PNMR Training Slides

(For Target Operator)

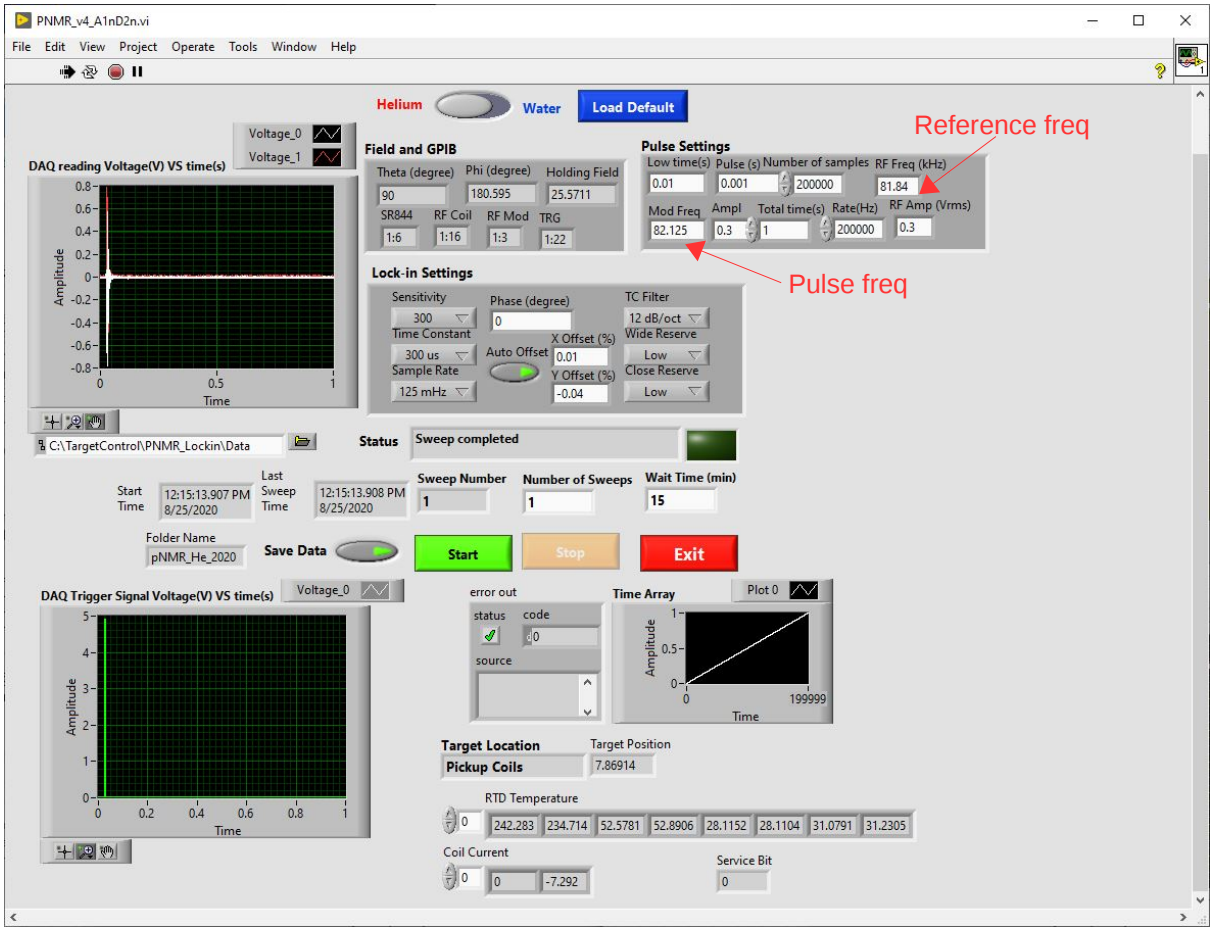
- How to do PNMR
- How to run the PNMR fitting program
- PNMR System Check before Measurement

  (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

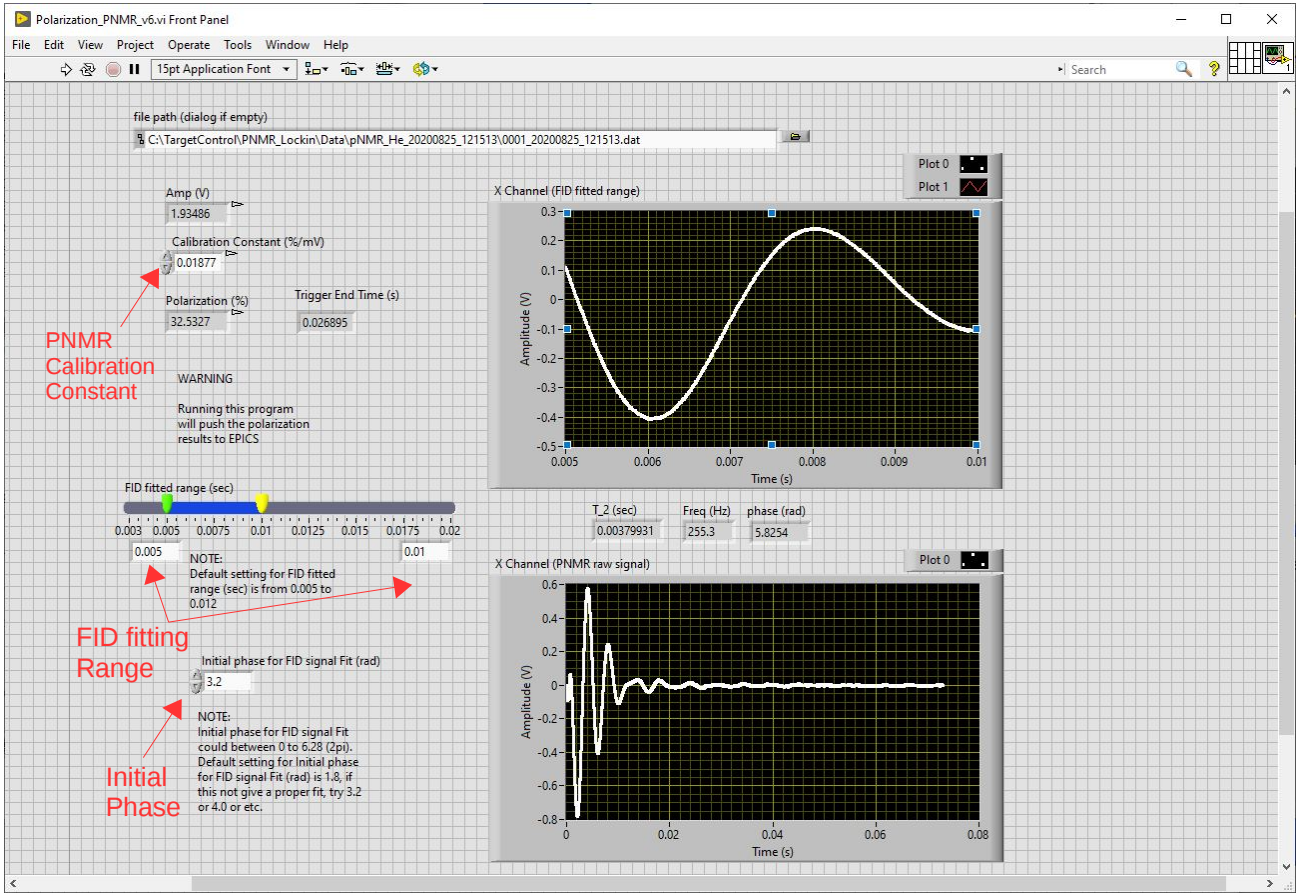


How to run the PNMR fitting program

- 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.

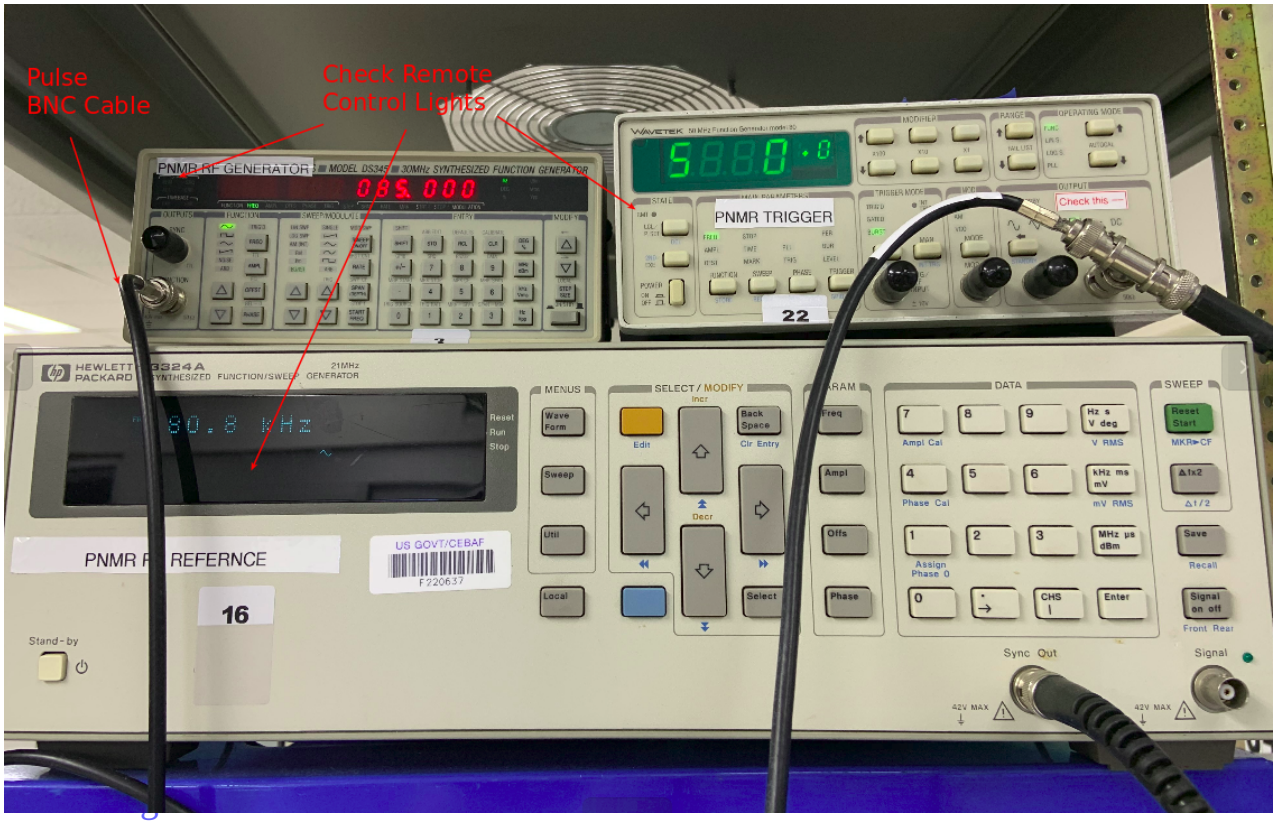
  (start with phase =1.8 rad, then could try 3.2 rad or 4.0 rad)
- make a log entry with screenshots



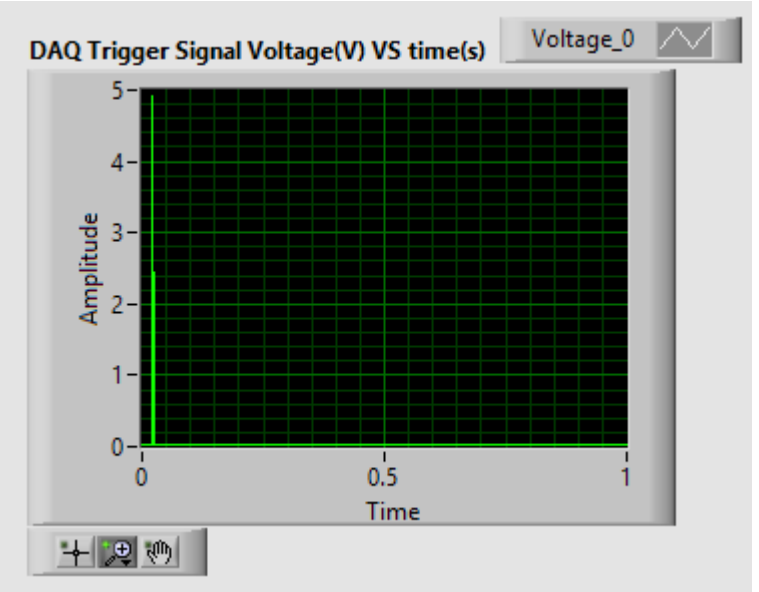
PNMR System Check

(before PNMR meausrement)

- 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:

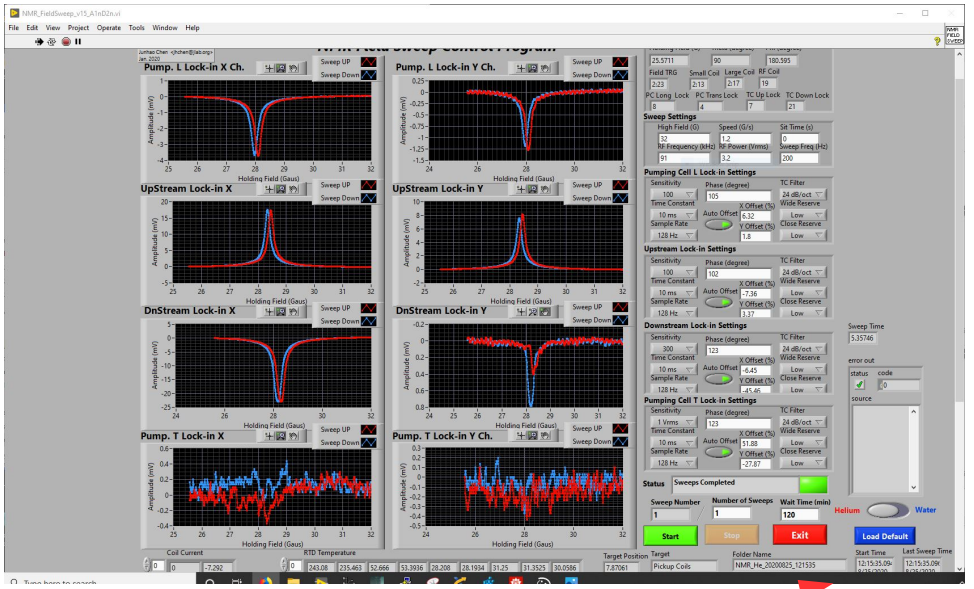
1) Disconnect PNMR Pulse BNC cable from DS 345.
2) Run “PNMR_v4_A1nD2n.vi” with proper setting for current target spin direction.
3) Check PNMR trigger signal, confirm the trigger signal is good.
4) Reconnect PNMR Pulse BNC cable back to DS 345.

PNMR vs NMR Measurements

- For every 12 hours, need to preform 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 preform PNMR 20 sec before regular NMR measurement every 5 hour.



Backup Slides

PNMR vs NMR Calibration Table

(on Cell Brianna 08/30)

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	0.01801	81.975	81.69	5 ms to 11 ms
18	5.6	270	205	80	4.8	6.6	7	Pick-up Coils	0.02489	82.935	82.65	5 ms to 11 ms
14.5	6.4	180	205	80	4.9	7.0	7	Pick-up Coils	0.04260*	82.265	81.98	5 ms to 11 ms

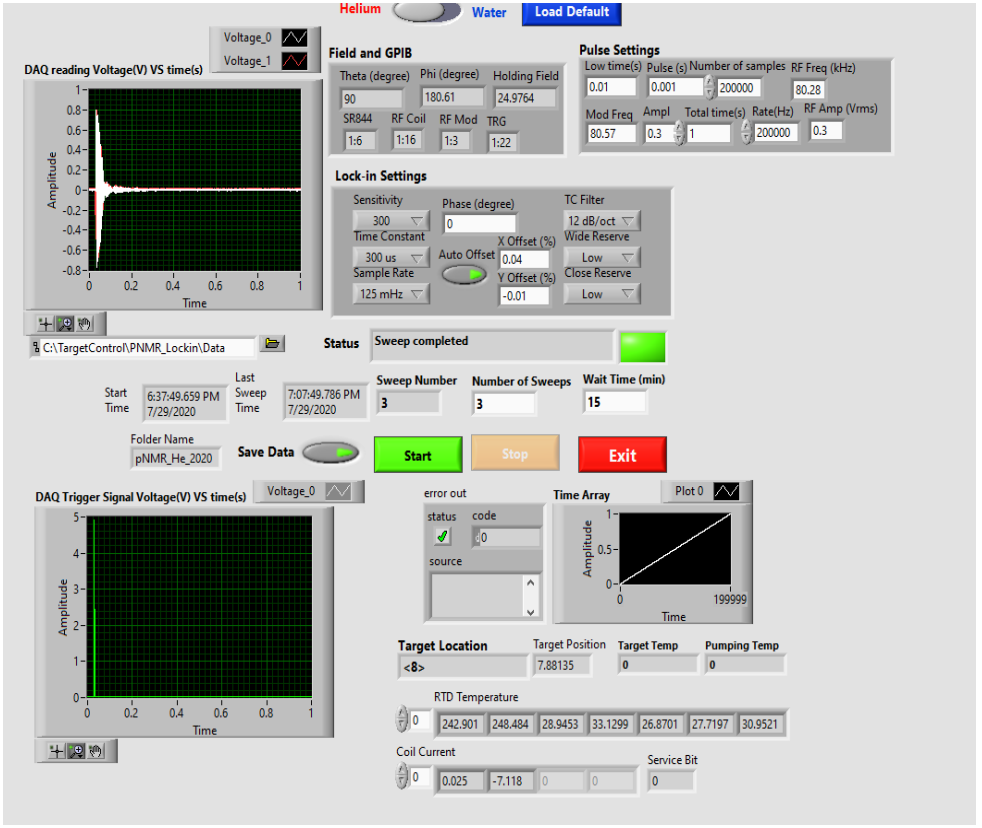
Note:

"*" means initial PNMR calibration constant, will finalize after 4 sets of PNMR vs NMR measurements under the same Holding field condition (same HL and HS currents).

For Target Operator:

When fitting the PNMR signal, pay attention to initial phase, fitted FID freq and T2 value. For similar FID freq, the fit program should give similar T2 results. If not, then try to fit from 5 ms to 10 ms to reduce the background noise on the small amp tail part of FID envelope.

Typical PNMR FID Signal

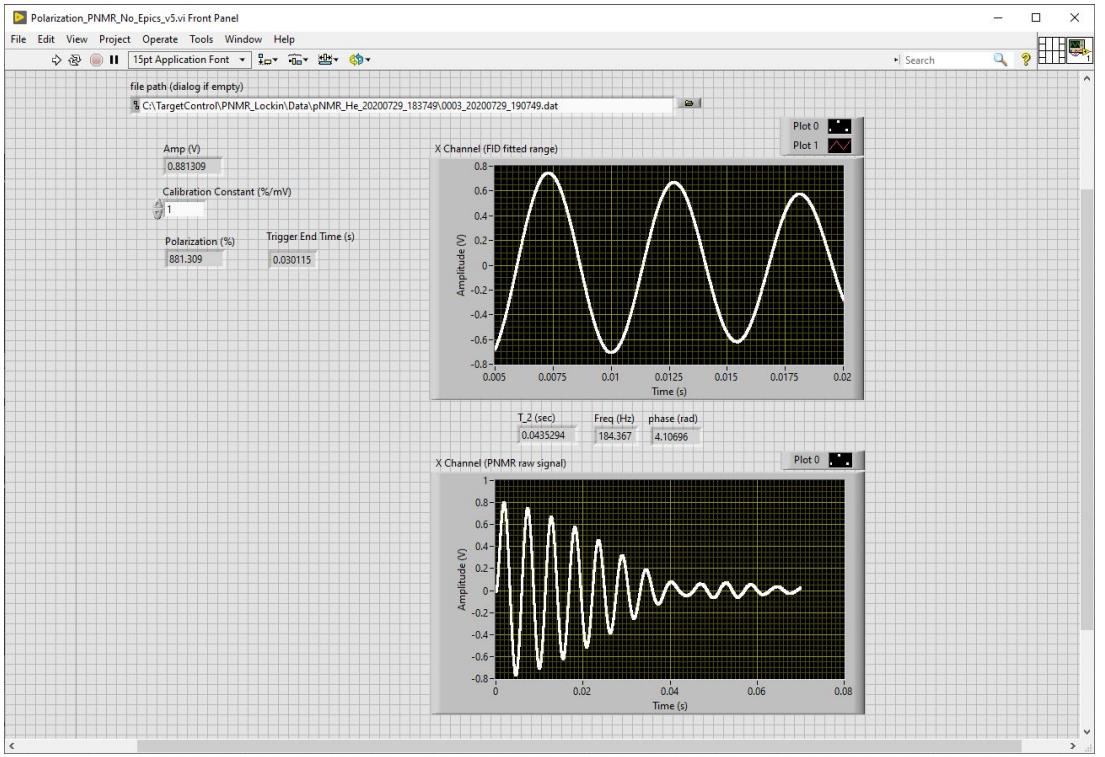


- Typical PNMR signal and signal fit
- Condition: pulse freq= 80.57 kHz, RF freq=80.28 kHz, t_pulse=1 ms, df=290 Hz
- Target spin 180deg with HB on for 11 deg, -7.5 GeV
- VL=4.7A, VS= 6.9A with convection at 9V

- 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.



FID Freq Correction On Signal Amp

(with respect to PNMR Pulse freq)

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

$$\omega = -\gamma H$$

where γ=-3.2434 kHz/G is ^{3}He gyro-magnetic ratio.

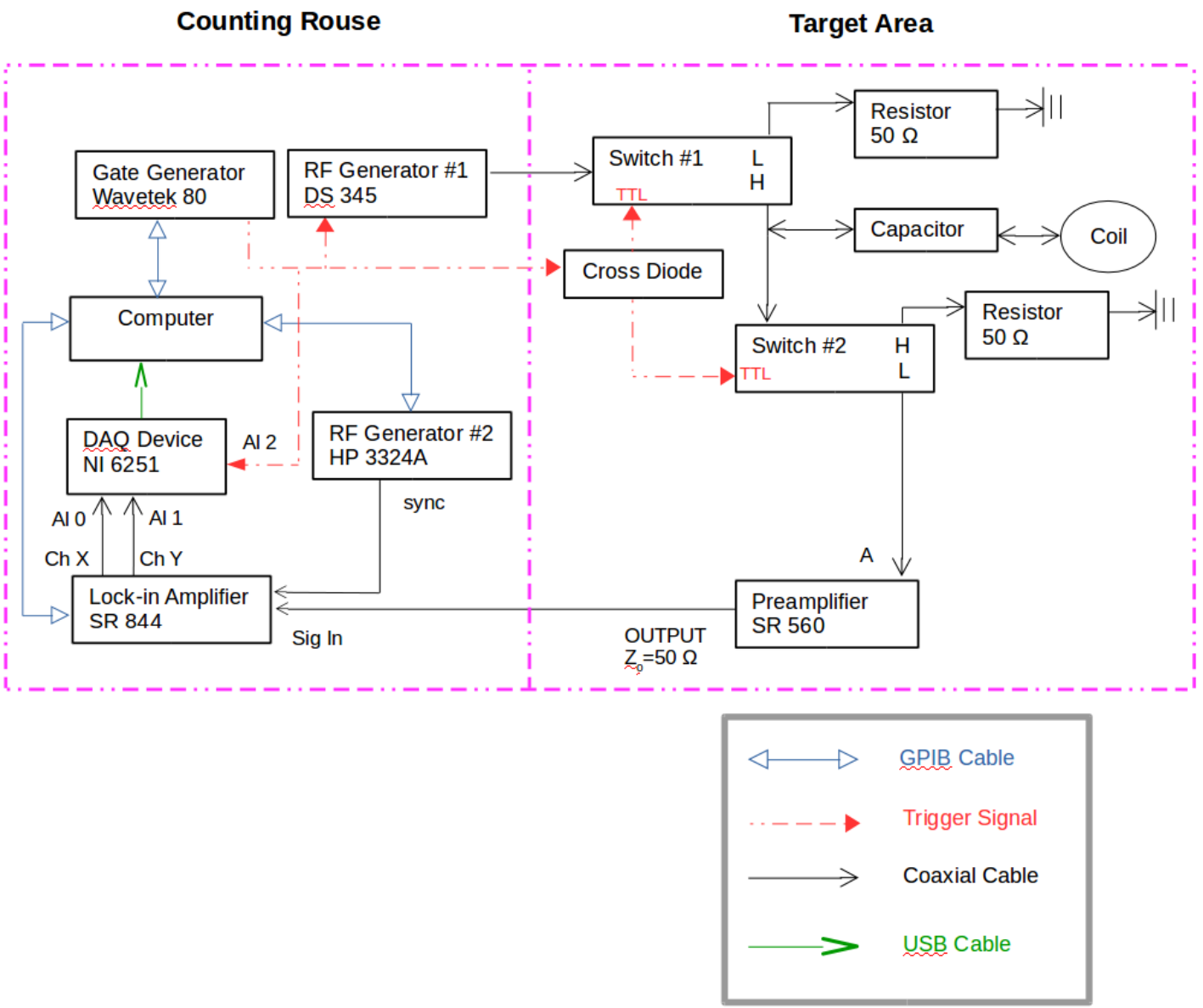
- This means for holding field gradient be 30 mG around PNMR coil region, we will have about 100 Hz freq shift for ^{3}He Larmor freq.
- The usage of a Lock-in amplifier makes the frequency for obtained FID signal becomes difference between Larmor freq and Lock-in amplifier reference freq.
- From initial 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=+0.3.

Note: for current PNMR system set up, set the reference freq ~285 Hz below the pulse freq.

PNMR with Lockin SR844 and DAQ Setup



- Keep Holding filed at 25G along z-direction (along beam direction) by Helmholtz coil.
- For Preamplifier the bandpass is 10 kHz to 100 kHz; the preamplifier 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}=1.0ms; 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.

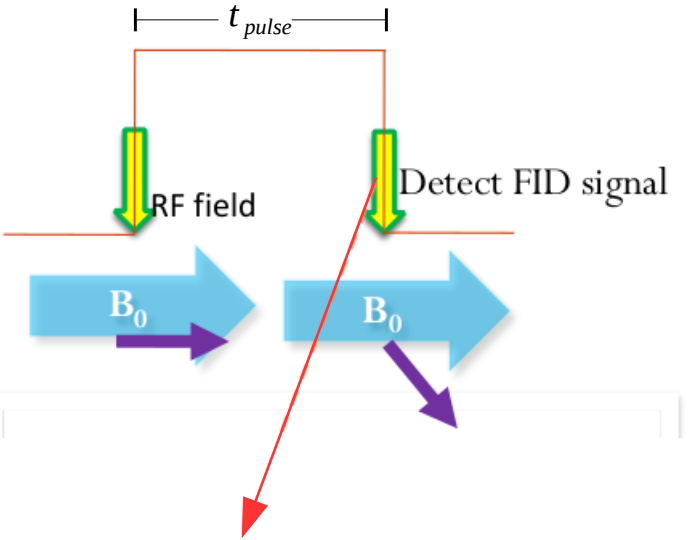
Pulse NMR Polarimetry

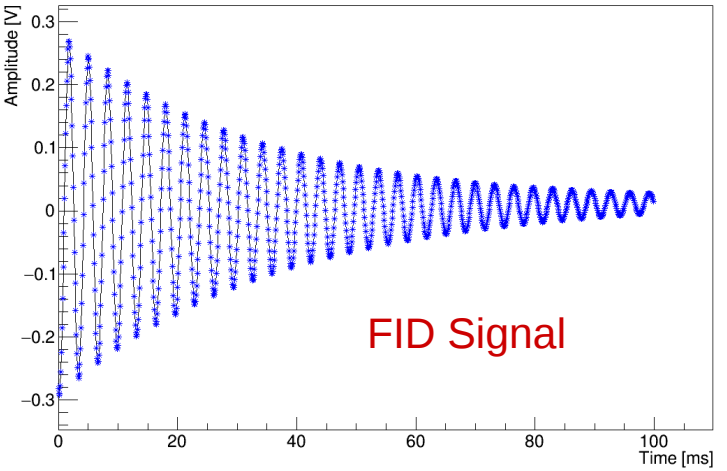
Advantage:

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

Principle:

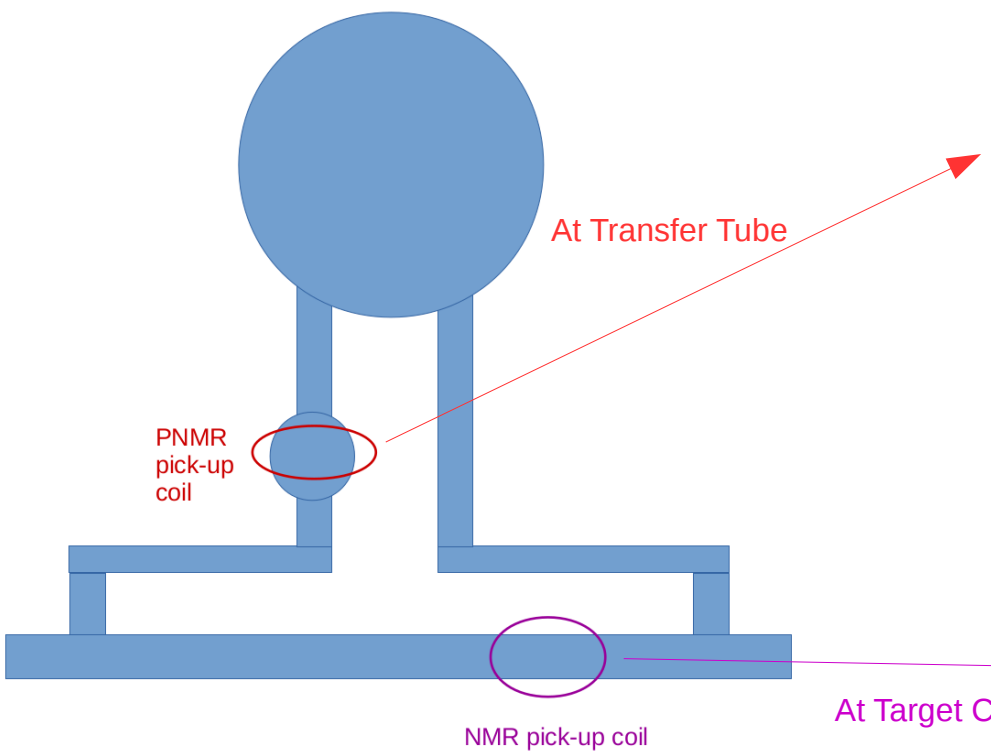
- Send a RF pulse at Larmor frequency which tips ^{3}He spin away from holding field axis: $\theta_{tip} = \frac{1}{2}\gamma H_1 t_{pulse}$
- When pulse ends, the spin precesses back to its initial state and experience free induction decay (FID).
- FID signal is picked up by the PNMR coil. Measure the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

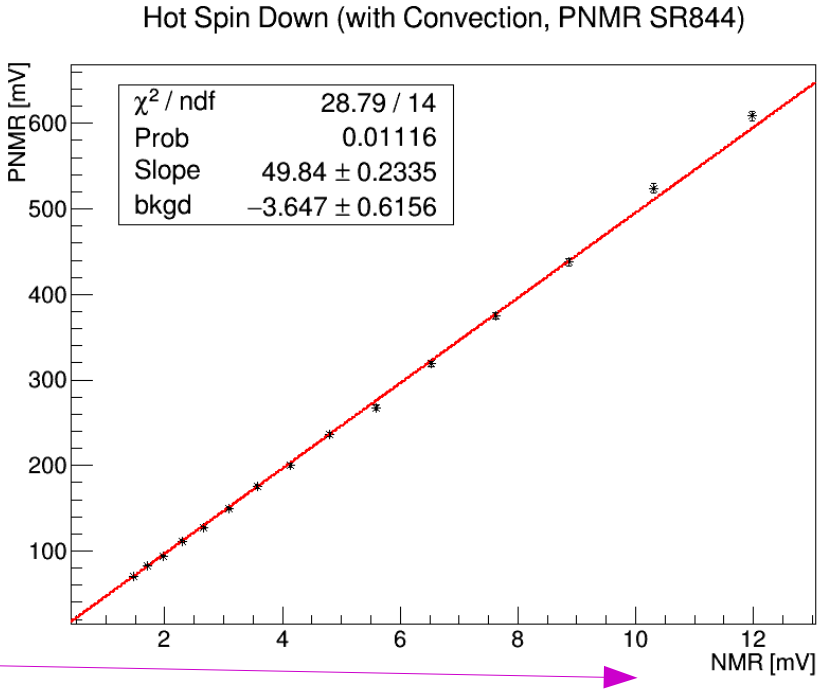




$$S(t) \propto M_z \sin(\theta_{tip}) \cos(\omega t + \phi_0) e^{-t/T_2}$$

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





- Hot spin down with convection 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.