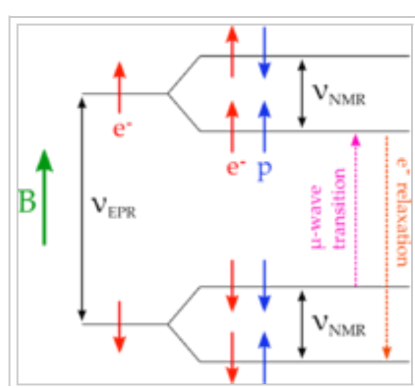
Practical Primer on the UVa Target

From Hall A Wiki

This is meant to brief target operators on the general mechanism and systems involved in the UVa target. Written by J. Maxwell.

Contents

Overview of the Mechanism



Our Dynamically Nuclear Polarized Target can provide greater than 90% proton polarization in an irradiated ammonia target sample, in a 5T magnetic field and at around 1K. The basic operating principle involves leveraging the spin-spin coupling of free electrons to the proton we wish to polarize. In a magnetic field, spin-spin coupling results in hyper-fine splitting, as seen in the diagram to the right.

Using microwaves of wavelengths corresponding to the energy gaps seen in the diagram, transitions can be induced to flip the spin of the proton along with the spin of the electron. As shown, the (down,down) state can be flipped to the (up,up) *aligned* state using microwaves, but by changing the microwave frequency it is also possible to flip the (down,up) state to the (up,down) state, *thereby allowing us to anti-align the proton without changing the magnetic field*. Thus both positive and negative polarizations are available using the same field.

Since the relaxation time of the electron at 1K is on the order of milliseconds, compared to the proton's tens of minutes, the same electron can be used to polarize many protons. The proton polarization is transferred away from the immediate vicinity of the free electrons via spin diffusion.

Thermal Equilibrium Polarization

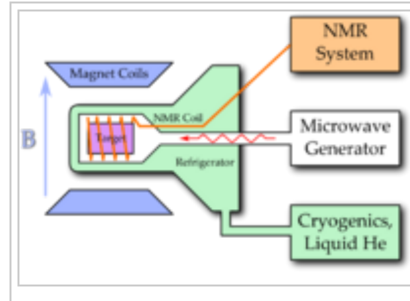
The starting point for our technique is quite simple, but still crucial to the operation of the target. By placing our material in a high magnetic field B and at low temperature T and waiting for the material to reach thermal equilibrium, we can expect from Boltzmann statistics that our polarization should be:

$$P_{TE} = \frac{e^{\frac{\mu B}{kT}} - e^{\frac{-\mu B}{kT}}}{e^{\frac{\mu B}{kT}} + e^{\frac{-\mu B}{kT}}} = \tanh\left(\frac{\mu B}{kT}\right)$$

If we assume a 5T field and 1K temperature, comes out to a proton polarization of around 0.3%. We also note that the electrons, whose magnetic moment is 660 times that of the proton, have near 100% polarization.

While 0.3% proton polarization is obviously not practical for experiments, this starting point will provide a crucial point of calibration as we attempt to measure the polarization with NMR.

Dynamic Nuclear Polarization



Enhancing proton polarization via the excitation of spin-spin transitions with microwaves is known as Dynamic Nuclear Polarization (DNP). There are 5 basic ingredients which go into this technique: a high magnetic field, a low temperature, a microwave system, an NMR system, and a suitable target material. We will briefly walk through these 5 building blocks, and what systems are necessary to provide them in the experimental hall.

Magnetic Field

The magnetic field is provided by a superconducting Helmholtz pair capable of producing 5T at great (10^-4) uniformity in a 3x3x3 cm^3 volume at the target cell. This magnet's open geometry allows for beam to pass at both parallel and perpendicular to the field. An Oxford Instruments power supply provides the necessary current (around 80A at 5T), and controls the modes of operation. During g2p, the magnet will be set at 5T or 2.5T. A reservoir of liquid helium at 4K keeps the magnet superconducting.

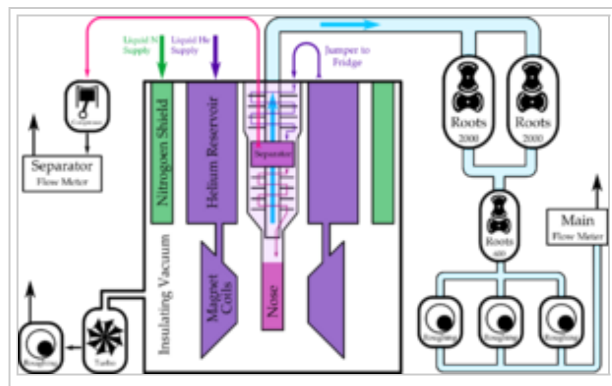
The two operating modes are *connected* and *persistant*. A superconducting switch, which is simply a length of superconducting wire near a heater coil, changes these modes. In *connected*, the switch is "opened" by heating the superconducting wire until it is resistive; this "connects" the magnet coils to the leads of the power supply connected on either side of the switch. In *persistant* mode, the switch is allowed to cool; as the wire again becomes superconducting, the relatively high resistance of the power supply leads makes it "invisible" to the current in the superconducting coils.

Magnet energization and de-energization may only be performed by a target expert. The ramp up and down must be carefully controlled to avoid losses in superconductivity called *quenches*.

Shim Coils

The uniform field region can be tuned using a set of shim coils, but in practice this is not necessary. However, leaving the shim coils superconducting while the main coils are being energized will lead to trouble. Unless the shims are held at zero current by their power supply, the current induced from the main coil's energization can result in shim quenches in which too much shim current causes a failure in superconductivity.

Low Temperature: Cryogenics



The target's temperature directly affects the efficiency of polarization. The temperature's effects are easily seen in a graph of polarization over time. As inevitable beam trips occur, the polarization rises as the heat load of the beam is removed. When the beam comes back, the polarization drops a few percent simply due to the heat load. An example diagram of the pumps and fridge which create and maintain the low temperature is shown to the right, although the precise pumps used in the hall are slightly different.

The fridge, magnet, and liquid nitrogen shield are hung in the *target can* which is held at vacuum by a diff pump. The liquid nitrogen shield, seen in the diagram in green, protects the liquid helium components from heat radiation from the room temperature can.

You can follow the path of the cryogens in the diagram to the right. In the refrigerator, the *separator pump* pulls liquid helium from the magnet reservoir into the *separator*. The separator can be thought of as a holding reservoir for colder liquid helium before it is transferred to the *nose*. The nose is bottom of the fridge, where the target material is held. As liquid helium is transferred from the separator to the nose, it passes through heat exchangers which are cooled by evaporating helium being pumped out of the fridge. To maintain the low temperatures despite as much as 1W microwave and beam power dumped into the target, huge roots blower pumps work to maintain a low pressure in the refrigerator. These pumps pull the evaporated helium up, past the heat exchangers and baffles, and out of the fridge.

Maintaining the level of liquid helium in the nose is critical to the operation of the target, and monitoring this level is one of a target operator's tasks. The level of liquid helium must remain above that of the target cups or the polarization will be lost and the material may be melted by the beam. The liquid level should be adjusted automatically by a PID loop, but it's crucial to watch this level to ensure the loop is working.

These are the key indicators of the refrigerator to watch, and the two valves we use to control them during normal running:

- **Main Flow**: This indicates the flow of gas being pulled out of the nose of the fridge by the big pumps. This flow will indicate the heat load on the target in the form of boil off gas flow.
- **Run Valve**: This controls the flow of liquid helium from the separator into the nose, and therefore is used to maintain the level of liquid helium over the target cups. Generally controlled automatically by PID loop.
- **Nose Level**: This indicates the level of liquid helium in the nose.
- **Separator Flow**: This is the flow of gas being pulled out of the separator, which acts as a buffer of cold helium to send to the nose. This flow is what pulls liquid helium from the magnet into the fridge.
- **Separator Valve**: Controls the separator flow, used to keep liquid helium in the separator. In general, we need a balance between the main flow and the separator flow to ensure the fridge isn't being emptied by more being pumped out (main flow) than is being pumped in (separator flow). Generally controlled automatically by PID loop.
- **Separator Level**: This indicated the level of liquid helium in the separator.

Microwaves

The microwaves induce the spin flip transitions and must be tuned very carefully to the frequency of the energy gap to maximize polarization. Unfortunately, as the target material accumulates radiation damage from the beam, this optimal frequency changes. **The most important task of the target operators is to constantly monitor and tweak the microwave frequency to maximize polarization.**

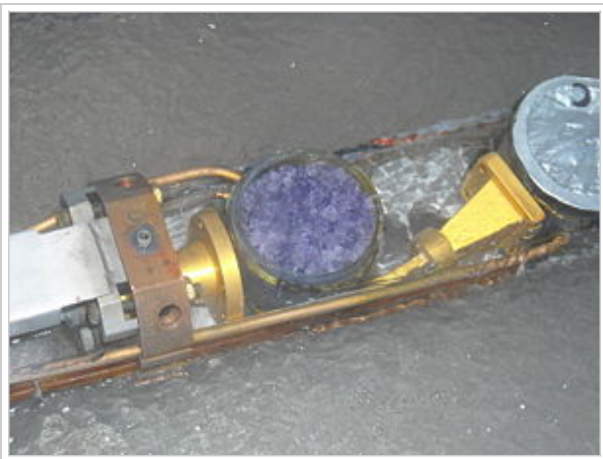
Ladder of new inserts, with two target cups, NMR coils and microwave horn.

The microwaves are provided by the EIO tube, which allows the frequency of microwaves to be changed within limits by adjusting a bellows on the oscillation cavity. Wave guides carry the microwaves from the tube to a horn which shine on the target cups. The picture to the right shows the gold horn above (to the right of, here) the two target cups on the new target inserts.

In g2p, two magnetic field strengths (5T and 2.5T) will be used and thus two nominal microwave frequencies will be used (~140 and 70 GHz). This requires two different EIO tubes, but the operation will be similar.

Target Material

Choosing a target material is a compromise between our desire for a pure proton target, and the practical necessities of materials which perform well under DNP and heavy radiation damage. Ammonia and deuterated ammonia (14NH3 and 14ND3) have emerged as the most attractive materials for our uses. When doped with paramagnetic centers to provide free electrons for the spin-spin coupling, ammonia can achieve greater than 90% proton polarization.



Ammonia target material upon removal from the beam during

SANE.

To dope the ammonia with free electrons, it is irradiated in a smaller accelerator before it comes to JLab. This irradiation produces radicals such as NH2 from the NH3 in what is called a *warm dose*. In the beam at JLab, temperatures are much lower, and different radicals, such as atomic H, are produced under this *cold dose*.

Each target insert holds two cups with ammonia material samples. The cups are cylindrical, and roughly 1 inch in diameter and length. For g2p, the same microwave guide will be used for both top and bottom cups; the photo to the right shows the old insert cups from a previous experiment.

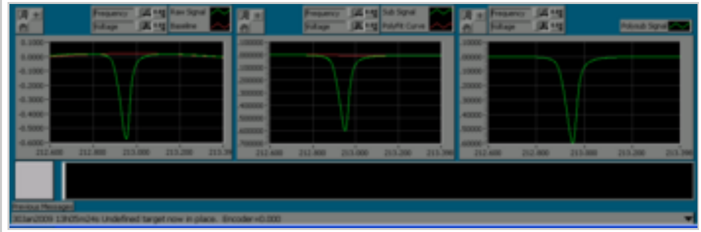
Anneals

The number of paramagnetic radicals in the material must be carefully balanced to achieve the greatest polarization. Although the free electrons from these paramagnetic centers are necessary to polarize via DNP, they also allow polarization decay short-cuts for the aligned protons. As radiation dose from the beam produces more radicals than needed, the DNP process becomes less efficient and the polarization will fall. However, by heating the ammonia, we can allow some of these radicals to recombine. This heating is called an *anneal*, and for an experiment that runs at 80nA beam current, will likely be necessary every day. After an anneal, the polarization can again reach maximal levels.

There is a limit to the lifetime of the ammonia however. As successive anneals are performed on a material sample, the decay rate of the polarization will increase, requiring more anneals per day. This is due to the buildup of radicals which cannot be recombined in an anneal. Eventually, the polarization decay rate will be so fast that it is no longer practical to use the material, so a new ammonia sample will be used. This replacement of material will occur once a week.

NMR

The NMR system is used to measure the proton polarization in the sample, and operates by observing spin flips of the proton at its Larmor frequency. By embedding the inductor of an LCR circuit in the target material, we can detect energy lost or gained in the circuit as a function of the circuit's frequency. A loss of energy in the circuit near the proton's Larmor frequency would indicate the *absorption* of energy as its spin is flipped to be anti-aligned with the magnetic field. Likewise, a gain of energy in the circuit would come from a proton *giving up* energy as it becomes aligned. This gain or loss is visible as a dip or peak in the NMR signal versus frequency. The area under this dip or peak is a proportional measure of the proton polarization in the material.



NMR signal integration panel of the NMR control program. Here the polarization is positive and enhanced greatly. The first panel shows the raw signal in green and baseline in red. The second shows the baseline subtracted and polynomial fit, and the third panel shows the final NMR signal to be integrated.

Baselines

To accurately measure the area of the NMR signal's dip or peak which is due to the polarization of the proton, we must carefully exclude any systematic changes in the NMR signal which are not due to polarization. To do this, we take a *baseline* measurement of the circuit's response **without** the polarization signal. This can be achieved by shifting the Larmor frequency of the proton out of range of our signal by changing the magnetic field. The baseline NMR signal is very sensitive to minute changes in the NMR circuit, and it it important to make frequent baseline measurements to ensure an accurate polarization measurement. A baseline should be taken at least every day after an anneal.

In addition to subtracting the baseline signal, a polynomial fit is performed to *wings* the NMR signal. This polynomial fit subtraction should remove any residual baseline signal and leave only the signal due to the target polarization.

Thermal Equilibrium Measurements

To calibrate our polarization, we must discover the proportionality factor, or *calibration constant*, which relates area under the NMR dip or peak to the proper polarization. To do this, we take advantage of the known polarization when the sample is at thermal equilibium. After forming the calibration constant using this static, known polarization and the measured NMR area, we can apply this constant when the target is being dynamically polarized with microwaves.

A thermal equilibrium measurement (or TE) requires removing the beam and the microwaves, setting the pressure and temperature in the nose to be as constant as possible, and waiting for the NMR area to stabilize. The relaxation time of the polarization depends on the temperature, so the temperature is raised above 1K to decrease the time spent waiting. Even so, this will likely take as much as an hour per cup. The number and quality of the thermal equilibrium measurements directly affects the error on the target polarization measurement, so the TE should not be rushed! In experimental circumstances, the pressure to hurry and get back to taking beam can result in sloppy TEs which adversely affect the experiment's systematic error. Take time to be accurate; time has been budgeted to allow for these TE measurements.

Polarization Display Panel (PDP) Overview

From Hall A Wiki

The Polarization Display Panel is the main user interface for the UVa polarized target. PDP is also the hub of a messaging system by which all the other target LabView programs communicate. While there are many windows that open when you click "TPS Start", PDP is the one that will control all the others for you. PDP puts nearly everything the operator needs to watch in from of him/her, and allows control of the NMR system and magnet power supply. While intimidating at first, PDP consists of a just a few panels to keep track of. Here they are arranged by function.

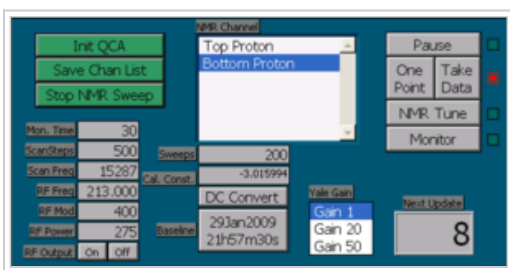
Polarization Display Panel

Contents

NMR Control and Analysis

NMR Control Panel

The NMR control panel is at the top left of PDP. Most of the values will be set automatically by text file configuration scripts when PDP starts.



- **Init buttons**: These are green buttons used to re-initialized the NMR system from configuration files.

NMR Control Panel

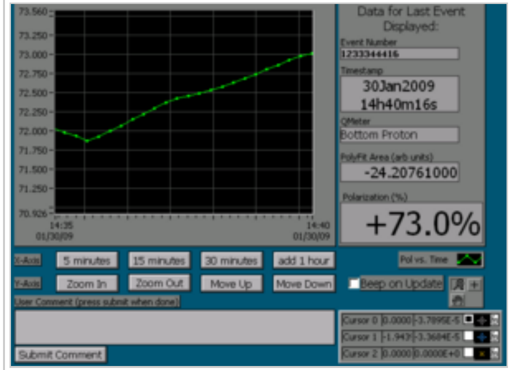
Save Chan List will save the current settings including the calibration constant. If you restart the program, the values saved will be loaded upon start-up. Try it.

- **NMR Values**: These grey text boxes are set from config files. They display information about the NMR sweeps and scans of RF used to measure polarization.
- **NMR Channel**: This is a selection box that allows you to choose which target cup to run the NMR system on. If the Top target is in place, you'll select Top Proton.
- **Sweeps**: This is the number of times the NMR system should sweep through the RF range to acquire the NMR signal. The sweeps are averaged, so the more sweeps, the more time it takes, but the lower the noise will be in the signal.
- **Cal. Constant**: The calibration constant is used to scale the final NMR signal area into a Polarization percentage. This number is set by performing a "TE" thermal equilibrium calculation.
- **DC Convert**: The NMR signal can acquire a DC offset, which you can see when the signal drifts away from the baseline. Clicking this will reset the DC offset. It is best not to push this while taking data, as the reset will skew the sweep average. Use this in "NMR Tune" mode.
- **Baseline**: This is the baseline file we are using. The baseline is the NMR signal with the magnetic field moved away from the resonant (Larmor) frequency of the proton. A baseline should be a clean Q curve, which we use to subtract away systematic noise. By clicking the baseline button the Baseline Dialog will appear.
- **Yale Gain**: This is a gain scaling. We use this to find the tiny TE signal when polarization is low. Once the polarization increases, we need to lower the gain to prevent electronic cropping.
- **Mode Buttons**: These buttons are used to change the PDP's current mode. Here are the modes and what they mean:
  - **Pause** is what it sounds like. PDP will finish the current set of sweeps and finish.
  - **One Point** takes one set of NMR sweeps and goes to Pause. Useful for baselines.
  - **Take Data** continues taking new sets of NMR sweeps until you push Pause.
  - **NMR Tune** cause the RF sweeps to go continuously without monitoring the output. Used during Tuning when we don't need to save the curve, but want to be able to see it to tune it.
  - **Monitor** takes data from all the other modules, such as the Magnet Control and Slow Controls, so that the system state can be written to Epics and the Event File without needing to acquire a Q curve. Used to monitor the system when we aren't taking data. The "Mon. Time" under the NMR values sets how long PDP waits before requesting more state data. A good values is 20 or 30 seconds.

Event View

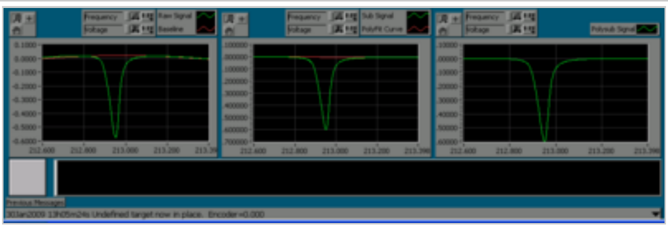
In the upper right of PDP, this panel displays the polarization over time, and some Event information for the current event.

- **Polarization Display**: Shows the polarization over time. Using the X and Y axis controls, you can view the data over 5, 15, or 30 minutes (and add an hour to any of those times), and zoom or shift in Y.
- **Comment Box**: Feel free to put any user comments about the event here, though we may not use them.



Event Display Panel

Signal View


Signal Display Panel

Across the bottom of PDP are views of the NMR signal. The 3 graphs show the signal after various alterations.

- **Raw and Baseline Signal**: To the left, the baseline signal is shown in red, and the raw NMR signal in green.
- **Subtracted and Poly Fit**: In the middle is a subtracted signal in green, with the baseline subtracted from the raw NMR signal. In red is a polynomial fit to this subtracted signal, which we use to subtract out any extra signal drift that the baseline didn't remove.
- **PolySub Signal**: To the right is the polynomial subtracted signal, which should show our pure signal. The area of this signal is proportional to the polarization of our material, via a calibration factor.

File Buttons

In the very middle of PDP is a small panel with file operation buttons. Click "Enable Buttons" to turn on these buttons. "New Event File" creates a new file for storing all target data. "New Base File" creates a new file to hold the baseline signal.

Magnet Control

Allows monitoring and control of the magnet. Since only experts will control the magnet, we won't go into this.

Status Monitors

In the middle are several panels that show the system status.

- **Insert and Nose Temps**: The far left shows temperatures and pressures on the insert and in the nose.
- **Flows and Levels**: Next are flow indicators of the fridge and separator, and liquid levels in pretty colors. If they get too low, do something.
- **Microwave Values**: Show the FM amplitude, offset, and the Frequency and power of the microwaves that induce polarization.
- **Misc Values**: Lastly, these show the vacuum pressure (visible on the other target screen as well), and two important temperatures: the Q-meters and the Collector. The collector on the microwave tube is interlocked so a high temp will cut it off.

Target Motion

Right middle, this shows the target location as an encoder value and selection box. The "Move Target" button brings up the target motion dialog. The target mask status is also show, but only updates in monitor or take data mode. The encoder will read 0.000 upon restart, until you click move target and done, when it will retrieve the correct value.

Baseline Dialog

The baseline dialog allows you to run with no baseline, take a new baseline, or select a previously taken baseline, which it shows you graphically arranged by date. The baseline created for the current material should be posted to the Hall C log, and noted in the logbook.

See Taking a Baseline.

Target Motion Dialog

You need to HOLD down the Up or Down button to get the target to move!

See Change Target Position.

Target Operator Duties

From Hall A Wiki

Here are your 5 duties: **Maintain Polarization, Maintain Cryogens, Move Target, Alarms and Safety, Log Everything.**

- Your first task on shift is to talk to the outgoing target operator and read the Hall A Log! Find out the following.
    - What target are we on?
        - What is the calibration constant and baseline we are using?
        - What is the encoder position for that target?
        - What frequency has provided the best polarization?
    - What alarms have occurred? How have they been addressed?
    - Is anything else different about the target today?
- Next make sure all the necessary control screens are up. You should have PDP, the Cryo Controls, strip charts, and the alarm handler accessible.

Check the Wiki for answers before you page a target expert!

Contents

Maintain Polarization

The polarization should be your constant worry. Even once you've found a good microwave frequency for the material, **be vigilant!** This frequency will change as the sample acquires dose!

Your constant attention to the microwave frequency is required! Change it often to ensure you have the highest polarization!

NMR

- The NMR system is how we monitor the polarization. Read the PDP overview for a tour of the software we use for NMR.
- "Take Data" to run the NMR, and hit "DC Convert" when you need to recenter the signal.

Microwaves

- Adjust the microwave frequency using the bellows (to the left of the target computer).

- Monitor the frequency you set using the monitor on the EIP frequency counter on the camera.
- Wait a few updates to see how your adjustment has affected the polarization. Write down the effects in the logbook.
- Continue to adjust to maximize the polarization. Write down the best frequency in the logbook.

The frequency at which the material best polarizes will change over time during the run. You must constantly adjust the microwave frequency to optimize polarization.

Maintain Cryogens

Nose Level

- Keeping the Liquid Helium above the targets is crucial.
  - If the level drops below a target cup, the polarization will drop to zero!
  - With both the beam and microwaves on, there is a large heat load evaporating helium.
- A PID loop should automatically adjust the run and separator valves to maintain appropriate levels.
  - If the PID loop is not working, it is your job to adjust the run and separator valves to keep the target running.
  - If the liquid level probe is not working, you can use the platinum resistors readings in PDP.
- Use the flows out of the fridge to anticipate changes in liquid level.
  - The **separator flow** (FI91127) is usually good around 20-30.
  - The **fridge flow** (FI9994) will change with the heat load of

microwaves and beam. With both on, 20's is good.
    - Keep the separator flow higher than the fridge flow in most cases.
        - These values are guides, and may not always work.

Magnet Liquid Level

- The magnet helium and nitrogen levels are controlled automatically.
- Ensure the levels stay within alarmed levels. If they drop too low or go too high, wait to see if the alarms go away. If they don't contact a target expert.

  There are 4 levels to watch

    - Magnet Helium (LL91111)
    - Magnet Nitrogen (LL91110)
    - Buffer Dewar Helium (LL91101)
    - Nose Level (mentioned above)

Move Target

Before move:

- Stop Beam
- Stop Microwaves

Move Target Physically

- Verify the correct encoder value.
- Follow the instructions of here to move target.
    - Start movement program, hold the button to move.

  Verify position on the encoder in the hall via camera!

Change NMR

There are 2 NMR coils, one in the Top cup, one in the Bottom.

- Set the channel.
- Set the calibration constant.
- Select a baseline.
- Take Data and run DC Convert. Change Gain when needed.
- If you are moving to a new cup and polarizing a new batch of material, start a new event file. See File Buttons.

Change Microwaves

There are 2 microwaves horns, one for Top and one for Bottom.

- Ensure microwaves are off (Transmit button in electronics room).
- Turn switch to new target position.
- Turn microwaves back on (transmit in electronics room).

Check Position

- Once beam comes back, ensure the position is correct!
- Start with lower beam current if you are unsure: 50nA
- Once you have enough events to replay, check the replay
- Look at the Slow Raster images.
    - Hot spots on the edges of the circle mean beam is crashing into our target cups!
    - Destruction of target cups mean delays, make sure your shift worker is watching the slow raster!
    - You can't move horizontally. MCC needs to steer beam. Watch the BPMs!

Alarms and Safety

- Whenever there is any important event (major alarms, etc.) respond to the alarm first, then make screen grabs of the relevant target windows (PDP or Cryo Controls, charts, etc) and post them on the hclog (with e-mail to the relevant experts, if needed)
  - Correct the problem that caused the alarm before proceeding. Call if you think an expert should be consulted.
  - Problems that don't cause alarms should be logged and experts consulted as needed, before proceeding.
- **Be responsible for target and magnet safety. The magnetic field is very high, and people in the hall may not be mindful for this.**

Log Everything

In the Paper Logbook:

- Run, Separator Valve settings
- Microwave frequency, bellows position, polarization

In the Hall A Log and Paper Logbook:

- Target movement and new encoder value
- Alarms that don't go away by themselves
- Screengrab of PDP every hour
  - For the screengrab, adjust polarization graph to show how polarization has changed since last screengrab.
- Screengrab of the cryo screen at the start of your shift

- This page was last modified on 22 September 2011, at 15:37.

New Baseline Procedure

From Hall A Wiki

This procedure was written for SANE and should be updated.

Contents

Before You Start

Baselines should be taken opportunistically. Any time during which it is known that the beam will be off long enough to take a baseline, take one. But do not interrupt data taking to take a baseline. When polarizing a new material, it is necessary to obtain a baseline to ensure accuracy of the NMR measurement. Also take a measurement at the end of each run.

Shifting the Larmor Frequency

There are two ways to shift the Larmor frequency in the cup. You can either change the current in the magnet to shift the field, or move the cup's position out of the high field region. Move the target out of the uniform region of the magnetic field. This will require moving the target up or down (observe motion limits) by more than an inch. Watch the nmr signal as you move. When you no longer see a polarization signal--just a q-curve, the Larmor frequency of the protons have shifted outside the range of the RF sweep. Record in the paper log-book your location for future TO's.

Acquiring the Baseline

- Now take a highly averaged data point without the proton spike in the NMR signal

1. Press the "Pause" button to stop the NMR data collection.

2. Press the "Baseline" button. A new dialogue box will pop up.

3. Press the "Create New Baseline" button. The dialogue box will disappear.

4. Change the number of sweeps to 300, and make sure you press enter afterwards.

5. If you press "One Point" you will begin taking NMR data. This will take several minutes, and you will not be able to stop it and re-enter nmr settings. Double check the NMR settings.

6. Press "One Point". Wait for the countdown to finish.

Selecting the Baseline as the Current Baseline

- Now that you've collected the baseline curve, you need to tell the NMR program that you would like to subtract it from the new signals rather than using the old baseline.

1. Press the "Baseline" button.

2. The same dialogue box will pop up, but on the list of baselines, the one you just took should be listed. It will be labeled with a date and time. Highlight your new baseline, and press the button selecting that as the baseline you want to use.

3. Change the number of sweeps back to it's previous value.

4. Document in the log book the

```
date
time
number of sweeps
Magnet Current
the target cell (top/bottom)
the gain
RFFreq
RFMod
```

Restoring the Target Position

- You are ready to restore the target position and resume polarizing and collecting target data.

Move the target back to the original position. Log changes and inform shift leader you are ready to continue with the run plan.

- Baseline procedure is complete

Thermal Equilibrium Measurement Procedure

From Hall A Wiki

This procedure was created for GEN, and must be updated to reflect changes in the target for g2p.

Contents

Assumptions:

- NMR System is tuned
- Magnet is at full field, persistent mode, leads are ramped down
- Nose is full, run valve in manual mode

Prepare Fridge:

- Stop RB3, RB2, and RB1 (wait 2 mintues between each), if necessary
- Put Run Valve, EV91120, in Manual Mode
- Establish a STEADY Nose level somewhere between 65% and 90%
- Only make slight changes to Run Valve for rest of TE (+/- 0.05 each 10 min)

Take a Baseline:

- Hit "Unlock Magnet Controls" button
- Type the full-field current in the box labeled "Setpoint" (eg: 77.085)
- Type 0.50 into "Setrate" box, if necessary
- Hit "To Setpoint" Button

- Wait for leads to reach full current (approx 1 min)
- Hit "Hold"
- Check that leads current and magnet current are equal
- Hit "Heater On" button
- Wait for the 30 second timeout to expire
- Type the baseline current into the "Setpoint" box (eg: 74.600)
- Hit "To Setpoint" to start the magnet sweeping
- Wait for magnet to reach baseline current (approx 6 min)
- Hit "Hold" button
- Put NMR into pause mode if necessary
- Hit the Baseline button
- Select "Create New Baseline", dialog box should then disappear
- Change sweeps to 5000 if necessary
- Double check that all NMR settings are where you want them
- Hit "One Point" button to take a single nmr measurement
- Wait for timer to count down
- Hit Baseline button
- Select the baseline you just took from the list of timestamps
- Document the details of the baseline in the logbook:
  - Date Time, #Sweeps, MagCurrent, Top/Bottom, Gain, RFFreq, RFMod
- Type full-field current into "Setpoint" box (eg: 77.085)
- Type 0.50 into "Setrate" box, if necessary
- Hit "To Setpoint" button
- Wait for magnet to reach full current (approx 6 min)
- Hit "Hold" button
- Hit "Heater Off" button
- Wait for 30 second timeout to expire
- Hit "To Zero" to ramp the leads down
- Hit "Lock Magnet Controls" button

Take TE measurements:

- Make sure ladder is in desired target position
- Make sure NMR is on desired channel (AND in agreement with target position!)
- Set sweeps to 5000, if necessary
- Hit "Take Data" button
- Wait for timer to count down
- Write the following in the logbook for the next 10 measurements:
  - Time, NMR Area, 4He Press, 4He Temp, 3He Press, 3He Temp, Nose Level

Target Movement Procedure

From Hall A Wiki

This procedure was created for SANE, and should be updated for changes to the target.

- **DO NOT** move target while beam is on! You may damage the insert.

```
Exception: When you are doing a position calibration,
it may be necessary to make small adjustments
when on the "hole" target position.
```

- Have Shift Leader to call MCC and tell them:

1. Turn off beam
2. Turn off the microwaves
3. It is not necessary in this experiment to mask target motion. Target motion is not tied in to the fast shut-down.

- Move target stick:

1. Check with Shift Leader that beam is indeed off.
2. Click the "Move Target" button on bottom right of NMR display.
3. Click and hold the "Move Table Up" or "Move Table Down" button
4. Watch the green indicator lights to determine where target table is
5. When light for the desired new position lights, you are close
6. Target position is most accurately determined by the Target Encoder
7. Ensure encoder value in LabView from monitor 7. The "Target" camera views some electronic racks. The box in the top of the left rack is the encoder readout. You can read it, and watch the lights on the

"Target Motion" panel.
8. Move table until Encoder is +/− 0.01 of number listed next to green light
9. There is significant hysteresis in the motion of the table. In order to position the table accurately it is necessary to always approach a target encoder value from the same direction. This direction is essentially arbitrary, but for the purpose of this experiment **we are approaching targets from lower encoder positions**. If you at a lower encoder position and moving up, just go to the target position carefully. If you are above the target position or overshoot a position, first move to an encoder value at least .1 below the desired position. Approach the desired position from here.
10. When table is properly positioned, hit the "Done" button
11. Wait 10−15 seconds for computer to write new position to EPICS
12. Note new position and encoder value in logbook and **electronic logbook**!
13. Change NMR channel to the appropriate target. If you are on a non-ammonia target, place the NMR program in "Monitor" mode.
14. Change the calibration constant if necessary. See the posted values or check the paper logbook.
15. Ensure the microwaves are still off, and change the microwave switch to the desired position. If you are on Carbon or Empty, any position will do.

- Of course, throughout this the beam is off. Once you have finished, tell the shift leader that the target has successfully moved.

Anneal Procedure

From Hall A Wiki

g2p Anneal Procedure will go here Don't forget to make new eventfile

Contents

Assumptions:

- Fridge running – all pumps on

Prepare NMR:

- Stop beam, if necessary
- Turn off Microwaves, if necessary
- Put NMR into Monitor Mode

Prepare Fridge:

- Stop Roots Blower 3 by pressing the RB3 Stop Button (in electronics room)
- Wait 2 minutes for pump to spin down

- Stop Roots Blower 2 by pressing the RB2 Stop Button (in electronics room)
- Wait 2 minutes for pump to spin down
- Stop Roots Blower 1 by pressing the RB1 Stop Button (in electronics room)
- Open Main Gate Valve, PV91141, if necessary (in electronics room)
- Close Bypass RB3 Valve, PV91142, if necessary (in electronics room)
- Close Roughing Valve, PV91143, if necessary (in electronics room)
- Place Run Valve, EV91120, into Manual Mode (cryo computer)
- Close Run Valve by entering a manual setpoint of zero
- Close Bypass Valve, EV91121, if necessary, by entering a position of zero
- Put the Separator Valve, EV91127, into Computer Control (not Manual Mode)
- Enter a value of 60 into the Set Val box of the EV91127 control

Empty the Tail of Helium:

- DO NOT move the target without first informing MCC – you''ll trip all Halls
- Move the target to the Top position, write in logbook
- Load the Anneal program (icon on desktop)
- Run the Anneal program (click white arrow on left of toolbar)
- Type in a setpoint of 60 (K) and hit "Send to ITC", write in logbook
- Hit the "Goto Setpoint" button to turn on the heater
- Observe the liquid level in the tail drop (7% is about the minumum reading)
- Wait 5 minutes after the liquid is gone
- Open the Run Valve to 0.3, write in logbook
- Move the target to Empty position, write in logbook
- (If Run Plan needs to do Carbon runs, this position is also OK)
- Use Lower camera to see the He4 pressure (Rack B, Device 5), write

in logbook

Begin the Anneal:

- Wait until all three sensors stabilize at 60K, write in logbook
- Type the desired Anneal temperature into the setpoint, Hit "Send to ITC"
- Note in the logbook the time when the anneal temperature is reached
- Log Top Platinum, Top T/C, Bottom T/C, and He4 Pressure every 5−10 minutes
- Leave the target at the Anneal temperature for the desired number of minutes
- To stop the anneal, hit the "Stop Anneal" button, write in logbook
- Let the anneal program continue to run, to document the cooldown process
- Cool Down the Refrigerator:
- Change the setpoint of the Bypass Valve to 1.0
- Change the Manual setpoint of the Run Valve to 1.0
- Wait until the Nose Level, LL91112, reaches about 80%
- Change the setpoint of the Bypass Valve to 0.0
- Change the Run Valve back to computer control (not Manual Mode)
- Enter a value of 32 into the Set Val box of the EV91127 (Separator) control
- The the Stop button on the toolbar of the Anneal Program, and then close it
- Wait for the Nose Level to (mostly) stabilize
- Observe the He4 pressure
- If the pressure is not below 12 torr, temporarily close the Run Valve
- Once the pressure is below 12 torr, start RB1 (electronics room)
- Wait for the pressure to drop below 2.2 torr
- Start RB2
- Wait for the pressure to drop below 1.0 torr

- Start RB3
- If necessary, re–open the Run Valve or put it under computer control

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Target Movement Procedure

From Hall A Wiki

This procedure was created for SANE, and should be updated for changes to the target.

- **DO NOT** move target while beam is on! You may damage the insert.

```
Exception: When you are doing a position calibration,
it may be necessary to make small adjustments
when on the "hole" target position.
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7. Ensure encoder value in LabView from monitor 7. The "Target" camera views some electronic racks. The box in the top of the left rack is the encoder readout. You can read it, and watch the lights on the

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9. There is significant hysteresis in the motion of the table. In order to position the table accurately it is necessary to always approach a target encoder value from the same direction. This direction is essentially arbitrary, but for the purpose of this experiment **we are approaching targets from lower encoder positions**. If you at a lower encoder position and moving up, just go to the target position carefully. If you are above the target position or overshoot a position, first move to an encoder value at least .1 below the desired position. Approach the desired position from here.
10. When table is properly positioned, hit the "Done" button
11. Wait 10−15 seconds for computer to write new position to EPICS
12. Note new position and encoder value in logbook and **electronic logbook**!
13. Change NMR channel to the appropriate target. If you are on a non-ammonia target, place the NMR program in "Monitor" mode.
14. Change the calibration constant if necessary. See the posted values or check the paper logbook.
15. Ensure the microwaves are still off, and change the microwave switch to the desired position. If you are on Carbon or Empty, any position will do.

- Of course, throughout this the beam is off. Once you have finished, tell the shift leader that the target has successfully moved.

Target Replacement Procedure

From Hall A Wiki

Procedure will go here. Do not forget to include photographing the cell and material and making new basefile!

- This page was last modified on 12 September 2011, at 14:55.

Magnet Energization Procedure

From Hall A Wiki

Ramping the magnet is to be done only by target experts: Don Crabb, Donal Day, James Maxwell, Jonathan Mulholland.

Ramp Up Procedure

Restrictions:

- DO NOT run up the magnet with the shim heater or power supply off – magnet will quench
- DO NOT exceed rate limits listed below – magnet can quench
- DO NOT allow loss of cryostat isolation vacuum – magnet can rupture
- DO NOT allow persons with medical implants near magnet – death can occur
- AVOID the need for a fill during ramping - warm gas can cause quench. Induce a fill if the level is near 20%.
- Ensure safety prerequisites for magnet ramping are met.

Procedure:

1. Turn on magnet power supply and, if necessary:
    - Remove any unsecured magnetic objects from area within 4m of magnet
    - If no hall access has been made since last magnet use, search can be skipped
    - Turn on shim power supply and set shim heater on to 0.1 A, if necessary (on top of Magnet PS, Rack D)
2. Put PDP in "Monitor," if necessary, to allow update of switch and shim

status

3. Hit "Unlock Magnet Controls" button in the Polarization Display Panel, **PDP**
   - **Verify** that there is no current in the leads (Power supply icon, far left)
   - **Verify** the Shim Heater is On (indicator in PDP and camera on PS). This must always be On!
4. Hit "Hold" button
5. Hit "Heater On" button and confirm this action in the dialog box that presents itself
   - **Ensure** the Heater On status with cameras on the PS and the indicator in PDP
   - Wait until timer counts down to zero
   - If the countdown starts before the indications, wait at least 30 seconds from the time the heater is on, ignoring the count-down
6. Set the first Setpoint and Setrate values. PDP should not allow you to exceed these rates, but be mindful.
   - Type the value 1.20 (this is in Amps/min) into the "Setrate" box
   - Type the value 60.0 (this is in Amps) into the "Setpoint" box
7. Hit the "To Setpoint" button

   Monitor the Voltage in the Coil and Leads (camera, PDP)! A high voltage is a sign of a coming quench.
   If it is increasing rapidly or exceeds 7.5 V, press "Hold"!
   Lower the rate and try again, ensuring the voltage stays low.

8. Wait for magnet to reach 60.0 A (45 min)
9. Press "Hold"
10. Set the Setpoint and Setrate values for the next current step:
    - Type the value 0.60 into the "Setrate" box
    - Type the value 72.0 into the "Setpoint" box
11. Press "To Setpoint"
12. Wait for magnet to reach 72.0 A (20 min)

13. Press "Hold"
14. Set the Setpoint and Setrate values for the last current step:
    - Type the value 0.30 into the "Setrate" box
    - Type the desired magnet current into the "Setpoint" box
    - Currents for full–field and for baseline measurements are on whiteboard
15. Wait until magnet current reaches the requested value (20 min)
16. Hit the "Hold" button
    - If persistent mode is not desired, stop here
17. Wait for 30 seconds
18. Hit the "Heater Off" button
    - **Ensure** the Heater Off status with cameras on the PS and the indicator in PDP
    - Wait until timer counts down to zero
    - If the countdown starts before the indications, be sure to wait at least 30 seconds from the time the heater is off, ignoring the count-down
19. If we are going to be ramping down the leads, hit "To Zero" button to ramp leads down
20. Hit "Lock Magnet Controls" button

Ramp Down Procedure

1. Hit "Unlock Magnet Controls" button in the Polarization Display Panel, **PDP**
    - **Verify** the Shim Heater is On (indicator in PDP and camera on PS). This must always be On!
    - **Verify** the Switch heater is OFF
2. Put PDP in "Monitor," if necessary, to allow update of switch and shim status
3. If necessary, Ramp the Power Supply to the Magnet Current
    - Type the value of the magnet current (this is in Amps) into the

"Setpoint" box
    - Press "To Setpoint"
    - Wait for the PS current to reach the Magnet current
4. Hit "Heater On" button and confirm this action in the dialog box that presents itself
    - **Ensure** the Heater On status with cameras on the PS and the indicator in PDP
    - Wait until timer counts down to zero
    - If the countdown starts before the indications, wait at least 30 seconds from the time the heater is on, ignoring the count-down
5. Set the first Setpoint and Setrate values. PDP should not allow you to exceed these rates, but be mindful.
    - Type the value 0.30 (this is in Amps/min) into the "Setrate" box
    - Type the value 72.0 (this is in Amps) into the "Setpoint" box
6. Hit the "To Setpoint" button

    Monitor the Voltage in the Coil and Leads (camera, PDP)! A high voltage is a sign of a coming quench.
    If it is increasing rapidly or exceeds 7 V, press "Hold"!

7. Wait for magnet to reach 72.0 A (20 min)
8. Press "Hold"
9. Set the Setpoint and Setrate values for the next current step:
    - Type the value 0.60 into the "Setrate" box
    - Type the value 60.0 into the "Setpoint" box
10. Press "To Setpoint"
11. Wait for magnet to reach 60.0 A (20 min)
12. Press "Hold"
13. Set the Setpoint and Setrate values for the last current step:
    - Type the value 1.20 into the "Setrate" box
    - Type the value 0.0 into the "Setpoint" box
14. Wait until magnet current reaches zero (45 min)
15. Hit the "Hold" button

16. Hit the "Heater Off" button
    - **Ensure** the Heater Off status with cameras on the PS and the indicator in PDP
    - Wait until timer counts down to zero
    - If the countdown starts before the indications, be sure to wait at least 30 seconds from the time the heater is off, ignoring the countdown
17. Hit "Lock Magnet Controls" button