Status of New HDice NMR Rack Testing

12/01/2106

- Signal and Noise Measurements
- Labview Program Tests
- Summary

Purpose

A series of tests were conducted with the new NMR rack and a cryostat at room temperature, after

1) each components were grounded separately,
2) the broken NMR reference cable was fixed,
3) the RF distribution box was swapped.

• The purpose of these tests is to check if the newly upgraded NMR rack is ready to be used for HDice experiments. (Note: after initial target calibrations, the rack must be “frozen” to retain the absolute polarization calibration. For that reason, it is essential to reach the final state of an NMR system before putting it into use.)

• The starting date of upgrading the second HDice NMR rack hinges on satisfactory room temperature test results and further testing with a cryostat at liquid helium temperature. (The latter will produce the real NMR signals for ultimate checking.)

Signal and Noise Measurements

- Signal
  - Scheduled to test next week. Both OLD and NEW racks will be moved near the PD, which is cold now. NMR signals produced by both racks will be compared.

- Noise
  - Noise was measured with a room temperature cryostat, PDII, and the new NMR rack. The results look promising. More tests are needed with a cold dewar and the well tuned program.

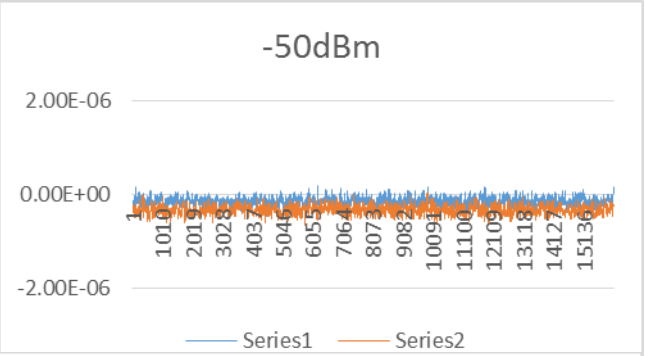
The signal-to-noise study can only be done with a fully functioned NMR rack.

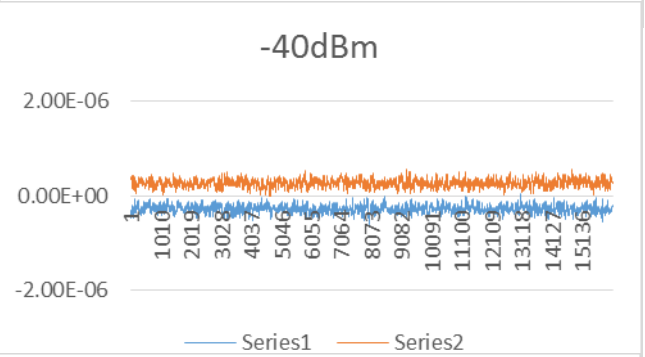
Noise test results

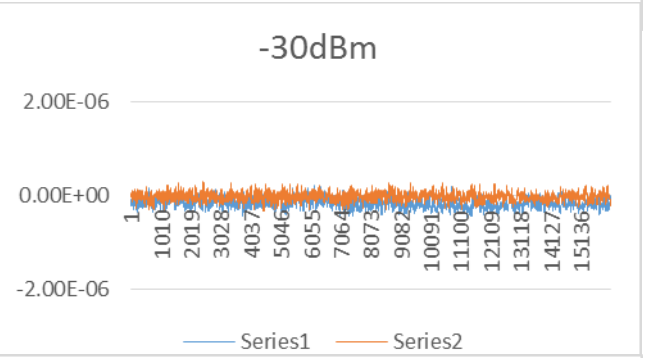
- The results of noise tests at room temperature with different RF power are shown in the slides 5, 6 and 7.

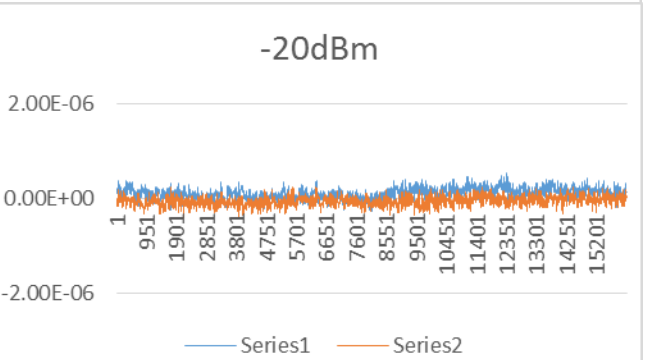
- In slides 5 and 6, the average of 4 and 200 scans, show no baseline drifting when the RF power is equal or below -30dBm (ie. at 1 microW).

- Slide 7 shows the noise variations, between -10dBm and -40dBm, calculated from slides 5 and 6. It is still dominated by the “white noise”, which is random and can be averaged out.

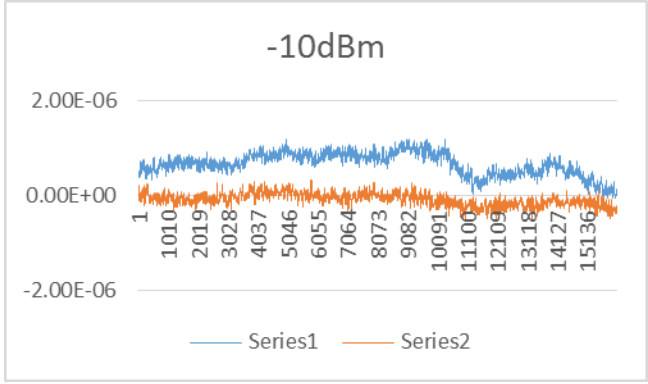








Noise (average of 4)



Standard Deviations vs RF Power

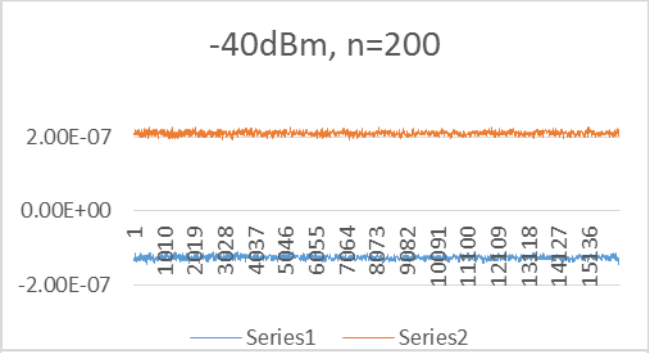
RF(dBm)	σx(V)	σy(V)
-50	1.0e-7	1.0e-8
-40	8.3e-8	8.4e-8
-30	1.1e-7	9.7e-8
-20	1.2e-7	1.0e-7
-10	2.4e-7	1.4e-7

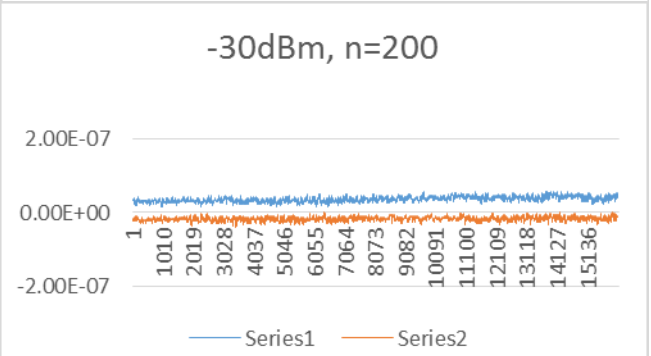
Run Conditions

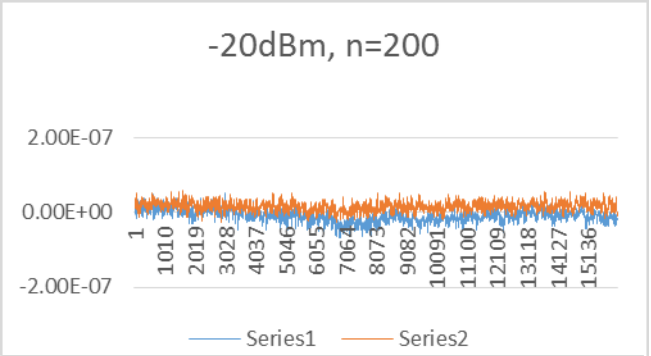
B(cntr)	B(span)	T(down)	T(Bott)	T(up)	B(wait)	T(wait)	#Cycles
250	300	30	1	30	400.00	1	4
250	300	30	1	30	400.00	1	4
250	300	30	1	30	400.00	1	4
250	300	30	1	30	400.00	1	4
250	300	30	1	30	0.00	1	4

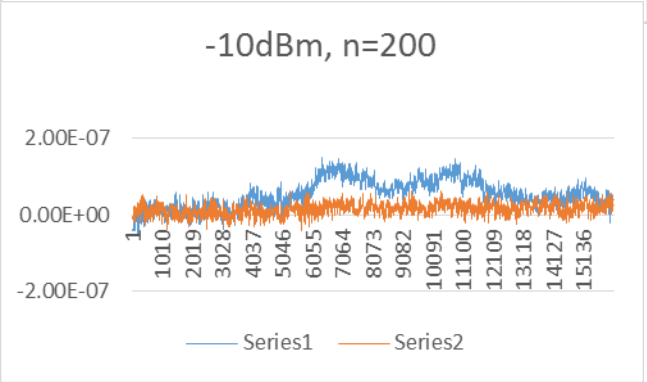
RF(dBm)	RF(KhZ)	FM(KhZ)	AF(kHz)	L1(level)	Expand	phase	LI(TC)
-50	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2
-40	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2
-30	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2
-20	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2
-10	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2

Noise was measured with applied RF power of -50dBm, -40dBm, -30dBm, -20dBm and -10dBm.









Noise (average of 200)

Standard Deviations vs RF Power

RF(dBm)	σx(V)	σy(V)
-40	5.1e-9	5.4e-9
-30	7.3e-9	5.9e-9
-20	1.7e-8	1.3e-8
-10	3.7e-8	1.7e-8

Run Conditions

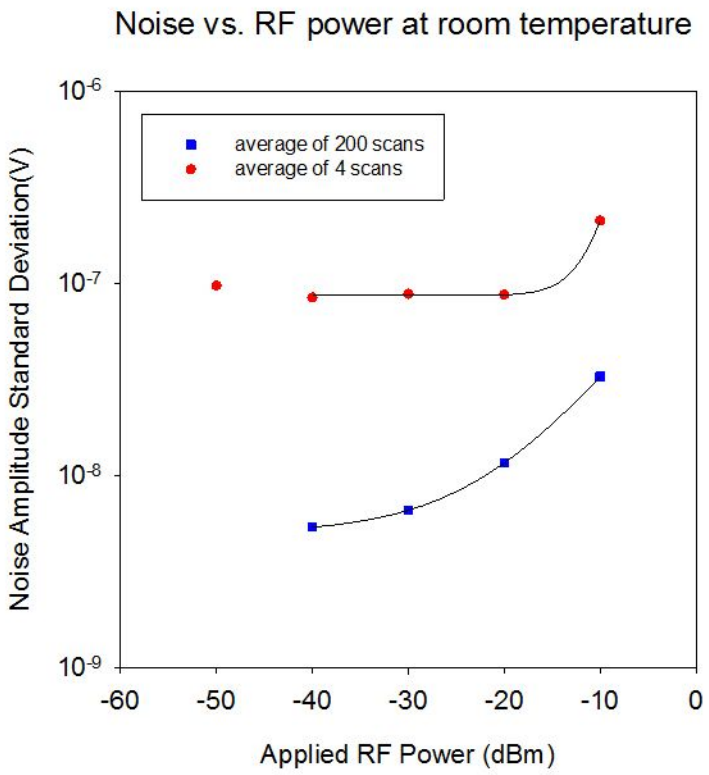
B(cntr)	B(span)	T(down)	T(Bott)	T(up)	B(wait)	T(wait)	#Cycles
250	300	30	1	30	0.00	1	200
250	300	30	1	30	400.00	1	200
250	300	30	1	30	0.00	1	200
250	300	30	1	30	400.00	1	200

RF(dBm)	RF(KhZ)	FM(KhZ)	AF(kHz)	L1(level)	Expand	phase	LI(TC)
-40	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2
-30	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2
-20	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2
-10	5344.80	0.00	0.00	1E-2	100	-47.13	3.00E-2

Noise was measured with applied RF power of -40dBm, -30dBm, -20dBm and -10dBm.

Noise

- The standard deviation of the measured noise with different RF power is plotted in the right. The red circle represents the 4-scan average and the blue square is the 200-scan average. The black lines are for guiding the eyes only.
- Since the 200-scan measurements normally require overnight and/or weekend runs, when the Test Lab human activities are at minimal, the measure noise level maybe lower than busy daytime values.
- These noise test results are promising.



Status of Testing NMR Program(s)

Two separated Labview programs, Fast Resonance Scan (FRS) and NMR Scan (NMRS), are needed for use with an HDice NMR Rack. The former is used to determine the NMR circuit RF parameters, which are used to setup the running conditions and offline target polarization calibrations and analyses. The latter (NMRS) is used to measure the actual NMR signals and monitoring polarization in situ and in online analysis.

Since the FRS has not yet been implemented on the new NMR rack, only a partial NMRS evaluation can be reported here.

- The updated Labview Program on the new HDice NMR rack is currently under evaluation, after being reconstructed in the HDice lab. After initial tuning up and RF distribution box swapping, the NMR scan program has been operated in many running conditions with a cryostat at room temperature.

- Several running conditions, including ramping range, ramping speed, scanning time, waiting time, etc, were tested so far. The newly purchased and installed current transducer and readout module (CT Box) and the Oxford IPS 120-10 power supply shunt were used alternatively for comparison.

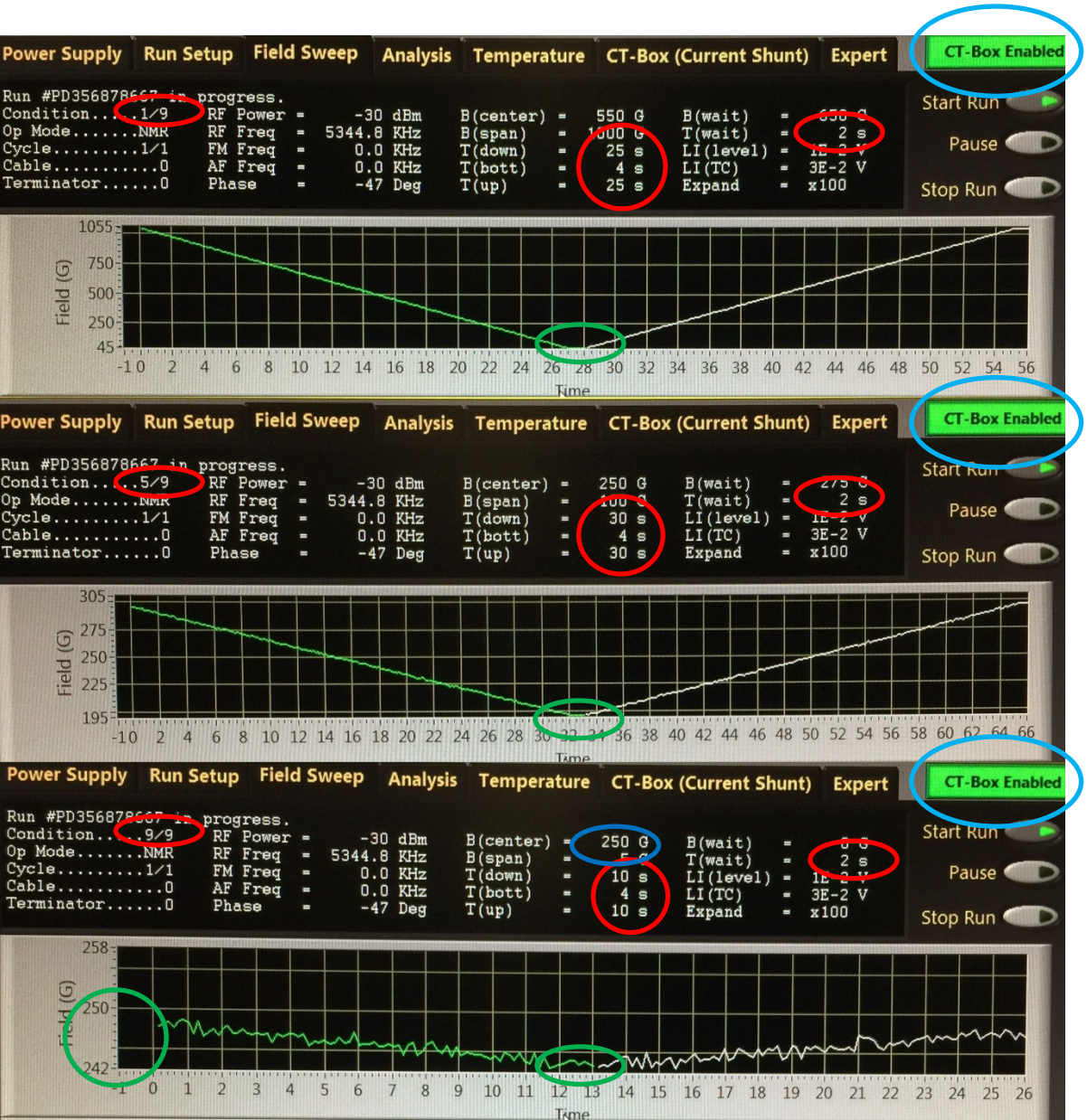
Status of Testing NMR Program(s)

- Most NMR Scan control program features tested so far are functioning. The known problems, which include the synchronized field value logging using the CT box, and field related signal averaging, have not been tested yet. The CT box hardware driver upgrade by CAEN (via DSG) is required for implementing the synchronized data logging.

- Some NMRS related problems, listed in the next few slides, have been identified during the scanning tests. These software problems may be straight-forward to fix, since most of them are related to a single aspect, field sweeping, etc.

- The testing will continue in the next few weeks, whenever the rack is not being occupied.

(A) Issues with Field Scans using the CT Box



- The running time settings are ignored. See table below.

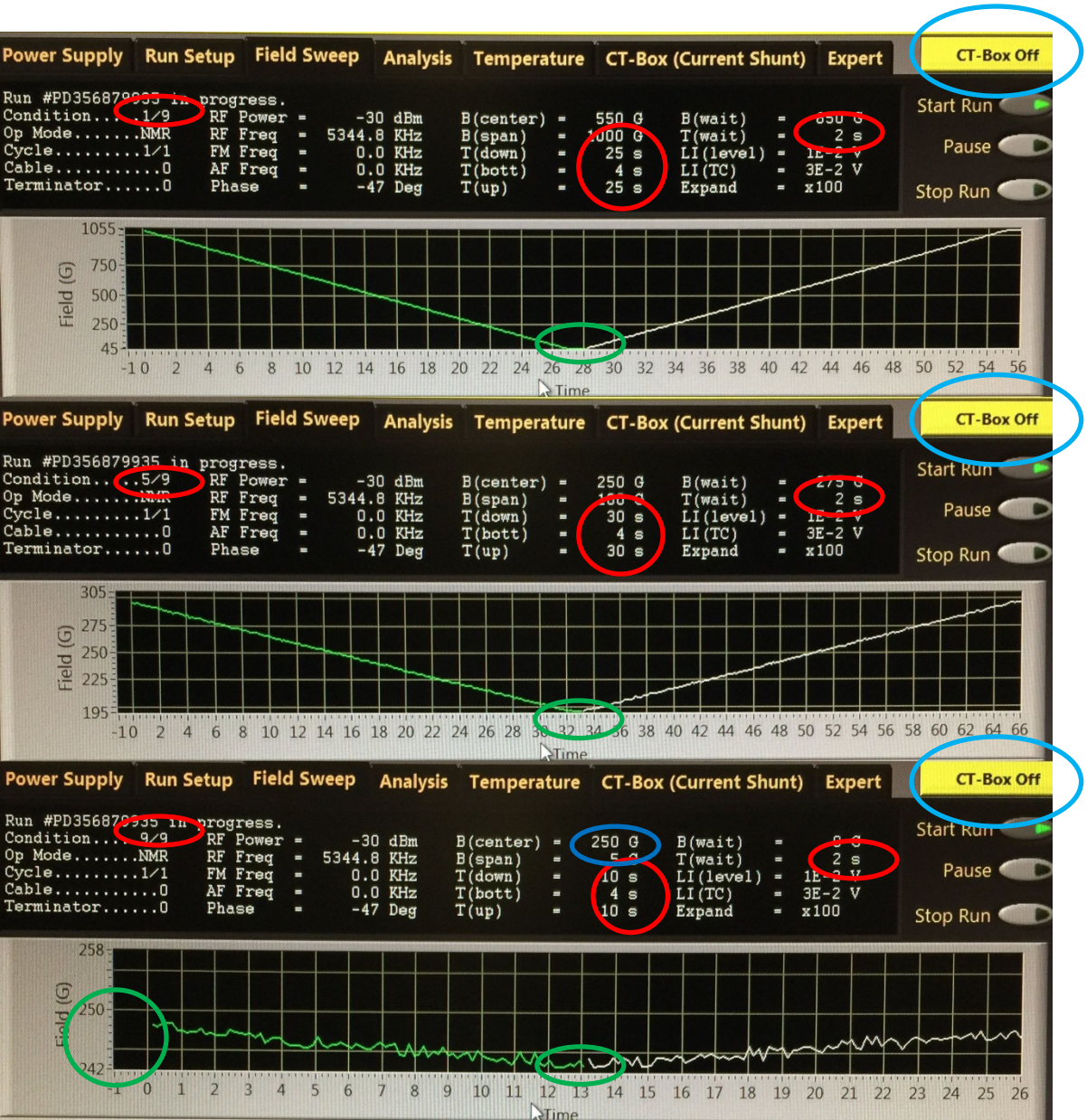
Cond. #	T(down)	plotted;	T(bott)	plotted
1/9	25s	**27s**	4s	**1s**
5/9	30s	**33s**	4s	**1s**
9/9	10s	**12s**?	4s	**1s**?

- The field plot do not match the preset values. See table below.

Cond. #	B(Start)	displayed
9/9	252.5G	**248G**?

- The field reading error was as much as 1 gauss, more than 10% of the NMR linewidth (4~10G). This would make the NMR signal averaging impossible. (Bottom plot)

(B) Issues with Field Scans when not using the CT Box



- The running time settings are ignored. See table below.

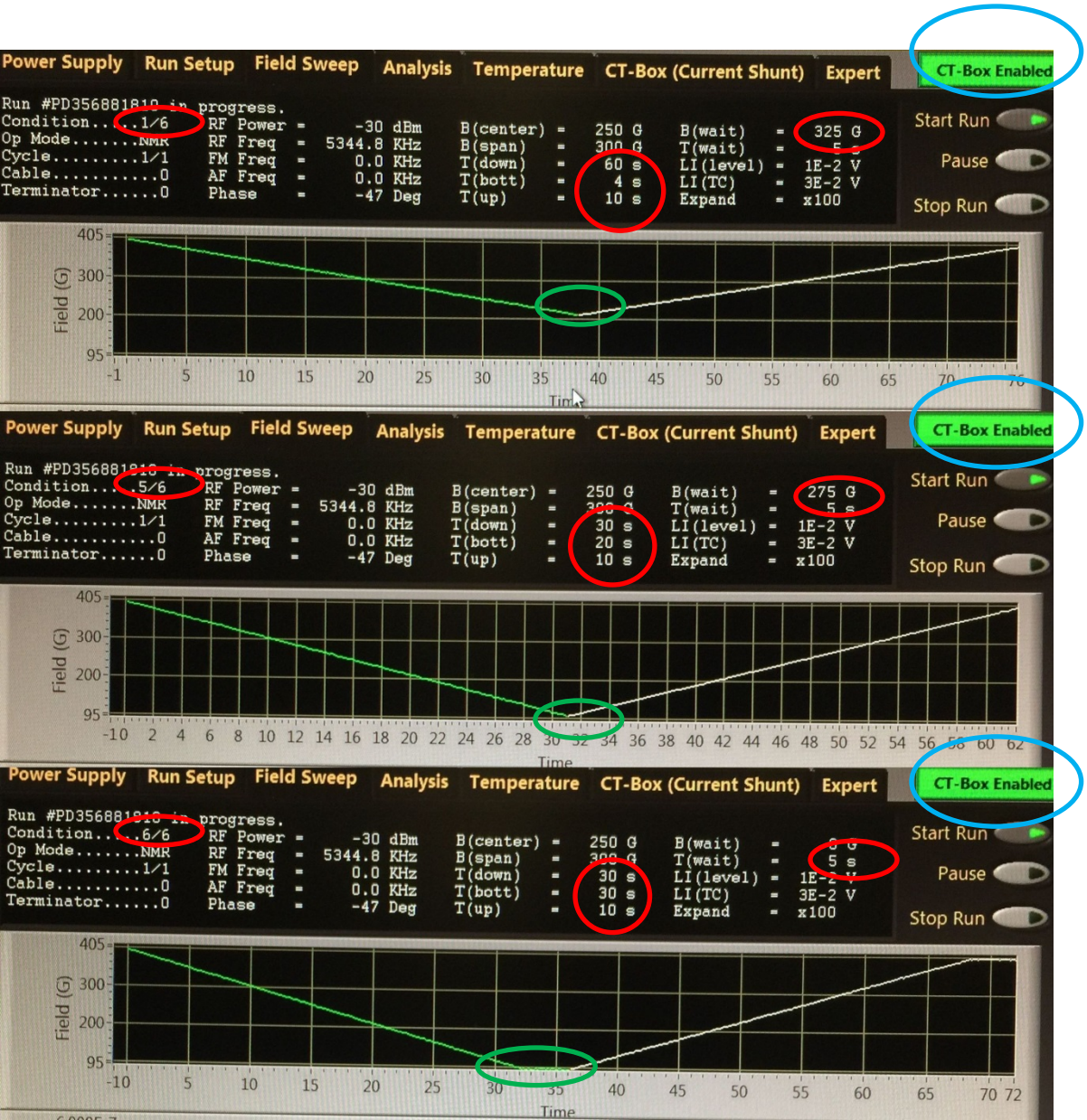
Cond. #	T(down) plotted;		T(bott) plotted	
1/9	25s	**27s**	4s	**1s**
5/9	30s	**33s**	4s	**1s**
9/9	10s	**12s**?	4s	**1s**?

- The field plots do not match the preset values. See table below.

Cond. #	B(Start) displayed	
9/9	252.5G	**248G**?

- The field reading error was as much as 1 gauss, more than 10% of the NMR linewidth (4~10G). This would make the NMR signal averaging impossible. (Bottom plot)

(C) Issues with Field Scans when using the CT Box



- The time settings are ignored. See table below.

	Condition 1/6			
	T(d)	T(b)	T(u)	T(w)
settings	60s	4s	10s	5s
plotted	**38s**	**0s**	**38s**	**0s**

	Condition 5/6			
	T(d)	T(b)	T(u)	T(w)
settings	30s	20s	10s	5s
plotted	**31s**	**0s**	**31s**	**0s**

	Condition 6/6			
	T(d)	T(b)	T(u)	T(w)
settings	30s	30s	10s	5s
plotted	**32s**	**4s**	**32s**	**4s**

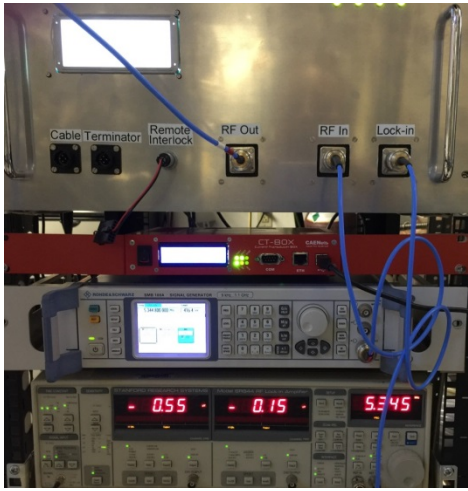
Field Scan Issues

- The timing issues are present regardless of whether or not the CT Box was in use.

- Field scan measurements were too noisy. (This might be changed after updating the hardware drivers.)

Additional finding(s)

- The display on both RF switch boxes turned blank while in use. (See picture on the right. It later turned out that the optical communication box was malfunctioning.)



Note: The purpose of this display is to provide an independent visual measure of the actual RF output power, derived from the attenuator-switching box, not an echo of the computer settings which are just a copy of the run table.

- Sometimes, the observed low-field value, deduced as B(center) – ½ B(span), is very far off from the setting value, meaning the field stopped sweeping down and started sweeping up before reaching the value written in the run table. (eg. It was off by about 100 gausses during one of the runs.)

Summary

- The new NMR scan program development has made significant progress; however, control issues remain. In addition, the field data logging with the new shunt has yet to be implemented. (This is essential in order to be able to synchronize multiple sweeps and so reduce the impact of noise during target calibrations.)

- The Fast-Resonance scan program has yet to be migrated to the new NMR rack.

- Some additional hardware issues (eg. RF display) need to be addressed.