Work Request Status
DSG-HDIce

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Detector Support Group
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- Work requests
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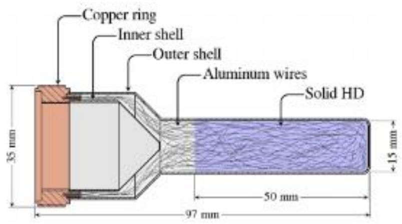
- Conclusion

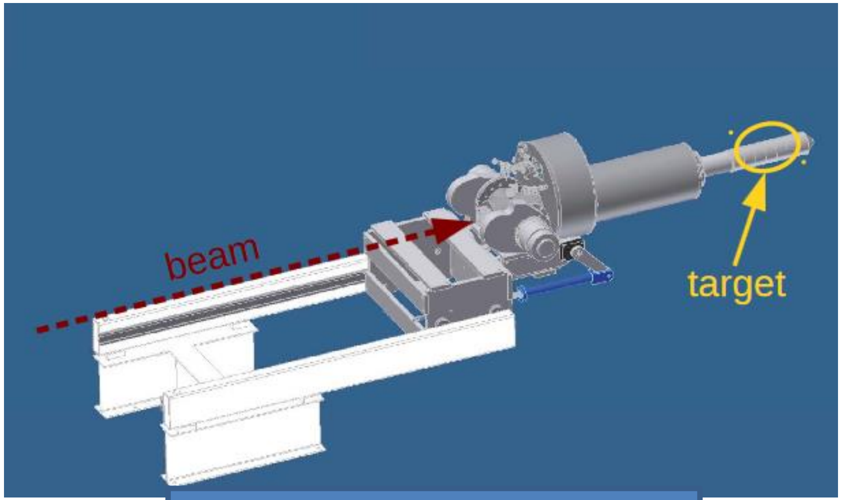
HDIce Experiment

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



Target

Aluminum wires

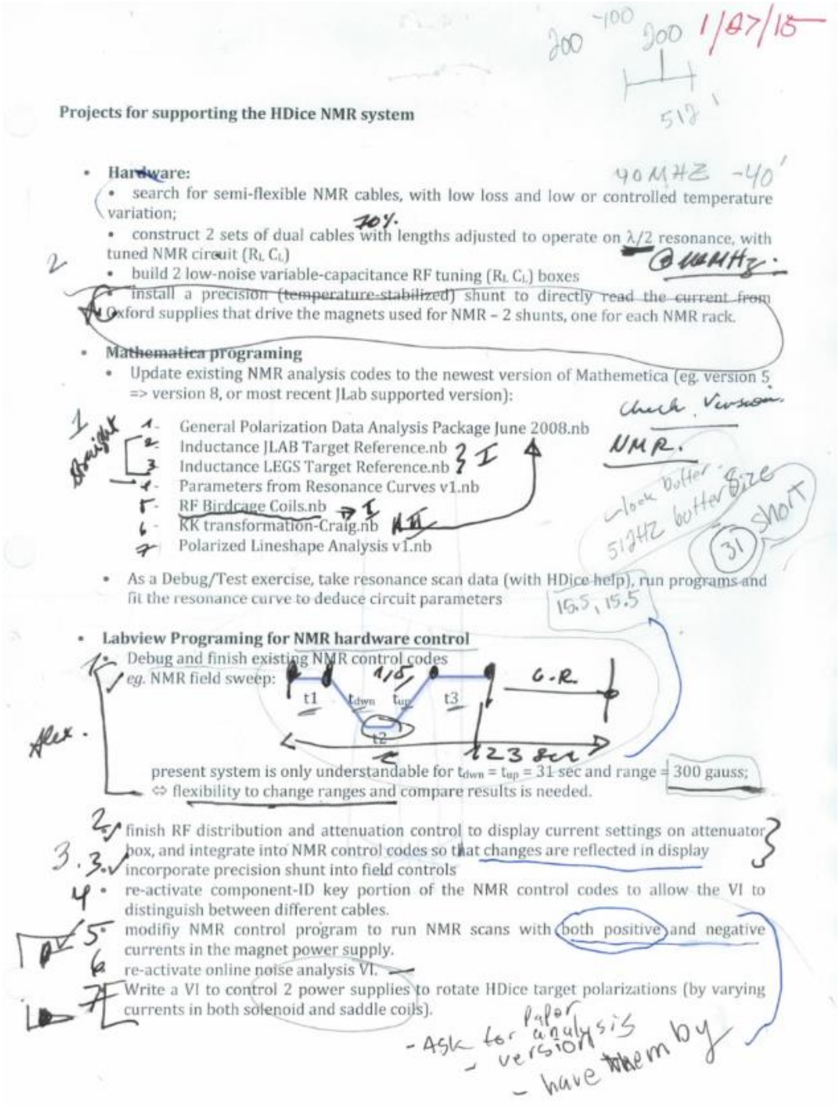


In-Beam Cryostat

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 duel cables with lengths adjusted to operate on λ/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.



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 λ/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 programing**
  - Update existing NMR analysis codes to the newest version of Mathemetica (eg. version 5 => version 8, or most recent JLab supported version):
    - General Polarization Data Analysis Package June 2008.nb
    - Inductance JLAB Target Reference.nb
    - Inductance LEGS Target Reference.nb
    - Parameters from Resonance Curves v1.nb
    - RF Birdcage Coils.nb
    - KK transformation-Craig.nb
    - 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
- **Labview Programing for NMR hardware control**
  - Debug and finish existing NMR control codes
    eg. NMR field sweep: t1 t_{dwn} t2 t_{up} t3
    present system is only understandable for $t_{dwn} = t_{up} = 31$ 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.
  - modifiy 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).

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.
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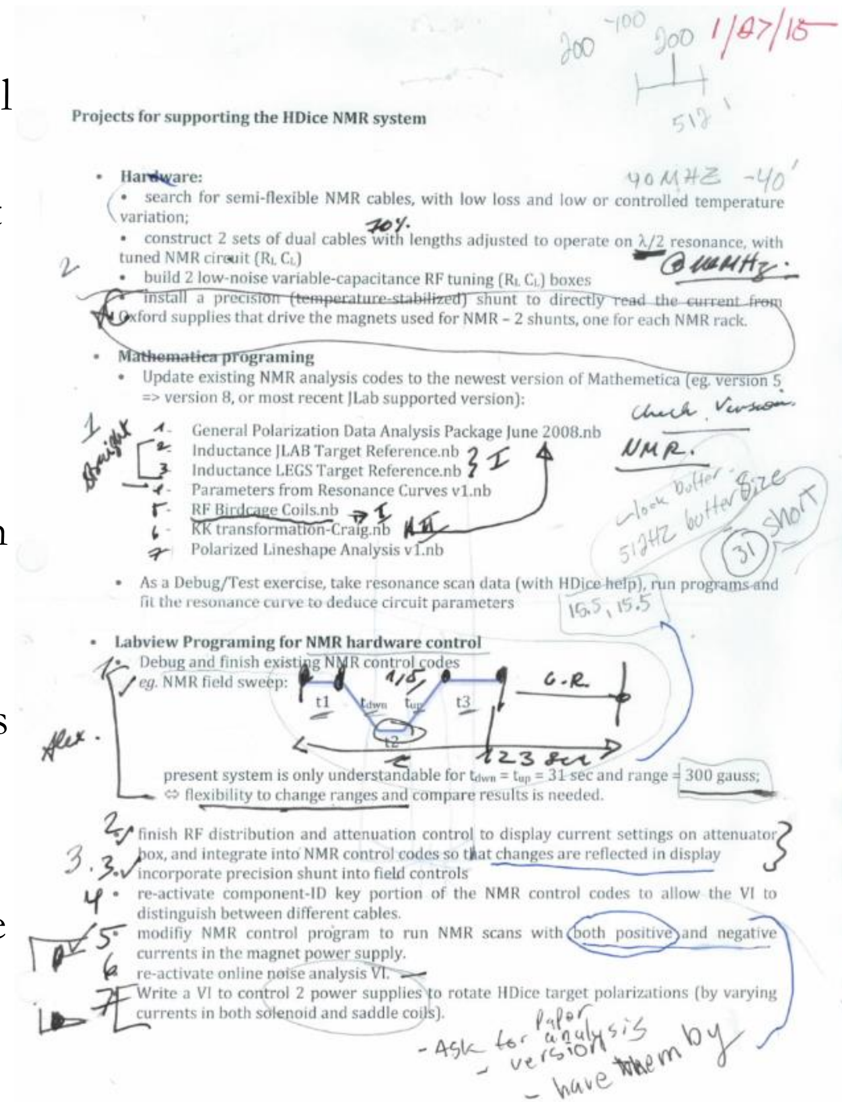

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Examples of Additional Work Requests

- 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.

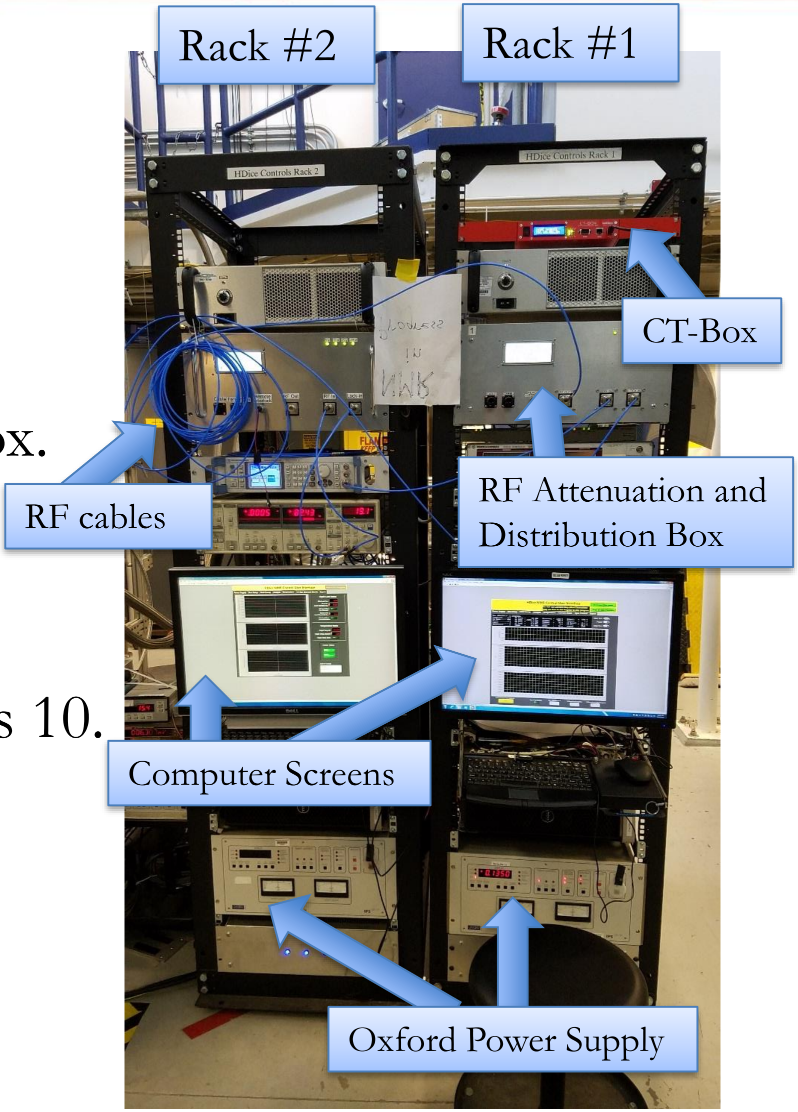
Examples of Additional Work Requests

- 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

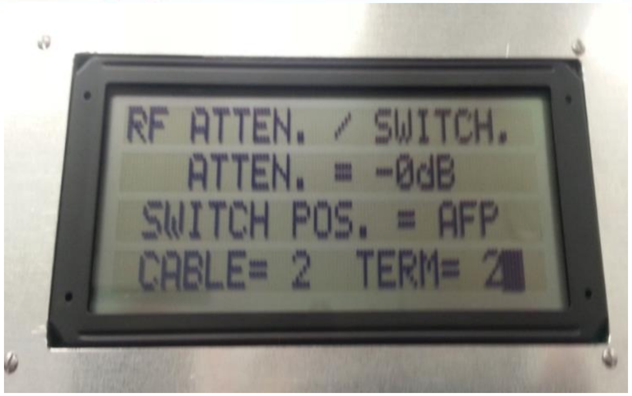
NMR Racks Built by DSG

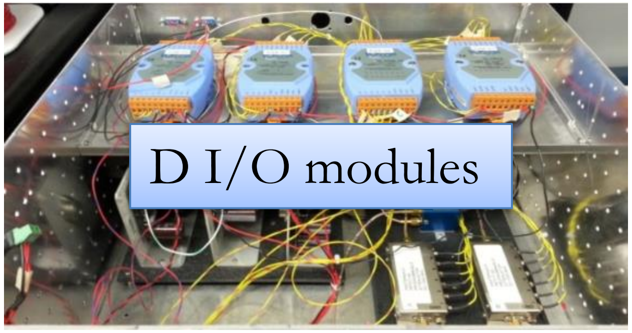
- Isolated racks.
- Fabricated and installed RF cables.
  - Low-noise
  - Semi flexible
- Built RF Attenuation and Distribution Box.
- Incorporated CAENels CT-Box.
  - Installed in Rack #1.
- Upgraded Rack #1 computer to Windows 10.
  - Rack #2 computer is Windows 7.
  - Needs to be updated to Windows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

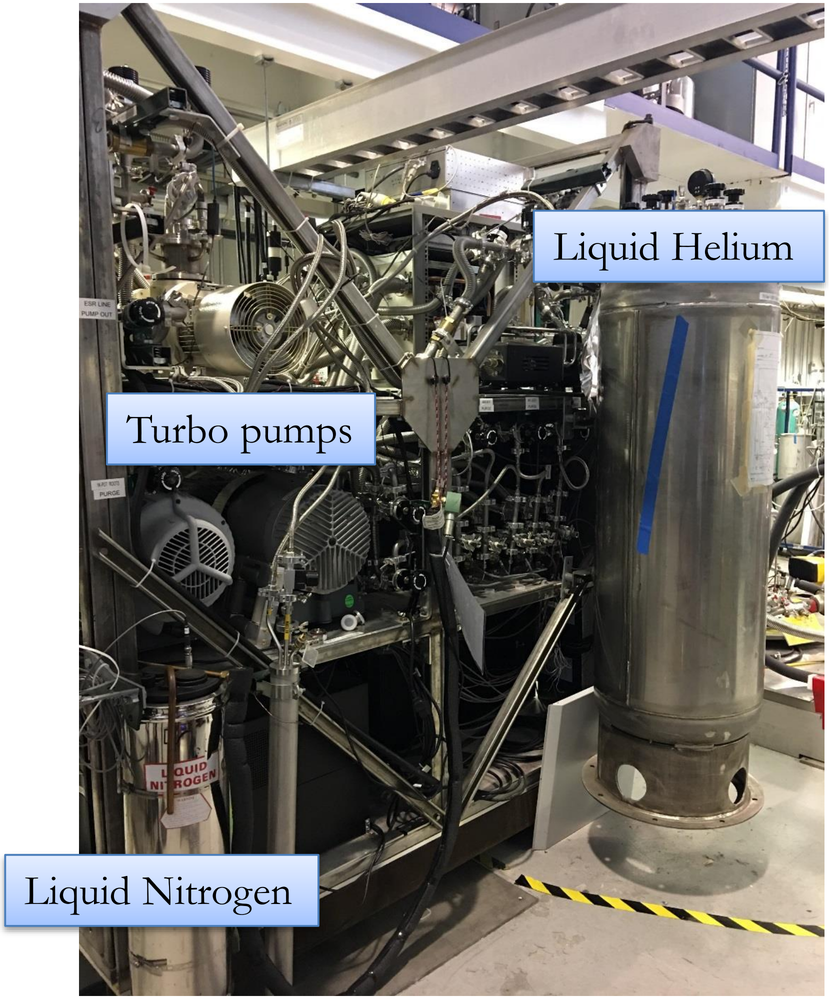




Pump Cart

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

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



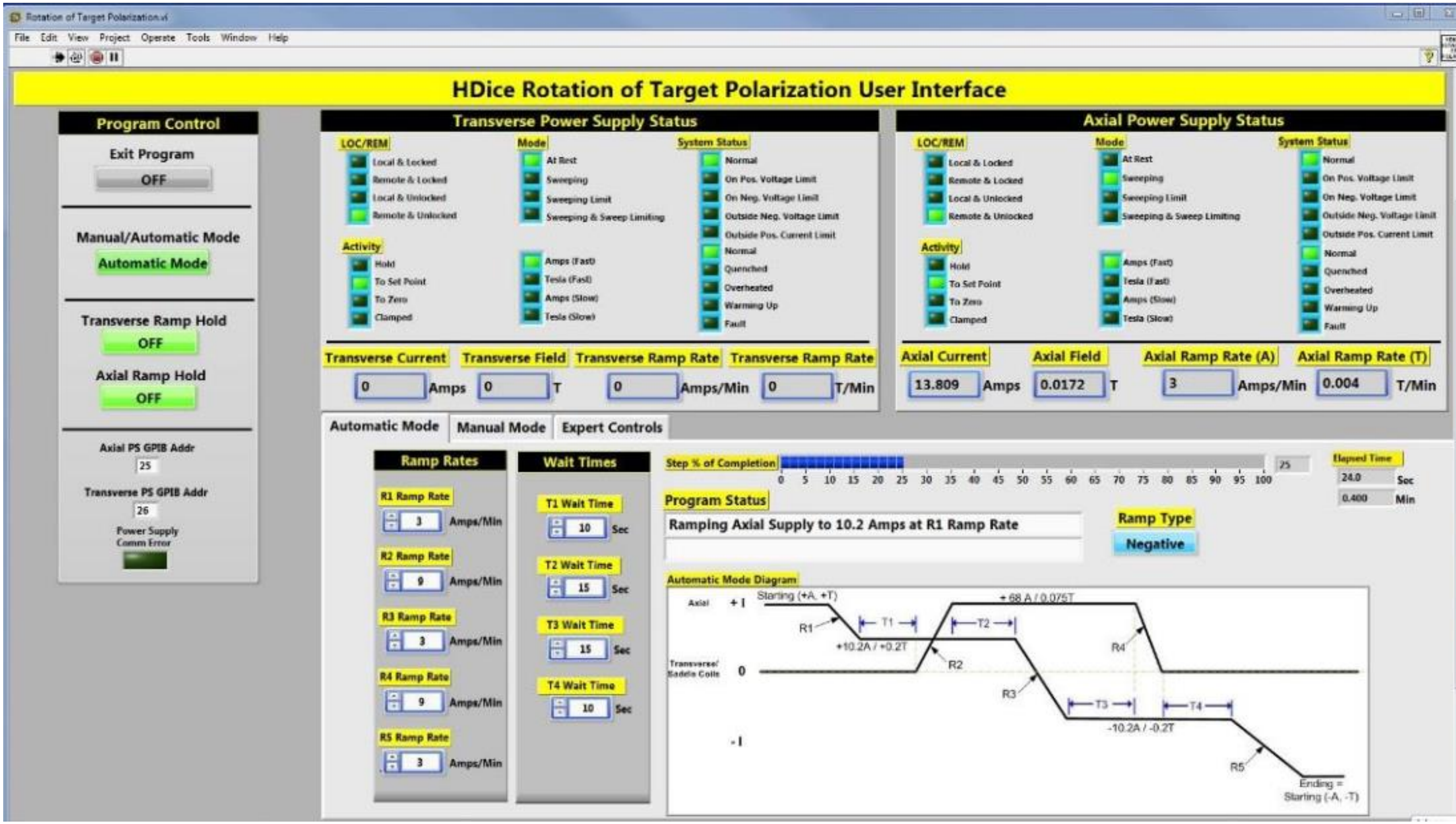
Software Work Done by DSG

- 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

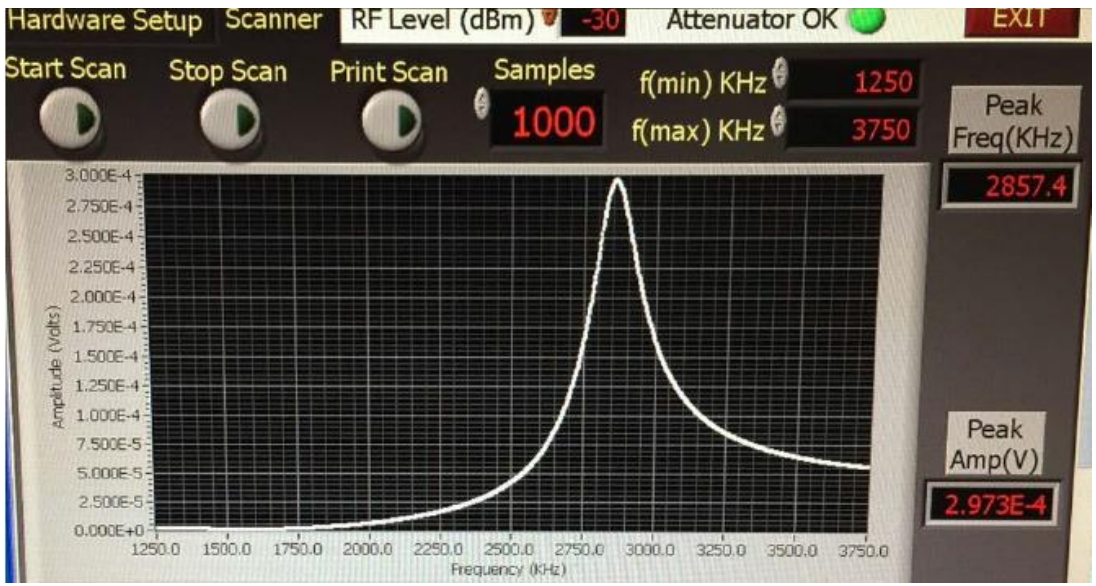
- Rotates spin direction for target polarization.
- Varies currents in both solenoid and saddle coils.
- Created and demonstrated RTP program.
- Features:
  - Controls two power supplies (axial and transverse [saddle]).
  - Includes Automatic mode and Manual mode.
  - Program developed for Mercury iPS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

Rotation of Target Polarization



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

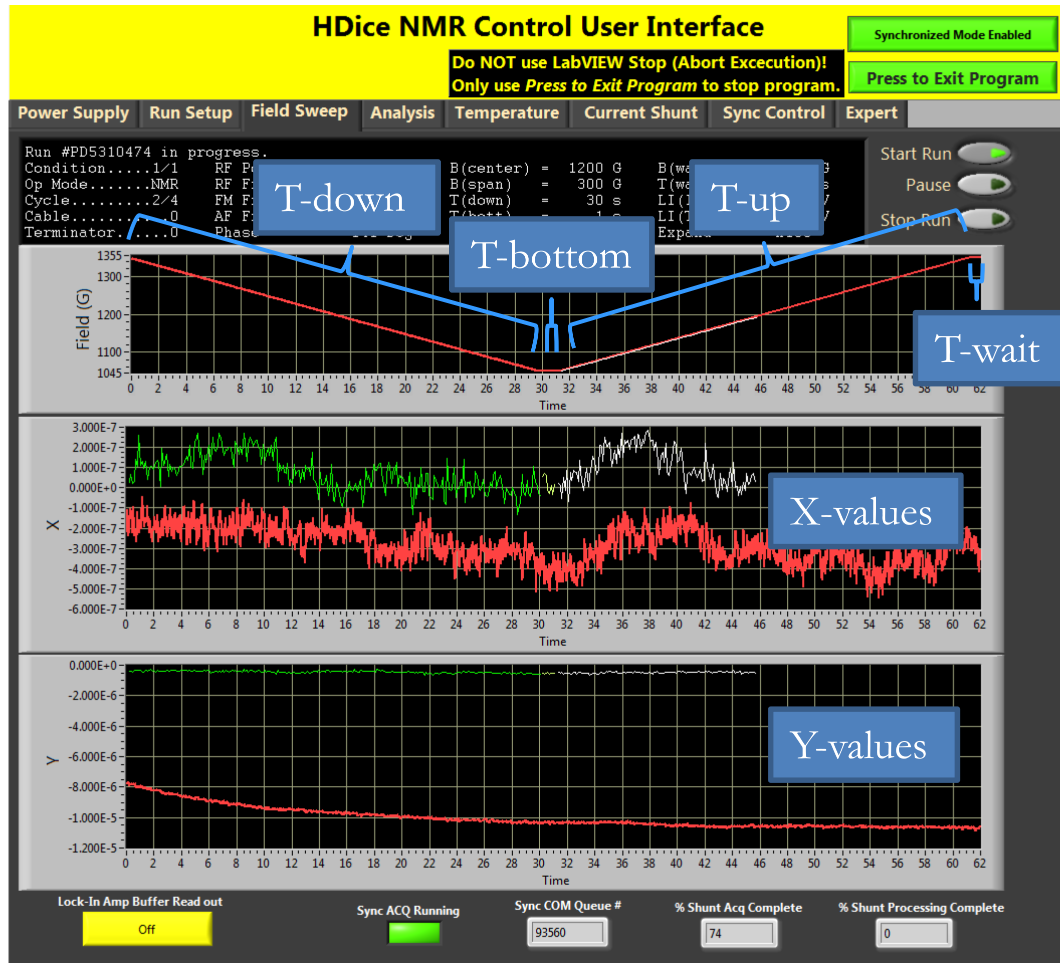
- Incorporated into LabVIEW NMR program file.

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.

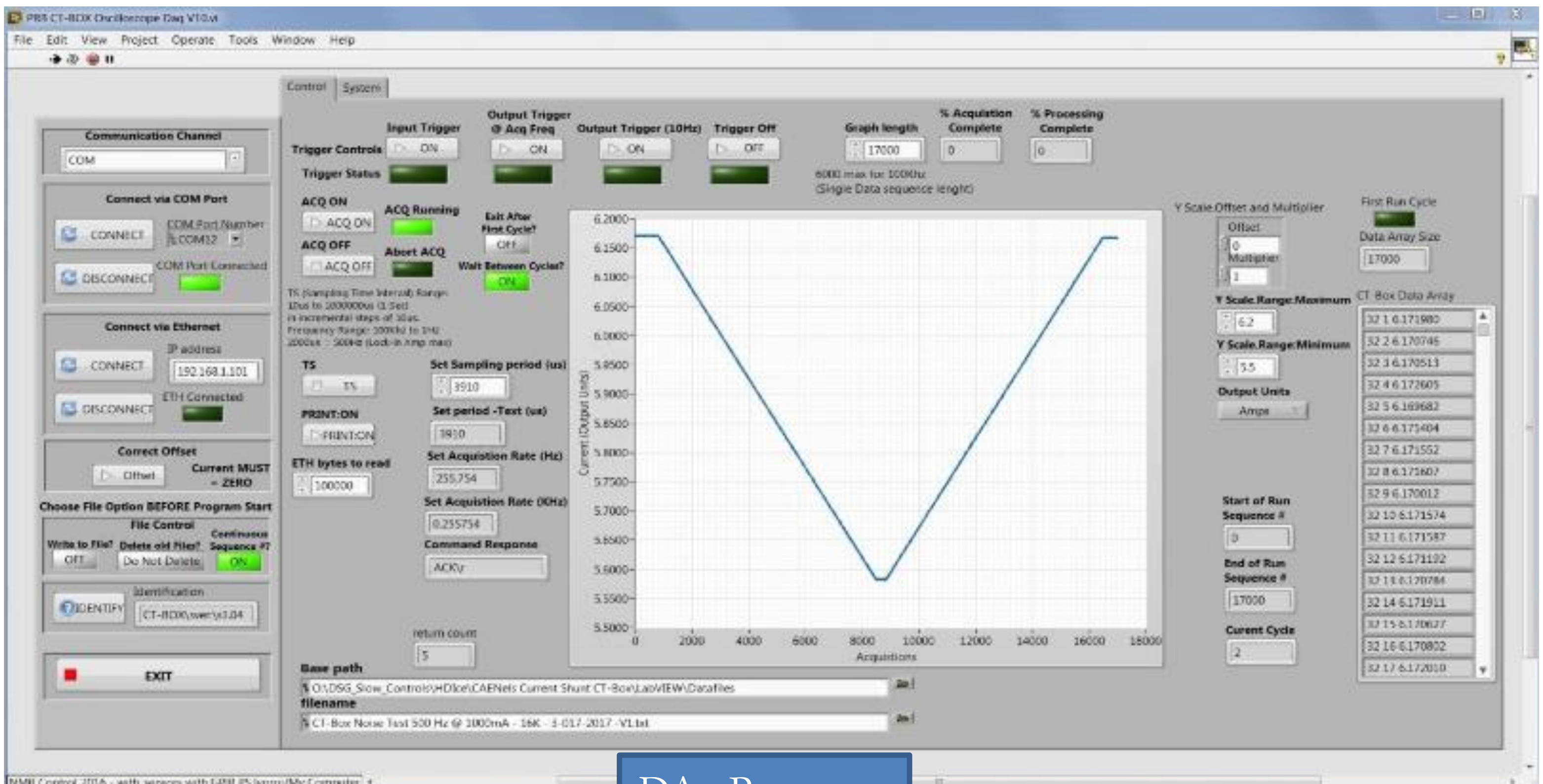
  - See Synchronization Status talk in March 2018 in the DSG website DSG/Talks

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

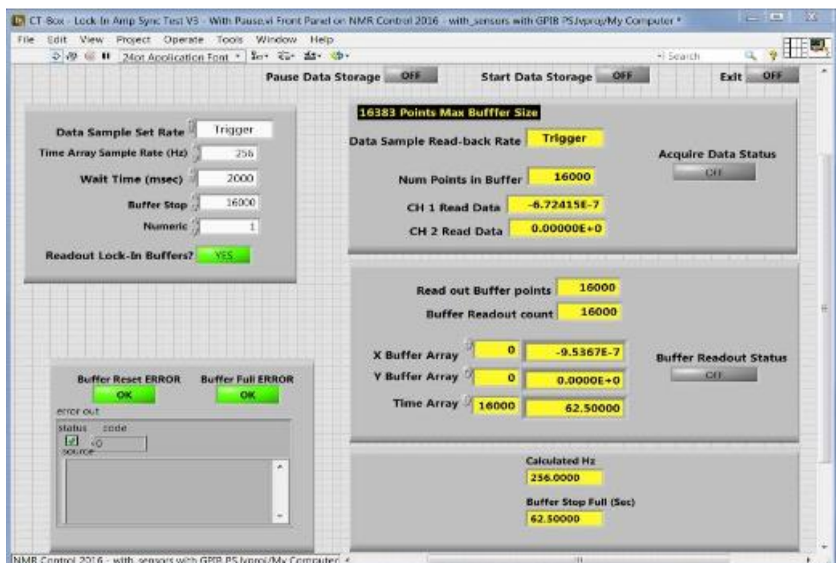
- CT-Box data acquisition program.
  - Created to measure current from output of power supply.
  - Tests CT-Box's frequency-dependent data acquisition and CT-Box's triggering.



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