Alarm and interlock system in cryogenic system of EAST

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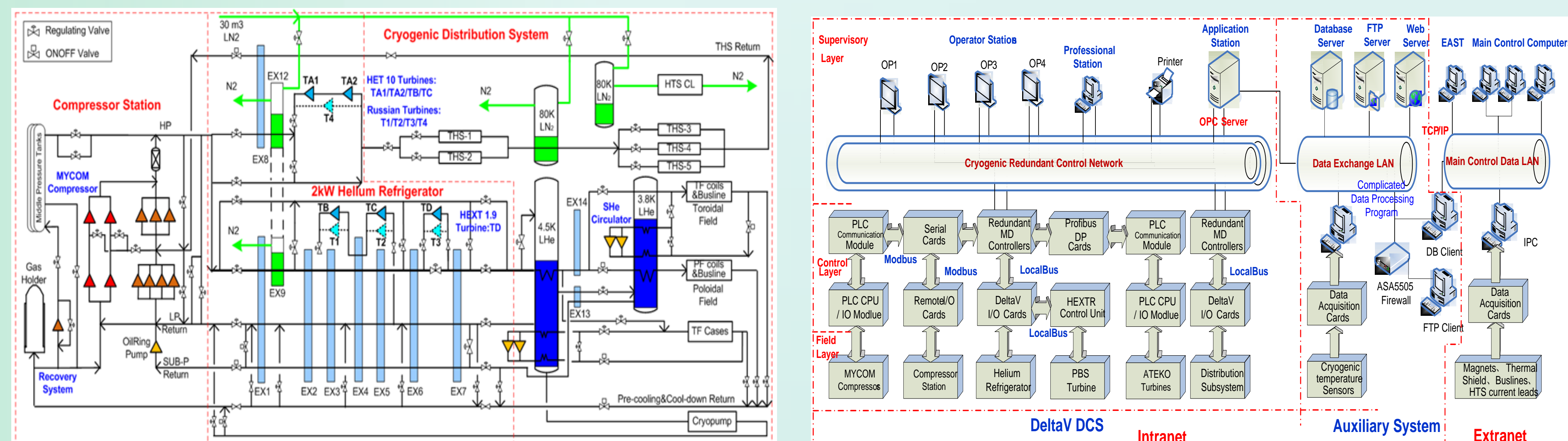*E-mail: huliangbing@ipp.ac.cn*

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INTRODUCTION

● EAST (Experimental Advanced Superconducting Tokamak) is the first full superconducting experimental Tokamak fusion device which has been carried out fourteen campaigns since its implementation at the end of 2005.

●The cryogenic system is to cool down the superconducting magnets and relating components. The total cold mass of EAST is about 250 tons.

●The basic design capacity of the refrigerator is 1050 W/3.5K +200W/4.5K +13g/s LHe +12~30kW/80K.

●EAST cryogenic control system (ECCS) is based on DeltaV DCS of Emerson Corporation.

●This paper presents the overview of the alarm and interlock system, especially in quench protection in cryogenic system of EAST

ALARM SYSTEM

● DeltaV provides an extensible processing mechanism to meet the requirements of alarm detection, filtering, prompting and recording.

●There are about 172 alarm conditions in the cryogenic system.

● The software alarm panel can be customized to make up the shortage of alarm system in DeltaV.

●The alarm client is based on OLE automation interface and VB.NET language and exchanged data with DeltaV DCS by OPC protocol.
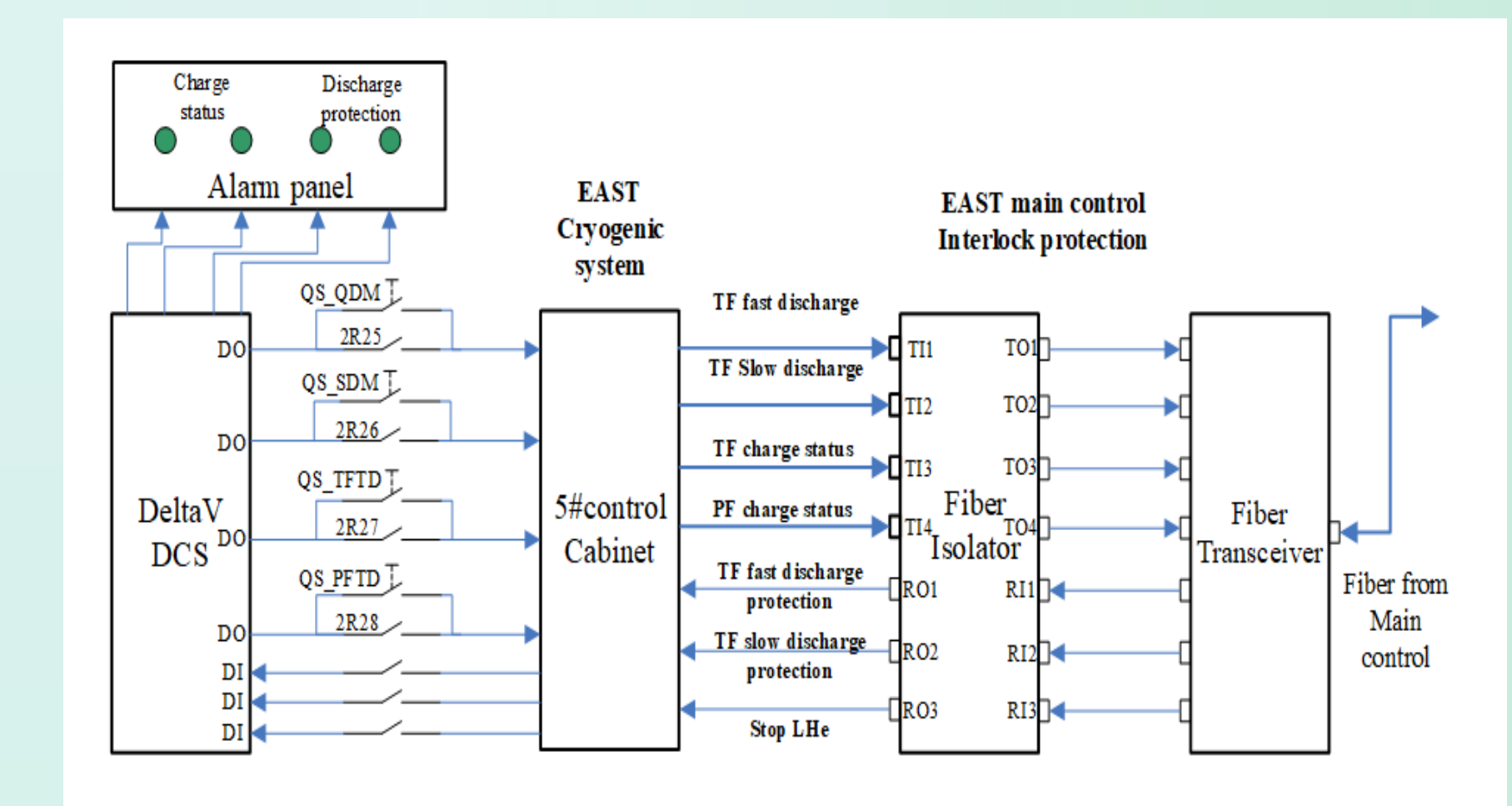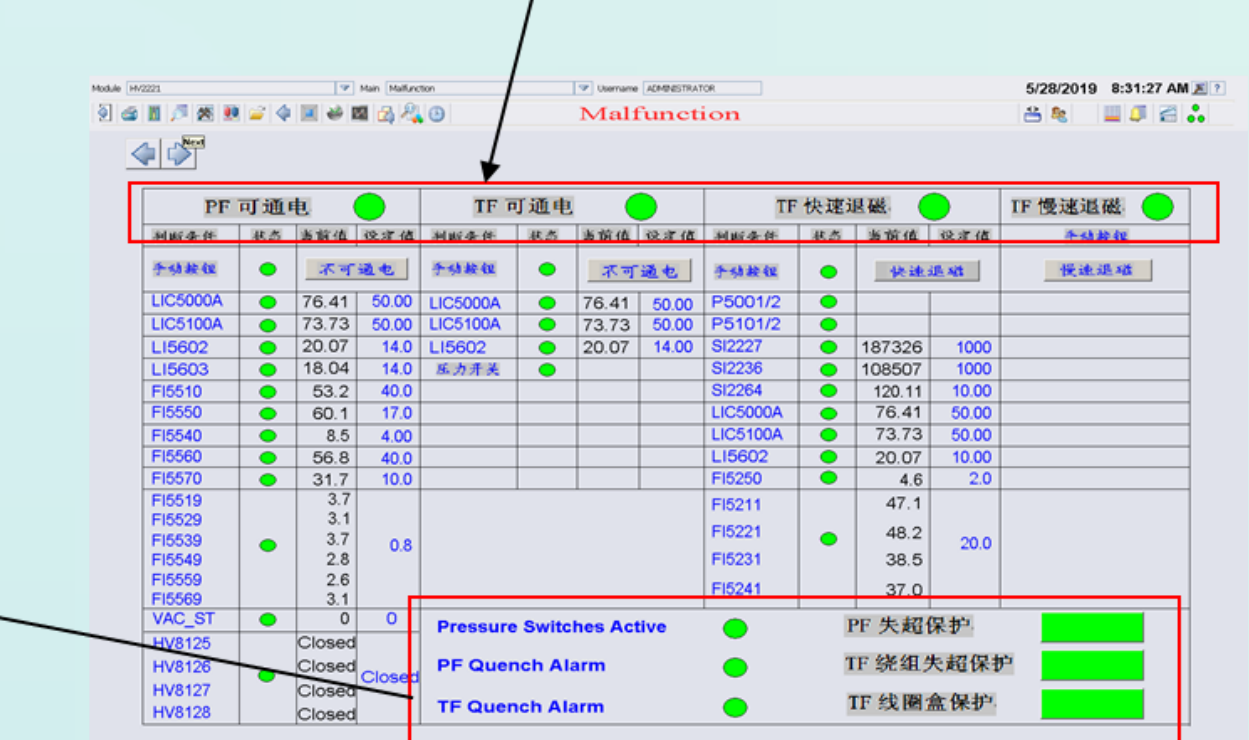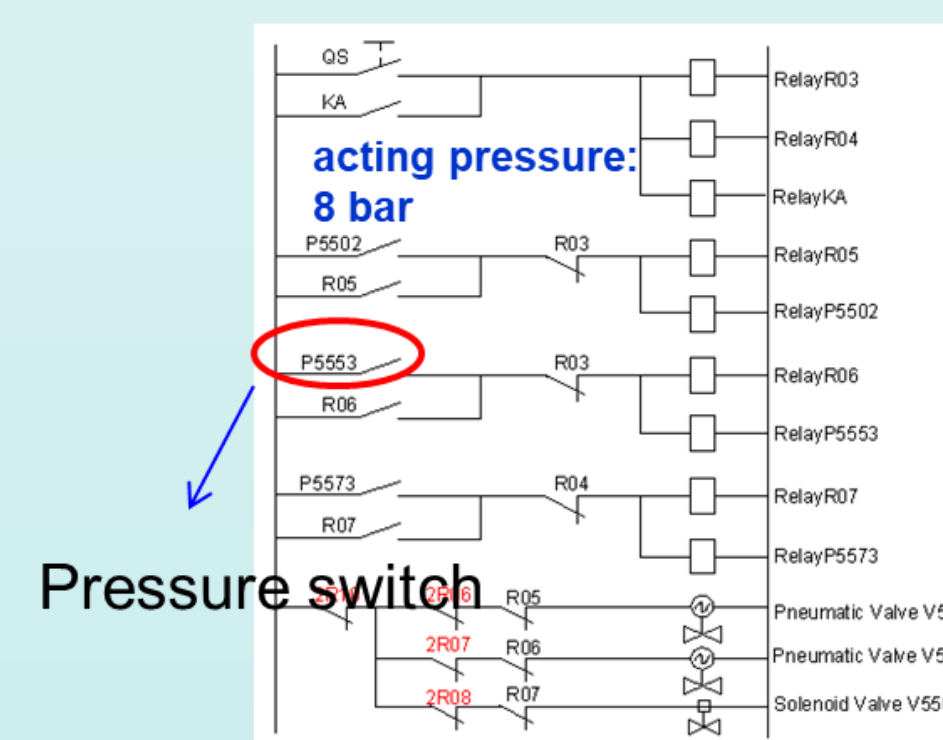

INTERLOCK SYSTEM

● There are about 35 interlocks conditions to protect the compressors, turbine expanders, 10000 liter Dewar and superconductor magnets.

●The high real-time protection signal directly sets the hardware prior protection circuit of field devices to shorten the interlock control response time and insure the security of equipment.

● The backup software protection strategy will be triggered when there is a failure in the hardware protection circuit. This protection measure is used such as the quench protection and turbine safety interlock control.

●For the protection signal which is important but the real-time requirement is not high, the security response mode of software configuration and hardware interlock circuit is adopted. When the protection logic of DCS failed to action, the hardware circuit will directly send the interlock protection signal. This method is used to the interlock control between cryogenic system and main control system of EAST.

Quench protection hardware in field   **Magnets chargeable condition**

OPERATION PERFORMANCE

● The fault modes of the EAST cryogenic system was analyzed. The fault rate is 5% before the system upgrade. The turbine and compressor fault stop caused by mechanical failure and can not be restated in short time again.

● EAST cryogenic system was upgraded with new helium screw compressors and new dynamic gas bearing helium turbines.The fault stop of turbines and compressors never happened after system upgrade in 2016.

●A real-time fault diagnosis expert system was developed to facilitate dealing with abnormal situations for improving the efficiency and reliability of the system.
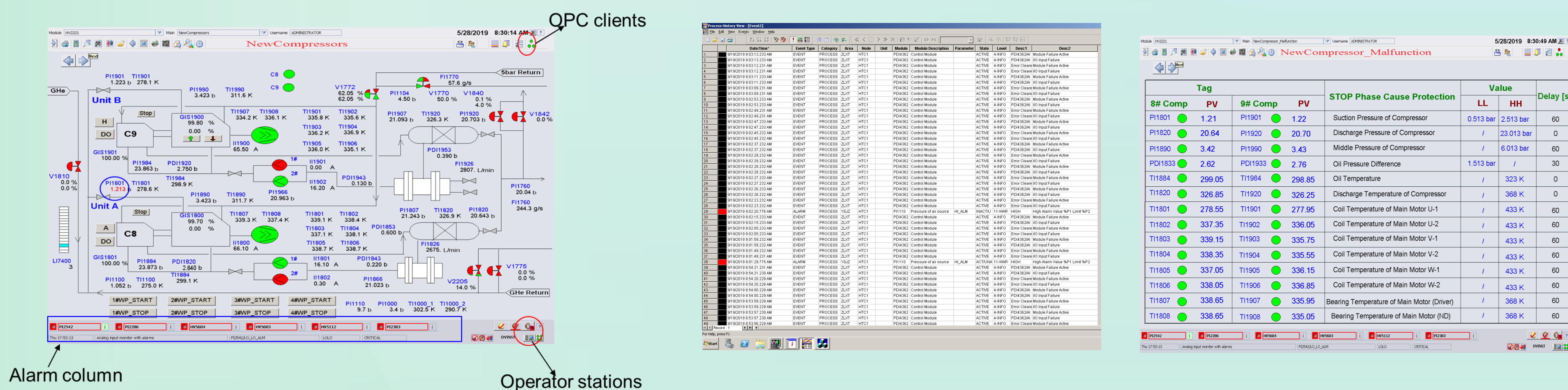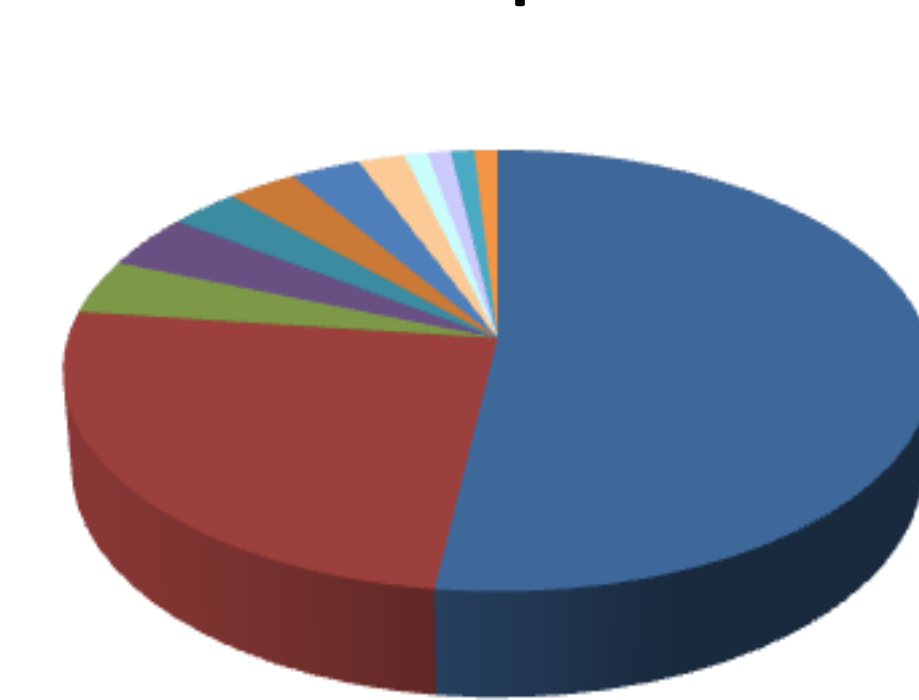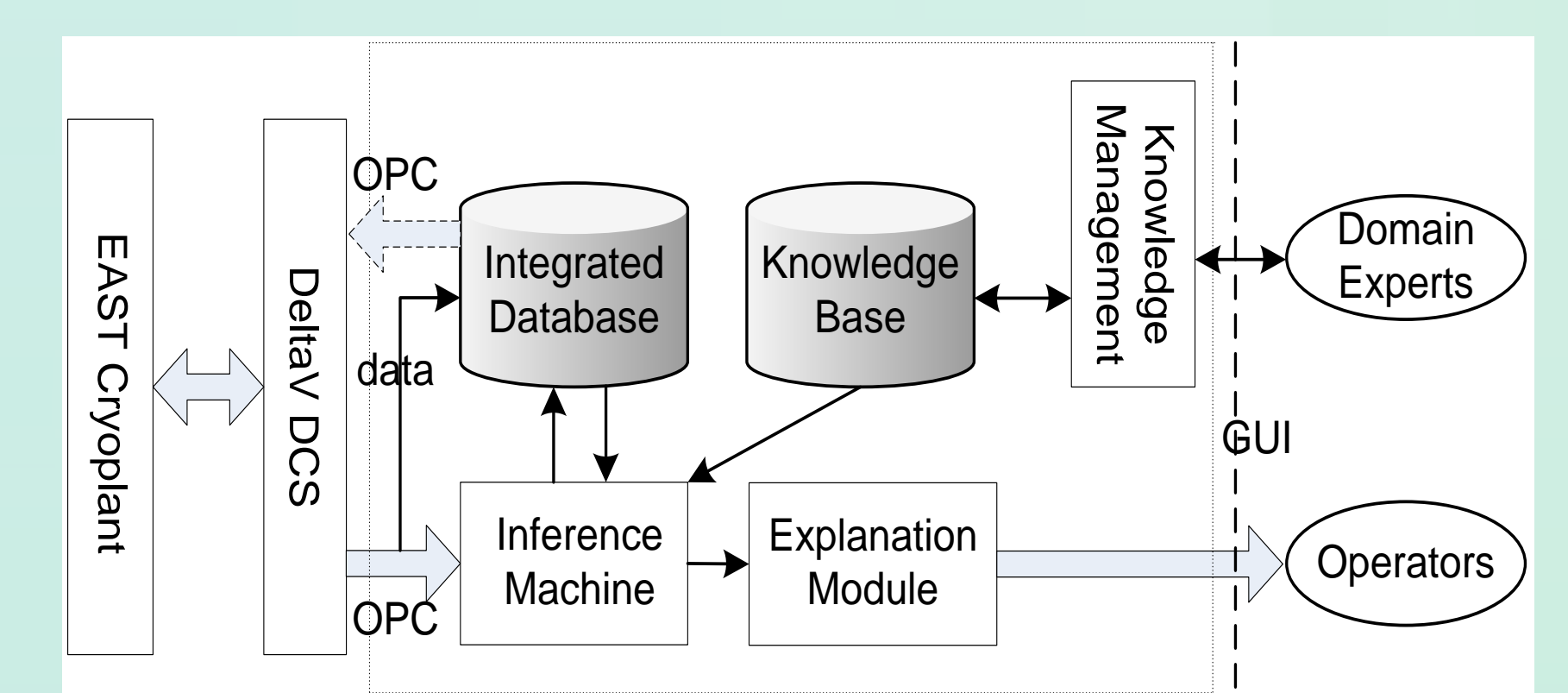

Abnormal events and faults (2006~2017)   The structure of the real-time fault diagnosis expert system

CONCLUSION

● The alarm and interlock system has been verified the long term stability, reliability and higher automation.
● The fault modes of the system as well as the corresponding effects and criticality have been analyzed for improving the reliability of the EAST cryogenic system.
● The typical fault of cryogenic system and the emergency control strategy will be simulated based on EcosimPro to enhance the reliability of the cryogenic system and automatic processing ability in fault state.