1D Imaging Experiment

Based on a past experiment on 1D imaging

Research Question: How can one-dimensional magnetic resonance imaging be used to show the distribution of protons in the sample along one direction?

Materials:

- TeachSpin Pulsed NMR Spectrometer and Oscilloscope
- Test tubes
- Silicone test samples
- Teflon spacers
- Buna-N test sample

Procedure:

Created 1D MRI images of 3 samples using cylindrical sample vials with a layered structure and a one dimensional linear magnetic field gradient to collect an image of the sample as a proof of principle. A linear gradient was applied along the cylindrical axis (y axis for the TeachSpin Spectrometer).

Hypotheses:

Sample 1: Silicone top layer, teflon spacer, silicone bottom layer

Prediction: For this sample, we expect to see two peaks with equal magnitude since we should only see signal from the silicone and not the teflon spacer.

This material is based upon work supported by the National Science Foundation under award DUE-2120545.

Sample 2: Silicone top layer, teflon spacer, silicone bottom layer (silicone layers are thinner than in sample 1)

Prediction: For this sample, we expect the signal to have a lower amplitude and a larger gap because of the smaller silicone layers, however both peaks should be equal.

Sample 3: Buna-N top layer, teflon spacer, silicone bottom layer

Prediction: For this sample, we expect a signal from both the Buna-N top layer and the silicone bottom layer, but with different amplitudes. We also expect the two layers to have different T_1 relaxation times due to the differing hydrogen content.

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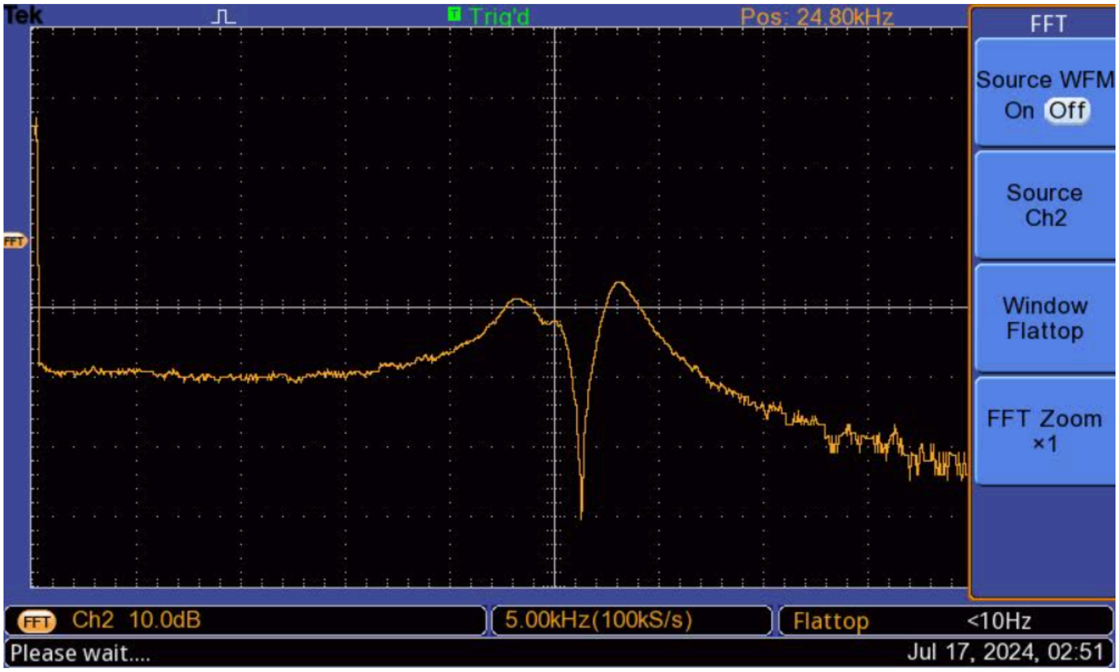
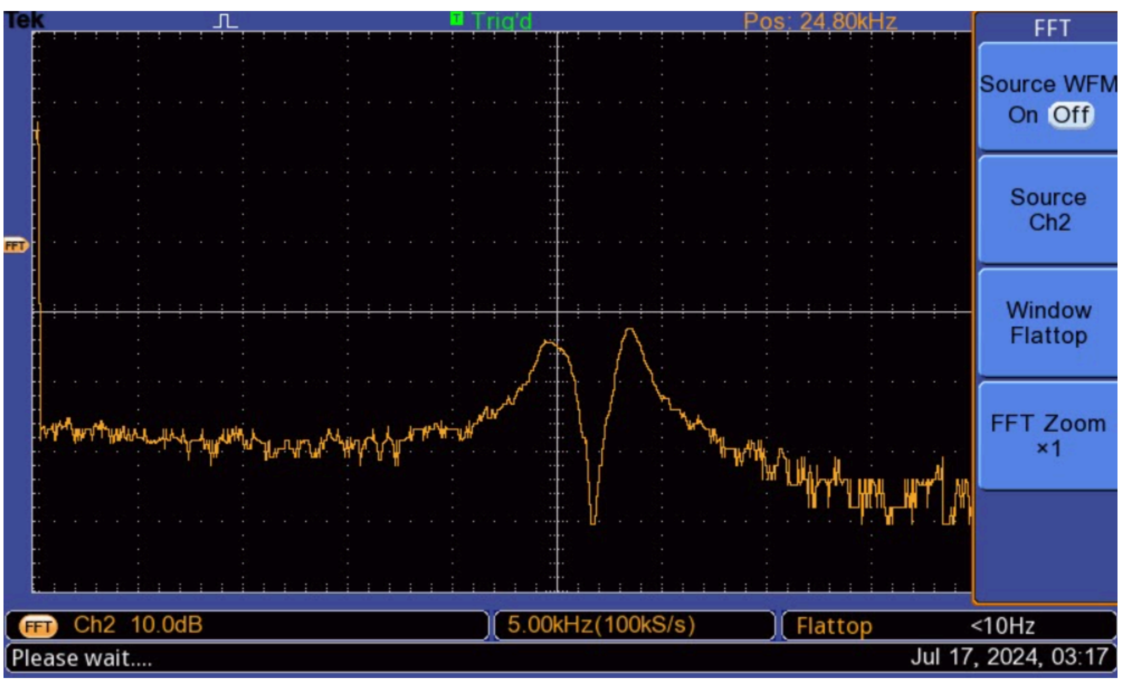
Data:

Sample 1: TR= 100 ms



Sample 2: TR= 100 ms



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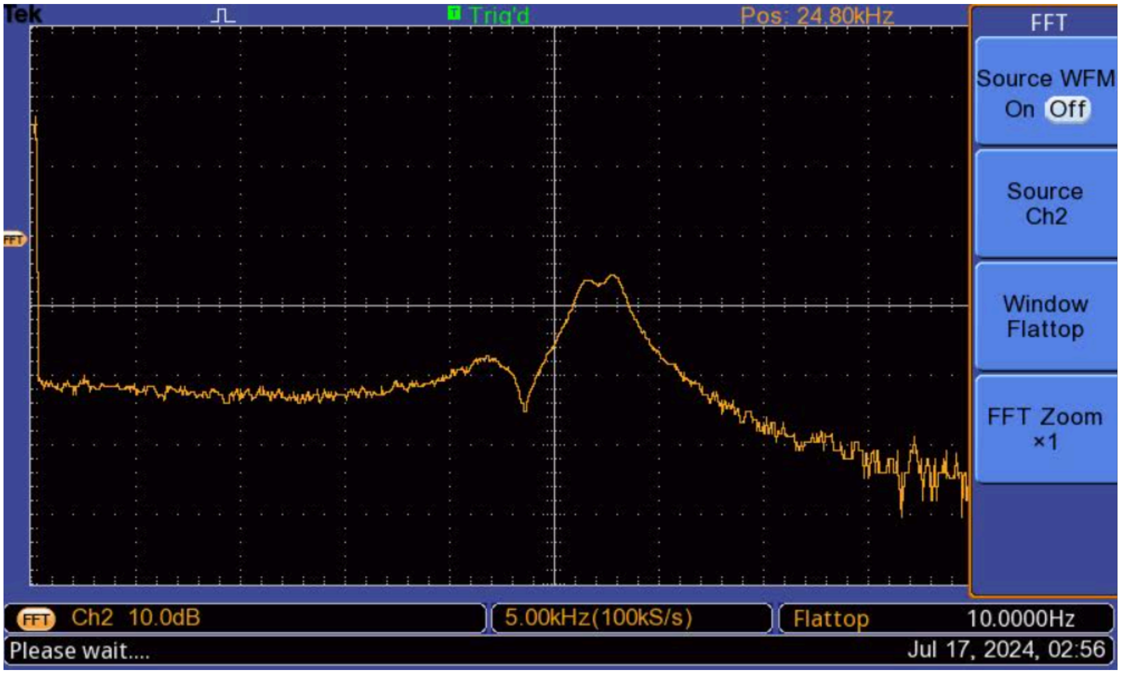
Sample 3: TR= 100 ms



Analysis:

Sample 1: The prediction is correct because there are two roughly equal peaks. The variation between the two peaks could be because of a slight difference in the amount of each silicone layer.

Sample 2: The prediction is correct because there is a more noticeable gap between the peaks compared to sample 1 and the peaks are more even.

Sample 3: The prediction was correct because there were 2 different amplitudes to compare between the silicone and Buna-N layers, showing they have different signal intensities.

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Conclusion:

For our experiment we used two silicone samples as well as a Buna-N sample as different rubber samples that provide a good proton signal in magnetic resonance imaging while also having solid structure. The data shows we can resolve the different layers of the samples along the cylindrical axis. From these three samples, it is clear that the Buna-N has less signal than the silicone. As we used fairly short TR times (100 ms), this difference in signal amplitude can be explained if the silicone has a shorter T1 time than the Buna-N. This means that silicone takes a relatively short time for the magnetization to recover to its equilibrium value after it has been disturbed, producing stronger NMR signal after 100 ms, in comparison to the Buna-N.

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Follow-Up Experiment:

Hypothesis: The difference in signal amplitude between can be explained if the silicone has a shorter T1 time than the Buna-N.

Procedure: Change the repetition time (TR) to be longer than 100 ms to see if the signal of the Buna-N approaches the level of the silicone or not.

Prediction: If the silicone has a shorter T_1 time than the Buna-N, then the amplitude of the Buna-N peak should increase with longer TR times. If the peaks stay with the same height difference independent of the TR time, then the peak amplitude difference cannot be explained by differences in T_1 values.

Data:

Sample 3:

TR= 100 ms

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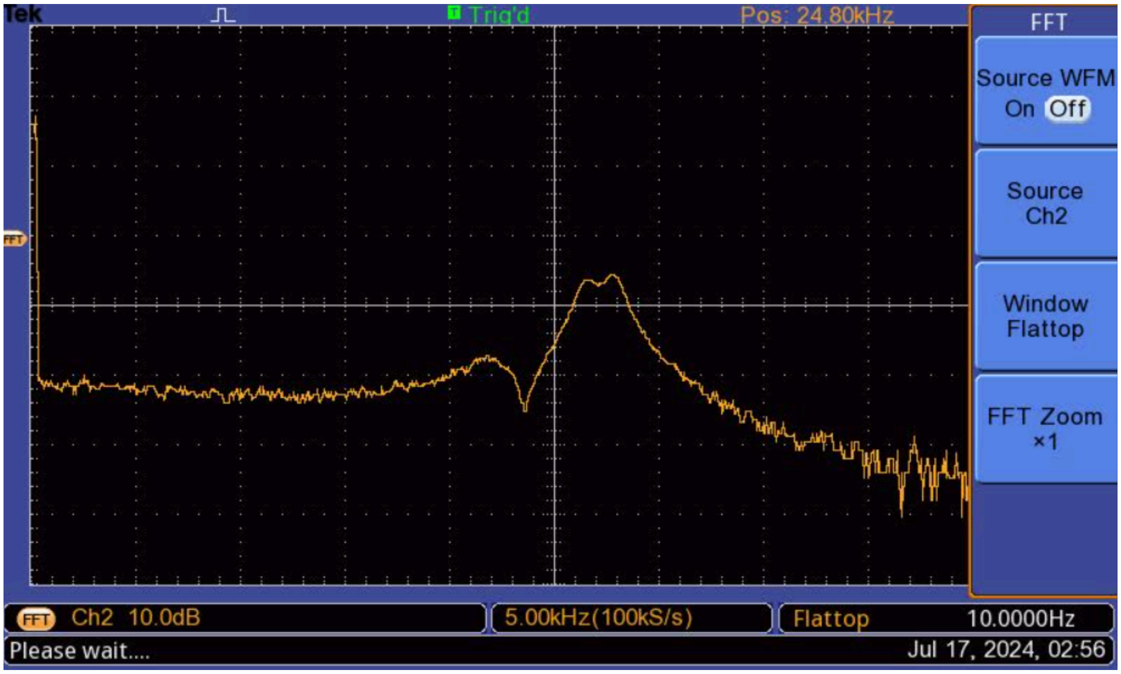
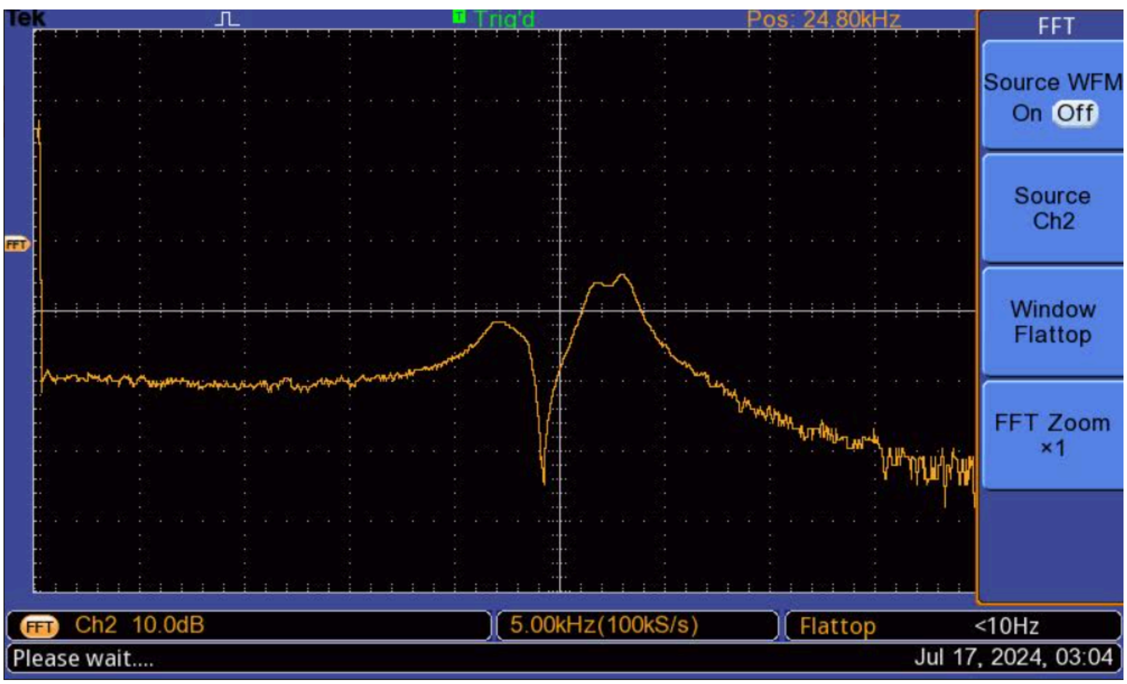


TR= 500 ms



TR= 900 ms

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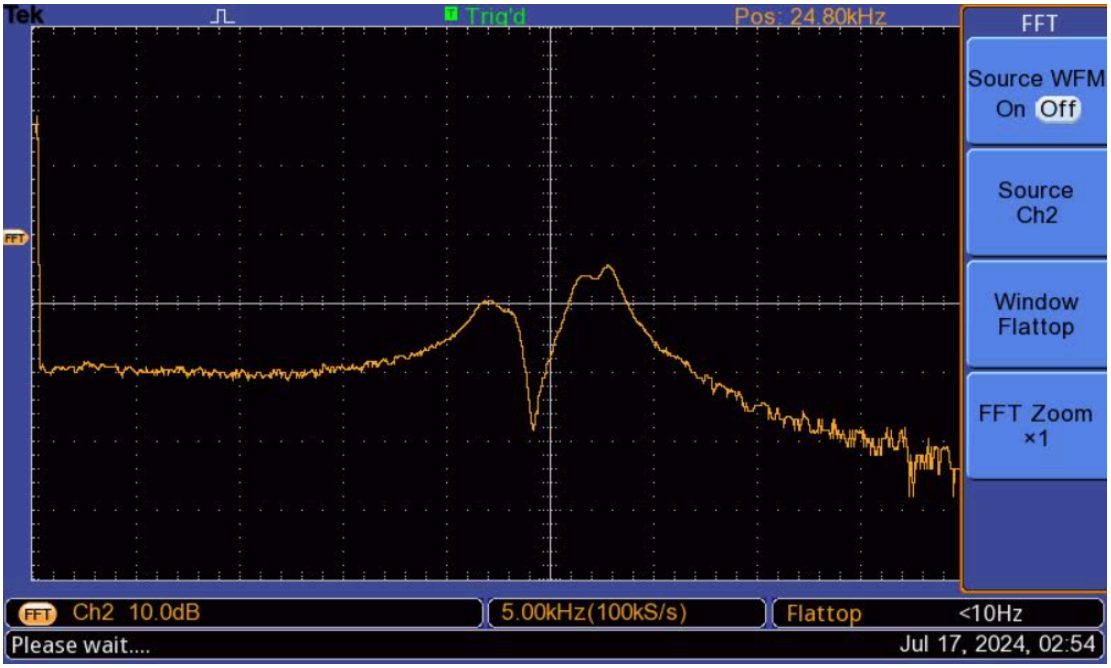

Analysis:

At a shorter TR time of 100 ms, the two peaks are noticeably different, with the Buna-N sample having a shorter peak than the silicone peak. As we increase the TR time, to 500 ms and then 900 ms, the Buna-N peaks starts to grow and look more similar to the silicone peak.

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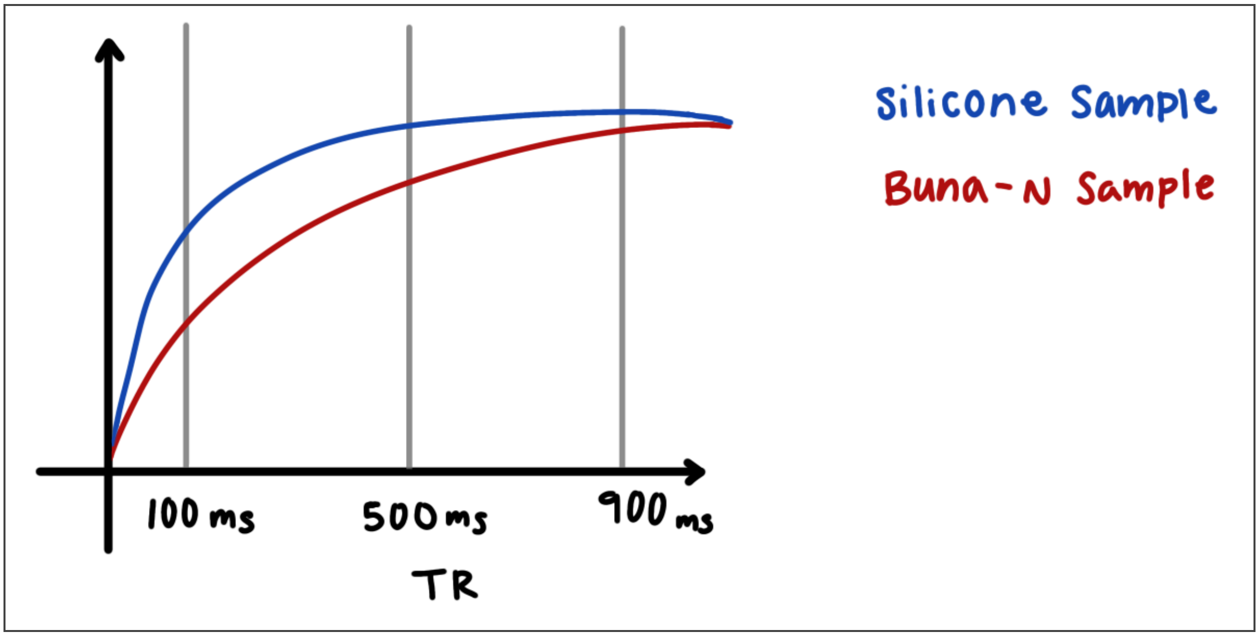

Conclusion:

Using a shorter TR, there was a difference in signal intensity primarily due to the difference in T_1 times. The 3 graphs for sample 3 show further confirmation that the silicone shows the larger and stable signal for all TR times, while the Buna-N signal more obviously increases as the TR time is increase. This suggests that silicone much have a faster (shorter) T_1 time than Buna-N, and this T_1 difference is the primary source for signal intensity difference in the previous experiments. This is a good example of how one can use short TR times to provide T_1-weighting in MRI to provide more contrast of tissues with different T_1 times.

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