EPICS @ IPR Projects

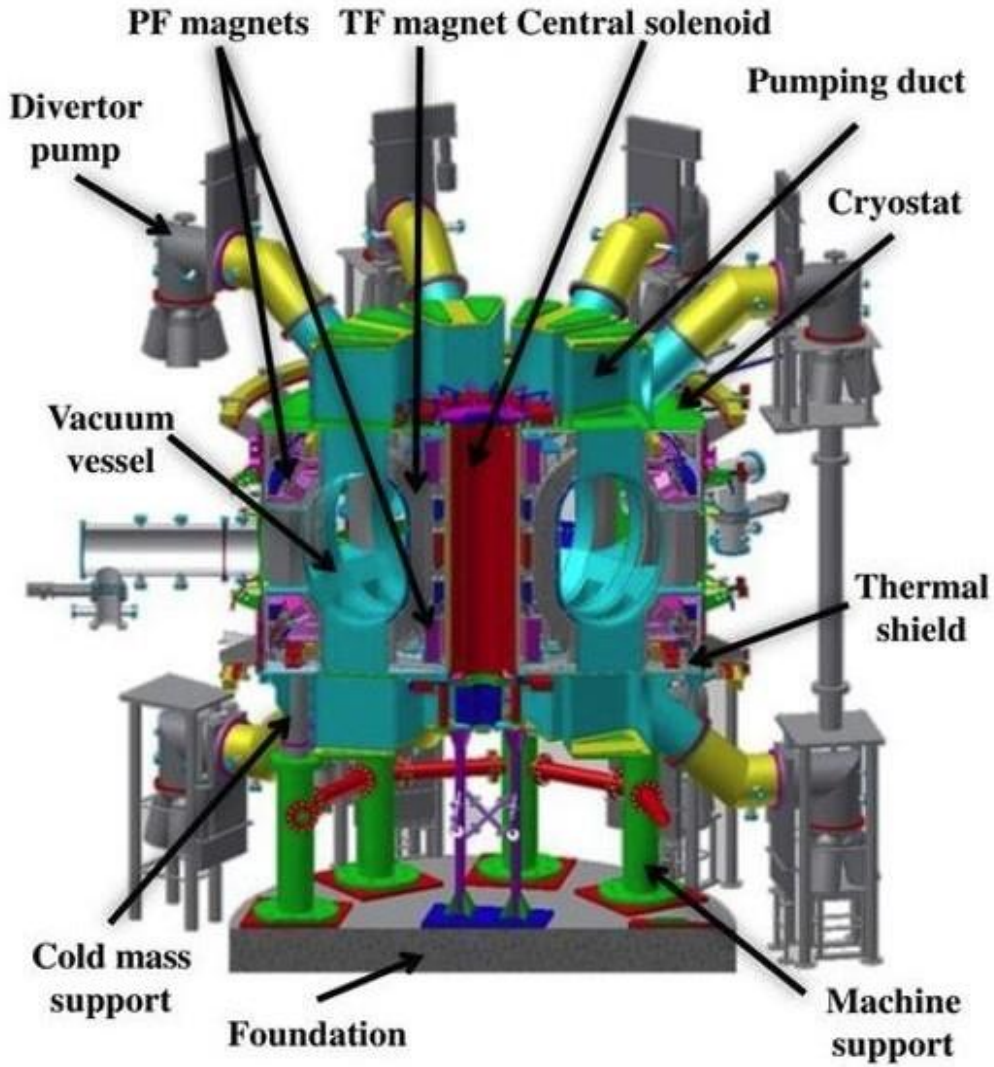
Vishnu Patel
DAC Division,
Institute for Plasma research

@EPICS India Collaboration Meeting, TIFR

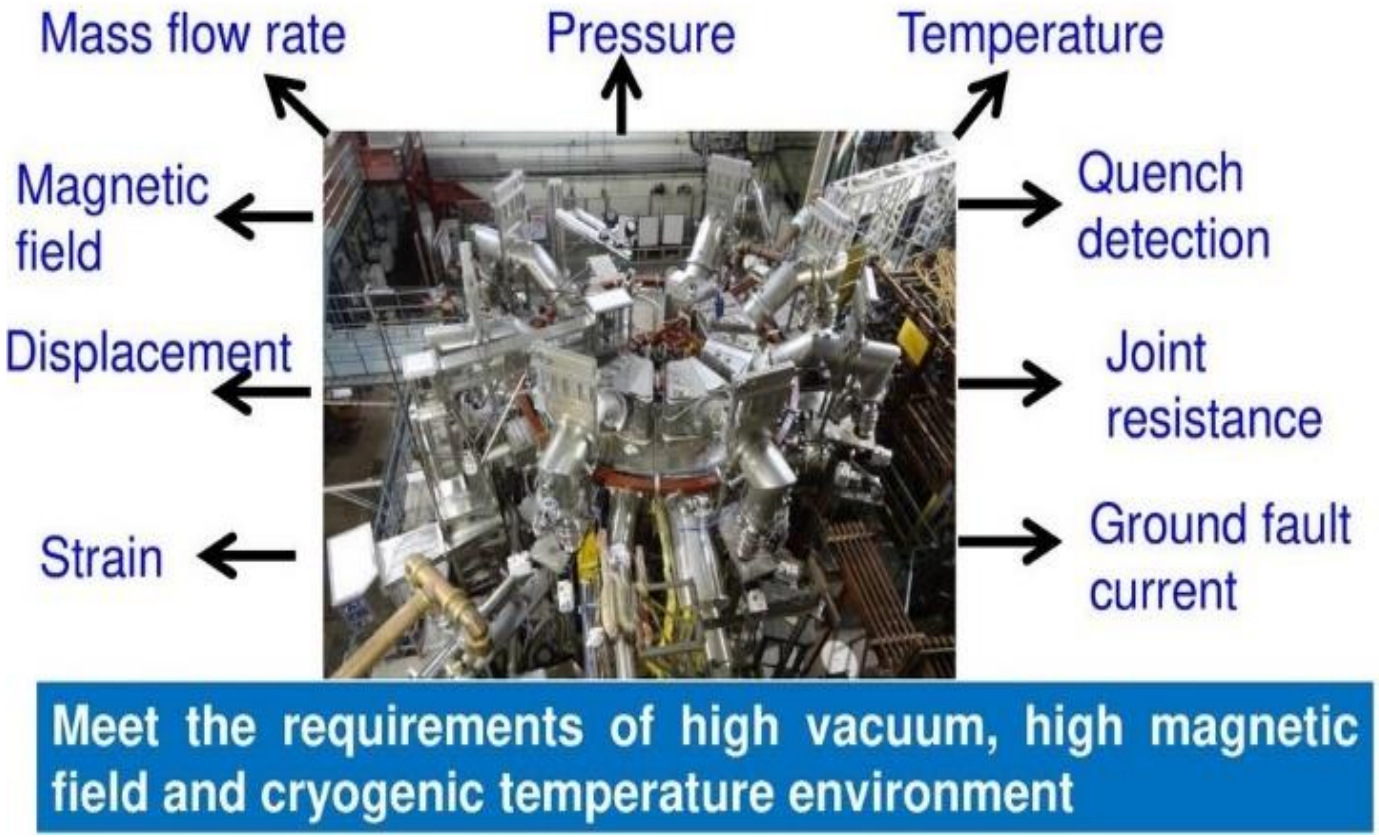
EPICS based Projects in IPR

- SST1 Key parameters Monitoring
- SST1-Cryogenics plant Monitoring
- NBI Cryogenics plant Utility system Control & Monitoring
- Indigenous development of HRL Plant Control and Monitoring
- Experimental Helium Cooling Loop Monitoring
- LIGO-India
- ITER-India

SST-1 Tokamak

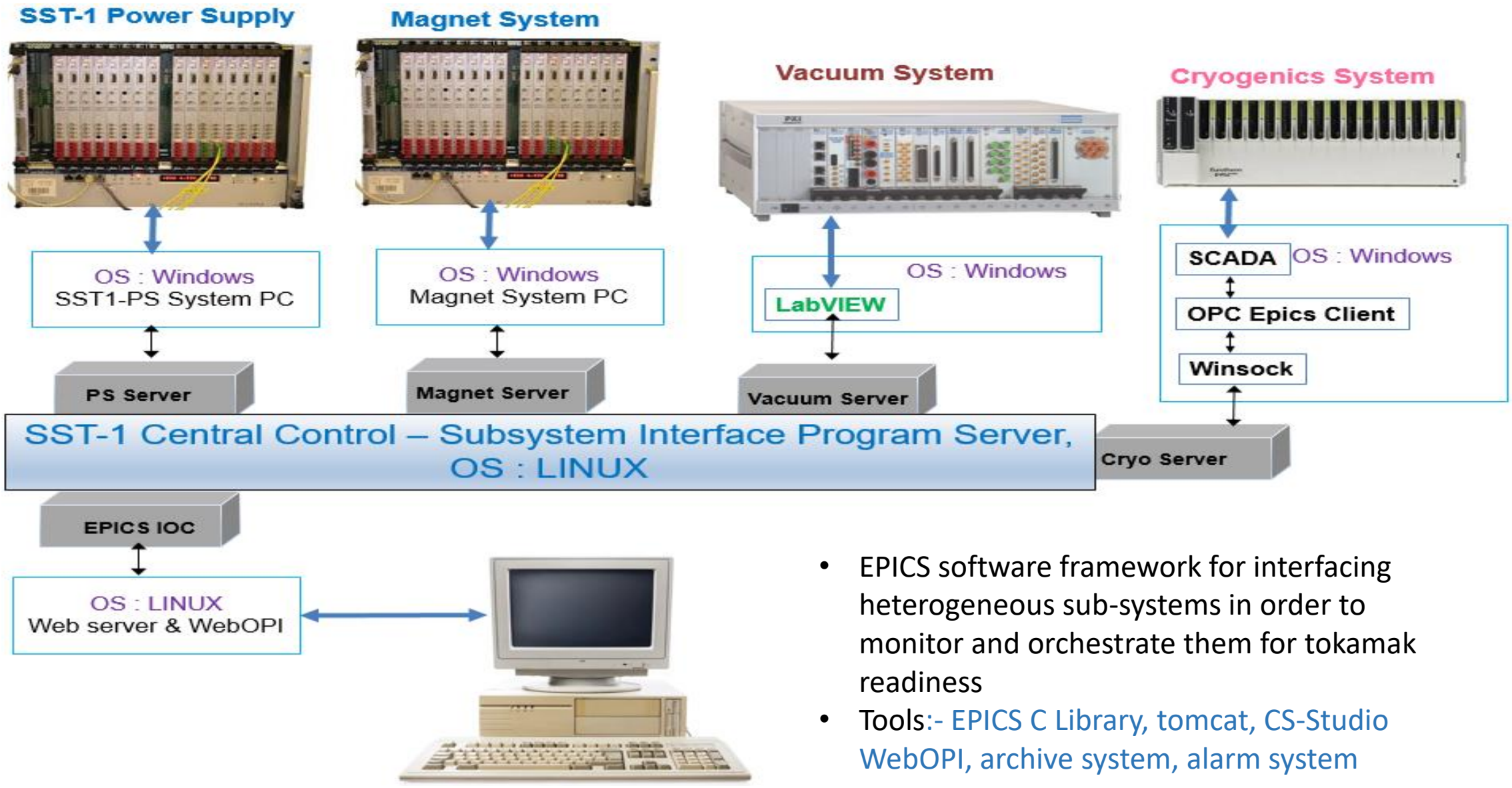


Different status monitoring instrumentation of SST-1



Meet the requirements of high vacuum, high magnetic field and cryogenic temperature environment

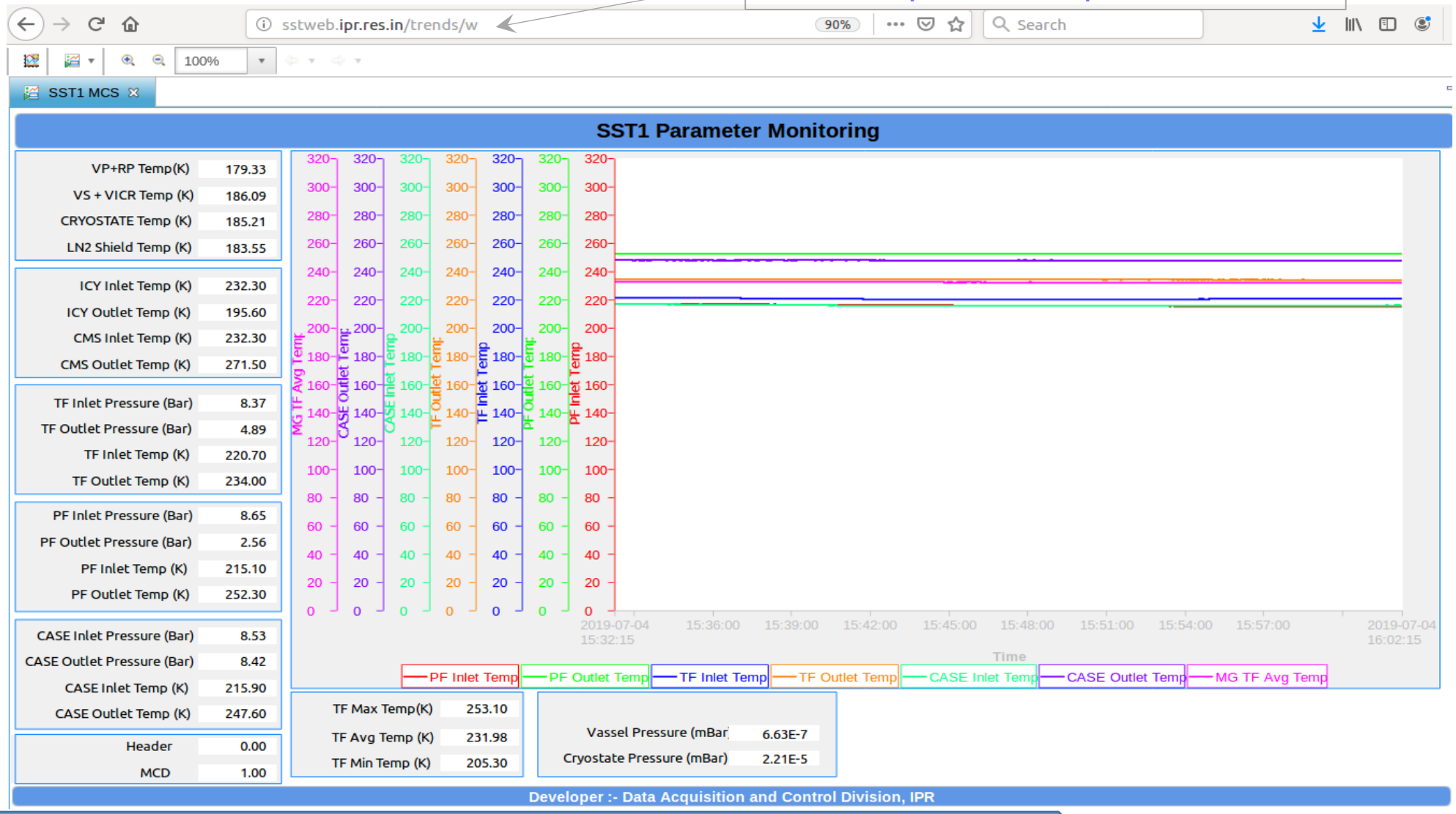
SST-1 Sub-System interfaces



- EPICS software framework for interfacing heterogeneous sub-systems in order to monitor and orchestrate them for tokamak readiness
- Tools:- EPICS C Library, tomcat, CS-Studio WebOPI, archive system, alarm system

SST-1 Key parameters web monitoring

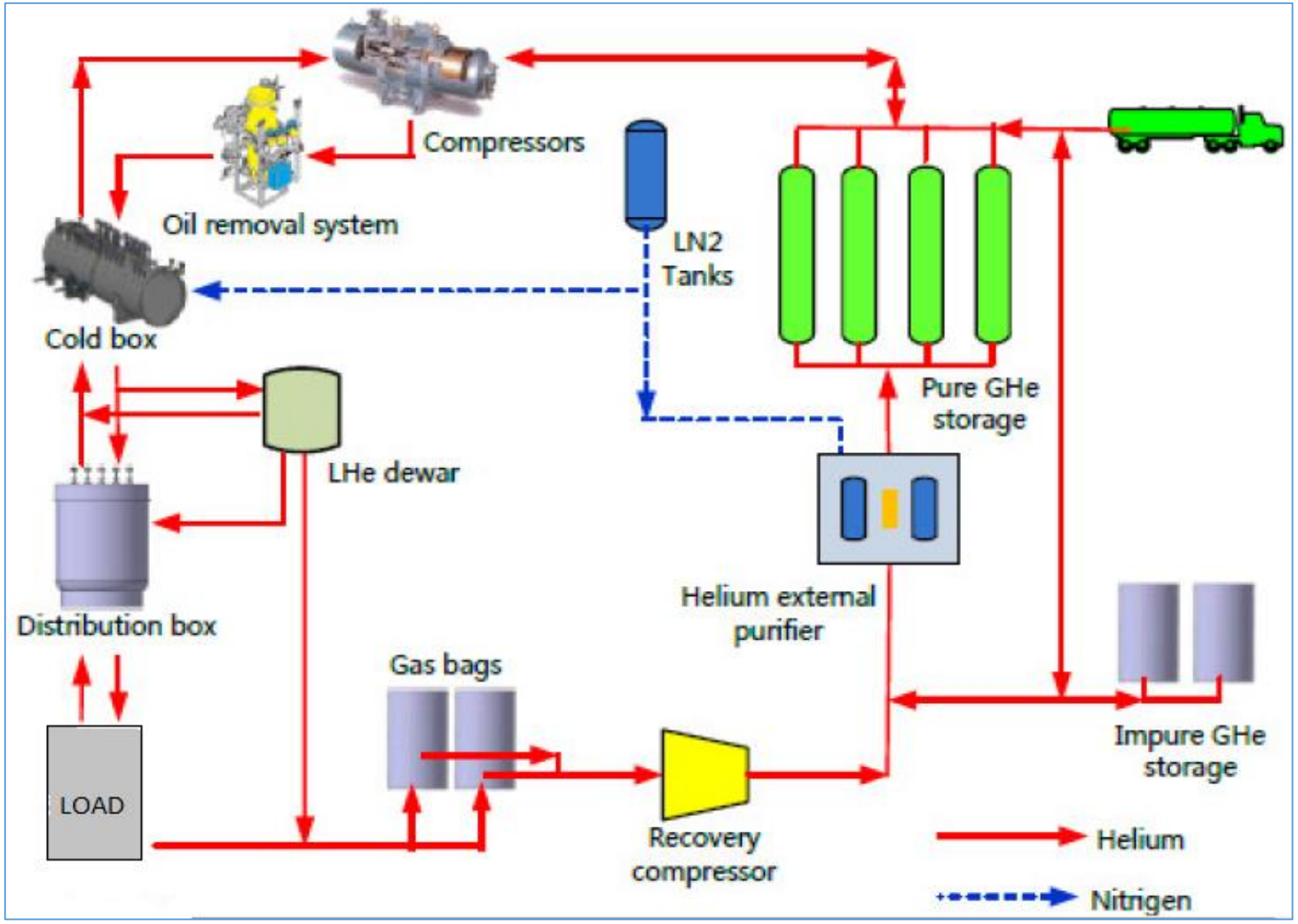
URL :- http://sstweb.ipr.res.in/trends/



Cryogenics Plant Systems

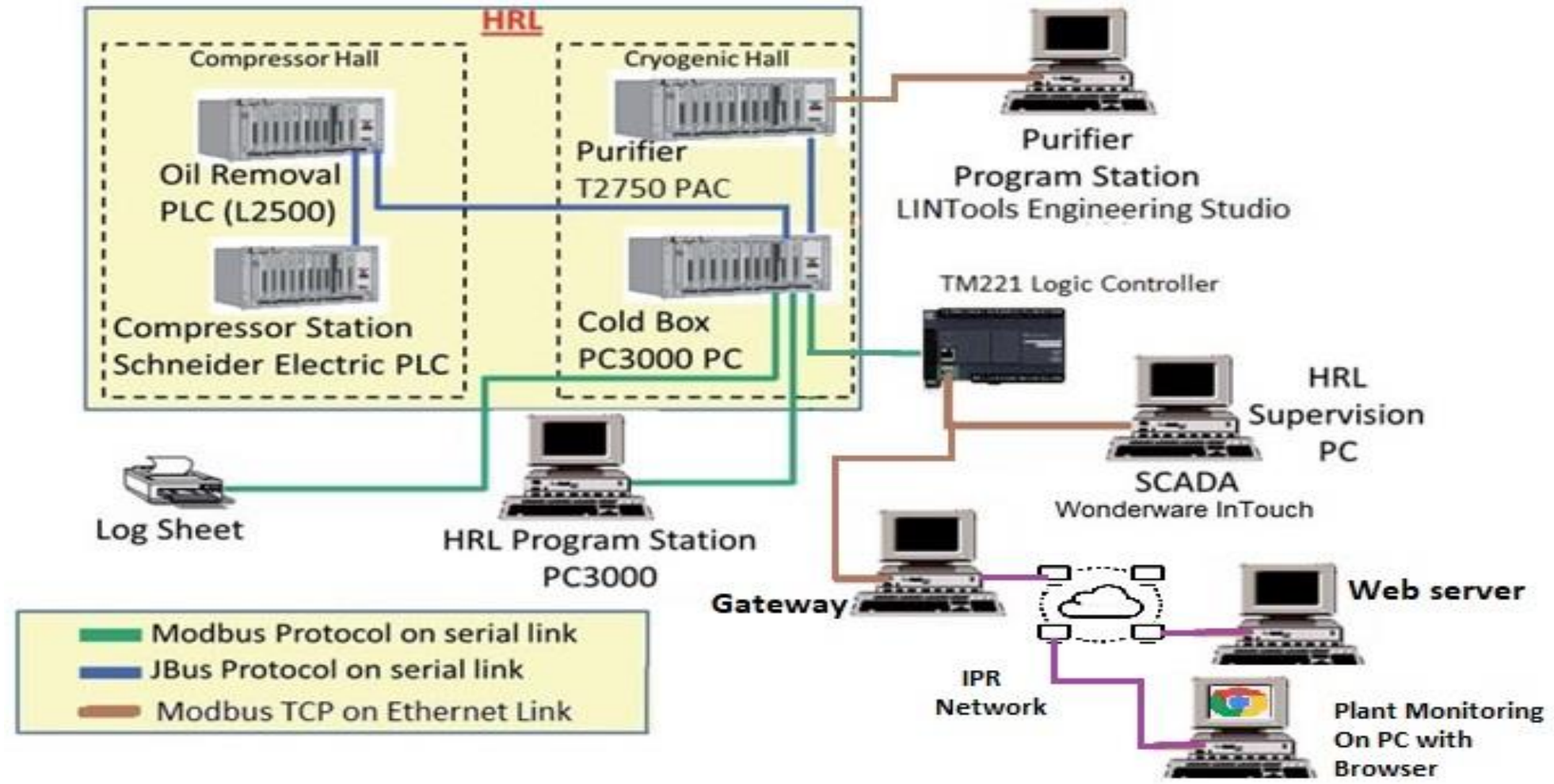
- IPR (Institute for Plasma Research) has been doing research in the area of fusion, superconductor, particle accelerators etc., where helium refrigerator-cum-liquefier is necessary.
- Tokamak fusion machines need HRL plant with cooling power at multiple levels and continuously for few months.
- Tokamak Heating systems are also required cryogenics system for different purposes.
- IPR is having 2 imported Helium plants
  - ✓SST-1 Cryogenics Plant
  - ✓NBI Cryogenics Plant

SST-1 Cryogenics plant System

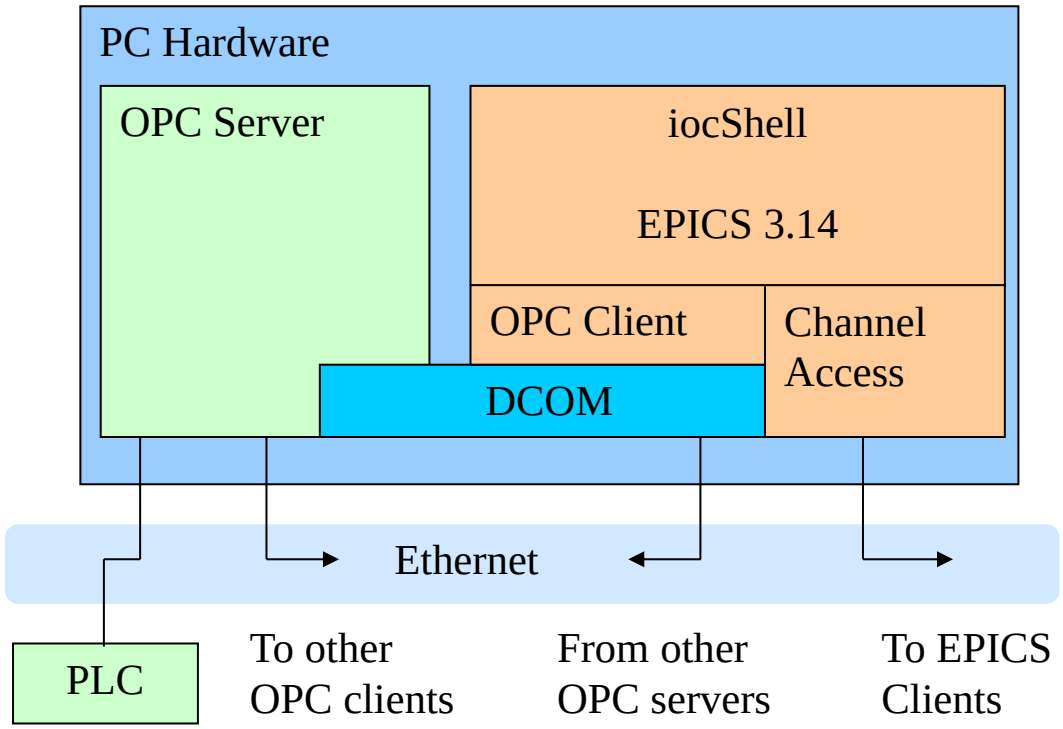


- 1.3KW Refrigerator-Liquifier system works efficiently. It has been into operation for more than 50 campaigns during the SST-1 Mission till date in either Two phase or Supercritical mode of operations with or without cold circulator.

SST-1 Cryogenics Control System

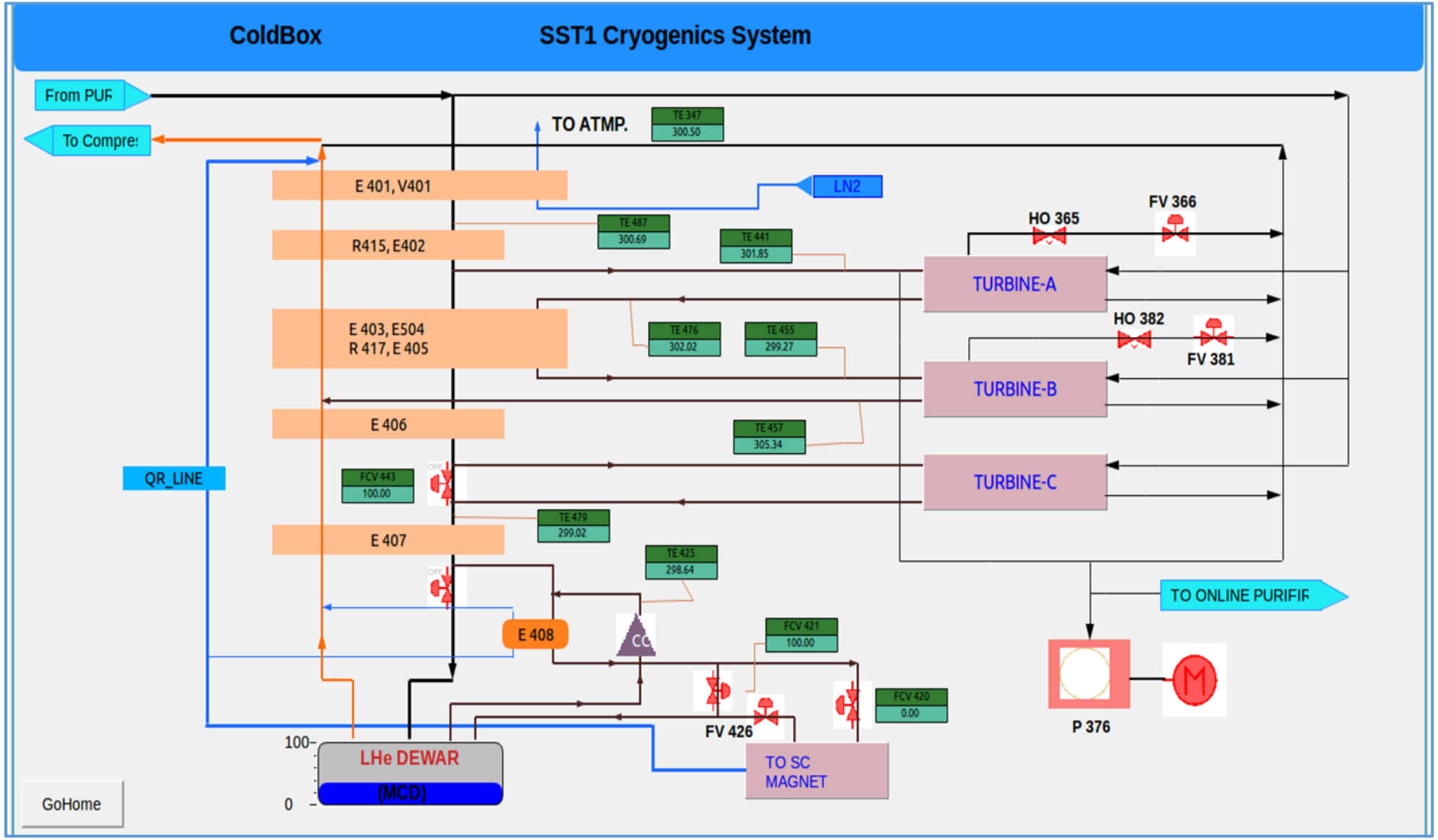


SST-1 Cryogenics Control System

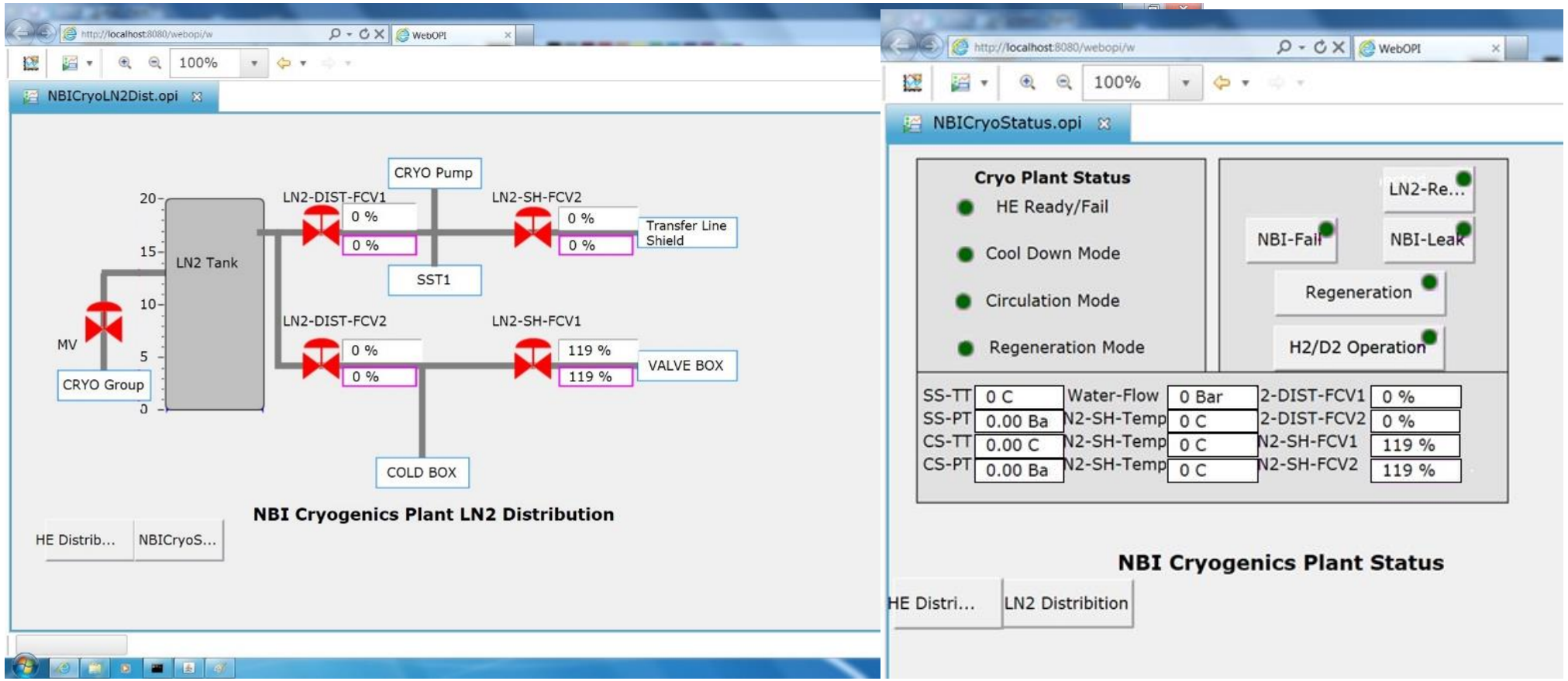


- Pre-compiled OPC Client libraries for windows is used.
- EPICS OPC Client to OPC server communication is established via DCOM
- Server time is used for exact variable timestamp.
- Property of OPC Item is mapped to the status and severity fields of the EPICS Record.
- Web Server – Tomcat, Display Builder WebRuntime

SST-1 Cryogenics Plant Coldbox



NBI Cryogenics Plant Utilities System

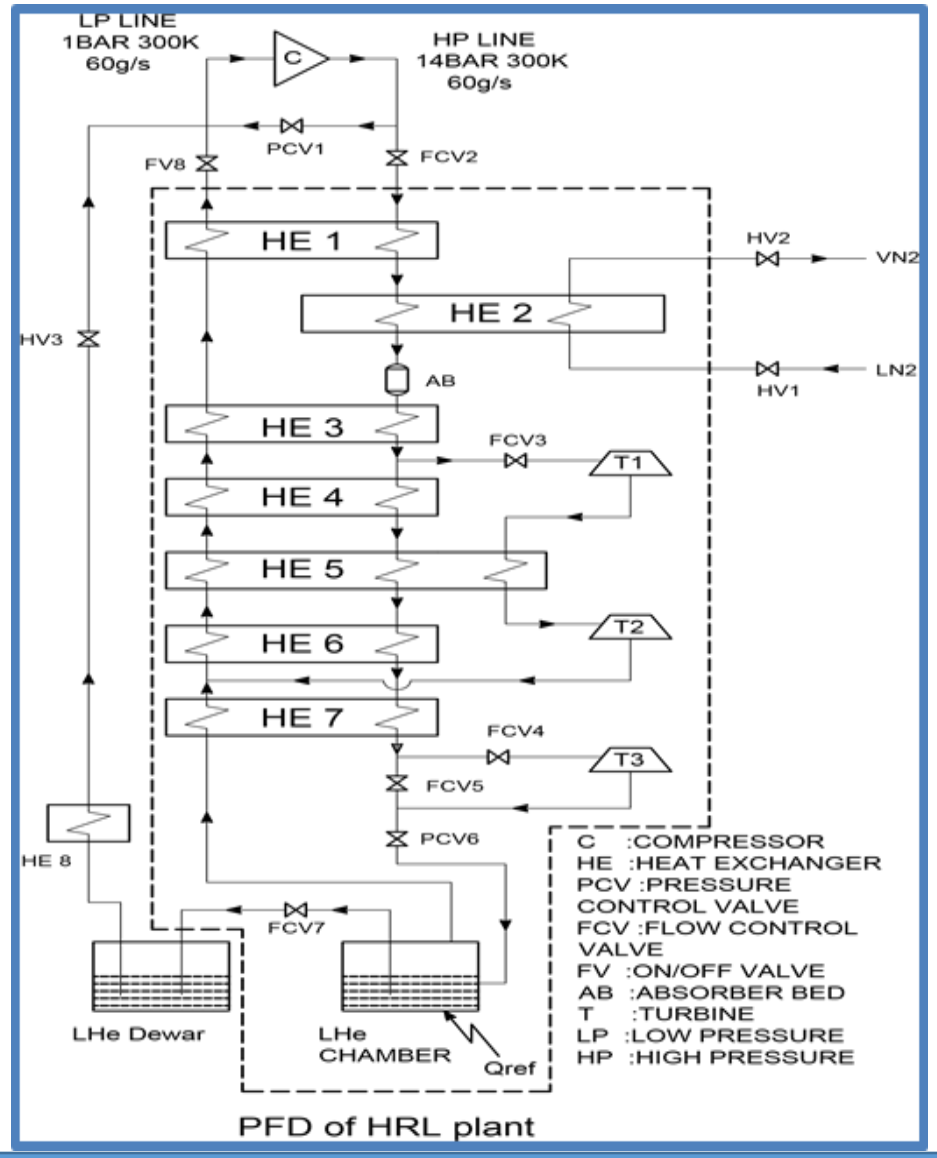


- EPICS Based control system
- Provide web access to the control of NBI Cryo Utility
- EPICS - S7 Protocol
- Web Server – Tomcat, webOPI
- CS-Studio

Indigenous development of HRL plant

- Complex helium plants are always custom-made.
- IPR is actively involved in the Tokamak Fusion machine research work along with various superconducting, cryogenics and other fields.
- IPR is also one of the core partner in building ITER at Cadarache, France.
- Looking at various requirements for future, India has taken up projects to develop HRL technology
- As a 1st step, a helium refrigerator plant of cooling power ~200 W at 4.5 k, 500 W at ~18 K and liquefaction power of 80 ltr/hr. has been taken up.

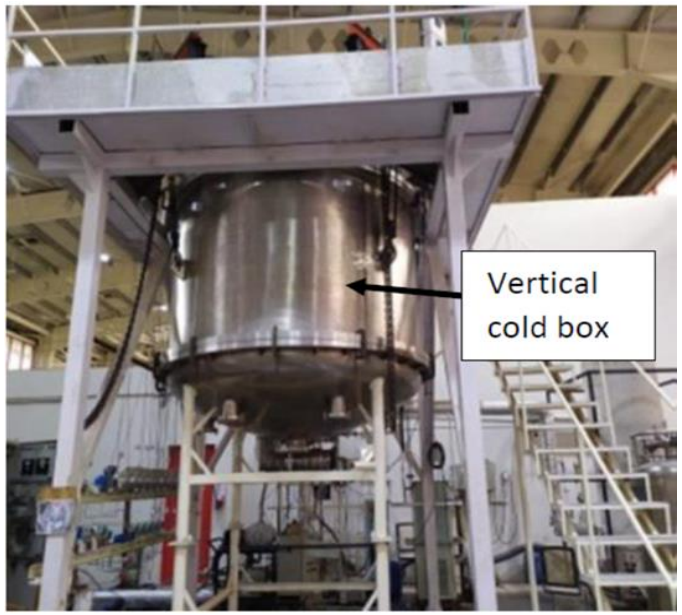
Indigenous development of HRL plant



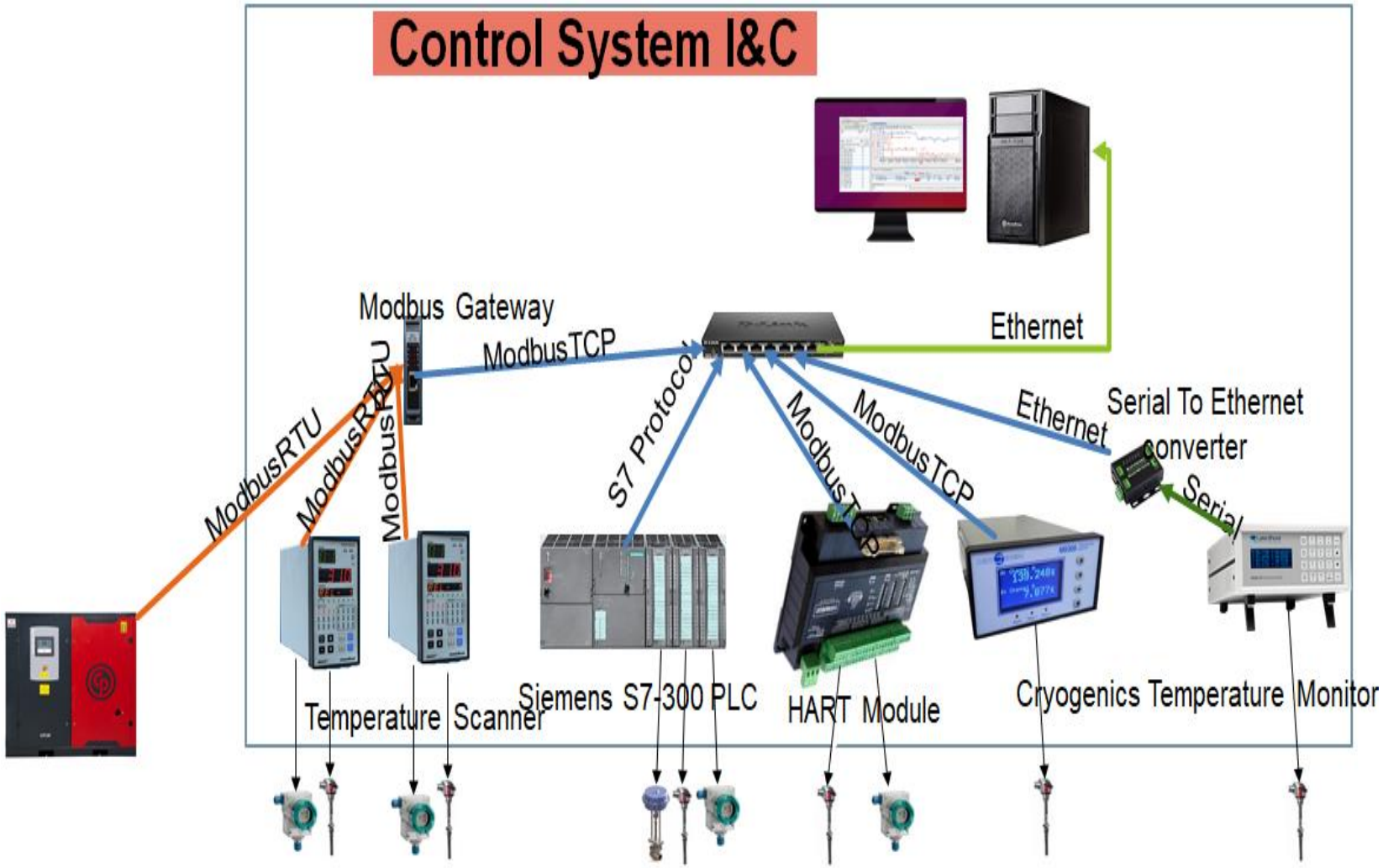
PFD of HRL plant

1. **Except helium turbines and cryogenic valves, all other critical components have been developed by indigenous effort.**
2. **A simple air-cooled open-loop air compressor has been converted to closed loop helium compressor suitable for operation of helium plant.**

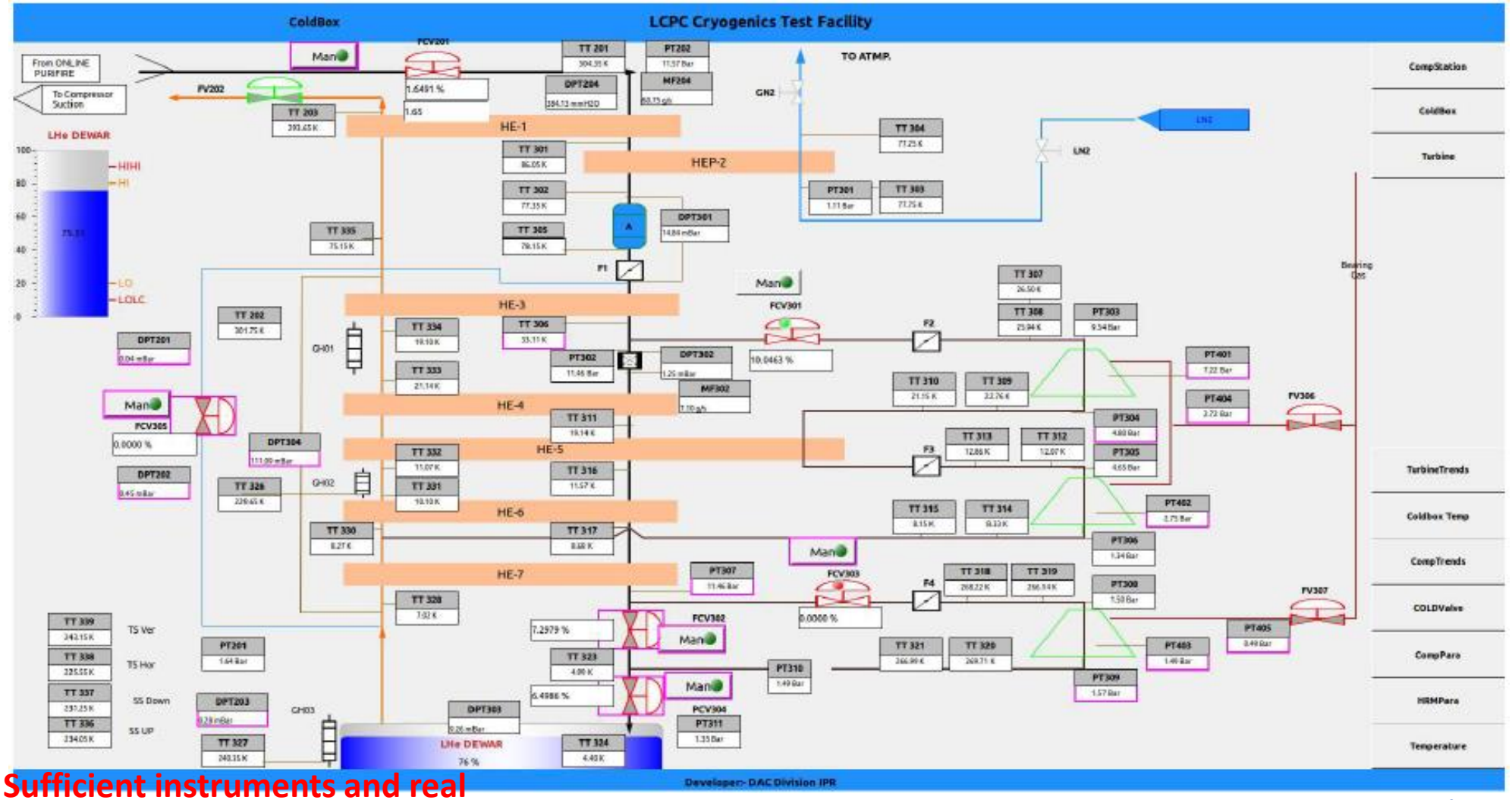
Instrumentation and controls (Developed in-house)



Picture of assembled cold box



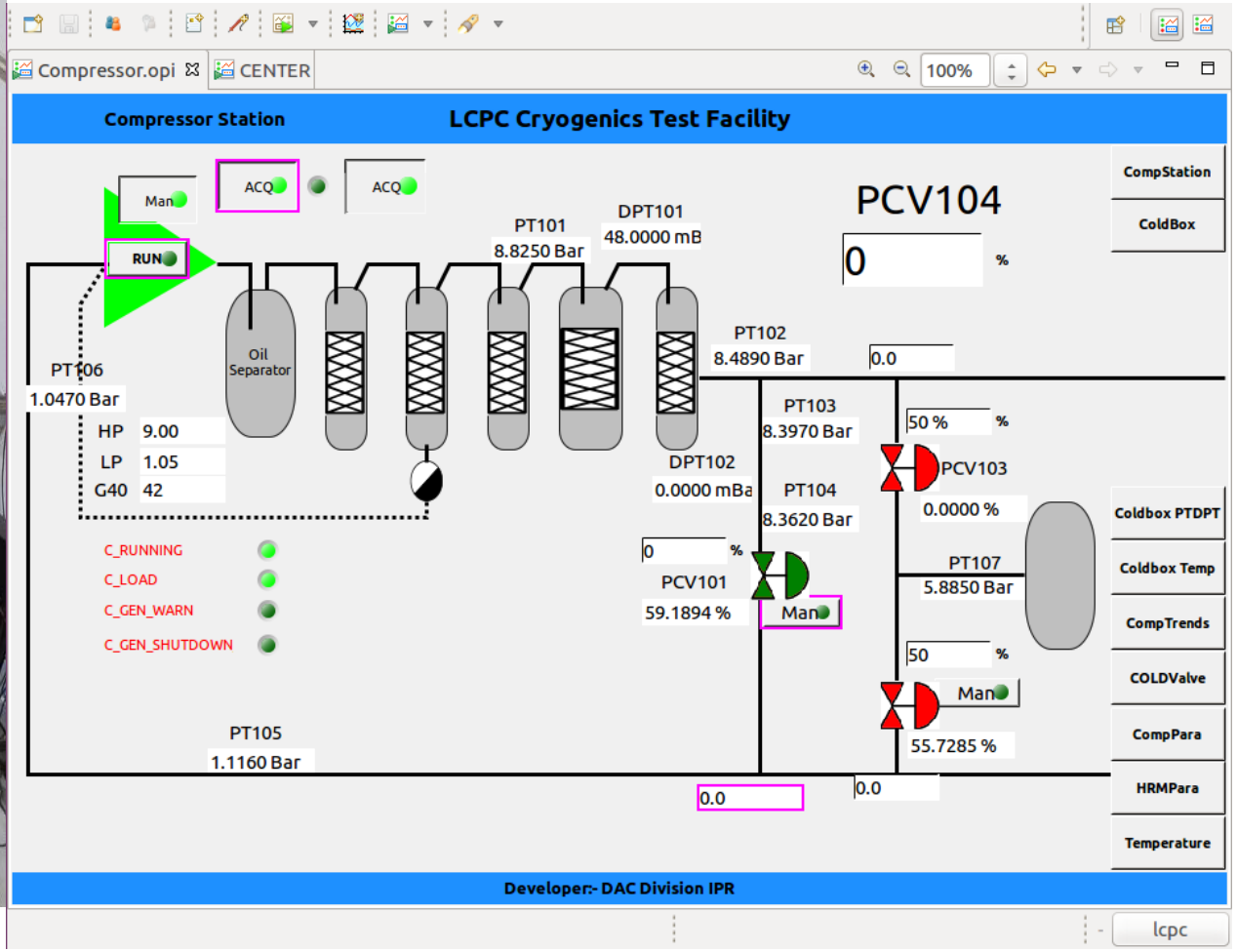
Plant Operation and control



Sufficient instruments and real time data trending has been developed in-house .

- EPICS Device supports – S7 Protocol, Modbus TCP/IP, Stream Devices
- CS-Studio, Web Server – Tomcat, webOPI

Helium compressor system

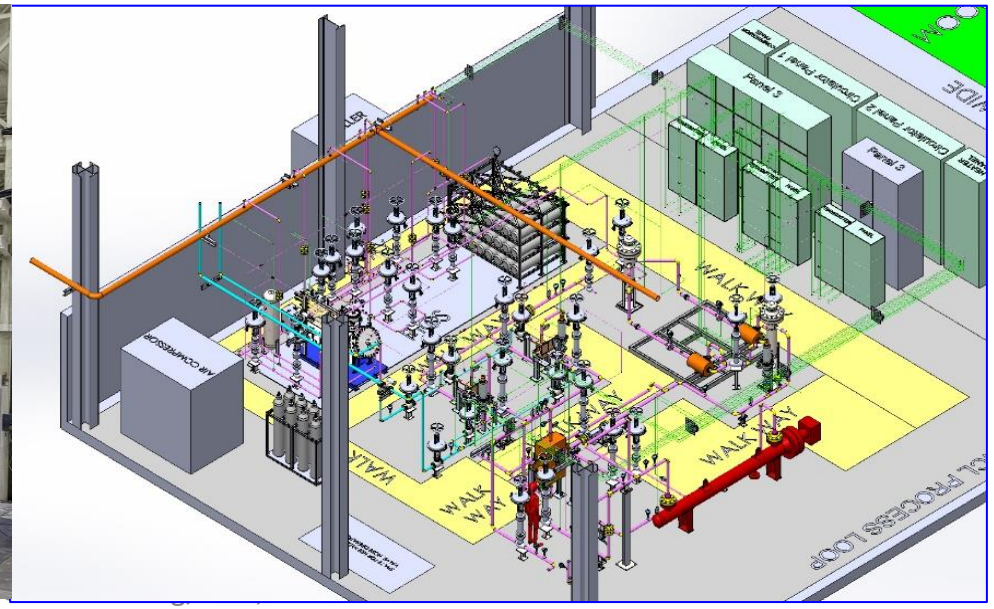


An open-loop, Air-cooled, oil-injected screw air compressor was converted to closed-loop air-cooled helium compressor.

Experimental Helium Cooling Loop (EHCL)

- EHCL (A scaled down system of ITER HCS) is a high pressure, high temperature closed loop cooling system
- Key objective is to test and develop helium cooled fusion components such as breeding blankets and diverters by testing various size and shapes of mock-ups
- Two parts: Main loop and Pressure and Inventory Control System (PICS)

Parameters	Operating	Design
Heat load (kW)	75.0	
Temperature (ºC)	300-400	450
Pressure (bar)	80.0	100.0
Flow rate (kg/s)	0.2-0.4	0.45



Experimental Helium Cooling Loop (EHCL)

- A complete sequence for operation of EHCL (circulation, heating, experimental campaign, shutdown etc;) was envisaged.
- Control logic (P,T and flow) for individual process loops were defined.
- SW Interlocks and Hardwired interlocks were defined.
- Provisions for alarm and trip were made.
  - EPICS – S7 Protocol, Stream Devices
  - CS-Studio
  - Web Server – Tomcat, Display Builder WebRuntime

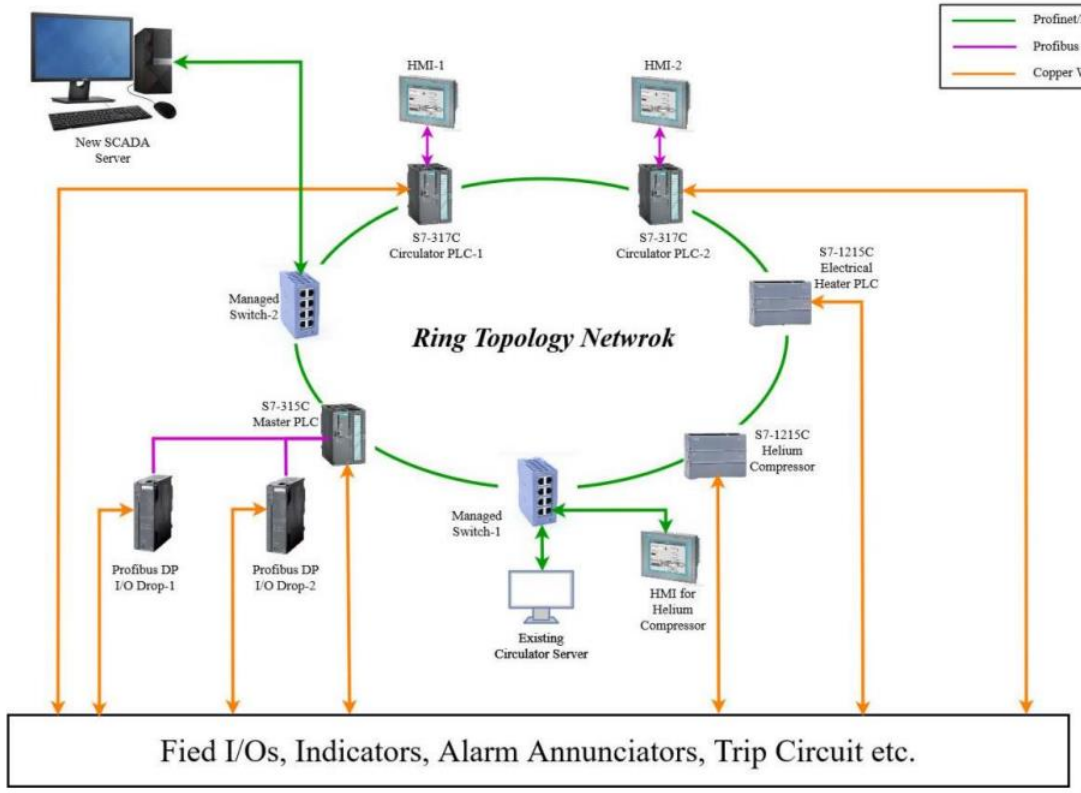


Figure 2 Automated system architecture

Other EPICS based projects

- RF phase shifter and stub tuner –
  - The RF phase shifter control system is developed using Raspberry PI
    - ✓ Python
    - ✓ PyDevice
  - The RF Stub tuner control system is developed using Schneider PLC
    - ✓ Modbus TCP/IP

WE have experience of..

- We developed EPICS drivers for NI-PXI boards and Siemens PLC for ITER Project
- We are developing EPICS application for IPR projects using S7 protocol, Modbus TCP/IP, Modbus RTU, Stream Devices, PyDevice for python interface.

Thank you..