Jefferson Lab
E06-010 Technical Note
July 2006

Spin Reversal Technote

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Abstract

Since in the experiment we are going to flip spin of target every 10-20 minutes to minimize systematic error, I write a Labview program to flip spin periodically. The result of spin-flip will lose 10% polarization.

1 Introduction

In the hall, we want to minimize the systematic error, so for polarized target, we try to flip target every 10-20 minutes.

The basic idea to filp spin is that we keep holding field fixed and sweep RF frequency from low value to high value. During the procedure, the target spin will be flipped. At the mean time, we will also control rotation stage which holds the quarter-waveplate to rotate 90 degree to make polarization direction of laser flipped,too. So even if we flip the target spin, the target will still be polarized by laser. This is one cycle I define in the Labview program. Then we wait for 10-20 minutes, sweep RF from high to low and rotate -90 degree of quarter-waveplate. The spin will be flipped back. The program will keep flipping the target spin as many cycles as you wish.

However, since the AFP loss exists during spin-flip process, we will lose some target polarization in the period of program running. This is why I test with different wait time (10 min or 20 min) just trying to compensate this loss. I will show you the result I got.

2 Operation Procedure

1. Check the circuit of Spin-Reversal. See Figure 1

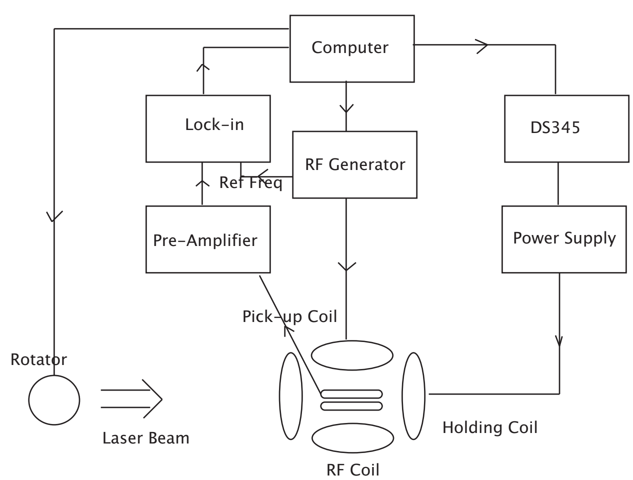

Figure 1: Circuit of Spin-flip

2. Go to C:\Physics Room\hyao\Spin reversal on computer "TRANSVERSITY".

3. Click on "Example.vi" and run it. It will generate global variable in the cache for rotation stage. Then make sure the "Current Position"(Current Angle of Quater-Waveplate) has the correct value. If not, do the following:

   - 1st gage point in tics=1

     2nd gage point in tics=6400

     1st gage point in units=1

     2st gage point in units=2
   - Cur pos units=current angle of quarter-waveplate. Click "Set"

   Now you can close it. But if you may check the status of rotation stage, you can leave it open.

4. Click on "Spin Reversal_Perfect.vi" and run it. You will see the panel like Figure 2

   - Parameters is the most important part in this program. It sets all the parameters we need to run program.

     Start Freq=Start/Stop Frequency of RF Generator(HP3324A)for Odd Cycle

     Stop Freq=Stop/Start Frequency of RF for even Cycle

     RF Ampl=RF Amplitude

     # of cycle=how many cycle=sweep do you need?

     Sweep Time=Time of RF sweep from Start/Stop Freq to Stop/Start Freq

     Wait Time=Time of waiting after one sweep is done

     Sensitivity,Time Constant=please see the manual of SR844 Lock-in

     Sweep Mode: Auto=Run # of cycles automatically Manual=Run 1 cycle from Start f to Stop f

     Rotation Angle=angle you want the quater-wave plate to rotate. For Odd cycle,-90. For Even cycle,+90.

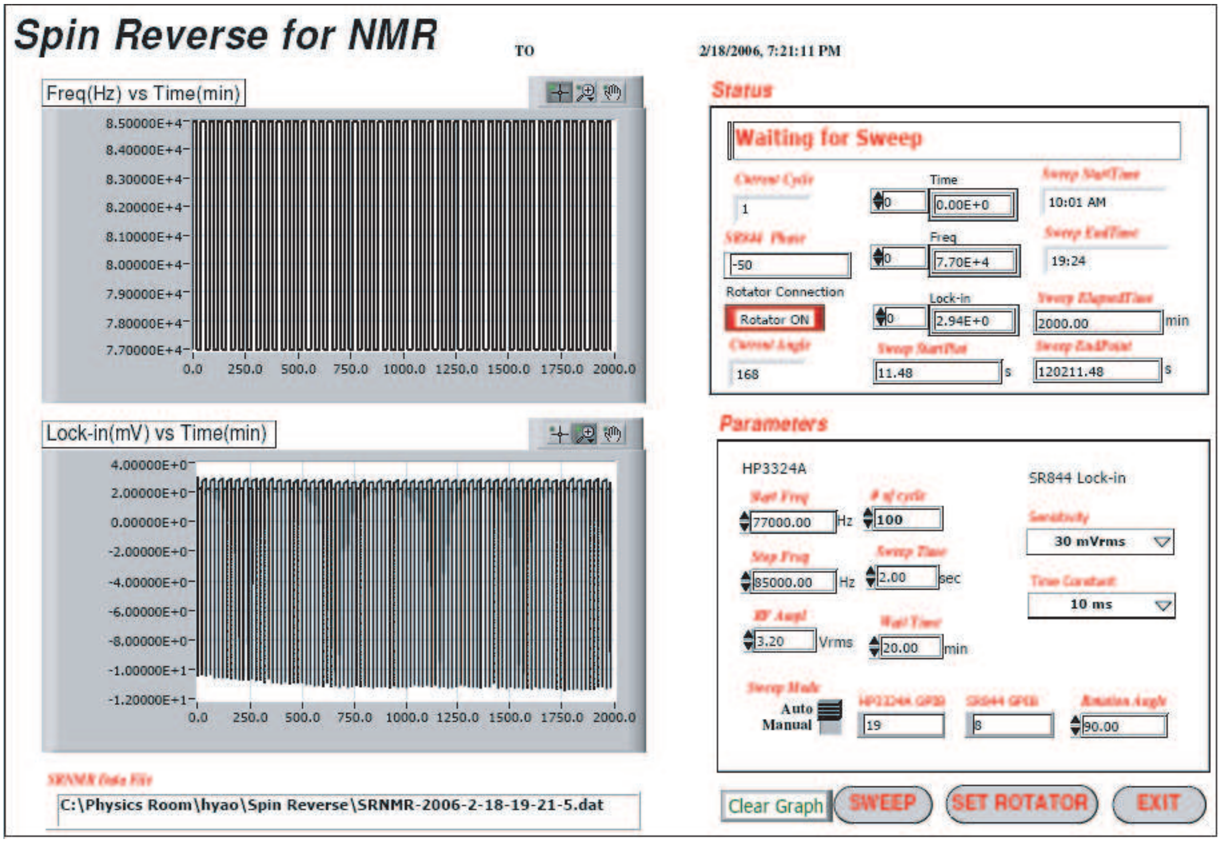

Figure 2: Spin-Reversal Program

- Status just tells you what's the status is now. You cannot input values.

  Current Cycle=Show the Current Cycle

  Rotation Connection=To make sure it's on before you run the program

  Current Angle=Tell you what's the angle of quarter-wave plate.

  Time,Freq,Lock-in=3 signal we will measure or calculate.

  Sweep StartTime=Show when 1 cycle runs.

  Sweep EndTime=Show when last cycle will end.

  The other three is just for me to check the program.

- The top diagram is Frequency vs Time.

- The bottom diagram is Lock-in vs Time.
- There are four buttons you can control.

  Clear Graph=Initialize two graph.

  Sweep=It will start the sweep and change to STOP button in case that you may want to stop the program at any time.Also it will disable all other three buttons.

  Set Rotator=Set connection with Rotation Stage and get current position of quater-wave plate.

  Exit=Close the program.

5. Input parameters you want and Click "SET ROTATOR" first to make sure Rotator connection is on. Then Click "SWEEP". "SWEEP" will become "STOP" to let you stop the program at any time. Please do not click too many times,Labview need time to response. So just wait for 5-10 seconds.

6. Once it is finished, you will be asked to save file. Yes or NO just as you wish. But if NO, you will lose all the data.

2.1 What we expect?

For us, the most important thing we want to know during the spin-flip process is how many polarization we can get even we know there AFP loss exists. From the theory, we get

$$\frac{P_e}{P_{max}} = \frac{e^{T_f/T_u} - 1}{e^{T_f/T_u} - (1-\delta)} \tag{1}$$

$$\frac{P_n}{P_{max}} = (1-\delta)^n e^{-nT_f/T_u} + (1 - e^{-T_f/T_u}) \sum_{i=1}^{n} (1-\delta)^{i-1} e^{-(i-1)T_f/T_u} \tag{2}$$

You can run the program "P.vi" as Fig 3 shows

- Pe=Polarization at equilibrium point.

  Pn=Polarization after n cycles sweep.

  Pmax=Max Polarization before spin-flip.

  Tf=Wait Time for each cycle.

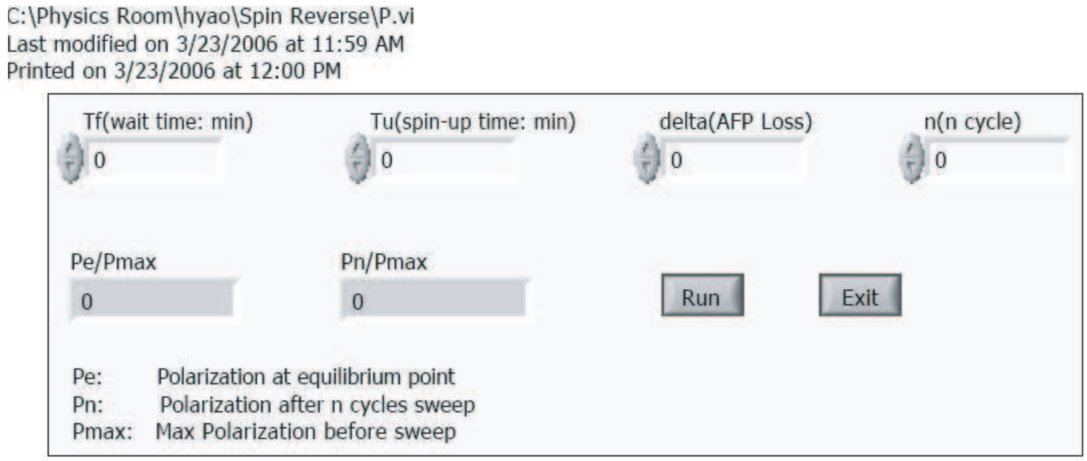

Figure 3: Polarization Calculation

Tu=Spin-Up Time for the target.

δ =AFP Loss per cycle.

n=n cycles sweep.

It will give you some sense how much polarization we will reach. The calculation gives us 20minutes waiting time is best for our experiment.

For cell "W&M", I measure the spin-up time for both polarized and opposite-polarized, see the Fig 4.

We see the spin-up time (12.43 hours) is almost same with these two opposite circular laser. We may say $T_u = 746 \pm 89min$. Now we have to know the AFP loss for this cell. I also get this Fig 5. So $\delta = 4\% \pm 1\%$.

So for $T_f = 10(20) \pm 0.01min$, we get Fig 6.

Finally, we get $P_e/P_{max} = 0.77 \pm 0.07$ for 10 minutes flip, $P_e/P_{max} = 0.87 \pm 0.04$ for 20 minutes flip. Next we shall measure the these two in the experiment to see if they are consistent with our expected value here.

2.2 Important Notice

1. Make sure run "Example.vi" before "Spin reversal_Perfect.vi".

2. Make sure click "Set Rotator" before "Sweep" in "Spin reversal_Perfect.vi".

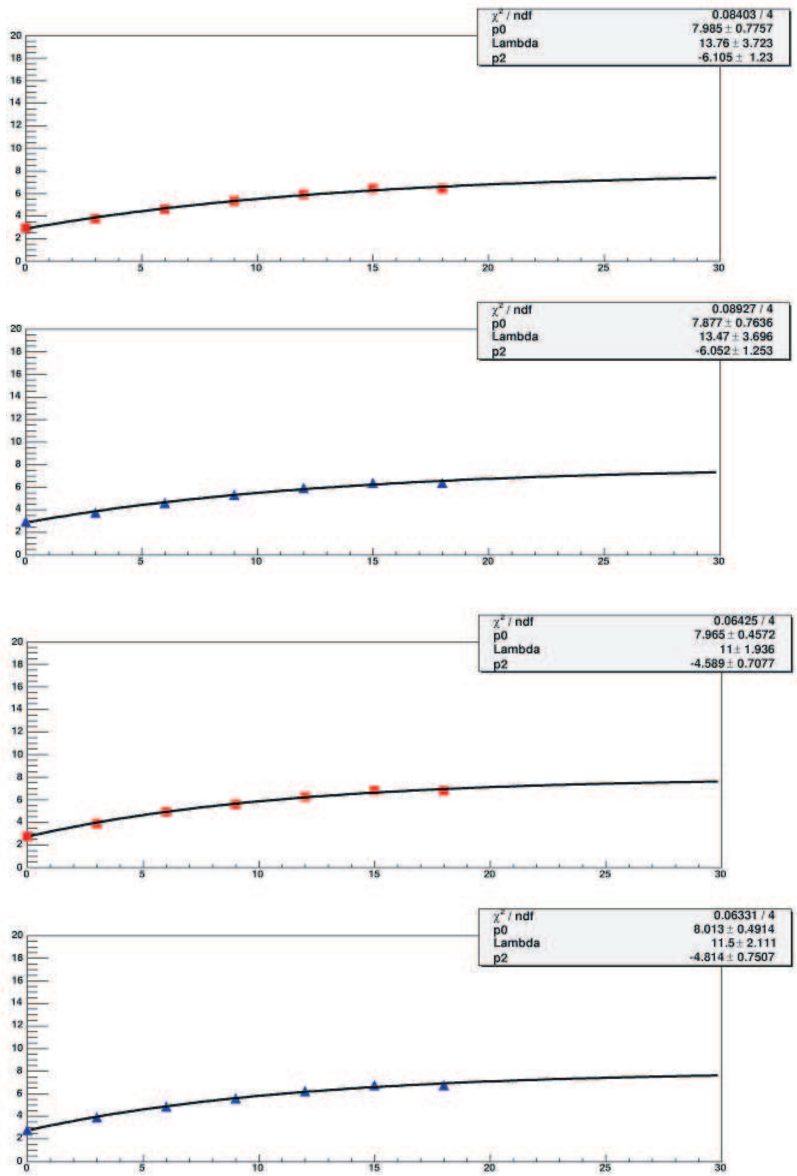

Figure 4: Spin-up with two polarized direction

0.000000	9.08288
3.0	9.01086
6.0	8.97615
9.0	8.88715
12.0	8.7632
15.0	8.57722
18.0	8.53396
21.0	8.5719
24.0	8.55863
27.0	8.42432
30.0	8.42432

Figure 5: AFP Loss

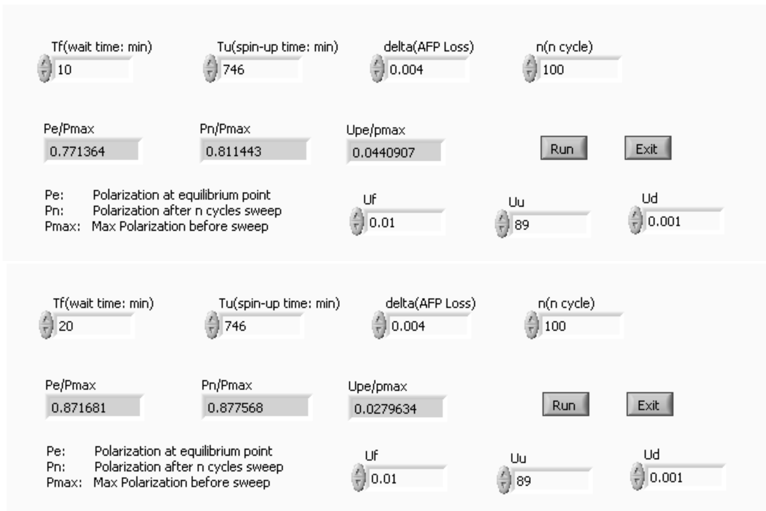

Figure 6: Estimation with 10(20) minutes

3. Since RF in in flashing mode, we will use RF Power Supply AG1021 with MGC Mode, to avoid automatically being off after no use for a long time.

4. Previous version of Spin Reversal kept RF on all the time during waiting time which actually caused polarization to decrease significantly.So I have changed.

3 Result

Fig 9 shows what is the typical signal for this version of SR program.

Fig 7 show the polarization before and after for 10 min flip is 11.09 ± 0.50, 8.46 ± 0.50.

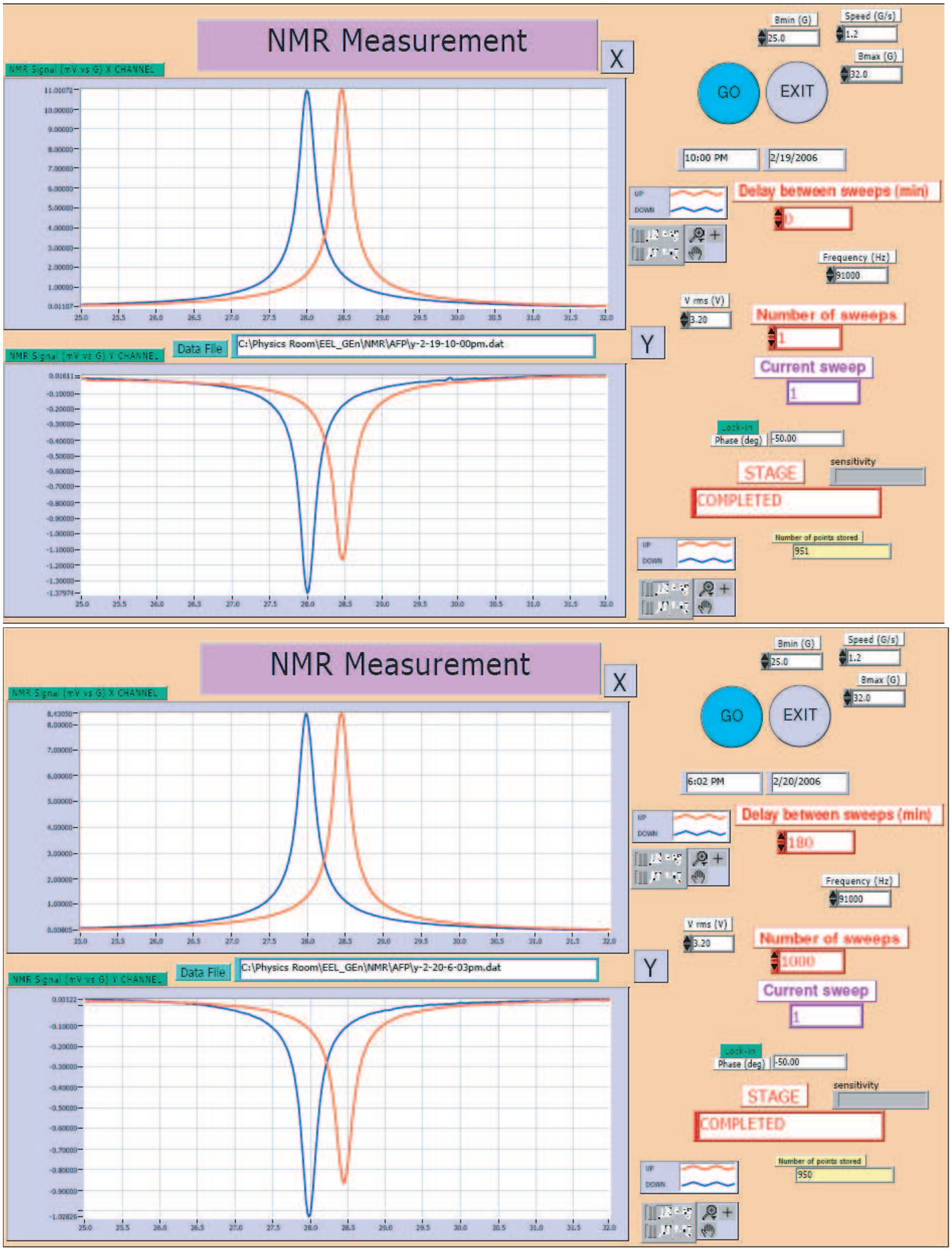

Figure 7: NMR with 10min

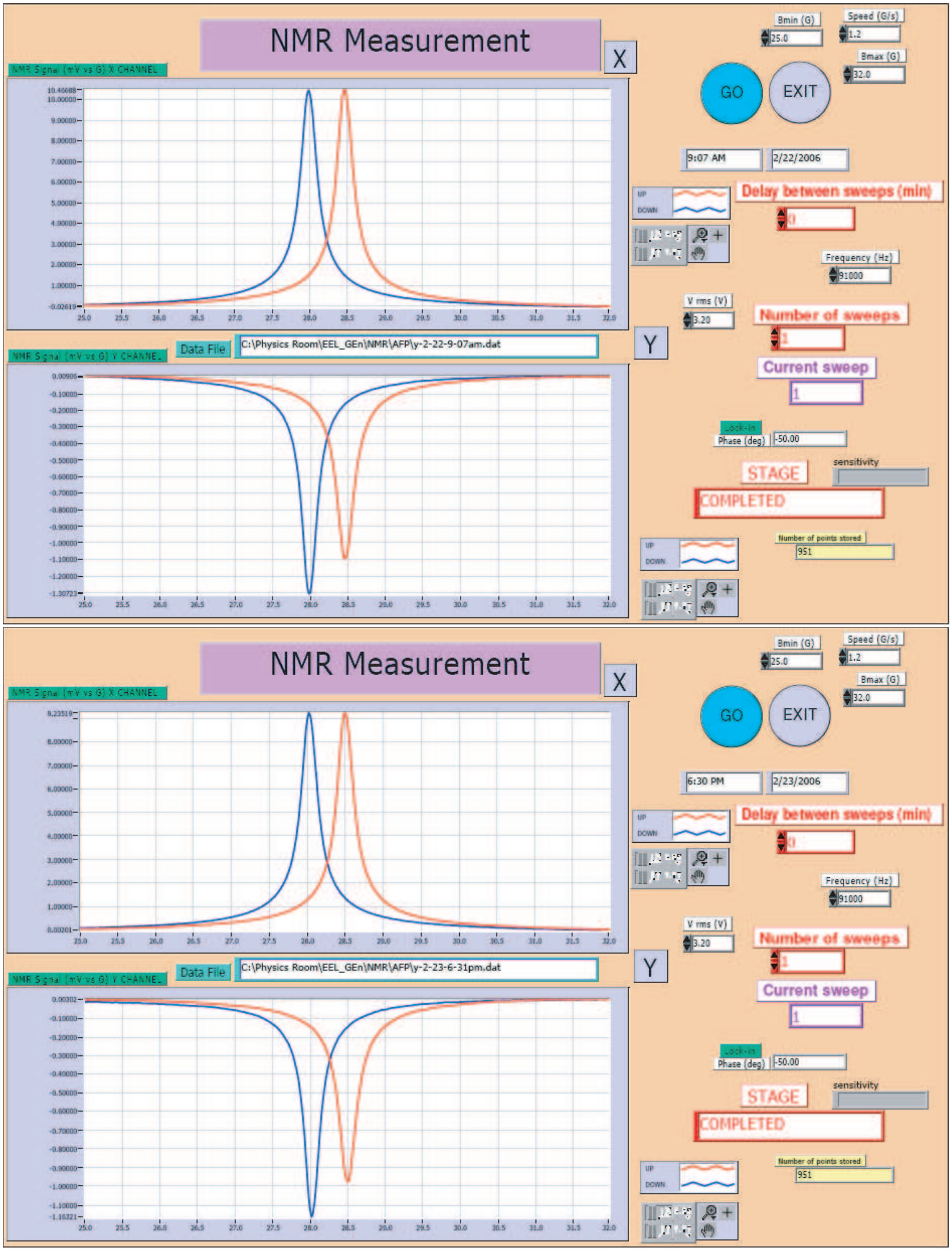

Figure 8: NMR with 10min

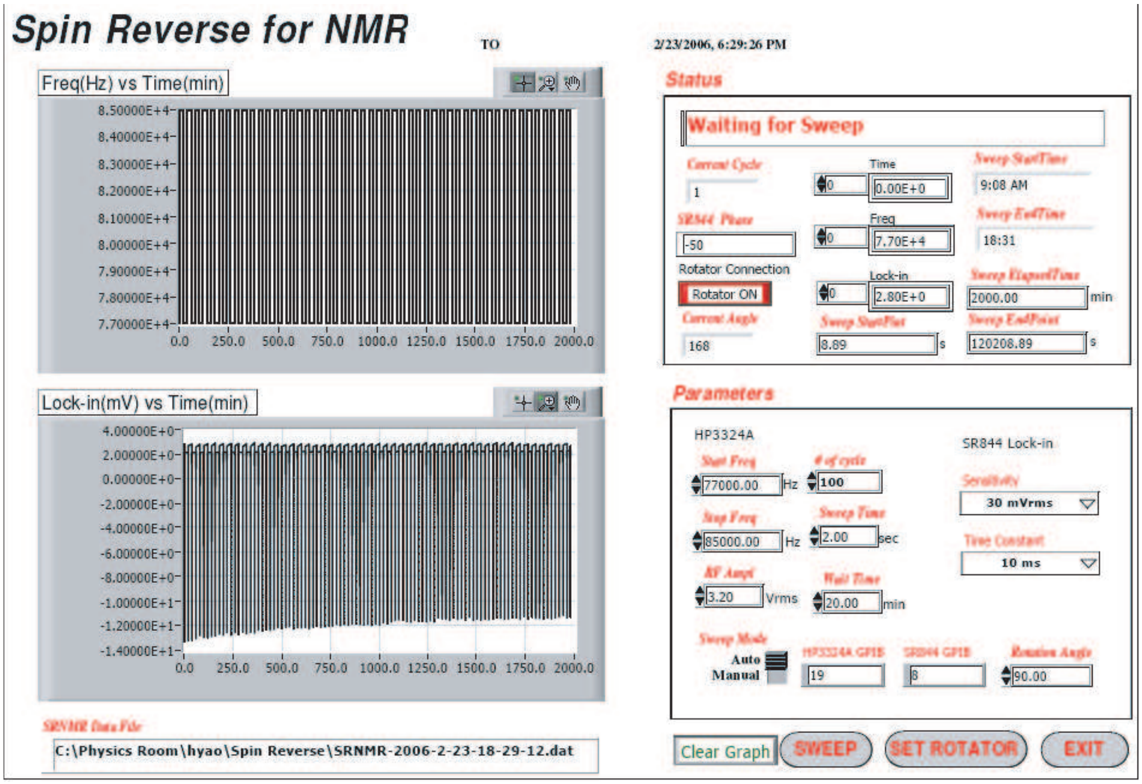

Figure 9: Typical Spin Reversal Signal

Fig 8 show the polarization before and after for 20 min flip is 10.56 ± 0.50, 9.28 ± 0.50.

So $P_e/P_{max} = 0.76 \pm 0.06$ for 10 min, $P_e/P_{max} = 0.88 \pm 0.06$ for 20 min.

Here is the final plot 10 which shows the result of expected value and measured value. It seems the experimental result is pretty consistent with the theory. So we can safely say the Spin Reversal can be controlled in our hand.

Acknowledgments

Thank JP.Chen and Dr.Meziani for helping me get this program done. And also thank everyone who help me during this time. Your help is so important for me that I will never forget. Thanks again.

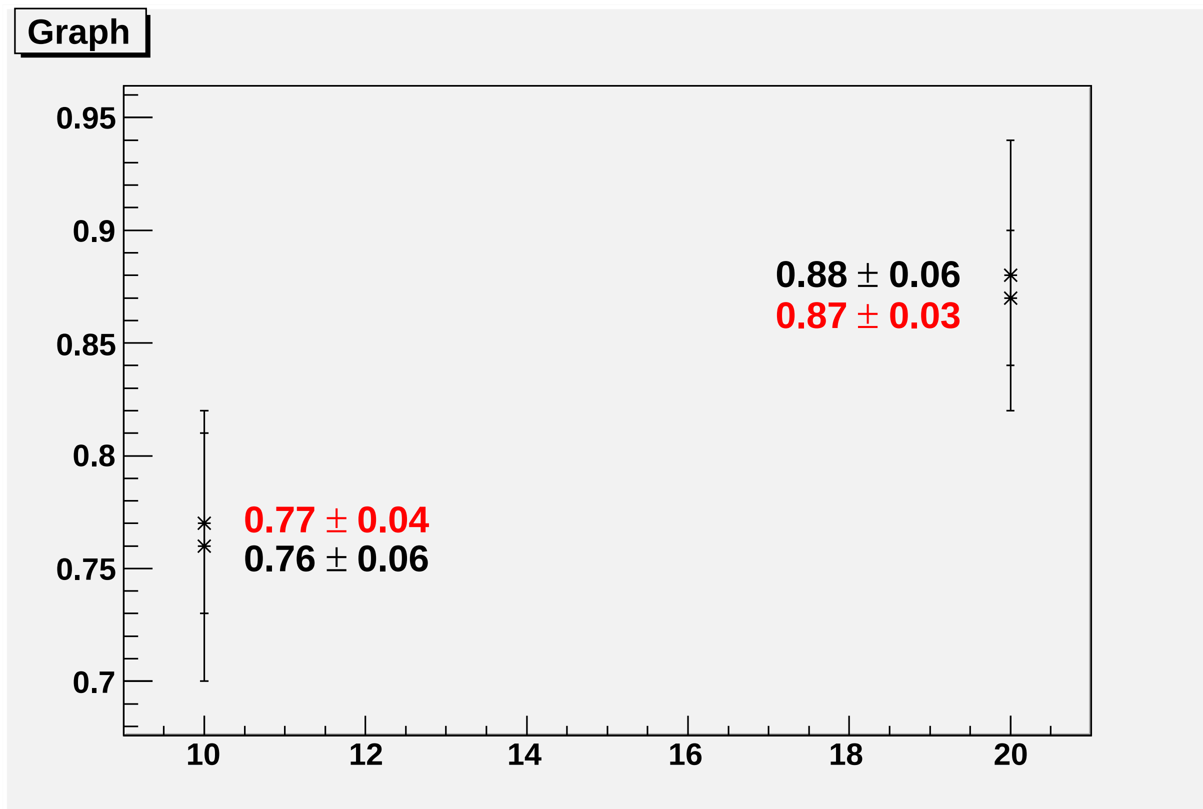

Figure 10: Result