Preliminary 1D Imaging Results using the Lab-Tools Mk3 NMR Spectrometer.

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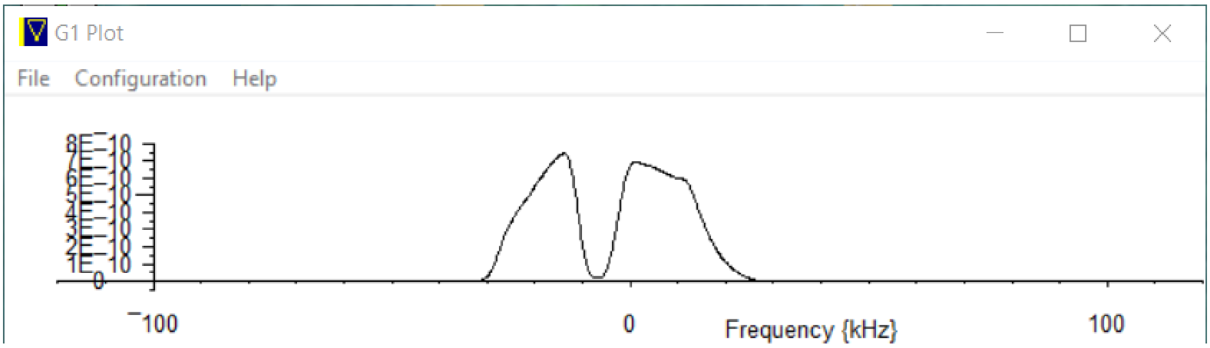
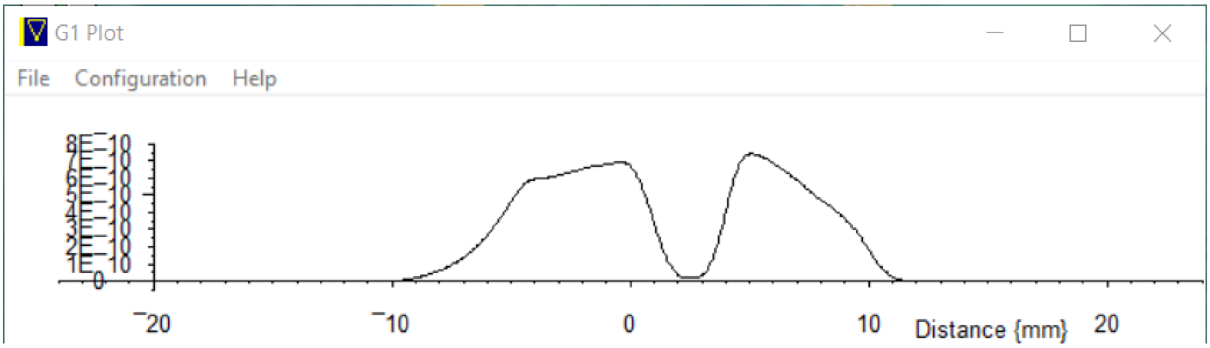
Magnetic field profile measurements were first made in the gap of an old horseshoe magnet (probably intended for use with Klystrons). These measurements were made using the Lab-Tools Mk3 NMR Spectrometer, by using a small water sample (2.5mm diameter, 2 mm long) in the standard room temperature probe. The spectrometer and probe were just nudged forward in 2.5mm steps, using the depth probe of a digital calliper, while recording the spectrometer frequency when it was locked to the NMR signal frequency.

The magnetic field profile in the plane of the horseshoe was a surprisingly linear gradient of about -64 $mT.m^{-1}$, while at right angles it was about a factor of 10 lower at + 7.9 $mT.m^{-1}$. The first thought was could this gradient be shimmed so the field was more uniform ? - and the second thought was could use be made of this low linear gradient in one dimension ?

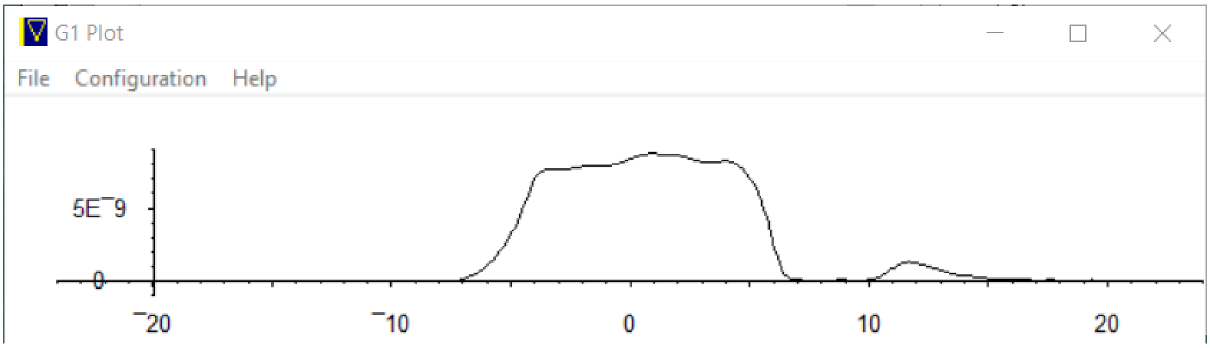
A structured 5mm OD sample was prepared using rubber cored from a white eraser, using a 5mm cork borer. One piece was 9.0 mm long, the other 7.0 mm long, with a 4.58 mm long glass spacer between them, for an overall length of 20.6 mm. This then just fitted into the existing 5mm coil in the room temperature probe, which has a 3 dB bandwidth of a few MHz.

A reasonable amplitude NMR echo was obtained at 2ms, and a Fast Fourier Transform (FFT) gave a structured frequency plot. Scaling this using the measured gradient gave a very believable 1D image of the original 20mm long sample, as a first image :



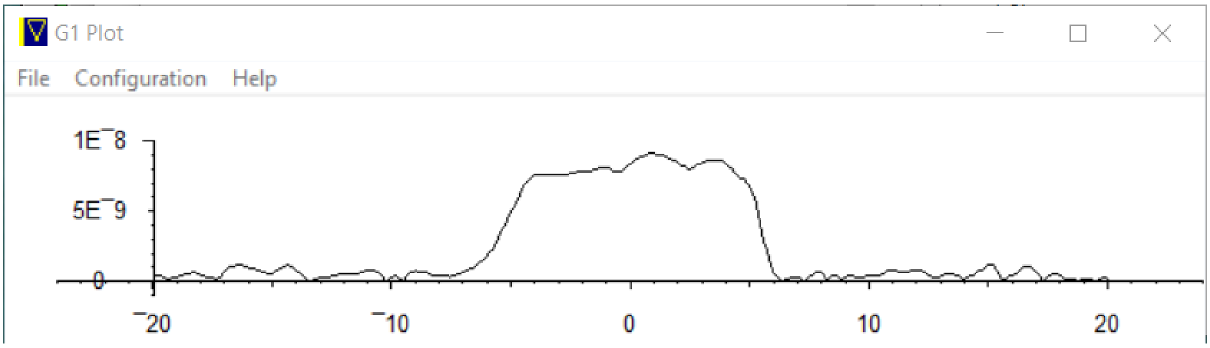


One question is why are the profiles not flat-topped ? Frequency limiting was considered, but increasing the receiver bandwidth by a factor of 10 just increased the noise, and did not change the averaged profiles. The answer appears to be the limited precision and range of the magnet's linear gradient : moving the whole probe with the structured sample further into the magnet (+ve dirn.) suppressed the image from one piece of rubber, but favoured the image from the other piece :

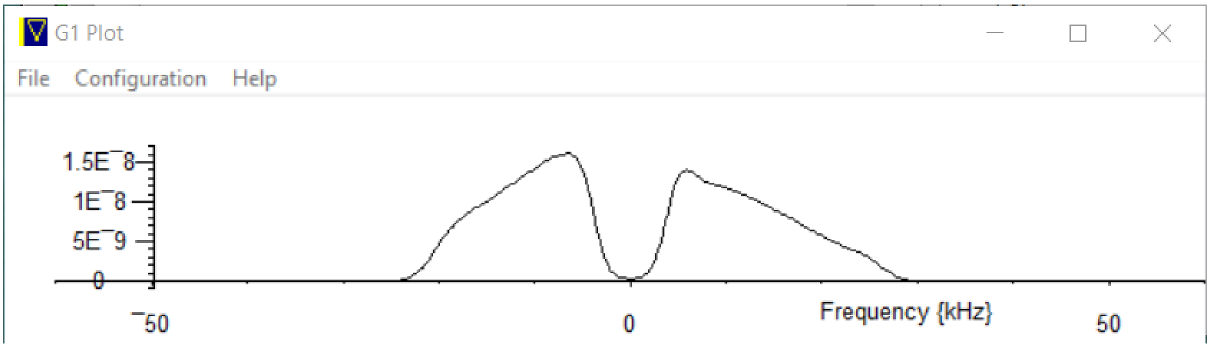


Again, increasing the receiver bandwidth made no difference to this image.

Signal-to-noise is fairly pleasing, in terms of the ability to say do fast image capture and quantification; this is the same view, with a single-shot capture :



Phase-cycling has as yet not been implemented, but FFT artifacts are pleasingly low; here is the two-piece rubber sample with 0 frequency located in the glass spacer. There is no DC artifact visible at 0 frequency. A $\cos^2$ window, and simple zero-padding to a power of 2 length for the FFT, are used.



Whilst this is only 1D imaging, that is mainly due to the limitations of the magnetic gradient systems currently available to Lab-Tools; given a general 3D gradient set with drivers, full 3D imaging of modest sized objects should be possible with the Lab-Tools Mk3 NMR Spectrometer. Imaging of larger objects should be possible when the Lab-Tools Digital NMR Transmitter has completed its testing stages.