Cryotarget Control Software

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Background

Purpose

Create a program that will record data about a liquid deuterium target, send data to shift workers and the main control system, and throw alarms if necessary.

Jefferson Lab

The primary goal of Jefferson Lab is to understand how quarks and gluons interact to form nucleons and nuclei. The main scientific instrument is CEBAF, a racetrack-shaped, mile-long electron accelerator that can produce electron beams up to 12 GeV. One of the experiments in Hall B at Jefferson Lab will measure the neutron magnetic form factor, G_M^n, a fundamental observable related to the distribution of current. This will be measured by striking a liquid deuterium target (Fig. 1) with the 12GeV electron beam and observing the debris in CLAS12, the CEBAF Large Acceptance Spectrometer (Fig. 2).

CLAS12 is an $80M detector composed of 40 layers of detecting elements with over 68,000 readouts. It is designed to measure the debris products between an electron beam and a target situated just inside the SVT.

Figure 1: Target

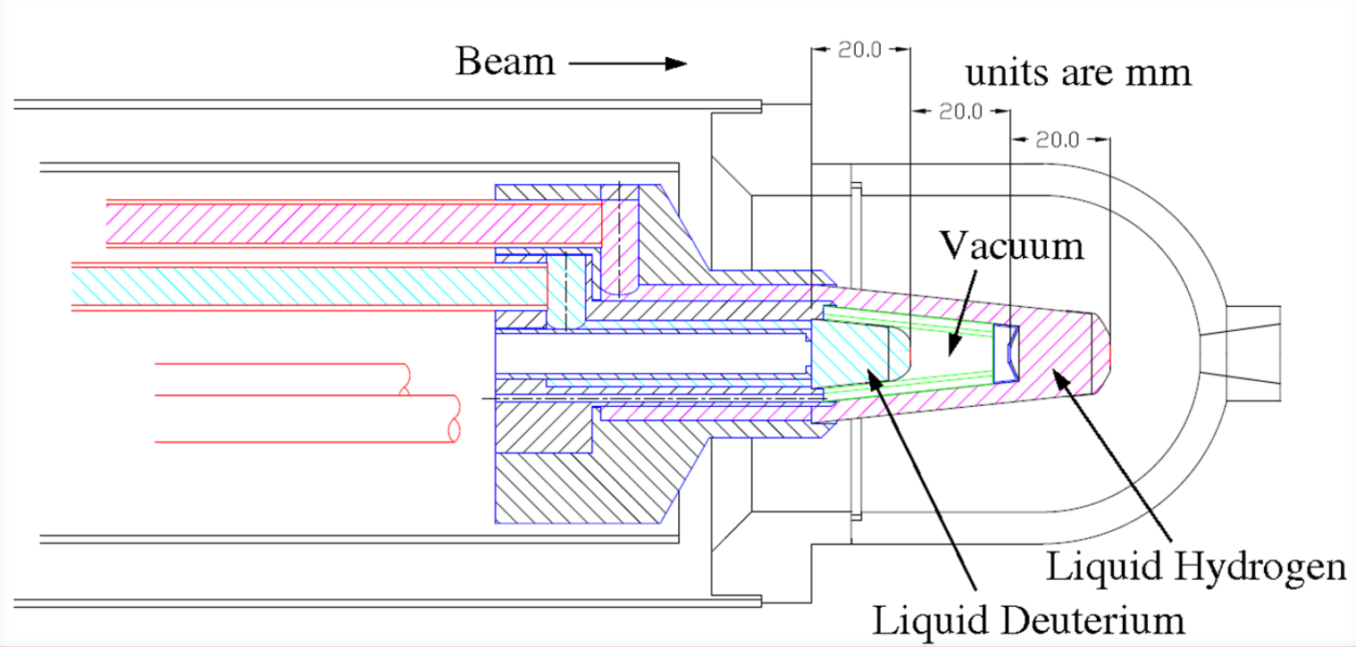
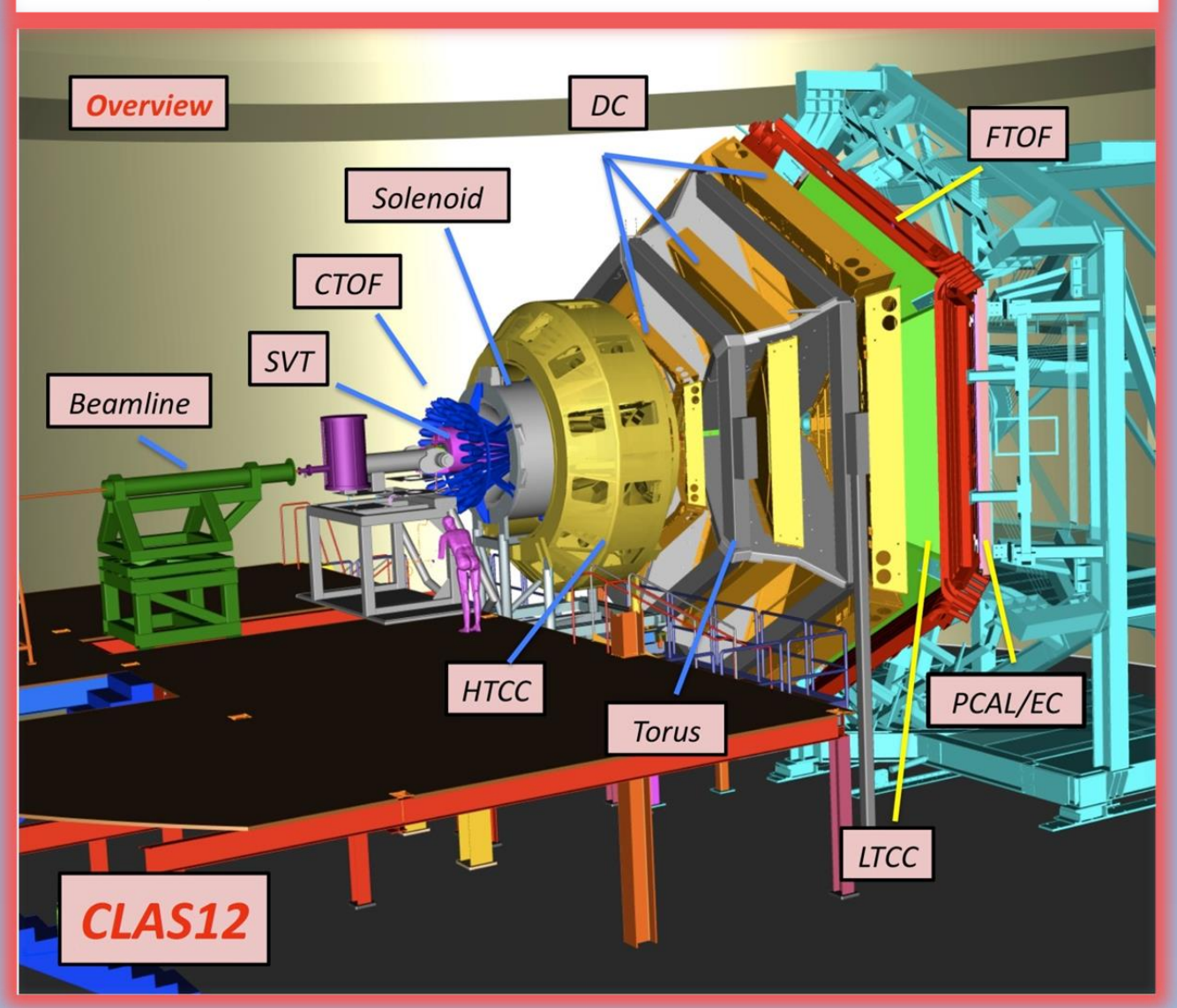


Figure 2: CLAS12



LabVIEW

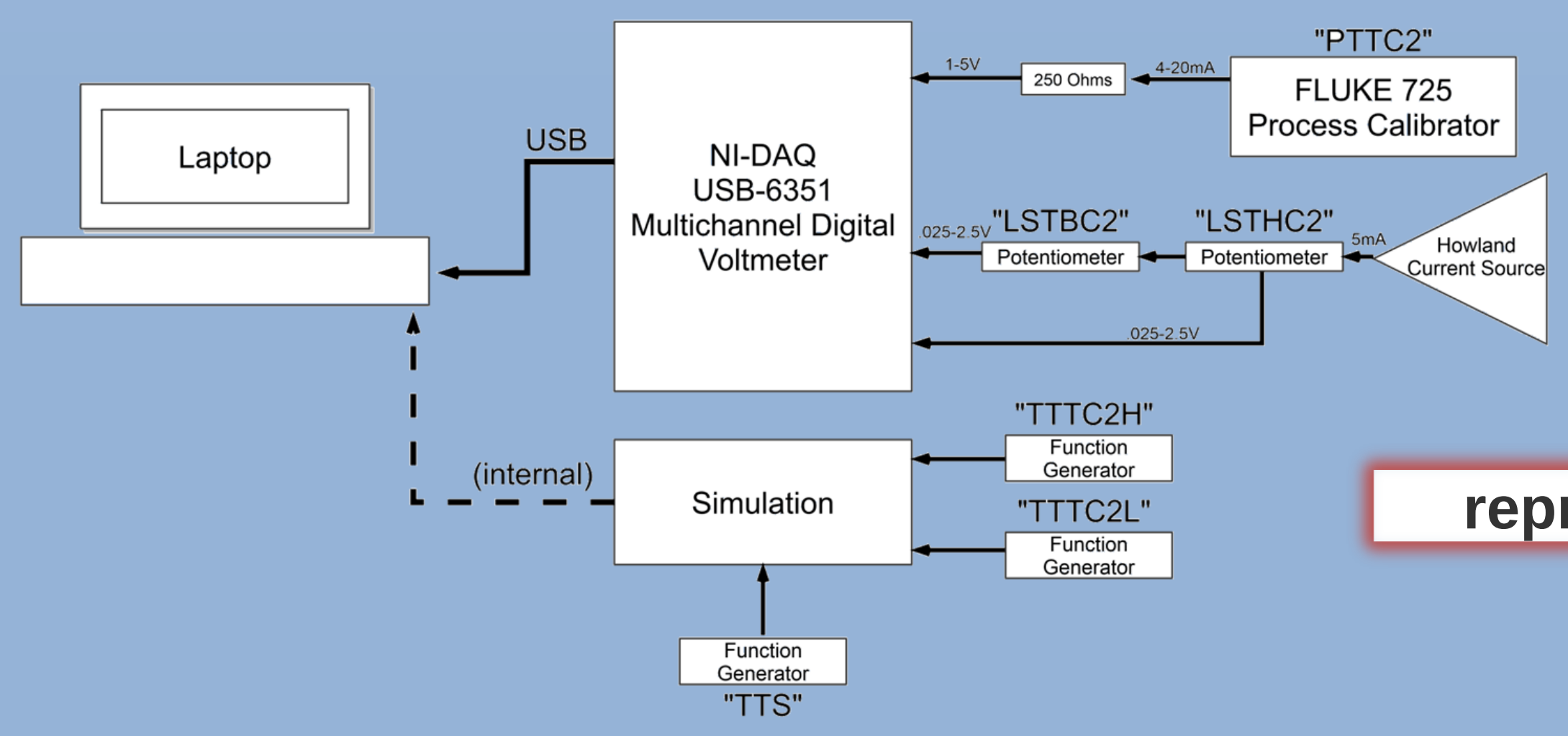
The code for this project was written in LabVIEW, a graphical programming language designed by National Instruments. LabVIEW is designed to easily interface with hardware through custom GUIs (Graphical User Interfaces), which will be discussed below.

Methods

Test Stand

A test stand was created to mimic the monitoring system that will be built for the G_M^n experiment. The lab setup is diagrammed in Fig. 4a, and the anticipated experimental setup is shown in Fig. 4b. In the test stand, sensor data is simulated via software or voltage signal and then processed by the LabVIEW program. For the experiment, a computer called a Compact RIO will be installed in the hall to run the LabVIEW program. Sensors listed in Table 1 will be connected to the computer via transducers that convert analog measurements to digital signals.

Fig. 4a: Test Bench



represents

Fig. 4b: Anticipated Setup

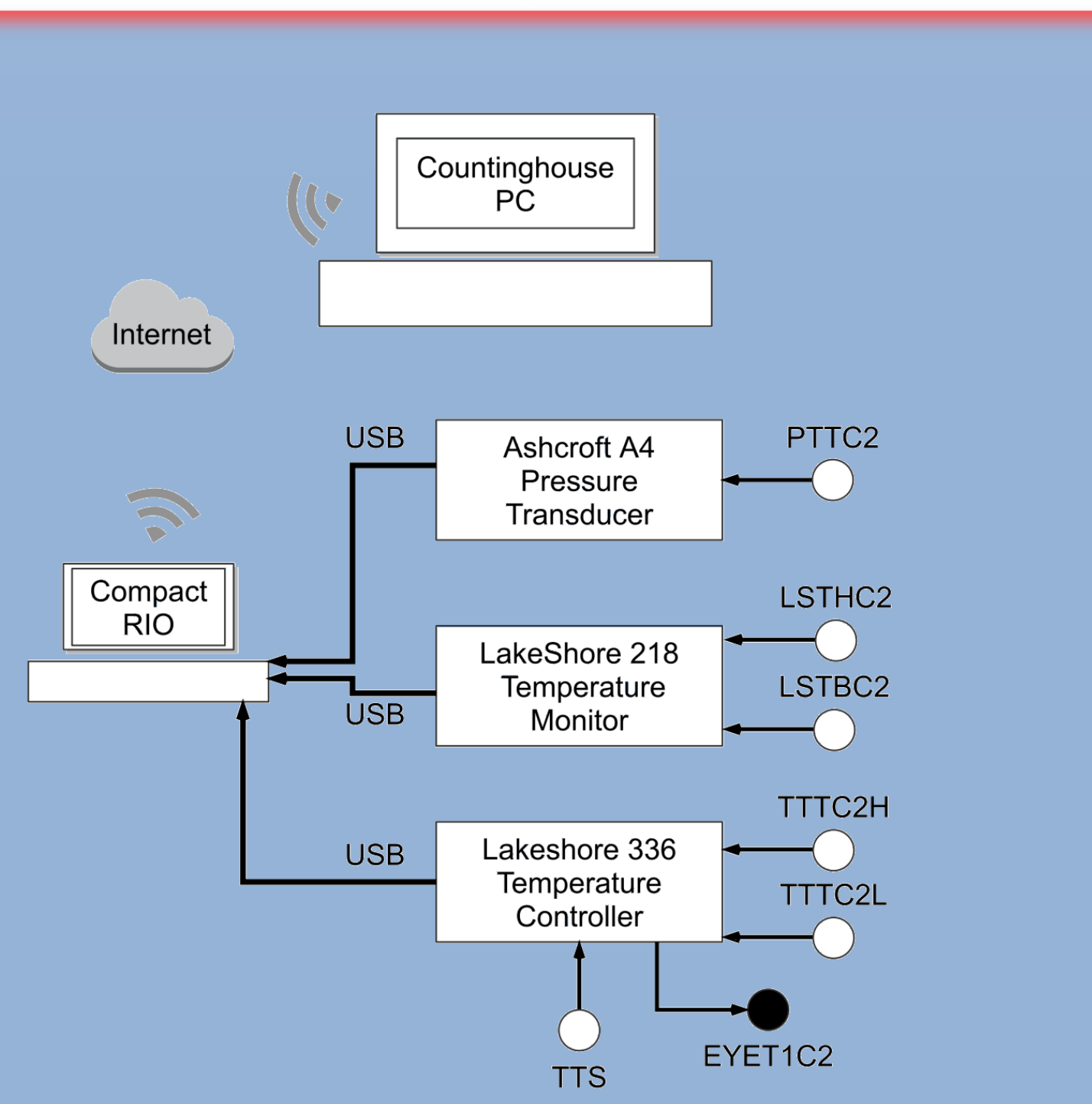


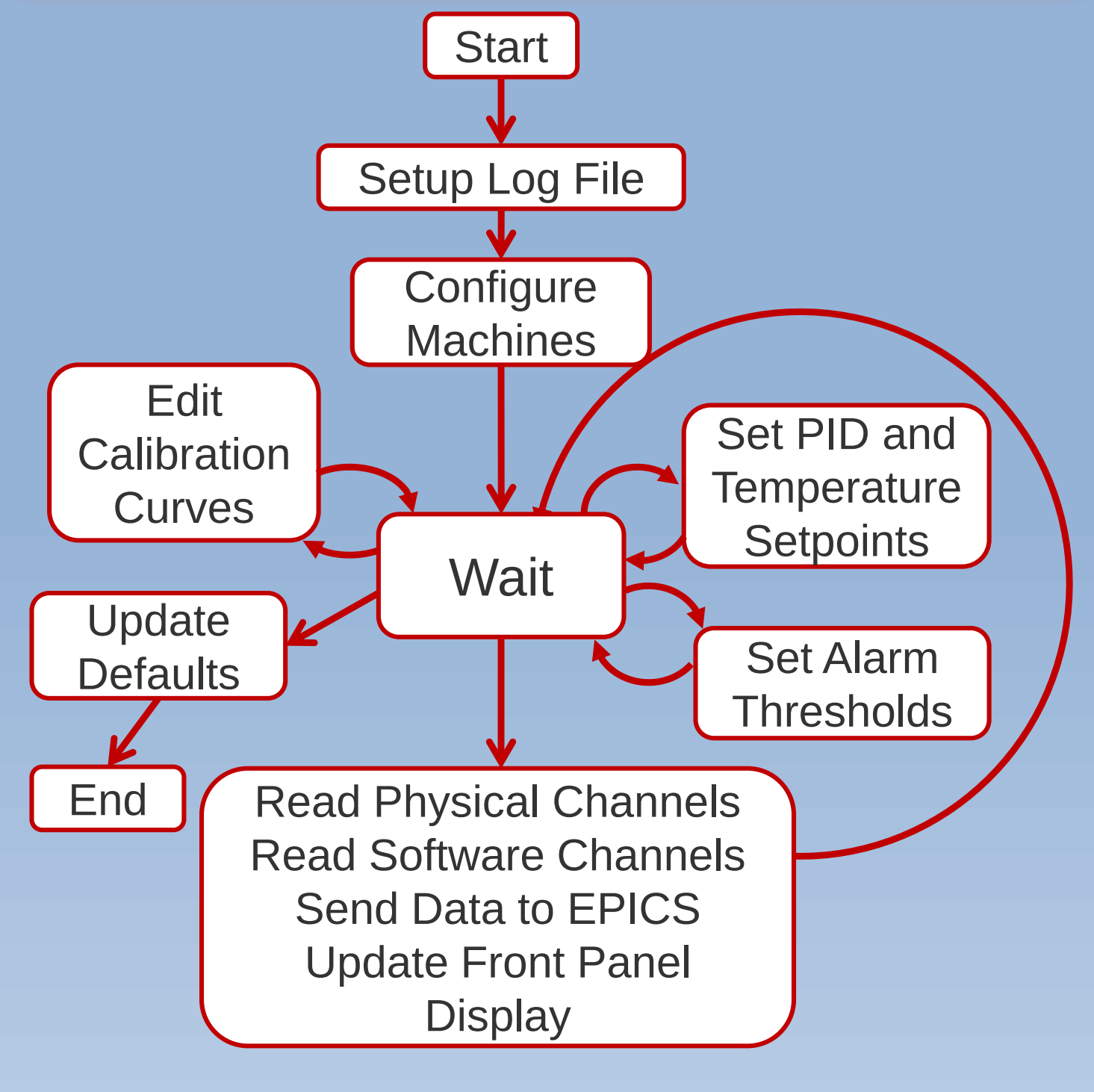
Table 1: Sensors

SIGNAL/READOUT NAME	LOCATION	DETAILS
PRESSURE TRANSDUCERS		
PTTC2	Top of target vacuum jacket on D2 relief line	0-5k torr abs., 4-20mA out
PTVTC2	Top of vacuum pump line	Atm. TO 1E-3mbar abs.
TEMPERATURE TRANSDUCERS		
TTTC2L	Condenser, bottom of the D2 volume	Ga-Al-As Diode w/LakeShore Calibration
TTTC2H	Condenser, top leg of the D2 target cell	Ga-Al-As Diode w/LakeShore Calibration
TTS	Target shielding	Si Diode w/LakeShore Calibration
LEVEL SENSORS		
LSTHC2	Condenser, top leg of the D2 target cell	500 ohm carbon resistor
LSTBC2	Condenser, bottom of the D2 volume	500 ohm carbon resistor
HEATERS		
EYET1C2	Condenser, D2 volume	25/50 Watt, 50 Ohm, 25/50 Volt

Procedure

- We wrote a flowchart (Fig. 5) to specify the program's operation sequence. (Arrows indicate which program states conditionally follow each other.)
- Based on that sequence, a structure (event-based state machine) was chosen and coded into a skeleton program.
- States were populated with module stubs, and program flow was tested.
- Stubs were replaced with functional modules that simulated, displayed, and logged data.
- After simulating all channels in software, hardware (NI-DAQ USB-6351) was purchased and incorporated to simulate physical channels with current and resistance.

Fig. 5: Flowchart

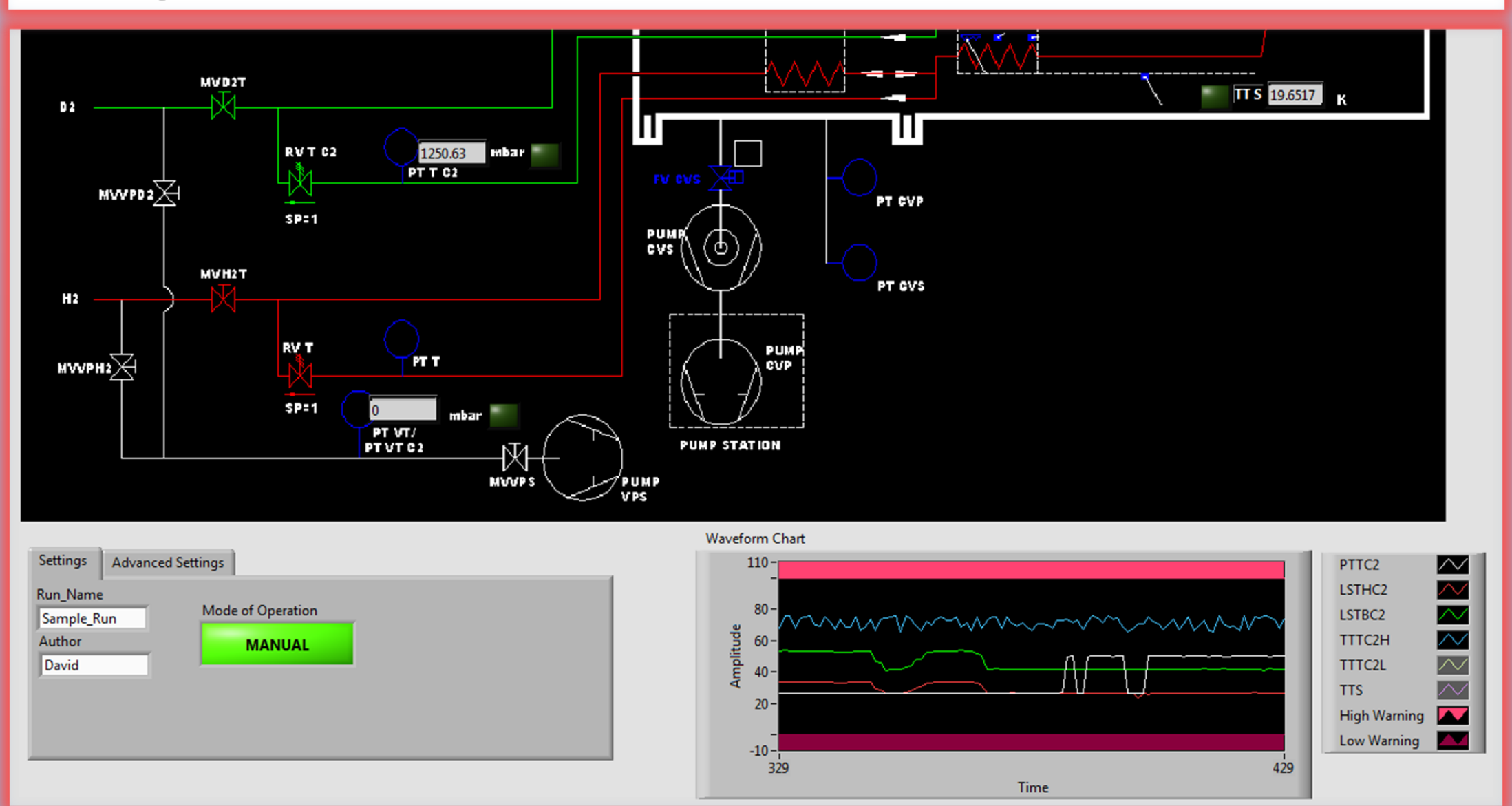


Outcome

Results

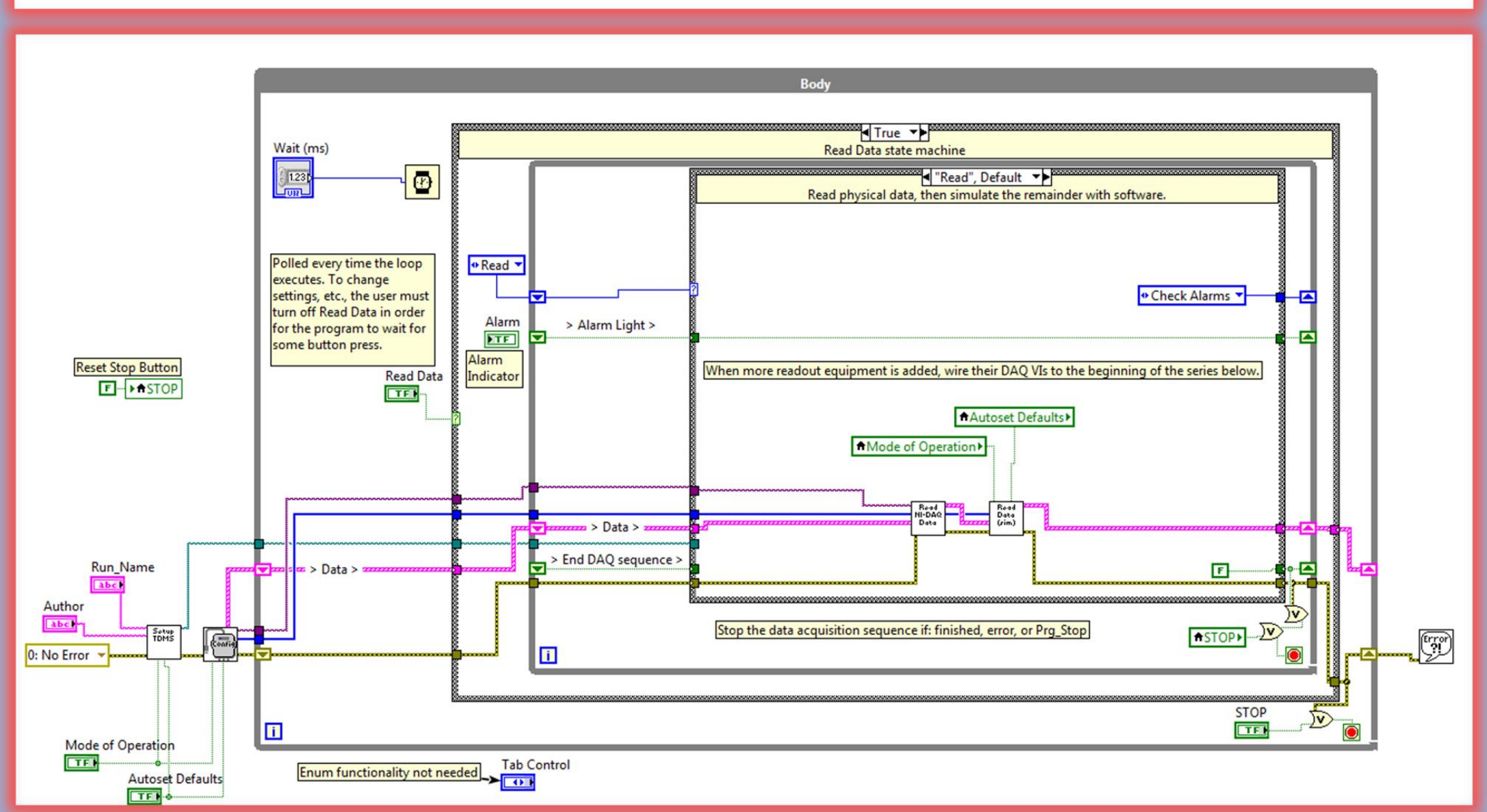
The program can read, log, and display values and alarms for physical and software channels that simulate data about the target in the upcoming G_M^n experiment. This is consistent with expected progress for the current stage of the experimental design process. A selected view of its interface is shown in Figure 6a, and a selection of its code is shown in Figure 6b.

Fig. 6a: User Interface Excerpt



The UI displays sensor values and alarms atop a diagram of the physical target components. Also presented are a menu and a chart of sensors' proximity to warning thresholds.

Fig. 6b: Code Excerpt



This code shows an implementation of a state machine in LabVIEW: the program sets up, and until stopped, reads data, evaluates it, and conditionally responds to alarms. Functionality within a state is encapsulated in modules.

Future Work

When new equipment is acquired, the program will be expanded to incorporate it. The time required for this work should be minimized by the program's scalable design. Prior to installing experimental equipment, the program will have to be ported to a rugged computer, which may require additional work to ensure compatibility