DSG – HDice Meeting

Date: August 20, 2020
Time: 2:00PM – 3:15PM

Attendees: Peter Bonneau, Aaron Brown, Pablo Campero, Tyler Lemon, Marc McMullen, Tom O'Connell, Xiangdong Wei

1. Lock-in amplifier *X* and *Y* acquisition will be removed from fsNMR program and replaced with a calculation using lock-in amplifier amplitude and phase.
    1.1. Acquisition of *X* and *Y* initially requested as it was thought to be faster than calculating *X* and *Y* from amplitude and phase.
        1.1.1. Time difference in LabVIEW between acquisition and calculation of *X* and *Y* are insignificant.
    1.2. Formula calculating *X* and *Y*

$$X = R\cos(\phi)$$

$$Y = R\sin(\phi)$$

$R =$ Amplitude measurement at frequency f
$\phi =$ Phase measurement at frequency f

    1.3. Formula used for S_x and S_y, scaled *X* and scaled *Y*

$$S_X = \frac{R - R_{0bkgd}}{R_{bkgd}} R_{0bkgd} \cos(\phi - \phi_0)$$

$$S_Y = \frac{R - R_{0bkgd}}{R_{bkgd}} R_{0bkgd} \sin(\phi - \phi_0)$$

$R =$ Amplitude measurement at frequency f
$R_{0bkgd} =$ Absolute maximum amplitude of background data
$R_{bkgd} =$ Background amplitude measurement at frequency f
$\phi =$ Phase measurement at frequency f
$\phi_0 =$ Phase of background data at R_{0bkgd}

2. DSG and HDice will coordinate usage of NMR rack PCs and Zurich Lock-in Amplifier.
    2.1. PC needed for development and debug of new requested fsNMR features and Zurich lock-in amplifier acquisition program.
    2.2. Email will be sent to inquire whether PC/instrumentation is in use.
    2.3. Response will be either approval to use PC or a time when PC is available.
    2.4. When running fsNMR program on NMR Rack 2 PC, Production Dewar settings will be used and attenuator power should be at most -25 dB.

3. Xiangdong Wei shared slides on fsNMR testing and results.
    3.1. fsNMR Program behaves as expected.
    3.2. Data Review program works as expected.
    3.3. Slides shared are below.

4. Xiangdong Wei presented slides on program needed for Zurich Lock-In Amplifier.
    4.1. Program is a long-term project that incorporates setting Zurich lock-in amplifier, background data readback, and cycle averaging.
    4.2. Slides shared are below.

Testing fsNMR with a Standard CH2-G14 Cell in cold PD-1

Xiangdong Wei

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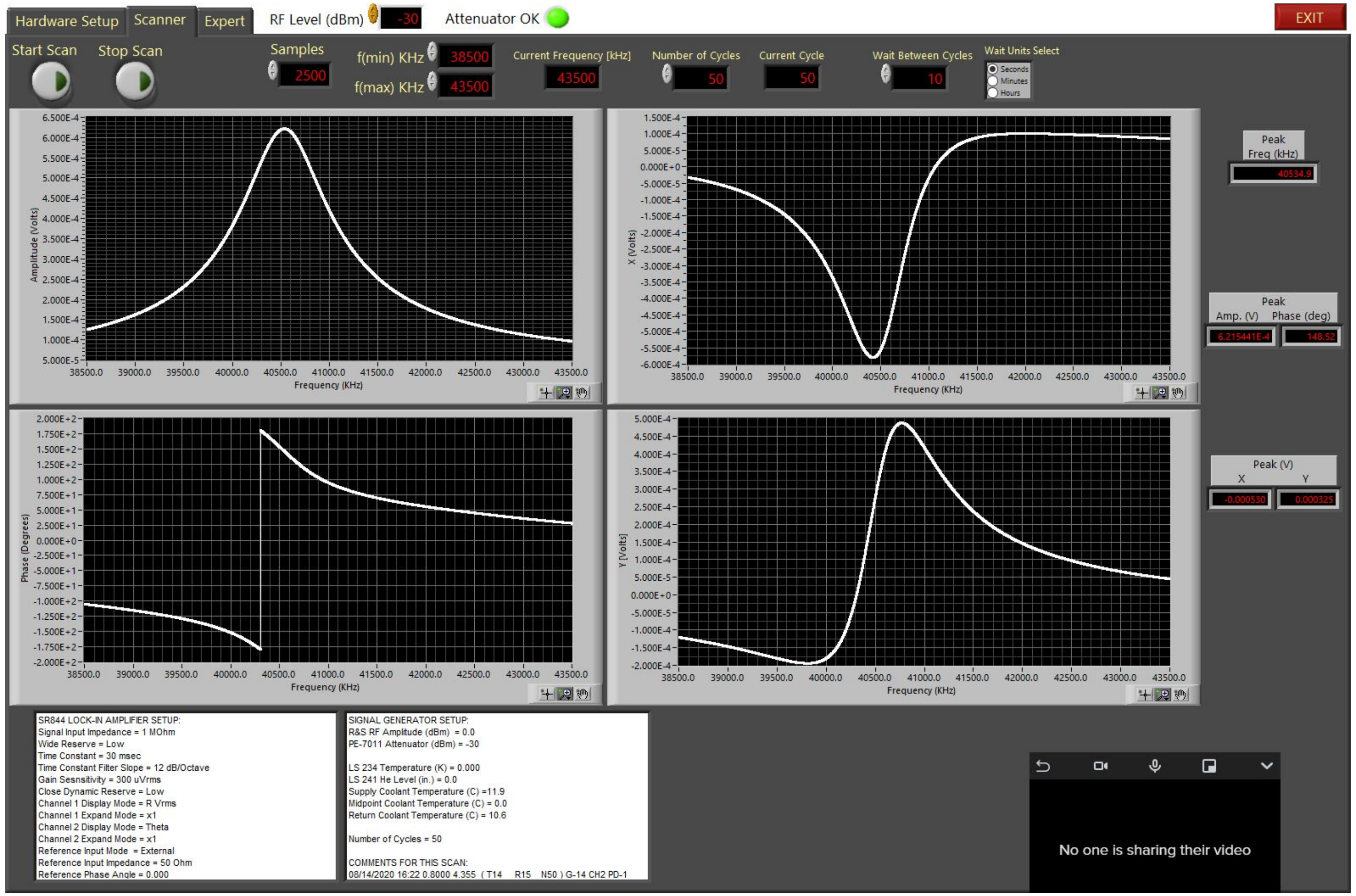
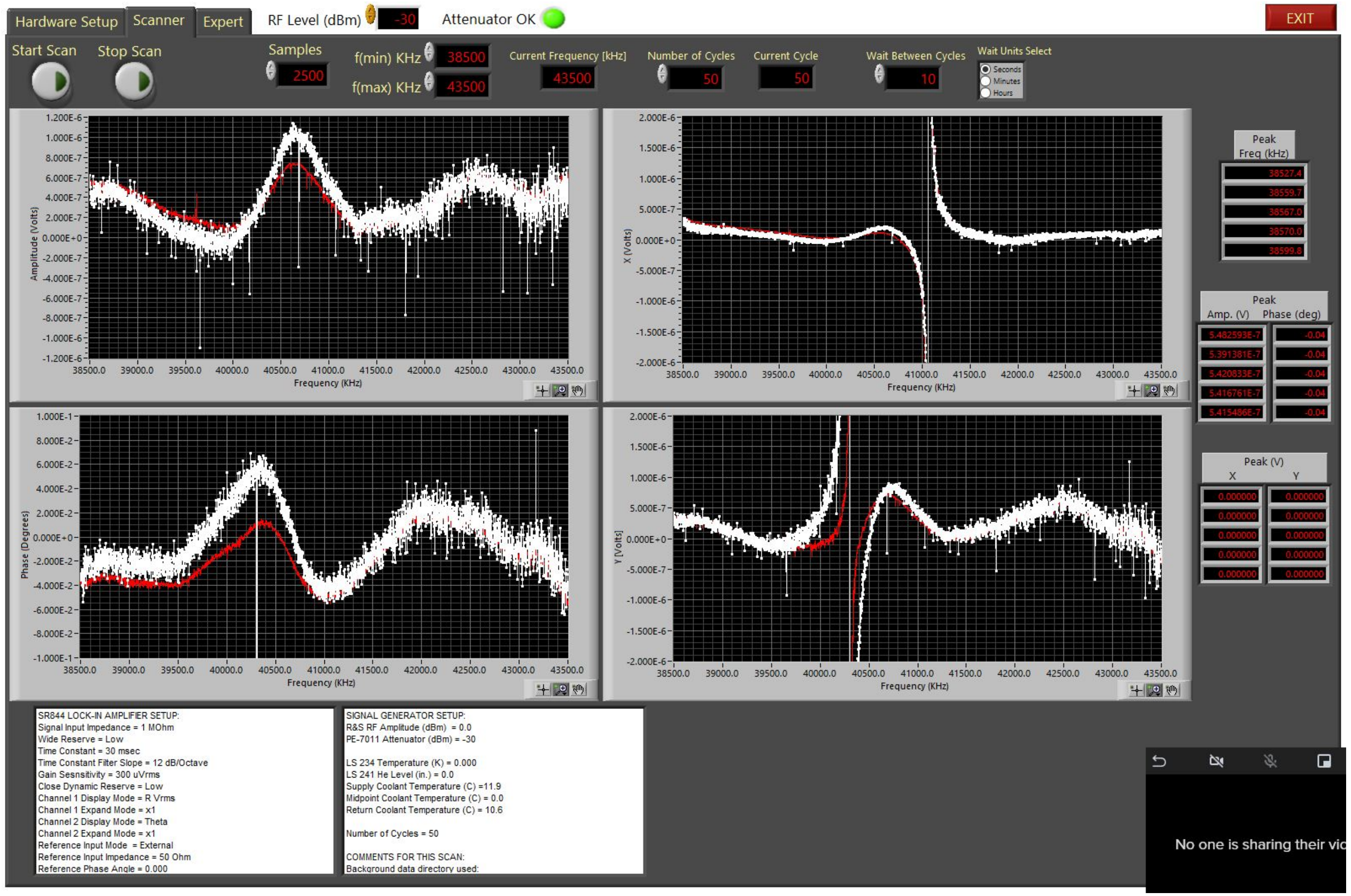
- The fsNMR program has been tested in cold PD-1 with a standard G14 size CH2 target cell for a week.
- Real NMR signals were measured in different conditions.
- In order to see the proton signal, which is a very small fraction of the detected RF signal at 4K and 1 tesla, the frequency swept ranges were shifter away from the “zero crossing” of X and Y channels. This situation will be eliminated when we implement the normalization with the RF amplitude curve, R.

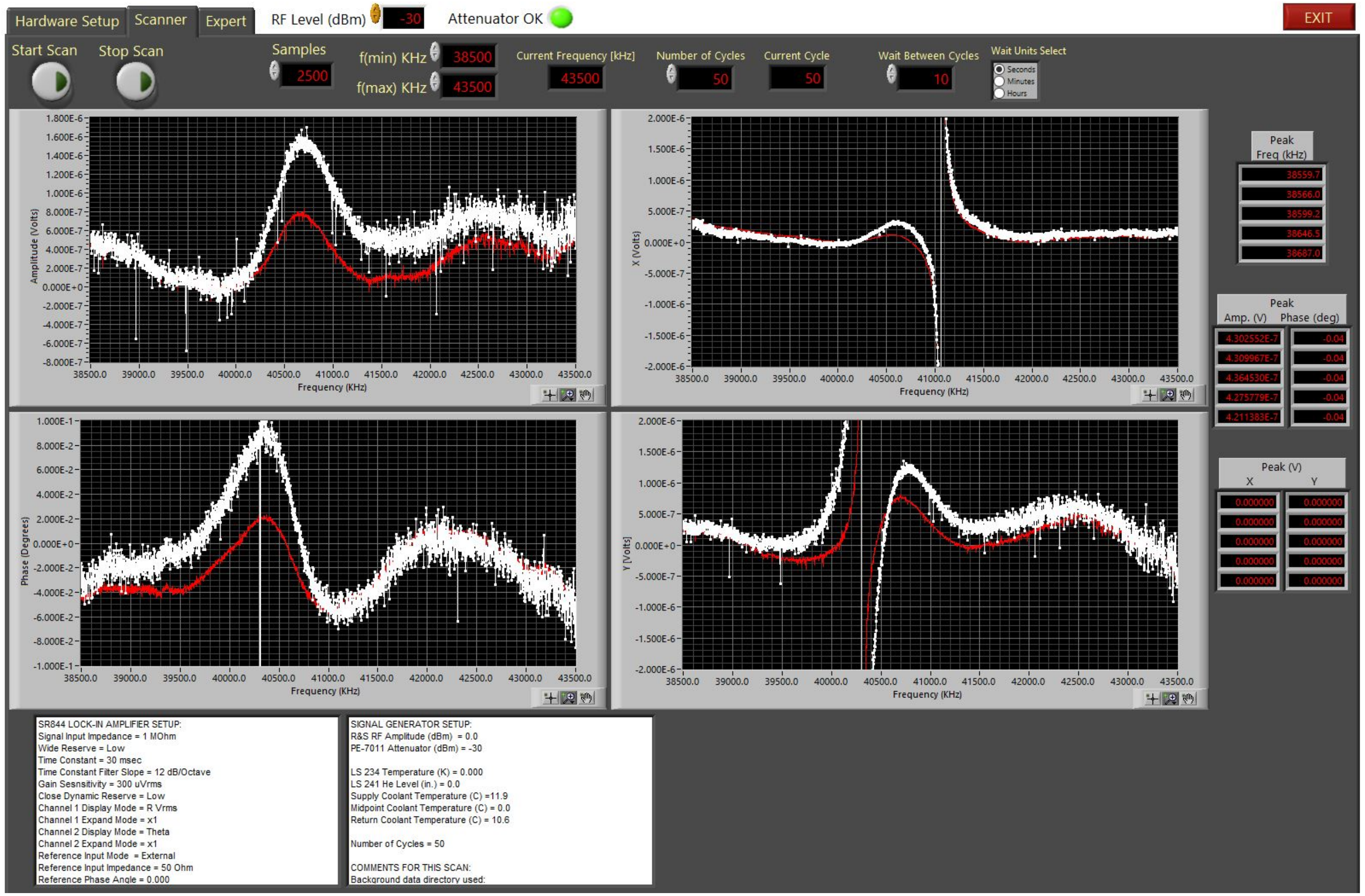
Measured RF amplitude curve, R, as the NMR background



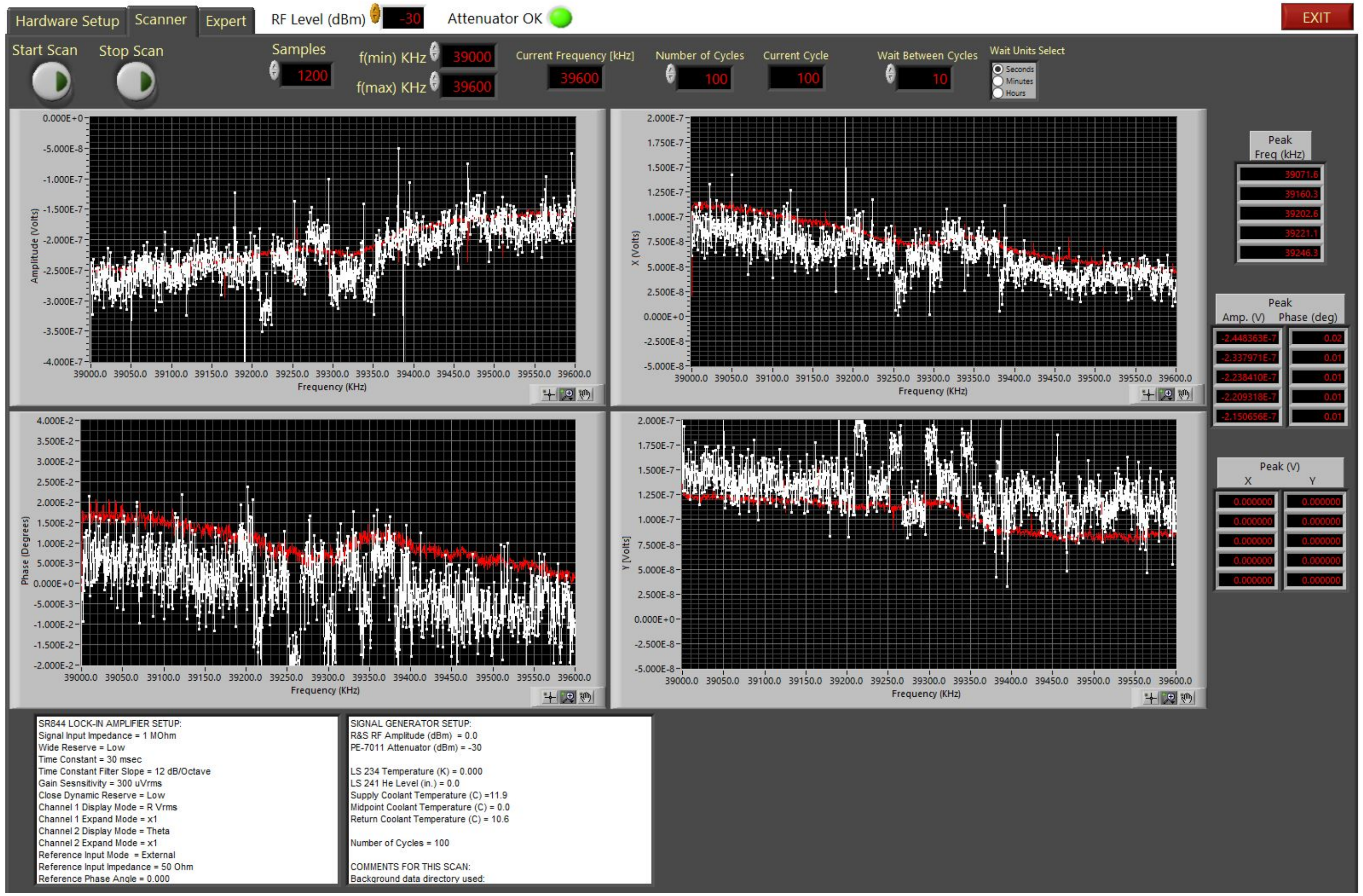
Measured NMR signals with -30dBm at ~41350kHz, (S~10^{-8}V, covered by the noise) and 0.9747Tesla.



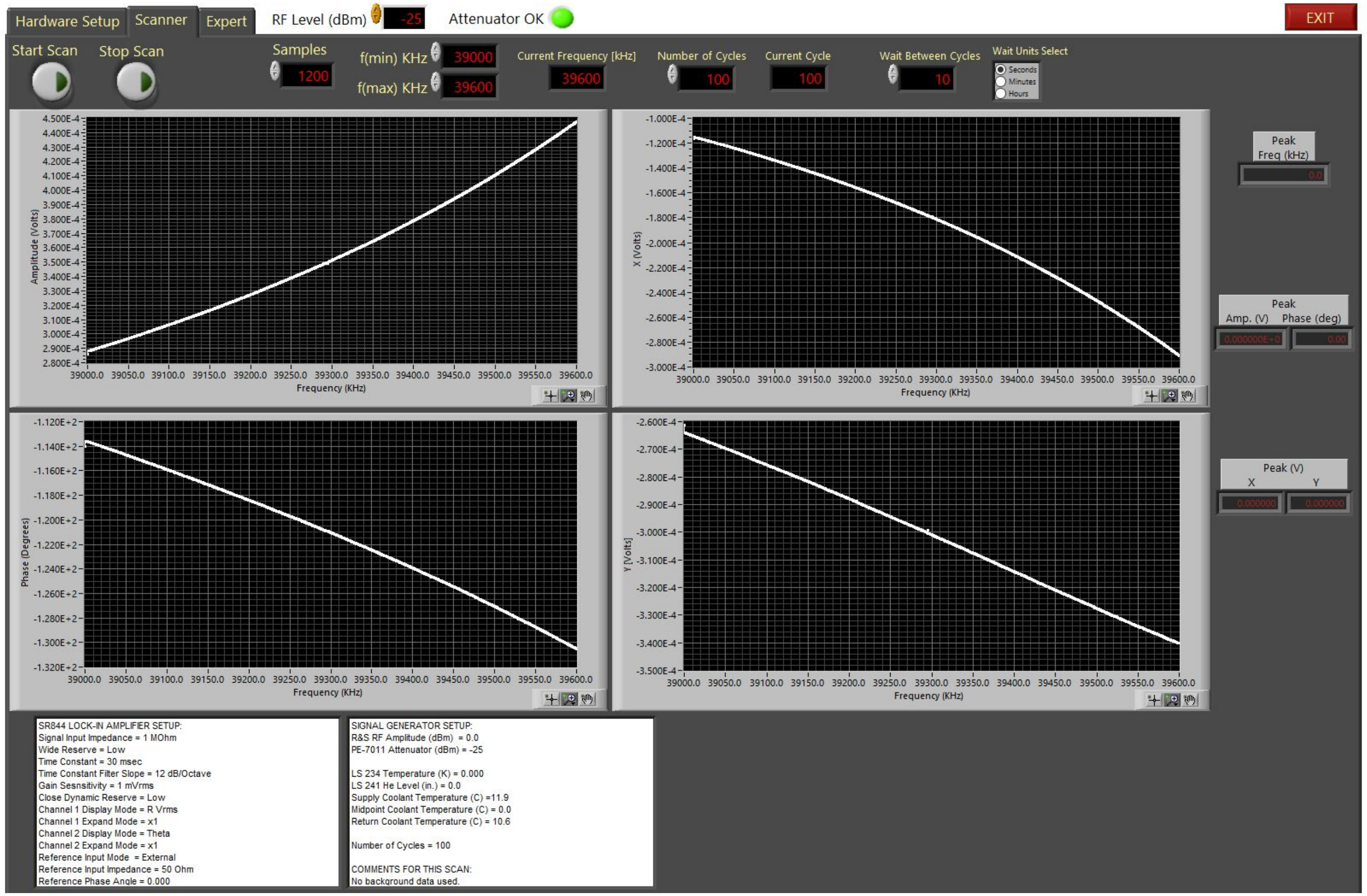
Measured NMR signals with -30dBm at ~40350kHz, and 0.9277Tesla. (the signal can be seen as the small wiggle on phase plot)



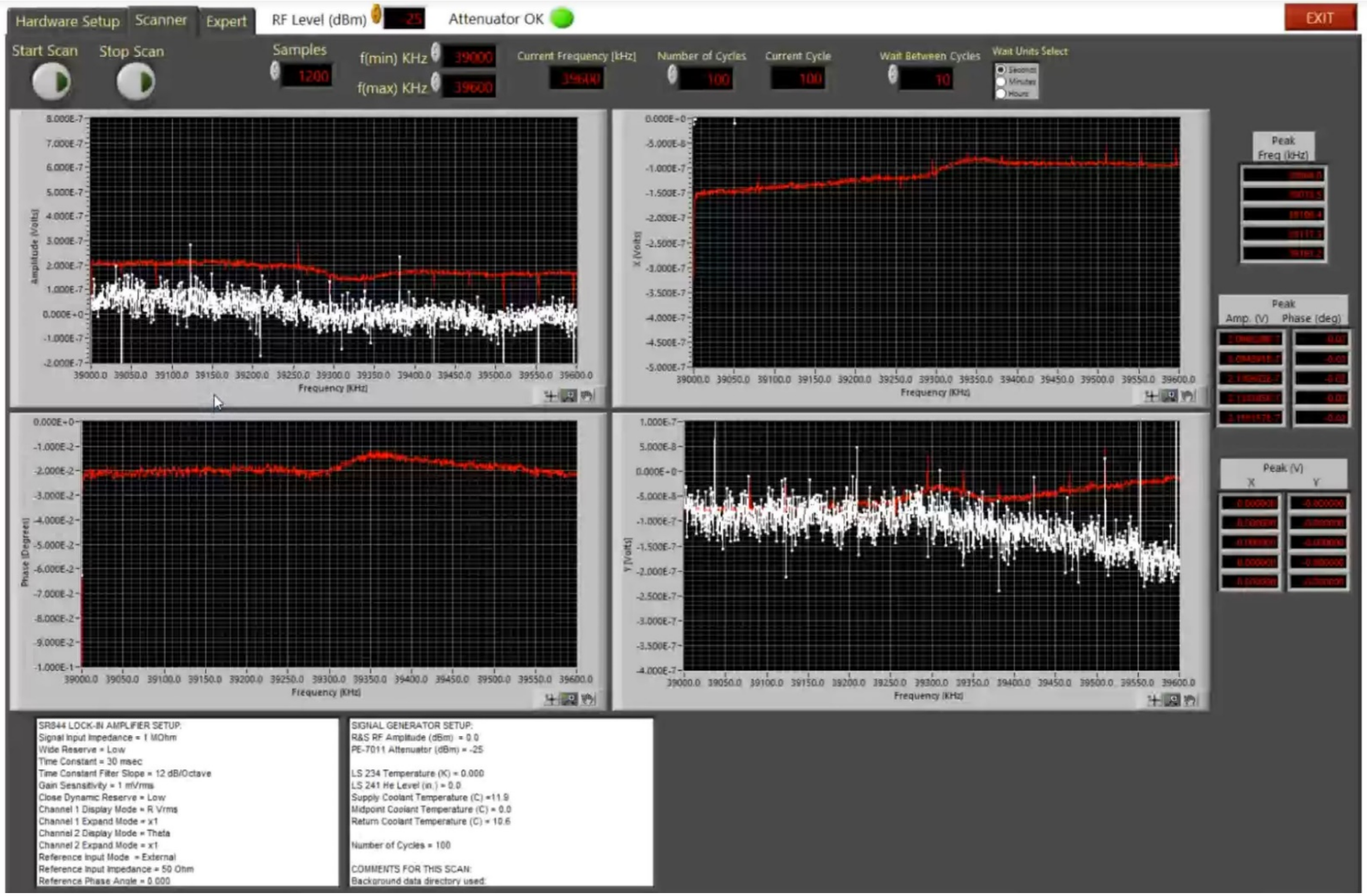
Zoomed in the RF frequency with -30dBm ($S \sim 10^{-8}$V, covered by the noise) and 0.9277Tesla. The averaged signals can be seen, behind live trace, in all 4 plots.



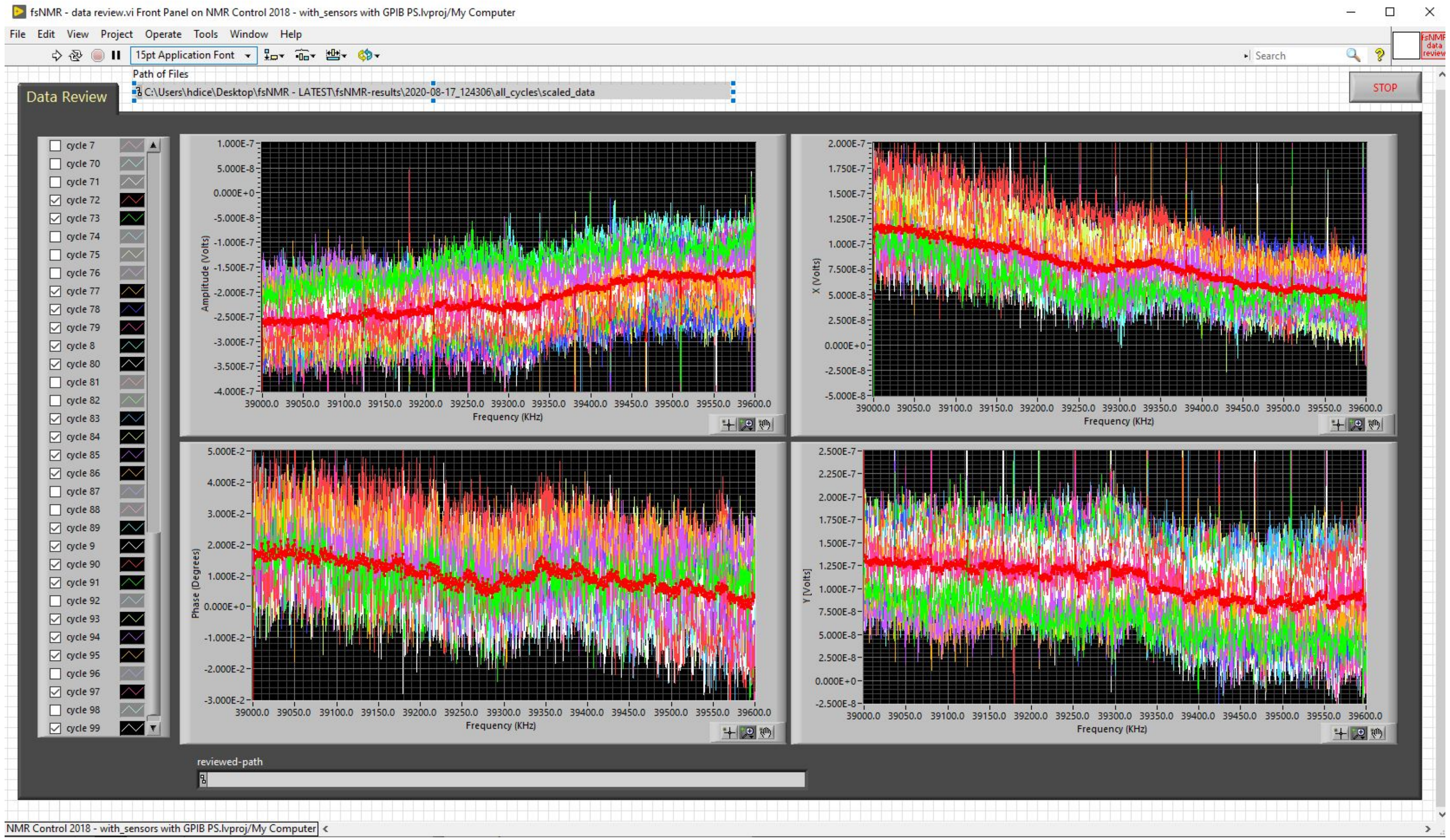
To improve S/N, background signal was measured at -25dBm and 0.8000Tesla. *The tiny jump at the left edge was the reason to skip some points when determining maximum for data normalization.*



NMR Signal was measured with -25dBm and 0.9277Tesla. The S/N was clearly improved (The potential cost would be more polarization used). The RF jumps, seen more clearly in the previous picture, posed less of the problem now.



The fsNMR reviewer program are being tested. Here shows the -30dBm at 0.9277T plots.



Proposed Software to Control UHFLI Lock-in Amplifier

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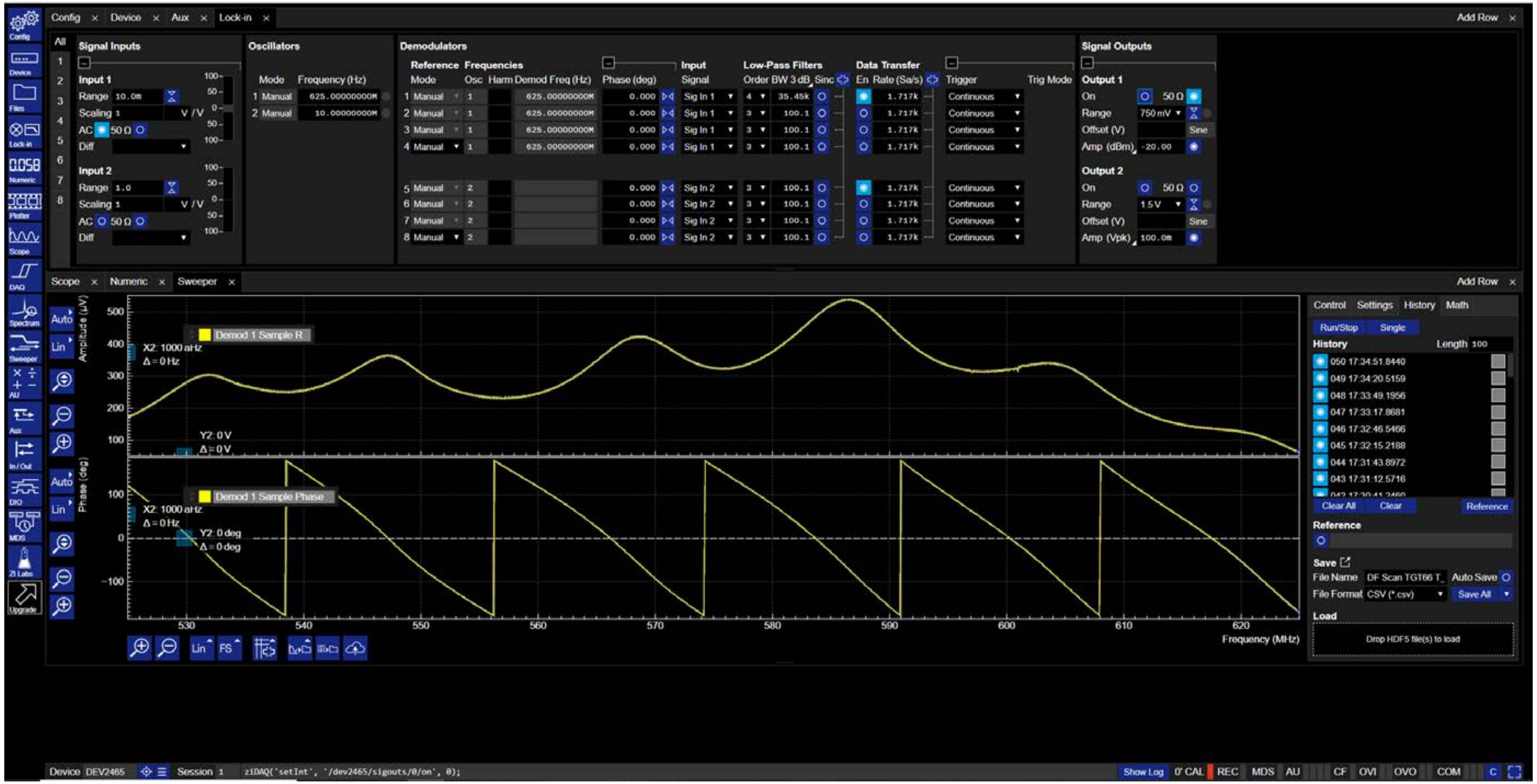
What we have

- UHFLI, the Zurich Instruments 600 MHz Lock-in Amplifier
  - Up to 600MHz
  - 2 Independent Lock-in Amplifiers in 1 case
  - 2 Built in RF Synthesizers
  - Control software, LabOne toolset
  - ….

What we know so far

- We can use the Frequency Sweep in LabOne to measure NMR signal
  - Manually trigger frequency sweeping for:
    - Setting running parameters
    - Recalling background data
    - Running background subtraction and data normalization
    - Recording data
    - Displaying individual traces selectively
  - But without further programming, one can not
    - Average data
    - Recall background
  - We haven’t explored the built-in simple math function yet.
  - The RF (power) setting can easily be altered unintentionally.
  - ….

Sample Screenshot



What we want

- A control program to add the missing functions so we can use an user setup file (or a GUI) to:
  - Setup RF conditions
  - Setup data path
  - Setup background files
  - Run data aquization
  - Subtract background and normalize data
  - Average the results
  - Display live and averaged signals
  - Save data file and final screen image
  - ….
- Basically, an overall later to add the missing functions for measuring NMR signals with frequency-scan mode at separately set magnetic field.