

magnETHical

BUILDING A 25 MHz NMR SPECTROMETER

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ETH Zürich

“What I cannot create, I do not understand”

—Richard Feynman

WHY?

NMR is used across various fields

- Research (Structure Analysis, Drug Discovery, ...)
- Medicine (Imaging, Diagnosis, ...)
- Industry (Process Control, Drug screening, ...)
- Education (Quantum Mechanics, Quantum Computing, ...)

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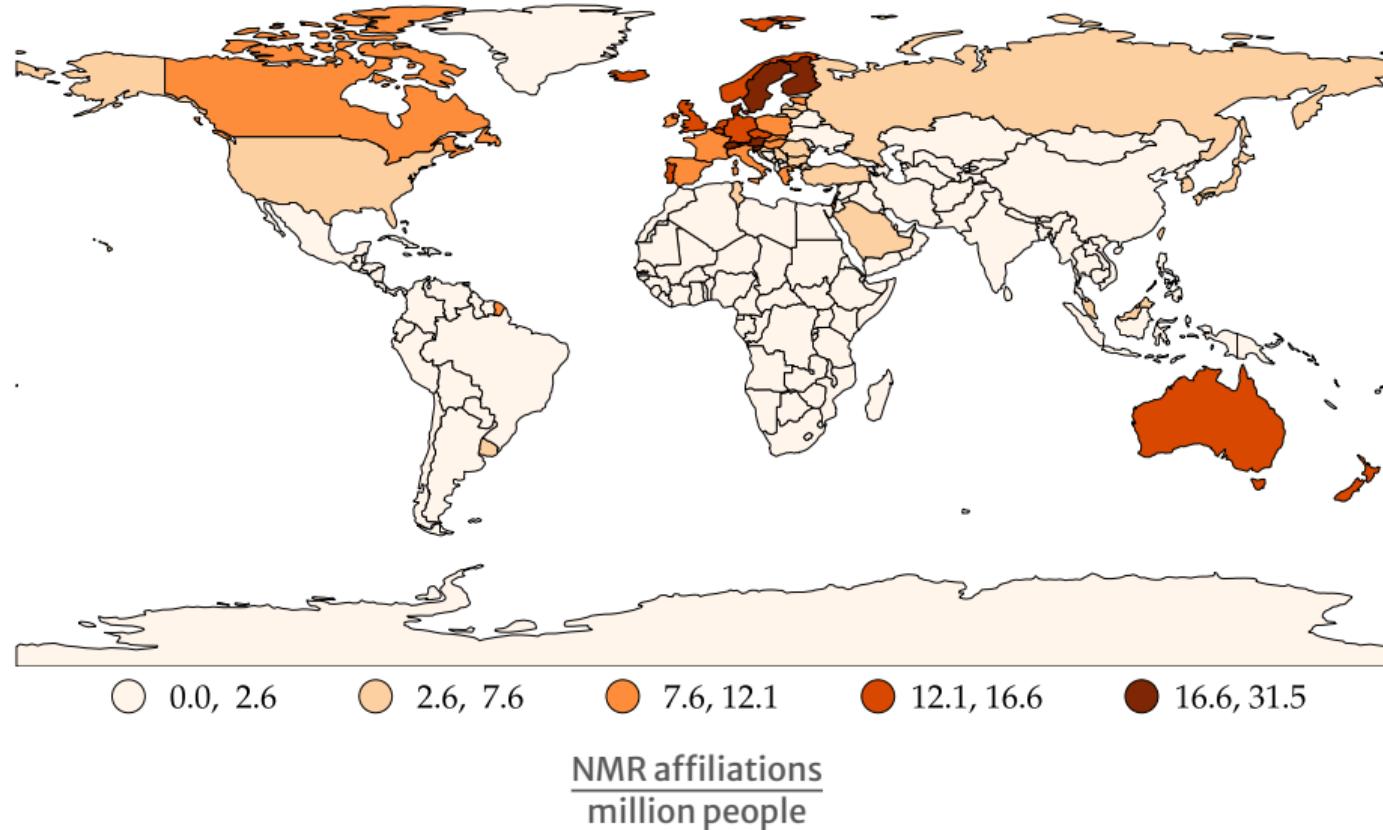
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There is not a lot of NMR research in the Global South



Build an accessible NMR spectrometer

Preview

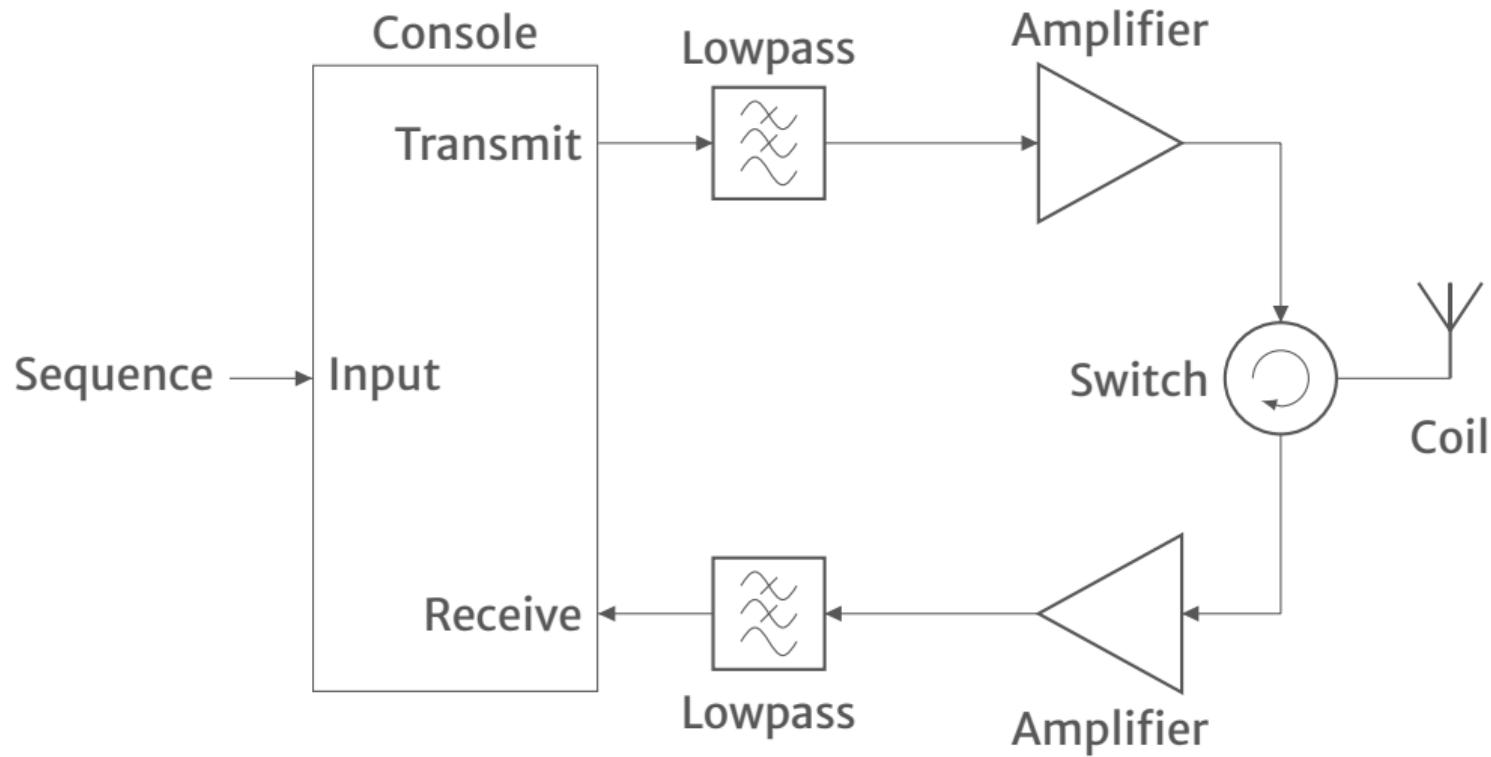
The parts

The complete setup

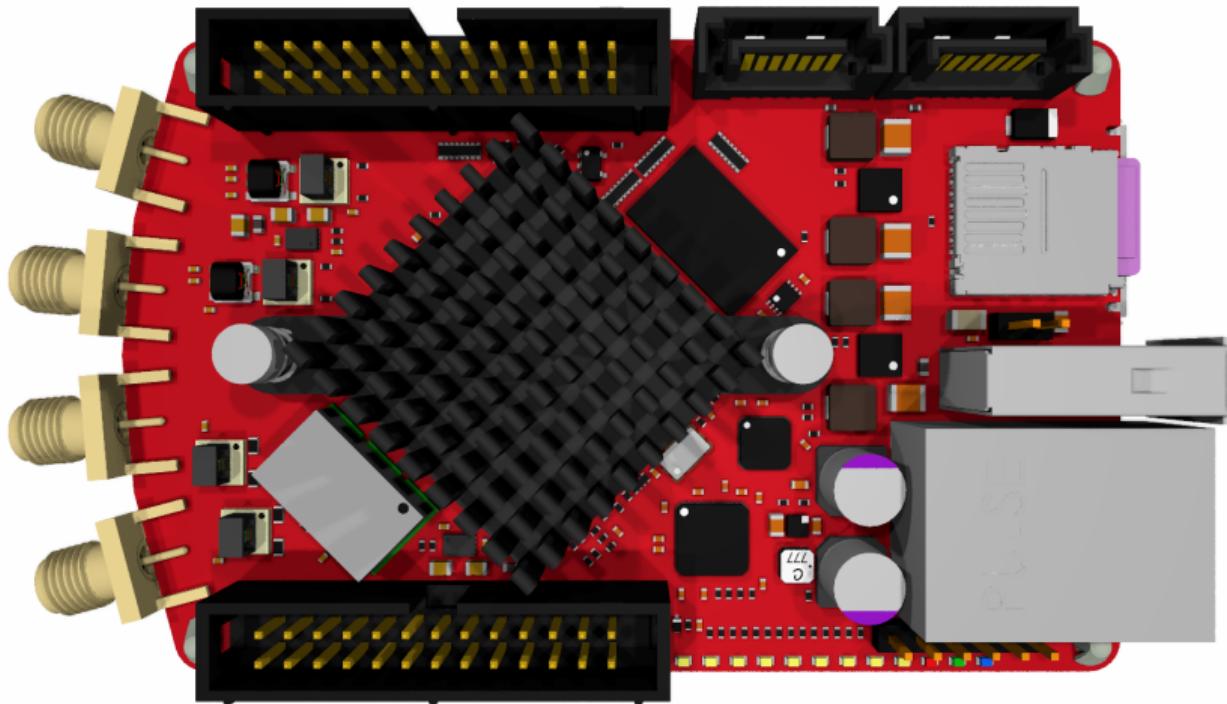
Measurement Results

THE PARTS

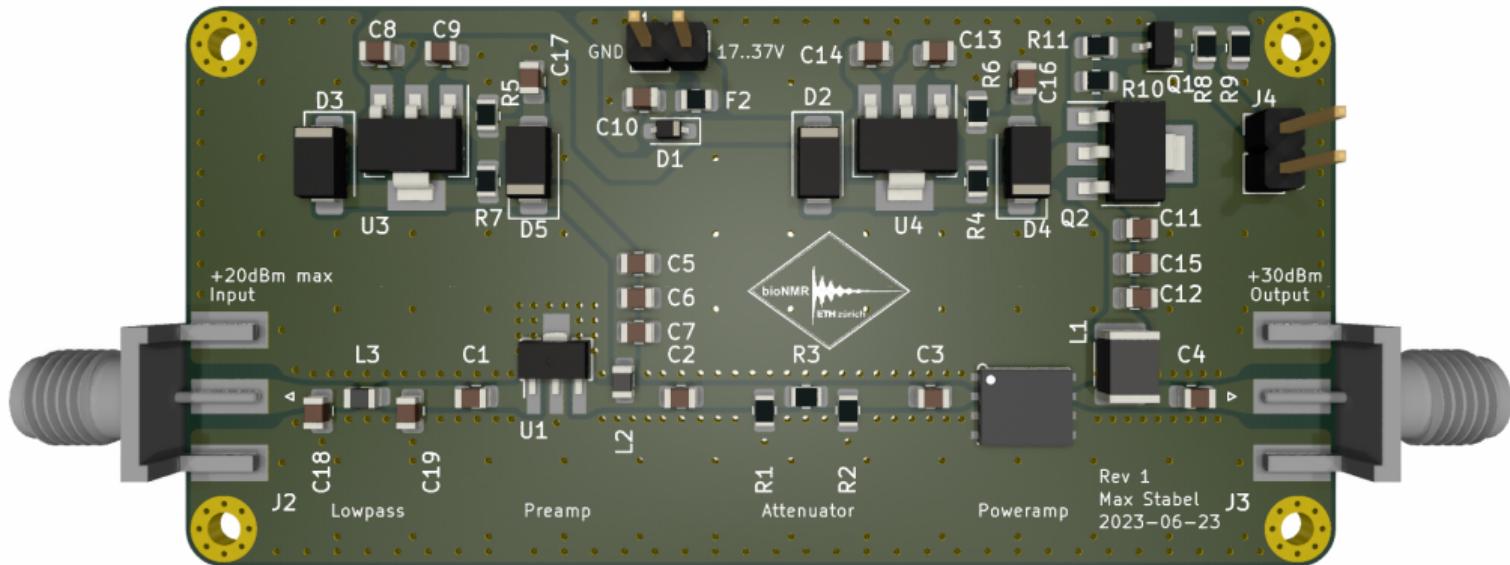
Our goal is to build an accessible NMR spectrometer



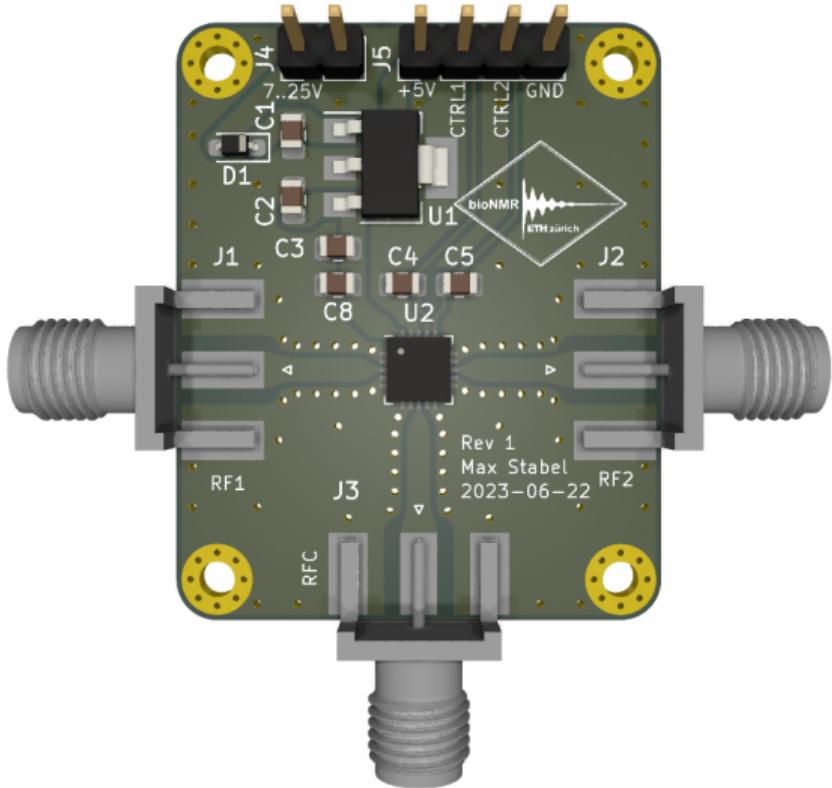
The console
is a ready-made FPGA board



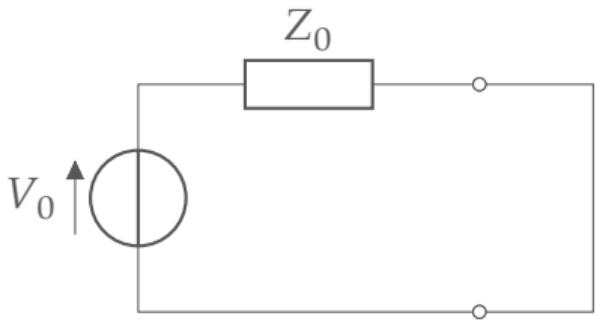
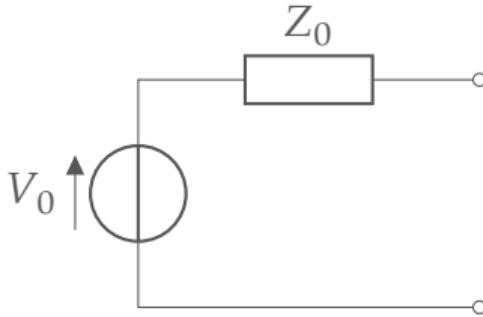
The power amplifier has two stages



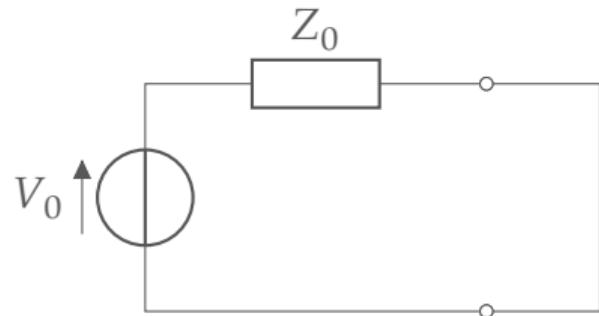
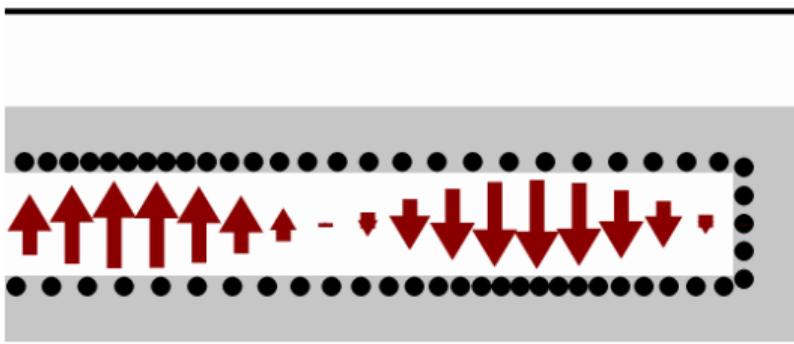
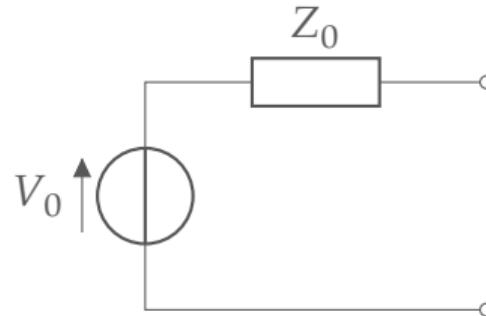
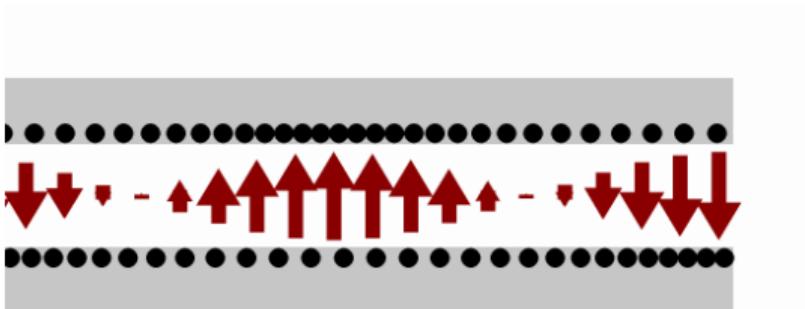
We use a transistor-based active switch



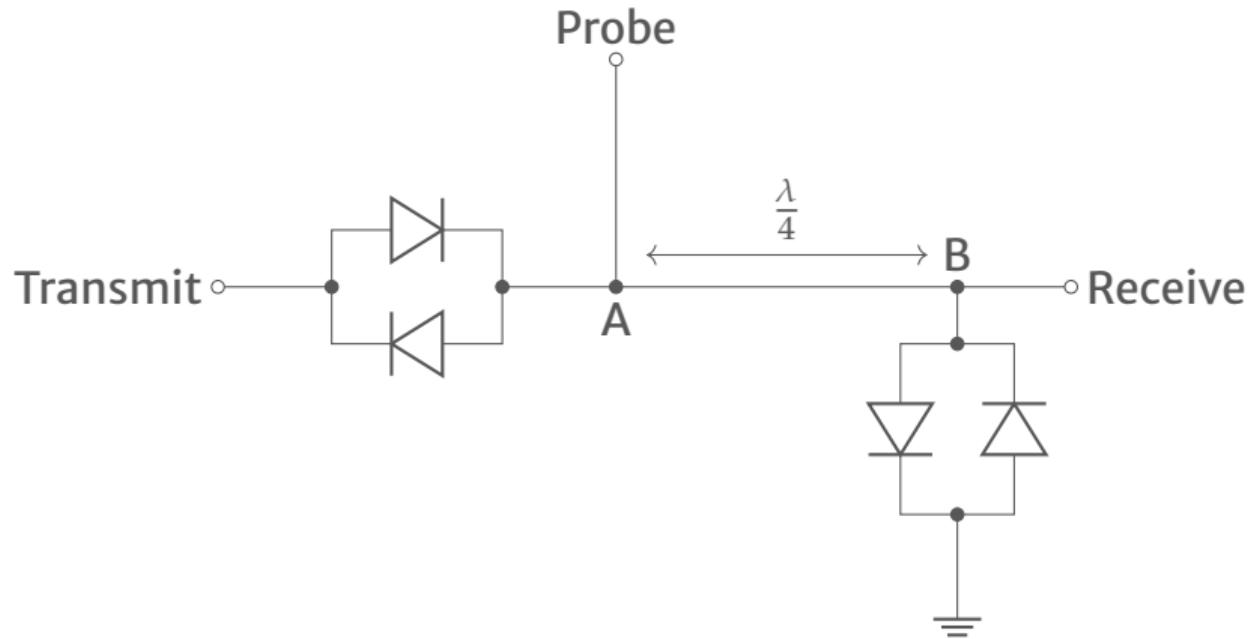
A transmission line transforms impedance



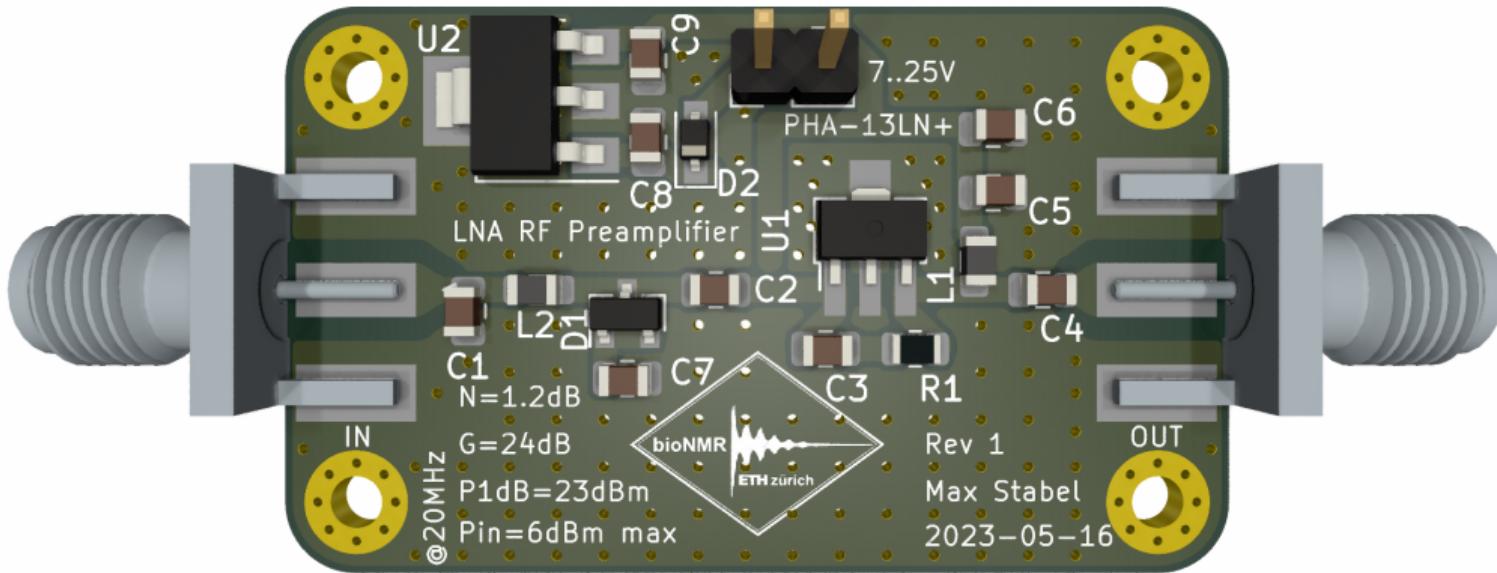
A transmission line transforms impedance



The passive approach leaked too much power



The low-noise amplifier



The probe



THE COMPLETE SETUP

Our NMR is affordable ...

Part	Price incl. VAT [CHF]
Power Amplifier	36.01
Switch	20.05
Probe	≈15.00
Low-Noise Amplifier	73.11
Shim Driver	257.08
Console	662.53
Magnet	≈9000.00
Sum	10142.80

... and competitive

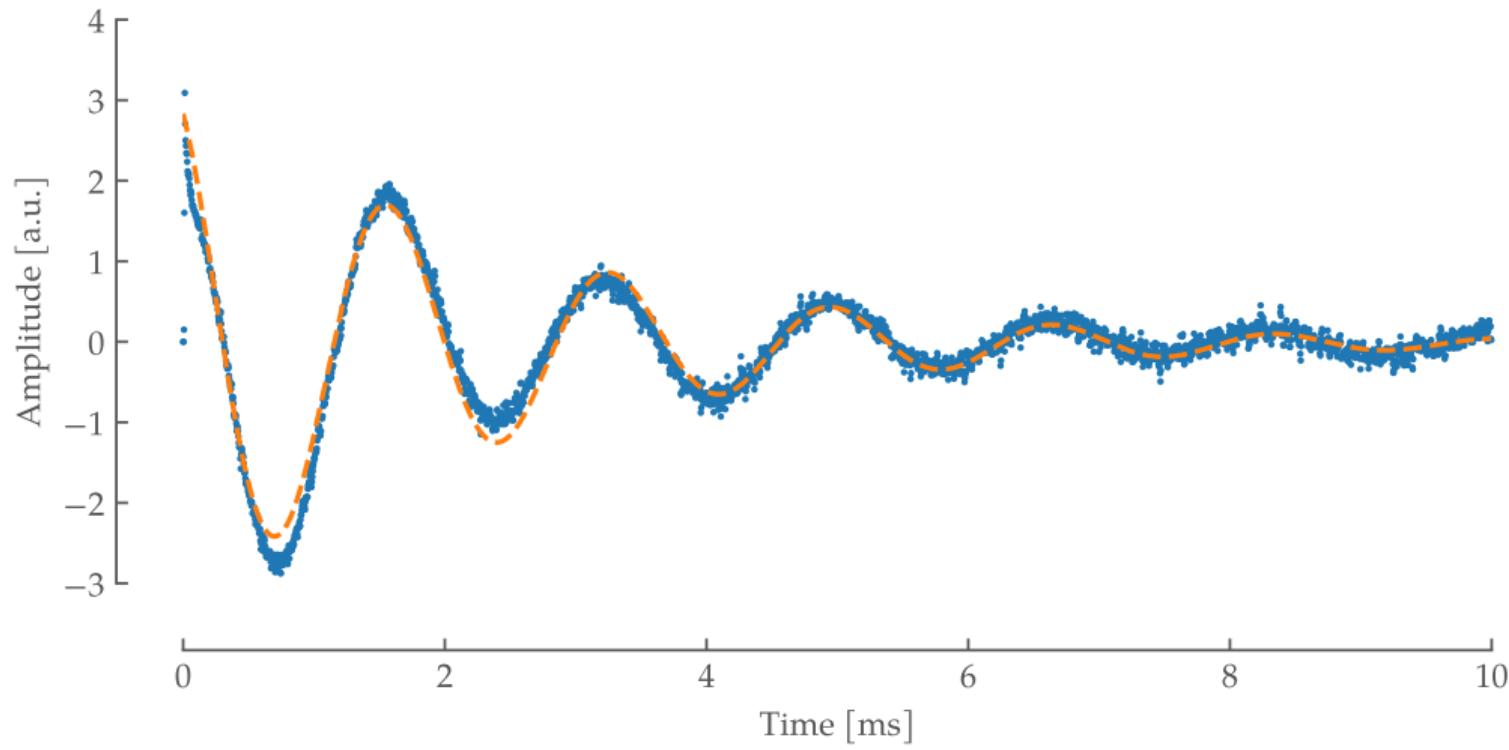
	Superconducting	Benchtop	<i>magnETHical</i>
Price [k CHF]	200–18 000	50–150	≈10
Frequency [MHz]	300–1200	40–125	25
Resolution [Hz]	≈0.2	0.2–1	≈2.5/50 [†]
Weight [kg]	600–15 000	25–150	≈5

[†]with/without shims

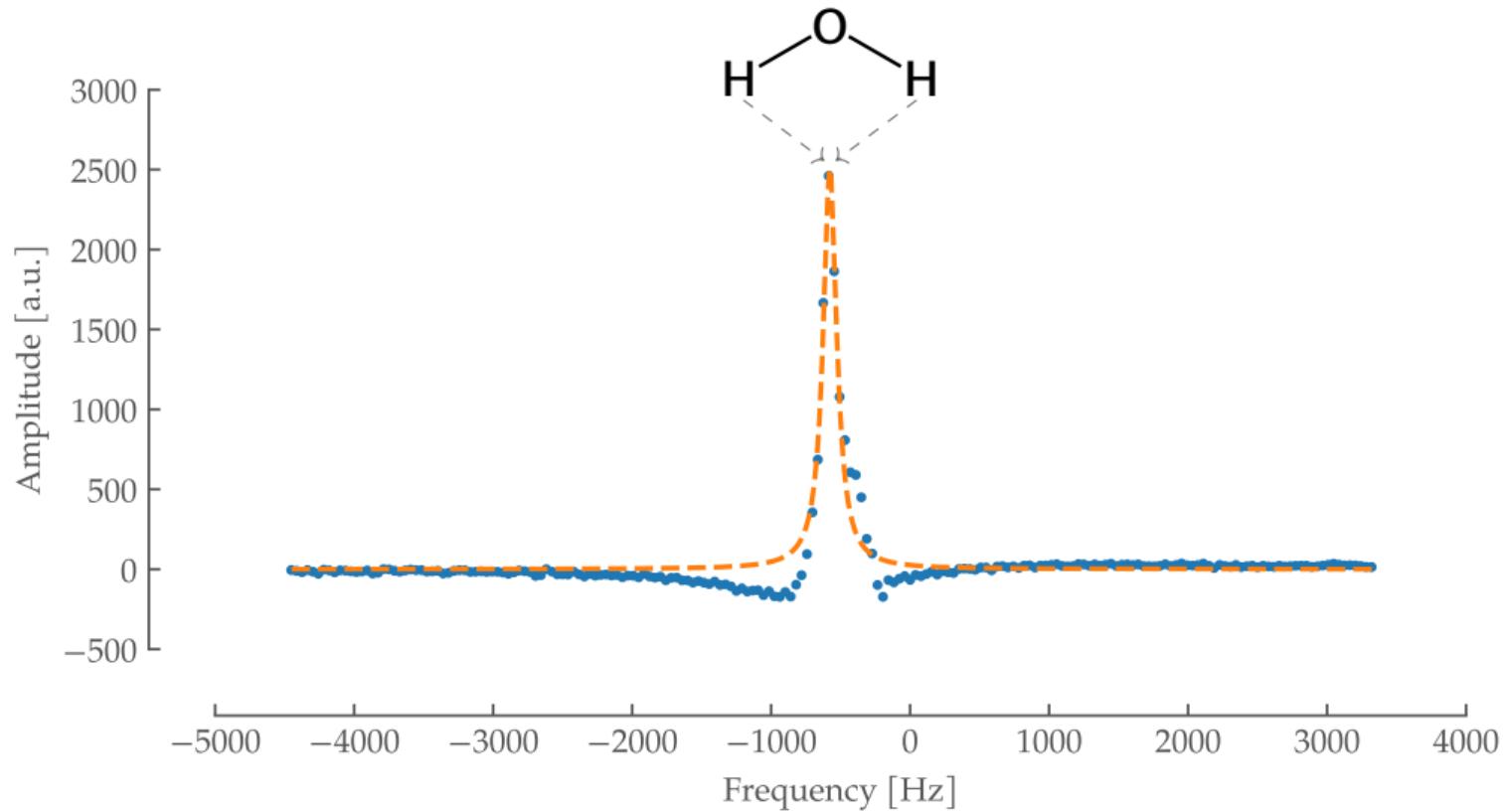
For 5mm standard NMR tubes

MEASUREMENT RESULTS

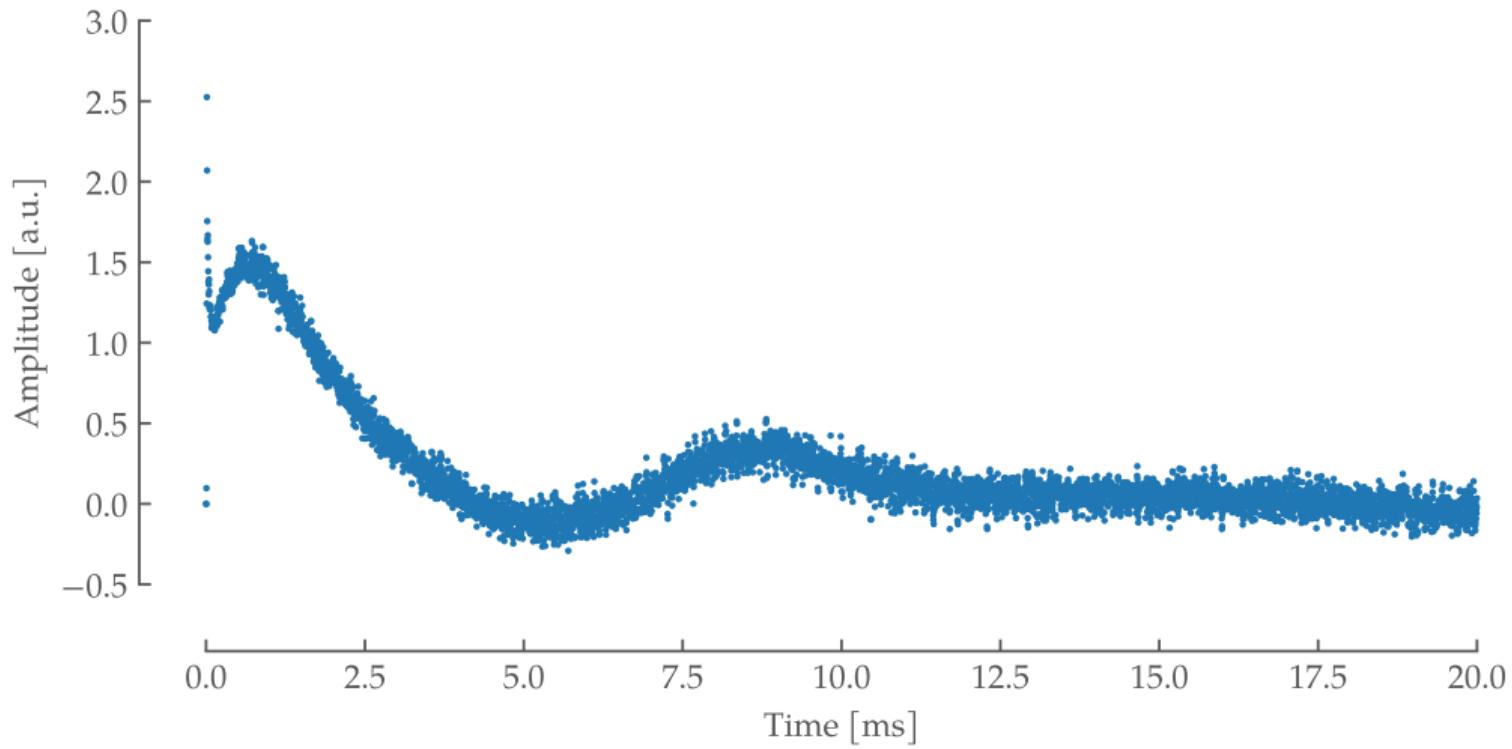
We can already see a water FID



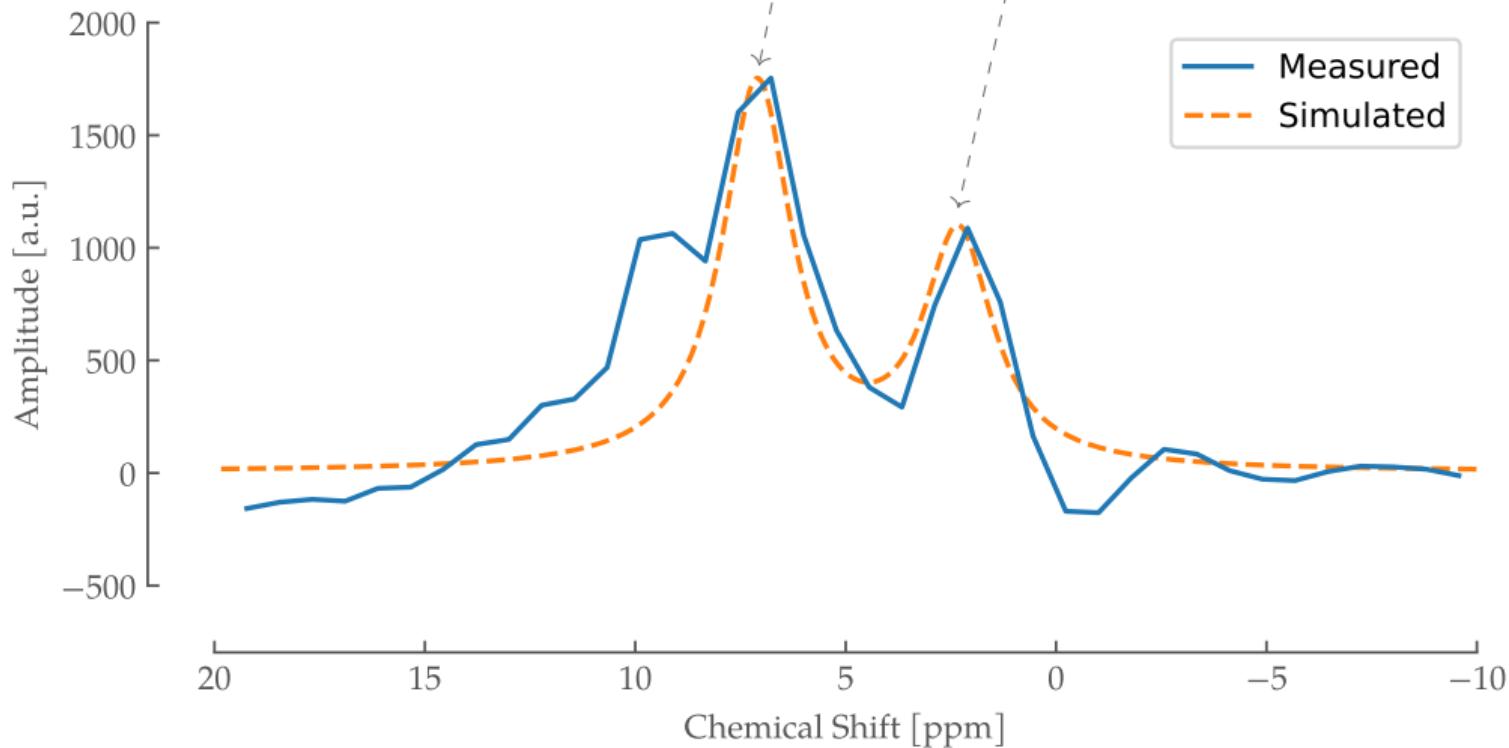
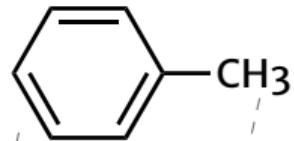
...and do a Fourier transform



Toluene also has a visible signal



We can even see the chemical shifts
of the Toluene peaks!



Demo time!

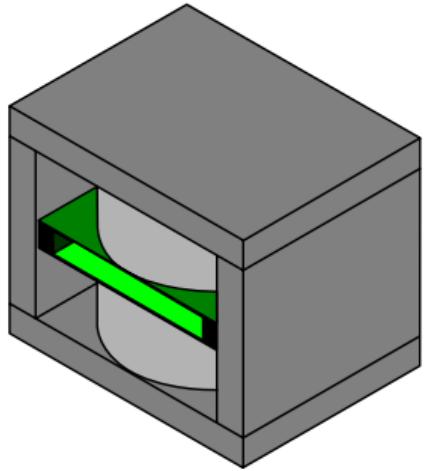
The setup is working

“I have not yet lost that sense of wonder, and of delight, that this delicate motion should reside in all ordinary things around us, revealing itself only to him who looks for it.”

“There the snow lay around my doorstep — great heaps of protons quietly precessing in the Earth’s magnetic field.”

— E.M. Purcell

Thank you!



*magn***ETH**ical

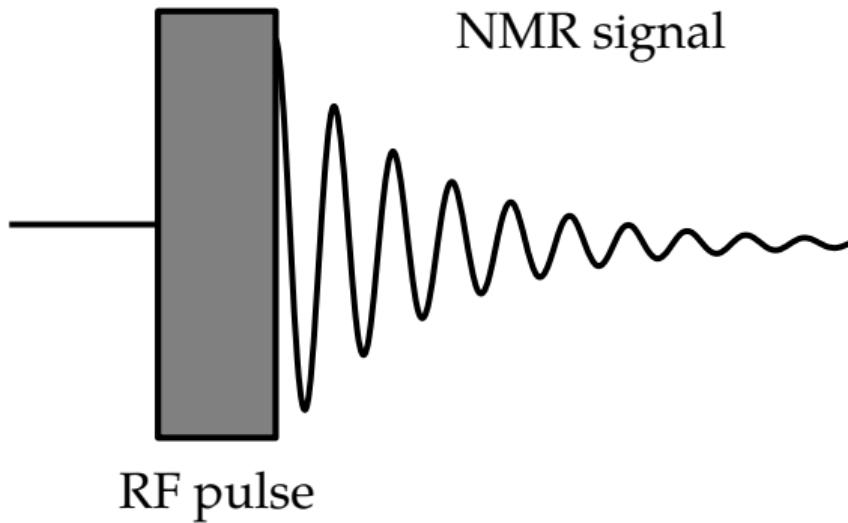
Find everything on



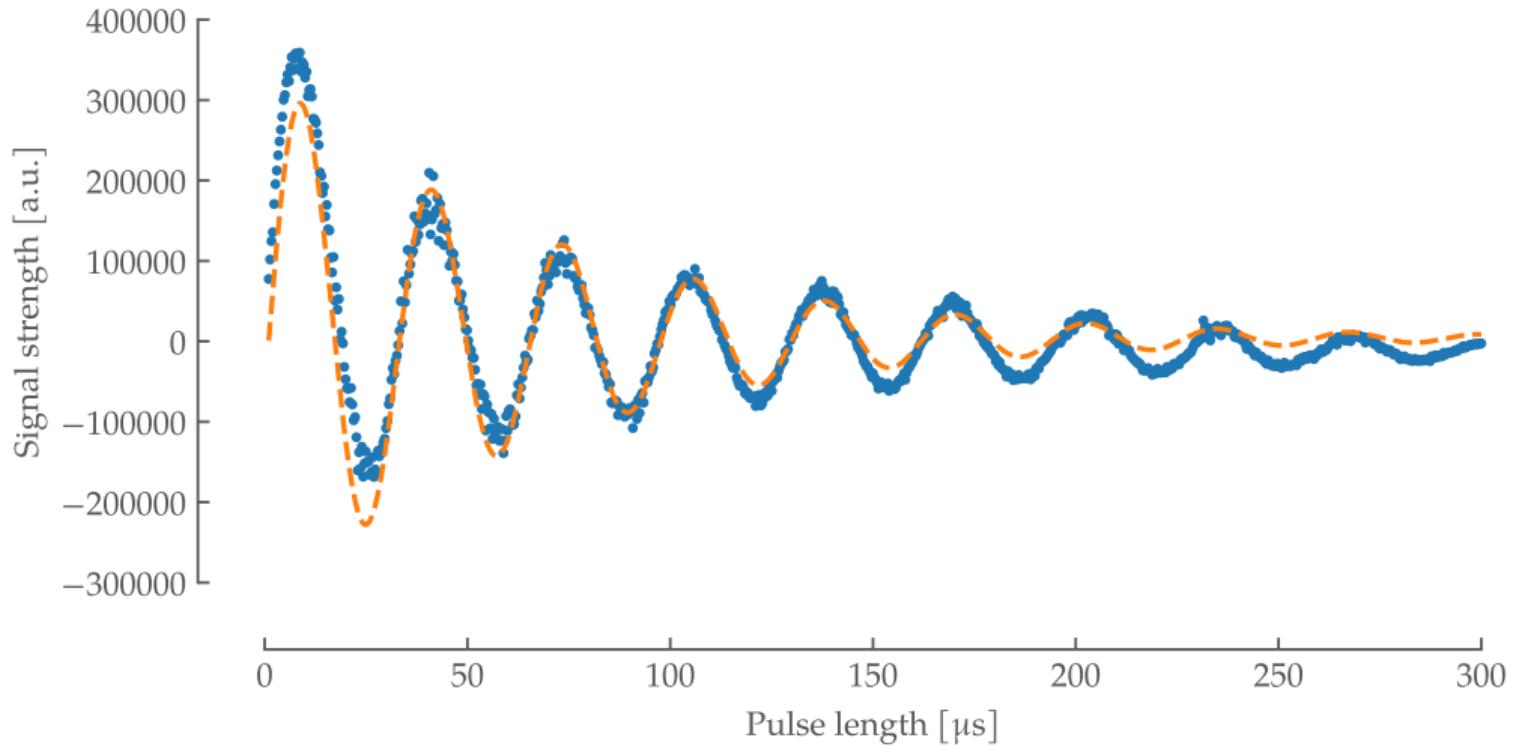
[https://gitlab.ethz.ch/mstabel/
nmr-spectrometer](https://gitlab.ethz.ch/mstabel/nmr-spectrometer)

Backup

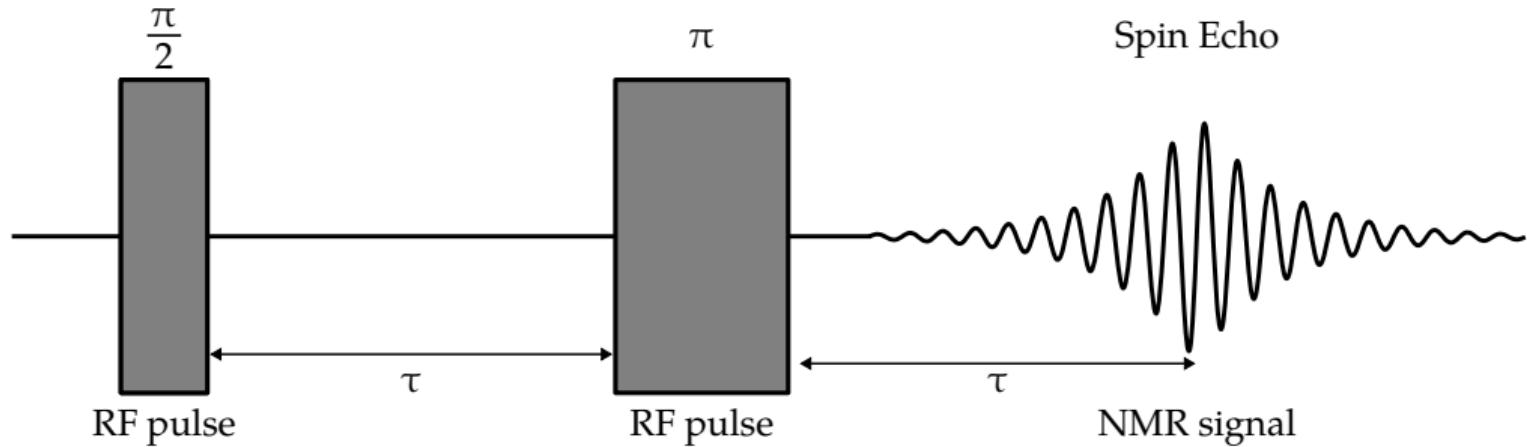
Simple Pulse Sequence



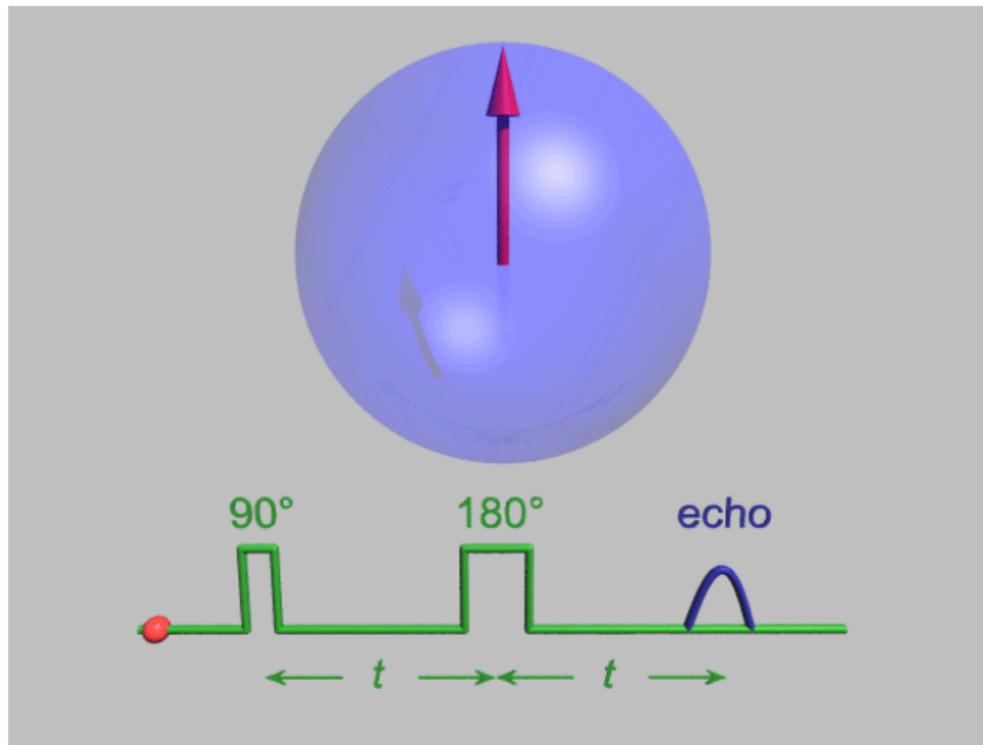
Rabi nutation (pulse calibration) of water



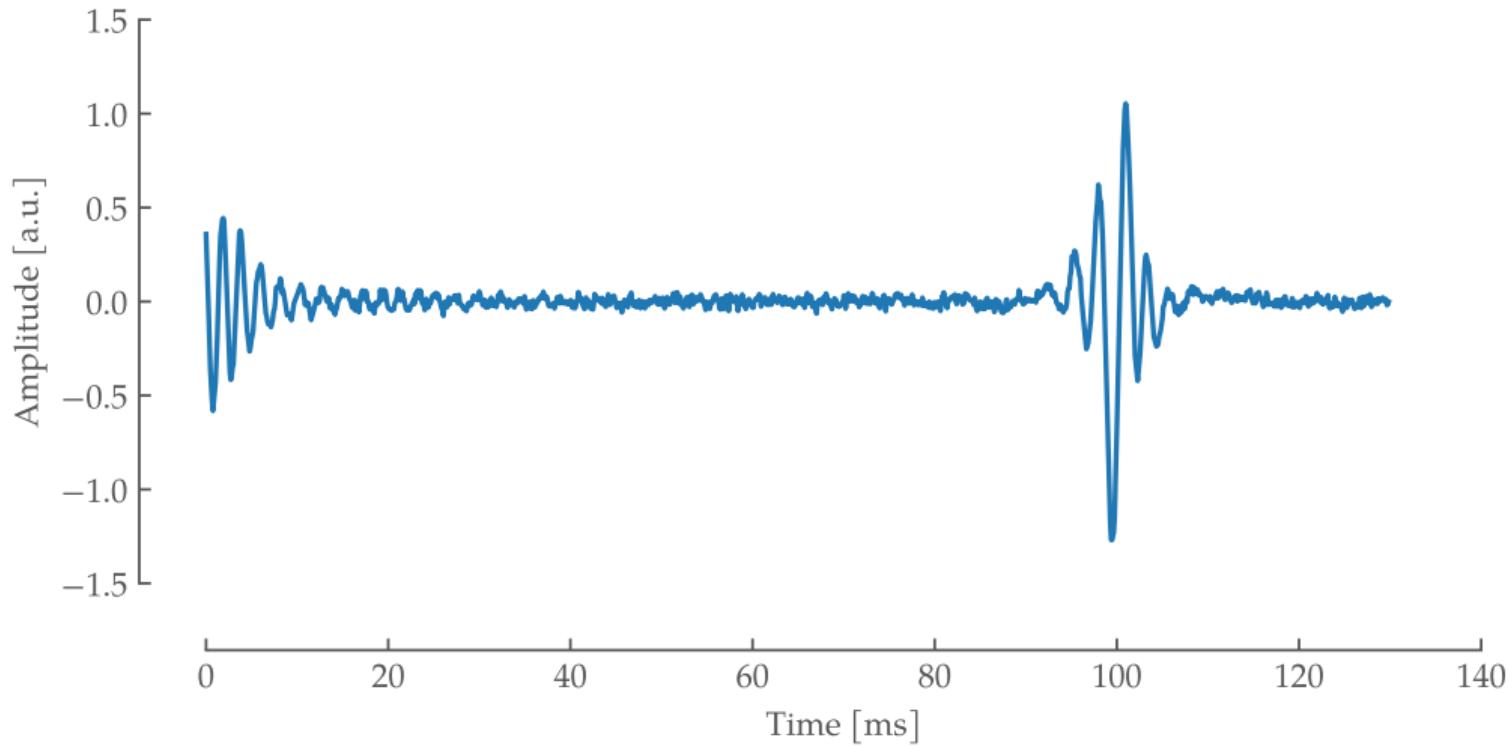
Spin Echo Sequence



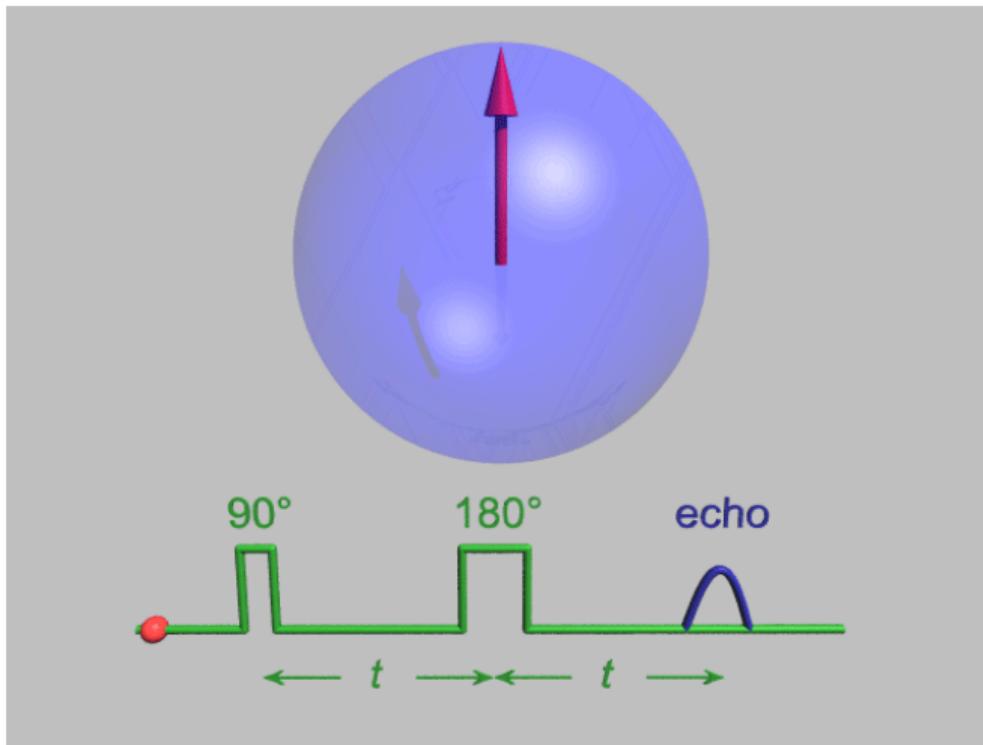
Spin Echo Animation



Spin Echo Measurement



T_2 Decay Animation



T_2 decay of water

