Target Operator Procedures v4.2.1

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1 Introduction

These procedures are intended as detailed descriptions of the various tasks operators of the TJNAF Polarized ^{3}He target will perform on shift. **All target operators should be familiar with these procedures before taking a shift as target operator.** For a description of the target system you should (and are required to read) the Target Operations Safety Procedures. For a general description of the physics of the target the theses of Steffen Jensen, Ioannis Kominis, Mike Romalis, or Kevin Kramer are all available on the E97-110 Web Site. Alternatively, all your questions can be answered by the friendly target experts on site.

2 General Responsibilities of the Target Operator

- **Maintain the integrity of the target cells and chamber -** The ^{3}He glass cells used in this experiment are quite fragile and everything that can be done needs to be done for their protection. The oven and target chamber can also be damaged by improper use of the lasers. The target operator should make sure the following is done to protect the target system:
  - **Make sure MCC ramps the beam up slowly.** They have a standard procedure for this, but if the operator sees this is not happening, the operator should call MCC and remind them to follow this procedure. The beam should ramp 1 microAmp every 3 seconds.
  - **Make sure the raster is on when the polarized ^{3}He cell or reference cell is in position.** Again MCC should be aware of this, but the target operator should monitor this with spot++ available on `adaql2`. The target cell can explode within minutes of taking beam with the raster off, so please check this regularly. If the beam has been taken off for a while, coordinate with your shift leader to put the target in the BeO position so the raster and beam position can be checked out.
  - **If the oven cools down, make sure the lasers are turned off.** Alarms are set up in case this happens, but the target operator should check that the oven is near the set temperature.

- **Turn the lasers on slowly, one at a time.** Wait at least 1 minute between turning each laser on. This will reduce the thermal shock on the pumping chamber.
- **Watch the flow of the cooling jets.** There are small jets of air spraying on the end of the target cell. If the air flow stops it becomes dangerous to have the beam on the target. This flow can be monitored on the RTD screen.

- **Maintain polarization of the target -** There are several things a target operator can do to maintain a high target polarization:
  - **Minimize the number of NMR measurements -** Every NMR measurement causes a small loss of polarization. Each shift there will be a set of instructions on how many NMRs to take and when to take them. If the operator follows these instructions they will be fine. If an NMR measurement fails, **do NOT perform another measurement without calling the target expert.**
  - **Moving the target cell -** The target can be moved to the following positions:
    * ^{3}He Target position - The position where the polarized ^{3}He data will be taken.
    * Carbon Foils/BeO Target position - This position has the carbon foil target for acceptance studies and the BeO target for beam positioning.
    * Empty position - No target, for background checks.
    * Reference Cell position - A reference cell filled with Nitrogen, ^{3}He and Hydrogen can be used for unpolarized data. This is the position where the reference cell is in the beam line.
  - **Performing and documenting NMR measurements -** NMR is one of the two methods we use for measuring our target polarization. The target operator will be responsible for performing and documenting this measurement.
  - **Alerting the EPR expert when you need to take an EPR measurement -** EPR measurements will be scheduled from time to time and it will be the responsibility of the Target Operator to page or call the EPR expert on call (this person will be listed on the white board).
  - **Keeping an eye on things -** The target operator should watch the various indicators and make sure nothing is outside the proper range of operation.

3 Seven Things the Target Operator Should Know at the Beginning of Every Shift

1. Target Ladder position (^{3}He Target, Empty, Carbon Foils, Reference Cell) [Look on the EPICS Control screen located on adaql3]
2. Latest target polarization [Look in log book, HALOG, or white board]

3. Target temperatures [Look on the EPICS control screen located on adaql3]
4. Target Laser status [Look on the EPICS control screen located on adaql3]
5. Target Holding field status, [Look at TV monitor displaying Fluke mulitimeter]
6. Fiber RTD temperature [Look on `he3laser`]
7. Target Expert on Call [Look at white board – different for each shift]

All of these should be checked and confirmed with the previous target operator before he leaves.

4 A Note on Running LabView Software

Some of the control system for this target was written in LabView and runs on a Windows XP machine. A few notes about the LabView controls:

- To tell if a VI is running the arrow in the top left hand corner will be black. If it's not black it means the VI has stopped. To run the VI simply click on the arrow.
- To stop a VI hit the red Stop sign in the top left hand corner.
- It's almost always bad to stop a running (versus one that's simply waiting for input, like the Target Operator Control Panel) LabView program. The NMR vi is especially dangerous. If you make a mistake simply let the program finish whatever it's doing and then correct your mistake.
- Useful programs can be found in the Target Operator folder on the desktop.
- The password for the `pol3he` account on the Target Control computer is `!pol3he!`.

5 How to Turn On and Off the lasers

Go to the GUI that controls the lasers. There are two types of lasers, the sigle lasers labeled 'Laser 1', etc. and the duo lasers that are labelled 'Duo 1' and 'Duo 2'.

5.1 Single Lasers

- Press 'Enable' on one of the lasers you want to turn on. Wait a few seconds for the laser to become enabled. Watch the light on the front panel of the laser will start to flash when it is enabled.

- Press 'Start' on the same laser. Check the webcam to make sure the laser is turned on. There will be a green light in the upper right hand corner. Please wait one minute then repeat for the next laser you want to turn on, until they are all turned on.
- To turn off the laser press the 'Stop' button on the GUI. Check on the webcam monitor to make sure they are off. There is no need to wait between lasers when you are turning them off.

5.2 Duo Lasers

These lasers are two lasers with one controller. There is no way to turn on just one laser at a time. However, the following procedure has the same effect.

- Set current on both lasers to zero
- Set laser one current to 35000 mA (unless a different value is specified).
- Press 'Enable', wait 10-15 seconds.
- Press 'Start', wait one minute.
- Set laser two current to 35000 mA.
- It is okay to turn off both lasers simultaneously by pushing the 'Stop' button.

6 How to Move the Target

- Alert your shift leader that you are going to move the target.
- Call MCC and tell them you want to move the target and that they should mask the target FSD and turn the beam off if it is on. They will also want to know to what position you are moving.
- Watch for the yellow banner that tells you that the target motion is maskedon the Hall A General Tools screen.
- Find the Target Motion GUI on `adaql3` in the Counting House.
- Figure out to which position you need to move the target.
- Press the button next to the position you want.
- Wait for the ladder to move into position.
- Confirm the position by looking at the Target Motion GUI
- Alert your shift leader that the target has been moved.

- If it's appropriate call MCC and ask them to unmask the FSD and turn the beam back on.

7 How to Fill and Evacuate the Reference Cell

- Go to the Reference Cell Controller, which is located above the Oven Heater Controller.
- To fill the reference cell, hold the N_2, H_2, or ^3He green button down while checking the high-pressure gauge, until the desired pressure is established.
- To vent the gas from the reference cell, hold the ventilation button down until the pressure drops below 0 PSIG.
- Ventilating the reference cell only empties the gas from the cell. It does not place the cell under vacuum. One should always vent the reference cell before evacuating.
- To evacuate the reference cell, hold the evacuation button down until the button starts flashing. At this point, the evacuation button will latch on and continue pumping on the cell. Once the cell is evacuated, pushing the green buttons will start to fill the cell again, and will turn off the turbopump.

8 Cautions for the Reference Cell

- Be careful with the ^3He, we have a limited supply.
- If the system is above atmospheric pressure, always vent it before pumping.
- Always monitor the high-pressure gauge when filling. Do not exceed 135 psig.

9 How to Perform an NMR Measurement

- Turn on the Upper Coil Lock-in 10 minutes prior to measurement.
- Alert your shift leader that you intend to take an NMR measurement.
- Tell MCC that you intend to perform an NMR measurement and that they need to turn the beam off. Wait for them to call back and say that the beam is off.
- If necessary, move target to the ^3He Target postion.
- It is necessary that the temperature be stable for a valid NMR measurement. If the temperature is varying by more than 10 degrees, then wait 15 minutes. If it continues to fluctuate, please page the target expert on call.

- Once the target is in the ^{3}He Target position and the temperature is stable, open the program "GEN_PRE_NMR_CHECKLIST(new).vi"
- The GEN Pre-NMR Checklist panel should appear. Fill out all the sections as follows:
  - *Target Operator Name* - Your Name.
  - *Time & Date* - Automatically updates when the program runs.
  - *Latest Run Number* - The run number of the last run.
  - *BigBite Current* - This often be found on the TO strip tool on `adaql3`, the variable name is 'MBIGBOXM'. This can also be found under the Hall A Main Tools → Magnet Controls → BIGBOX Controls → Readback.
  - *RF Current Monitor* - This is the measurement of the RF current and will be filled in by hand during the NMR measurement.
  - *Target Ladder Postion* - You should be in the He-3 Cell position, if you are taking an NMR measurement in another position (after being **explicitly** told to do so by a target expert), please indicate the correct position.
  - *Oven Air Flow* - Located on the oven control chassis at the left of target control computer. This fluctuates quite a bit, the precise value doesn't affect the measurement.
  - *Oven Temperature PV* - Located on the oven control chassis. "PV" stands for process value. This is the readback value used to control the oven temperature. This will fluctuate 1-2° from the set value.
  - *Oven Temperature SV* - Located on the oven control chassis. This is the set value for the oven and shouldn't be changing at all.
  - *Heater Temperature* - This is the temperature of the heaters that provide the hot air for the oven.
  - *RTD 1 – RTD 5* - Located on the computer `adaql3`. These are the temperatures of various locations on the cell.
  - *Fiber RTD 1 – Fiber RTD 7* - Found on the VNC viewer connected to `he3laser`.
- Run the program by clicking on the arrow in the upper lefthand corner of the screen, note that this should update the time and date fields to the current time and date.
- Hit 'Ctrl-P' to print the NMR Settings screen and retrieve the print out on cha2hp, the printer in the back room of the Counting House.
- Now start the program "NMR Measurement_Twocoil.vi"
- The NMR Measurement screen should appear. Click on the 'Go' button.

- Check the green light on the HP3324A Function Generator (FG). It is located directly to the right of the control computer on the top shelf of the control rack. If it's not on, simply put the FG in local mode (by pressing the 'Local' button on the bottom left hand corner of the FG) and press the Signal ON/Off button located right next to the green LED light. The green light should now be on.
- Read the oscilloscope above the reference cell controller. The RF signal should be on Channel 1. Fill in the RF Current Monitor section of the NMR Settings printout by writing the number below 'Ch1 Pk-Pk' listed on the right of the oscilloscope screen. You may have to change the vertical and horizontal scale. The output should be a sine wave about 300mV Pk-Pk.
- The NMR Sweep should have two peaks in each channel (corresponding to the up and down sweeps). Don't worry if they are pointing up or down, only their size matters.
- Once the NMR sweep is completed, type 'CTRL-P' to print out the output.
- Close the screen.
- For the most part, the target will be in the correct position to take data. If the runplan calls for a new position after the measurement, then follow the directions in the section titled, "How to Move the Target".
- Alert your shift leader that the measurement is completed, and the target is in the desired position.
- If applicable, call MCC and ask them to unmask the target and turn the beam back on.
- Turn off upper coil lock-in. Punch holes in your printouts and add to the binder marked "NMR Measurements". The printouts are in reverse chronological order, so just put the printout in so that it's the first one read.

10 How to Extract a Polarization from an NMR Measurement

- NMR analysis can be done at any time, so please make sure the target is in the proper position and configuration before beginning analysis.
- To begin the analysis, begin the program "GEN_NMR_ANALYSIS(new).vi" in the Target Operator folder
- Start the program by clicking on the arrow in the upper left corner of the program.
- For the most part, this is fairly self explanatory, check follow the buttons in order:

1. *Get Sub-Directories* - This updates the list of subdirectories. As a target operator, you will need the subdirectory labelled `<recent NMR files>`
2. *Get Data File List* - This updates the file list. Until you push this button, you may not see your most recent files. Select the file that you would like to fit.
3. *Read Single Data File* - This reads in the file that you selected. A two-coil NMR measurement generates four files, and you are expected to fit the peaks of all four files.
4. *Zooming and Scaling* - This is NOT a button. For this step, use the mouse to select the data that you would like to fit. Each file has two peaks. The first is read when the magnetic field sweeps up (called the "UP" peak), the second comes from sweeping the field back down to its nominal value (and is called the "DOWN" peak)
5. *Select Data and Autoguess* - After you have zoomed onto the peak that you would like, and have enough of the background to fit by eye, clicking on this button will cut the data on the screen and make an initial guess. This guess is usually far off, so don't worry...yet.
6. *Plot Initial Guess* - This is done after you select the data and autoguess. But, if you would like to change the initial guess using the parameters listed at the bottom of the screen, pushing this button will plot that initial guess. If a guess doesn't look particularly good, try Fit Data first to see how good of a guess it actually is.
7. *Fit Data* - This is what finally gives you the values. At this point you can evaluate the goodness of the fit. If the fit is not particularly good, then try to select a slightly different set of data. The fitting algorithm is particularly sensitive to the background slope of the beginning of the data set, so a slight change in the data set can make for a much better fit.

- Write down the signal height of both the UP and DOWN sweeps in the log book. Then repeat this for the other three files.

- To close the vi, **use the red, rectangular "STOP" button** located below the button "7. Fit Data". This program has a number of sub-programs running in the background. Closing the program without using the "STOP" button might not close all sub-programs.

- Once you have the UP and DOWN signal heights for the X and Y files for both the upper and lower coils, you are to compute the polarization by applying this formula to the lower coil values:

$$P = \frac{C}{2} * (\sqrt{X_{Up}^2 + Y_{Up}^2} + \sqrt{X_{Down}^2 + Y_{Down}^2})$$

where P is the target polarization, C is the calibration constant that you can get from the counting house whiteboard, X_{Up} is the signal height of the Up sweep in the x-channel,Y_{Up} is the signal height of the Up sweep in the y-channel, and X_{Down} and Y_{Down} are the signal heights of the Down sweep.

- Write down the polarization in the log book, make a HALOG entry and write the polarization on the white board.
- Dan Protopopescu wrote a script that calculates the polarization from the lower coil values. It also prepares a HALOG entry. If you use this script you must still update the white board and the paper logbook with the appropriate values. The script is ~adaq/halog/src/halogentry+nmr.tcl.

11 Things to Keep your Eye On

- Make sure the cell is still intact. There are several ways of doing this:
  - Check the spectrometer rates. They will go down significantly if the target is missing.
  - If the spectrum on the Outgoing Laser Spectrum on the computer screen suddenly increases or decreases in magnitude by a significant amount.
  - RTDs 6 and 7 will go down significantly (over 10 degrees), if the cell explodes.

If you think the cell exploded, turn off the lasers immediately and call the Target Expert.

- The oven readouts on the oven heater controller chassis located to the left of the target control computer.
  - Air Flow Meter- Measures the air flow into the oven. Seems stable at about 200. Should never be below 100, and should be looked at by an expert if it is below 150.
  - Oven Controller - There are two numbers on this control. The bottom number is the set point. The top one is the actual temperature of the oven. These two should be within a couple degrees of one another. If there is a significant deviation (20 degrees or more), it needs to be looked at by an expert. If the temperature is below 160 Celsius, the lasers should be turned off immediately. Note that when the lasers are turned on or off the temperature will be unstable for about ten minutes, but then will settle down.
  - Heater Temperature - The external temperature of the heating element used to heat the oven. It's there to make sure the insulation around the heater pipe is not burned or melted. It is generally around 350° C. If it gets above 400 then there is likely a problem and an expert should be called in. Visually inspect the

top of the target with the Hall camera to make sure you don't see any smoke or haze coming from the pipes.

- The RTD temperature sensors (read on the Target Operator screen or on the EPICS screen) should be stable when taking data and the lasers have been on a while. Turning the lasers on and off and moving to different positions will cause small changes in the temperature. The pumping chamber RTDs are usually around 240-250° C. The target chamber RTDs are usually around 30-45° C.
- The RF Current Monitor Oscilloscope should not have a sine wave displayed on it if you are not taking an NMR measurement. If you see one, just hit the Signal On/Off button on the NMR Fucntion Generator to the right of the target control computer and make a note in the log book.

11.1 Quick Reference

See Table 11.1 for a list of parameters that should be monitored, with a corresponding action for each item.

Parameter	Nominal	Range	Action
Air Flow Meter	220	±50	call target expert
Oven Controller	(SV value)	±20°	wait 5 min, double check, then call target expert If < 150° TURN OFF LASERS IMMEDIATELY
Heater Temperature	350	±50°	call target expert
Laser Spectrum	red line		call target expert if flat or no "dip"
Target Polarization	last value	±5%	call target expert
Target Magnet Current	4.6 A	±0.1 A	call target expert

Table 1: This table lists the various parameters and their acceptable range. When a parameter is outside of its acceptable range, take the required action. The action required is usually paging the target expert on-call.

12 Document Maintenance

This document is maintained by Aidan Kelleher. Please forward any questions or comments to `kelleher@jlab.org`.