Environmental Monitoring for Belle II

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Introduction

The Belle II detector consists of 6 subdetector systems, for which the readout systems are installed inside and around the detector. Backend readout systems reside in the Electronics Hut (Ehut) located next to the detector, where various monitoring systems are also placed. We use two backbone systems to distribute and share the monitor information and one graphical user interface (GUI) tool.

Figure 1: Belle II control room.

1. NSM: a custom-made Network Share Memory (NSM) tools, which has been used in Belle and was updated for Belle II
2. EPICS: widely used tool in high energy physics experiments
3. CSS: Control System Studio, with native EPICS handling and an additional plugin for NSM

The Belle II control room is placed in the underground side room of the experiment hall where the Belle detector is located. The Belle II detector is operated by two control room shifters. In addition, a safety shifter is assigned for the safety of the experiment, and subdetector shifters take care of their subdetector systems. Our environmental monitoring tools provide the information of the detector to these shifters and store data on the central DAQ database server.

Monitoring GUI

Our monitoring GUI is based on CSS. The monitoring information is shown on a 50-inch 4K resolution display in the control room. Our monitoring GUI is focused on following aspects:

- Summarized information for non-expert users and control room shifters
  → Only average and maximum are shown where applicable
- Easy to read and identify problems from distance
- Unified design of GUI including color scheme
  → Unified color scheme: normal = green, warning = orange, serious = red
  → Unified design icons for the same type of variables
- Easy for development on a small screen
  → The large single screen is partitioned into four small panels, where each panel corresponds to a FullHD resolution
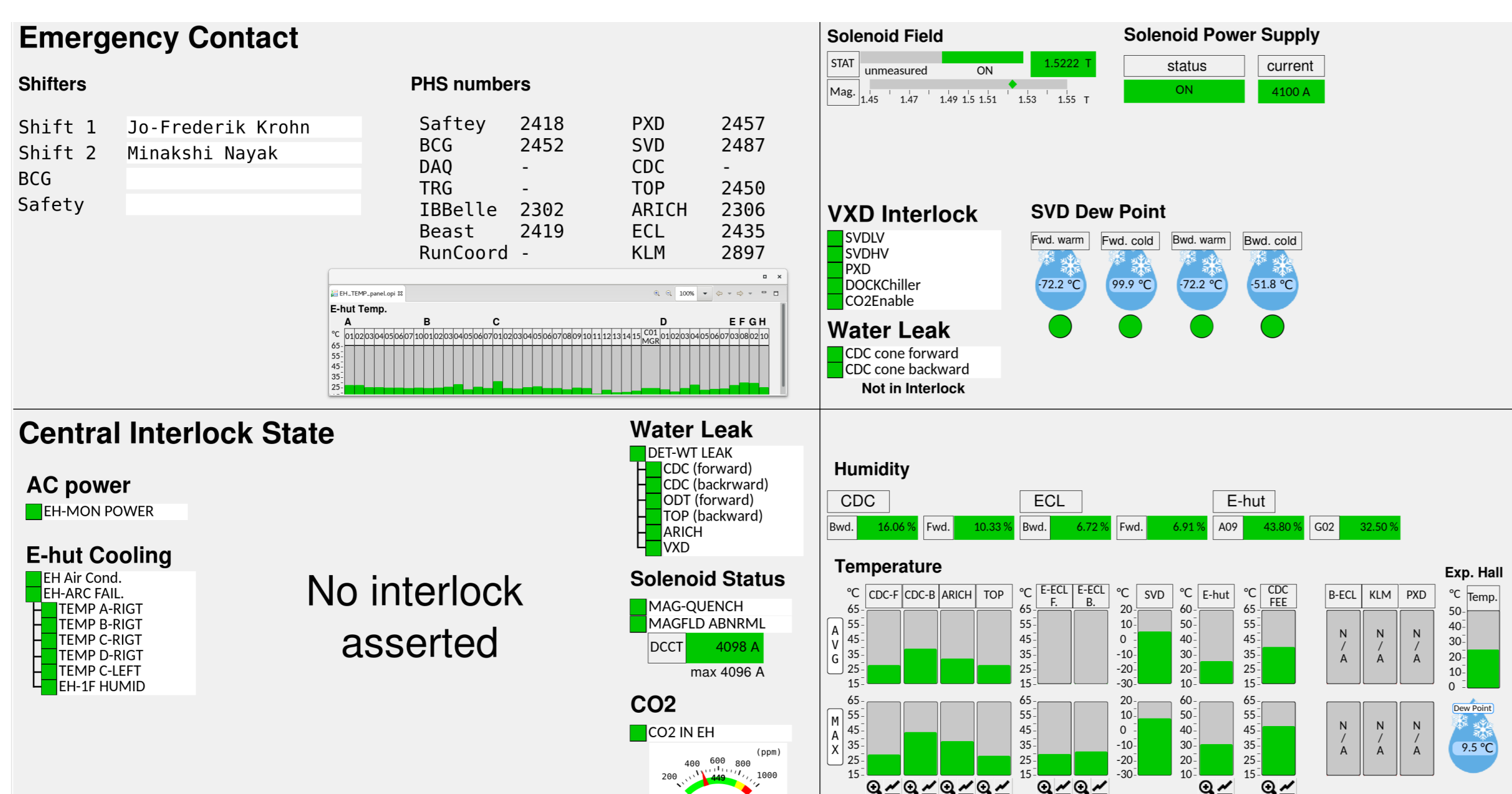

Figure 2: Monitoring GUI installed in control room

Archiver

To store our detector information, provided by the form of NSM variables and EPICS process variables (PVs), we are using the EPICS Archiver Appliance. The archiver runs on the central DAQ database server, to record the history of environemental variables including various temperature, humidity, magnetic field, voltage, luminosity, and so on. In order to archive NSM variables, we prepared an NSM → EPICS conversion process (nsm2cad), because the EPICS Archiver Appliance is able to record EPICS PVs only. At this moment, the number of actively archived variables is 2377.

The management system (mgmt webapp) is protected by ID and password, to prevent modifications by unauthorized users. The viewer is open to anyone who can access the DAQ network. People can see the trend graphs through a web viewer or CSS. The archiver is also connected to the monitoring GUI. Button sets (small graph button in Figure. 2) are prepared, then people can easily find the trends of monitoring variables.
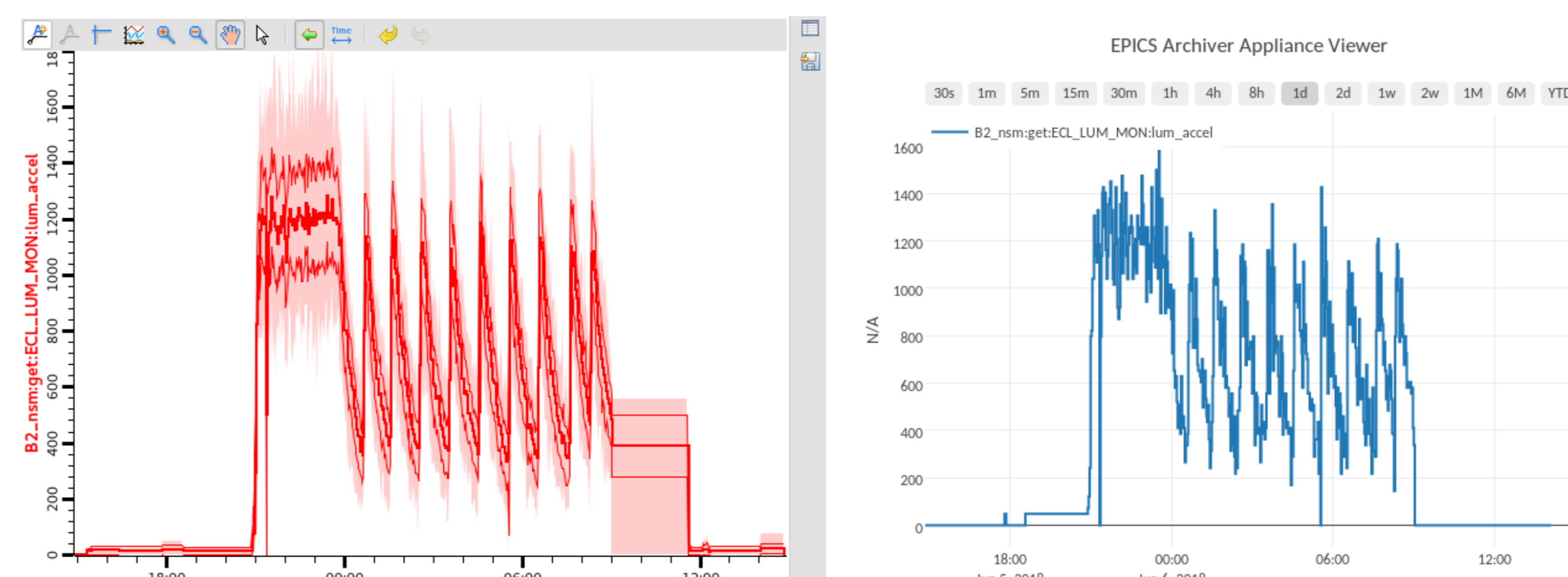

Figure 3: Appliance metric

Figure 4: Archiver viewer on CSS (left) and on a web browser (right)

Alarm System

The purpose of the alarm system is to provide a sound warning for control room shifters and send email notification to subdetector experts. The alarm system is made of two parts, a daemon process and a GUI. The daemon is an NSM application, and the GUI is a CSS application.

One of the important aspect is to treat enormous number of variables. We made the alarm daemon to collect multiple values from which a single combined warning state is generated. Alarm daemons also send email notifications to each responsible expert. The warning state is sent to the GUI, and the GUI generates a sound for shifters. The GUI can include / exclude each variable for sound and email alarm.

Figure 5: Alarm GUI for central interlock

The alarm system is in the commissioning stage. The connection between GUI and daemon-GUI works fine, but we have a trouble in the alarm daemon itself. For example, when collecting values from each variable, there is some unexpected delay in the response.
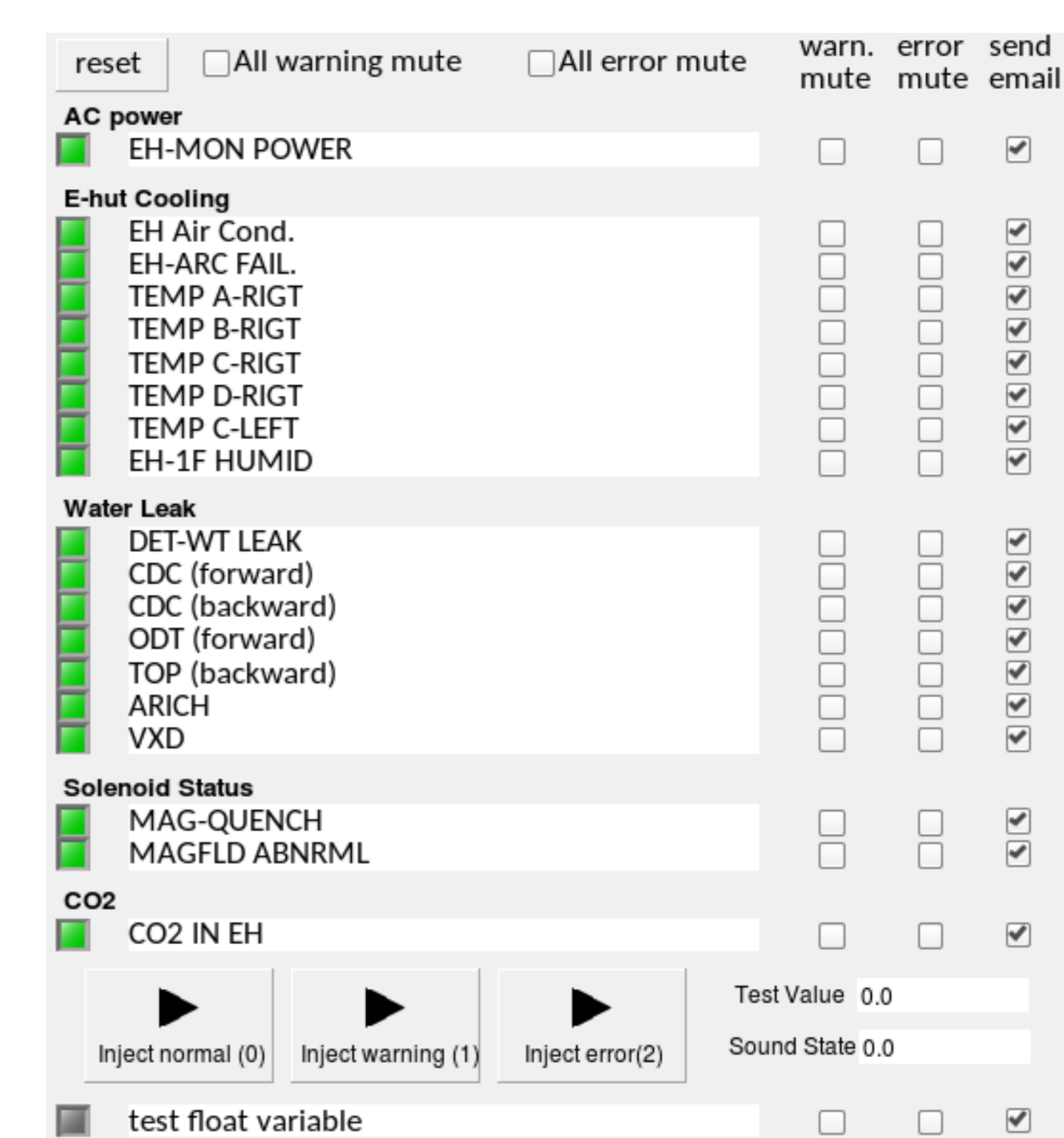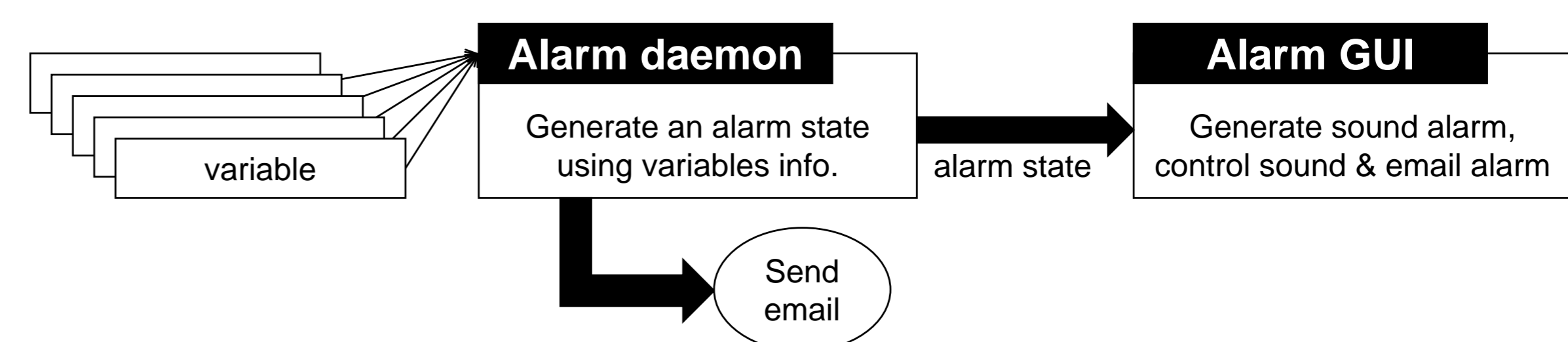

Figure 6: Conceptual plot of alarm system

Conclusions and Plan

The Belle II phase 2 operation has been successfully carried out in which the environmental monitor tools are one of crucial component. The monitoring tools have been improved upon various experiences during the commissioning of the Belle II detector, while there are still remaining works to be done. These will be solved before the phase 3 operation with the fully integrated Belle II detector. Here are the action plans:

1. Monitoring GUI
   - Implement a detection and refresh mechanism when the values are not updated, by the frozen CSS panel or by a malfunction of the PC.
2. Archiver
   - Prepare a procedure to clone the archived data, especially for the use in the offline analysis
   - Increase the number of PVs to handle by an order of magnitude
3. Alarm System
   - Complete the commissioning of the alarm system, which is not used yet for the daily operation during the phase 2 operation.