# Current Capabilities:

### Hardware Controls:

**Spectral Instruments X-ray Camera:**

There is one X-ray camera used to view the Deuterium-Tritium (DT) fill level of a target and the final layer uniformity. Controls for the camera are exposure time (integration time), gain and digital gain, taking an image, images to average (takes X images and averages them into one image), and setting a region of interest (in software, not on the camera).

**Navitar Objectives and Zoom/Focus Controller:**

There are two Navitar long working-distance objectives for high-magnification imaging of the target; they are both remotely controlled for zoom and focus on the target. The controls for each Navitar are go to home (go to zero zoom or focus), go to limit (go to the max zoom or focus), go to a specific zoom or focus, +/- 1, and +/- 10, respectively.

**Basler Cameras:**

Two Basler cameras attached to Navitar long working-distance objectives are used to view the target from different angles and get shadowgraph images. Controls for the cameras are exposure time, gain, acquire an image (at a certain frequency and as an on-demand command), and setting a region of interest (in software, not on the camera).

**Gardasoft Illuminator:**

One illuminator is used with two channels, one for each Basler camera, to provide enough light to capture a shadowgraph image. The controls for the illuminator are set brightness, set pulse duration, save a setting as high or low, change to the saved high or low setting. Each channel on the illuminator has its own set of controls.

**Master control module (MCM) (Lakeshore temperature controller, DT valve controls, tritium monitor):**

The MCM is an electronics board that interfaces with the Cryogenic Data Acquisition and Control System (CDACS) board that allows different programs control over hardware on board the Moving Cryostat (MC) at separate times. Cryoview 2 connects to the MCM to gain access to the Lakeshore for getting and setting temperatures of the Cold Finger Extension (CFE) and the Layering Sphere (LS). The MCM also grants Cryoview 2 control over gas-chromatography (GC) valves used for filling targets with DT; each valve has a register that can be read to detect if there is a DT leak in the target during the filling process which would cause the MCM to automatically initiate a DT recovery protocol. Controls for the MCM are get/set temperature (of either the CFE or LS), acquire control over valves, relinquish control over valves, open/close a valve, and get states of valves/control status/leak detection.

### Functions:

**HDF4 (In Progress):**

Data about the target is saved to HDF files using HDF4 format. Data includes images from all three cameras, dates, fill information, and layer information. The functionality to create HDF files and save images to datasets has been completed but the other information to save has not been completed.

**Database Communications (In Progress):**

The database is used to connect to the hardware, acquire target information (such as target ID), acquire layering configurations, and save data about the target. The hardware connections have been implemented but the rest is in progress.

**Target Filling (In progress):**

Target filling is done to fill the target to a specified fill level with DT. The process uses the MCM controls over valves to scrub the target of residual 1H (protium), then fill the target with the DT. The X-ray camera is used to determine the fill level so LS temperature adjustments can be made to reach the desired fill level. MCM controls over temperature are used to increase or decrease the fill level (by changing the vapor pressure inside the target) and to freeze the ice plug that holds the DT in the target once filled by lowering the CFE temperature. The algorithm for scrubbing and filling the target has been developed but it has not been tested with the MCM or been approved by the rest of the team.

### Other:

**Pop-out Views:**

A separate window is opened for each camera to allow the user to have a larger image of any view for analysis. There is also a window that will open during the fill process that shows the state of each valve and if there is a leak in the target and the MCM has initiated the DT recovery sequence.

**Monitor Network Connection:**

If connection to the network is lost, then the user is notified. The status of the network connection is always displayed on the GUI.

**Monitor temperatures:**

The user can monitor if the LS and CFE temperatures are staying within range of allowable temperatures to ensure target viability.

# Planned Capabilities:

### Hardware Controls:

**Micro X-ray Inc. X-ray source:**

An x-ray tube with a tungsten anode and an electron beam focused to ~8 µm is used to create a cone of x-rays to illuminate the capsule for phase-contrast imaging of the capsule. The controls for the source include acceleration voltage and electron-beam current to adjust the x-ray spectrum and intensity, respectively. There will also be certain safety interlocks in place that will need to be checked before the source can be energized.

### Functions:

**Target Layering**

Once a target is filled, a uniform DT ice layer must be formed on its interior. LS and CFE temperature ramps will be stored in the database and the user will have the ability to select the correct one for the target. The two optical views of the target will be used to measure the uniformity of the ice layer and determine if the layer formed correctly. The x-ray view will also be used to measure the final layer thickness and to remove the P1 defect near the fill tube. Layering will be done in three stages. First the user will control the LS temperature to melt the ice until there is a single crystal, then the LS temperature will be slowly reduced again to “catch” that crystal. The layering is then done by using the temperature curve to slowly lower the LS temperature to grow a uniform ice layer out of the crystal. Finally, if there is a P1 defect, the CFE temperature is changed to remove it. Both forming the ice layer and removing the P1 defect are desired to be automated processes.