Jefferson Lab

Procedure

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Tittle	Hall A tritium target operator manual
Description:	

This document is a user operation manual for the Hall A Tritium Target (HATT). For more information see the tritium target wiki: https://wiki.jlab.org/jlab_tritium_target_wiki/index.php/Main_Page. This manual is based on the web pages written by C. Keith.

An online users guide can be found at:
https://userweb.jlab.org/~ckeith/T2targ/T2targManual.html

For engineering details and further information, see the pressure system folder PS-TGT-12-001 on DocuShare and other references given in this document.

Note: when clicking on the hyperlinks, use the copy link feature. Direct access has been disabled on some secure servers.

Contents

1. Revision History

Revision: 0	10/13/2017	Original
Revision: 1	11/20/2017	Updated main GUI page information and added Cryostat status page
Revision: 2	11/21/2017	Corrected section 7.4
Revision: 3	12/7/2017	Updated main GUI and JT control sections. Added expert guidance section.

2. Definitions

- CANS: Central Alarm Notification System
- COO: Conduct of Operations applicable to the tritium experiments
- ERG: Emergency Response Guidelines
- ESR: End Station Refrigerator
- GUI: Graphical User Interface
- HALOG: Hall A e-log https://logbooks.jlab.org/book/targetlog
- HATT: Hall A Tritium Target
- IOC: Input Output Controller. This is a single board computer that operates in a VME crate (for the purposes of this target system only).
- JLAB: Thomas Jefferson National Accelerator Facility
- JTG: JLAB Target Group
- JTG e-log: JLAB standard Target Group electronic logbook available at: https://logbooks.jlab.org/book/targetlog
- MCC: Machine Control Center
- PSS: Personnel Safety System
- RCD: Radiation Control Department
- RWP: Radiological Work Permit
- SSO: Safety System Officer
- TAM: Tritium Air Monitor

Nomenclature:

- *Cell*: shall refer to the HATT tritium cell unless otherwise specified.
- *Chamber*: shall refer to the Hall A Target scattering chamber.
- Confinement: Control of the tritium inventory such that failure of the primary containment results in an exhaust of the tritium inventory to a suitable controlled location.
- Containment: Control of tritium inventory which does not allow tritium to escape.
- *Controlled Access*:   State of Hall where the doors remain locked (using magnetic locks) and entry is controlled remotely by the Safety System Operator (SSO) in the MCC Control Room.
- *Restricted Access*: State of Hall where the doors remain locked and the CANS system is used to control access. (This deviates from the normal Hall A restricted access definition).
- *Tritium Mode*: Status of the Hall when the tritium target is installed in the chamber.

3. Purpose and Scope

The purpose of the procedure is to describe the process steps required to operate the Hall A Tritium Target (HATT) including how to respond to alarms and prepare the target for access into Hall A. Process steps for experts only are also described. This procedure does not apply to installation, removal, or cool down/warm up of the target.

4. Facility

The procedure shall be performed in JLAB Experimental Hall A and the Hall A Counting House. The Hall may be in Controlled or Restricted Access while performing process steps this procedure.

The floor of Hall A is shown below. Note the control racks on the beam right of the Hall. The target controls are located in these racks.
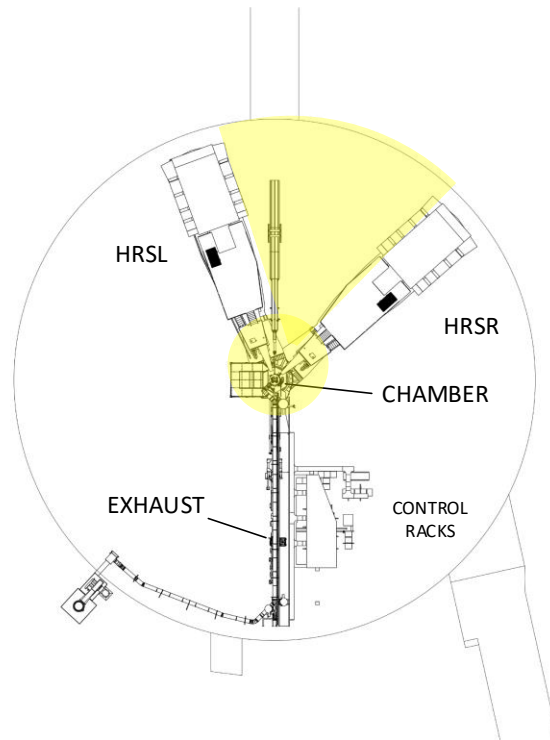

Figure 1: Hall A floor. The yellow highlighted area is restricted and RCD approval is required prior to entry.

5. Authority

The following skills are required for target operators:

- PH019: Safely and effectively function as a Hall A/C Cryotarget Operator.
- PH020: Safely and effectively function as a Hall A Tritium Target Operator.

The authority to use this procedure shall be determined by the Tritium Program Manager.

Process steps indicated as "EXPERT ONLY" shall be completed by or under supervision of the following personnel:

Name	Contact
Chris Carlin	x5971
J.P. Chen	x7413/ Cell 218-0722
Silviu Covrig-Dusa	x6410/ Cell (843) 697-1753
Chris Keith	x5878/ Cell 746-9277
David Meekins	x5434/ Cell 968-9076
Greg Smith	x5405/ Cell 871-4371
Target Cell Phone	(757) 218-0071

Table 1: List of system experts

The target expert on-call can be reached on the dedicated target cell phone.

6. Controls

6.1. Administrative

6.1.1. Training

In addition to the standard work practices (JLAB ES&H manual) which shall be followed the following training is required:

- SAF 801C Rad Worker I
- SAF 110 Hall A Awareness
- SAF 110T Tritium Hazards in Hall A
- PH019: Safely and effectively function as a Hall A/C Cryotarget Operator.
- PH020: Safely and effectively function as a Hall A Tritium Target Operator.

6.1.2. Access Control

Access to Hall A will be controlled by the CANS system. The Tritium Program Manager and Physics Division DSO shall manage the CANS access.

6.1.3. Procedural

Several procedures are in place to ensure that the status of the safety system and other subsystems is verified and documented, including:

TGT-PROC-17-001	Hall A and C Cryotarget Lifter Test and Certification
TGT-PROC-17-005	HATT Tritium Exhaust System Config Verification
TGT-PROC-17-008	Hall A CANS test procedure for tritium mode
TGT-PROC-17-009	HATT vacuum system exhaust verification checklist
TGT-PROC-17-011	FSD Test/Verification Checklist
TGT-PROC-17-012	Beam Steering and Checkout (Ion/ Raster FSD)
TGT-PROC-17-014	Alarm system verification checklist

These procedures are located in the JLAB Document Repository and links are available on the tritium target wiki (link given above).

6.2. Engineered

The following engineered controls are in place.

- Tritium air monitoring system and alarms
- Accelerator fast shutdown (FSD) system
- Tritium exhaust system

Details of these controls are discussed in detail in TGT-RPT-17-003. Operators are not required to be aware of these details.

6.2.1. Process and Instrumentation

The tritium target is a JLAB pressure system. The system process and instrumentation diagram can be found at the following link. https://misportal.jlab.org/jlabDocs/document.seam?id=100654. Reference this document for location of valves, instrumentation (e.g. thermometry), etc.

7. Principles of Operation

7.1. Tritium Containment and Confinement

While the target system is designed to complete basic physics experiments, the most important function is to contain and confine the tritium. The principle is to have multiple layers of containment and or confinement (also known as defense in depth). While the tritium cell is installed in the chamber, there are three such layers. The tritium cell contains about 1050 Ci of tritium (roughly 0.1 g) and is the primary containment or 1st containment layer. The scattering chamber is the 2nd layer and is considered a confinement. Finally the Hall is considered a confinement layer due to the access controls and exhaust system.

Many measures have been taken to mitigate the risks associated with the tritium cell. Those directly affecting the operation of the target are:

- Augmented FSD system
    - There are now 6 FSDs associated with the target and ancillary systems.
    - Hardware interlocks on relevant temperatures
- Vacuum system is now part of confinement system and must be exhausted properly
- The Hall is also part of the confinement system and access controls have been put in place.
    - Operators of the target must have the training SAF110T which is required to access Hall A.
- Upstream beryllium isolation window
- Tritium Air Monitors (TAM)

These measures are discussed in more detail in the Sections below.

Many more details are available in the report TGT-RPT-17-003 found in the JLAB document repository.

7.2. Basic Operation

The HATT is similar in operation to the Hall A/C standard cryogenic target. The target ladder consists of 5 gas cells (with one evacuated to serve as an empty). There are several solid targets that are installed below the cells. This is shown in the figure below.
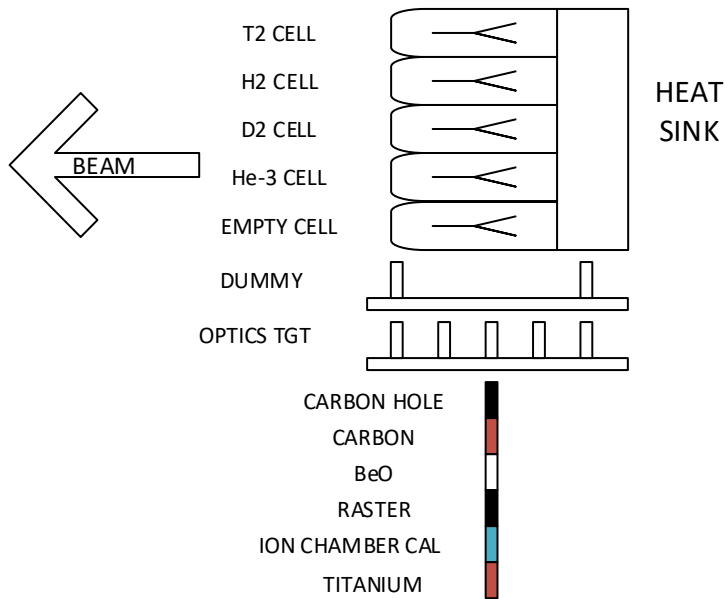
TARGET LADDER SCHEMATIC

Figure 2: Tritium Target Ladder Schematic

The motion system for the HATT allows each target to be positioned vertically in the beam and is identical to that of the standard A/C cryotargets. The gas cells are sealed meaning that the target fluids are not recirculated as they are in the standard cryotargets. Instead of removing heat from the recirculated target fluid, the cells are cooled by conduction through a copper heat exchanger which is cooled by 15K helium from the ESR. The 15K helium from the ESR is warmed to 40K prior to entering the heat exchanger by a PID controlled heater. The 40K helium must be re-cooled to about 25K before it returns to the ESR (on cold return). This is accomplished by mixing the helium exiting from the heat exchanger with a bypass stream of 15K helium. The refrigeration schematic is shown in the figure below. This represents a significant departure from the standard cryotarget configuration and users must be aware of not only of the target temperatures (heat exchanger temperatures) but also the supply and return temperatures of the helium.
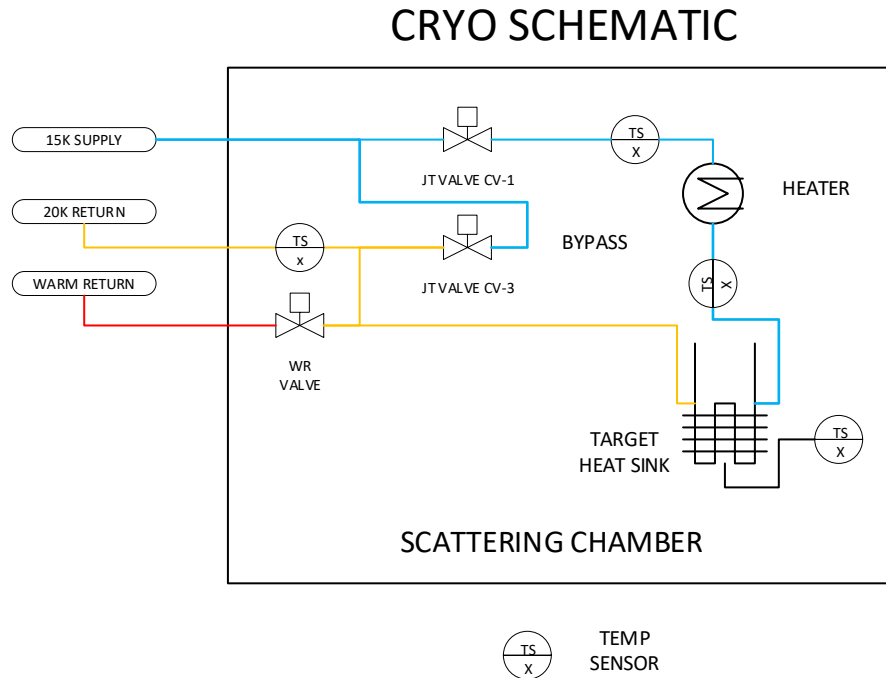
CRYO SCHEMATIC

Figure 3: HATT refrigeration schematic.

More details of the system can be found in the process and instrumentation diagram (P&ID) for the system given by the link https://misportal.jlab.org/jlabDocs/document.seam?id=100654.

7.3. Vacuum and Exhaust System

The vacuum and exhaust system schematic is shown in Figure 4 below. Note that the scattering chamber vacuum is isolated from the upstream beamline vacuum by a beryllium foil window. The window is made from beryllium (99.8%) by Materion Brush Inc. with the following properties.

- IF-1 Brand Be foil EB welded to 2.75" CF flange
- 1.4" disk mounted in 1" aperture
- He leak tight to 10^-9 atm-cc/sec
- Max design temperature 300C
- CF flange is aluminum 2219-T651 (temper prior to welding)

The window protrudes into the scattering chamber on a reentrant tube which also contains a collimator. The beam will deposit an estimated 3W of heat which shall be removed by water recirculated through copper cooling coils by a chiller. The window is positioned roughly 15cm upstream from the entrance window face (thin section). An FSD has been installed on a flow switch ensuring that the water flow to the window cooling circuit is on when beam is enabled.

Because the vacuum system is an integral part of the confinement system, FSDs on several vacuum gauges and switches have been installed.
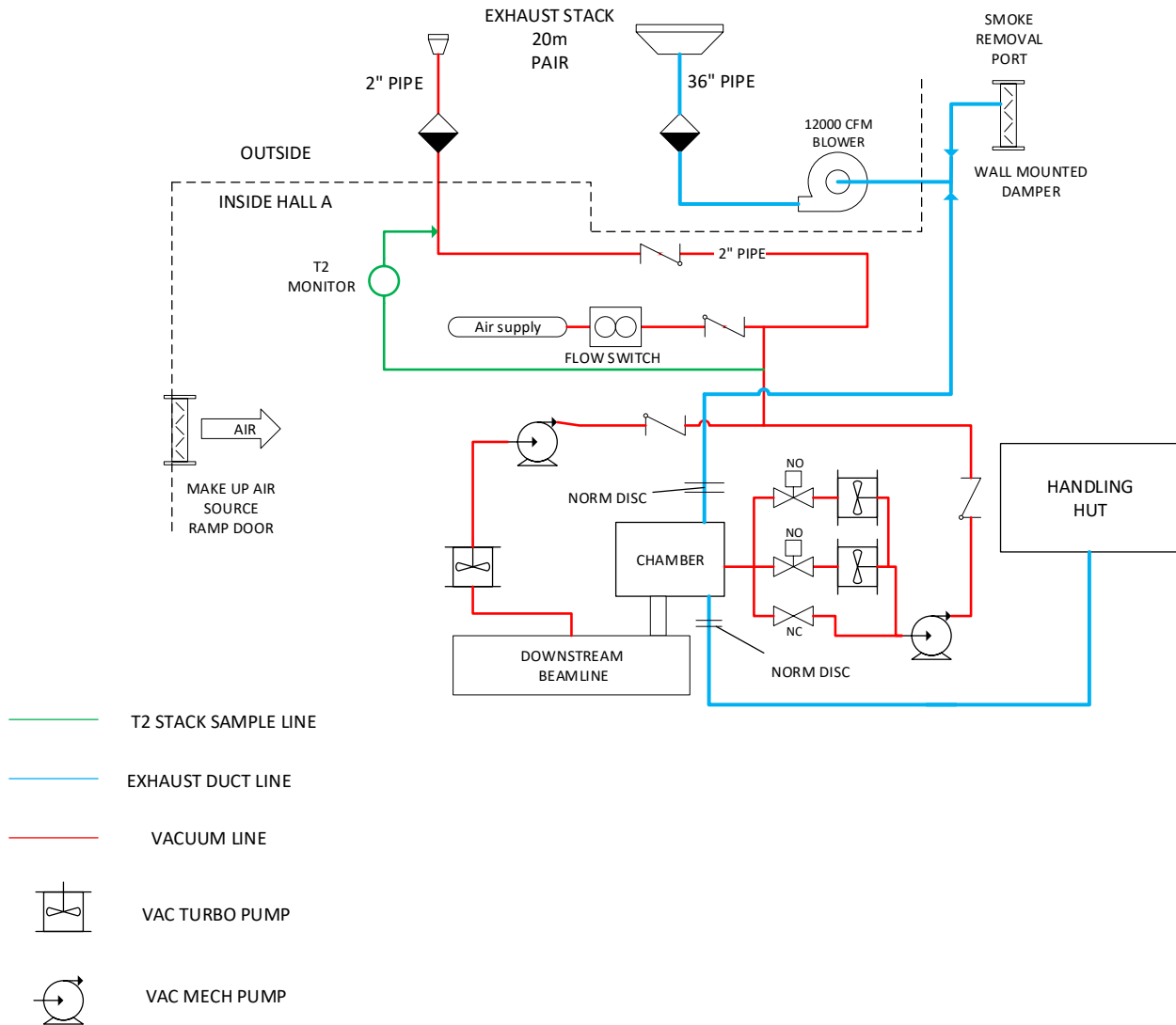
Figure 4: Vacuum and exhaust system schematic

The vacuum pump exhaust is ducted through the normal hydrogen target vent system. The normal termination located behind the counting house has been extended to the Hall A dome and connected to the 2 inch stack (runs in parallel to the 36 inch main stack). This line shall be purged by air at a rate of at least 1-2 cfm. The vacuum exhaust system is shown in red in the above figure. This exhaust stream is continuously purged and sampled by a dedicated monitor (green circuit). The flow switch in Figure 4 triggers a FSD when the purge is in fault condition.

The exhaust system serves multiple functions. However, the primary function is to remove tritium from the scattering chamber and/or Hall A in a controlled manner should the primary containment system fail. The system functions for several different release cases and, also remove the vacuum system pump exhaust. The system exhausts contaminated air to a stack located on the Hall A dome as shown in Figure 5 . The stack has a height of about 20 meters above the grade at the nearest site boundary.

Figure 5: Tritium stack and blower located on the Hall A dome.

7.4. Tritium Air Monitors

Detection of tritium in Hall A while beam is being delivered, presents a number of challenges. It is difficult to distinguish tritium from the normal background present when the beam is on. There are also no readily available local monitors capable of surviving in the high radiation field present when the beam is on. Therefore, two types of devices are in use for the purpose of tritium detection in the Hall and for stack monitoring.

- Redundant remote air monitors for continuous monitoring of the air in the Hall
  - Canberra TAM 100D. This system is independent from the exhaust and vacuum system shown in Figure 4 and is therefore not shown.
- Remote monitor which samples air pumped from the stack through a tube to a secure location.
  - Technical Associates STG-7L4. This is shown schematically in Figure 4 as the green line.

The remote TAM 100D monitors also interface with the FSD and exhaust systems. A schematic of the alarm logic is given in the figures below. These monitors also engage the alarm system when in the fault condition.
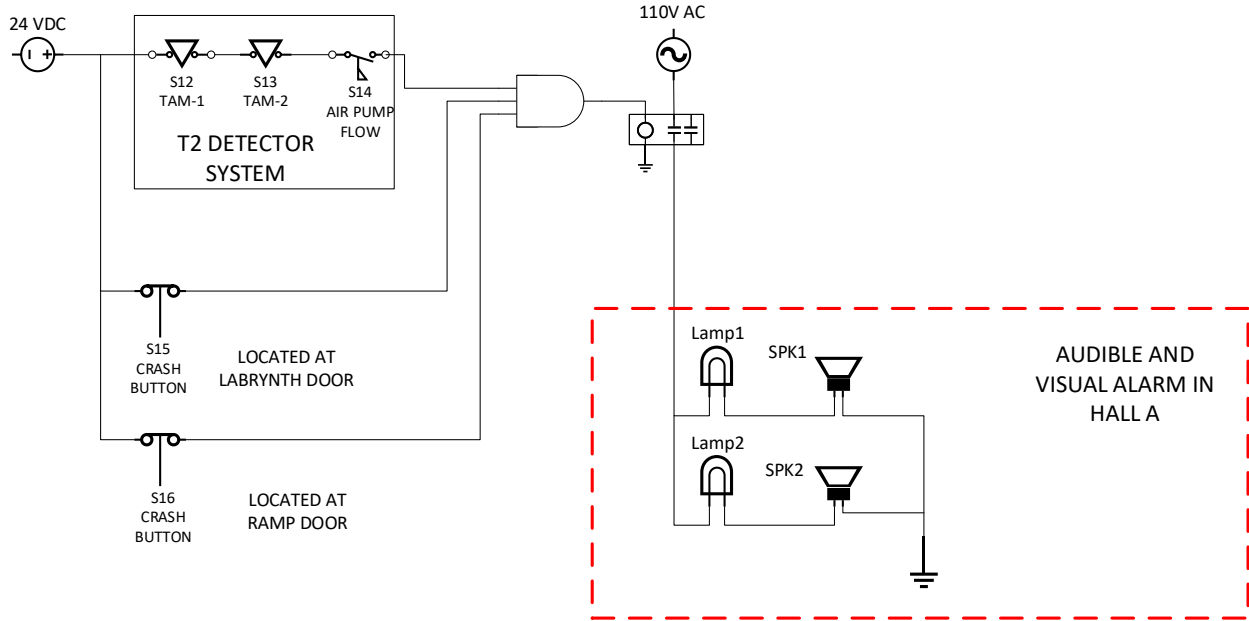
Figure 6: Tritium air monitor TAM 100Ds and alarm interface schematic.

The figure below gives a flow schematic for the TAM 100Ds sampling circuit.
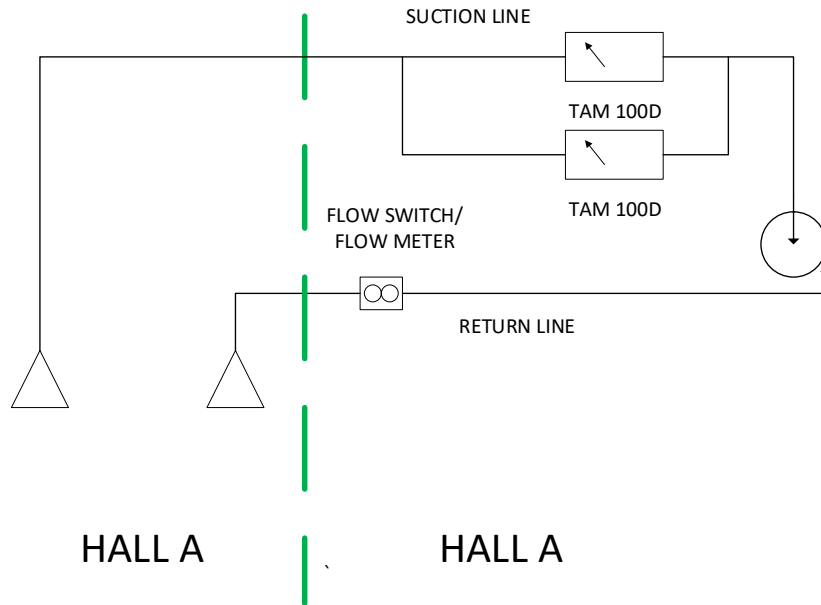
Figure 7: TAM air sampling schematic

7.5. FSD System

Several multiply redundant interlocks are used to protect the target cells and beryllium isolation window. A schematic of the FSD interlock system is shown in the figure below. Note that these interlocks are all hardware interlocks and do not require software or network to be in operation. In the event of a power, failure these interlocks will all fail true and activate the FSD system. The MCC will

attempt to clear the FSD. . If an FSD does not immediately clear, the MCC will contact the Hall A counting house. The target operator shall then call the target expert on call who will address the issue as required.
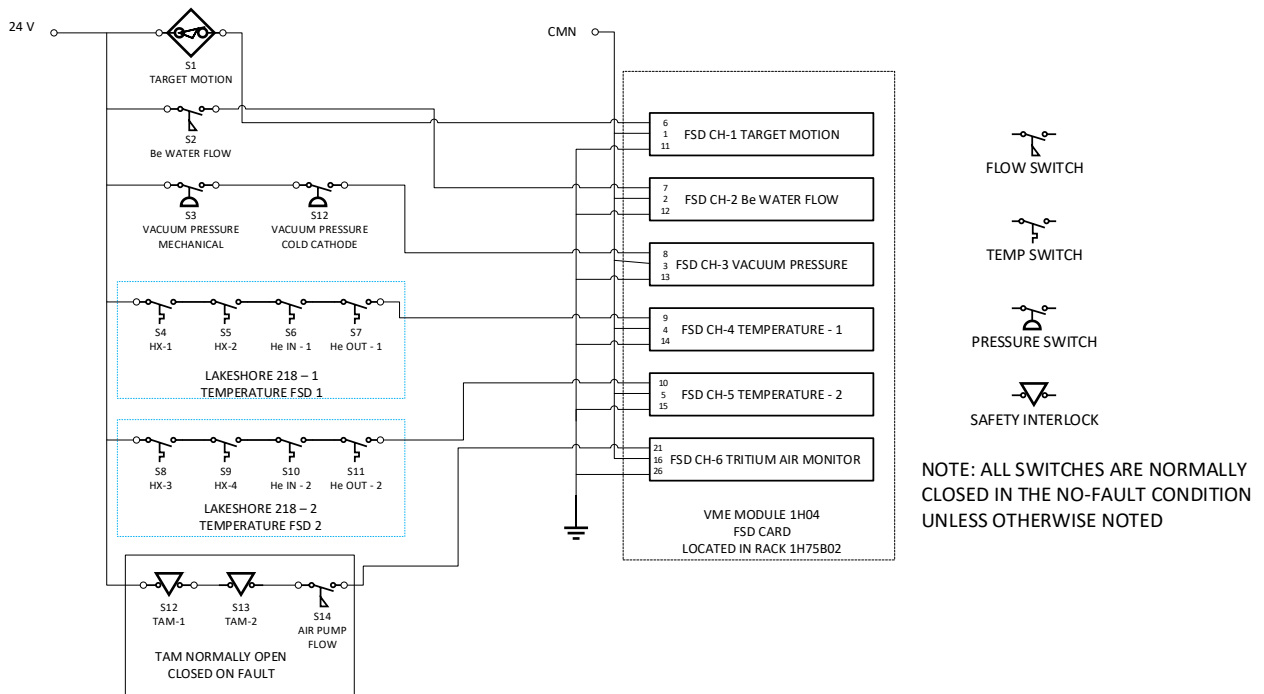

Figure 8: Schematic of the FSD system for the Tritium Target. This is part of the JLAB drawing TGT-103-1001-0002

The standard cryotarget user should be familiar with the vacuum pressure and target motion FSDs. There are 4 additional FSDs in the HATT.

1. Tritium Air Monitor
   a. When this FSD faults the operator must call the target expert on call.
   b. Call the MCC as well.
2. Temperature controller 1
   a. This will fault if any temperature exceeds the set point. This is to protect the cell from high temperatures (in excess of 150K).
   b. The likely cause of this will be and ESR failure of some kind.
3. Temperature controller 2
   a. Redundant to Temperature controller 1 with same function
4. Beryllium window coolant flow.

This will fault on low flow. Call the target expert on call if this fault does not clear immediately.

8. User Interface Operation

8.1. Main GUI and Startup

Log into the counting house computer *POLTARAC* as user *poltar.* Contact a Target Expert if you don't know the password. Open a terminal window, and type:

-> cd Desktop/T2targ
-> ./tgtgui

The main graphical user interface (GUI) shown below should appear. This shows all the pertinent information necessary for monitoring the target and provides links to other GUIs for adjusting the target controls (e.g. Target Motion, JT Valves, Heater etc.). Almost all read back parameters (such as temperatures and pressures) are color-coordinated with the associated alarm settings. A green value indicates that a parameter is within acceptable range, while yellow and red indicate that the parameter has either a minor or major alarm status respectively. A white read back indicates a communication error between the GUI and the control IOC.
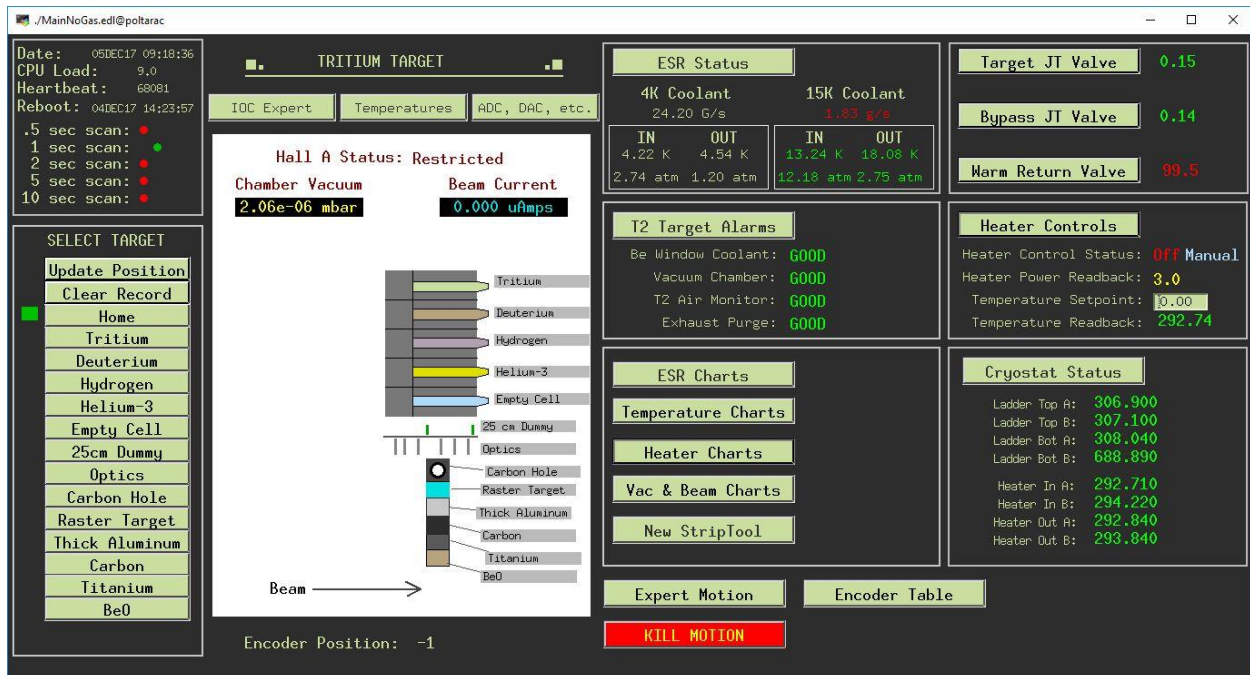
Figure 9: Main GUI screen

At the top center portion of the GUI, the user will see a series of related display buttons, most of which are for expert debugging of the target controls. Another button is labelled NewStripTool; it starts a fresh StripTool that the user can utilize for plotting target data.

The upper left portion of the main GUI displays information about the control IOC. You should see a series of red and green flashing lights indicating that the various EPICS scan tasks are operational. If one

or more of these freezes, the IOC may need to be rebooted. For help with this issue, contact the target expert on call.

The series of buttons beneath "SELECT TARGET" are used to move the target to a pre-specified location. See Section 8.7 for more information about using these buttons.

The status of the target's scattering chamber is shown in the center "drawing". An arrow should indicate the location of the target stack relative to the electron beam. The beam current and scattering chamber vacuum pressure are displayed at the top.

To the right of the drawing are expert controls for target motion. These controls are to be used by or under the supervision of a target expert.

Read back and related display buttons for the target's cryogenic coolant are above the expert motion portion of the main GUI. These can be used to access information about the coolant used to keep the target cold.

The right side of the GUI is divided into three sections. The first section is for the three cryogenic valves that control the flow of helium coolant through the system and has buttons for related displays for these valves. The second is for the high power heater that is used to maintain a steady temperature of the targets. Here the user will find a button to launch the heater control GUI and a button to launch a strip chart for the heater. The third section displays the temperatures at various target locations and has a button to a detailed display for target system and another button to launch a *stripchart* of the temperatures. The button labelled Charts will launch a preselected series of strip charts associated with

- Heater power
- Target Temperatures
- Chamber vacuum

8.2. Cryostat Status

The cryostat status page gives a useful overview of the cryostat. This includes a flow schematic, valve settings, thermometry read backs, etc. This page is shown in Figure 10 and should prove to be very useful to the operator.
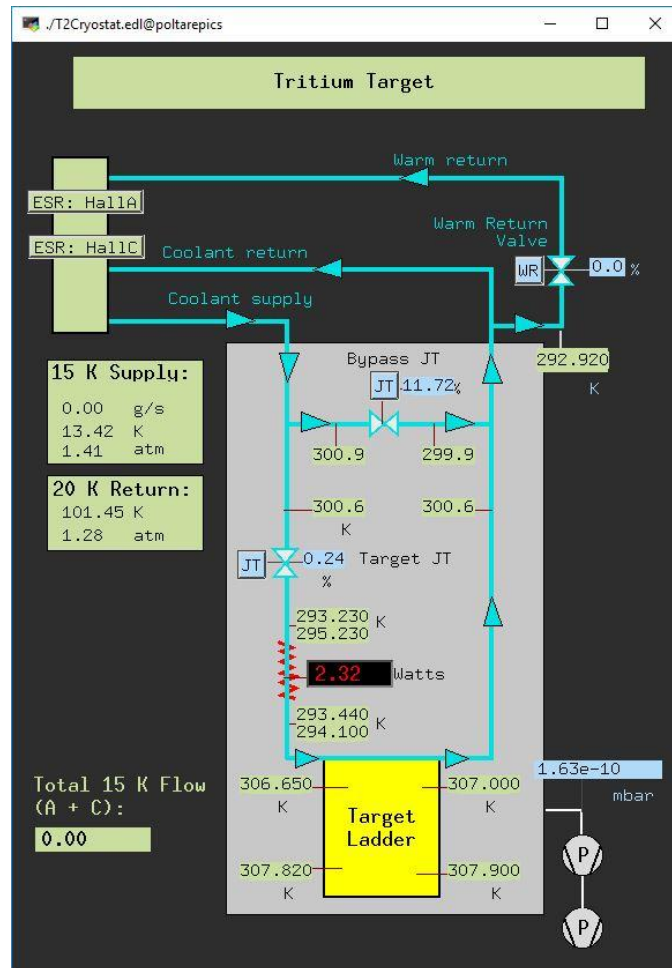
Figure 10: Cryostat Status screen

8.3. Charts

We use the **StripTool** to chart the behavior of many target parameters as a function of time. This application has been in use at JLab for several years, and should be familiar to Hall A/C Cryotarget operators. For convenience a number of scripts have been defined that automatically start **StripTool** and launch a number of pre-defined charts.

1. The **Temperature Charts** button on the right side of the main GUI will start two charts associated with the selected cryotarget loop:
   o Heat exchanger temperatures
   o Coolant Temperatures
2. The **Cryo Charts** button will launch a StripTool application with multiple ESR parameters displayed: Inlet and Outlet temperatures, Inlet and Outlet Pressures, and 15 K helium flow.
3. The **Heater Charts** button will launch a StripTool application displaying heater power.
4. The **New StripTool** button will launch a blank strip chart that the Target Operator can populate with almost any EPICS signal(s) desired.

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A complete description of **S-tripTool** can be found at the StripTool Users Guide. A few of the more common actions are described below.

- To change the vertical, Y scale of one or more channels being charted:
  - o Right click on the desired strip chart, and choose "Controls Dialog". The screen to the right should appear; press "Modify" button next to the channel(s) you wish to change. Enter the new **Min** and **Max** y-scale values.
  - o Press "Update" for each of the channels that you have modified;

To change the horizontal, time scale of one or more channels being charted:
- right click on the desired strip chart, and choose "Controls Dialog". The screen below should appear;
- select the *Controls* tab;
- press "Modify" button at the bottom of the **Time controls** section
  - o enter the new Time Span in hr:min:sec format;
  - o Press **Update**

8.4. EPICS Alarms

The cryotarget controls use the EPICS **ALH** alarm handler to monitor the system and alert the user to off-normal readings. There are redundant alarm settings (HiHi, HIGH, LOW, LoLo) on temperature readings as well as the heater.

Unfortunately, it is not unusual for one off-normal event to produce several alarms. For example, if the He refrigerant supply temperature rises, an alarm on the inlet temperature will be produced. However, the HX and outlet temperatures as well as the heater power will all most likely alarm.

The **ALH** application has been in use at JLab for several years. A full description can be found at the ALH Users Guide. The Alarm Handler can be started by pressing the **T2 TARGET ALARMS** button located in the middle on the main cryotarget GUI. This will launch the primary alarm display window shown below. The window will appear GRAY under normal conditions, and flash RED if any alarms exist.

Figure 11: ALH application window

If the alarm window is RED, it indicates that one or more read backs in the target system is off-normal. To find out which one(s), left-click on the alarm window and the "Alarm Tree" shown below will open. As shown below
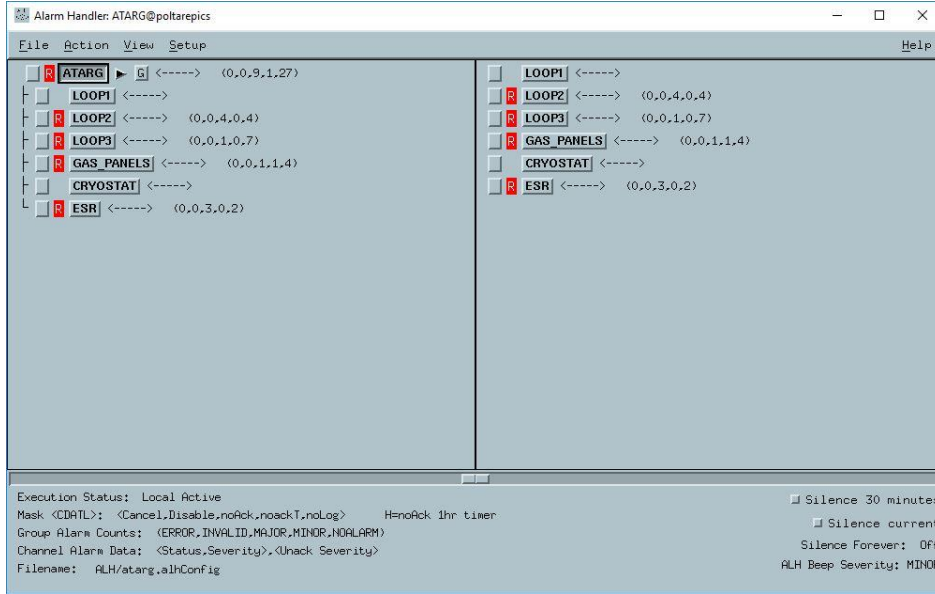
Figure 12: ALH alarm tree window

To see more information about which specific channels are experiencing an alarm state, it is necessary to expand the Alarm Tree. Press the group button on the left side of the tree. The tree will expand in the right column to show the individual elements of that group.

Figure 13: ALH branch view

To see *why* an element is alarming, press the **P** button next. This will open the window like the one shown below, which shows the alarm settings for Loop 2's inlet temperature.

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This indicates that the haCryo_Supply_T has exceeded a limit (shown in RED). A RED reading indicates a MAJOR alarm value has been exceeded, either LOLO or HIHI. A YELLOW reading indicates a MINOR alarm value.
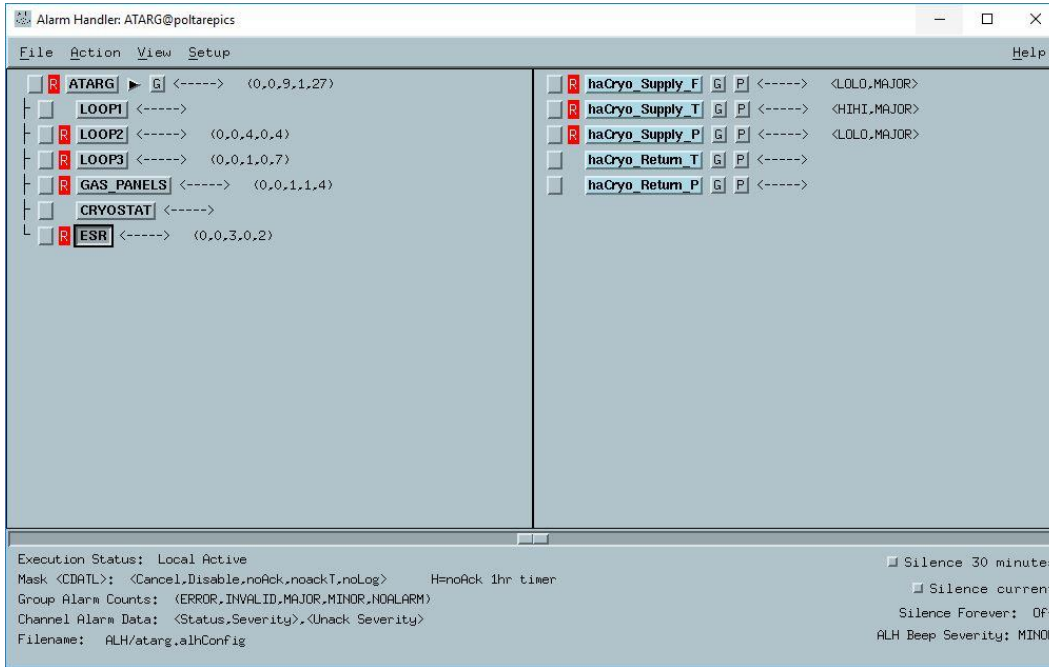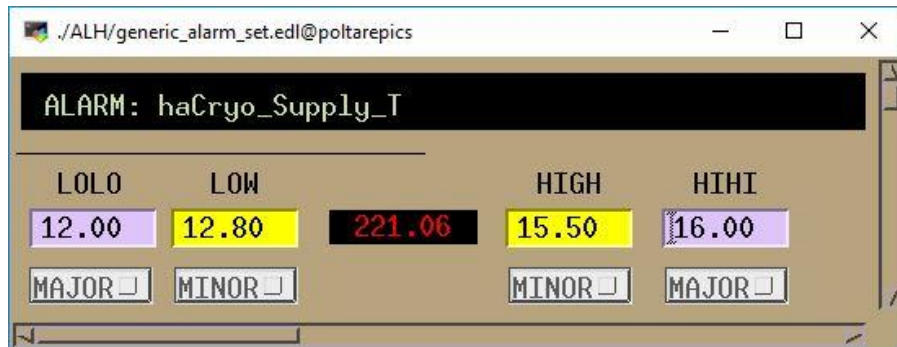

Figure 14: ALH alarm view on 15K He supply temperature

In this example, the 15K supply temperature is above the HIHI limit. The alarm severity (LO, LOW, HIGH, HIHI, or NO_ALARM) can be changed as well, using the pull-down menus.

Target Operators should never change alarm settings without being directed to by a target expert.

Pressing the **G** button next to **hcL2_hp_power_R** will open the window below, which has some guidance for the Target Operator. In this case it simply recommends paging the target on-call expert. Usually the guidance isn't very helpful, and the Operator should contact the on-call Target Expert.

8.4.1. Specific Alarms

The following table lists some specific EPICS alarms that also trip a FSD for the HATT system:

Sensor	Device/Channel	Action
Coolant temperature, pre-heater TS-10	Temperature monitor LS-218 #1 ch 1	FSD on high alarm
Coolant temperature, pre-heater TS-7	Temperature monitor LS-218 #3 ch 1	FSD on high alarm
Coolant temperature, post-heater TS-8	Temperature monitor LS-218 #1 ch 2	FSD on high alarm
Coolant temperature, post-heater TS-9	Temperature monitor LS-218 #3 ch 2	FSD on high alarm
Heat sink temperature, TI-11	Temperature monitor LS-218 #1 ch 5	FSD on high alarm
Heat sink temperature, Ti-12	Temperature monitor LS-218 #1 ch 6	FSD on high alarm
Heat sink temperature, TI-13	Temperature monitor LS-218 #2 ch 5	FSD on high alarm
Heat sink temperature, TI-14	Temperature monitor LS-218 #3 ch 6	FSD on high alarm
Target Motion	BDS-5 motor controller	FSD on motion enable

Additional alarms (e.g. 15K flow to Hall A, and scattering chamber vacuum) are also enabled. The default values for these alarms shall only be adjusted under supervision of a target expert.

8.5. Heater

The heater is a small coil of resistive heater wire installed inside the piping of the helium coolant for the T2 target. It is used to regulate the temperature of the coolant as it flows through the copper heat sink for the stack of gas targets. The coil is connected to a 1500 Watt power supply located in the Cryotarget electronics rack inside Hall A. Computer control of the power supplies is accomplished using two Digital-to-Analog Convertors (DACs) and two Analog-to-Digital Convertors (ADCs). One of the DACs sets the power supply's current limit, and the second sets its voltage output. The ADCs are used to read back both the current and voltage. Pressing the **Heater** button on the main GUI brings up the screen below.
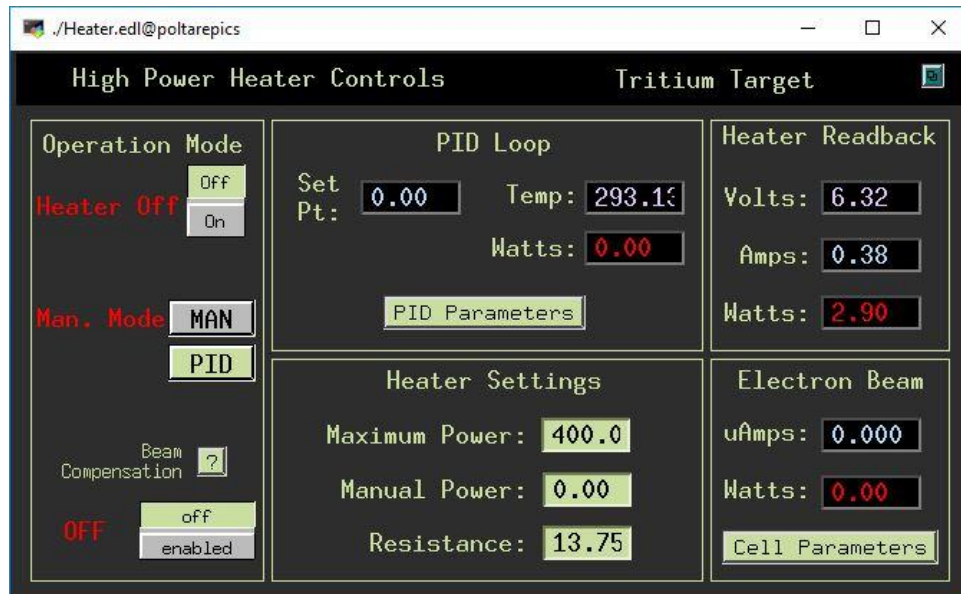
Figure 15: Heater control window

All the pertinent information about the heater and controlling it is displayed here:
- the ON/OFF status
- whether the heater is in PID or Manual mode
- whether the heat deposited by the electron beam is compensated
- voltage, current and power read back
- inputs for the maximum power, the manual power setting, and the resistance of the heating element;
- read backs of the electron beam current and a calculation of the heat it deposits in the target

Each of these is discussed in more detail below. There are also related displays that allow more expert adjustments to the heater controls. The target operator shall only use these features under the supervision of a target expert. There are three operational modes for the heater:
1. **OFF:** The power to the heater element is set to zero
2. **MAN:** The target operator manually specifies the heater power, in Watts. The heater must be **ON** for this to have effect.
3. **PID:** The target control computer automatically adjusts the heater output power to maintain a specific temperature of the target fluid. PID stands for Proportional, Integral, and Derivative, a common form of a feedback control loop. The heater must be **ON** for this to have effect. The various PID parameters, including the temperature set point, are accessible in a related display. Launch this display by pressing the **PID Parameters** button.

There is an additional control in this portion of the GUI, **Beam Compensation**. This feature has been disabled for the tritium target. In normal operation, the temperature of the target heat sink is automatically controlled by the computer using a PID feedback loop. The computer monitors the appropriate thermometer installed in the coolant piping and adjusts the high power heater in order to regulate the temperature at a user-specified *set point*. The value of the temperature set point is displayed in this part of the Heater GUI, along with the actual value of the control thermometer (**Temp**) and the desired heater output (**Watts**). Note that this is not necessarily the actual power being

produced by the heater. Instead it is the value that the PID loop believes is necessary for control and is primarily displayed for debugging purposes. The actual outputs of the heater power supply: **Volts**, **Amps**, and **Watts**, are displayed to the right.
The input boxes located in this part of the Heater GUI allow the user to adjust the Maximum value of the heater output, the value used in Manual mode, and the value of the heater resistance. In short:

- The **Maximum Power** value actually sets the heater power supply's current limit, either in Manual or PID mode. This utilizes the heater resistance and is determined as
  $I_{max} = sqrt(P_{max}/R)$
- The **Manual Power** setting sets the heater output power whenever the heater controls are in Manual Mode. The control computer adjusts the voltage across the heating element according to:
  $V_{man} = sqrt(P_{man}R)$
- The **Resistance** box allows the user to adjust the value of the heater's resistance that is used by the computer in the above calculations. It is usually set by the JLab Target Group, and shouldn't be changed without permission from a Target Expert.

8.5.1. PID Parameters

Changes to thePID settings can be accomplished by pressing the **PID Parameters** button, which should open the GUI shown below. Input boxes allow the target operator to change the temperature setpoint (**Set Pt.**), along with the **Prop**ortional, **Integ**ral, and **Deriv**ative parameters for the PID feedback loop. The operator can change the **Scan** setting as well, which is how often (in seconds) that the control computer adjusts the heater output.

There are four other settings associated with the EPICS PID record that can be accessed by the user:

- **MIN** is the minimum power that the PID loop will apply to the heater
- **MAX** is the maximum. This value is directly associated with the PID loop, and is overrided by the maximum heater output that is described above. That is, the PID will not request an output power greater than the one entered into the **MAX** box, and the control computer will not output any power greater than the maximum value entered into the **Maximum Power**box in the main heater GUI.
- **dMIN** is the minimum *change* that the PID record will process. The heater output will not change unless the value calculated by the PID record exceeds **dMIN**.
- **dMAX** is the maximum *change* that the PID record will process. The heater output will not change by more than this value in one **Scan** time.

Typical settings for the PID parameters can be seen by pressing the button at the very bottom of this GUI. There are two thermometers installed in the piping downstream of the heater, and either of these can be used to control the PID. The control thermometer can be selected using the Select Sensor button. *None of these values should be changed without the permission of a Target Expert.*
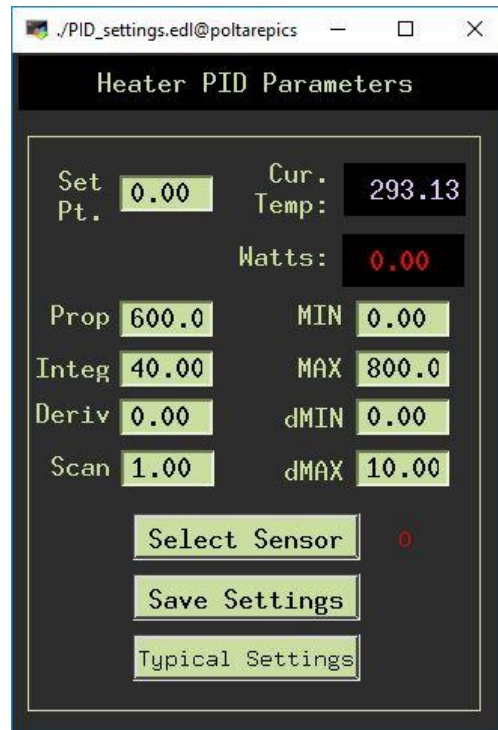
Figure 16: Heater PID window

8.6. Cryo (JT) Valves

Three valves are used to control the flow of helium coolant into and out of the T2 target cryostat: two JT valves and the Warm Return ball valve. The two Joule-Thompson (JT) valves are needle-type valves used to meter the flow of 15 K helium gas from the End Station Refrigerator (ESR). The needle in each valve is actuated by a DC motor, and position (in percent open) is read by a linear displacement differential transformer (LVDT) sensor. These two items interface with a control chassis that is located in the cryotarget electronics rack inside Hall C. The chassis allows the user to operate the JT valve either locally, using switches on the chassis front panel, or remotely through the target EPICS GUI.

The **Target JT** valve meters the coolant flowing through the target heat sink. This gas is warmed to about 40 K by a heater and thus maintains the stack of gas targets at that temperature. This valve should be opened until the heater power needed to warm the gas to 40 K is about 40 W.

The **Bypass JT** valve is used to mix some 15 K gas with the 40 K gas that exits the target heat exchanger. This is necessary because ESR operates most efficiently when the cooling gas returns at a temperature no greater than about 25 K. The valve should be opened until the gas returning to ESR is at a temperature of about 25 K.

From the Main GUI, click on the **JT Valve** button associated with the bypass or the target. The JT Valve GUI shown below should appear. The controls allow the user to open or close the valve only in small steps, in order to avoid large, sudden changes at ESR.

- Enter the desired step size into the **Step Size** entry box

- Press either the **Step Open** or **Step Close** button. You should see the requested step appear in the **Rel. Write** box.

You should see the **Current Position** change by approximately that amount. Due to hysteresis in the valve actuator, it may be necessary to press the button more than once. Avoid pressing it several times in rapid succession. If the **Current Position** continues to be unresponsive, confirm that the **High** and **Low Limits** have not been exceeded. If the problem persists, contact the target expert on call. The control window is shown below.
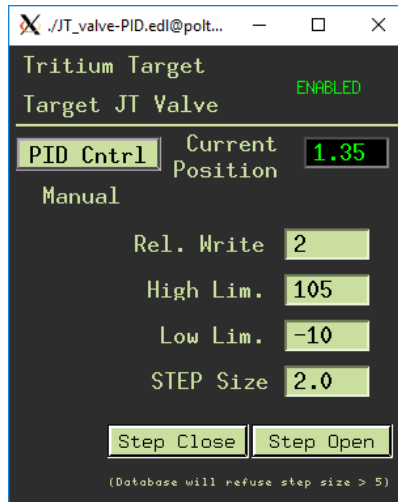
Figure 17: JT control window

PID Control of the JT shall not be utilized at this time. The button PID Cntrl however is used for opening a second window which provides more control options. This window is shown below.

Figure 18: PID Cntrl window

At the top of the window ensure that the control of the valve is enabled; the LED will show green/red if enabled/disabled. Ensure that manual mode is set to yes. Users shall not change the other values on this window unless directed to by a target expert.

8.6.1. Warm return Valve
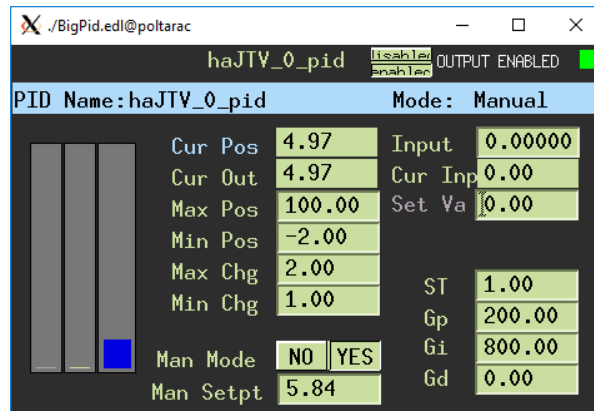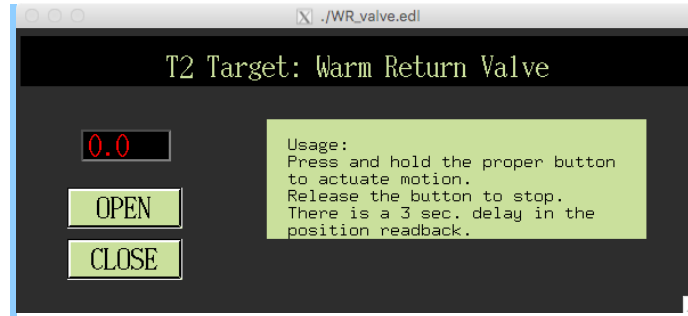
The Warm Return Valve is a ball valve located outside the target cryostat and is used only during the initial cool-down and final warm-up of the T2 target. As such, the Target Operator should NOT operate the Warm Return Valve without direct guidance from a Target Expert or if directed to by JLAB Cryo-group. Operation of this valve is self-explanatory (see figure below).

8.7. Target Motion

The Hall A tritium target is actually a system of sixteen separate scattering samples. These samples are attached on top of one another in what is commonly referred to as the target stack. The assembly comprises five gas target cells (one empty), along with various solid target foils. One gas cell is empty, while the other four are filled with hydrogen, deuterium, helium-3, and of course, tritium. The solid foils can serve a variety of purposes: as physics targets, background subtraction, spectrometer calibration, etc.

Each sample is placed into the electron beam by lifting the target stack to height of the beam. This is accomplished using the BDS Lifter, a servomotor attached to three guide rails on top of the scattering chamber. A magnetic encoder, attached to the motor, keeps track of the target's location. A series of electrical contact switches ("end-of-travel" switches) protect the target from exceeding either the highest or lowest allowed position, while the "HOME" switch defines the stack's zero position, from which all sample locations are measured.

Prior to the experiment, the JLAB Survey and Alignment Group positions the target stack in the correct location, and the correct encoder value for every sample is determined by the Target Group. The preloaded values can be seen by pressing the BDS Positions button at the center of the main GUI.

All encoder values are measured relative to the stack's Home position, and are stored in the target's control computer. Home is determined by a contact switch attached to one of the lifting rails. It is usually given an encoder position of zero and corresponds to the target at its maximum vertical limit. In other words, the electron beam passes below the bottom-most scattering sample when the target is in the Home position.

IMPORTANT: target motion automatically generates a Fast Shut-Down (FSD) signal that kills the electron beam. Always call MCC (x7046) prior to moving the target and ask them to mask the FSD signal for target motion.

8.7.1. Procedure to move target

A column of buttons on the left side of the main target GUI is used to move the target stack to one of the 16 predetermined sample positions. Each sample is given a descriptive name (like "Tritium", or "Carbon") and its encoder value is loaded onto the target IOC each time the IOC boots. To move to one of these positions:

- call MCC and ask them to mask the FSD for target motion
- press desired sample button
- the **BDSMove** GUI appear (see below)
- confirm that the destination listed on the GUI is correct, and press the **MOVE TARGET** button
- close the **BDSMove** GUI
- the **Encoder Position** value, displayed under **LIFTER STATUS** should start to changed
- when the lifter reaches its final destination, an arrow should appear next to the desired target sample in the target schematic displayed on the main GUI. This arrow appears when the **Encoder Position** read back matches the programmed value +/- 50 encoder "bits". Each bit corresponds to about 1 um of vertical distance
- call MCC and inform them that the target motion is complete
- if the target fails to move, moves to the wrong location, or generates an error under **LIFTER STATUS**, contact a Target Expert.
- in the event of an emergency, hit the **KILL MOTION** button and call a Target Expert;

8.7.2. Update

Pressing the **Update Position** button at the very top of the **Select Target** list forces the target IOC to request and report the current encoder value from the BDS Lifter.

8.7.3. Clear Record

The **Clear Record** button, second from the top of the **Select Target** list, is there to fix a problem endemic to the EPICS control software. EPICS will only process a record if the value of that record has *changed.* If the BDS Lifter ceases motion before it reaches its final destination, pressing the destination button again will have no effect because the destination hasn't *changed.* In this event, the Target operator has two options: press another destination button, or press the **Clear Record** button. The latter simply clears the EPICS record that corresponds to the destination.

8.7.4. Home

Inform MCC prior to moving the target to the "HOME" position so that the target motion FSD can be masked. Pressing the Home button will force the BDS to run its "Home routine". The main purpose of this routine is to reset the encoder position to zero at a known, fixed location. This will be necessary, for example, if the BDS lifter loses electrical power. Pressing Home will launch the new GUI below, and then pressing the Run HOME button will start the Home routine.

The BDS lifter will begin to move the target upward, towards the Home switch and complete a homing routine. After the completion of the homing routine, the lifter will stop and the BDS encoder value will be set to zero.

8.7.5. Vertical Motion Control

This button is for expert use only. Target operators shall not use this function unless directed to by a target expert.

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9. IOC Reboot

The IOC may require a reboot during normal target operations for reasons similar to those of the standard cryotarget. Unlike the standard cryotarget, there is no need to use an auxiliary heater supply to maintain the temperature. Take the following steps to reboot the IOC:

1. Call MCC and request that the beam be turned off in Hall A (if this is applicable).
2. Reboot the IOC using the standard method for the cryotarget.
3. Call the target expert on call if the IOC does not recover from the reboot procedure.

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10.   Securing the Target for Hall A Access

Prior to making an access (either a controlled access or in preparation for restricted access) into the Hall:

1. Move the target to the "HOME" position as given in Section 0.
2. Inform the MCC that Hall A needs to go to "Controlled Access".
3. The MCC operator shall confirm verbally and on the status GUI in the MCC that the target is in the "HOME" position.
4. The access can now proceed as normal.

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11.   Back-out Procedure

Given the complex nature of the system, back procedures are not given here. When off normal events occur contact the target expert on call immediately. An expert shall determine if assets from the target group are required to address the issues.

12. Guidance for Experts

This section is intended for use by experts only.

12.1. IOC Issues

If IOC issues cannot be resolved by reboot then Chris Keith or Chris Carlin should be contacted immediately.

12.2. Target Vacuum Issues

There are (3) FSDs on the vacuum pressure. If one of these faults, we are to assume that tritium may be present until an assessment can be made. This is conservative approach. In the past there have been many failure modes for the vacuum pressure in the chambers. Assessment shall be performed by the JLAB Target Group and any others who might assist.

Recently it has been discovered that vacuum issues often trigger the stack monitors to alarm, typically low/no flow alarms. These alarms shall be considered in the assessment.

The target expert shall call the target group if one of these alarms persist.

12.3. Tritium Alarms

12.3.1. Stack Alarms

The stack alarms have been an issue for RadCon. The stack purge alarm which is audible in the counting house and is also on the GUI is under the target group's purview. Other alarms on the stack system are for RadCon use only. If this alarm activates, address the alarm. If it does not clear then inform the target group D. Meekins or C. Keith and RadCon. There is no need to stop the run but the issue must be fixed by access as promptly as reasonably possible. Access to the Hall during normal working hours to fix the issue shall be provided.

12.3.2. TAM FSD

There are several reasons why the TAM alarm might be triggered. This is shown in the figures in Section 7.4. If these monitors trip and do not reset call the RadCon on call immediately. RadCon should be getting pages and calls from the alarm system and the MCC so don't be concerned if they do not call you right away. They may be on the line to the MCC. Do not allow anyone to enter the Hall. If personnel were in the Hall at the time of the alarm (audibles would be engaged) these personnel must wait in the counting house to meet with RadCon. Inform the MCC of any affected personnel.

12.4. Temperature Alarms on the Target

There are numerous temperature alarms/FSDs on the target that are redundant. A bad thermometer may be causing a problem in which case the Tritium Program Manager must be called. An appropriate path forward will be determined after an assessment has been made.

12.5. Cryo-Alarms

The JLAB Cryogroup is requiring us to monitor the return temperature and pressure. These have been mapped in our GUI/database to haCryo_Return_T and _P. Should either of these exceed the limits set by cryo, we must contact Cryo immediately.

- The supply temperature (T1 outlet temperature) limits are 12 to 14 K
- The return pressure (suction pressure) limits are 2.5 to 3 atm.

12.6. Be Window Coolant Flow

An alarm/FSD has been installed on the coolant circuit for the Be isolation window. This is affected via a flow switch on the water circuit. If this does not reset, contact the Tritium Program Manager. Access to the Hall will be required.

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13.   Emergency Procedures

See the experiment ERG.

14.   Documentation of Procedure

Documentation shall be as required in the COO. Document all off normal events in the HALOG.

15.   References

1. JLAB Tritium Family Emergency Response Guidelines (ERG)
2. JLAB Pressure System Folder PS-TGT-12-001 and all documentation therein.
3. Tritium Target WIKI: https://wiki.jlab.org/jlab_tritium_target_wiki/index.php/Main_Page
4. Lakeshore 218 user manual.