A reliable, low-cost automated LN_2 filling system for the STARLiTe clover array

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The STARLiTe (**S**ilicon **T**elescope **A**rray for **R**eactions **Li**vermore National Lab **Te**xas A&M) consists of segmented annular silicon detectors surrounded by a HPGe clover array in close geometry (see Ref. 1). These HPGe clover detectors are cooled with liquid nitrogen and, when biased, the dewars containing the liquid nitrogen for each detector must be refilled at 12 hour intervals. With up to six detectors in the array, this amounts to approximately 1 hour of beam time lost per day for manual filling, which over the course of a 1 week experiment amounts to the equivalent of a lost 8 hour shift. Given the value of beam time, such downtime should be minimized.

In response to this need, a system has been designed at Texas A&M Cyclotron Institute (TAMU-CI) for this purpose. It consists of a programmable micro controller interfaced with a six channel relay array for powering six independent cryogenic solenoid valves attached to a common manifold fed by a large LN_2 dewar (see Fig. 1). The microcontroller is an Ardunio Pro Mini which is based on the (ATmega328). This microcontroller was chosen for its ease of use (it is C programmable through a TTL serial connection using open source software), compact form factor (0.7” x 1.3”) and low cost (around $20). A relay driver IC (ULN2003) was used to interface the TTL digital output of the microcontroller to 12V relays. These relays switch the 120VAC power to the cryogenic solenoid valves that control the flow of LN_2 to the clover detector dewars.

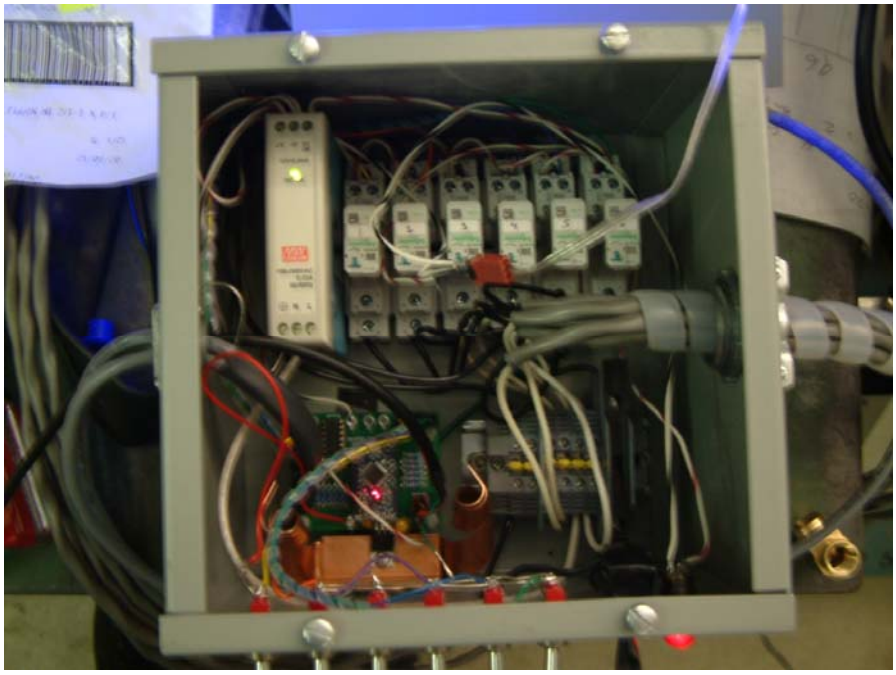

FIG. 1. LN2 system. Microcontroller is seen in the bottom left and the relays are in the upper right.

The Arduino Pro Mini has 8 analog inputs of which 6 are used for monitoring the temperature in the exhaust line of each clover in order to detect the presence of LN_2. The 12 digital I/O pins (excluding those used for the TTL serial communication) are split between the aforementioned relay control outputs and inputs for an array of switches that allow the user to initiate a fill (either one that must be manually turned off by the user or one terminated by liquid sensed in the exhaust line).

A low cost Intel Atom-based computer is used to monitor the fill cycles of the clover dewars. A Python script was written which handles the communication with the autofill system as well as provides an easy to use graphical user interface (Fig 2) to display information on the fill cycles and to accept user commands. While the computer is used to monitor the fill cycles, the autofill system does not require a connection to the computer to operate and will continue running as long as it is powered. In the event of a power loss, the autofill system will start a new fill cycle once power is restored and resume filling at the previously set interval (typically 12 hours) thereafter. The monitor computer is also used to send alerts via SMS in the event of a fill cycle not finishing in a reasonable amount of time, which could be indicative of an empty LN_2 dewar. A second script was written to allow remote users to check on the system via an SSH session.

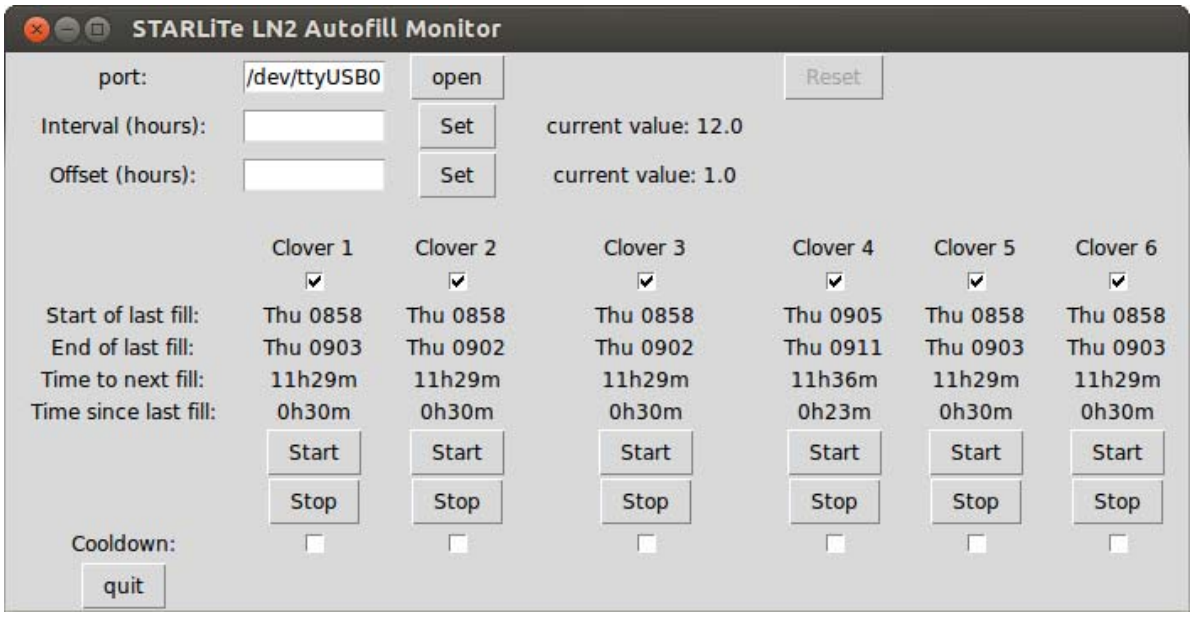

FIG. 2. Control/monitor GUI.

The exhaust line LN_2 sensors are PT-100 RTD probes connected to a voltage divider circuit that keeps a small current (about 20mA) flowing through the sensor. The purpose of this current is to provide a small amount of heat input to the sensor that must be overcome by direct contact with liquid nitrogen as opposed to the cold gaseous nitrogen that is present during the fill cycle before the clover dewar is full. A delay and a requirement for a continued LN_2 temp reading was also implemented to ensure that a brief splash of LN_2 is not sufficient to terminate the fill. In practice this has proven effective.

In summary, a reliable, low cost automatic LN_2 fill system has been designed and built at TAMU-CI for use with the STARLiTe clover detector array.

[1]. S.R. Lesher *et al.*, Nucl. Instrum. Methods Phys. Res. **A621**, 286 (2010).