



Developing Resonance Techniques (Part of Task 4)

Tasks:

- Demonstration of RF μ SR experiments using NMR style pulsed techniques
- Development of an in-situ NMR spectrometer

Deliverables:

- Demonstration experiments showing simultaneous excitation of the muon and nuclear spin (Q4, 2010)
- In-situ NMR apparatus demonstrated (Q2, 2010)
- Report of NMR performance, including demonstration data (Q3, 2010)



Programme of Work

1. Application of NMR style pulse sequences to RF μ SR

- Review applicable sequences;
- Demonstration of RF Decoupling / Composite Pulse spin inversion;
- Consider future developments

2. RF insert for ISIS High Field spectrometer (HiFi)

- Essential to extending pulsed RF μ SR to the high field instrument

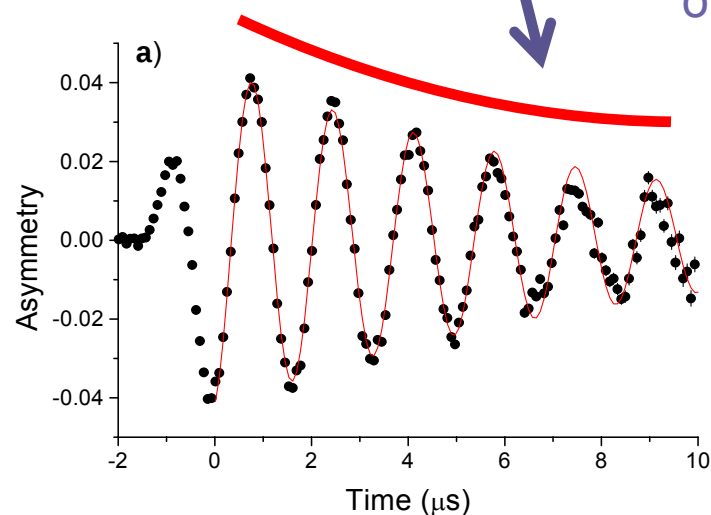
3. Development of an in-situ NMR spectrometer

- Identify suitable apparatus;
- Assemble and carry out demonstration experiments;
- Consider a future NMR test facility for developing RF coils for (1)



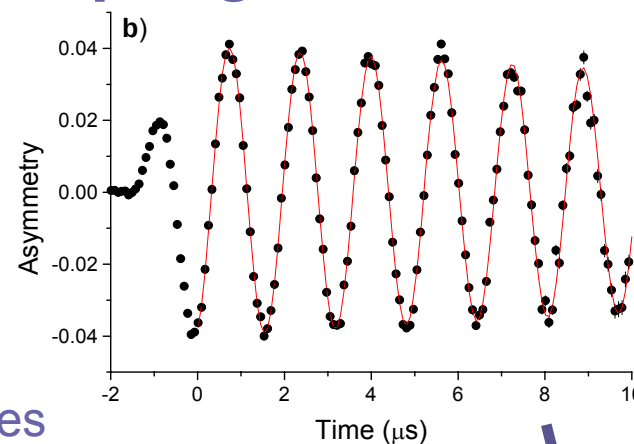
Pulsed RF Techniques – RF Decoupling

Decay **envelope** tells us about the environment the muon is probing



RF irradiation of nuclei

modifies environment



New information about muon coupling and dynamics – a model for proton behaviour

N.J. Clayden and S.P. Cottrell. Phys. Chem. Phys. **8** 3094 (2006)



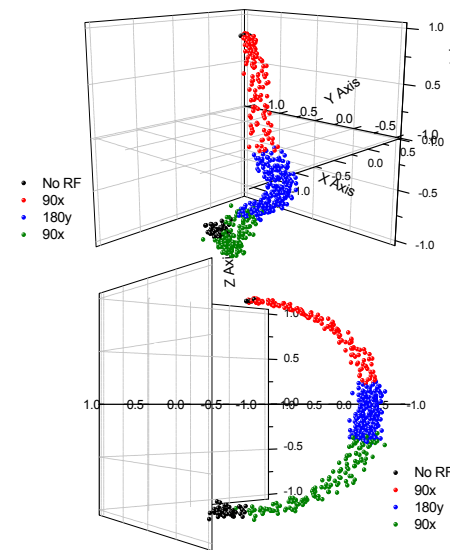
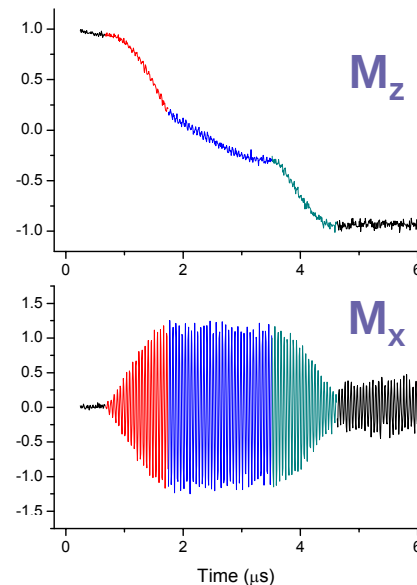
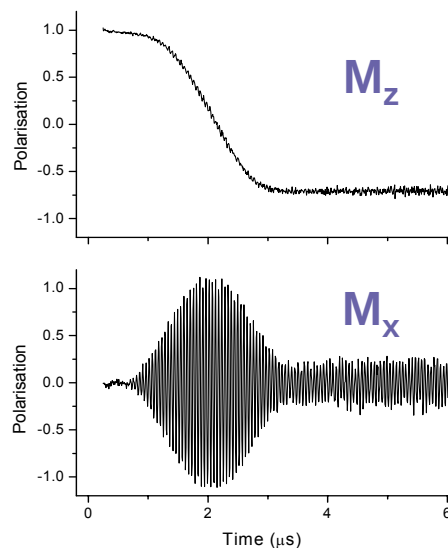
Pulsed RF Techniques – Composite Pulse

Composite pulses are often used in magnetic resonance to correct for finite pulse artefacts (a particular problem with pulsed RF μ SR)

The composite inversion sequence $\pi/2_x \pi_y \pi/2_x$ demonstrates this:

Simple π pulse: $\Delta M_z = 85\%$

Composite pulse : $\Delta M_z = 100\%$



Uniquely,
 μ SR
can look
inside the
RF pulse!



RF Centre Stick for the ISIS High Field Spectrometer

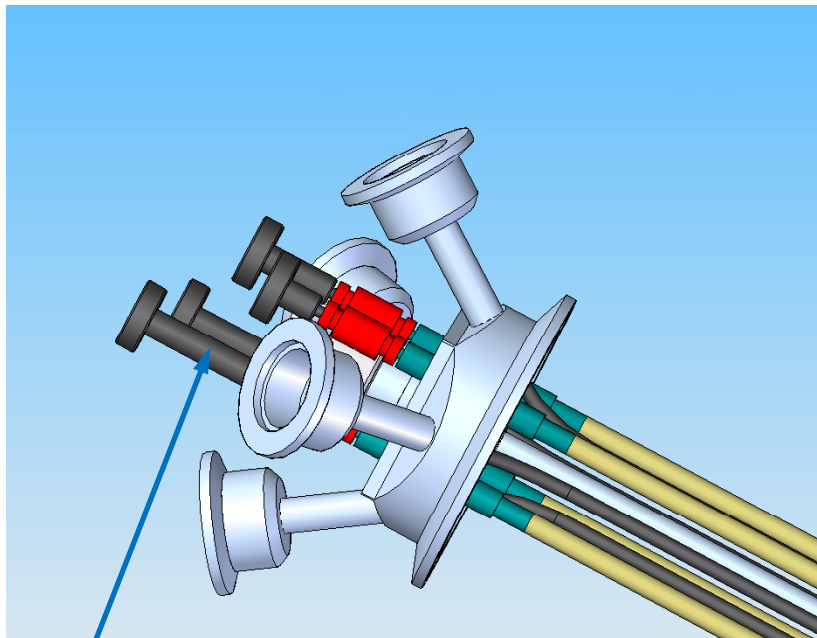
Essential for implementing pulsed RF techniques on HiFi
(but can also be used with benefit on existing EMU spectrometer)

Design criteria:

- Insert for existing OI Variox cryostat (1.5-400K)
- Reliably accept high RF powers (up to 1kW)
- Position tuning capacitors close to sample for widest tuning range

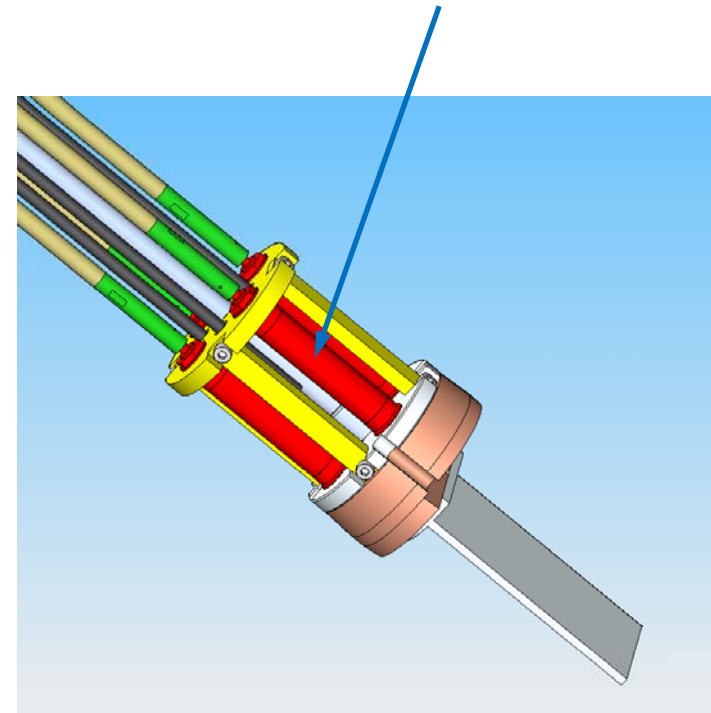


Initial design study:



Remote RF tuning using
external drive to capacitor
(involves vacuum feedthrough)

Voltronics capacitors selected
(non-magnetic, cryogenic, 1500V)
Four capacitors for double resonance





NMR – in-situ and off-beam

In-situ NMR:

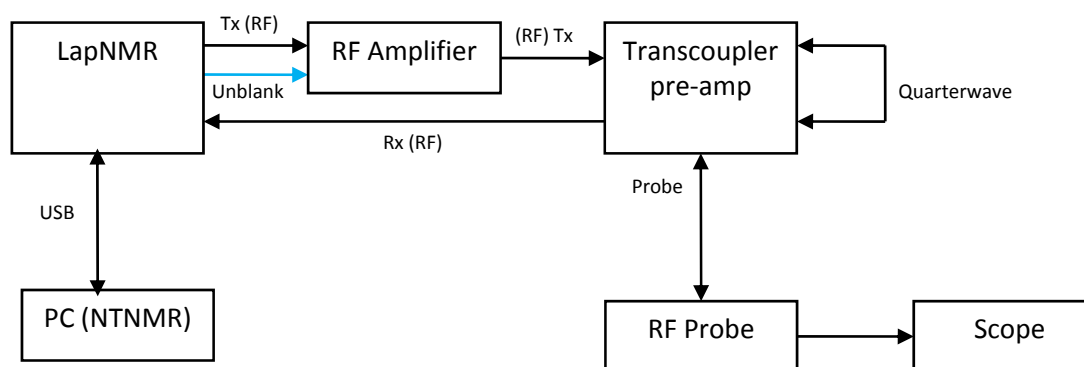
To study samples under conditions identical to the μ SR experiment

Off-beam NMR:

To test and characterise RF coils in preparation for experiments

Both applications require a portable and easily assembled NMR apparatus
We selected Tecmag's LapNMR (see <http://www.tecmag.com/lapnmr.html>)

Easy connection to
existing RF kit

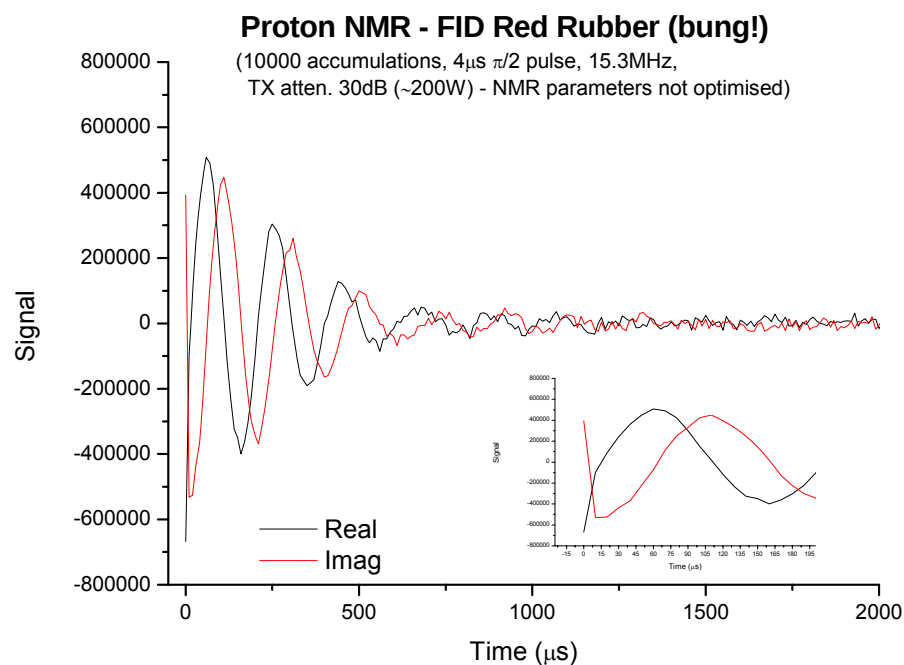




NMR

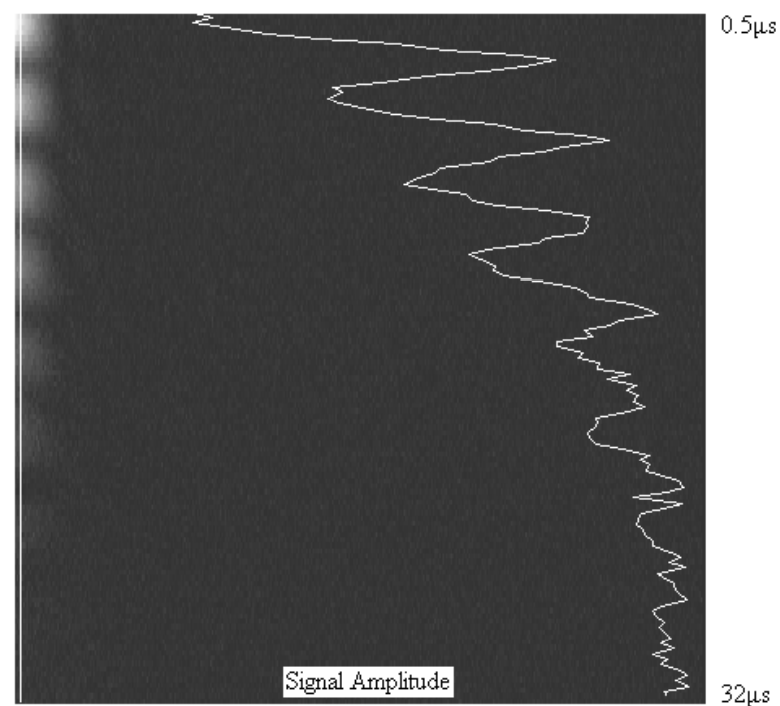
In-situ measurement

Proton NMR signal from rubber



Coil development

Scanned RF pulse length to determine optimum $\pi/2$ pulse and corresponding RF field strength (321 kHz).

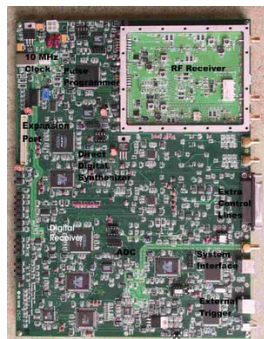




An off-beam facility for coil evaluation?

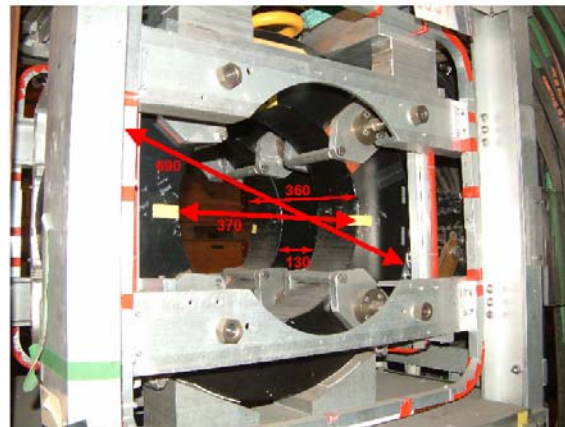
Developing RF coils outside of ISIS beam time should save time and money.

Access to the muon spectrometers can be difficult even during beam shutdown ... a separate test facility would be of benefit.



LapNMR

+



Magnet provided by PSI

= Potential for building an off-beam test facility