Interlock System for the Hall B Forward Tagger

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The backup, National Instrument's (NI) cRIO-based, interlock system for the Hall B Forward Tagger (FT) is network-independent and standalone, taking control in the event the EPICS-based main control system fails, or if network communication is lost.

The FT's cRIO-based interlock system is a reconfigurable, embedded control and acquisition system, which runs on a LabVIEW Linux operating system. The cRIO obtains signals—calorimeter and hodoscope temperatures, calorimeter humidity, and N_2 gas flow— directly from the sensors and instrumentation Fig. 1.

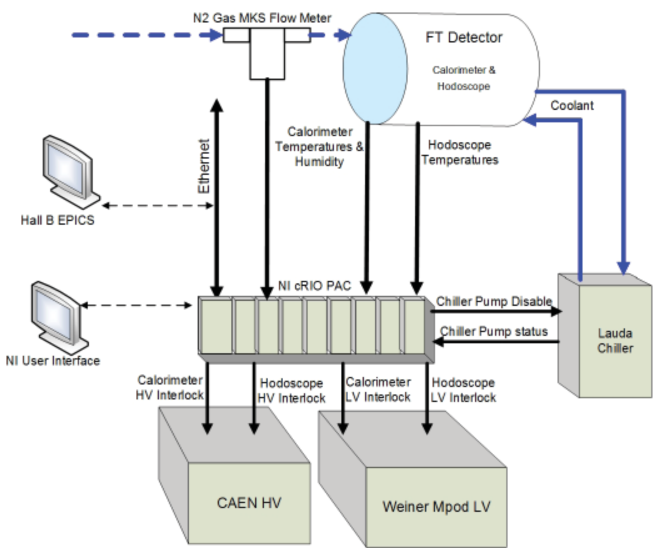


FIG. 1. Block diagram of the FT hardware interlock system.

Monitored signals are listed in Table I. Corrective action is taken if a signal is outside its pre-programmed limits.

For the calorimeter, the Weiner Mpod low voltage and CAEN high voltage modules, and the Lauda chiller, are interlocked. For the hodoscope, low voltage and high voltage modules are interlocked.

The calorimeter and the hodoscope interlocks are independent. If the calorimeter temperature or humidity sensor causes interlock activation, the system will first ramp down the high voltage and then the low voltage for the calorimeter and will not affect the high or low voltage of the hodoscope, and *vice-versa*.

If an interlock condition were to occur, the system will disable the individual high voltage and low voltage modules via the front panel connector on each module, overriding EPICS controls and the channels' pre-programmed ramp down rate. To re-power the low voltage and high voltage channels, resets of both the hardware interlock and the EPICS control systems are needed.

The cRIO system is mounted in a 5U NI chassis, which also holds the 24 V and 5 V power supplies and the terminal block for low voltage and signal distribution, Fig. 2.

Two keyed, override switches mounted on the front panel allow system experts to update the software while the FT detector is powered. During detector operation, these switches are locked in the enabled position.

Signal type	# of cRIO channels	Input/output	Description
calorimeter temp.	6	RTD inputs	NI 9216 module; for PT100 4-wire RTDs
hodoscope temp.	2	RTD inputs	NI 9216 module; for PT100 4-wire RTDs
calorimeter humidity	2	analog input [V]	NI 9205 module and HIH-4000-003 sensors powered by +5 V power supply on DIN rail
chiller interlock	1	analog output [A]	NI 9265 module; uses 0–20 mA interface to Lauda chiller LRZ 912 analog input module
chiller status	2	analog input [V]	NI 9205 module; monitors pump on/off and pressure
high voltage interlock	6	relays	NI 9485 module; calorimeter and hodoscope high voltage modules are interlocked individually. Ground needed on interlock signal to enable channels.
low voltage interlock	2	TTL DIO	NI 9401 module; each low voltage module is interlocked individually. +5 V on interlock signal to enable channels.
calorimeter gas flow	1	analog input [V]	NI 9205 module; 0–5 V interface to MKS mass flow meter

TABLE I. Signal types monitored, number of channels in cRIO, and input or output type.

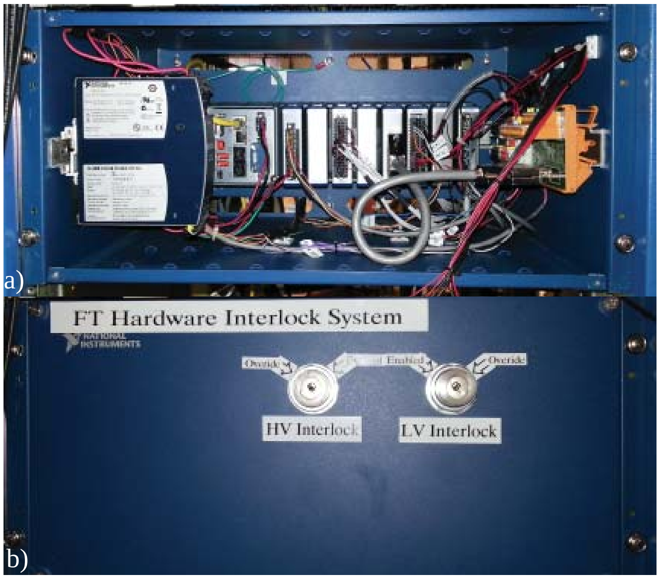


FIG. 2. FT cRIO chassis. a) Front panel removed, showing interior, b) front panel, with keyed switches.

The calorimeter's Lauda chiller has an expansion slot for an independent interface to the interlock system. Using a Lauda LRZ 912 analog input/output, 0–20 mA interface card to the cRIO 9265 module allows the interlock system to turn off the chiller pump without interrupting communication with EPICS, as well as provides pump pressure and pump running status signals to the interlock system.

The interlock system has an EPICS user interface, which allows the operator to monitor remotely the FT and to reset the system after an interlock event. The user interface, Fig. 3, is written in CS-Studio BOY and monitors all sensors and the status of the interlocks. In the expert tab, control settings for thresholds and interlock enables are available. The user can set threshold and control settings if the *EPICS Controlled Thresholds* signal is enabled by the LabVIEW EPICS interface.

The interlock system has a LabVIEW user interface, Fig. 4. In addition to the basic controls and monitoring capability of the EPICS interface, the LabVIEW user interface has detailed information on system status, maintenance mode features, raw data monitoring, and expert-level controls. The cRIO does not require the user interface program to be running to protect the detector. For safety, only one user interface session is allowed at any time. Figure 4 shows the LabVIEW *raw data monitoring* and *threshold and enable control settings* tabs.

The hardware and software for the FT hardware interlock system was completed in June, 2017 and installed on the FT in the EEL building. The system will be moved to Hall B when the FT is installed in CLAS12.

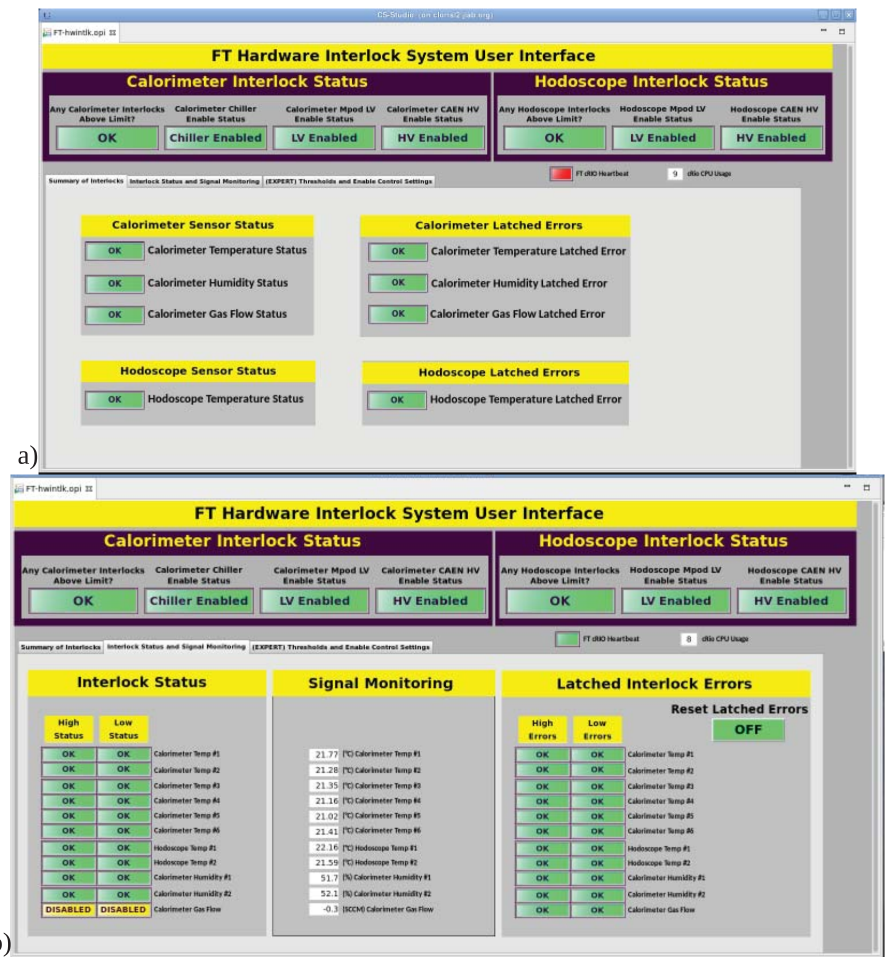
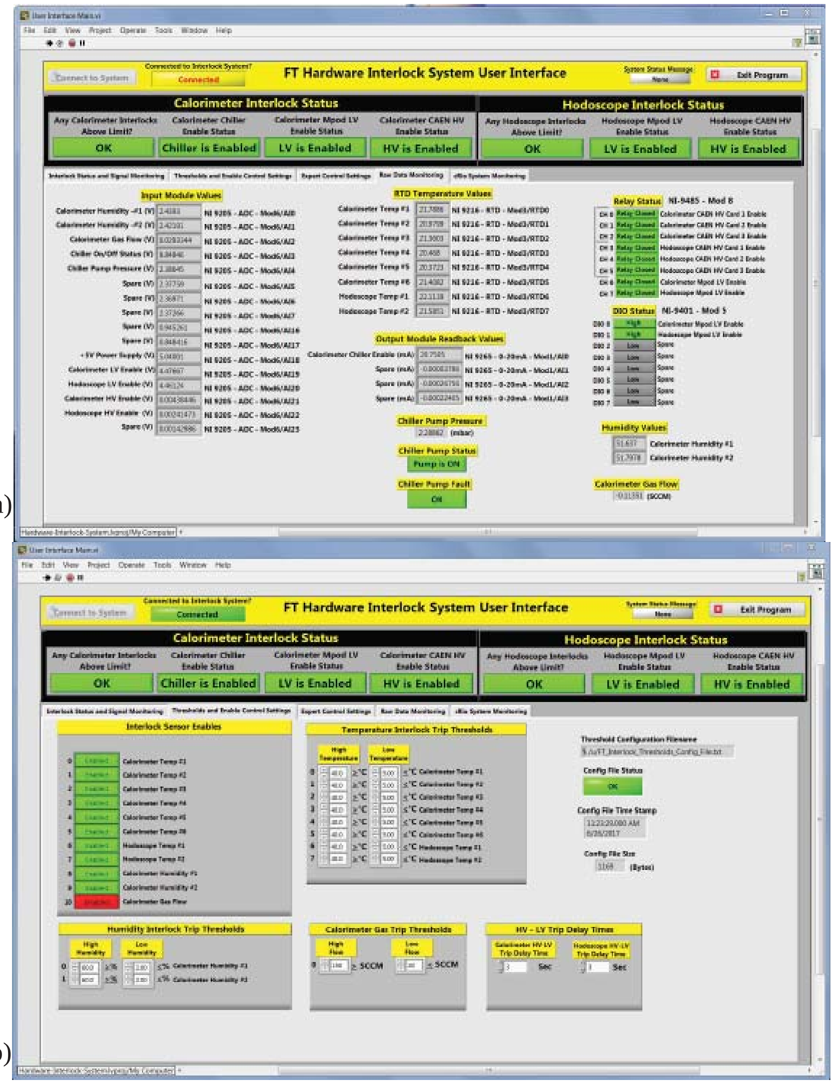


FIG. 3. EPICS CS Studio-BOY user interface tabs. a) Summary of interlocks, b) interlocks and signal monitoring.



a)

b)

FIG.4. LabVIEW user interface. a) Raw data monitoring, b) threshold and enable control settings.