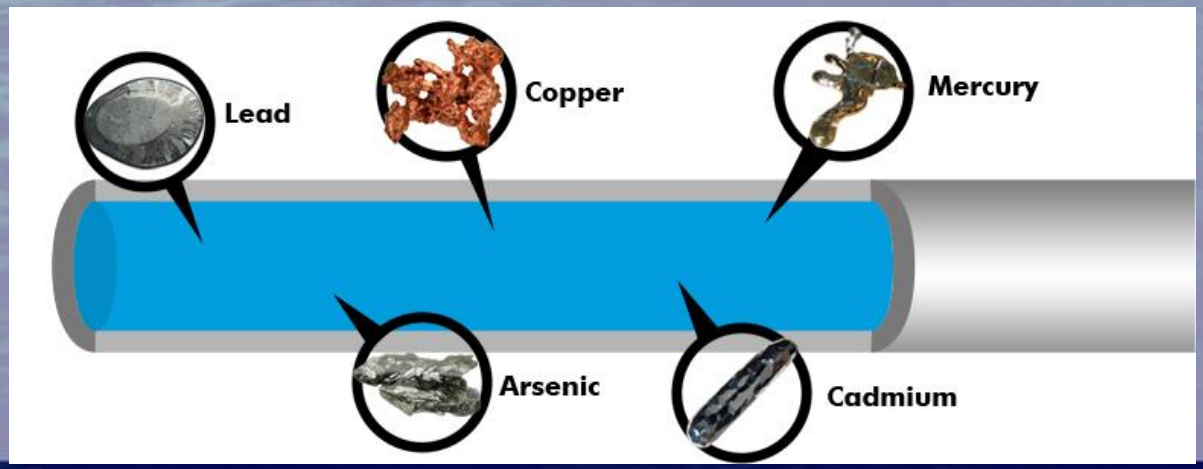
NUCLEAR MAGNETIC RESONANCE (NMR)- WATER FILTRATION

Anastasija Cumika

PHY 431
Advanced Physics Lab
May 14, 2019

THEORY: WATER PURITY

- Purified water is water that has been mechanically filtered or processed to remove impurities and make it suitable for use.
- Types of impurities:
  - Heavy Metals (lead, cooper)
  - Chemicals (chlorine, pesticides, fluoride)



REASONS TO FILTER YOUR TAP WATER

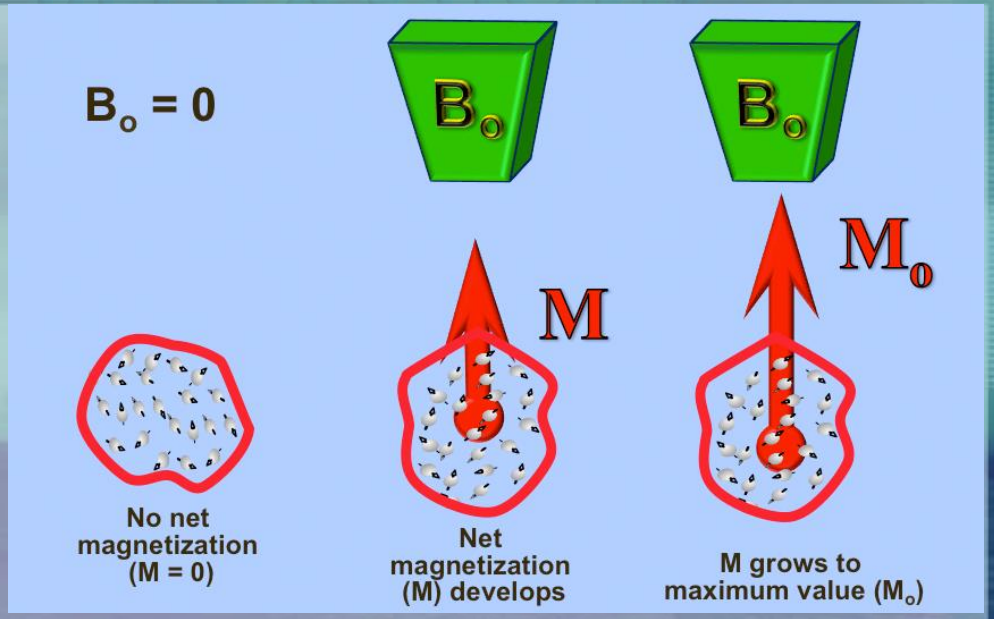
Drinking clean, filtered water protects the body from disease and leads to overall greater health and energy.

- Water filters:
  - greatly reduce the risk of certain cancers including by removing chlorine and chlorine byproducts from drinking water.
  - reduce the risk of gastrointestinal disease by more than 80 percent by removing bacteria drinking water.
  - provide the healthiest water for children's developing immune systems.

NMR: T_1 (SPIN-LATTICE RELAXATION)

$$M_z(t) = M_0 - 2\,e^{-\frac{t}{T_1}}\,M_0$$

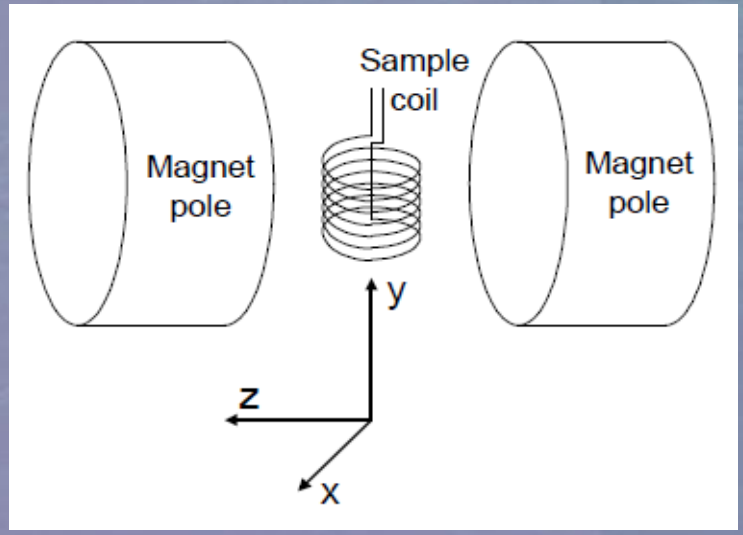
(Initial $M_z = -M_0$)



- T_1 characterizes how fast it takes to magnetize the sample so it reaches thermodynamic equilibrium (maximum $M_z = M_0$).
- As the amount of impurities in water decreases, T_1 characterization time increses.

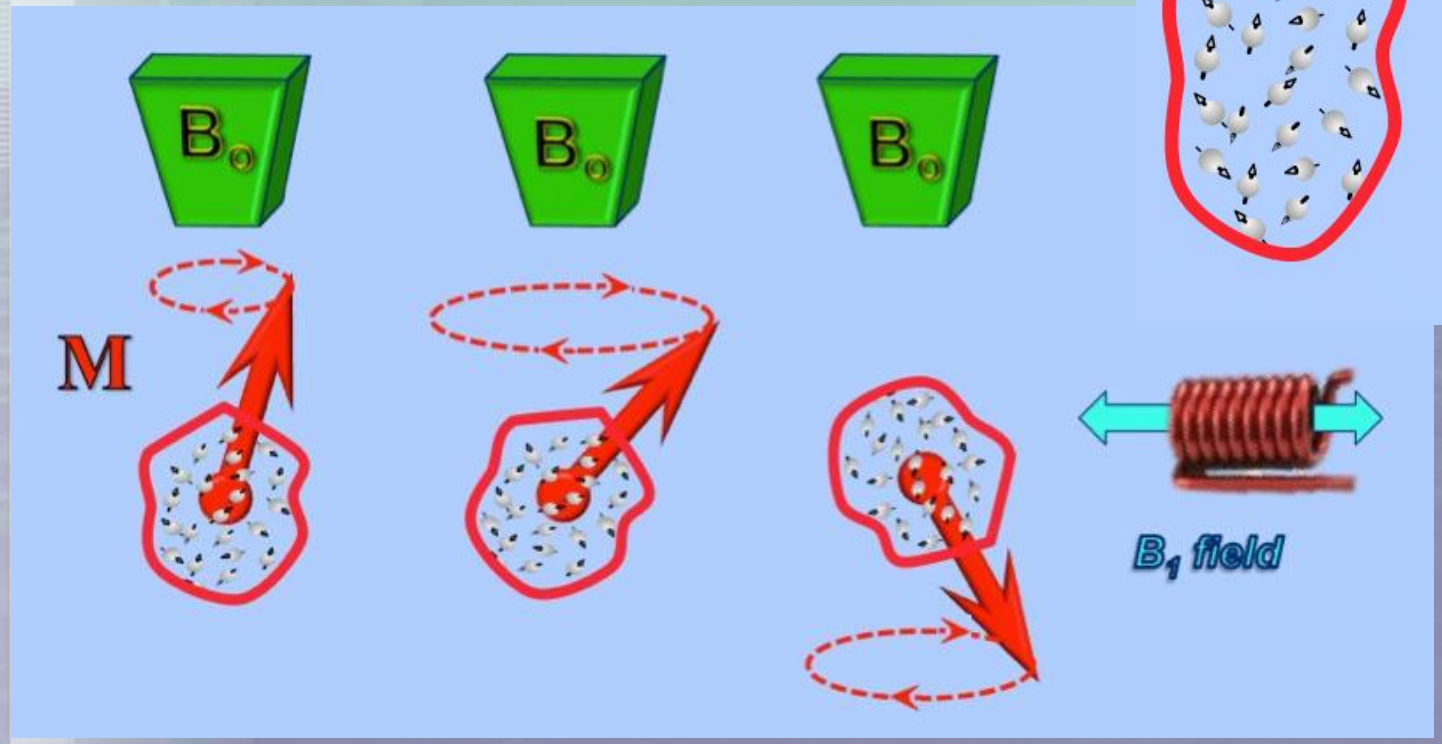
MEASURING THE MAGNETIZATION

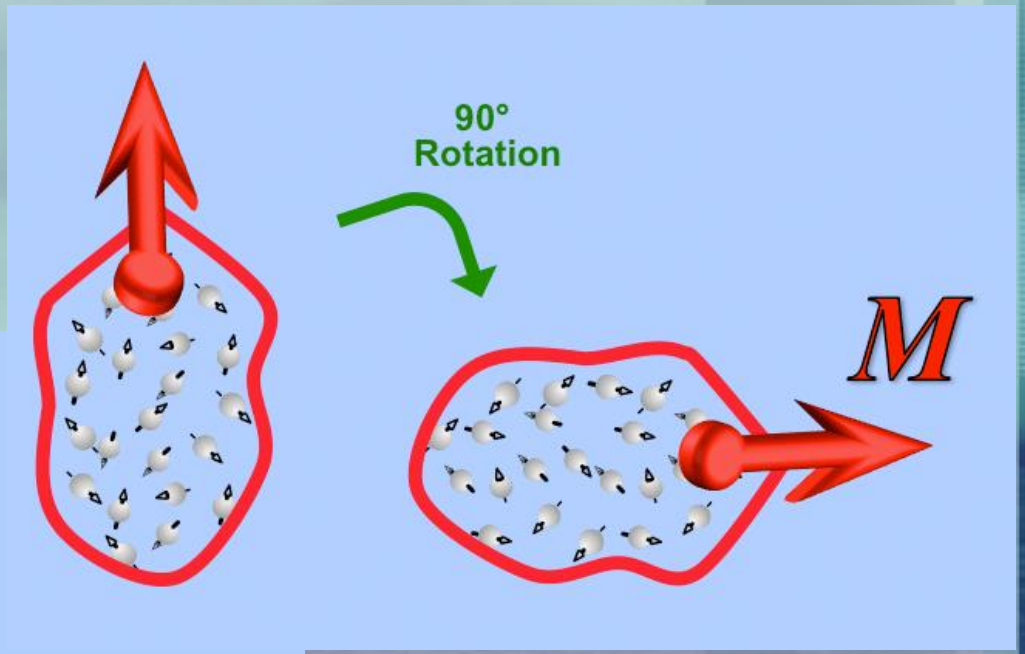
- Sample coil:
  - Magnetization induces the current in the coil that apparatus measures and we can observe the Free Induction Decays (FID) signal on the oscilloscope
  - supplies oscillating RF field that can change the orientation of the magnetization
- Can measure magnetization only in x-y plane.
  - 90° pulse and 180° pulse



90° PULSE AND 180° PULSE

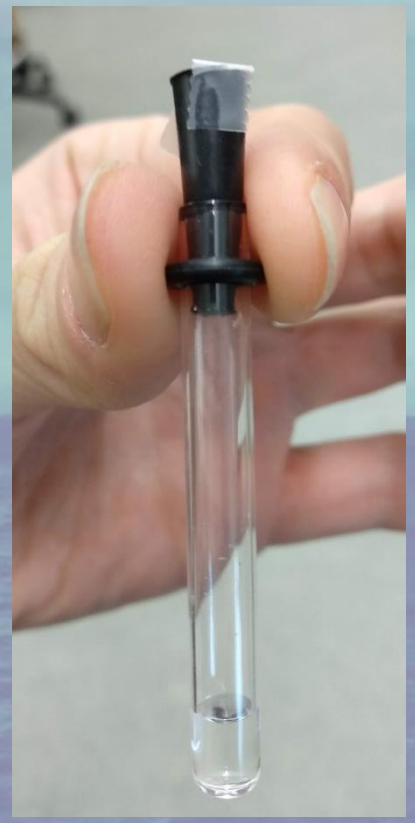
- Rotation angle depends on the length of the RF pulse



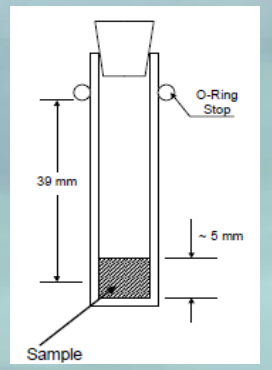


PROCEDURE: SAMPLE PREPARE

Great Value Water Filter Pitcher (model# QP5-01) manufactured by Brita LP.

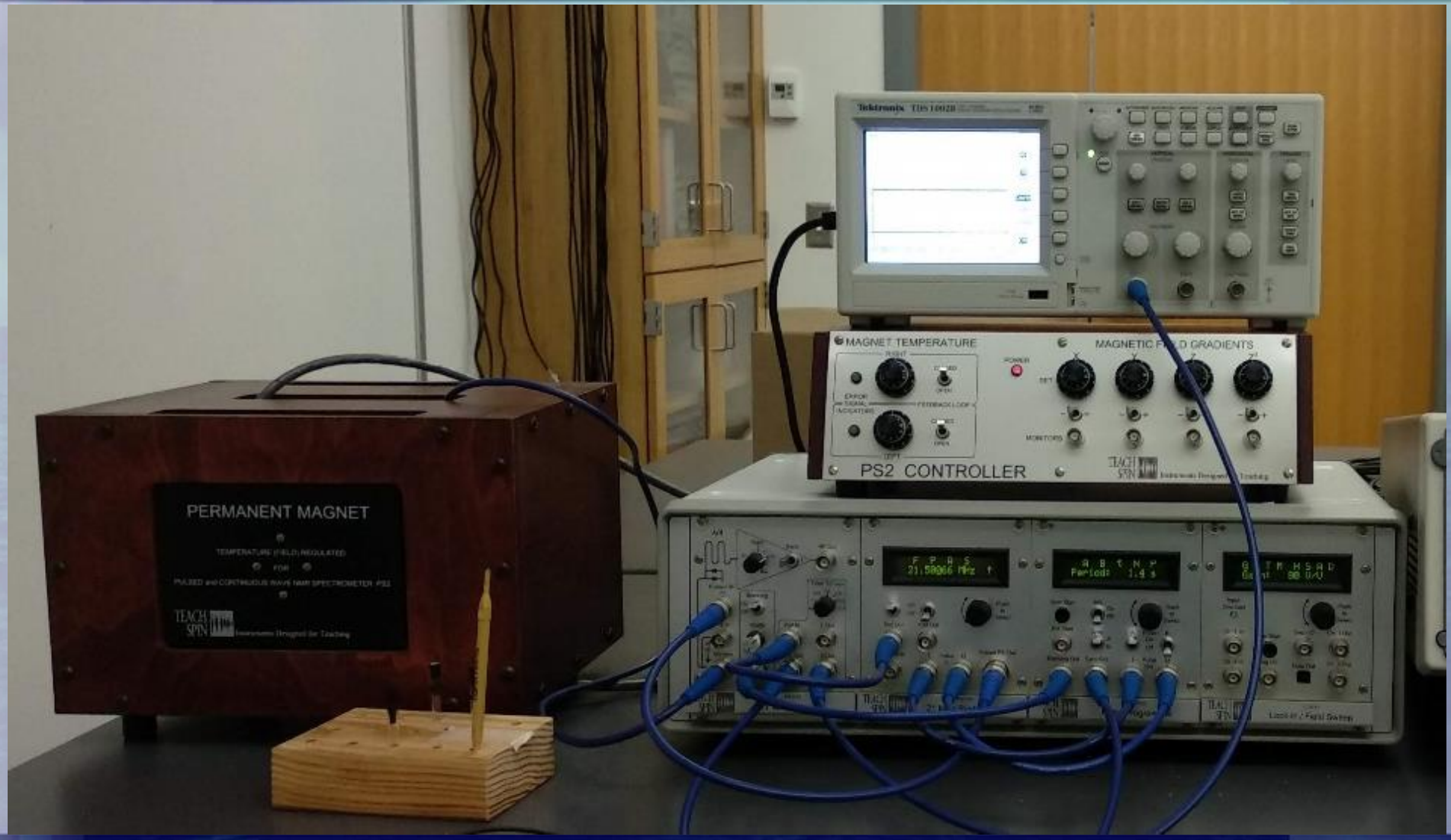


Water sample in the beaker



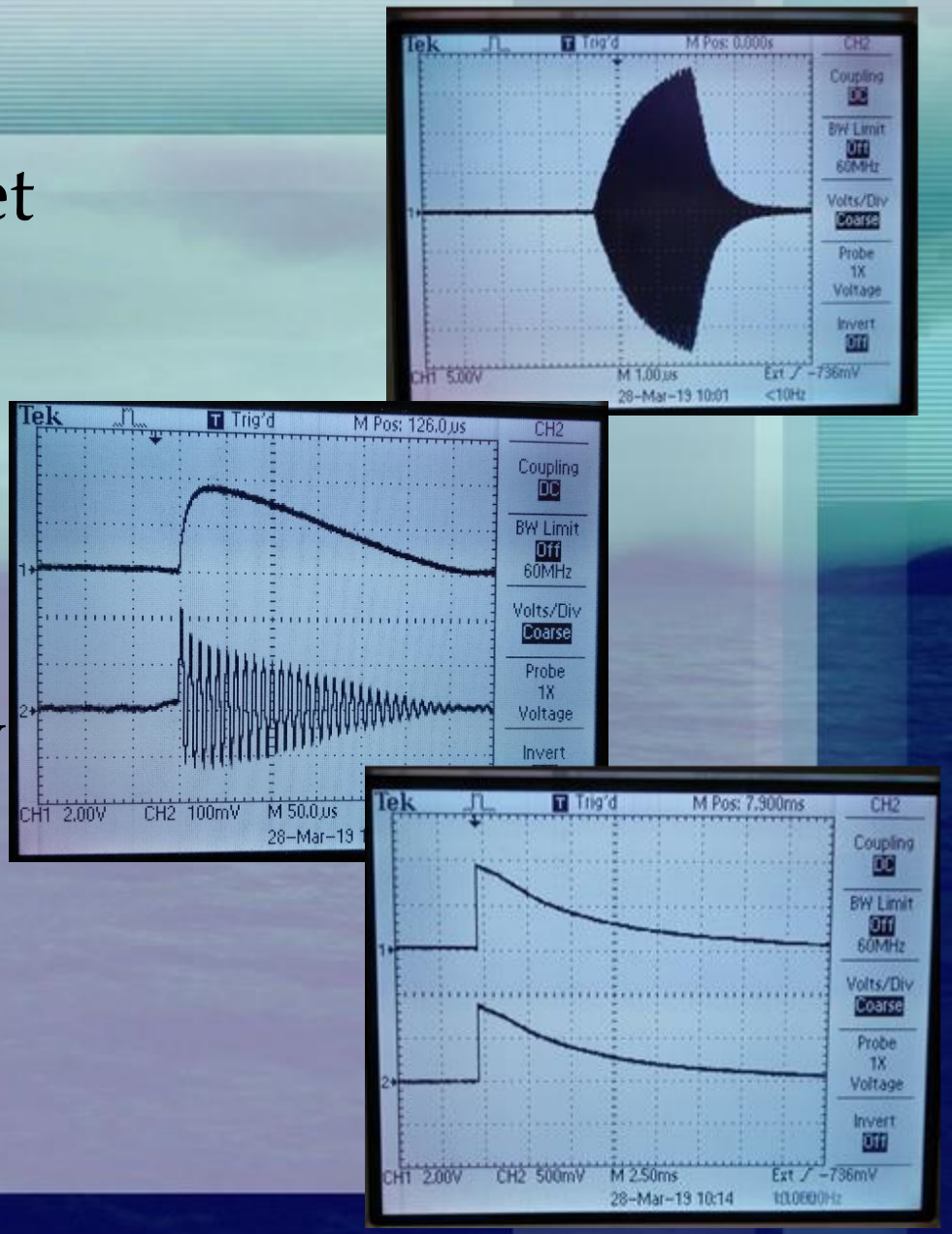
12 samples:
#0 – unfiltered
#1-8 – filtered
#9-12 – reference samples.

NMR INSTRUMENT



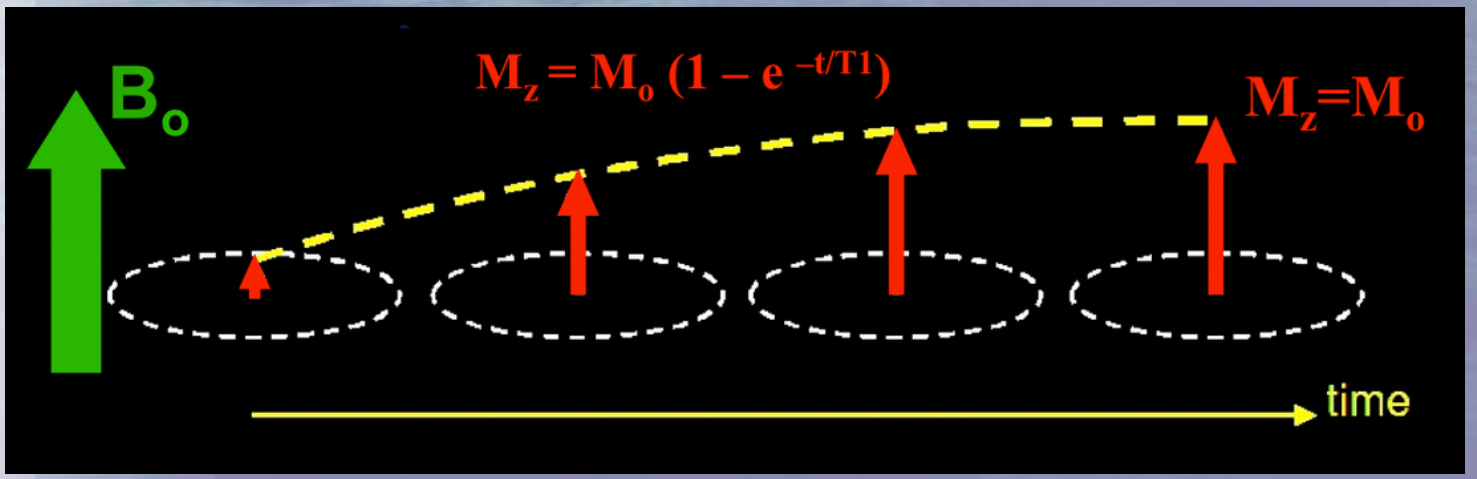
TUNING

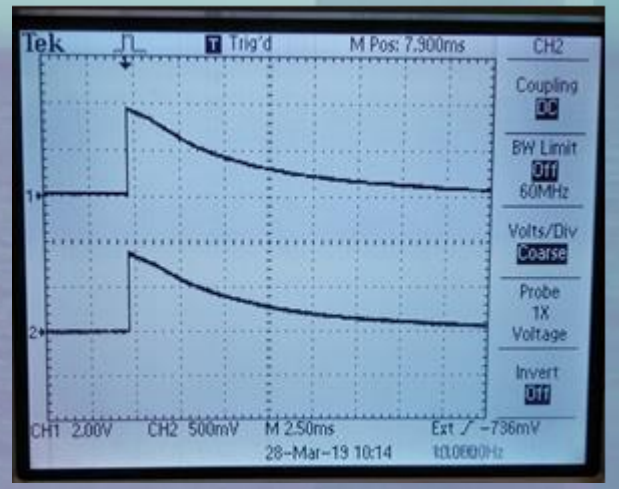
- Set the temperature on the magnet
- With RF probe to tune the tuning capacitor so that sample coil is in resonance with the applied RF signal.
- Set RF signal in the resonance with the sample Lamar frequency
- Homogenize the magnetic field
- Eliminate the “ringdown”
- Find 90° pulse and 180° pulse length



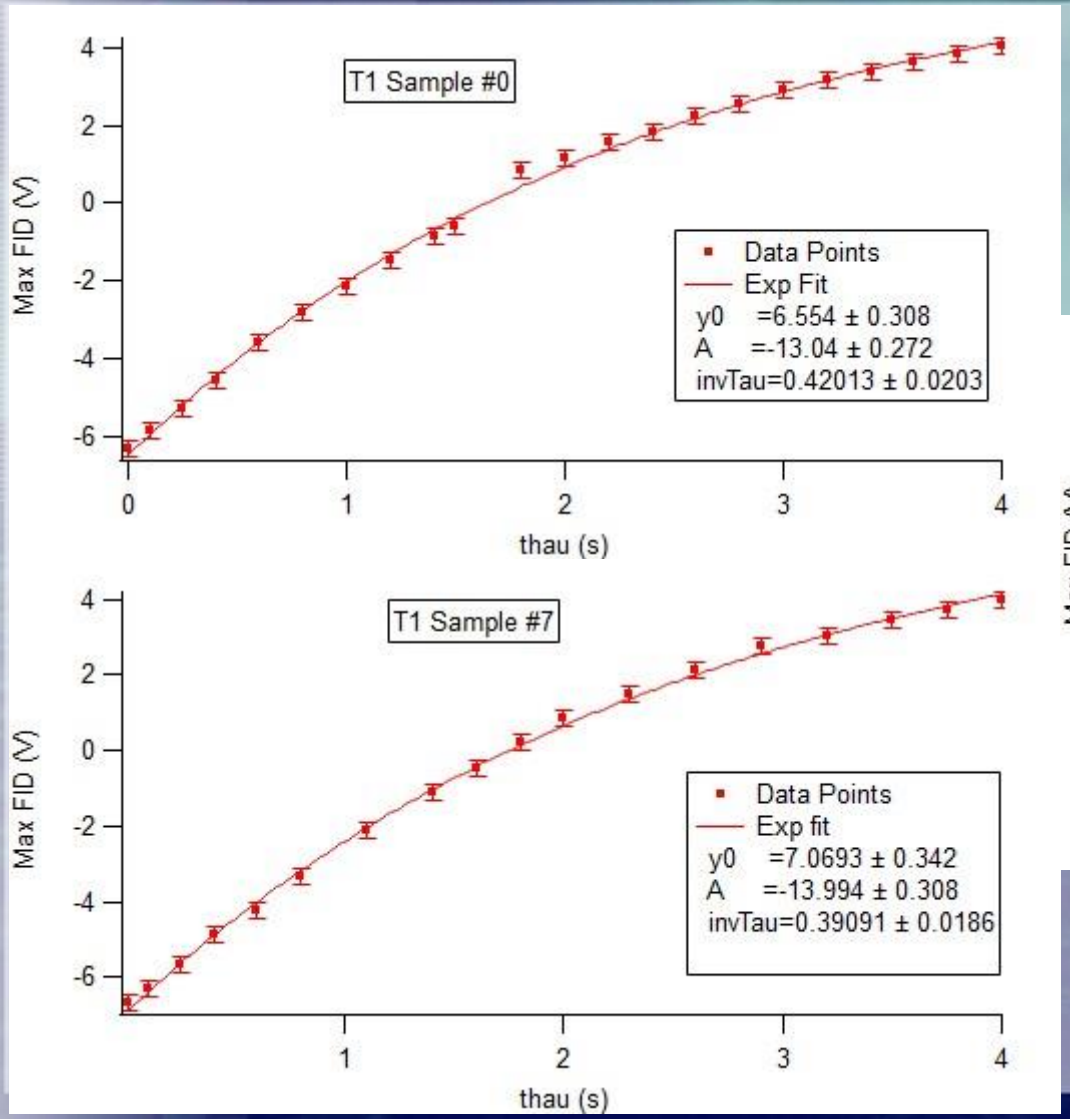
MEASURING MAGNETIZATION

- Repetition Period = 26s
- ALen - 180° pulse (~3.8 μs), BLen - 90° pulse (~7.6 μs)
- Reference Phase (my case ~-120°)
- N (# B pulses) = 1
- Delay time (τ) – variable (from 0 to 4s)

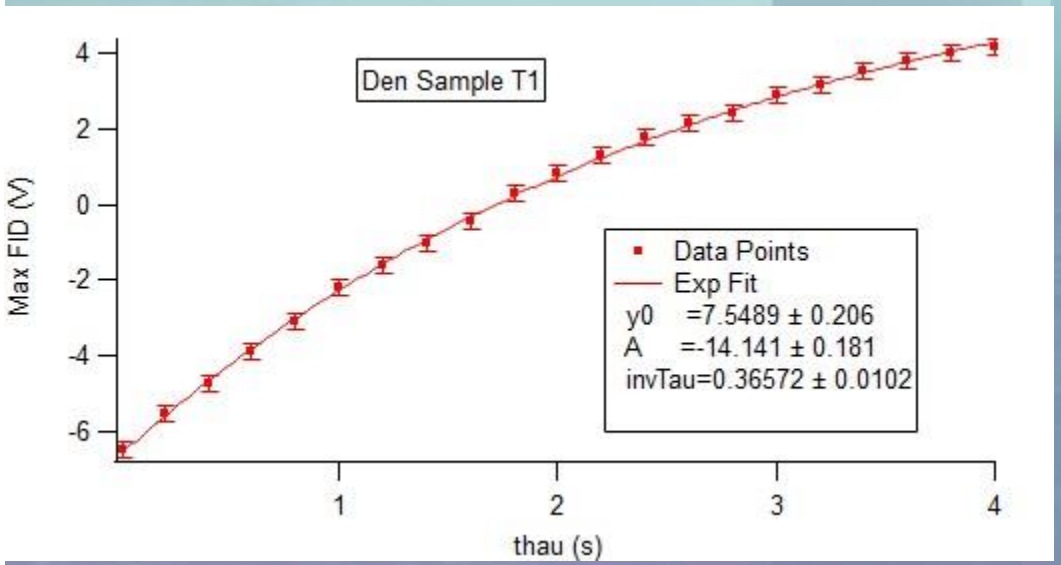




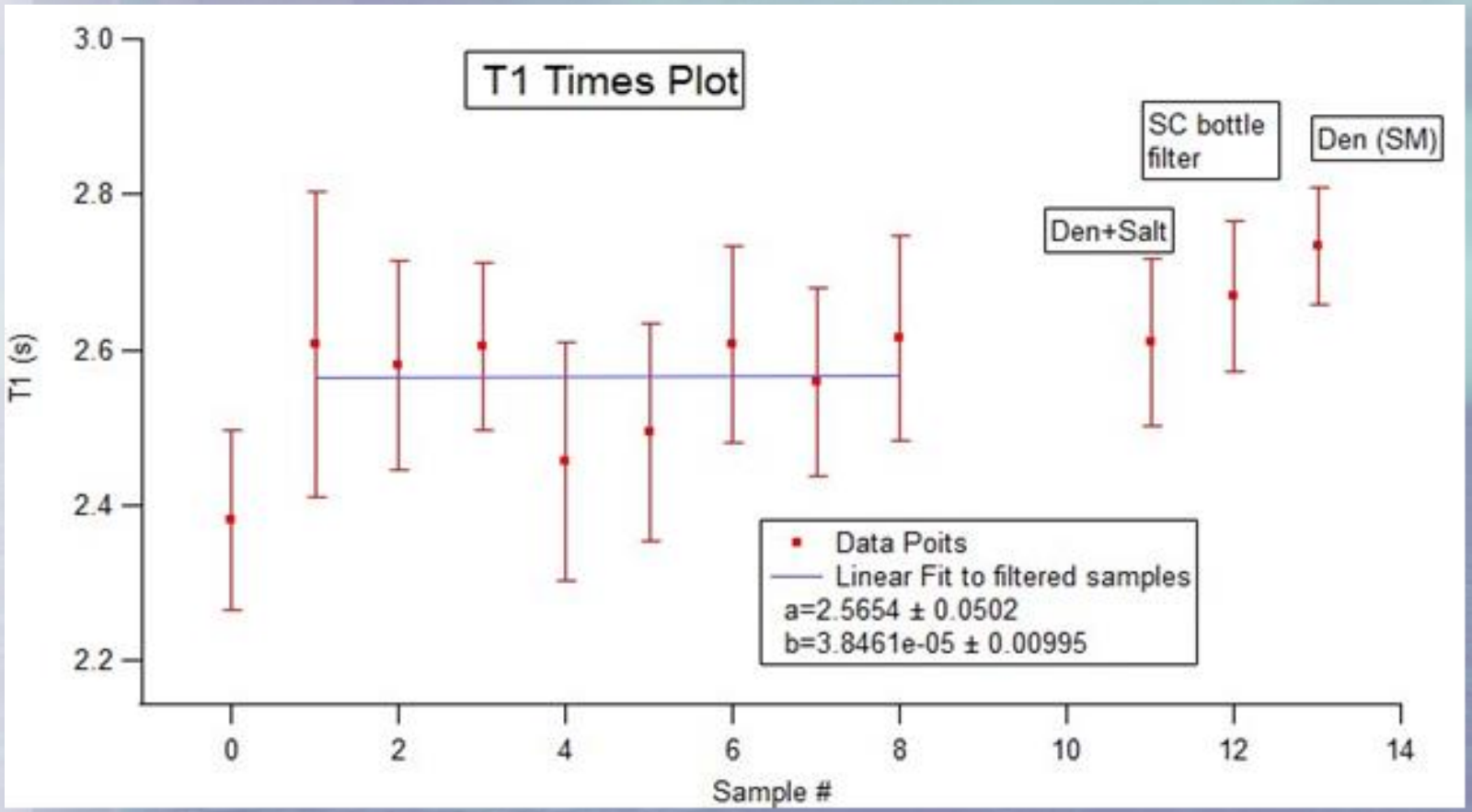
RESULTS: T1 PLOTS



$$T_1 = 1/invTau$$



T_1 VALUES COMPARED



Sample	T1
#0	2.380216
#1	2.607086
#2	2.57958
#3	2.605049
#4	2.455313
#5	2.495508
#6	2.608582
#7	2.558134
#8	2.61561
Salt Water	2.609467
Science Ceter	2.668944
Den	2.734332

CONCLUSION

- Water purity does not get better after one filtration
- Water from the Great Value Filter Pitcher is not as pure as the water from the Science Center for bottle refill or from The Dolphin Den fountain drink machine
- Great Value Filter Pitcher is not a good quality filter
- Purest water out of our samples is the water from the Dolphin Den fountain drink machine.

REFERENCES

- [1] “Ten Reasons To Filter Your Tap Water”, *Waters*, Retrieved on May 10, 2019 from https://www.waterscoaustralia.com.au/pages/why-filter-water,
- [2] B.Wolff-Reichert, “A Conceptual tour of PNMR” (TeachSpin, Buffalo, New York, 2010).
- [3] “Pulsed/CW NMR Spectrometer, PS2-A INSTRUCTOR’S MANUAL”, (TeachSpin, Buffalo, New York, 2010), Rev 1.4.