Measurement of Hydrogen T_1 and T_2 Relaxation Times in Copper Sulfate Solutions Using PNMR

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Physics 403, Fall 2021

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Outline

Goal and Motivation

Characterize the relationship between relaxation time of hydrogen and concentration of a solute.

Figure: [2]

What is PNMR?

PNMR, or Pulsed Nuclear Magnetic Resonance, falls under the umbrella of MRI techniques that many of us are familiar with.

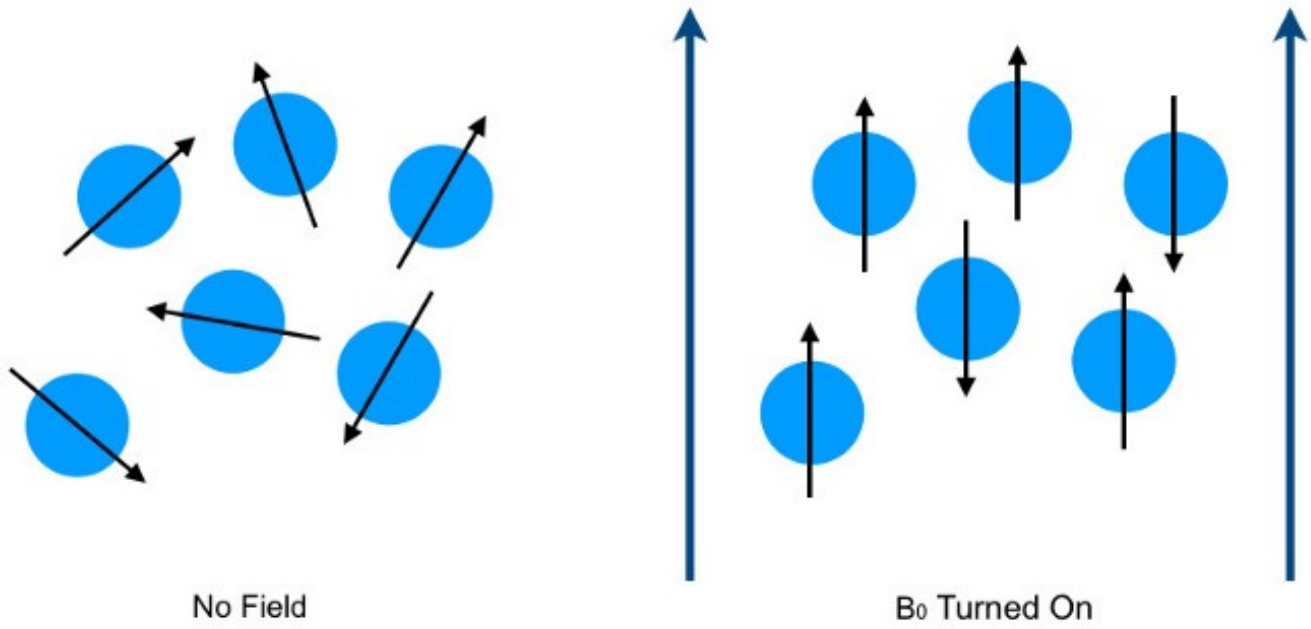

Figure: Initial Polarization [4]

Relaxation Path

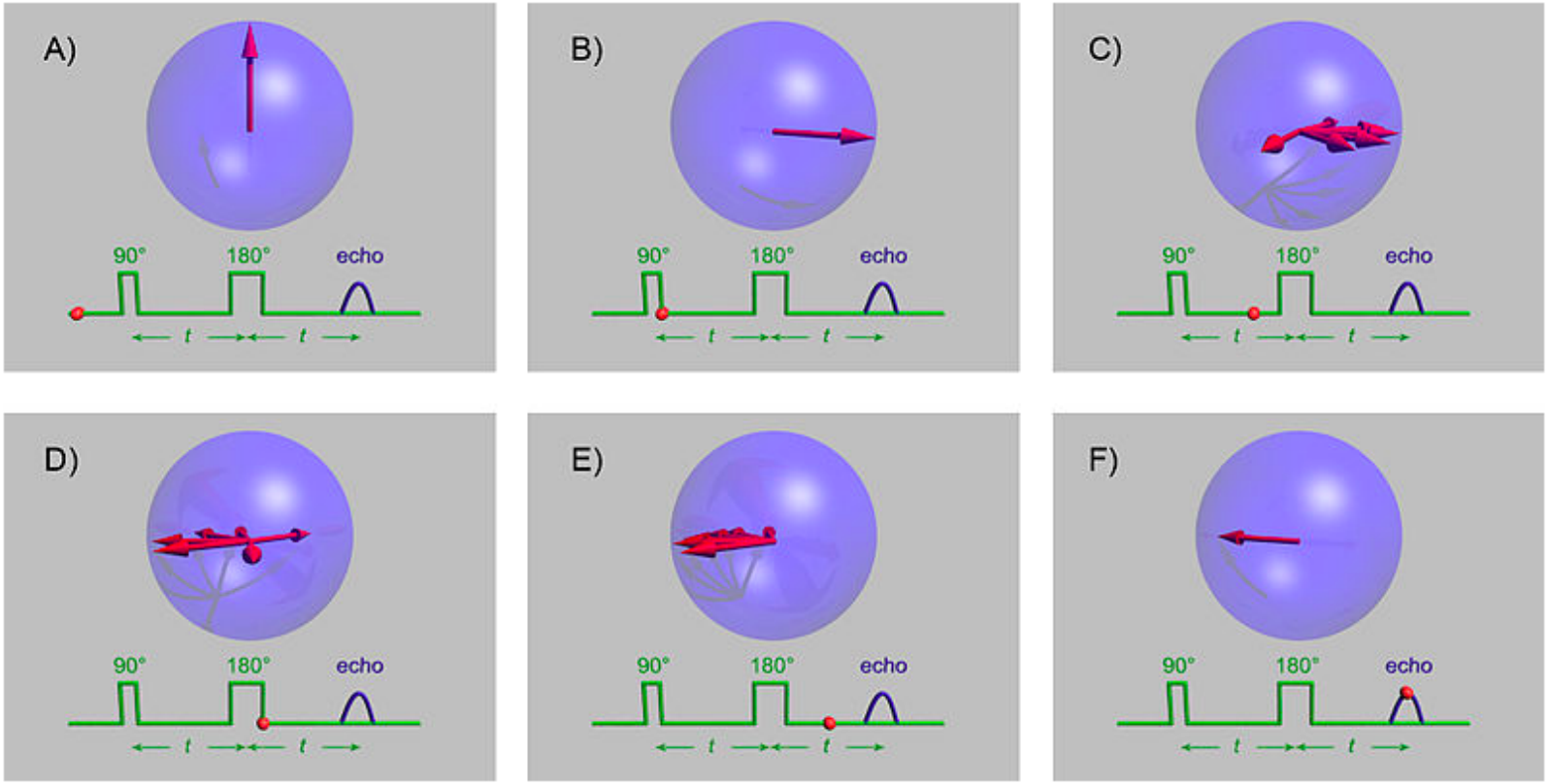

Figure: General Relaxation Path [1]

90° Pulses

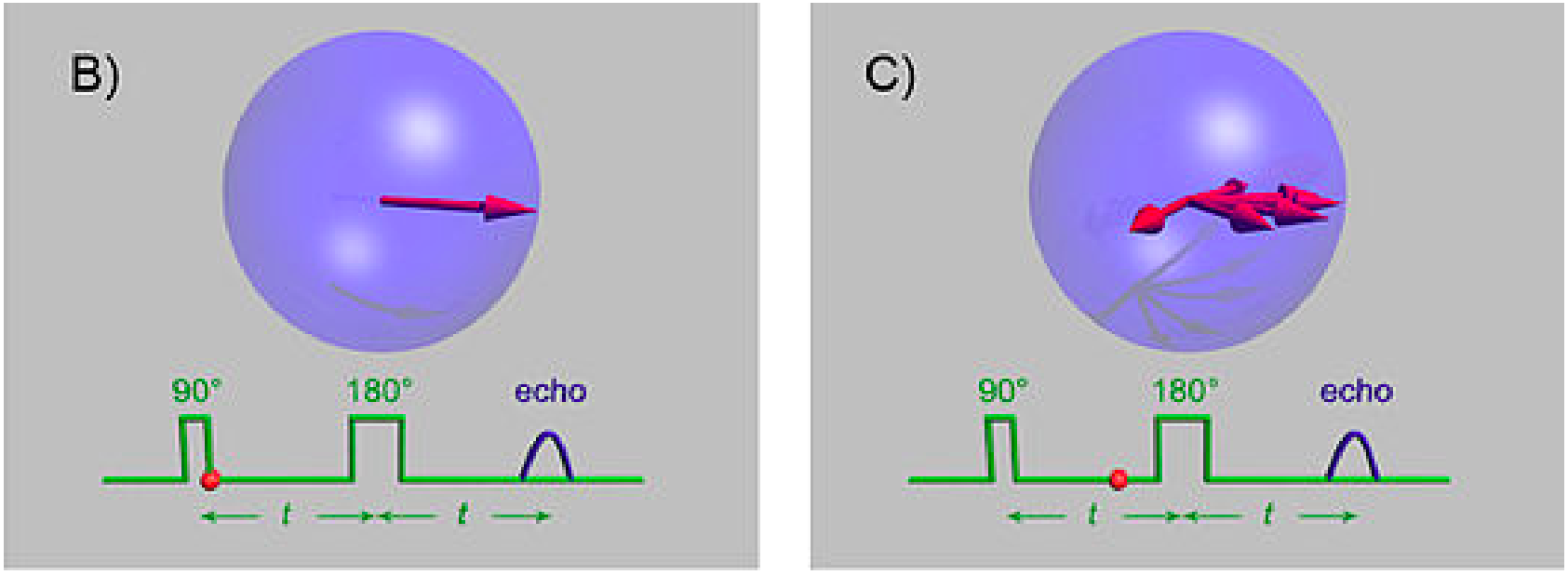

Figure: Result of the 90° Pulse [1]

180° Pulses

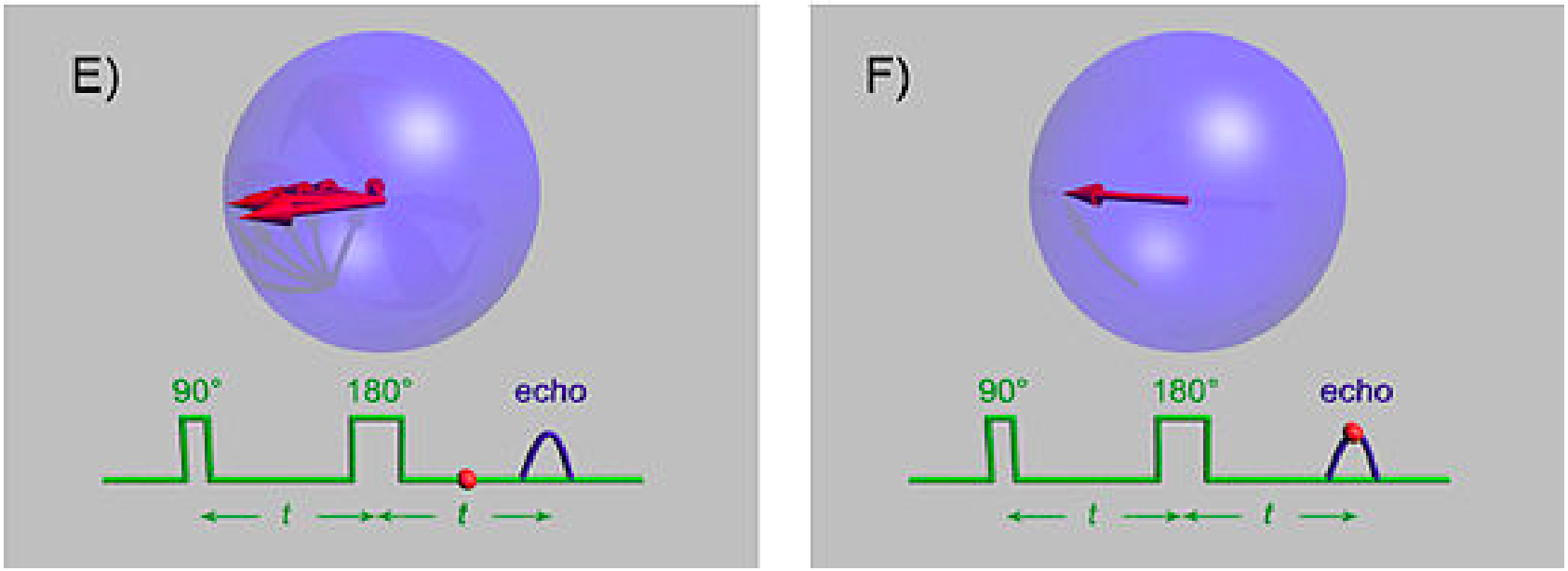

Figure: Result of the 180° Pulse [1]

Conventional MRI

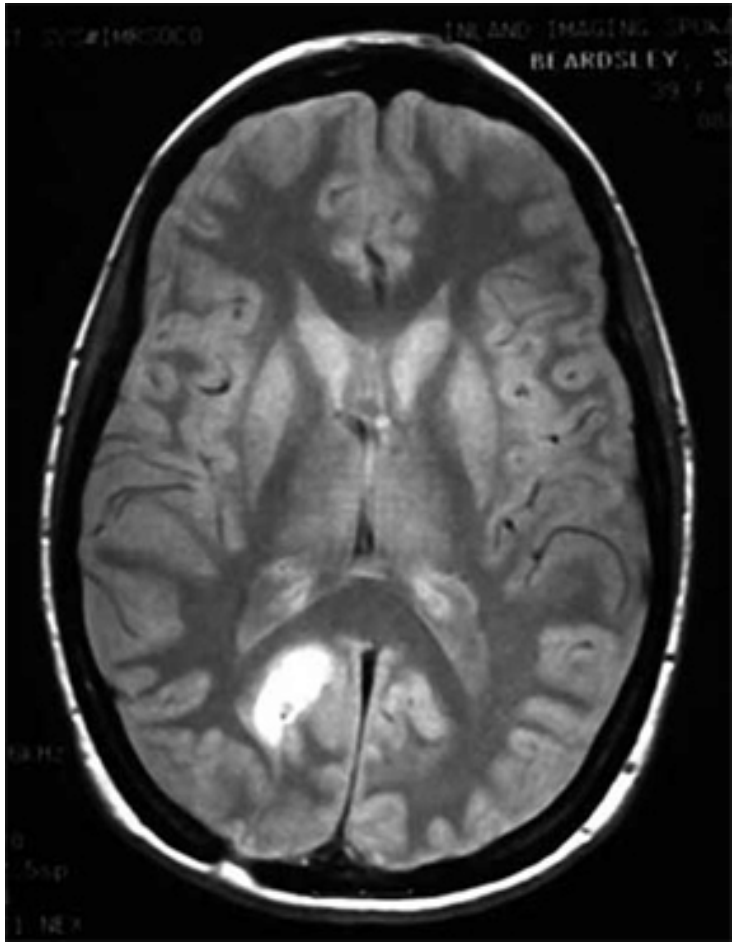

Figure: MRI Scan of a Brain [5]

Conventional MRI

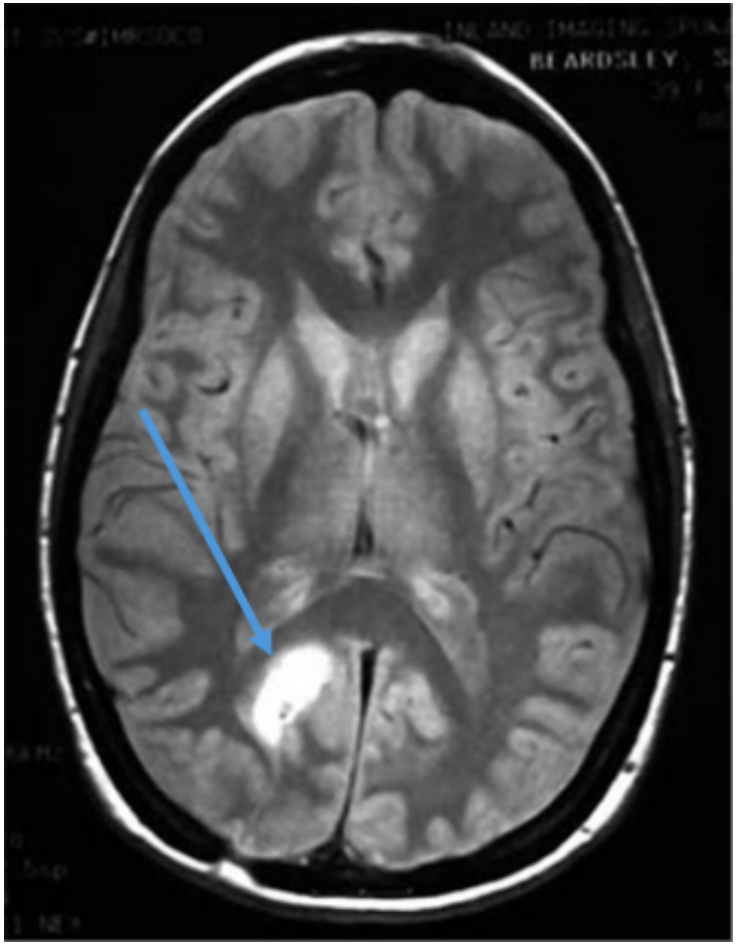

Figure: MRI Scan of a Brain [5]

Metabolite Identification

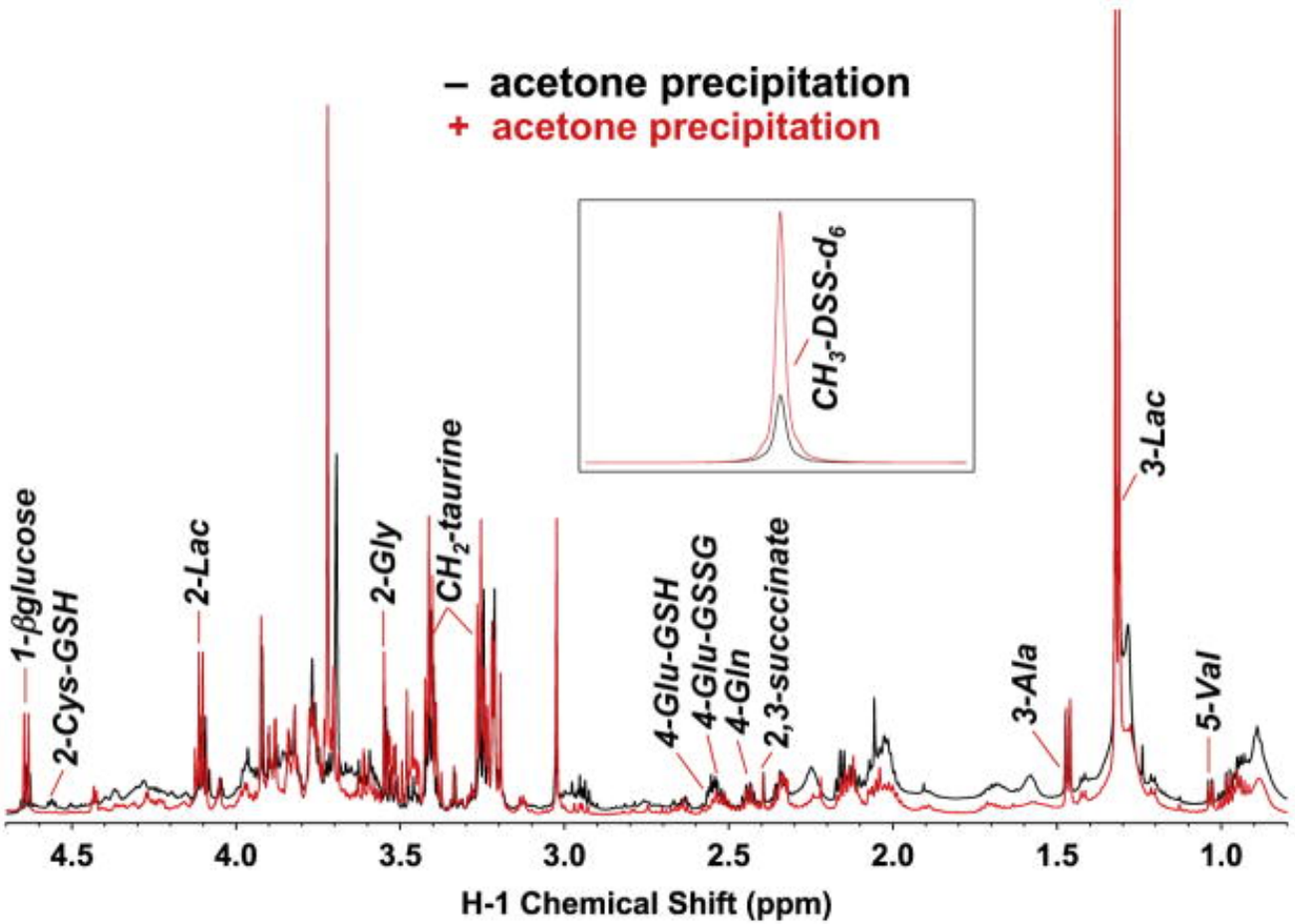

Figure: [3]

Outline

180°|90° Pulses

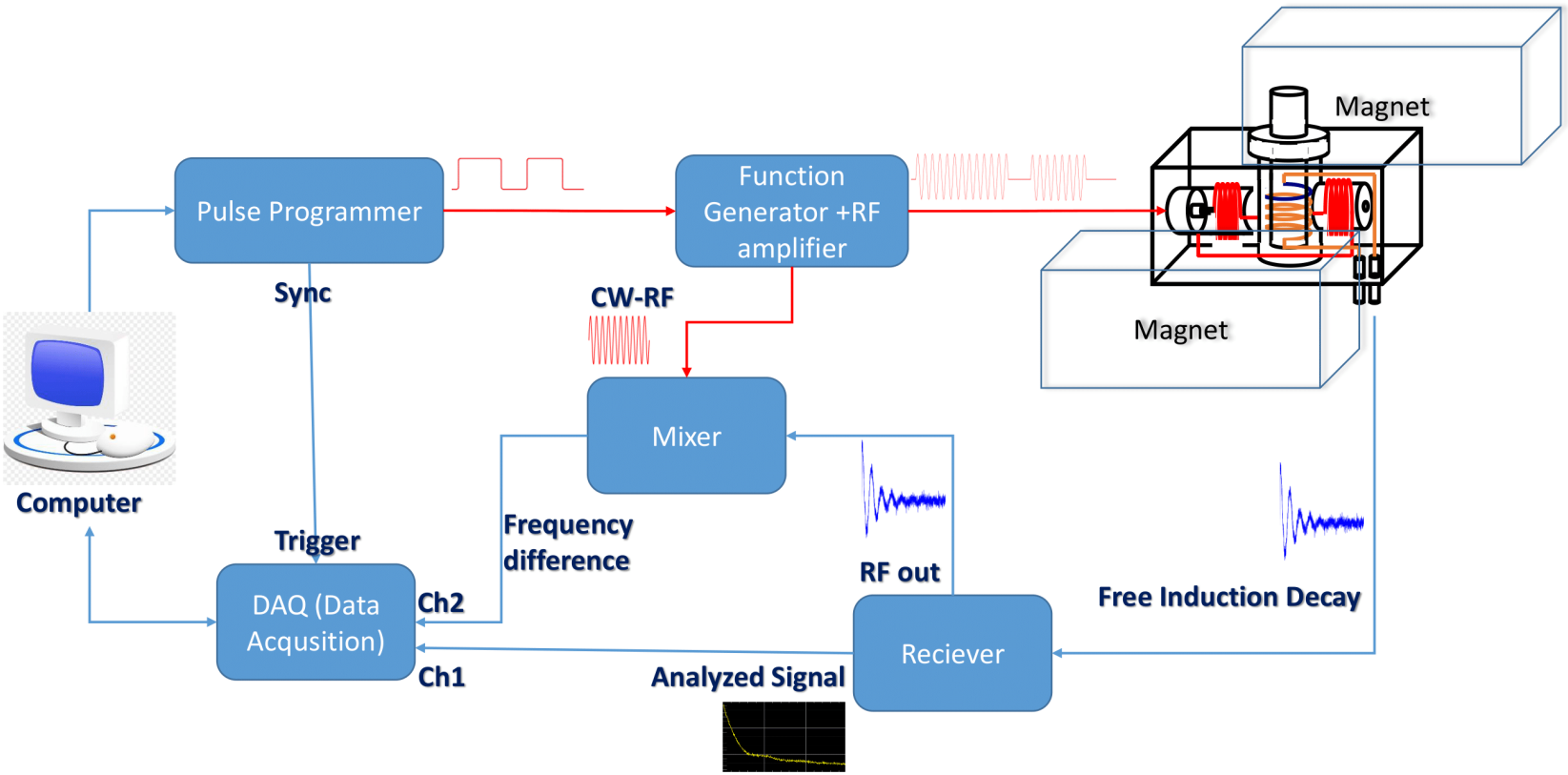

Figure:

Outline

Sample Relaxation Times

Sample	Conc. [mg/ml]	T_1 [ms]	T_2 [ms]
A	$34.0 \pm 6.0 \times 10^{-2}$	$3.9 \pm 3.9 \times 10^{-2}$	$4.2 \pm 1.3 \times 10^{-1}$
B	$65 \pm 1.1 \times 10^{-1}$	$2.3 \pm 1.7 \times 10^{-2}$	$2.4 \pm 1.2 \times 10^{-1}$
C	$85.3 \pm 1.2 \times 10^{-1}$	$1.7 \pm 1.2 \times 10^{-2}$	$1.7 \pm 8.5 \times 10^{-2}$
D	$3.37 \pm 1.6 \times 10^{-2}$	$13 \pm 2.5 \times 10^{-1}$	—
E	$30.5 \pm 9.2 \times 10^{-2}$	$4.7 \pm 2.1 \times 10^{-2}$	$4.6 \pm 4.9 \times 10^{-2}$
F	$92 \pm 1.2 \times 10^{-1}$	$1.45 \pm 1.6 \times 10^{-2}$	$1.6 \pm 6.6 \times 10^{-2}$
G	$12.24 \pm 2.1 \times 10^{-2}$	$8.8 \pm 8.2 \times 10^{-2}$	$11 \pm 2 \times 10^{-1}$
H	$53.31 \pm 8.1 \times 10^{-2}$	$2.02 \pm 3 \times 10^{-2}$	$2.2 \pm 1.1 \times 10^{-1}$
I	$84 \pm 1.1 \times 10^{-1}$	$1.6 \pm 3 \times 10^{-2}$	$1.7 \pm 4.4 \times 10^{-2}$
J	$27.5 \pm 5.4 \times 10^{-2}$	$4.9 \pm 2.2 \times 10^{-2}$	$4.6 \pm 6.0 \times 10^{-2}$
K	$28 \pm 1.8 \times 10^{-2}$	$3.7 \pm 2.6 \times 10^{-2}$	$3.9 \pm 9.3 \times 10^{-2}$

Table: $CuSO_4$ Samples

Outline

Further Analysis of Sample K

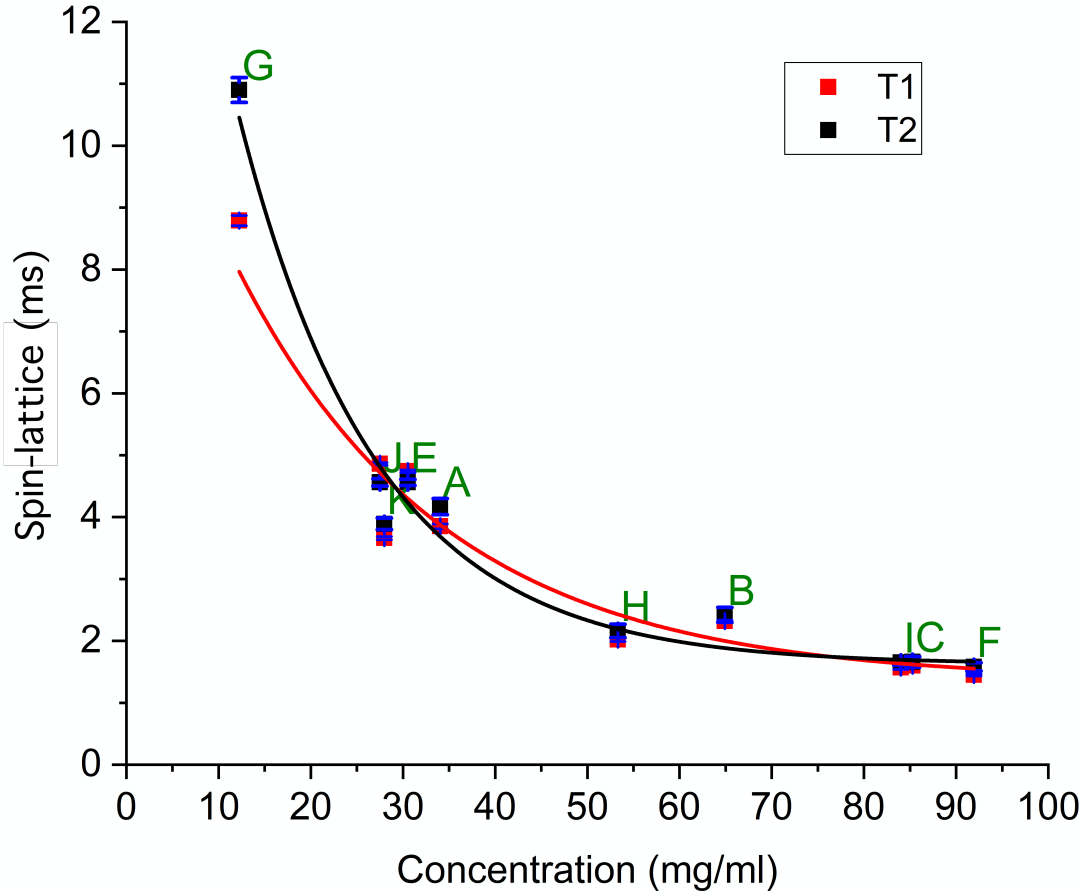

Figure: Relaxation Time vs. Concentration

Further Analysis of Sample K

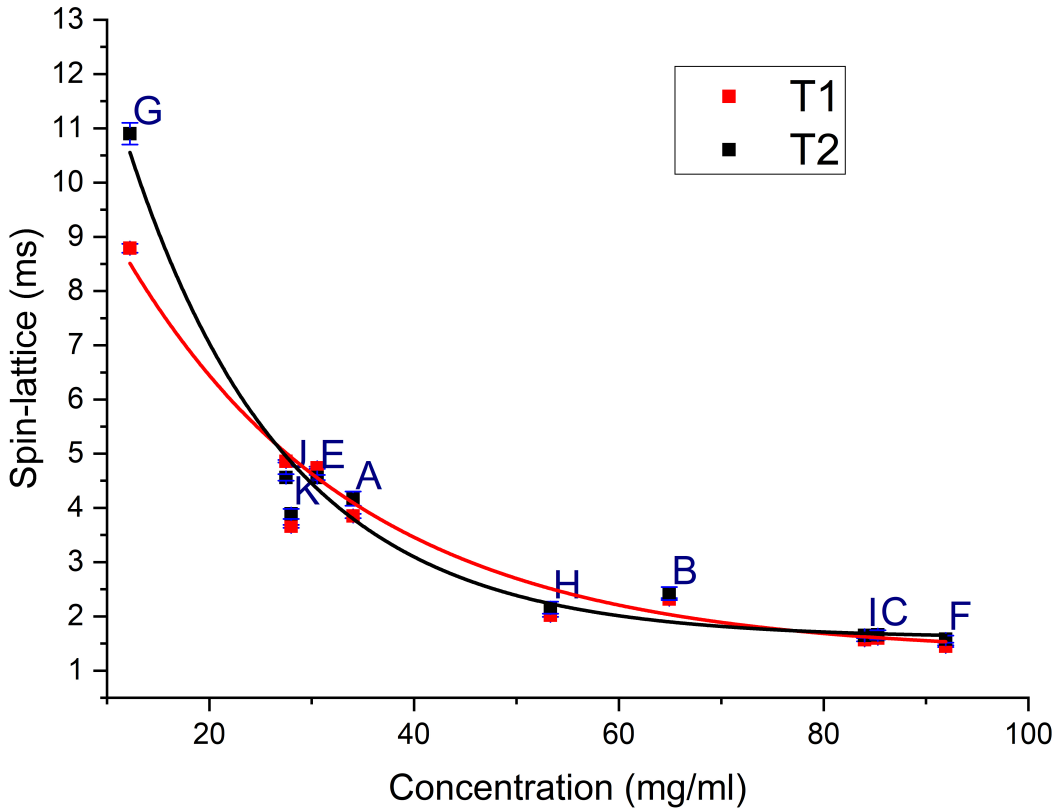

Figure: Relaxation Time vs. Concentration

Further Analysis of Sample K

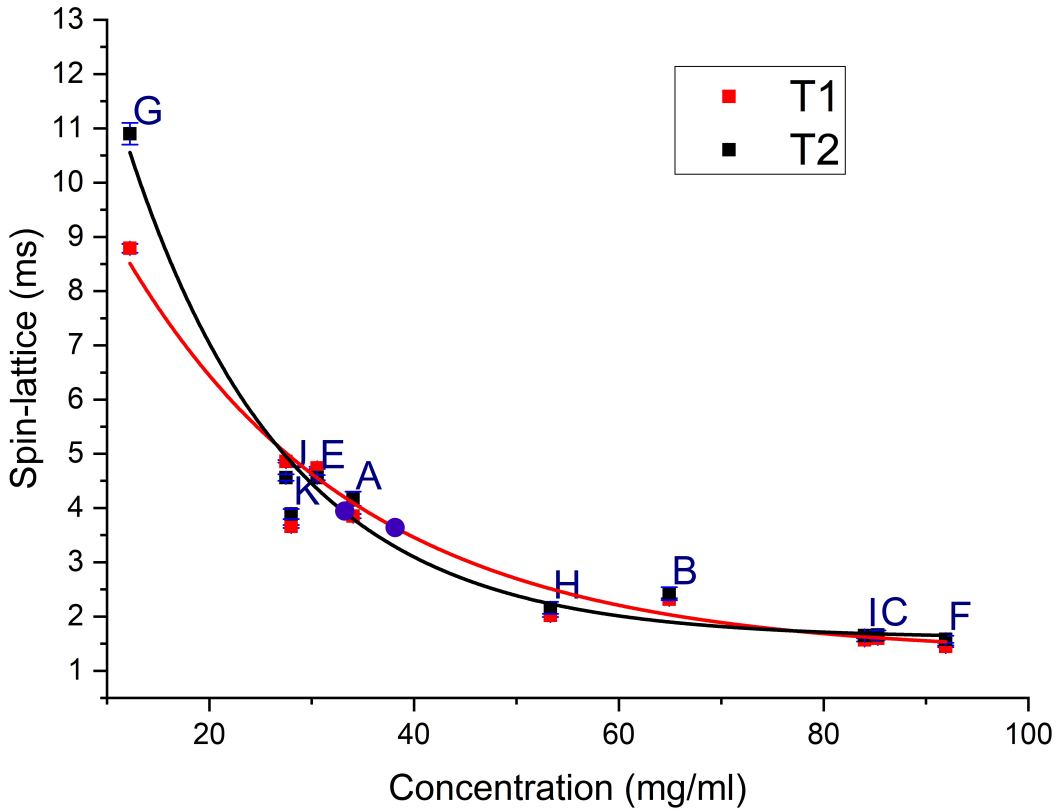

Figure: Relaxation Time vs. Concentration

References I

[1] Spin echo, 2020.

[2] Sarah Cady.
Tales from the nmr lab, May 2020.

[3] Teresa W.-M. Fan and Andrew N. Lane.
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[4] Ben Nashman.
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[5] Tamije S. Perumal and Viji Palanisamy.
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Acknowledgement

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Relaxation Path

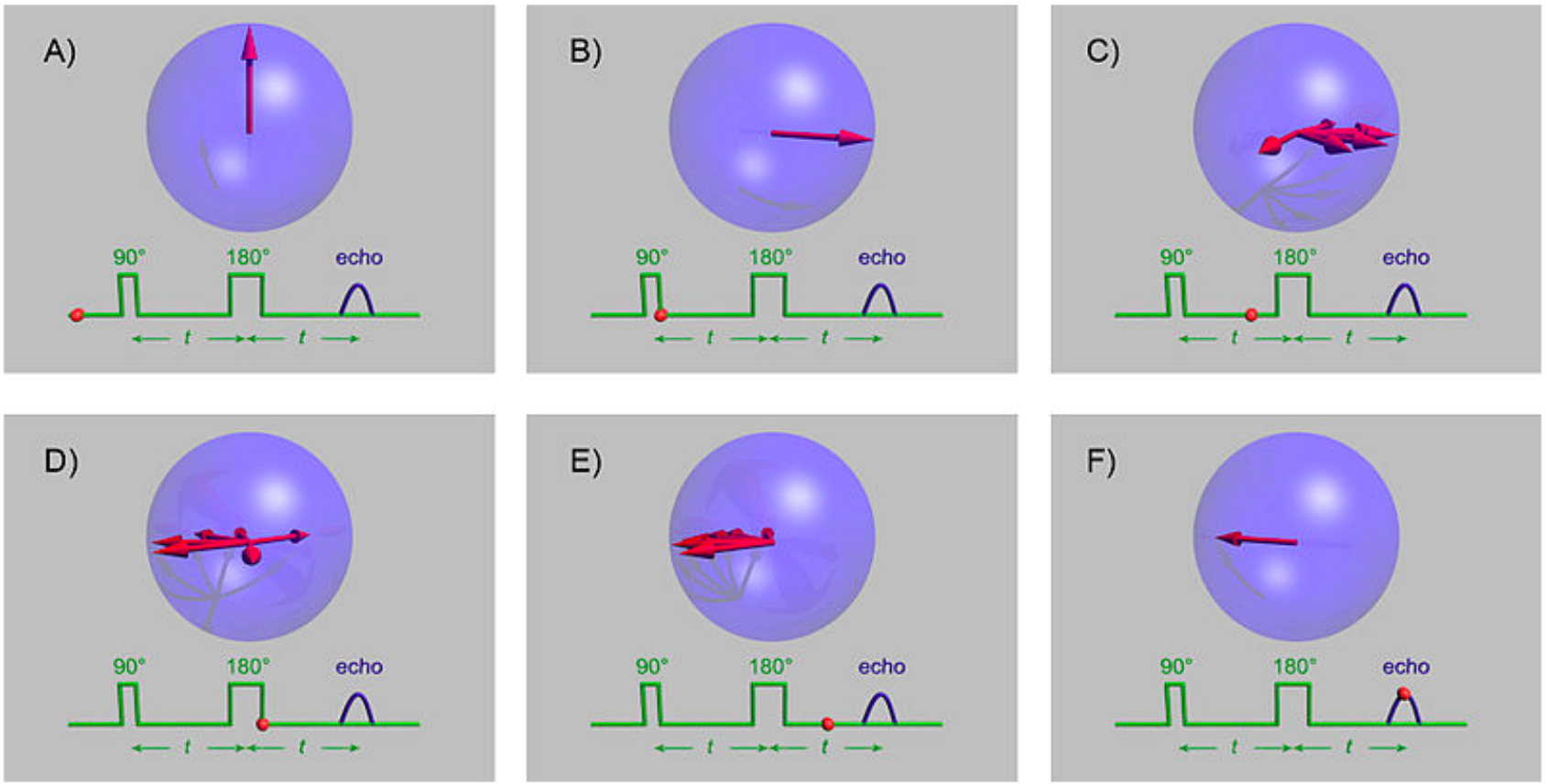

Figure: General Relaxation Path [1]

Frequency Deviation

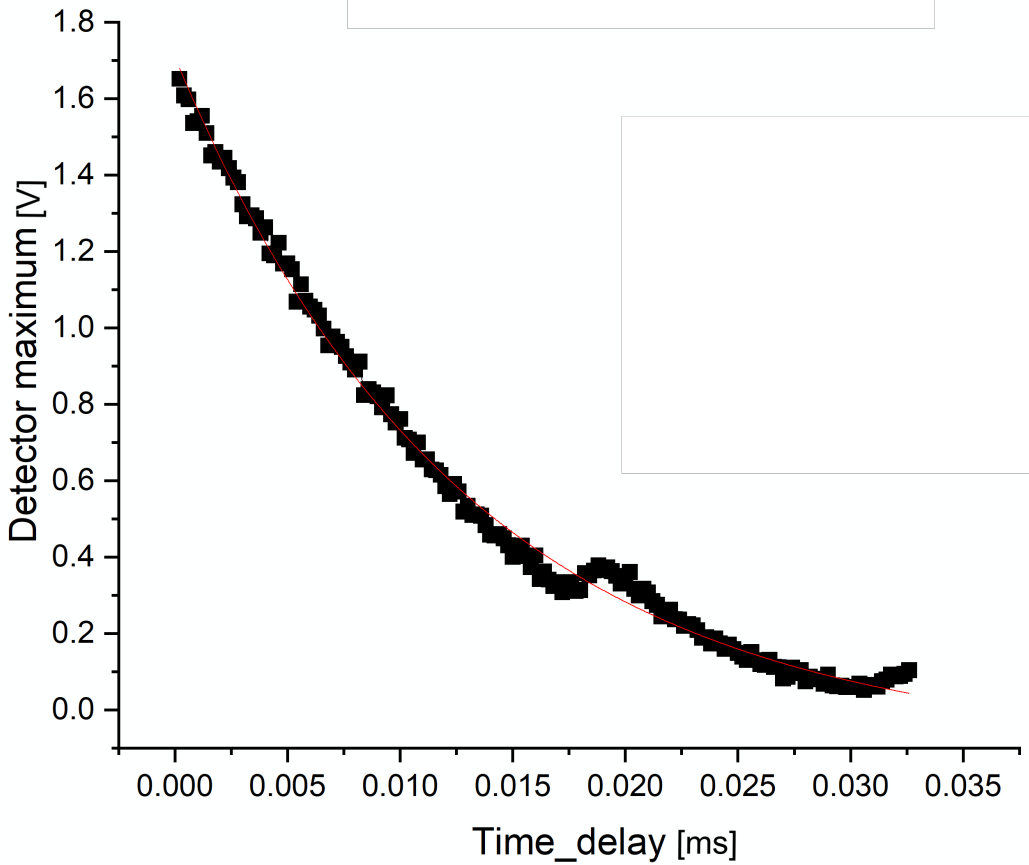

Figure: Sample D $[3.37 \pm 1.6x10^{-2}]$: T_1

Exceeding Relaxation Time

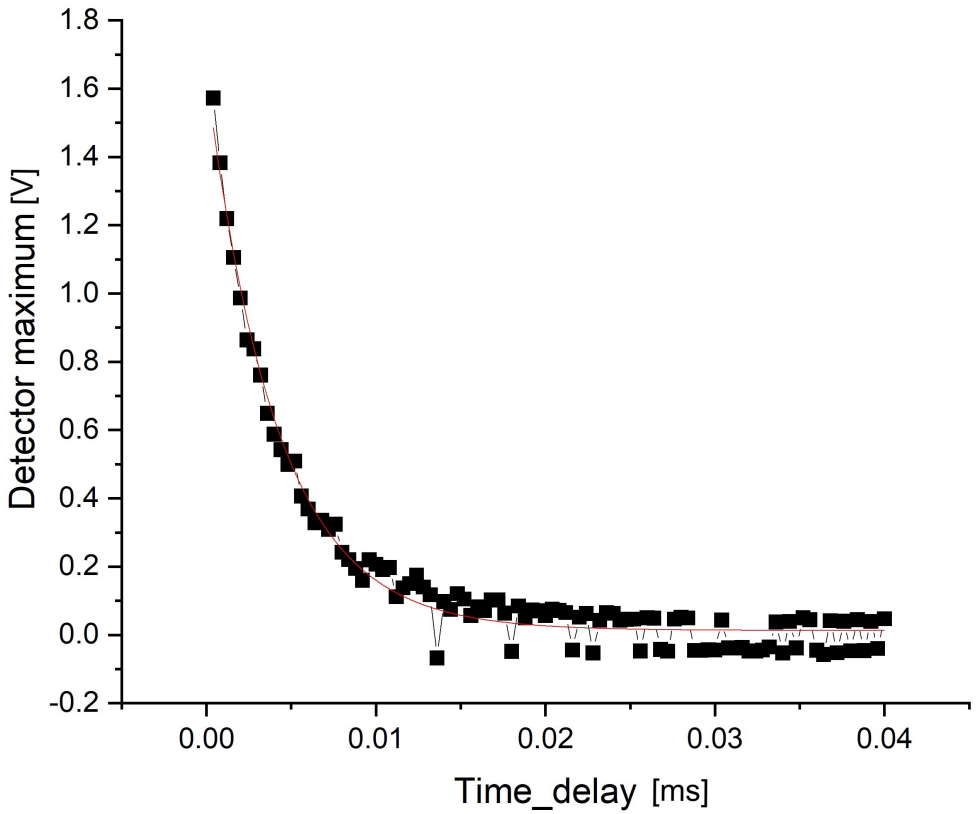

Figure: Sample A $[34.0 \pm 6.0x10^{-2}]$: T_2