Target Operator Procedures v2.0

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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 a 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 or Mike Romalis are all available on the E99-117 or E97-103 Web Sites. 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 raster++ available on adaqs2. The target cell can explode within minutes of taking beam with the raster off, so please check this regularly. If the beam has been 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 the oven is near the set temperature.
  - **The transverse lasers can only be on when the cell is in the Polarized ^{3}He Cell position**. Most likely this won't harm the cell,

but it can damage the oven. Again, software interlocks are in place, but a target operator should make sure this is not done.

  - **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 helium spraying on the end of the target cell. If the helium 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 instruction they will be fine.
  - *Never have the lasers on when the field is in the wrong direction* - A target operator will have to be continually aware of what configuration the lasers are in, if the laser half-wave plates are in or out and the direction of the holding field. The following are valid configurations:
    * Holding Field = 0 degrees, Half-wave plates are out, lasers are in longitudinal configuration
    * Holding Field = 90 degrees, Half-wave plates are in, lasers are in transverse configuration
    * Holding Field = 180 degrees, Half-wave plates are in, lasers are in longitudinal configuration
    * Holding Field = 270 degrees, Half-wave plates are out, lasers are in transverse configuration

    All other configurations will reduce the polarization.
  - *Minimize the time with the lasers off* - The lasers must be turned off at certain times (when taking an NMR in the transverse direction, during any field rotation, when moving the target). The target operator should try to perform these actions promptly and try to do them correctly the first time. Of course, racing through and making mistakes is worse than doing it slowly!
  - *Minimize the number of field rotations* - There is a small polarization loss when rotating the field, so any extra rotations will reduce the polarization.

- *Moving the target cell* - The target can be moved to the following positions :

  - Pick-Up Coil position - In the target are a set of coils that detect the resonance signal during an NMR measurement. This is the position where that measurement is made.

- ^{3}He Target position - The position where the polarized ^{3}He data will be taken
  - Carbon/BeO Target position - This position has the carbon foil targets 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 ^{4}He can be used for unpolarized data. This is the position where the reference cell is in the beamline.

- *Rotating the Holding field* - The main 25 Gauss holding field of the target can be rotated using the Holding field control panel. The target will be run in 0, 90, 180 and 270 degree configurations. NMR measurements can only be made in 0 and 180 degree configurations, so if the target is taking data in a 90 or 270 degree configuration, the field will have to rotated to 0 degrees for the NMR measurement and then back again for data taking.

- *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 Five things the target operator should know at the beginning of every shift

- Holding field direction (0,90,180 or 270 degrees) [Look at the Longitudinal and Transverse Coil Currents on the TV Monitor above the TO computer and using the following table:
  - 0 degrees = Trans. Coils ~ 0 Amps, Long. < -7 Amps.
  - 90 degrees = Trans. Coils > 7 Amps, Long. ~ 0 Amps.
  - 180 degrees = Trans. Coils ~ 0 Amps, Long. > 7 Amps.
  - 270 degrees = Trans. Coils < -7 Amps, Long. ~ 0 Amps.]

- Laser configuration (transverse or longitudinal) [Look on the EPICS Control Screens located on hirestx26 or the lights on the laser enclosures displayed on the TV Monitor]

- Target Ladder postion (Pick-Up Coil, ^{3}He Target, BeO/Carbon, Empty, reference cell, BeO/Carbon, Pick-Up Coil Position) [Look on the EPICS Control screen located on hirestx26]
- Half-wave plate position (In or Out) [Look at the TV monitor. The 'HERE' sign should be on 'In' or 'Out'.]
- Latest target polarization [Look in log book or halog]

All of these should be written on the white board and should be confirmed with the previous target operator.

4 A note on running Labview software

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

- Most VIs you will see will already be running. To tell if a VI is running the arrow in the top left hand corner will be black. If its 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 and Field rotation ones are especially dangerous. If you make a mistake simply let the program finish whatever its doing and then correct your mistake.
- If Labview ever crashes or you need to reboot the entire machine, you can restart the Target Operator Panel by double clicking on the 'TO Screen.vi' shortcut icon in the middle of the Window Background.
- The password for the Administrator account on the Target Control computer is : "!pol3he!".

5 How to Turn On and Off the Lasers

- Check you holding field direction, and determine what position the half-wave plate needs to be and and which lasers (longitudinal or transverse) you have to turn on. Check the configuration listings in the 'General Target Operator Responsibilities'. You can find the holding field direction by looking at the
- If you are turning on the transverse lasers make sure the target is in the ^{3}He Target Position.

- Check the TV monitor on the half-wave plates to determine what position the half-plates are currently in. The position will be under the 'HERE' sign.
- If the half-wave plates need to be moved, go to the Half-wave plate GUI running on one of the computers in the HALL A Counting House. Press the 'Go' Button under the "Move Half-Wave Plates IN" or "Move Half-Wave Plates OUT" position. Wait for the Half-wave plates to move to their position.
- Go to the GUI that controls the lasers. Figure out which ones are transverse which ones are longitudinal.
- 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 its enabled.
- Press 'Start' on the same laser. Check the TV monitor 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 TV monitor to make sure they are off.

6 How to Move the target

- Alert your shift leader that you are going to move the target.
- Call MCC and tell them that 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.
- If the transverse lasers are on, turn them off.
- Find the Target Motion GUI on one of the computers in the counting house.
- Figure out which position you need to move it to.
- Press the button next to the position you want.
- Confirm the position by looking in the
- Wait for the ladder to move into position.
- Alert your shift leader that the target has been moved.
- If it's appropriate turn on the lasers following the 'How to Turn on the Lasers On and Off' procedure.

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

7 How to Rotate the Holding Field

- Figure out what the field angle is and what you want it to be.
- Alert your shift leader that you are rotating the holding field.
- If the beam is on, Call MCC and tell them to turn the beam off. Wait for them to tell you it is off.
- Turn off all lasers according to the 'How to Turn On and Off Lasers' section.
- The Target Operator Control Panel should be running on the target control computer. If not, double click on the 'TO Screen.vi' shortcut in the middle of the Windowns background.
- Click on the 'Rotate Holding Field' button on the left. A new panel should appear on top.
- At the top there is a pull-down list of angle changes. Click on the arrow on the right of the list and select the angle change you want to make by clicking on it.
- Make sure this is the change you want to make.
- Click on the 'Go' button
- The program will ask you to check to see if the standby light on the Latch FG is lit. This function generator is located directly above the target computer and is labeled. The light is on the 'OUTPUT' panel and is labeled 'STANDBY'. Make sure it is off. If its on, you need to turn it off. Put it in local mode by pushing the 'LCL/P.SET' button on the 'STATE' panel then simply use the right arrow on the 'OUTPUT' panel to move the light to one of the wave function (the fourth from the left is a good one, its automatically reset by the computer so as long as the FG is not in 'STANDBY' it will work fine).
- The program will then bother you about the lasers again. Make sure they are off.
- The program will then set up the function generators for rotation. Then it will rotate the field. This takes about 5-10 minutes.
- The VI will tell you when it is done. Click 'Exit'.
- Make an entry in the Target Logbook that the field was rotated and what angles it was rotated from and to. Also make an entry into the halog.

- Turn the lasers on according to the 'How to Turn Lasers On and Off' section.
- Alert the shift leader that the field has been rotated.
- If applicable, ask for the target to be unmasked and to turn the beam back on.

8 How to Perform an NMR Measurement

- Alert your shift leader you intend to take an NMR Measurement
- Tell MCC that you intend to perform an NMR measurement and they need to turn the beam off and mask FSD for the target. Wait for them to call back and say that the beam is off.
- If the transverse lasers are on, turn them off according to the "How to turn the lasers on and off" section.
- If the holding field is at 90 or 270 degrees, you have to rotate the field to zero degrees to do an NMR measurement. In 0 or 180 degrees no rotation is necessary. Please follow the directions in the 'How to Rotate the Holding Field section.' You can move the target into the Pick-Up Coils position while the field is rotating.
- Follow the procedure 'How to Move the target' to move the target to the Pick-up coils position.
- It is necessary that the temperature be stable for the NMR to be valid. If you are in longitudinal mode then this usually isn't a problem, since you can simply leave the lasers on through the whole process. If you have rotated from transverse, make sure you wait until the temperature stabilizes (around 15 minutes from the time you turned the lasers off).
- Once the target is in the Pick-Up Coils position and the field is in the proper direction and the temperature is stable, click on the button next to NMR Settings.
- The NMR Settings panel should appear. Fill out all the sections framed in yellow as follows:
  - *Operator Name* - Your Name.
  - *Latest Run Number* - The run number of the last run
  - *Switches* - Three switches must be set to take a good measurement. The rotation box switch (in the panel on the right of the control computer) must be ON. The field rotation chassis (also on the right, a couple of panels above the rotation box) should be in BYPASS (the left most switch, labeled bypass/through). The RF Capacitor Box (to the left of the computer on the bottom) should be set to NMR.

  - *Pre-Amp Settings* - The pre-amp is in the target area and can't be read by the computer. It settings can be read off the Pre-Amplifier camera by an expert or someone with very good eyes. It shouldn't change, so if you can't read it just leave it as the default.
  - *RF Current Monitor* - This is the measurement of the RF current and will be filled in by hand during the NMR measurement.

- Hit 'Ctrl-P' to print the NMR Settings screen and retreive the print out on cha2hp the printer in the backroom of the counting house.
- To close the NMR Settings screen hit the red stop sign on the left top, then click on the X in the top right hand corner. (or hit the soon to be implemented 'Exit' button.)
- Now the 'TO Screen' program should still be running. Now click on the button next to 'Perform NMR Measurement'.
- The NMR Measurement screen should appear. Click on the 'Go' button.
- The program will let you know its okay to leave the lasers on.
- You will be asked to check the green light on the HP3324A Funtion Generator. Its on the bottom right hand corner of the Function Generator which is located directly to the right of the the control computer. If its not on, simply put the Function Generator 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 button. The green light should now be on.
- The program will then turn the RF Current on.
- Read the the oscilloscope above the RF Capacitor Box. The RF signal should be on Channel 2. Fill in the RF Current Monitor section of the NMR Settings printout by writing the number below 'Ch2 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 2V Pk-Pk.
- Once you write this number down, Click on 'Ok' and the NMR Sweep will begin. It takes about 45 seconds.
- 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.
- Click on 'Exit' to leave the screen.

- Now that the NMR measurement is done, move the cell back into the ^{3}HE Target position. If you need to run in 90 or 270 degree mode rotate the field back into postion using the 'How to Rotate the Holding Field' procedure. These steps can be done simultaneously
- Alert your shift leader when the cell and field are in position.
- If you are in transverse mode, turn the lasers back on according to the 'How to turn the Lasers On and Off Procedure'.
- If applicable call MCC and tell them that the target is in position and

9 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 any analysis.
- To begin the analysis, press the button next to 'Extract Polarization' on the Target Operator Screen
- On the 'Extract Polarization' screen press 'Go'
- You'll be asked whether you want to fit the latest NMR. Press 'Yes' if you want to do this and it will automatically load the latest 'X' channel file. You will still have to analyze the 'Y' channel seperately.
- If you hit 'No', it will bring up a browser. The NMR files are located in the `'E:\A1n Data\Nmr\'` Directory. You can get there by typing the directory name in, or pressing the Up Folder Key several times, until you the see the `'A1n Data'` directory. Click on the `'A1n Data'` and the `'Nmr'` directory. Select the file you would like to analyze. The files are time stamped in the following format '(x or y)-(month)-(day)-(hour)-(minute)(am or pm).dat'. Simply pick the file from the time you did the NMR. There is a file for the X and Y channel. At this time, you have to analyze both. Start with the 'X'.
- Once you pick your file, the program will try to fit the function. The top graph is the data in blue and the fit in red. The bottom graph is the difference between the two. The program fits the Up and Down sweeps simultaneously.
- If the red line is pretty much on top of the blue one, then the fit is successful. If not then you need to do it again with a better set of starting parameters. We use five parameters to fit the curve :
  - FWHM - The full width half max of the signal corresponds to the magnitude of the RF Field. Since this doesn't change it should always be around 0.080 G.

- Background Slope - A linear slope in the background. It should always be around 0.0.
- Resonance Field - The field strength where the resonance occurs. This parameter will change, since the field drifts around a bit. Generally if you get this parameter correct the fit should succeed. Simply look at the data and read the x-value of the peak.
- Signal Height - This is the actual parameter that is proportional to the ^{3}He polarization. It is approximately equal to the peak height.
- Background Offset - A constant offset. Again should be near 0.0.

To adjust these parameters, change the 'UP Initial Coeffecients' and 'DOWN Initial Coefficients' at the bottom of the screen. Then simply press 'Go' again and choose the same file. Repeat this process until you get a nice fit. If you never get a nice fit, that's okay. Just make an entry in the log book that you took the NMR and an expert will analyze it later.

- Write down the signal height in the log book of both the UP and DOWN sweeps. Then repeat this for the Y channel file.
- Once you have the UP and DOWN signal heights for both X and Y files. Youare to compute the polarization. Apply this formula:

$$P = \frac{C}{2} * \left(\sqrt{X_{Up} * X_{Up} + Y_{Up} * Y_{Up}} + \sqrt{X_{Down} * X_{Down} + Y_{Down} * Y_{Down}} \right) \tag{1}$$

where P is the target polarization, C is the calibration constant that you can get from a yellow post-it note attached to the monitor (make sure you use the correct one), 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.

10 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 Target Operator screen suddenly increases in magnitude by a significant amount (over 20
  - RTDs 6 and 7 will go down significantly (over 10 degrees) if the cell explodes.

If you think a 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 320. Should never be below 100. Should be looked at by an expert if it is below 200.
  - 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 of degrees of one another. If there is significant deviation (20 degrees or more), it needs to be looked at by an expert. If the temperature is below 130 Celcius, 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 Temperture - The external temperature of the heating element used to heat the oven. Its there to make sure the insulation around the heater pipe is not burned or melted. It is generally around 160 C. If it gets above 200 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 160-170C with the lasers off and 180-200C with the lasers on. The target chamber RTDs are usually around 40-55C.
- The Helmholtz coil currents are displayed on the camera above the target control computer and also on the target control computer itself. Make sure at least one of the coils has a current around 7 (or -7) amps and the other is around zero. You can check which direction the field is in by consulting the table in 'Five things the target operator should know' section.
- The RF Current Monitor Oscilloscope should not have a sine wave displayed on it if you are not taking an NMR. If you see one, just hit the Signal On/Off button on the RF Excitation FG to the right of the target control computer.