Pulse NMR with Lockin and DAQ

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Outline:

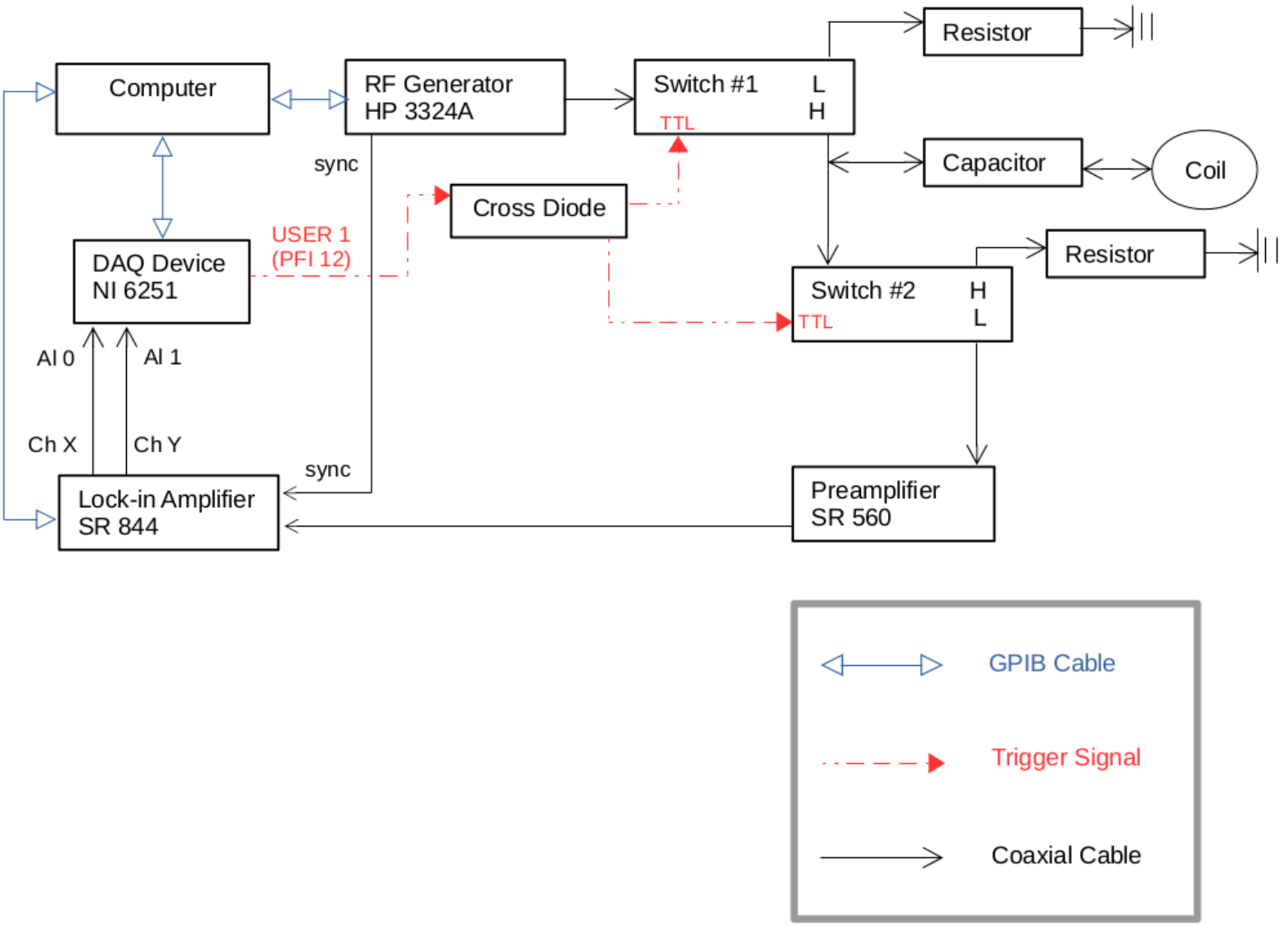
1. Pulse NMR Polarimetry
2. PNMR with Lockin and DAQ set up
3. Advantage for PNMR with Lockin/DAQ
4. PNMR vs. NMR calibration
5. Improvement on precision of PNMR measurement
6. Future work

Pulse NMR Polarimetry

- Holding field (H0= 25 Gauss) is applied along the He spin axis
- Perpendicular RF pulse close to Larmor frequency is sent to the PNMR coil. (f_RF=80.8 kHz, Larmor frequency ~81.1 kHz)
- RF pulse tips spin away from holding field axis
- When pulse ends, the spin precesses back to its initial state
- Spin precesses at Larmor frequency and experience free induction decay (FID)
- Signal is picked up by the PNMR coil
- Calibrate PNMR with NMR

  (NMR polarimetry is well established, relate to He polarization directly)

PNMR set up with Lock-in Amplifier and Fast DAQ Card



Advantage for PNMR with Lockin/DAQ

- The original setup is PNMR with Oscilloscope

  Disadvantages: large resolution uncertainty

  1. Vertical resolution: 8bit (Oscilloscope 1002B）

     0.8% resolution uncertainty compared to signal (measured by full scale).

  2. Vertical scale: changed manually depends on signal level.

     Hard to estimate the signal level manually. In general, the signal is not measured by full scale which results even greater resolution uncertainty.

- The new setup is PNMR with Lockin/DAQ

  Advantages: small resolution uncertainty

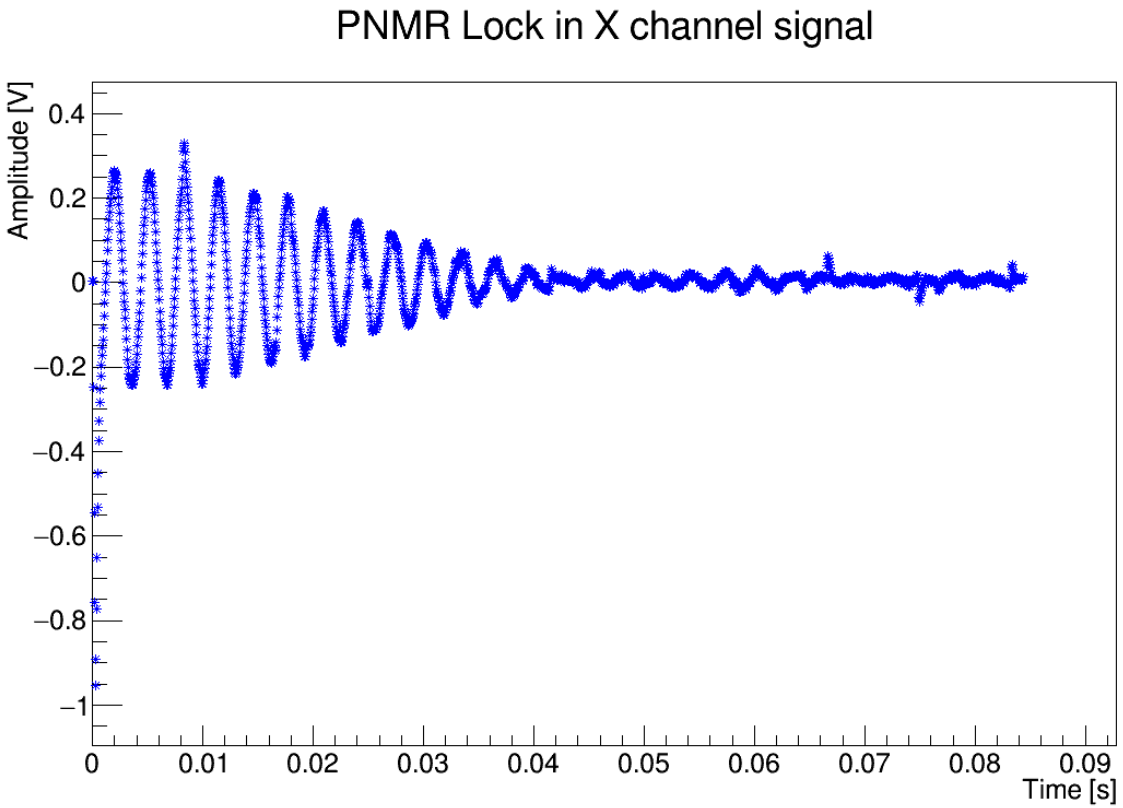
  1. ADC resolution: 16 bit (DAQ NI 6251)

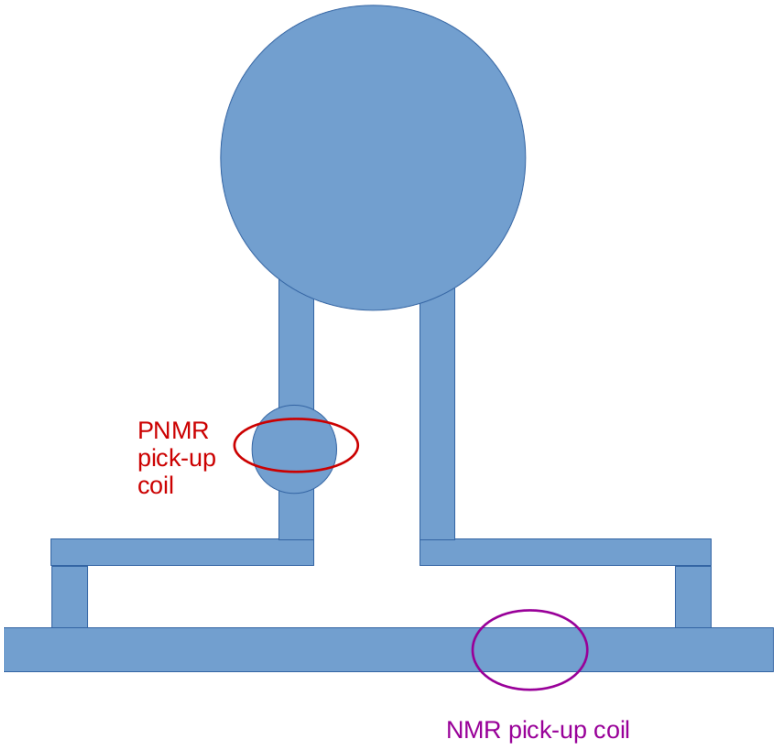
  0.003% resolution uncertainty compared to signal (measured by full scale).

  2. Vertical scale: handled by Lock-in amplifier’s sensitivity

  Automatically sets the sensitivity based on detected signal.

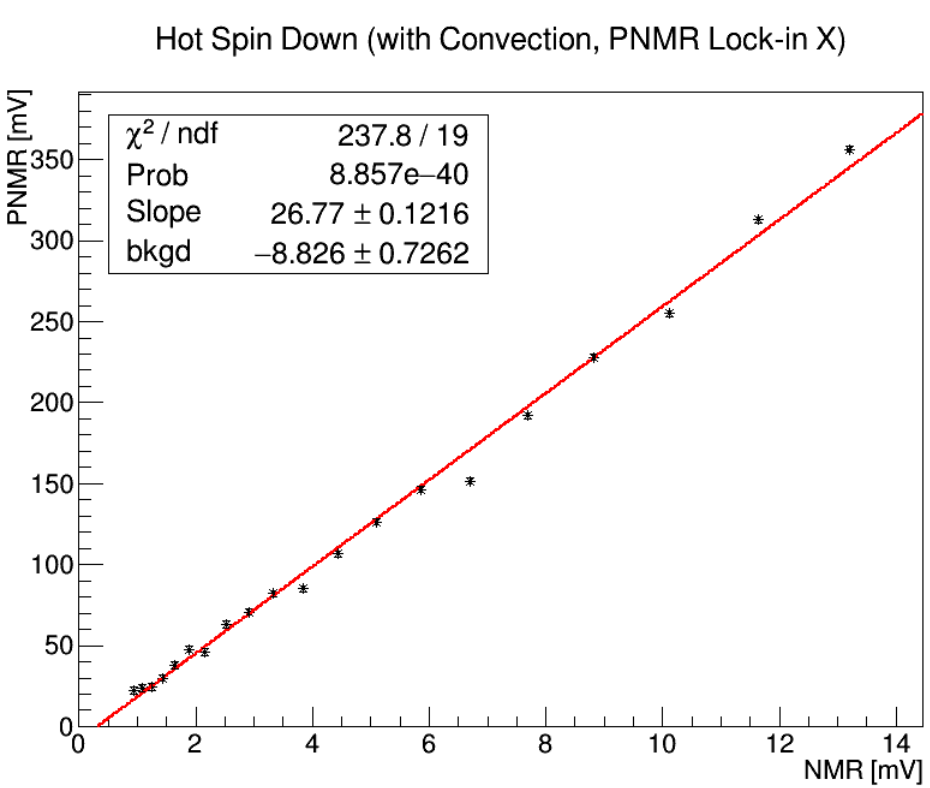
PNMR (at transfer tube) vs. NMR (at target chamber)

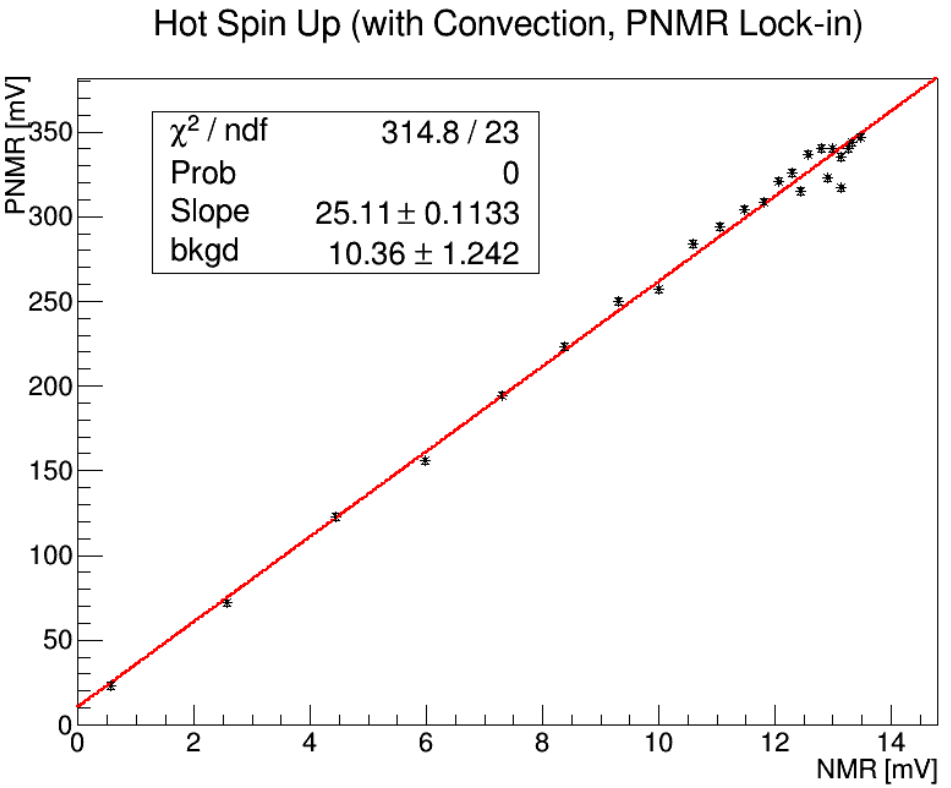




- Successfully obtained the FID signal for PNMR with Lockin/DAQ.
- Then took PNMR and NMR measurements together for calibration.

PNMR (at transfer tube) vs. NMR (at target chamber)





- Hot (oven temperature ~211 degree Celsius)

  Spin up and spin down measurements (1 hour). With convection.

  Pulse NMR measured around 1-inch sphere on the transfer tube.
- Still need to improve the precision of PNMR measurement.

  For calibration, PNMR vs. NMR curve should be more linear.

Improvement on Precision of PNMR Measurement

- Some Noise sources for PNMR signal:

  1. AG series RF amplifier: high frequency noise.

  2. RF switches transient response: a wide bandwidth low frequency noise.

- How to Improve:

  1. AG series RF amplifier:

  Turn off the amplifier during PNMR measurement.

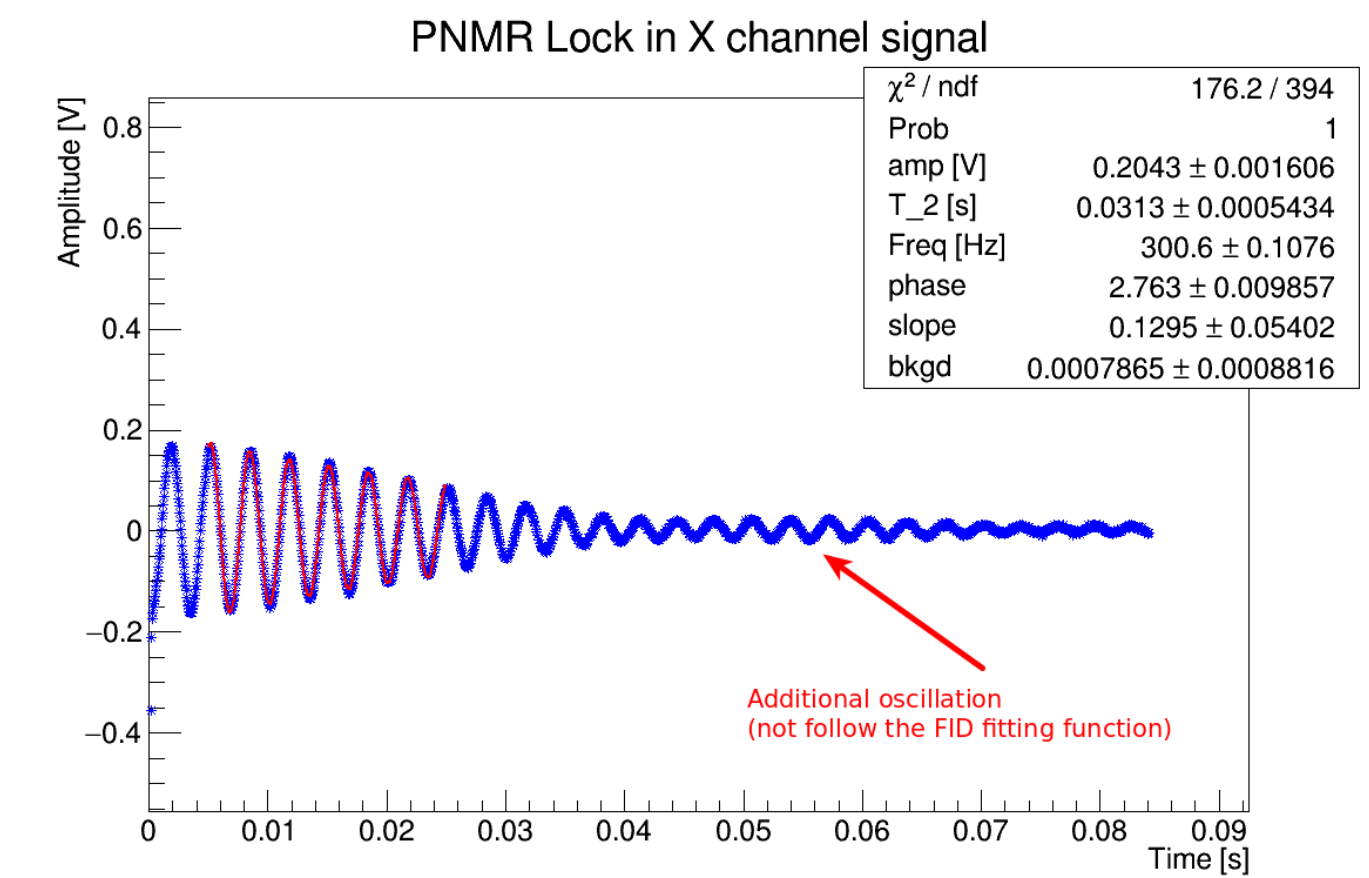
  (the amplifier is for NMR AFP measurement)

  2. RF switches transient response:

  Use lower time constant for Lockin low pass filter will reduce the residue of the transient response on PNMR signal after a short time.

  (Changed the Lockin amplifier from SR844 to SR830 to get tau=30 us)

Improvement on Precision of PNMR Measurement



- Obtained a cleaner PNMR signal.
- Current fit for the signal (from 5 ms to 25 ms) by the FID fitting function:

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

- More work need to be done on study the systemic error for PNMR signal as well as understand the oscillation which do not follow the FID fitting function.

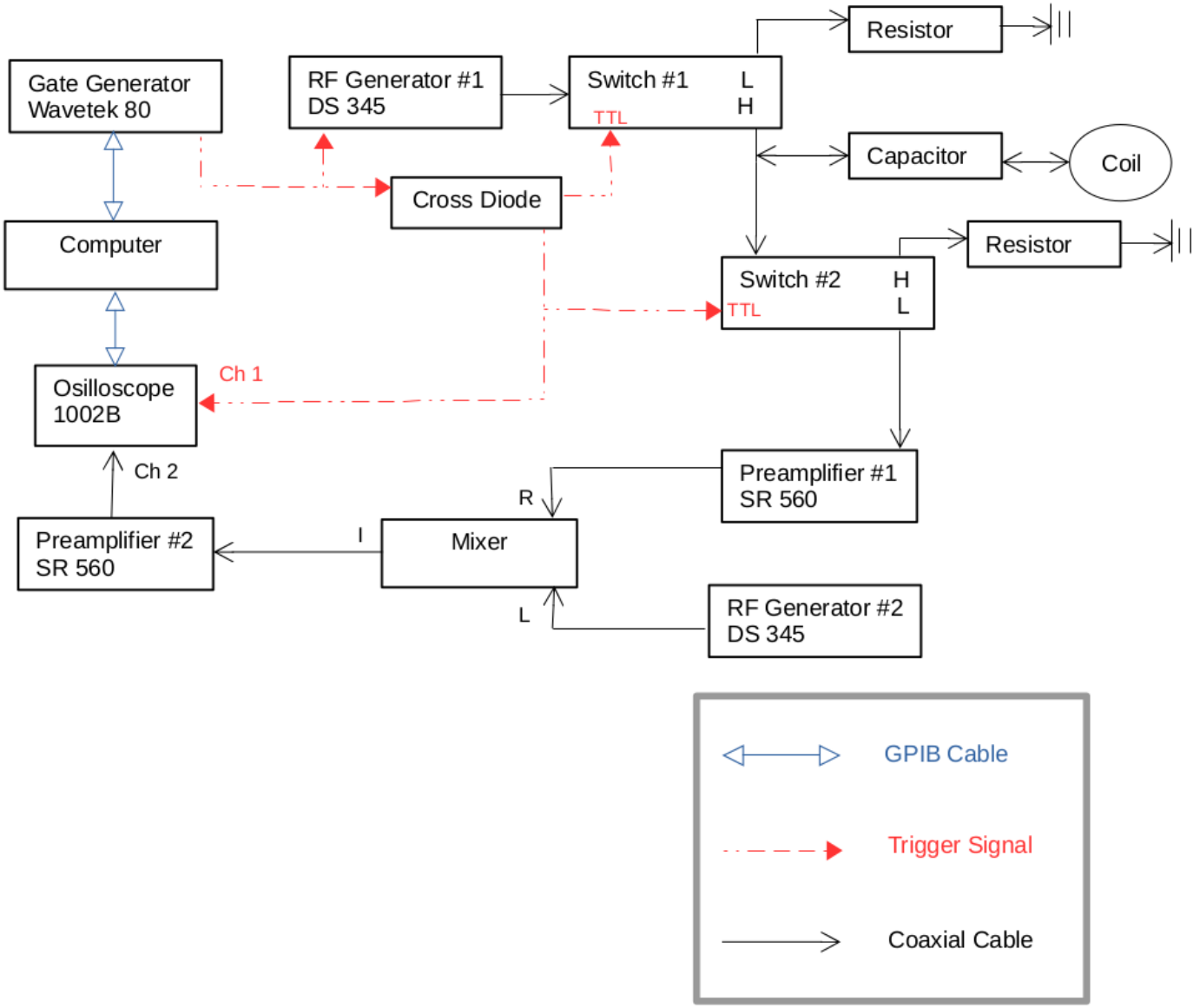
Future Work

- Find out the cause for oscillation which do not follow the FID

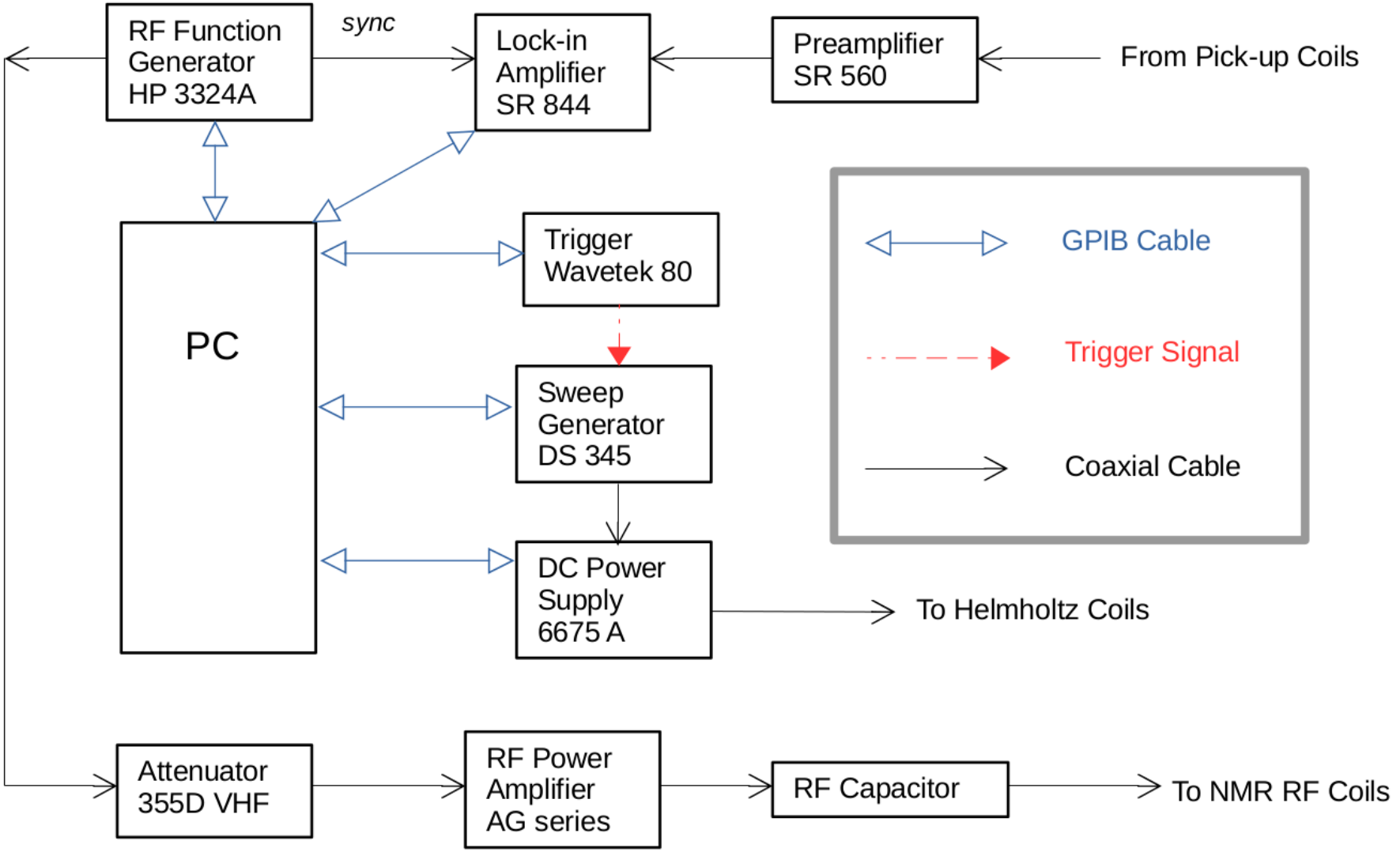
  (might need to develop a better fitting function)
- Have a more detailed study and reduce the systemic noise on PNMR signal.
- Take more PNMR measurements with similar NMR amplitude to study the statistical error.
- Calibrate PNMR with Lockin/DAQ with NMR up to 1% uncertainty.

Backup Slides

PNMR set up with Oscilloscope



NMR Setup


RF Function Generator HP 3324A
sync
Lock-in Amplifier SR 844
Preamplifier SR 560
From Pick-up Coils
PC
Trigger Wavetek 80
Sweep Generator DS 345
DC Power Supply 6675 A
To Helmholtz Coils
GPIB Cable
Trigger Signal
Coaxial Cable
Attenuator 355D VHF
RF Power Amplifier AG series
RF Capacitor
To NMR RF Coils