Lab Notebook for

PHY 445

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Lab notebook for PHY 445 Spring 2026

Contents

1 Feb 5, 2026

Link to the lab website: https://you.stonybrook.edu/phy445/experiment-overview/

Note: We are allowed to have 1–2 extra days for this experiment as there was no lab manual given.

1.1 Experiment: Nuclear Magnetic Resonance

Experiments that we will run:

- We will test T_1, T_2, T_2^*, and T_2' for three samples: distilled water, tap water, and water with metal in it (or honey if we do not have that);

Sub-experiment one: distilled water

We got the distilled water from the HEP-ex water room; poured it into the little pipe without a pipette because the only one we found was super dirty and probably full of AIDS.

Distilled water: T_1 Experimental set-up and tuning for measuring T_1 for distilled water:

- RF frequency matching: Tuned it until there was a minimal sine curve. Measured frequency is 21.01291 MHz.
- $\pi/2$ pulse: $1.12 \pm 0.005\,\mu$s
- π pulse: $7.32 \pm 0.005\,\mu$s

Now we tried to measure T_1 for distilled water, but this was very hard:

- We didn't know how to export the osc. data to fit it.
- We didn't know if the pulse was just one peak of the sine curve or if it was the entire curve.
- Corliss came over and helped us kind of. We didn't know how to do anything. He pointed out that we were syncing on A when we probably should have been syncing on B.
- TA came over and helped us more; got back to my original question which I'm just going to email Prof. Liu.
- After class, emailed Prof. Liu the following:

  > Hi Professor Liu,
  >
  > My partner and I are trying to measure the T_1 timescale for the NMR experiment in PHY 445. We know that we have to fit a damped sine curve to the response of the nucleus to the A pulse to determine T_1. After asking both the TA and Professor Corliss for advice on how to do this, we are still not sure how to take the oscilloscope data and translate it into a form that we can fit a curve to. Do you have any advice on how to do this?

Also, you previously said that some sort of iron solution is commonly used in this experiment to test different responsivities to the external magnetic field and RF pulses. Will this be made available to us next Tuesday?

Thanks,
Will Lancer

2 Feb 10, 2026

- Prof. Liu responded:

  Hi Will,

  Prof. Xu Du is taking care of the NMR measurement this semester. You probably confused me as Prof. Du?

  Regarding the data, usually you can take the oscilloscope data from a USB drive and import it into the computer. Then you can fit it from there. (Depending on which oscilloscope you are using this semester.)

  Everything should be in the test kit – usually I will suggest you use the mineral oil first, and then the rubber.

- Whoops! Literally everyone in the lab thought that Prof. Du was Prof. Liu. #rip. #duNotLiu.
- Anyway, time to continue with this experiment.

Ok, we're going to switch our experiment to mineral oil on Prof. Liu's recommendation.

2.1 Sub-experiment: mineral oil

We're using the light mineral oil. Time to re-measure all of our stuff!

- RF frequency matching: $21.11319 \pm 0.00001\,\text{MHz}$.
- $\pi/2$ pulse: **(didn't take for some reason?)** $\pm 0.005\,\mu\text{s}$.
- π pulse: $6.76 \pm 0.005\,\mu\text{s}$.

We think that we want an A pulse and then a B pulse. The former being a π pulse and the latter being a $\pi/2$ pulse. But we don't really see that on the oscilloscope. We varied tons of numbers, and then figured out that we can put just one B pulse. We did that, but when we vary τ, we don't see the amplitude of B change; this isn't what we expected, as we'd expect the curve to follow the equation $\sim 1 - e^{-\tau/T_1}$.

2.2 Enter Professor Du, the King of NMR™ 

We called Prof. Du over and he determined after some debugging that we were way off our resonance frequency. We were using the previous value, but he determined that it should be $21.00854 \pm 0.00001\,\text{MHz}$. The A pulse and B pulses were wrong because we were off resonance: the new ones are $A = 6.72 \pm 0.005\,\mu$s and $B = 2.60 \pm 0.005\,\mu$s.

NOTE: ALL OF THESE VALUES ARE FOR BEESWAX, NOT MINERAL OIL. Xu "The Goat of NMR" Du switched us to that material in his infinite wisdom.

The lesson from this is that the vertical scale of the blue line was *super* zoomed out; because of this, I tuned it to what seeemd tiniest but it was wayyyy off. So, make your vertical and horizontal scales fit the scales at hand or else you will get cooked.

Great. I then was curious about what the period was and why moving it around shifted the amplitude of the B pulse, so we called over Prof. Du again and he explained it to us. We then increased the period from 100ms to 600ms because the relaxation time of oil is kinda long.

After switching the period, I noticed the frequency was looking sus and a little bit beatastic, so we changed it again to make it not beating:

- RF frequency matching: $21.00740 \pm 0.00001\,$MHz.
- π pulse: $6.76 \pm 0.005\,\mu$s.
- $\pi/2$ pulse: $3.36 \pm 0.005\,\mu$s.

3 Feb 12, 2026

Got into lab. Eric and friends did some bullshit to the scope and the whatever frequenct setter thing. We fixed it, and switched the RF frequency to: $21.01509 \pm 0.00001\,$MHz.

We are now going to determine T_1 for the light mineral oil. See Alo's lab notebook for the relevant table.

3.1 Beeswax T_1 measurement

Remeasured the relevant values:

- RF frequency matching: $21.01183 \pm 0.00001\,$MHz.
- π pulse:
- $\pi/2$ pulse:

3.2 Nevermind, fml

We realized that our previous A and B numbers were for BEESWAX, NOT MINERAL OIL. So we need to retake our data!!! So fun! Experiments are just so wonderful and not absolutely shit, I just love them! This definitely isn't wasting my life!

Relevant values:

- RF: $21.01155 \pm 0.00001\,$MHz.
- π: $7.36 \pm 0.005\,\mu$s.
- $\pi/2$: $3.68 \pm 0.005\,\mu$s.

Asked my best buddy ChatGPT to plot the table for me. He gave us these tables:

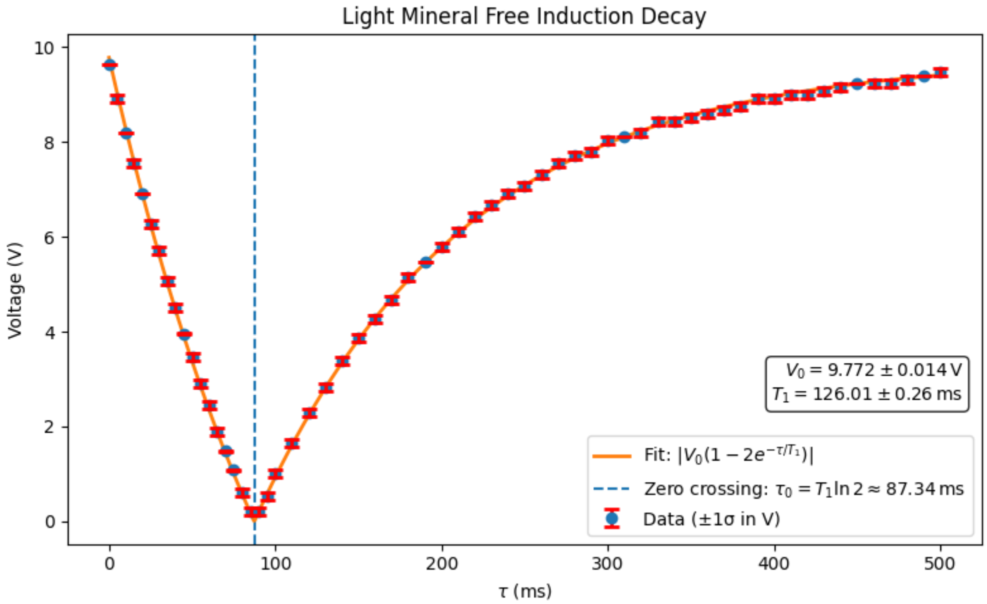

Figure 1: chungus 1

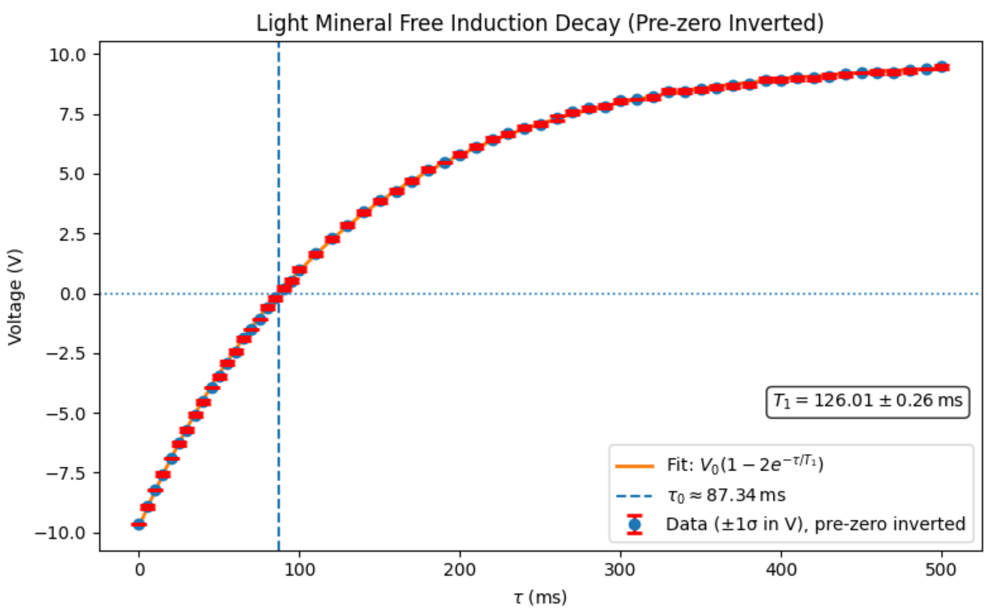

Figure 2: chungus 2

3.3 Beeswax, pt. 2

RV:

- RF: 21.00852 ± 0.00001 MHz.

- π: $6.80 \pm 0.005\,\mu$s.
- $\pi/2$: $3.46 \pm 0.005\,\mu$s.
- Period: $700 \pm 0.5\,$ms.

See Alo's table for the raw data.

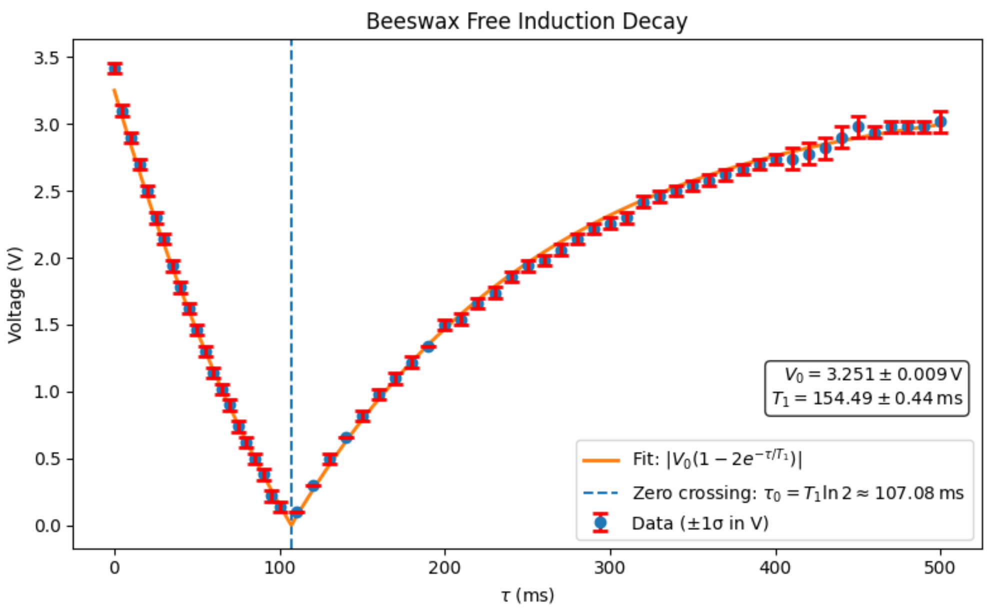

Figure 3: chungus 3

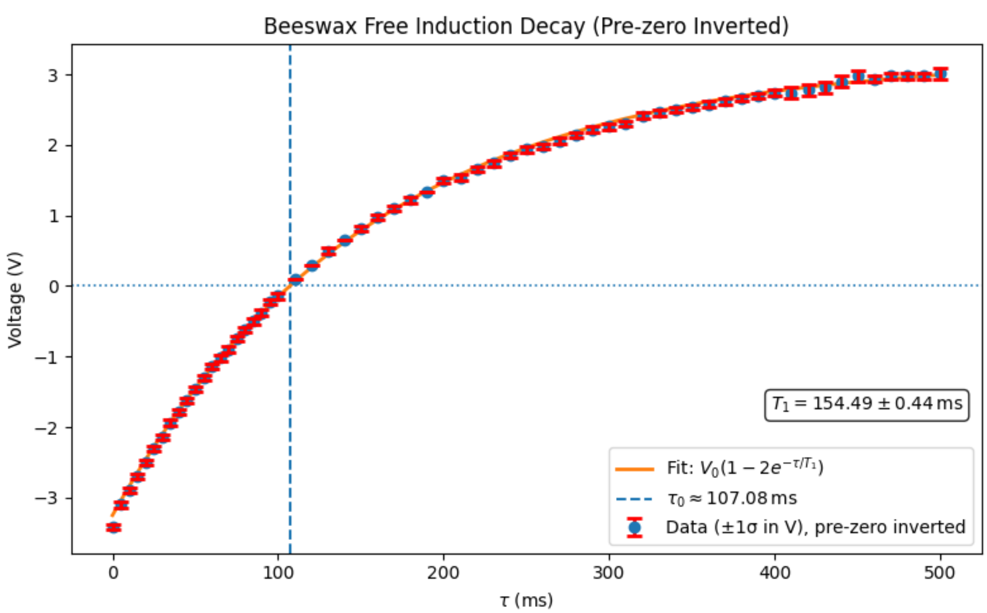

Figure 4: chungus 4

4 Feb 17, 2026

Let's chung our way through this day... this class genuinely sucks. Whatever. Let's do the spin-echo experiment.

4.1 Spin-echo: light mineral oil

- RF: 21.015224 ± 0.00001 MHz.
- π: $7.62 \pm 0.005\,\mu$s.
- $\pi/2$: $3.98 \pm 0.005\,\mu$s.
- Period: 600 ± 0.5 ms.

Señor Du helped us with these values.

Now we are going to do the spin-echo experiment. This procedure goes as follows:

1. Apply a $\pi/2$ pulse: this is the A pulse.
2. Apply a million π pulses: these are the B pulses.
3. The spin-echo curve envelope will go like $e^{-t/T_2'}$; you just extract this data and fit it to a curve to get T_2'.

We will use 30 π-pulses and fit the curve to get T_2'. I think we will have to use thumbdrive to export the data on the scope for this one—just taking the data points may not be enough, or at least that's not what the other groups did.

We got this epic data from the spin-echo experiment:

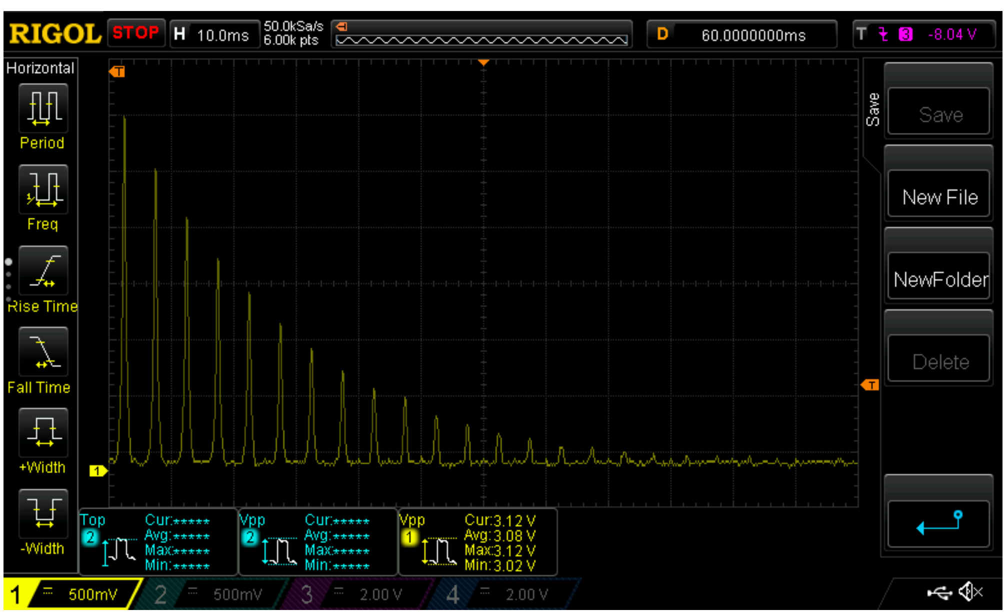

Figure 5: Spin-echo raw data for light mineral oil

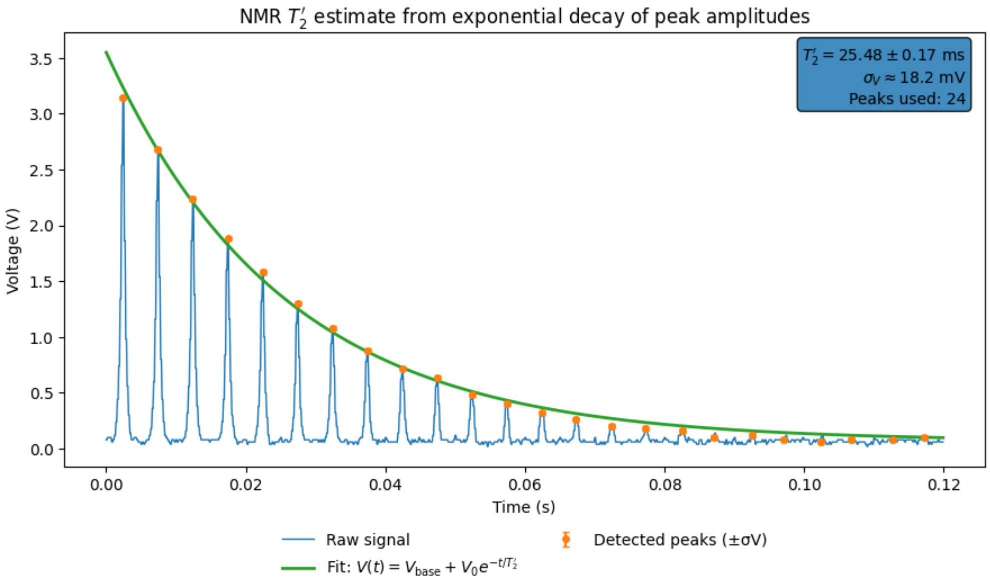

Figure 6: Spin-echo data for light mineral oil

We are the goats of NMR.

4.2 Beeswax-maxxing

Relevant values:

- RF: $21.01583 \pm 0.00001\,$MHz.
- $\pi/2$: $7.62 \pm 0.005\,\mu$s.
- π: $3.98 \pm 0.005\,\mu$s.
- Period: $700 \pm 0.5\,$ms.

Tables type shit!

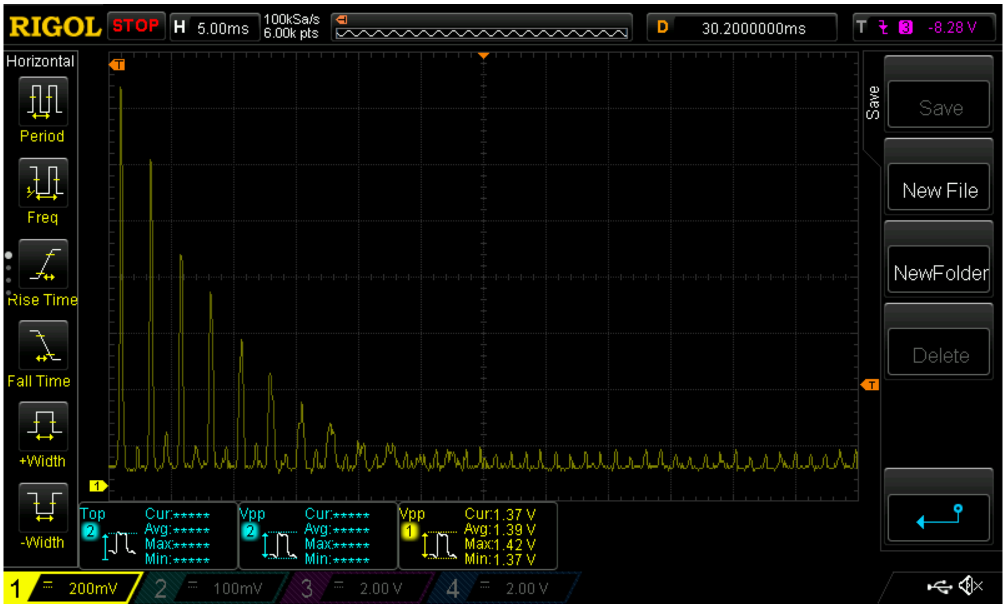

Figure 7: Spin-echo raw data for beeswax

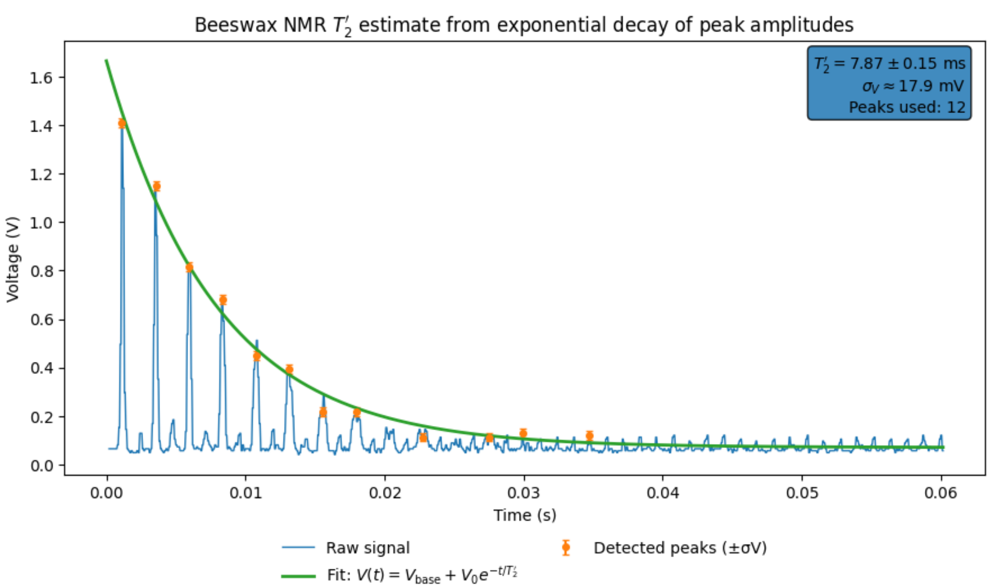

Figure 8: Spin-echo data for beeswax

We are the goats of NMR, part 2.

5 Feb 19, 2026

Back at it again. We just need to measure T_2 today, and then we are free from the shackles of NMR. The midlab report is due today; Alo submitted it for us. She now knows how to use Git, which is great.

I believe the way you measure T_2 is by pulsing a $\pi/2$ pulse and just waiting for the voltage to decay back to zero. Then you fit that to e^{-t/T_2} and you're done. Let's check with Du to see if that's Tru.

We checked with Du: this is indeed Tru. Time to Mu-ve on!

5.1 Light mineral oil: T_2

The orangutans we share this experiment with messed up the stuff on the scope and with the light mineral oil sample. We now get to clean up their mess.

Relevant values:

- RF: $21.01596 \pm 0.00001\,\text{MHz}$.
- $\pi/2$: $4.08 \pm 0.005\,\mu\text{s}$.
- Period: 600

We had to put the ring on the sample quite low to avoid a big shoulder. This wasn't the case before, but the other people on this experiment completely messed up the same and didn't store it correctly, so the light mineral oil wasn't concentrated entirely at the bottom of the tube. This lowered the measured voltage, but shouldn't be a big deal.

We got this picture from the scope, and this curve was fit to it by my bestie ChatGPT 5.2 Extended Thinking. Samriddhi was goated and let us use her personal flashdrive to get this data, and the previous data.

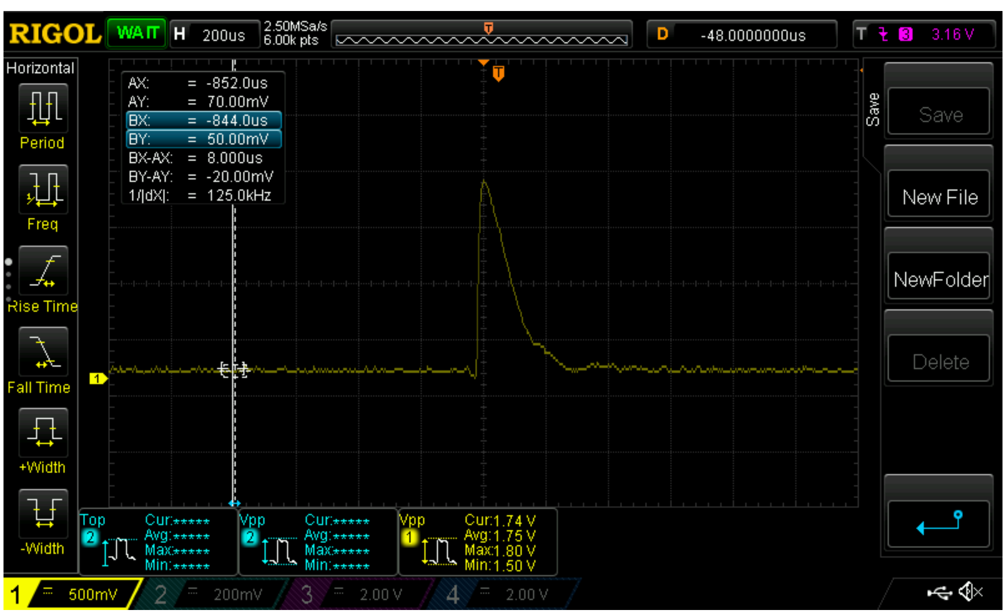

Figure 9: Raw T_2 data for light mineral oil

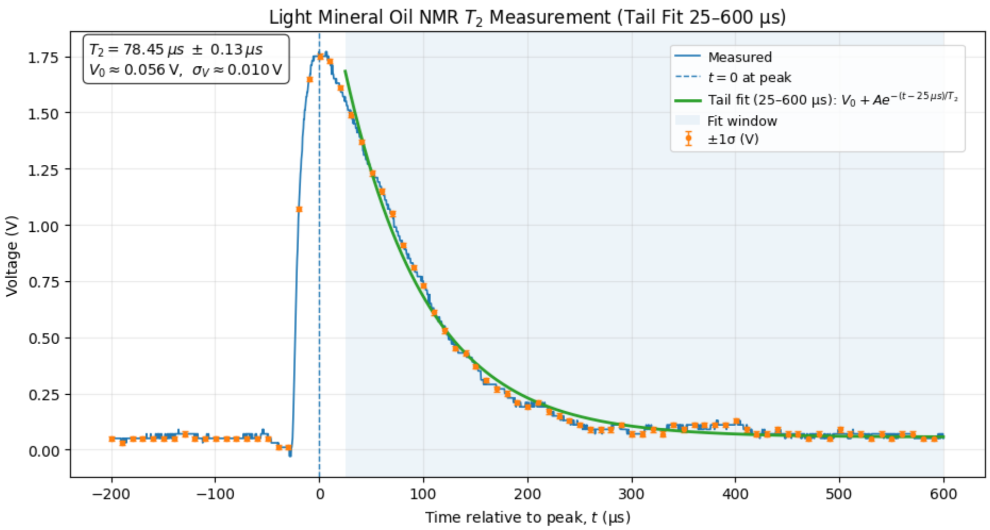

Figure 10: T_2 data for light mineral oil, fit to e^{-t/T_2} curve. $T_2 = 2.15 \pm 0.05\,\mathrm{ms}$.

5.2 Beeswax: T_2

Relevant values:

- RF: $21.01245 \pm 0.00001\,\mathrm{MHz}$.
- $\pi/2$: $4.10 \pm 0.005\,\mu s$.
- Period: $700 \pm 0.5\,\mathrm{ms}$.

Note that each horizontal block on the raw data below is 50 microseconds long.

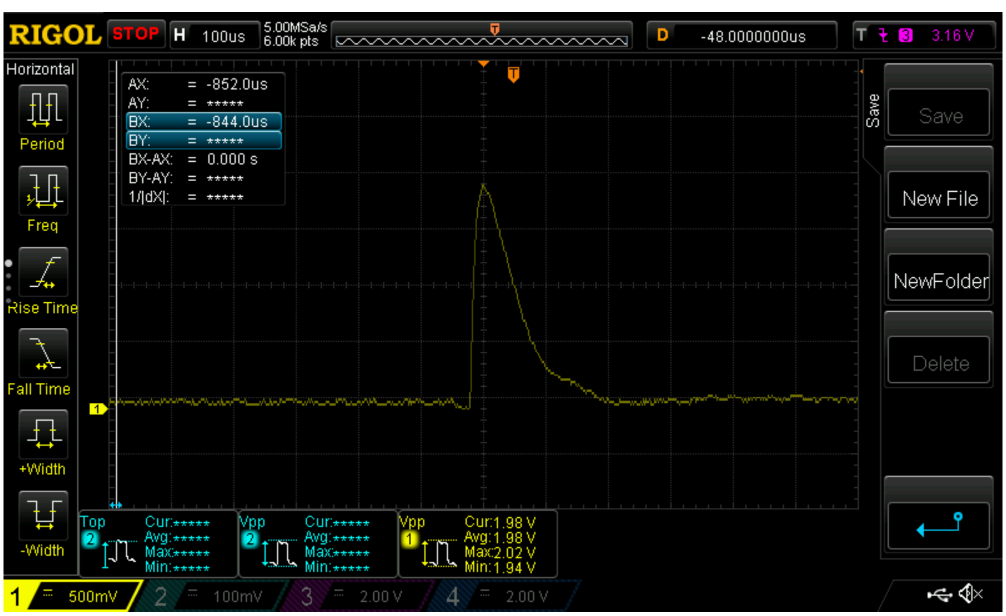

Figure 11: Raw T_2 data for beeswax

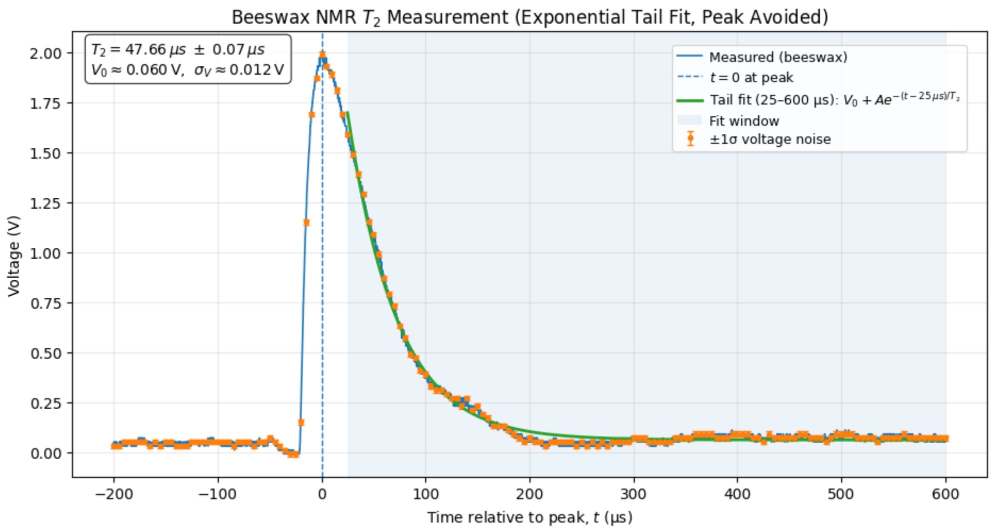

Figure 12: T_2 data for beeswax, fit to e^{-t/T_2} curve