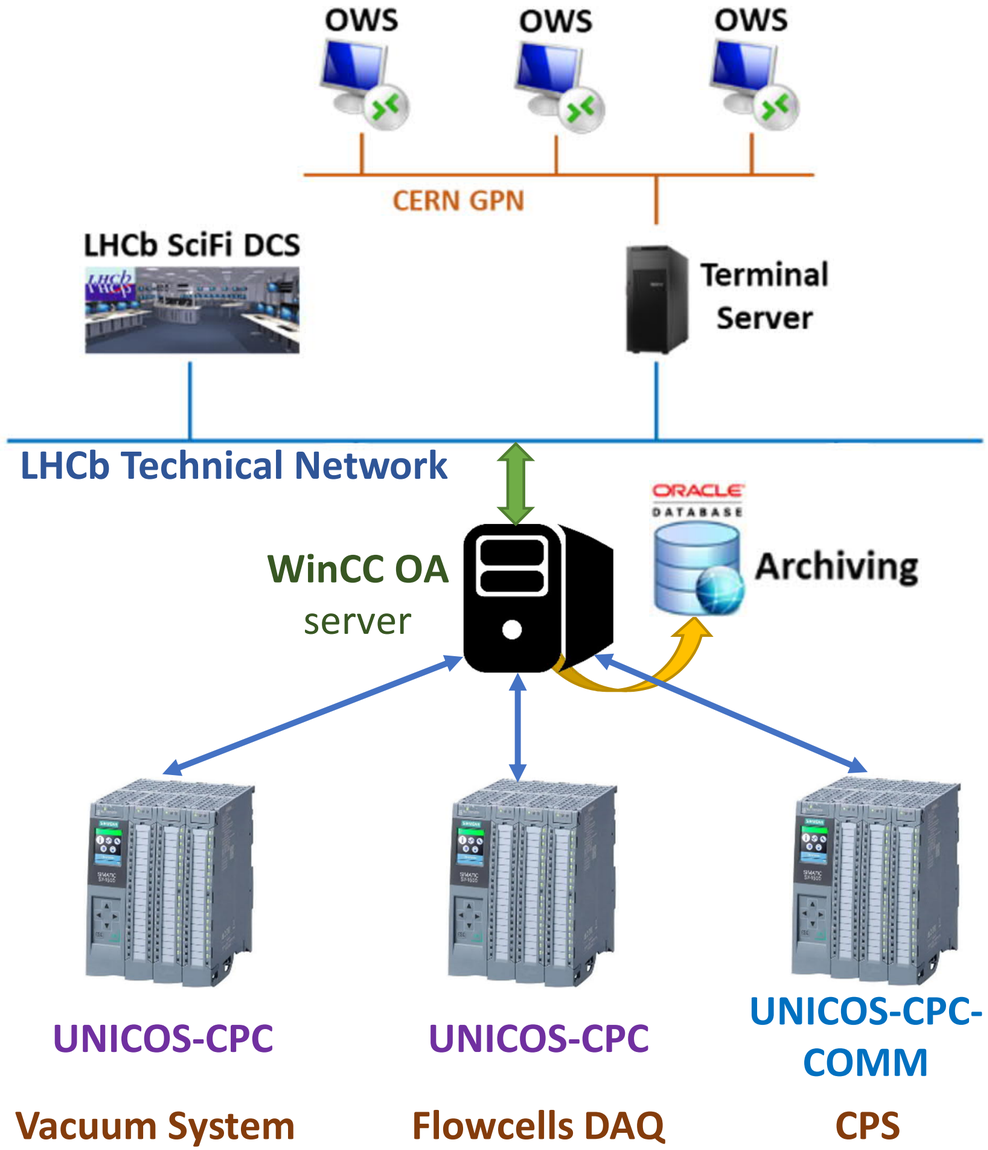
The SciFi tracker consists of three stations each with four detection planes. The detector is built from individual modules (0.5 m ×4.8 m), each comprising 8 fibre mats with a length of 2.4 m as active detector material. The fibre mats consist of 6 layers of densely packed blue-emitting scintillating fibres with a diameter of 250 μm. The scintillation light is recorded with arrays of state-of-the-art multi-channel silicon photomultipliers (SiPMs). A custom ASIC is used to digitize the SiPM signals. Subsequent digital electronics performs clustering and data-compression before the data is sent via optical links to the DAQ system. To reduce the thermal noise of the SiPM, in particular after being exposed to a neutron fluence of up to 1012 neq/cm2, expected for the lifetime of the detector, the SiPM arrays are mounted in so called cold-boxes and cooled down by 3D-printed titanium cold-bars to −40˚C. The detector is designed to provide low material budget (1 % per layer), hit efficiency of 99 % and a resolution better than 100 μm. These performance figures must be maintained over the lifetime of the detector which will receive radiation dose up to 35 kGy near the beam pipe. The full detector, comprising 590 000 channels, is read out at 40 MHz.



SciFi detector with the CPS, Flowcells and vacuum lines (in the back)



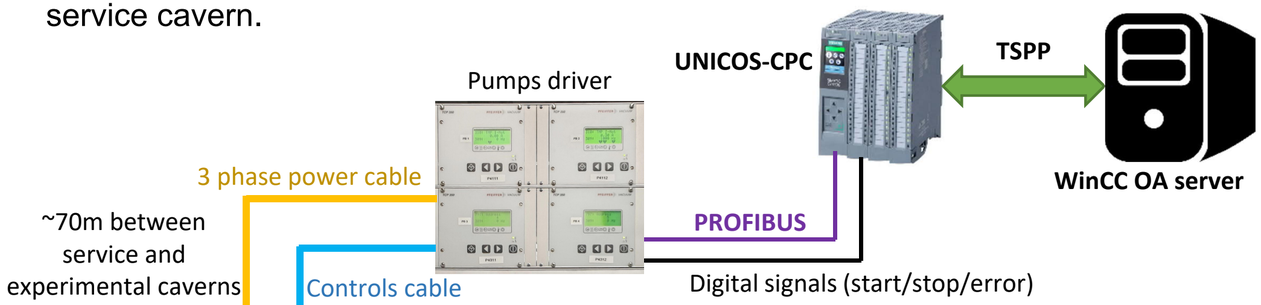
Side view of the LHCb upgrade detector

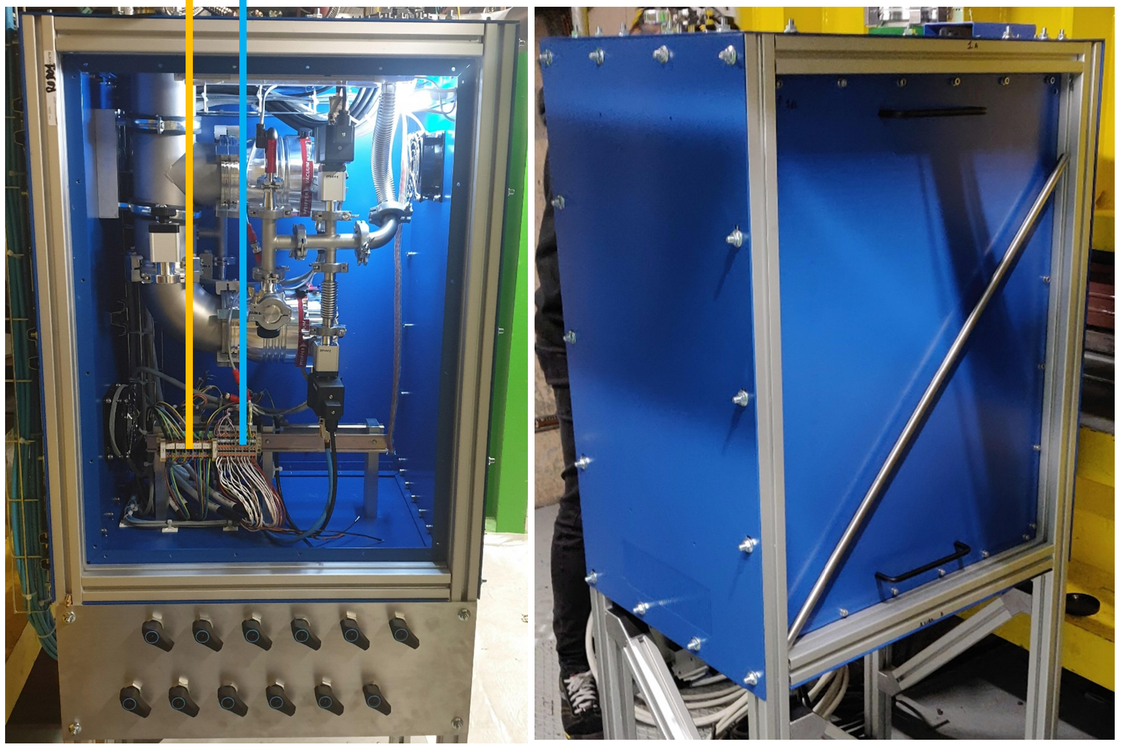


SciFi control system overview

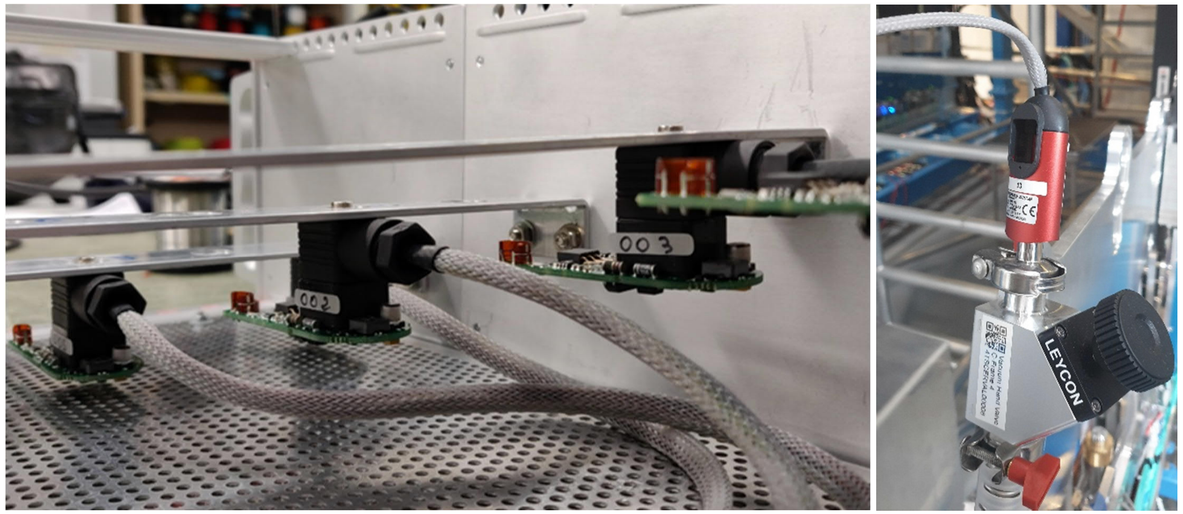
VACUUM SYSTEM

Turbomolecular pumps are located on both sides, very close to the detector, and need to be protected against magnetic field. To allow safe operation, pumps, electro valves and two pressure gauges have been placed in the 2-layer iron shielded case. Additionally, pump drivers have been detached and located in the PLC rack in the LHCb service cavern.



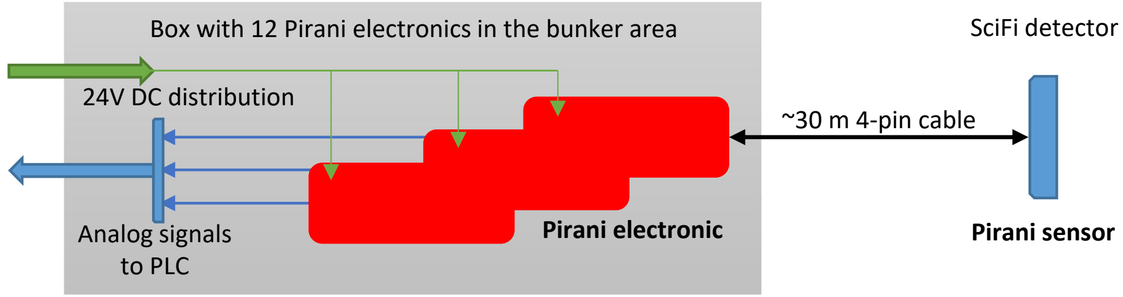


SciFi vacuum system – Turbomolecular pumps control and shielding



SciFi vacuum system - Pirani gauge electronic (left) and sensor (right)

Each of the 12 C-Frames has two vacuum gauges for the upper manifold and lower manifold, 24 Pirani sensors in total. The presence of ionising radiation, cumulating to 50 Gy over the lifetime of the experiment, requires detaching the readout electronics from those Pirani gauges that are mounted on the manifolds. Two 3U racks (one per side) with 12 readout electronic PCB are located in the safe distance from the detector (in the bunker area). Tests shows that detaching electronic and sensor adds small offset on the readout value, which is acceptable.

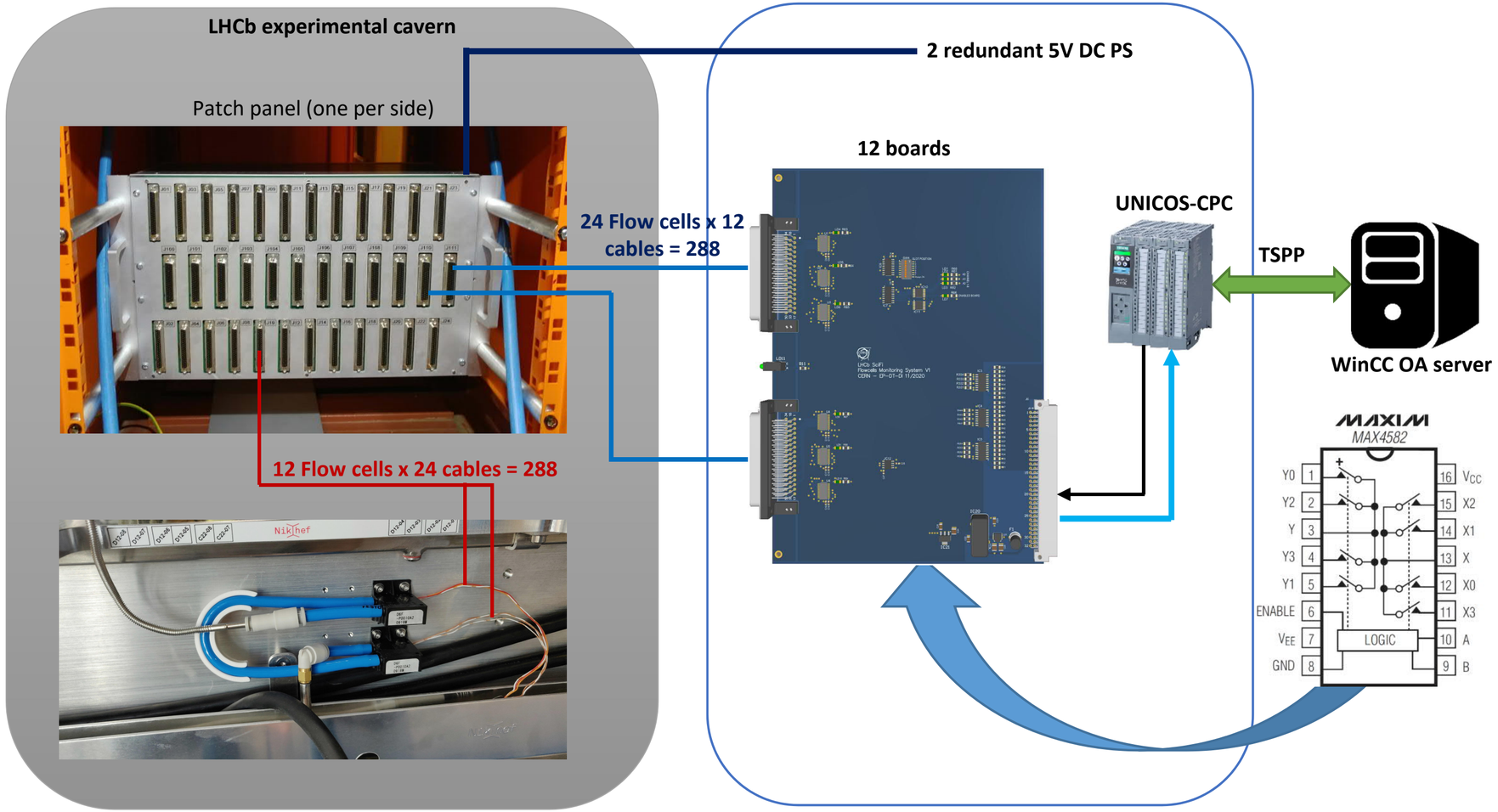


SciFi vacuum system – Pirani remote electronic box - layout

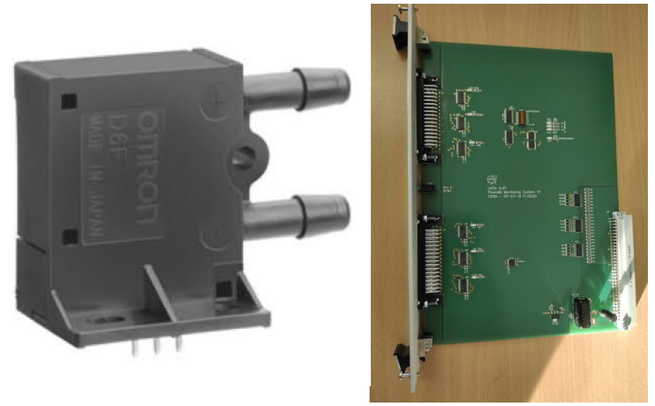
FLOWCELLS DAQ SYSTEM

The low dew point in the SiPM boxes is achieved by flushing a dry gas through the box. A small overpressure compensate for leaks which could let humid air diffuse into the box. Flowmeter devices are installed on the outgoing line of each cold box in order to monitor continuously the gas flow. To insure a reliable measurement a fully redundant flow measurement is made with two flowmeters by outgoing line.

All the flow cells signals (48 per C-frame, **576** in total) are connected to two patch panels boxes, where power is distributed (two independent power supplies) and signals are separated (normal & redundant). The patch panel is connected with the DAQ rack using 12 MCA50 cables with the length around 60m each. The readout system is based on a 12 multiplexing boards. To preserve the redundancy, flow signals are separated into two multiplexers sub-racks. Multiplexed signals are connected to the SIEMENS S7-1500 PLC.



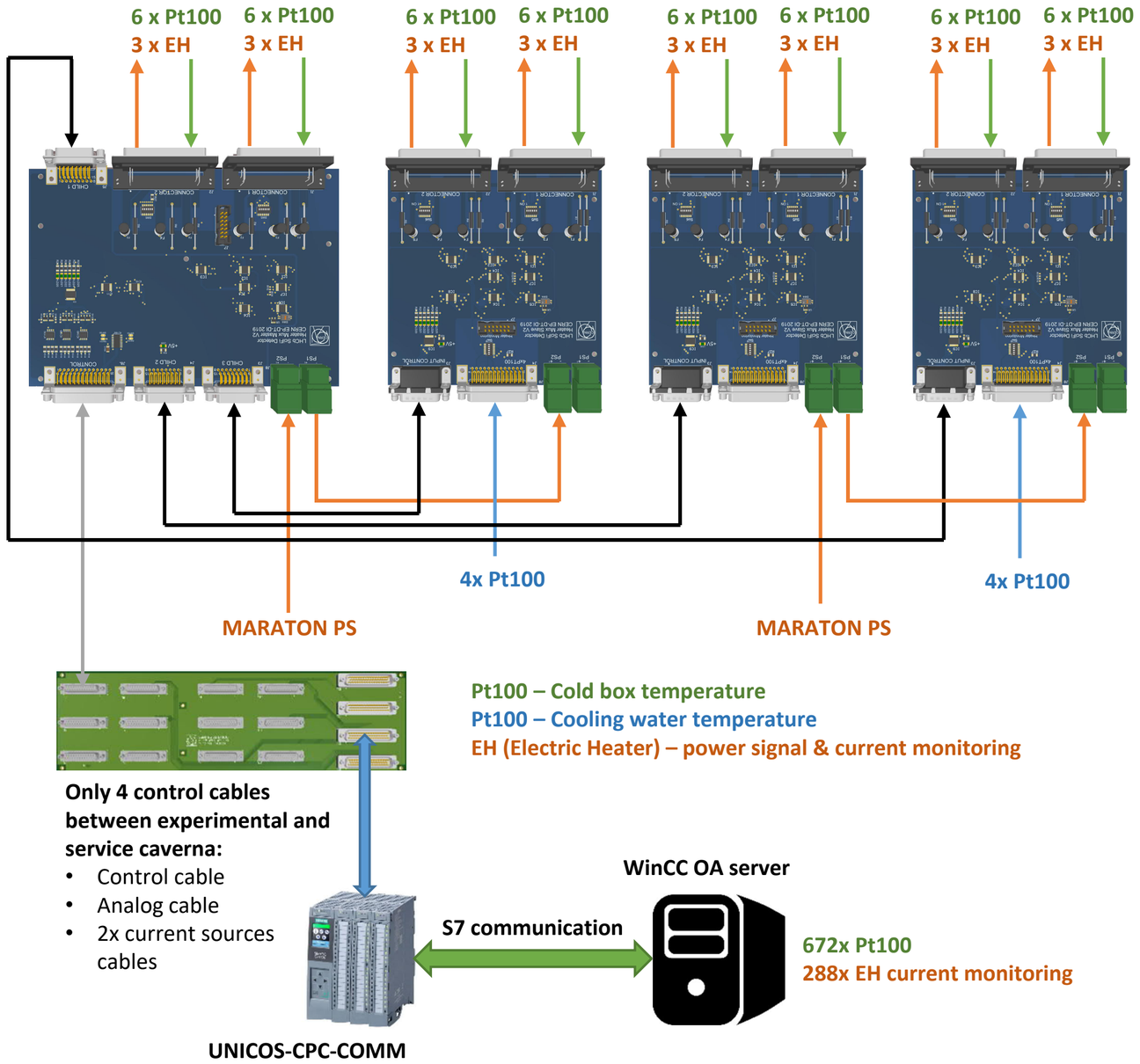
SciFi Flowcells DAQ – system layout



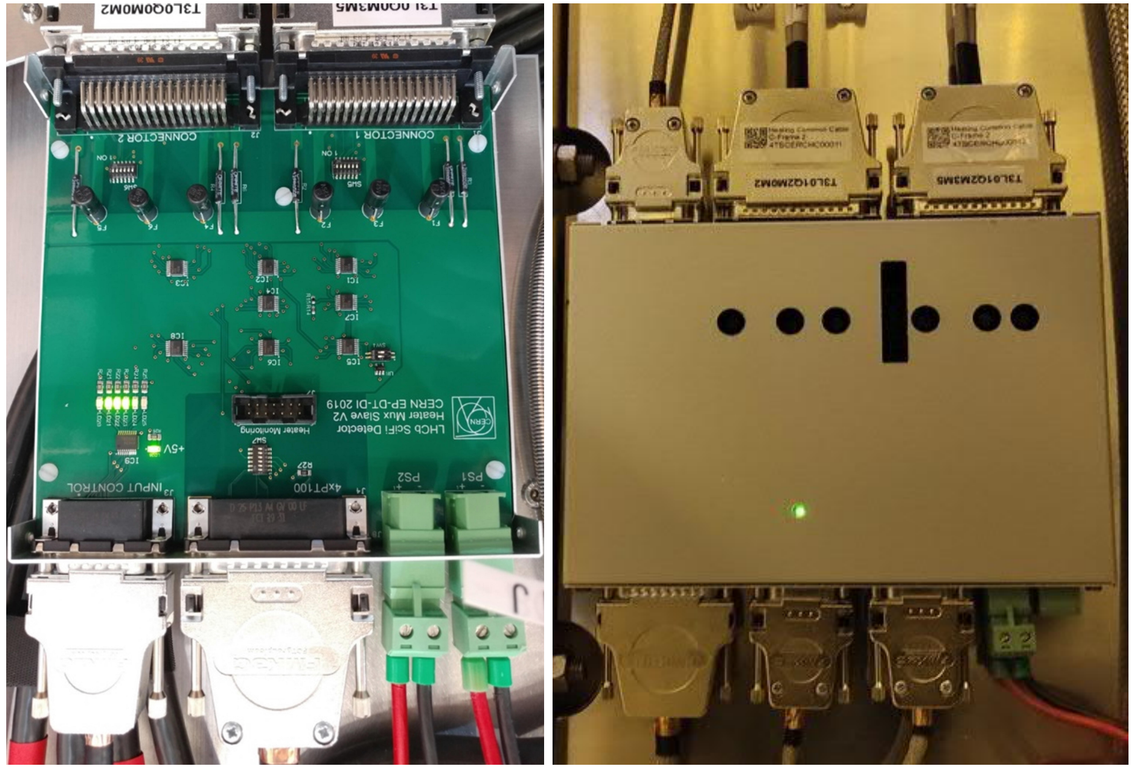
OMRON D6F-P MEMS Flow Sensor (left), PCB board (right)

576 flow signals acquired by two eight channels analogue inputs cards (12 channels needed). To multiplex the channels in the boards, six digital output signals are required. The complete readout cycle takes around 30s, meaning that each flow measurement is updated every 30s.

CONDENSATION PREVENTION SYSTEM



SciFi CPS – system layout



SciFi CPS – “child” board (left) and “master” board (right)

The CPS (Condensation Prevention System) allows the monitoring, and the survey of **672** temperature sensors, Pt100 type, that are connected to radiation tolerant electronic interfaces, multiplexed and connected to a PLC, which collects all the information that is sent, a posteriori, to the Detector Control System. In case of condensation a heating wire that has been wrapped around the cooling transfer lines and the box housing the SiPMs. The CPS measure the **288** heating wires current.