

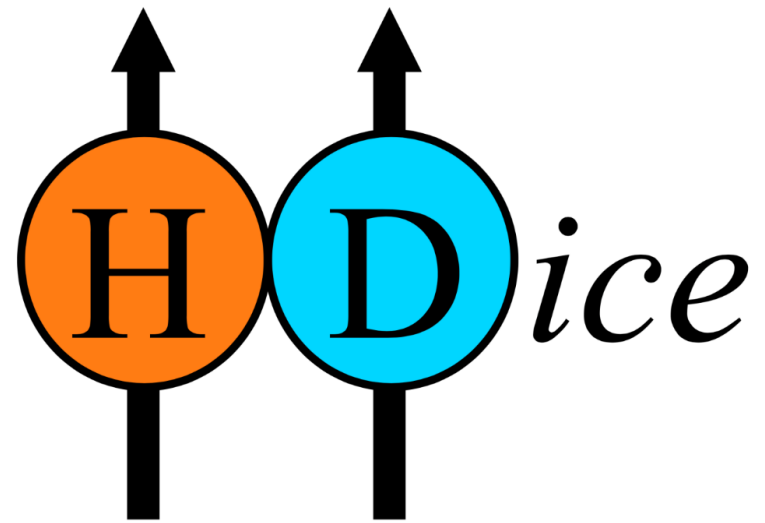


# Work Request Status DSG-HDIce

Amanda Hoebel  
Detector Support Group  
April 17, 2019

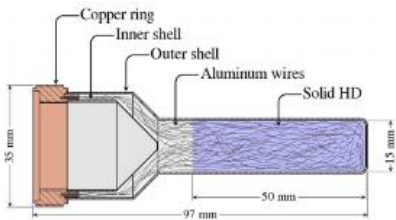
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- HDIce experiment
- Work requests
- Work done by DSG
- Current problems
- Work requests pending approval
- Conclusion



# HDIce Experiment

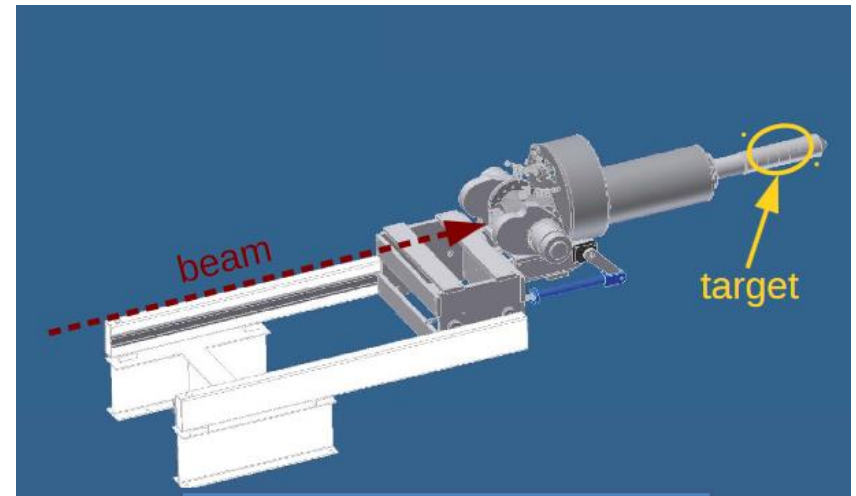
- Frozen spin target made of hydrogen and deuterium.
  - Aluminum wires remove heat from target.



Target



Aluminum wires



In-Beam Cryostat

See [HDice Target](#) talk June 2015 in the DSG website DSG/Talks

# Original Work Request

## • Hardware:

- Search for semi-flexible NMR cables, with low loss and low or controlled temperature variation.
- Construct 2 sets of dual cables with lengths adjusted to operate on  $\lambda/2$  resonance, with tuned NMR circuit ( $R_L, C_L$ ).
- Build 2 low-noise variable-capacitance RF tuning ( $R_L, C_L$ ) boxes.
- Install a precision (temperature-stabilized) shunt to directly read the current from Oxford supplies that drives the magnets used for NMR-2 shunts, one for each NMR rack.
- Debug and finish existing NMR control codes.

200 -100 300 1/07/15  
512

40 MHz -40'

70%

@ 40 MHz

Projects for supporting the HDice NMR system

- **Hardware:**
  - search for semi-flexible NMR cables, with low loss and low or controlled temperature variation;
  - construct 2 sets of dual cables with lengths adjusted to operate on  $\lambda/2$  resonance, with tuned NMR circuit ( $R_L, C_L$ );
  - build 2 low-noise variable-capacitance RF tuning ( $R_L, C_L$ ) boxes
  - install a precision (temperature-stabilized) shunt to directly read the current from Oxford supplies that drive the magnets used for NMR - 2 shunts, one for each NMR rack.
- **Mathematica programming**
  - Update existing NMR analysis codes to the newest version of Mathematica (eg. version 5 => version 8, or most recent JLab supported version):
    - 1. General Polarization Data Analysis Package June 2008.nb
    - 2. Inductance JLAB Target Reference.nb
    - 3. Inductance LEGS Target Reference.nb
    - 4. Parameters from Resonance Curves v1.nb
    - 5. RF Birdcage Coils.nb
    - 6. KK transformation-Craig.nb
    - 7. Polarized Lineshape Analysis v1.nb
- As a Debug/Test exercise, take resonance scan data (with HDice help), run programs and fit the resonance curve to deduce circuit parameters
  - 15.5, 15.5
  - 512 Hz better size
  - 31 short
- **Labview Programming for NMR hardware control**
  - Debug and finish existing NMR control codes eg. NMR field sweep:
 

present system is only understandable for  $t_{\text{down}} = t_{\text{up}} = 31$  sec and range = 300 gauss;  
flexibility to change ranges and compare results is needed.
  - finish RF distribution and attenuation control to display current settings on attenuator box, and integrate into NMR control codes so that changes are reflected in display
  - incorporate precision shunt into field controls
  - re-activate component-ID key portion of the NMR control codes to allow the VI to distinguish between different cables.
  - modify NMR control program to run NMR scans with both positive and negative currents in the magnet power supply.
  - re-activate online noise analysis VI.
  - Write a VI to control 2 power supplies to rotate HDice target polarizations (by varying currents in both solenoid and saddle coils).

- Ask for paper  
- version analysis  
- have them by

# Original Work Request

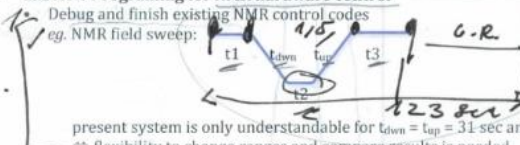
## Software:

- Finish RF distribution and attenuation control to display current settings on attenuator box, and integrate into NMR control codes so that changes are reflected in display.
- Incorporate precision shunt into field controls.
- Re-activate component-ID key portion of NMR control codes to allow VI to distinguish between different cables.
- Modify NMR control program to run NMR scans with both positive and negative currents in magnet power supply.
- Re-activate online noise analysis VI.
- Write VI to control 2 power supplies to rotate HDIce target polarizations (by varying currents in both solenoid and saddle coils).

200 -100 300 1/07/15  
512

40 MHz -40'  
@ 10 MHz

### Projects for supporting the HDIce NMR system

- Hardware:**
  - search for semi-flexible NMR cables, with low loss and low or controlled temperature variation;
  - construct 2 sets of dual cables with lengths adjusted to operate on  $\pi/2$  resonance, with tuned NMR circuit ( $R_i, C_i$ );
  - build 2 low-noise variable-capacitance RF tuning ( $R_i, C_i$ ) boxes
  - install a precision (temperature-stabilized) shunt to directly read the current from Oxford supplies that drive the magnets used for NMR - 2 shunts, one for each NMR rack.
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  - Write a VI to control 2 power supplies to rotate HDIce target polarizations (by varying currents in both solenoid and saddle coils).

check version NMR.  
look better size 512Hz better size 31 short  
15.5, 15.5

Alex.

Ask for paper - version by - have them by

# Examples of Additional Work Requests

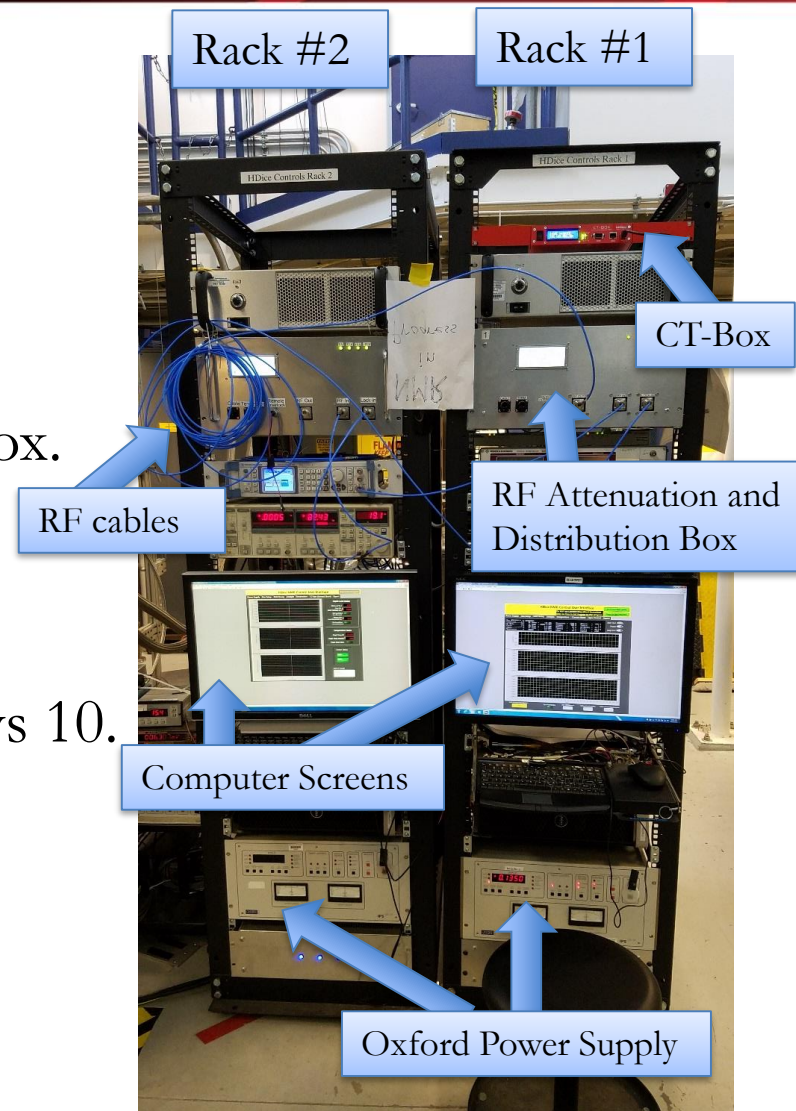
- Insulate Rack 1 and Rack 2.
- Redo grounding wires in Rack 1 and Rack 2.
- Replace and test Pump Cart cRIO.
- Incorporate Mercury iPS power supply into RTP program.
  - Code had to be re-written for VISA drivers. Mercury iPS did not have GPIB, which is what old Oxford supplies had.
- Make T-down and T-up variable times in NMR program.
- Add T-bot and T-wait to NMR program.
- Add synchronization to NMR program.

# Examples of Additional Work Requests

- Incorporate temperature and liquid helium level sensors into NMR program.
  - Update all programs to latest version of LabVIEW.
  - Update Rack #1 PC to Windows 10.
- See [HDice Progress Review](#) talk on April 2016, [HDice Review Talk](#) August 2016  
[HDice Status Report](#) talk on March 2017, in DSG website DSG/Talks

# NMR Racks Built by DSG

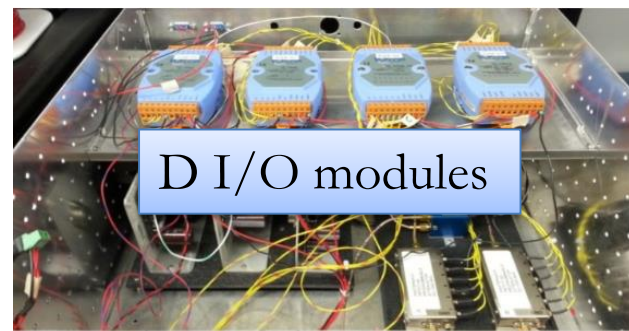
- Isolated racks.
- Fabricated and installed RF cables.
  - Low-noise
  - Semi flexible
- Built RF Attenuation and Distribution Box.
- Incorporated CAENels CT-Box.
  - Installed in Rack #1.
- Upgraded Rack #1 computer to Windows 10.
  - Rack #2 computer is Windows 7.
  - Needs to be updated to Windows 10.
- Created documentation for both racks.





# RF Attenuation and Distribution Box Built by DSG

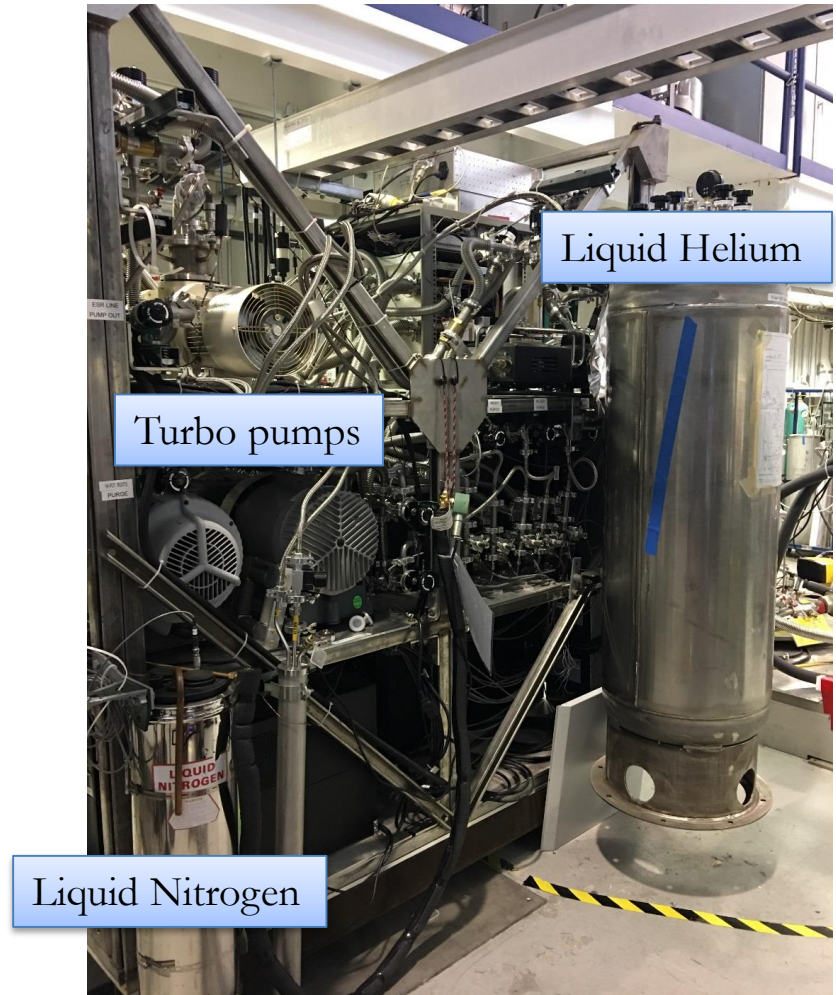
- Two boxes upgraded, one box built new.
- Upgraded existing boxes to display current settings and integrated into NMR control so that changes are reflected in display.
- Redesigned
  - RF Attenuation Daq modules interface for component-ID key reading.
  - Redesigned and rewired modules' connections.



# Pump Cart

Controls nitrogen and helium for In-beam cryostat (IBC).

- Replaced and tested cRIO.
- Created flow chart of Pump Cart program.



# Software Work Done by DSG

- Developed Rotation of Target Polarization program.
- Modified programs.
  - Fast Resonance Scanner.
  - Nuclear Magnetic Resonance.
- Updated to latest version of LabVIEW.
- Developed documentation for all programs.
  - Flow charts in Visio.
  - Instrumentation manuals.

# Rotation of Target Polarization

- Rotates spin direction for target polarization.
- Varies currents in both solenoid and saddle coils.
- Created and demonstrated RTP program.
- Features:
  - Controls two power supplies (axial and transverse [saddle]).
  - Includes Automatic mode and Manual mode.
  - Program developed for Mercury iPS (new supplies, no GPIB).
    - Updated drivers to VISA.

# Rotation of Target Polarization

Rotation of Target Polarization User Interface

**Program Control**

Exit Program: OFF

Manual/Automatic Mode: Automatic Mode

Transverse Ramp Hold: OFF

Axial Ramp Hold: OFF

Axial PS GPIB Addr: 25

Transverse PS GPIB Addr: 26

Power Supply Comm Error

**Transverse Power Supply Status**

LOC/REM: Local & Locked, Remote & Locked, Local & Unlocked, Remote & Unlocked

Mode: At Rest, Sweeping, Sweeping Limit, Sweeping & Sweep Limiting

System Status: Normal, On Pos. Voltage Limit, On Neg. Voltage Limit, Outside Neg. Voltage Limit, Outside Pos. Current Limit, Normal, Quenched, Overheated, Warming Up, Fault

Activity: Hold, To Set Point, To Zero, Clamped

Amps (Fast), Tesla (Fast), Amps (Slow), Tesla (Slow)

Transverse Current: 0 Amps, Transverse Field: 0 T, Transverse Ramp Rate: 0 Amps/Min, Transverse Ramp Rate: 0 T/Min

**Axial Power Supply Status**

LOC/REM: Local & Locked, Remote & Locked, Local & Unlocked, Remote & Unlocked

Mode: At Rest, Sweeping, Sweeping Limit, Sweeping & Sweep Limiting

System Status: Normal, On Pos. Voltage Limit, On Neg. Voltage Limit, Outside Neg. Voltage Limit, Outside Pos. Current Limit, Normal, Quenched, Overheated, Warming Up, Fault

Activity: Hold, To Set Point, To Zero, Clamped

Amps (Fast), Tesla (Fast), Amps (Slow), Tesla (Slow)

Axial Current: 13.809 Amps, Axial Field: 0.0172 T, Axial Ramp Rate (A): 3 Amps/Min, Axial Ramp Rate (T): 0.004 T/Min

Automatic Mode | Manual Mode | Expert Controls

**Ramp Rates**

R1 Ramp Rate: 3 Amps/Min

R2 Ramp Rate: 9 Amps/Min

R3 Ramp Rate: 3 Amps/Min

R4 Ramp Rate: 9 Amps/Min

R5 Ramp Rate: 3 Amps/Min

**Wait Times**

T1 Wait Time: 10 Sec

T2 Wait Time: 15 Sec

T3 Wait Time: 15 Sec

T4 Wait Time: 10 Sec

Step % of Completion: 25

Elapsed Time: 24.0 Sec, 0.400 Min

Program Status: Ramping Axial Supply to 10.2 Amps at R1 Ramp Rate

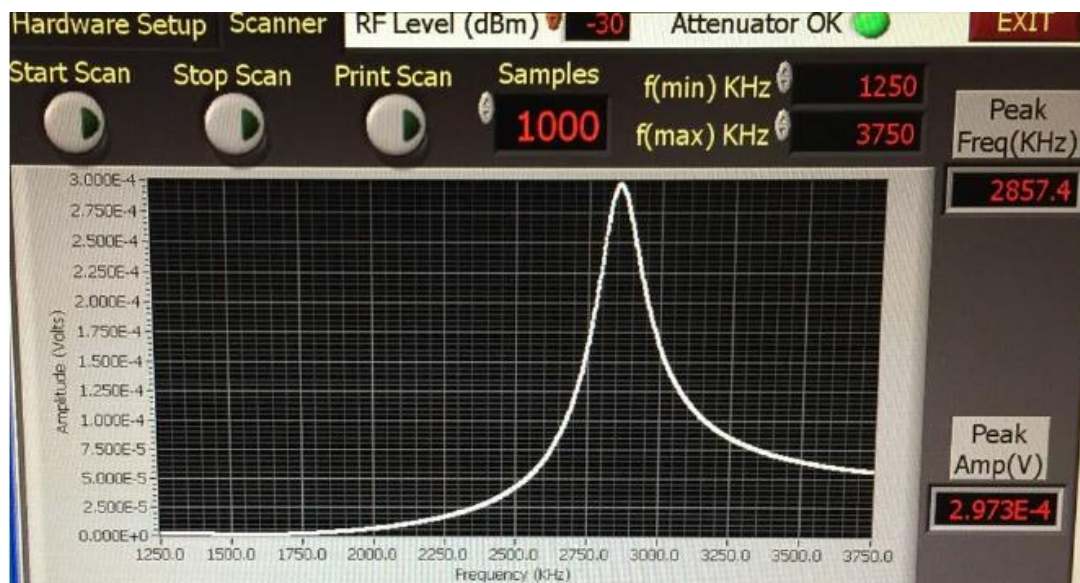
Ramp Type: Negative

Automatic Mode Diagram

Diagram Description: The diagram plots current (Amps) against time. The top trace is Axial current, and the bottom trace is Transverse/Saddle Coils current. The Axial current starts at 0, ramps up (R1) to +10.2A / +0.2T, holds (T1), ramps up (R2) to +68 A / 0.075T, holds (T2), ramps down (R3) to -10.2A / -0.2T, holds (T3), ramps down (R4) to 0, and finally ramps down (R5) to the ending point. The Transverse/Saddle Coils current remains at 0 throughout the process.

# Fast Resonance Scanner Program

- Sweeps RF frequency at constant magnetic field.
  - Determines RF parameters for setting up NMR run conditions and calibration constants.



Resonance peak at 2857 KHz

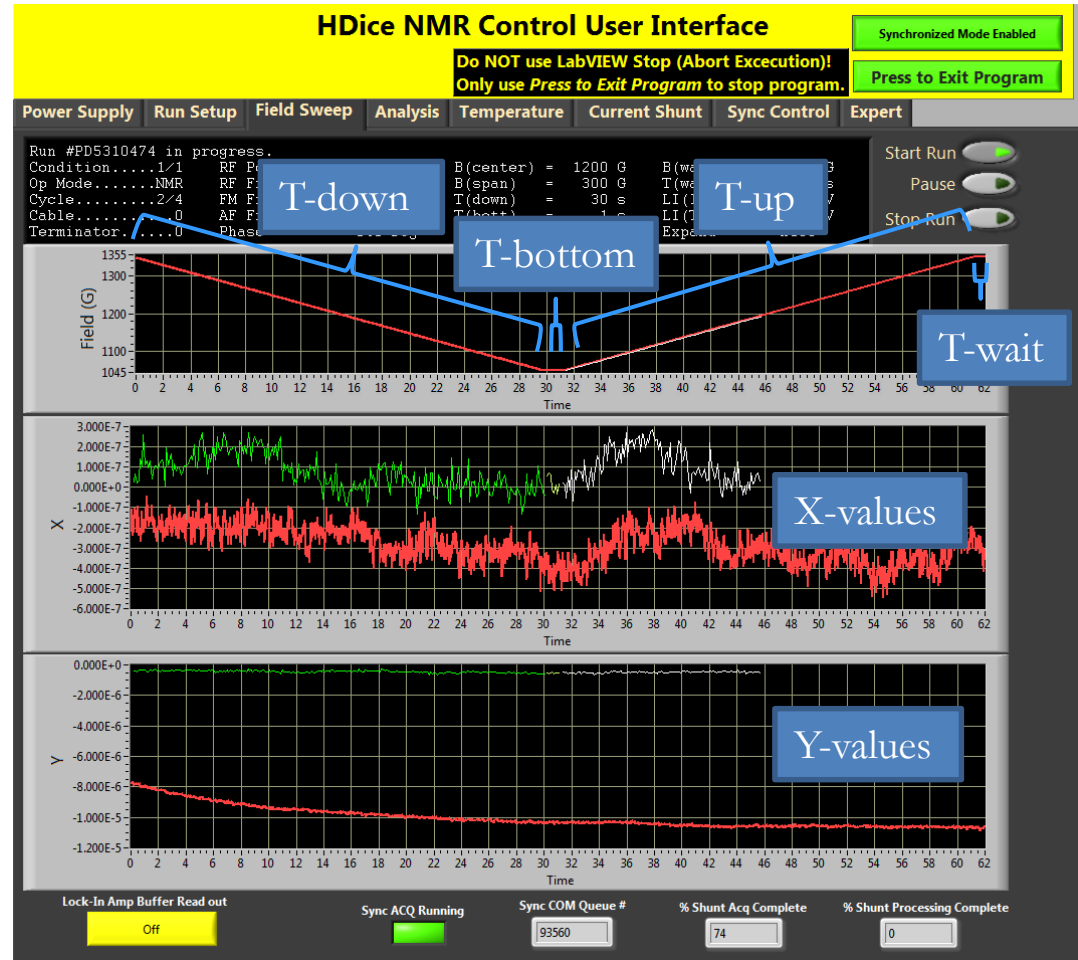
- Incorporated into LabVIEW NMR program file.

# NMR Program

- Sweeps magnetic field at a constant RF frequency.
  - Measures actual NMR signals for monitoring and analyzing polarization.
- Rewritten to include
  - Varying T-up, T-down, T-bottom, and T-wait times.
  - Varying field ranges (original range was fixed at 300 G).
- Implemented signal averaging.
- Modified to run scans with positive and negative current.
- Features added to program with option to enable and disable:
  - Synchronization Mode.
  - Sensors for temperature and liquid He level.

# NMR Program

- Signal averaging.
  - Red lines in graphs.
  - Averaged over cycle number.
- X-values and Y-values from lock-in amplifier.
  - Auto-scale to ensure signal is visible.





# Synchronization of CT-box with Lock-in Amplifier

- Synchronization incorporated into NMR program.
  - Provides an independent and accurate ( $<0.01\%$ ) magnet current measurement.
  - Current measurements are synchronized with lock-in amplifier measurements.
  - CT-Box maximizes number of acquisition points for variable NMR sweep lengths (up to 16,000 points, limited by memory of lock-in amplifier).
  - Stores measurements in NMR data files.
  - See [Synchronization Status](#) talk in March 2018 in the DSG website DSG/Talks

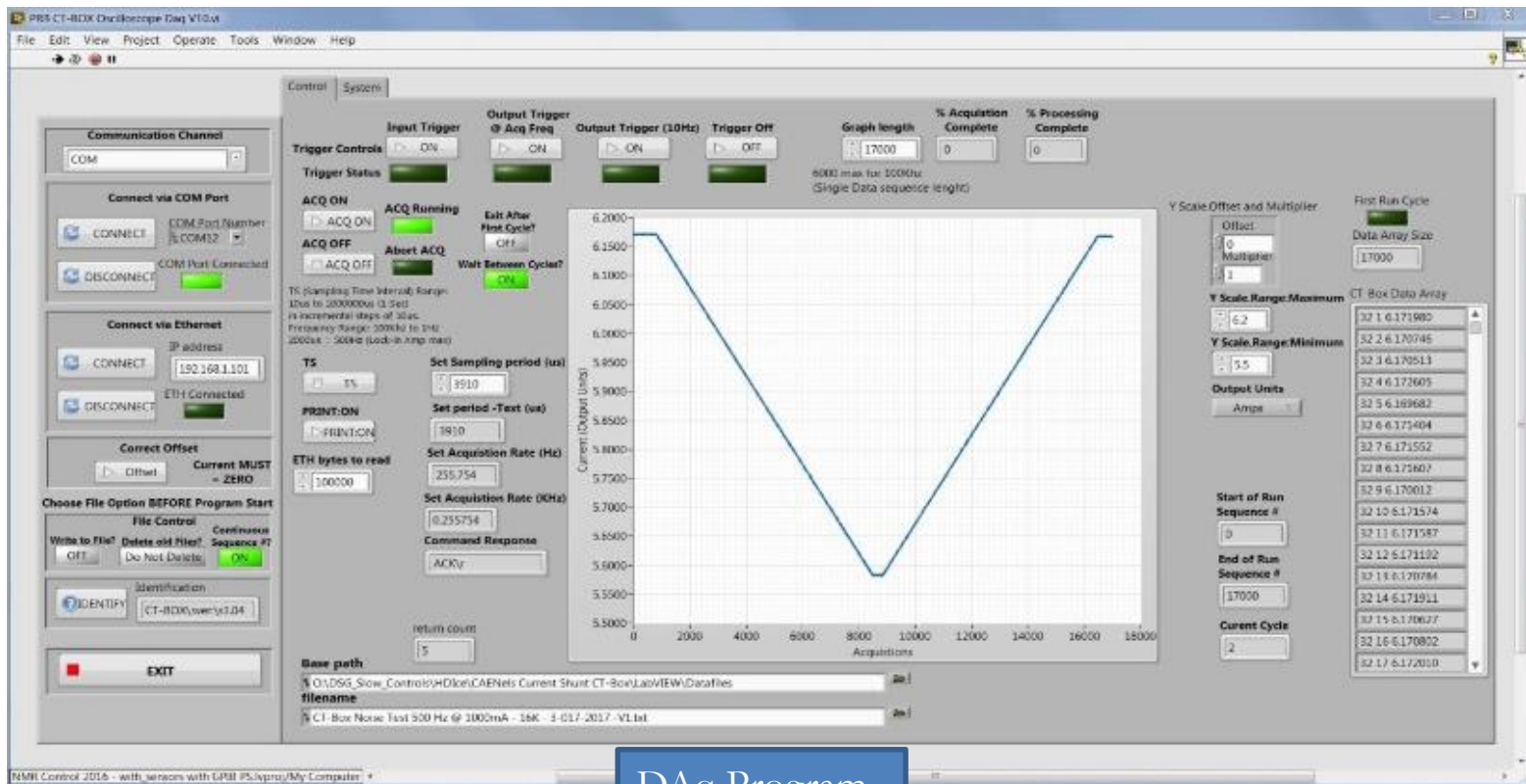
# CAENels CT-Box Current Shunt



- New product by CAENels.
- Required extensive development of library of LabVIEW device drivers (55 to 60).
- LabVIEW Daq code developed using DSG device driver library to test CT-Box.

# Synchronization Programs

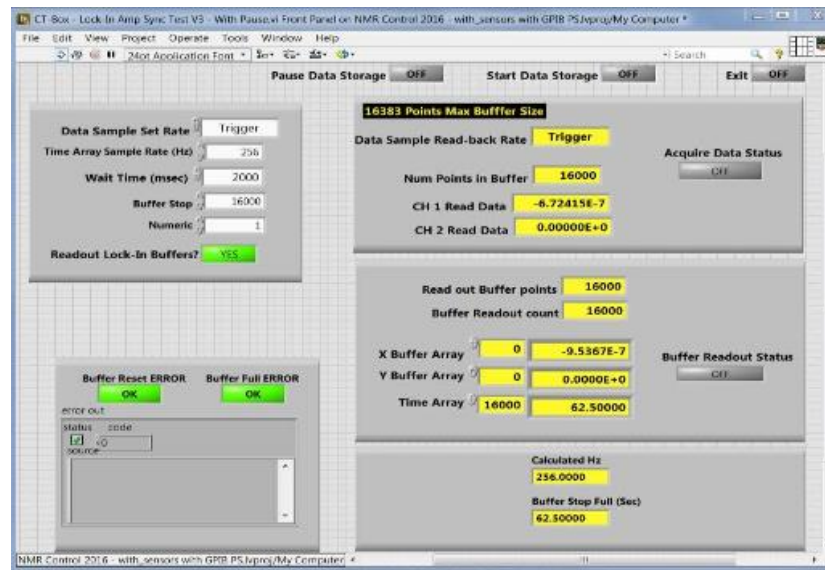
- CT-Box data acquisition program.
  - Created to measure current from output of power supply.
  - Tests CT-Box's frequency-dependent data acquisition and CT-Box's triggering.



DAq Program

# Synchronization Programs

- Lock-in amplifier test program.
  - Used with CT-Box data acquisition program to test following:
    - Lock-in amplifier data acquisition.
    - Data buffer storage and read-out.
    - Lock-in amplifier dual data stream.
    - Lock-in amplifier external triggering capabilities and limitations.



Lock-in Test Program

# Mathematica

- Program originally from Brookhaven.
- Creator of program no longer employed.
  - Could not obtain needed information to further program.
- Cancelled.

# HDIce Current Problems

- Rack #1 upgraded Windows 10 PC would not update to version 1809.
  - Computer center is performing update.
- Dilution fridge card tripping off power supply.
  - DSG looking at problem.
- Quench occurred in transfer cryostat magnet.
  - Caused damage to magnet winding.
  - Magnet winding not yet started.
    - Will take ~6 weeks.

# Work Requests Pending Approval

- Upgrade of Rack #2.
  - Procurement of second CT-Box.
  - Update of existing PCs to Windows 10.
  - *Waiting for CT-Box analysis so second CT-Box can be ordered?*
- Create NMR program that varies frequency with fixed current.
- Look into development method for beam position monitor.

# Conclusion

## All requests completed as of July 2018.

- Rack #2 completed July 2016.
- Rack #1 completed July 2018.
  - Since August 2018, DSG has been addressing issues presented by HDIce as they are requested.
    - These requests are listed as Additional Work Requests.

## DSG staff involved in this project:

Mary Ann Antonioli, Peter Bonneau, Pablo Campero,

Brian Eng, Amanda Hoebel, Mindy Leffel, and Tyler Lemon