The Fast Resonance Scan (FRS) Program for HDice Target

Dec. 08, 2016

Xiangdong Wei

Purpose of the Program

There are two separated Labview programs, Fast Resonance Scan (FRS) and NMR Scan (NMRS), installed on every fully functioned NMR control computers. Both of them are absolutely necessary for measuring target polarizations with HDice NMR Rack.

- The FRS --- Sweeping RF frequency at a constant magnetic field to determine the NMR circuit RF parameters for setting up run conditions and calibrations constants.

- The NMRS --- Sweeping magnetic field at a constant RF frequency to measure actual NMR signals for monitoring and analyzing polarization online and collecting NMR data for offline analysis.

FRS Principle

- Both FRS and NMRS programs should never run in the same time.

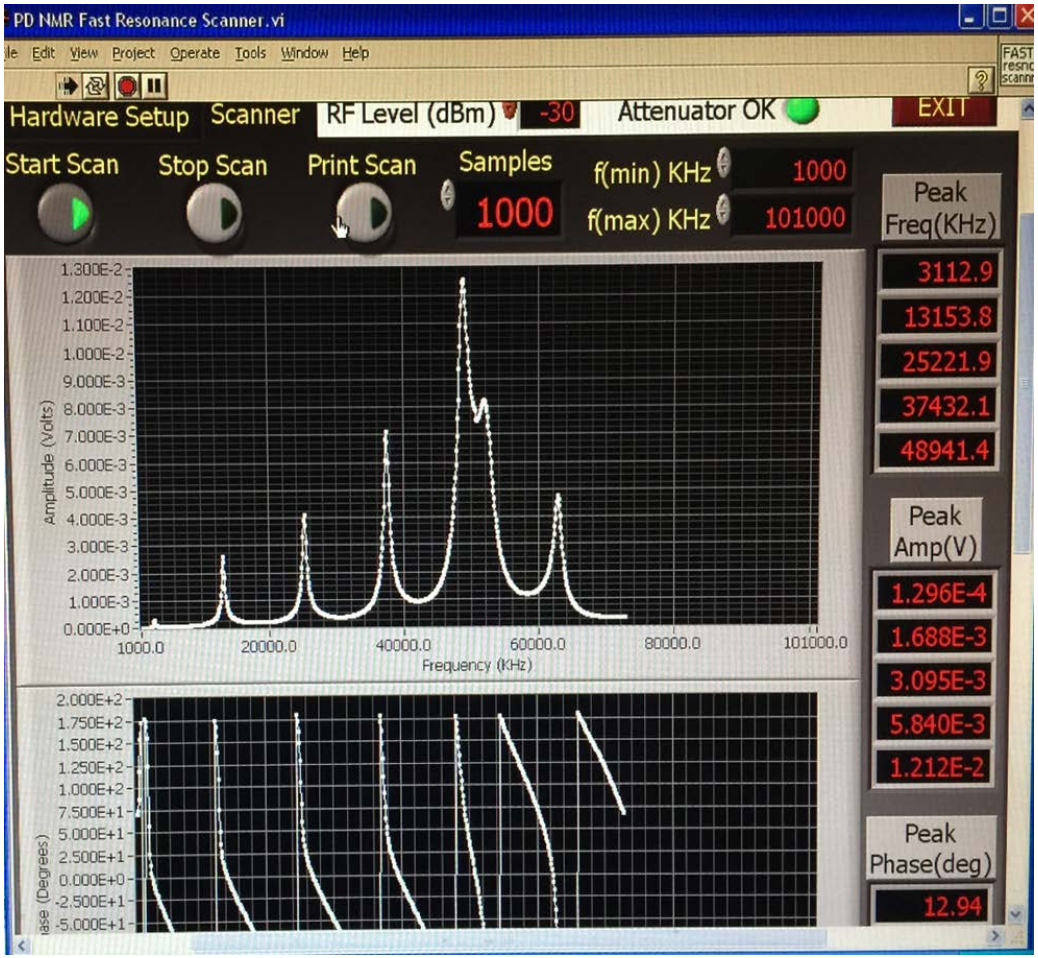
- Although both control the same rack, the component set involved in the program is slightly different. Unlike NMRS, which uses every component on the rack, the FPS does not use magnet field (and current shunt) information and does not average the data.

- The FRS operation sequence, in principle, is the following:

  - Initialize the RF signal chain and set the rack output power to -63dBm. (Synthesizer, RF Distribution Box, Lockin Amplifier, etc.)
  - Set the RF power, Frequency Sweep Range, Number of Samples.
  - Send the RF into NMR transmitter coil while sweep the RF frequency.
  - Detect the RF response from the NMR receiver coil and record data array (Frequency, Size and Phase).
  - Perform quick peak search and display results.
  - Provide windows for user comments before and after sweep.
  - Save data files and generate printable run summary file with graphs.

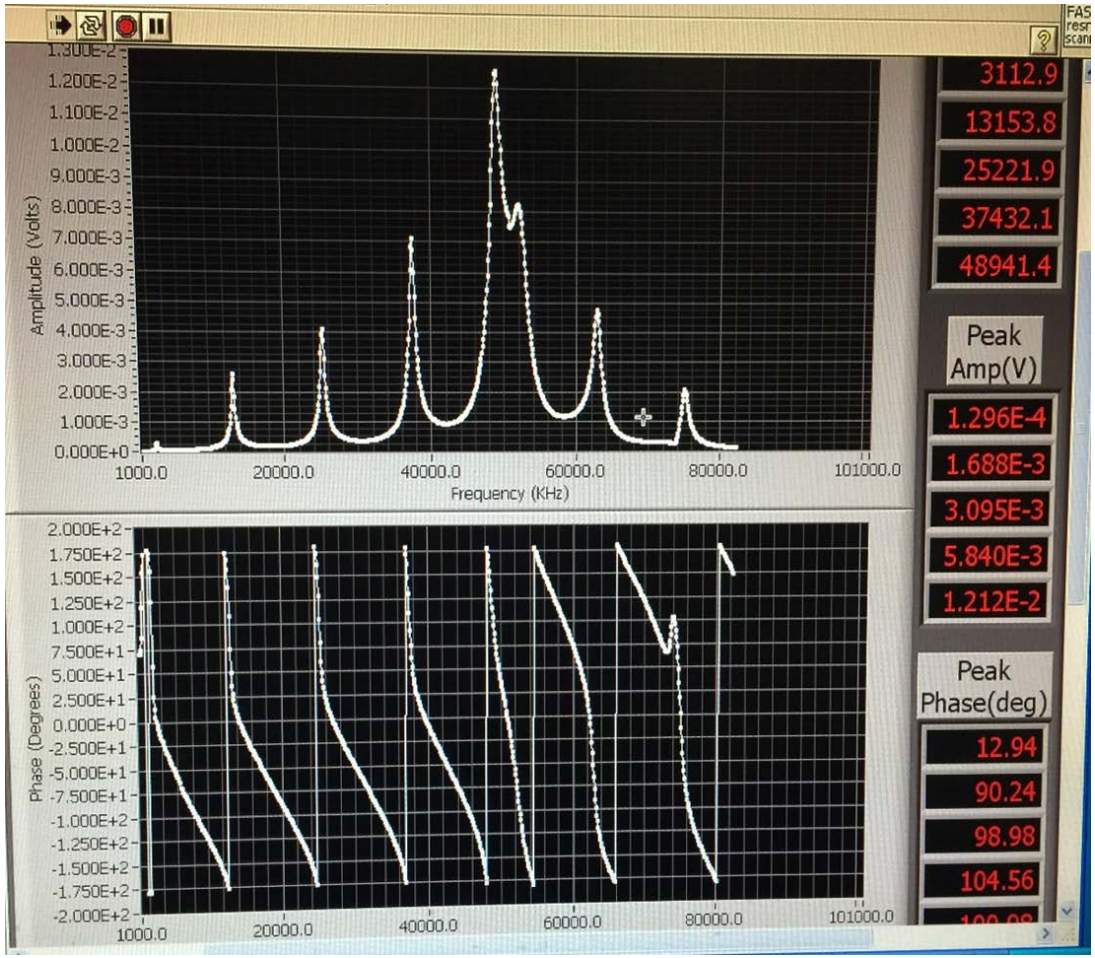
Screen Shots (1) of the Program

Settings and Detected Signals



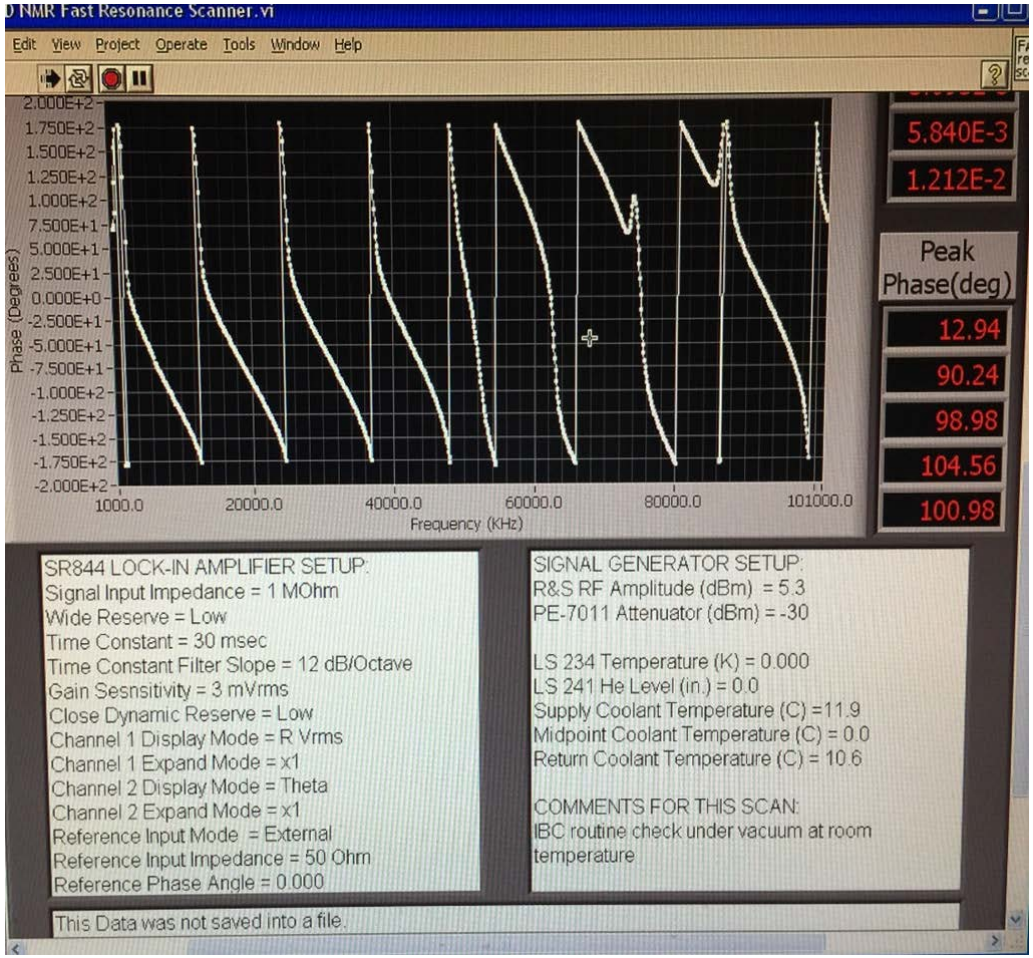
Screen Shots (2) of the Program

Detected Signals and Peak Information



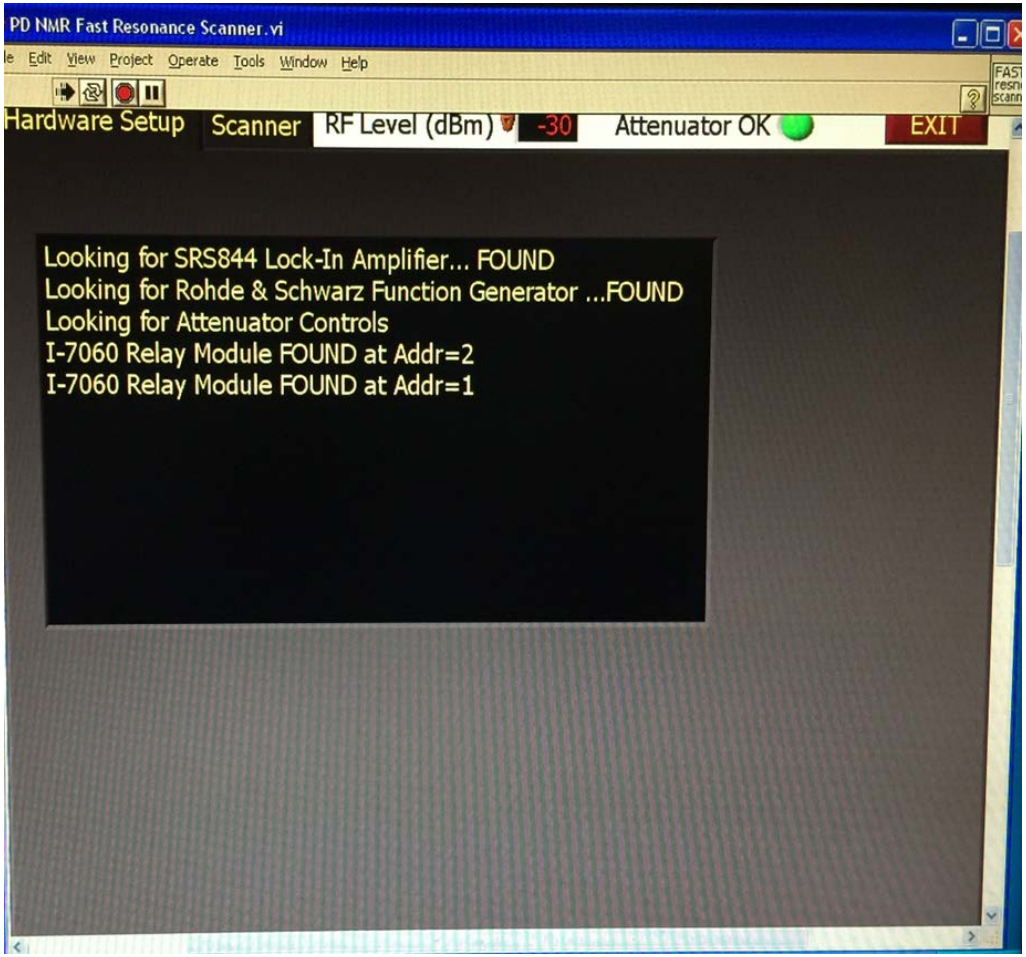
Screen Shots (3) of the Program

System Settings and Operator Comments



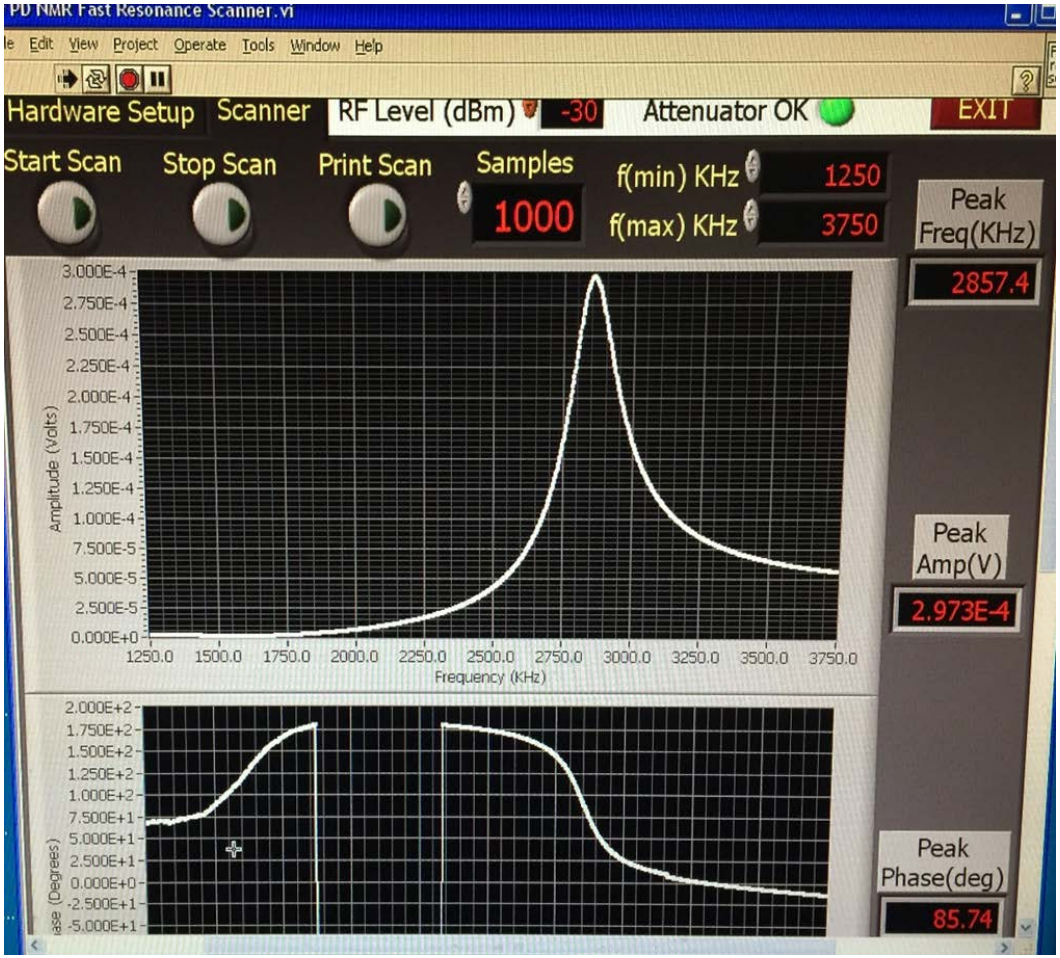
Screen Shots (4) of the Program

Hardware Setup Information



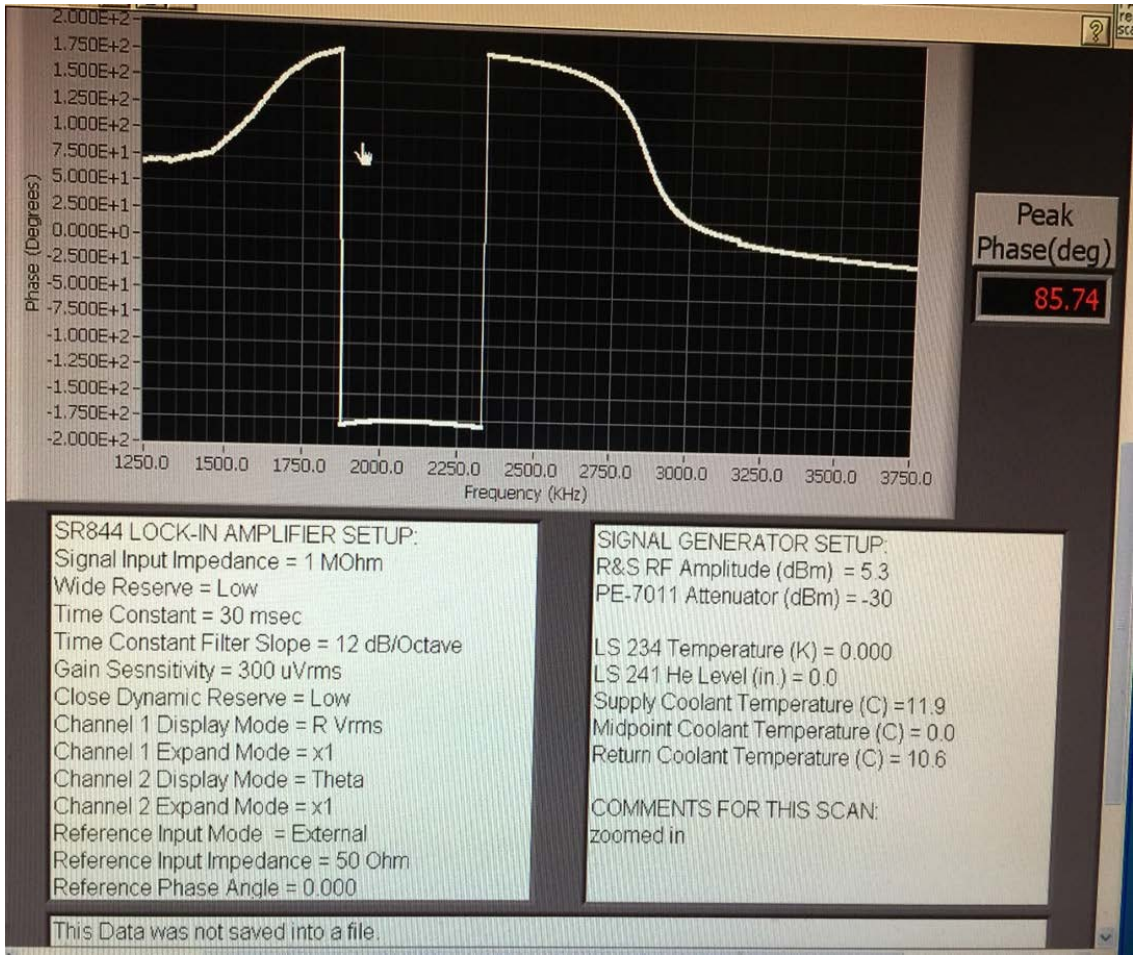
Screen Shots (5) of the Program

Zoomed in for Peak Details

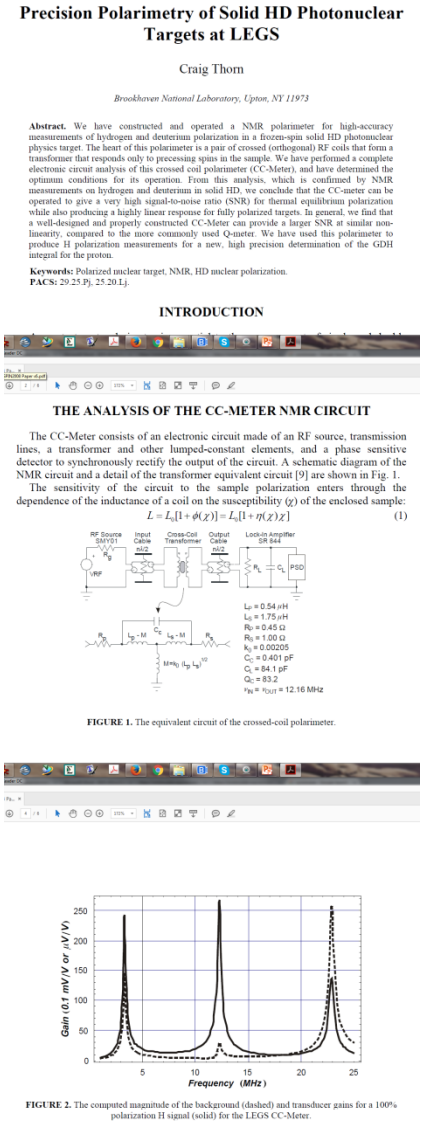


Screen Shots (6) of the Program

Zoomed in for Peak Details



Samples of Using FRS Results



Precision Polarimetry of Solid HD Photonuclear Targets at LEGS

Craig Thorn

Brookhaven National Laboratory, Upton, NY 11973

Abstract. We have constructed and operated a NMR polarimeter for high-accuracy measurements of hydrogen and deuterium polarization in a frozen-spin solid HD photonuclear physics target. The heart of this polarimeter is a pair of crossed (orthogonal) RF coils that form a transformer that responds only to precessing spins in the sample. We have performed a complete electronic circuit analysis of this crossed coil polarimeter (CC-Meter), and have determined the optimum conditions for its operation. From this analysis, which is confirmed by NMR measurements on hydrogen and deuterium in solid HD, we conclude that the CC-meter can be operated to give a very high signal-to-noise ratio (SNR) for thermal equilibrium polarization while also producing a highly linear response for fully polarized targets. In general, we find that a well-designed and properly constructed CC-Meter can provide a larger SNR at similar non-linearity, compared to the more commonly used Q-meter. We have used this polarimeter to produce H polarization measurements for a new, high precision determination of the GDH integral for the proton.

Keywords: Polarized nuclear target, NMR, HD nuclear polarization.
PACS: 29.25.Pj, 25.20.Lj.

INTRODUCTION

THE ANALYSIS OF THE CC-METER NMR CIRCUIT

The CC-Meter consists of an electronic circuit made of an RF source, transmission lines, a transformer and other lumped-constant elements, and a phase sensitive detector to synchronously rectify the output of the circuit. A schematic diagram of the NMR circuit and a detail of the transformer equivalent circuit [9] are shown in Fig. 1.

The sensitivity of the circuit to the sample polarization enters through the dependence of the inductance of a coil on the susceptibility (χ) of the enclosed sample:

$$L = L_0[1+\phi(\chi)] = L_0[1+\eta(\chi)\chi] \quad (1)$$

FIGURE 1. The equivalent circuit of the crossed-coil polarimeter.

FIGURE 2. The computed magnitude of the background (dashed) and transducer gains for a 100% polarization H signal (solid) for the LEGS CC-Meter.

The results from FRS program are used for setting up run condition tables for NMRS program and for offline polarization calibrations.

The picture on the left is an example of how the FRS results are used for polarization analysis. (These area selected screen shots from Craig Thorn's SPIN2008 article.)

The frequency response signals were used to fit the NMR circuitry parameters and fitting results were fed into the NMR circuit model to predict the correct system gains. These gains were then used to analyze the NMRS results for determining the polarizations of the HDice target.

Conclusion

- The Fast Frequency Scan program is one of the essential components of the HDice NMR system. The target polarization will not be measured correctly without it.