

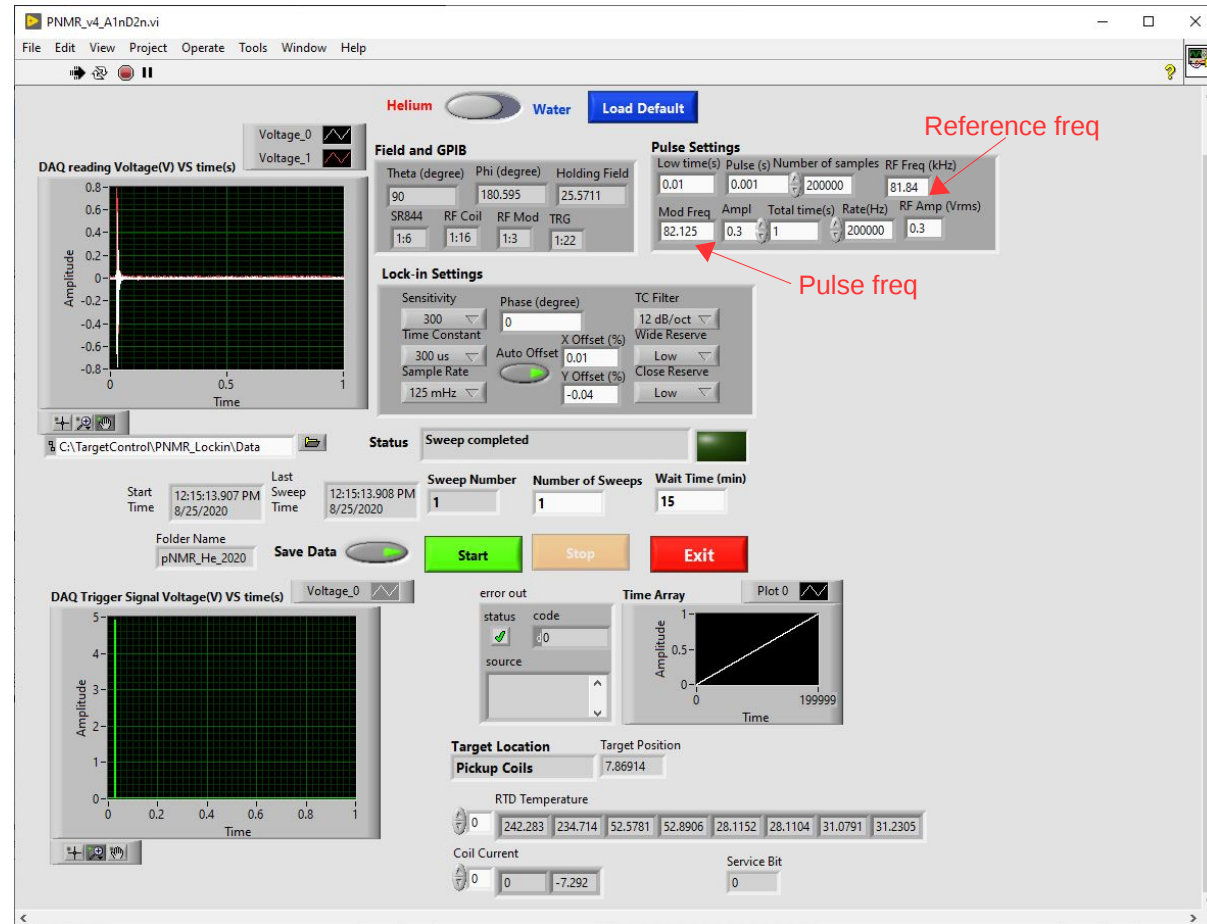
PNMR Training Slides

(For Target Operator)

- How to do PNMR
- How to run the PNMR fitting program
- PNMR System Check before Measurement
(follow **PNMR Initialization** process if needed)
- PNMR vs NMR Measurements
(perform PNMR 20 sec before regular NMR measurement)

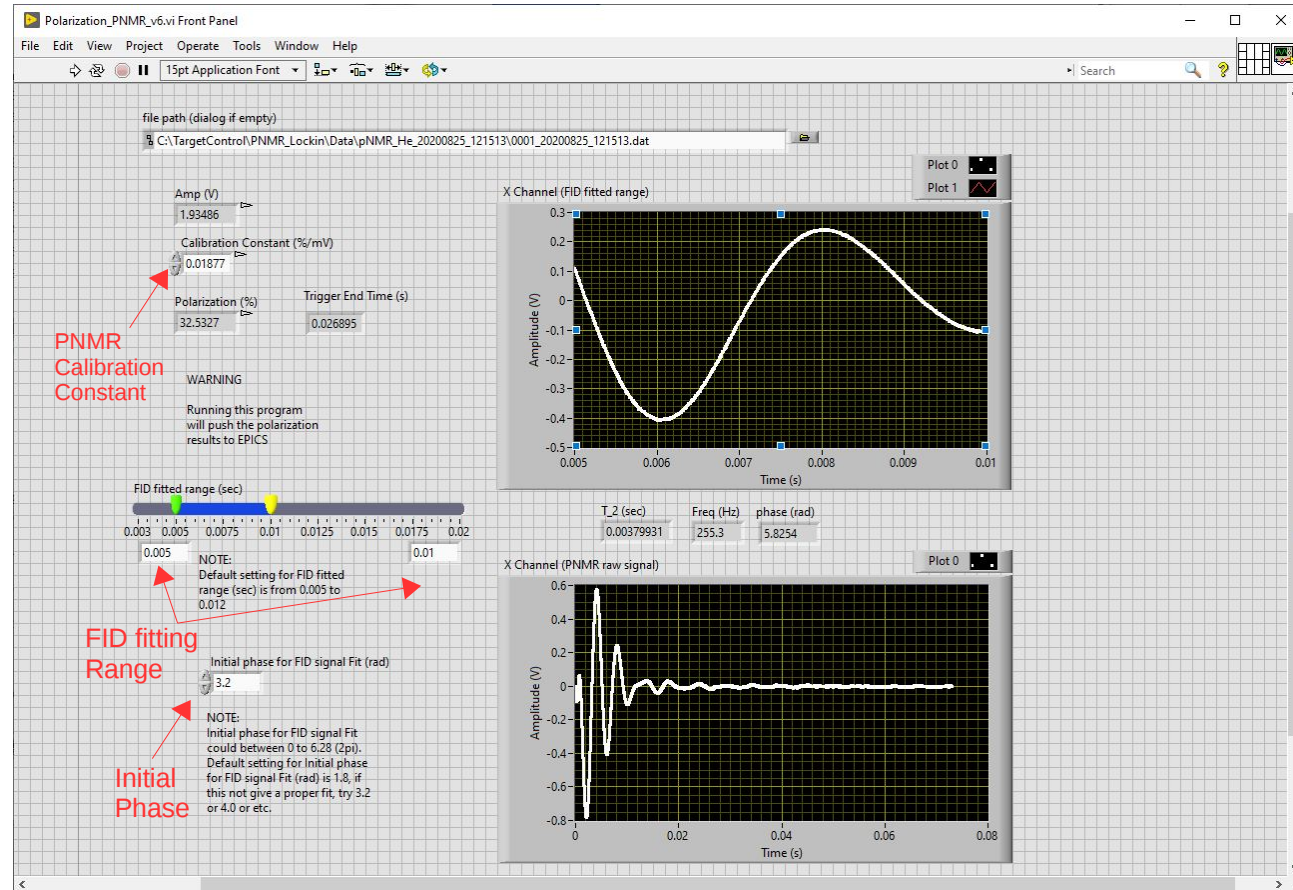
How to do PNMR

- Move the target to the pick up coil position
- Open the PNMR_v4_A1nD2n.vi program
- Click on the right arrow icon on the top left to run the program
- Make sure that the button indicates “Helium” and not “Water”
- Click on the blue “Load Default” button to initialize the PNMR settings.
- Search for PNMR vs NMR Calibration table which can be found on the wall behind the target computer, type in corresponding Pulse freq and Reference freq under “Pulse Settings” region
- After making sure the settings are correct for current target spin direction, click on “start”
- Make a log book entry



How to run the PNMR fitting program

- Open the Polarization_PNMR_v6.vi program
 - Load the file in C:\TargetControl\PNMR_Lockin\Data\pNMR_He_****\file_name.dat that has the recent pNMR measurement
 - Type in the correct calibration constant for this field setting which can be found on the wall behind the target computer
 - Type in the correct FID fitting range
 - Type in initial phase which will give good FID signal fit.
 - Click on the white arrow which runs the program.
 - If FID signal fit is good, no error will occur from fitting program.
- If not, try different Initial phase (from 0 to 2π rad) which will give a good FID signal fit.
- (start with **phase = 1.8 rad**, then could try **3.2 rad** or **4.0 rad**)
- make a log entry with screenshots

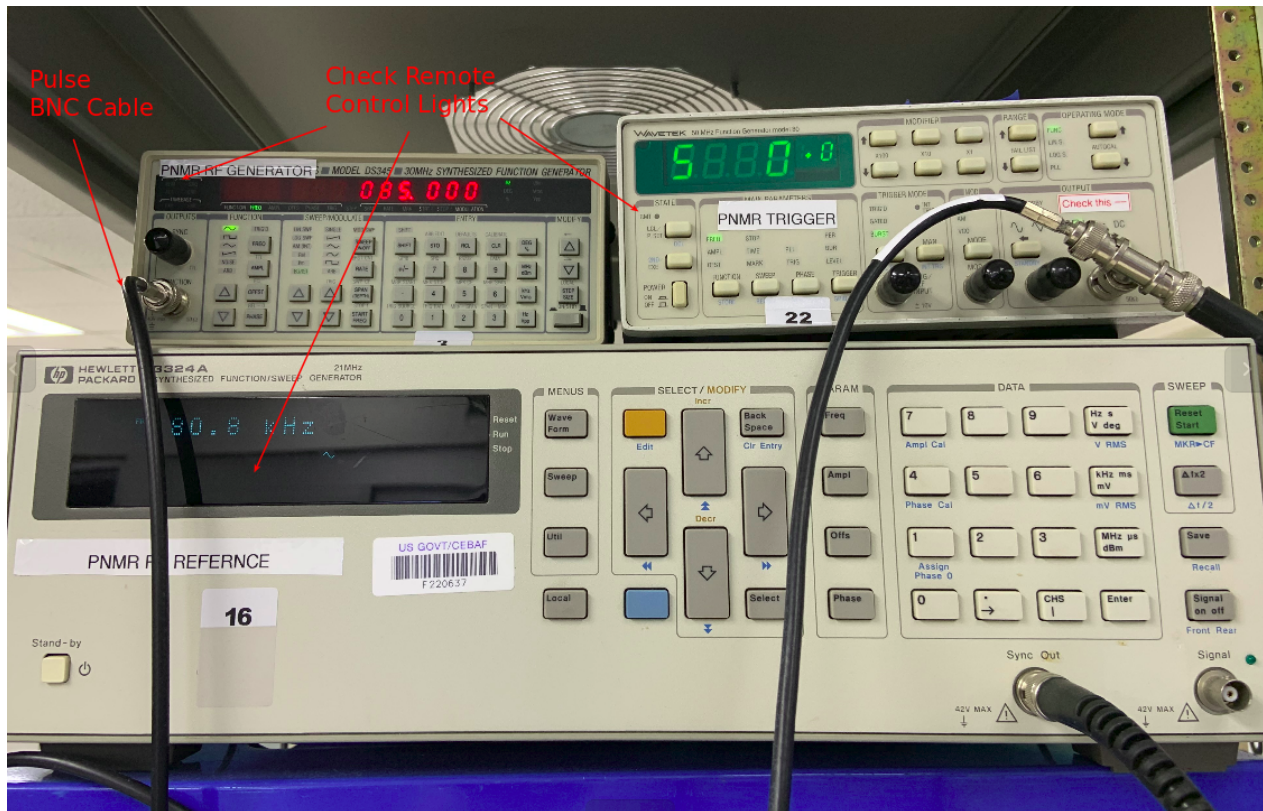
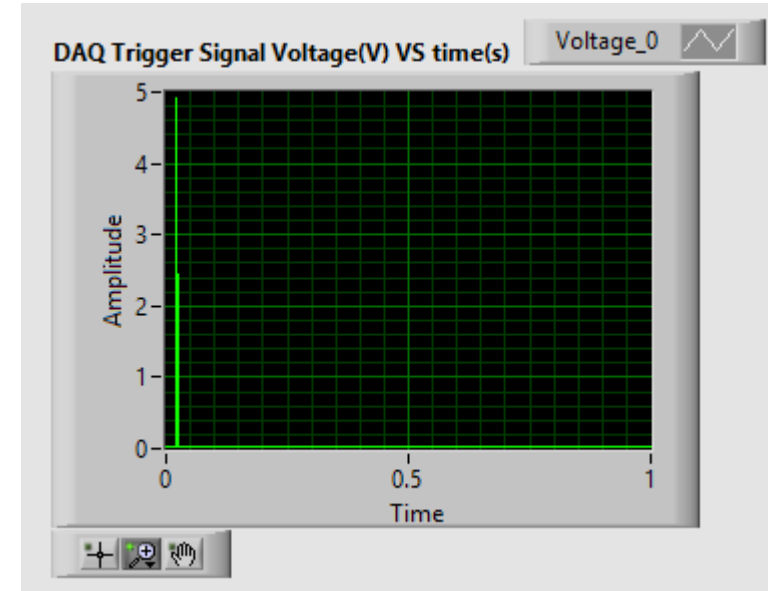


PNMR System Check

(before PNMR measurement)

- Every time restart the target PC “polhe4”, the remote control for PNMR instruments will be lost. (remote lights not lit)
- Need Target Operator to pay attention to the status of PNMR instruments and perform initialization steps to regain remote control of PNMR instruments.

- Typical PNMR Trigger signal



PNMR Initialization:

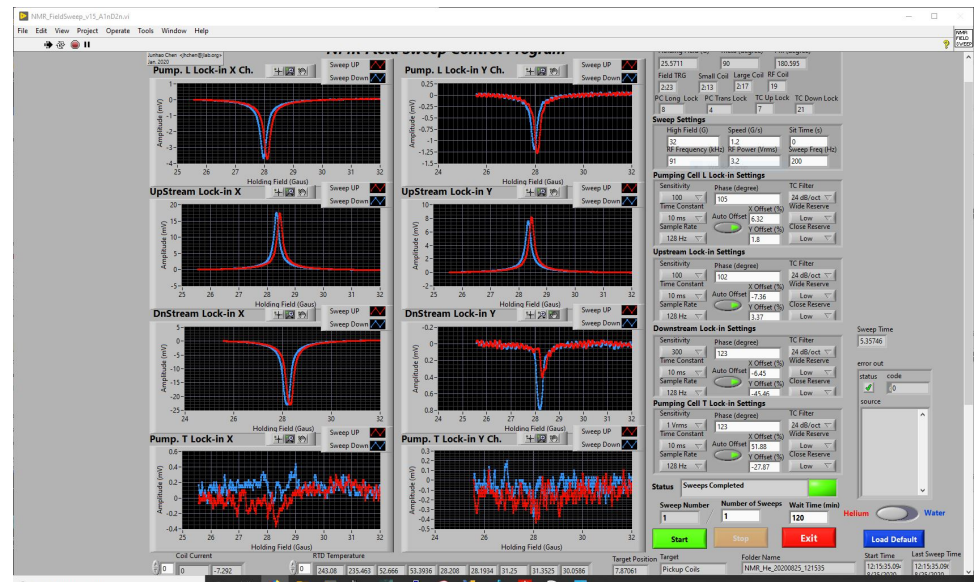
- 1) Disconnect PNMR Pulse BNC cable from DS 345.
- 2) Run “PNMR_v4_A1nD2n.vi” with proper setting for current target spin direction.
- 3) Check PNMR trigger signal, confirm the trigger signal is good.
- 4) Reconnect PNMR Pulse BNC cable back to DS 345.

PNMR vs NMR Measurements

- For every 12 hours, need to perform PNMR vs NMR Measurements in order to confirm the PNMR calibration constant is reasonable for current production run conduction.
 - For PNMR vs NMR measurements, perform PNMR 20 sec before NMR.
- (should use the windows **clock** on target PC “polhe4” to check time)

PNMR vs NMR calibration:

Sometimes need to perform PNMR vs NMR calibration, then perform PNMR 20 sec before regular NMR measurement every 5 hour.



NMR Time
(20 sec after PNMR)

Backup Slides

PNMR vs NMR Calibration Table

(on Cell Brianna 08/25)

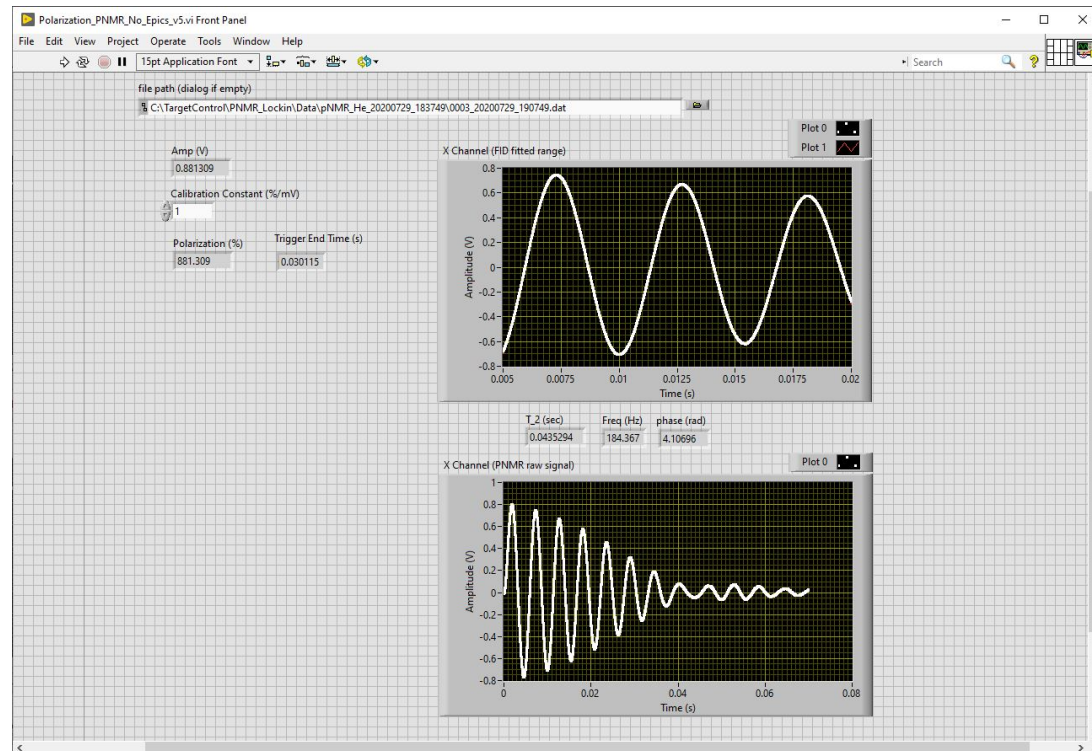
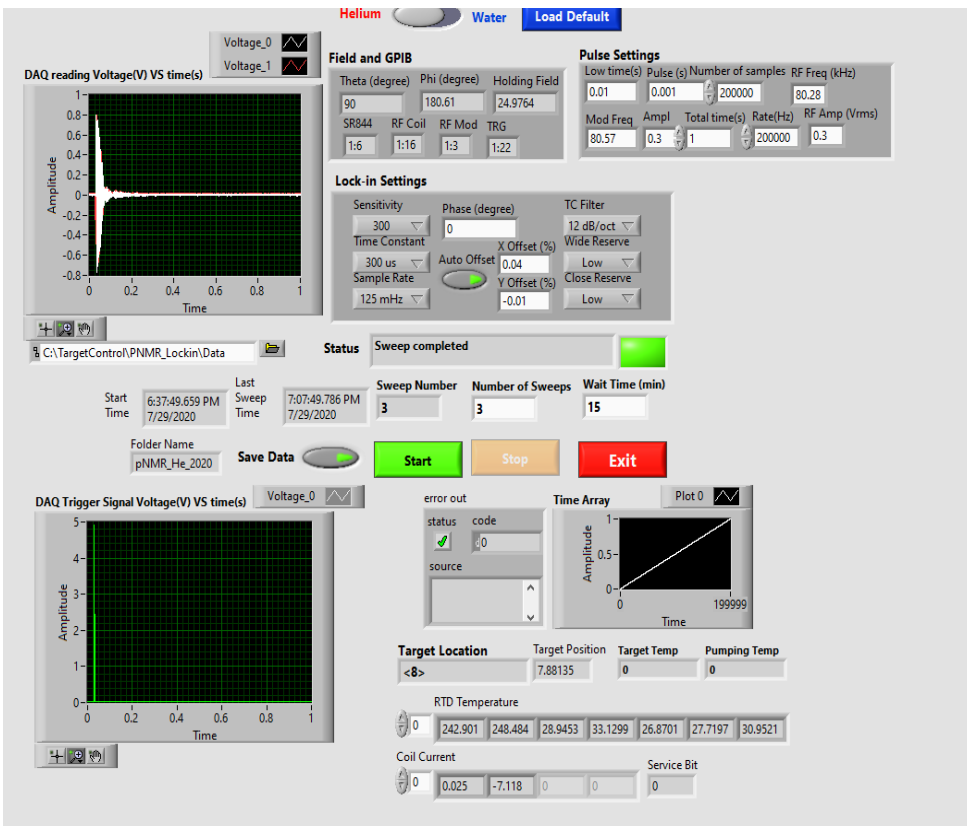
SHMS angle (deg)	HB momentum (GeV)	Field Direction (deg)	Oven Temp (deg C)	Laser Power (W)	Corr. Coil VL (A)	Corr. Coil VS (A)	Convection PS (V)	Target Position	Calibration Constant (%/mV)	Pulse Freq (kHz)	Reference Freq (kHz)	FID fitting range (msec)
18	5.6	180	205	80	5.2	7.0	7	Pick-up Coils	0.01877	82.125	81.84	5 ms to 10 ms

Typical PNMR FID Signal

- Current fit for the signal by the FID fitting function to obtain PNMR amplitude A_0 .

$$S(t) = FID(t) = A_0 \cos(\omega t + \phi_0) e^{-t/T_2} + a*t + b$$

- Obtain PNMR_amp/NMR_amp ratio in order to calibrate PNMR with NMR.



- Typical PNMR signal and signal fit
- Condition: pulse freq= 80.57 kHz, RF freq=80.28 kHz, t_pulse=1 ms, df=290 Hz
- Target spin 180deg with HB on for 11 deg, -7.5 GeV
- VL=4.7A, VS= 6.9A with convection at 9V

FID Freq Correction On Signal Amp

(with respect to PNMR Pulse freq)

- For ^3He Larmor freq in Holding field H:

$$\omega = -\gamma H$$

where $\gamma = -3.2434$ kHz/G is ^3He gyro-magnetic ratio.

- This means for holding field gradient be 30 mG around PNMR coil region, we will have about 100 Hz freq shift for ^3He Larmor freq.
- The usage of a Lock-in amplifier makes the frequency for obtained FID signal becomes difference between Larmor freq and Lock-in amplifier reference freq.
- From initial PNMR vs NMR calibration, noticed PNMR FID signal amp become higher when FID signal frequency become lower.
- Tried to use a linear model to correct amplitude for different FID signal frequency.

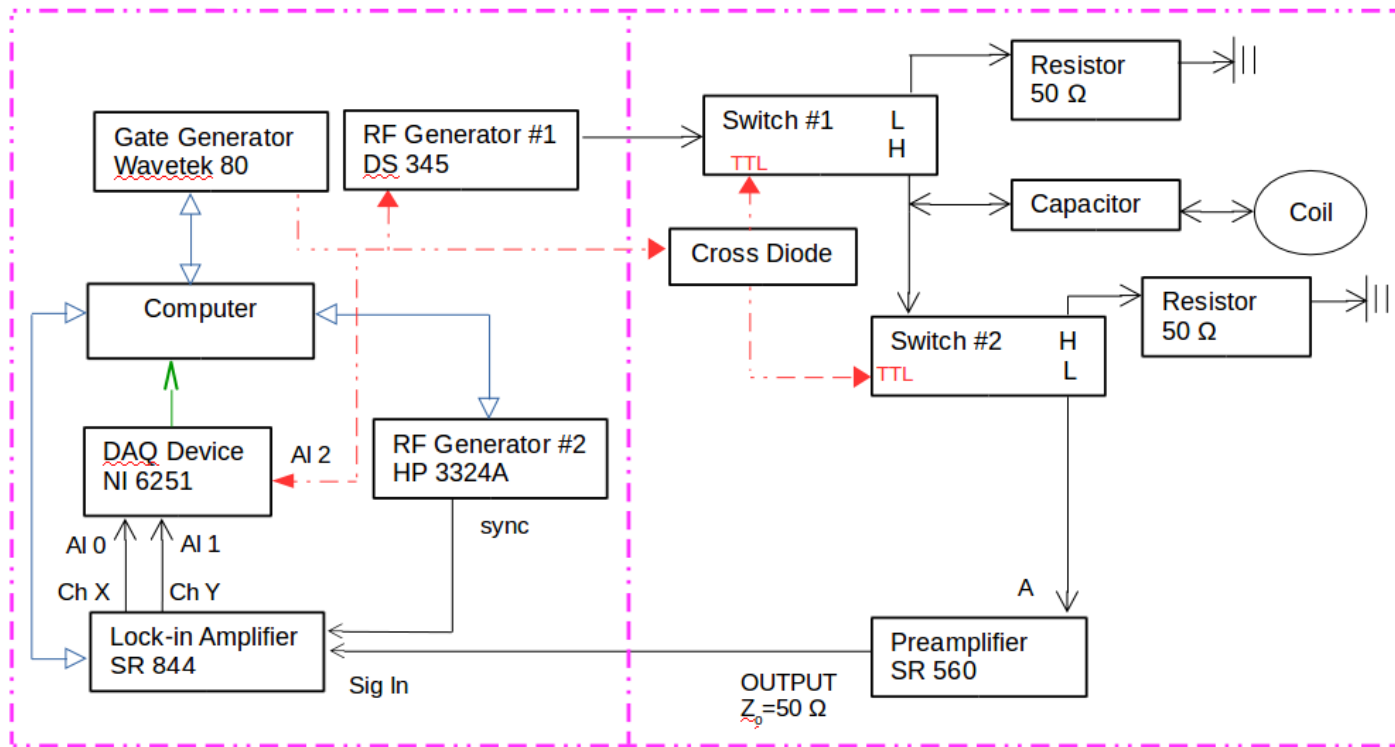
$$A_{corr} = A_0 * \left(1 + c \frac{f_{FID} - \Delta f}{\Delta f}\right)$$

Where A_0 is the fitted FID amp, f_{FID} is FID signal freq, Δf is the difference between pulse freq and reference freq. Constant c is the factor for signal amp change, currently used $c=0.5$.

PNMR with Lockin SR844 and DAQ Setup

Counting Rouse

Target Area



- Keep Holding filed at **25G** along z-direction (along beam direction) by Helmholtz coil.
- For Pre-amplifier the bandpass is 10 kHz to 100 kHz; the pre-amplifier has gain of 20 times.
- The input pulse sine wave signal from DS 345 has $f_{in}=81.085$ kHz, $V_{rms}=0.3$ V with $t_{pulse}=1.0$ ms; while the reference signal for Lockin is from the sync of HP3324A with $f_R=80.8$ kHz.
- RF switches: **ZYSWA-20-50DR** controlled by TTL low/high signal. If TTL signal is high, function generator will send the input pulse to the PNMR coil. When the TTL is low, FID signal from the PNMR coil will pass the second RF switch, then go through the rest setup.

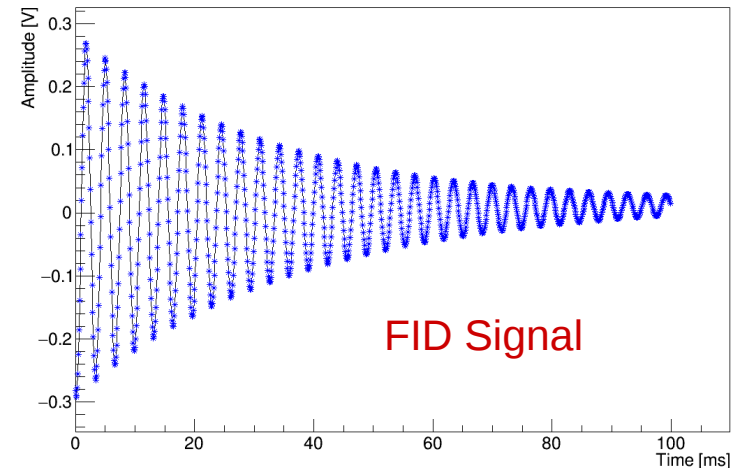
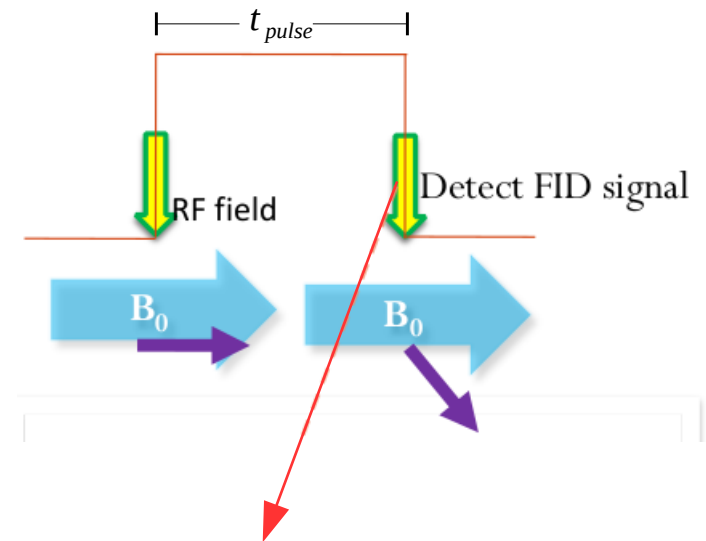
Pulse NMR Polarimetry

Advantage:

- Took shorter time to complete measurement, less depolarization compare to AFP-NMR.
- For future metallic end cells, provide local polarimetry at transfer tube.

Principle:

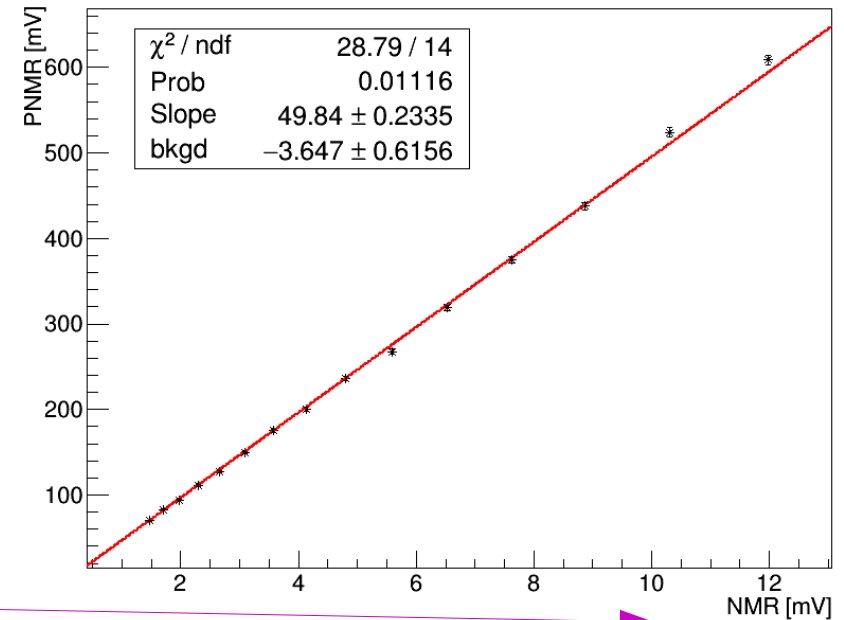
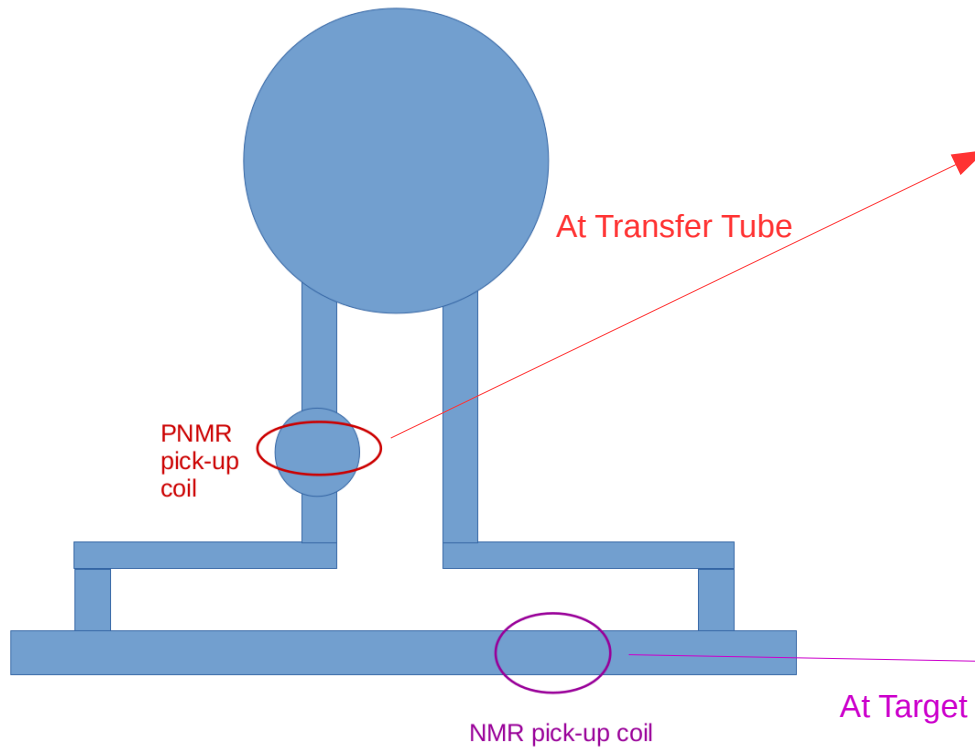
- Send a RF pulse at Larmor frequency which tips ^3He spin away from holding field axis:
$$\theta_{tip} = \frac{1}{2} \gamma H_1 t_{pulse}$$
- When pulse ends, the spin precesses back to its initial state and experience free induction decay (FID).
- FID signal is picked up by the PNMR coil. Measure the transverse component of magnetic moment proportional to ^3He polarization.



$$S(t) \propto M_z \sin(\theta_{tip}) \cos(\omega t + \phi_0) e^{-t/T_2}$$

PNMR (at Transfer Tube) vs. NMR (at Target Chamber)

Hot Spin Down (with Convection, PNMR SR844)



- Hot spin down with convection measurements. Pulse NMR measured around 1-inch sphere on the transfer tube.
- Current fit for the signal by the FID fitting function to obtain PNMR amplitude A_0 .

$$S(t) = FID(t) = A_0 \cos(\omega t + \phi_0) e^{-t/T_2} + a*t + b$$

- Calibrate PNMR with NMR with linear fit.

PNMR Lockin SR844 signal

