A Programmable logic controller - based system for the recirculation of liquid C_6F_{14} in the ALICE High Momentum Particle IDentification detector at the Large Hadron Collider

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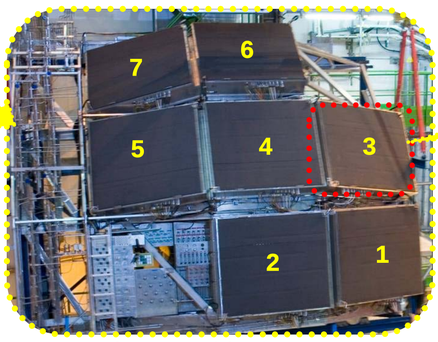
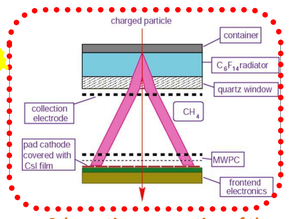
ALICE – HMPID detector

The ALICE High Momentum Particle Identification (HMPID) detector is a proximity focusing RICH performing charged hadrons identification in the momentum range 1-5 GeV/cat the CERN LHC. HMPID consists of seven identical RICH modules for Cherenkov ight imaging. It uses liquid C_6F_{14} as Cherenkov radiator medium in the twenty-one quartz vessels coupled to Multi-Wire Pad (MWPC) equipped with pad segmented CsI photo cathodes.

Front view of ALICE experiment



The seven modules of HMPID

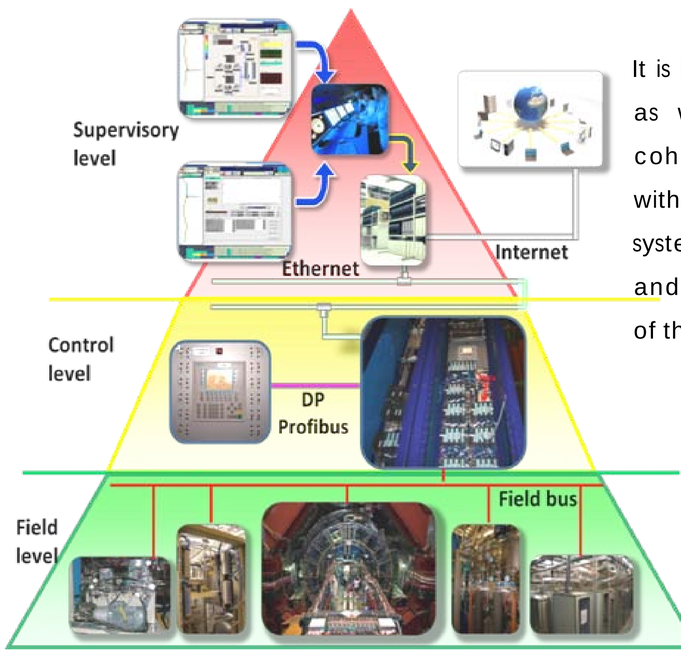


Schematic cross-section of the HMPID -RICH module

The C_6F_{14} Liquid Circulation System (LCS) is a closed, pressure-regulated, apparatus which purifies, fills, re-circulates and empties the radiator vessels. Its safe long term operation is ensured by a dedicated Control System (CS). This latter is included in the HMPID Detector Control System (DCS).

C_6F_{14} Control System

C_6F_{14} CS is a Programmable Logic Controller (PLC) – based control system.



CS Hardware Architecture

It is highly reliable and scalable, as well as simple and robust; coherent and homogeneous with all detector control sub-systems; operable permanently and independently of the state of the other HMPID subsystems.

Its architecture implements three hierarchical levels:

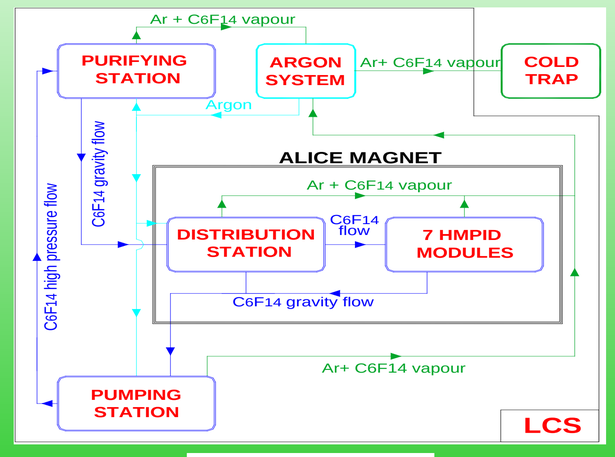
- **field level;**
- **control level ;**
- **supervisory level.**

C_6F_{14} Control System Field level

LCS represents the first level with all used sensors and actuators.

The liquid is continuously pumped from the pumping station to the purifying stations where appropriate filters, able to remove all contaminants, ensure the best liquid transparency. From the purifying stations the liquid flows by gravity, at fixed flow rate, into the distribution station. This latter is designed to control the flow rate into the detector's radiator vessels as well as to maintain the hydrostatic pressure value in each vessel minor than 140 mbar. Once filled the radiator vessels, the liquid returns into the main storage tank of the pumping station from where the cycle starts again. During all the operations anhydrous argon is flushed in to the system.

The C_6F_{14} released vapours are conveyed towards the cold trap station that condenses at -40 °C them for reuse.

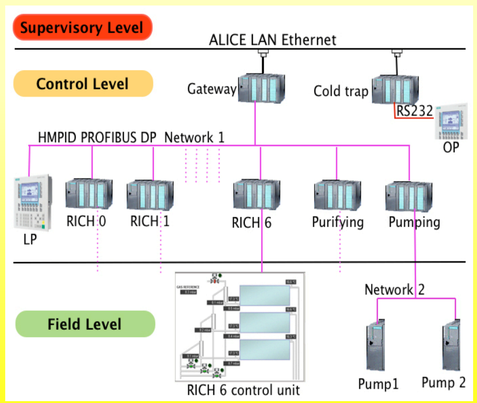


LCS state diagram

C_6F_{14} Control System Control level

Hardware

The control layer is the core where the control software processes run. It controls the underlying sensors/actuators by receiving and sending information through field buses. Its design has been oriented towards the definition of elementary units ($RICH_{th}$, purifying and pumping stations) which can be controlled and monitored singularly in LCS.



Control level hardware architecture

The hardware of the control layer consists of a network of Siemens S7-300 PLCs, one per control unit, reflecting the traditional Master-Slave requirements.

They are interconnected using the PROFIBUS DP communication protocol.

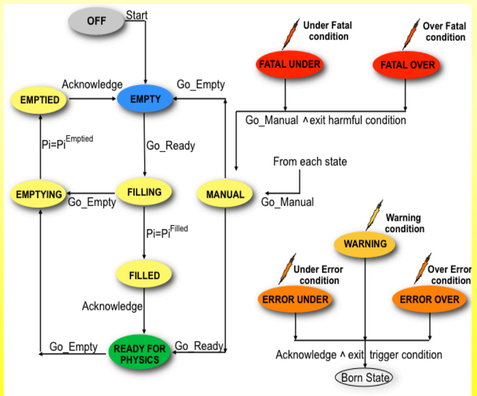
The Master PLC acts as gateway between the supervisory and control level

Unit modeling

The behaviour of each elementary unit has been modelled as a Finite State Machine (FSM). According to the Cern JCOP prescriptions three increasing severity alarm levels have been identified: WARNING, ERROR and FATAL. Both the warning and error allow the system to continue the normal operation. The fatal level alarm is active when harmful conditions happens. In this case the CS has been designed to react automatically preventing damages.

Within CS, the automatic and manual operational modes have been defined.

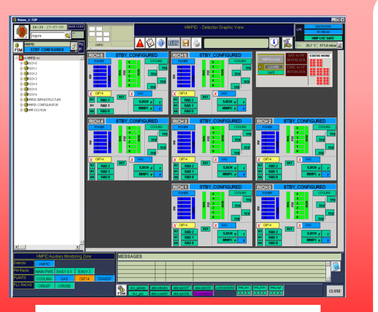
The control system has been developed in the environment Siemens STEP 7 through the software tool Simatic Manager.



Rich module State Diagram

C_6F_{14} Control System Supervisory level

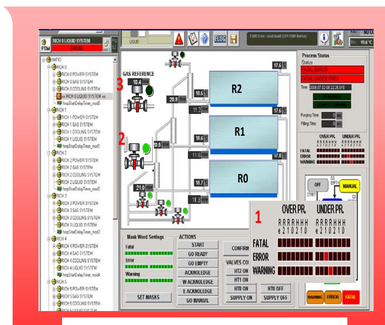
The supervisory level is the upper one. It supervises, via ALICE LAN Ethernet, the control process through a PVSS II as Supervisory Control And Data Acquisition (SCADA) system. This level enables the interfacing and the integration in HMPID DCS. It provides, the human-machine interfaces, alarm message handling and allows the data recording. The database is implemented as the ORACLE Real Application Cluster (RAC). All data stored in the archive are available for display and analysis using a graphical User Interfaces (UI).



The HMPID DCS UI

The "UI RICH 0 liquid system" picture shows an example of CS action when a fatal under happens. It immediately closes the draining valves which are "normally open" (box 2) and the supply valve which is "normally closed" (box 3).

At the same time the HMPID DCS SMS system tool is enable to send an alarm message to the expert operator via the GSM network mobile. When the harmful condition has been recovered the Go_Manual command can be issued.



UI RICH 0 liquid system

Conclusions: C_6F_{14} CS was implemented according to industrial standards using the Siemens S7 300 PLC as control devices, FSM structure for modular and automatic command executing and PVSS as SCADA environment. CS allows LCS to run for 24 hours a day, correctly and safely. Since the first LHC operation in 2008, LCS under CS control enables HMPID detector to successfully collect data.