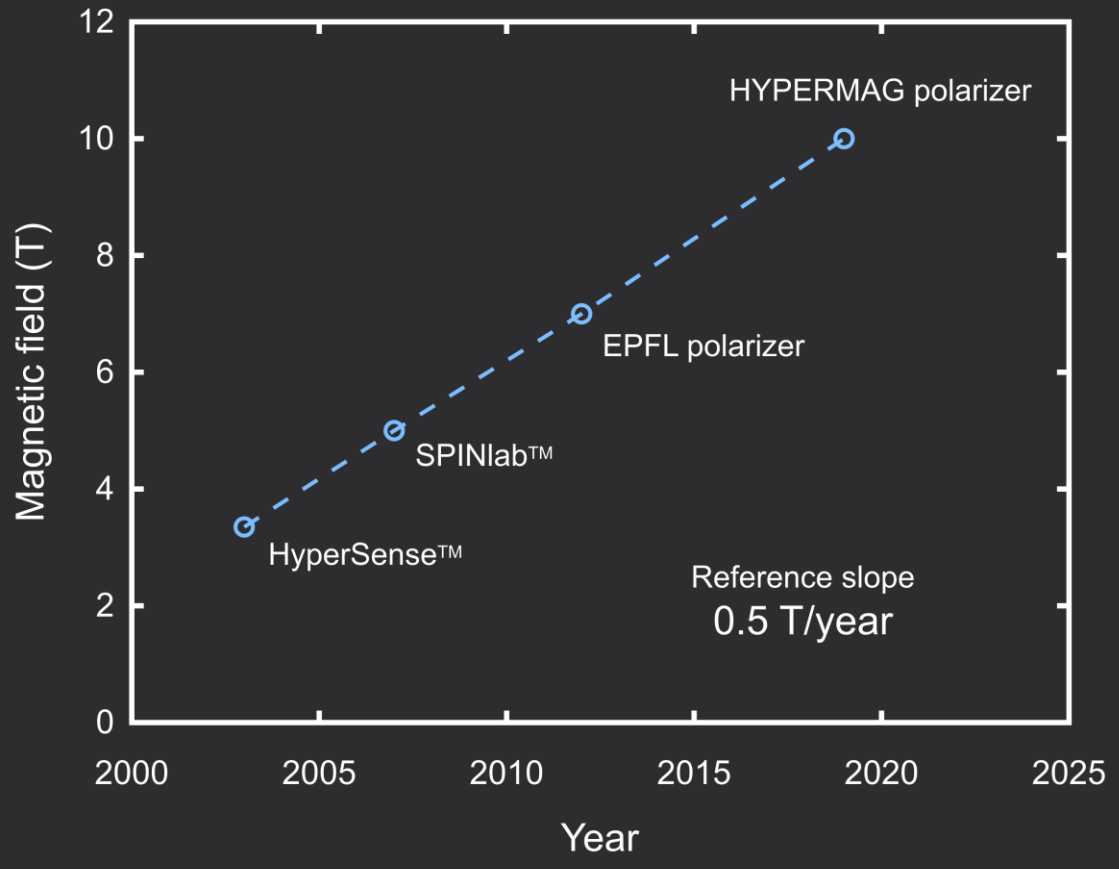
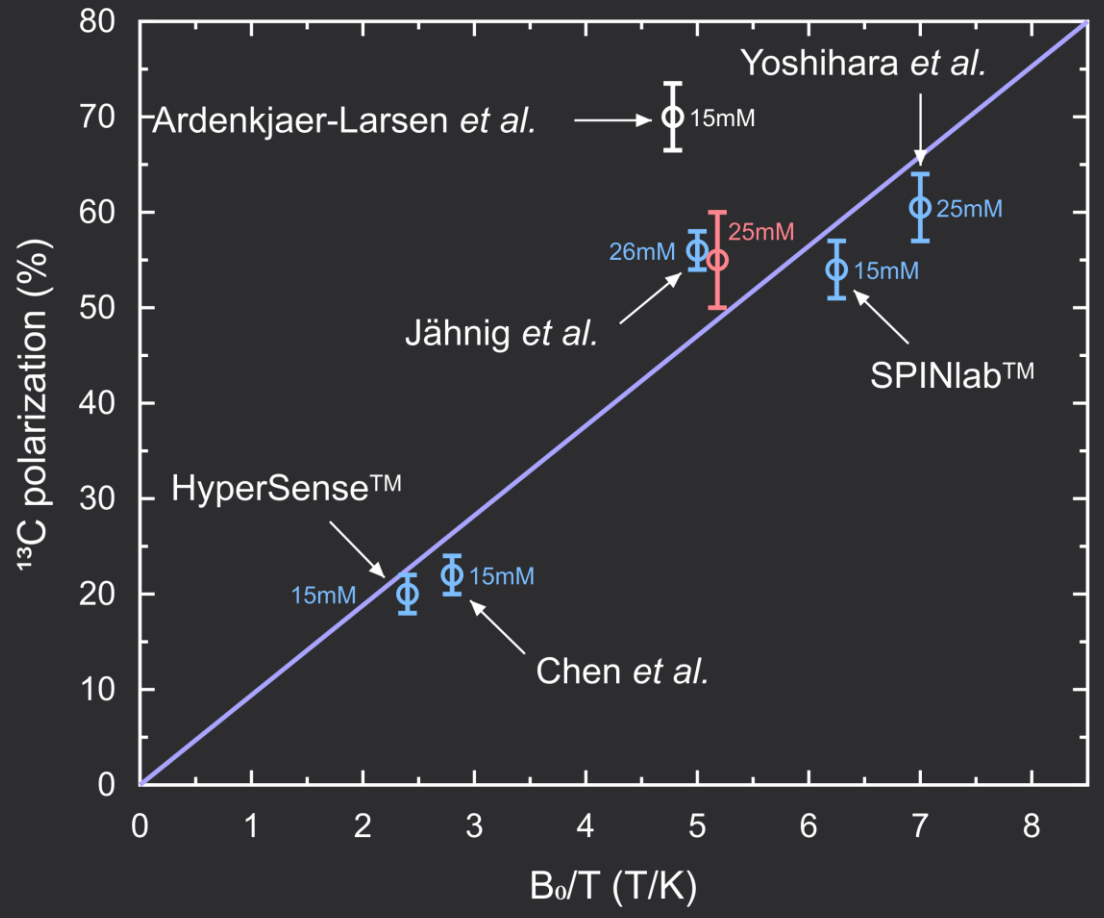
High throughput dDNP without cross polarization

Hyperpolarization Workshop - Aarhus - October 2026

Why go at high field?



Adapted from T. Cheng et al, NMR in Biomed. 2020



High polarization at which cost?

$$\underbrace{Pol = a \cdot \frac{B_0}{T}}$$

Higher field means higher polarization

$$\underbrace{\frac{1}{T_{1n}} \propto C \frac{T^2}{B_0^{2.3}}}$$

Achieving max polarization can easily take hours

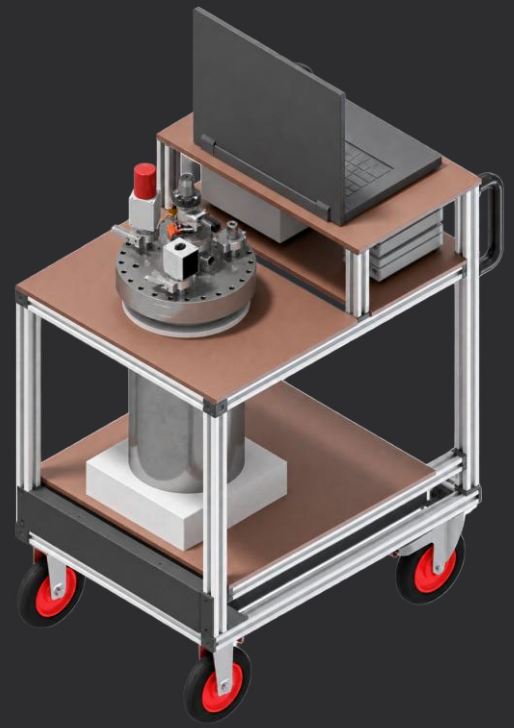
Can we increase the throughput?

...50% ^{13}C polarization is not always required...

“take a traditional polarizer and dissolve beforehand”



“relax the experimental conditions ”



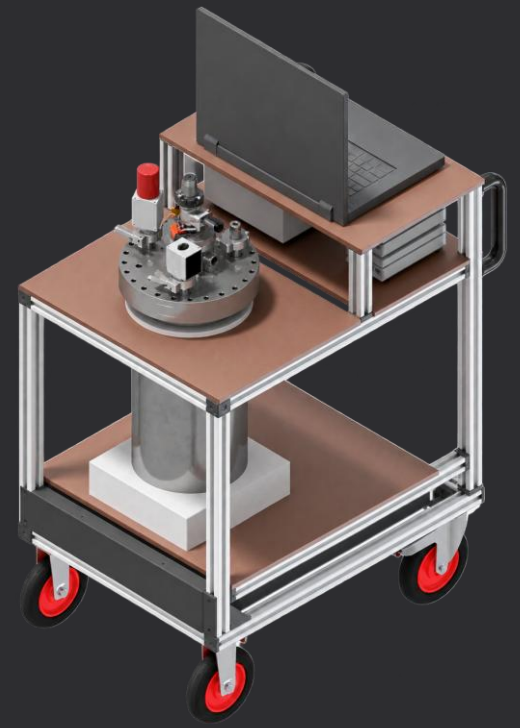
Can we increase the throughput?

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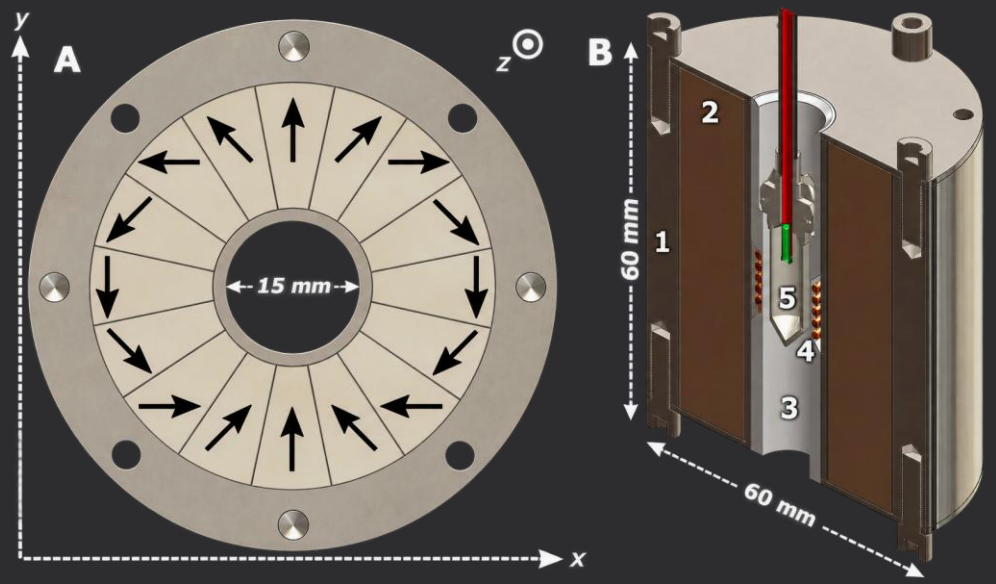
"take a traditional polarizer and dissolve beforehand"

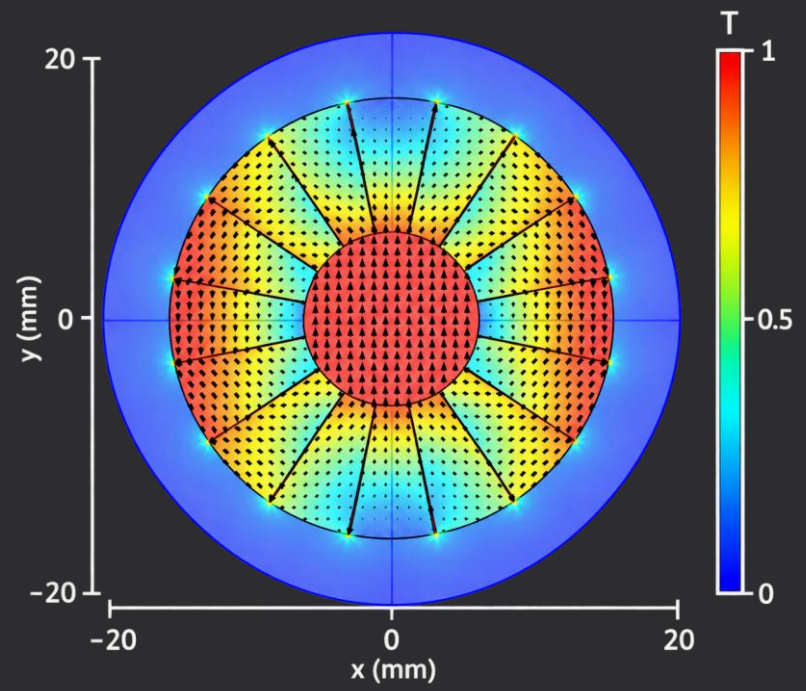


"relax the experimental conditions "



How to build a portable polarizer: the key element

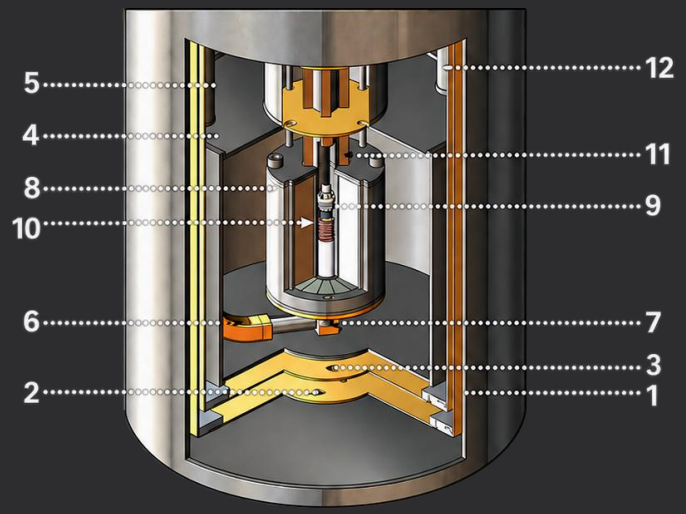


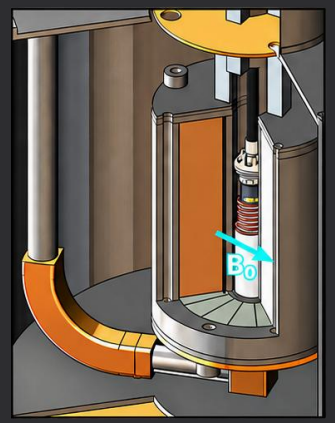


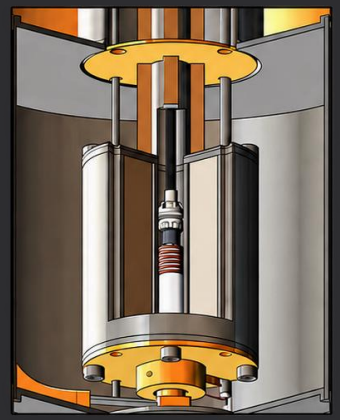
- Magnetic material SmCo (16 elements)
- OD 60 mm, ID 15 mm
- Field close to 1 T
- **Homogeneity 200 ppm → 0.5 MHz of Electron Spin Resonance dispersion**

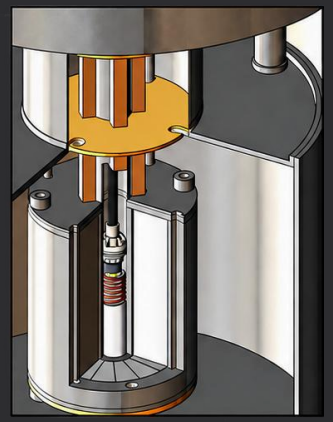
Adapted from A. Capozzi, SciRep, 2026

How to build a portable polarizer: the design









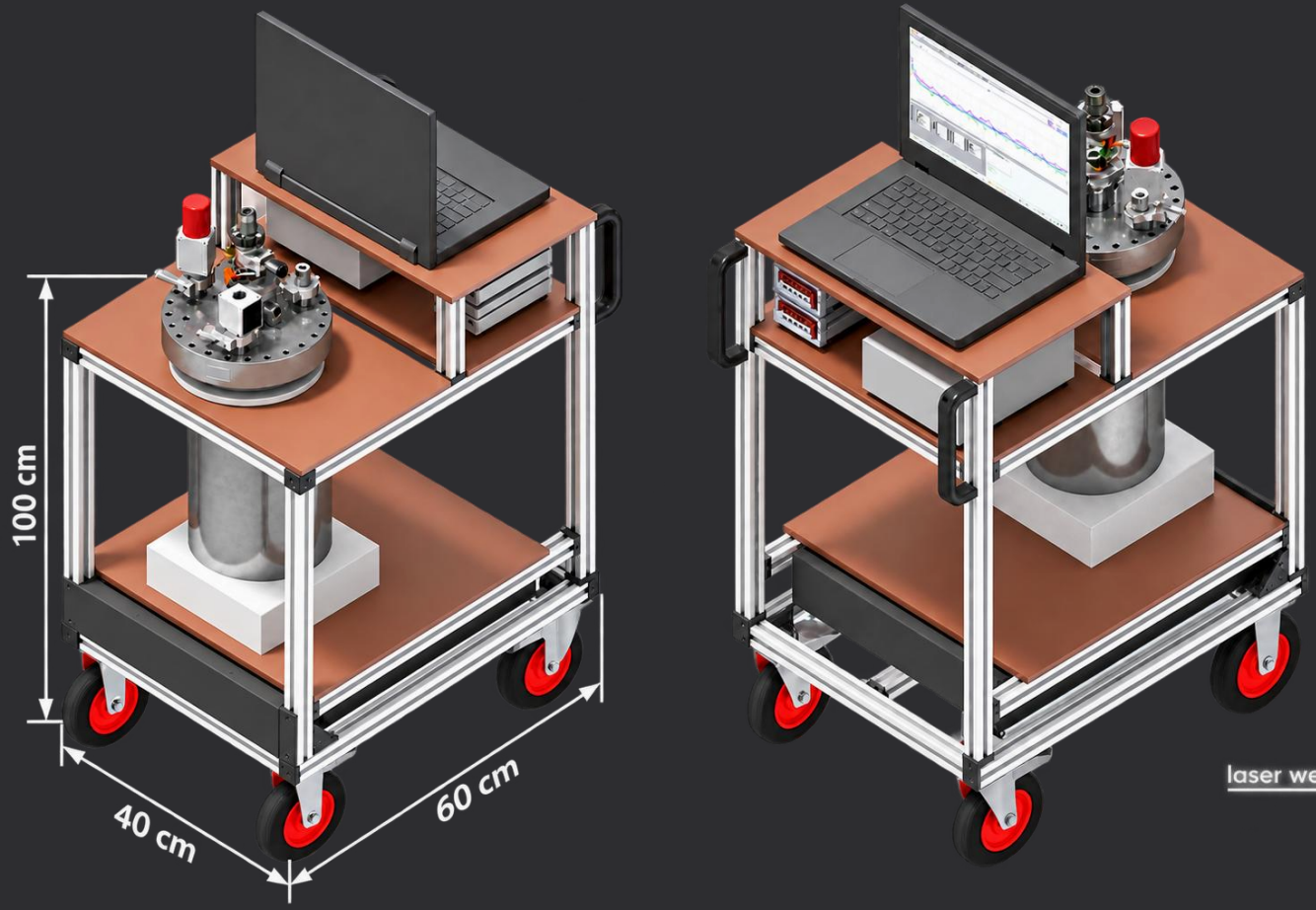
Main elements:

- Microwave irradiation from the bottom (6,7,8)
- Sample space 1 cm^3 (9)
- Filling with sample present (12)

Cryogenics performances:

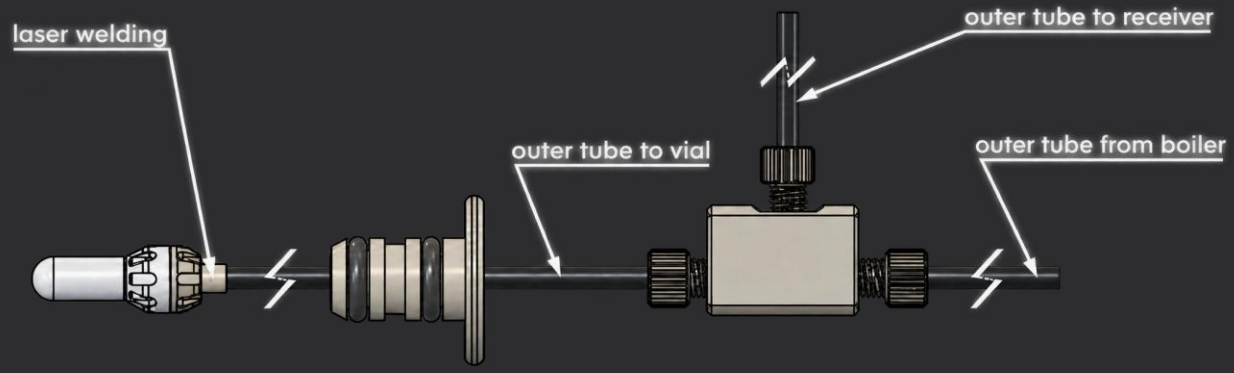
- Holding time at **liquid nitrogen** temperature up **48 h**
- Holding time at **liquid helium** temperature up **10 h**

How to build a portable polarizer: the result

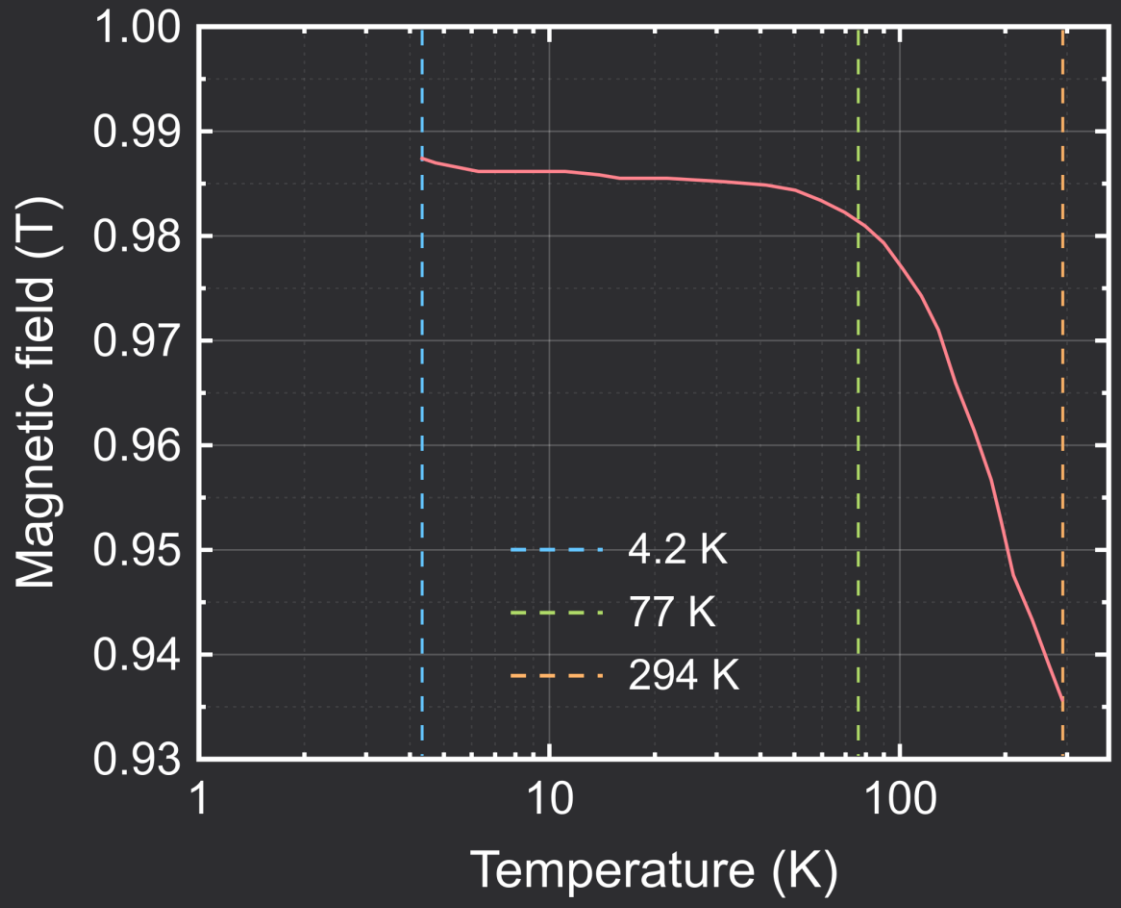


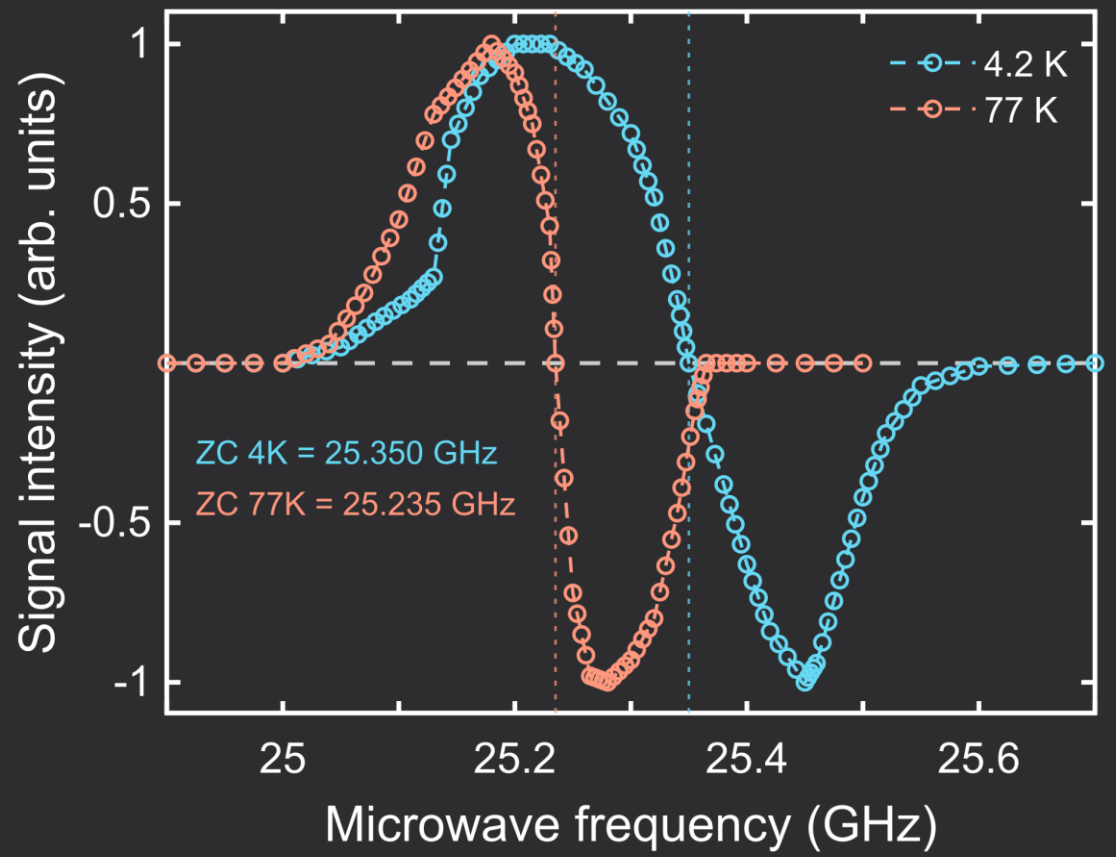
Main features:

- Total weight 40 kg
- Magnet safe
- Sample handling using Fluid path
- Sample size up to 300 uL



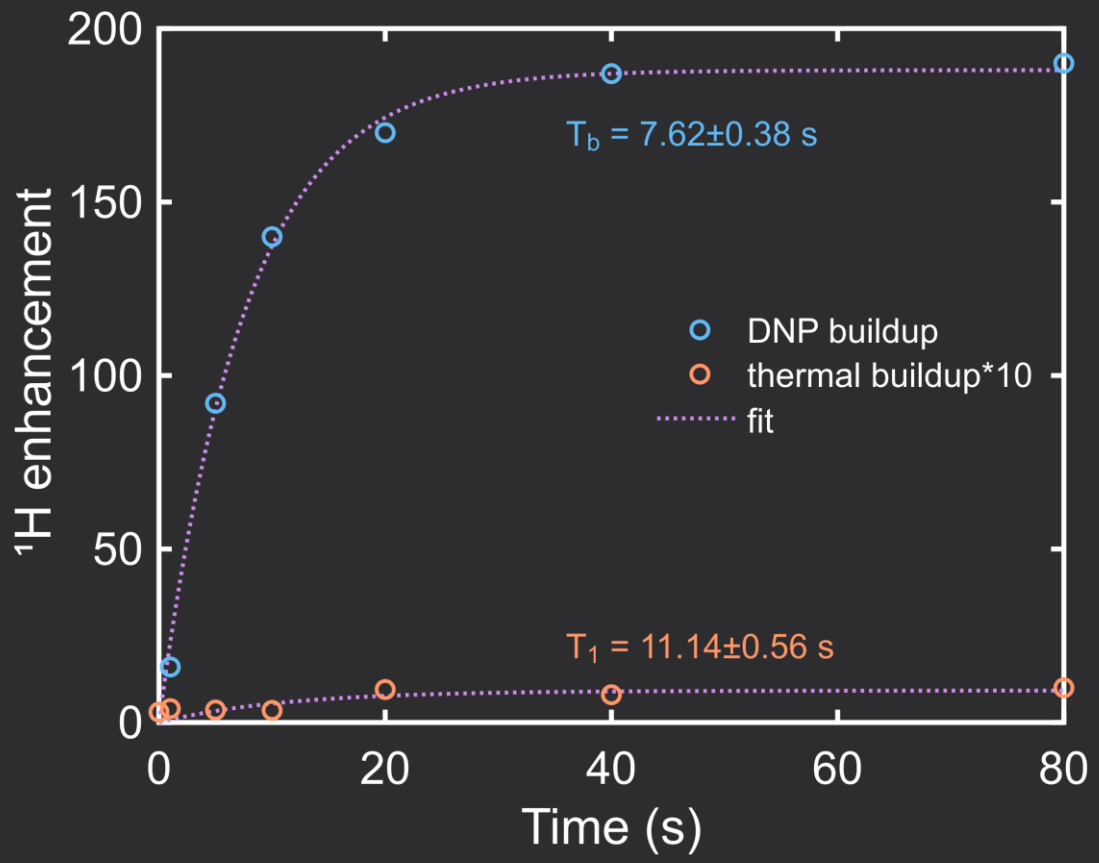
Polarizer performance: from nitrogen to helium

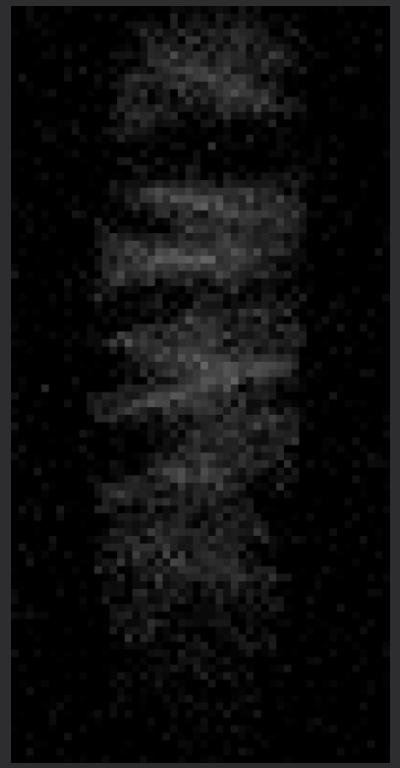




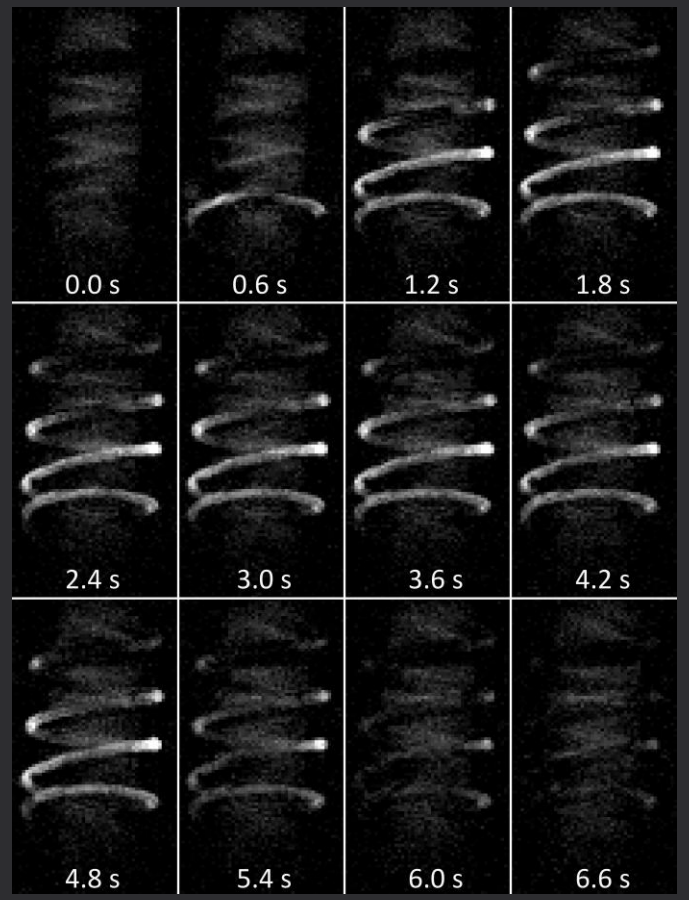
Polarizer performance: water polarization

4.2 K, 25 mM TEMPOL





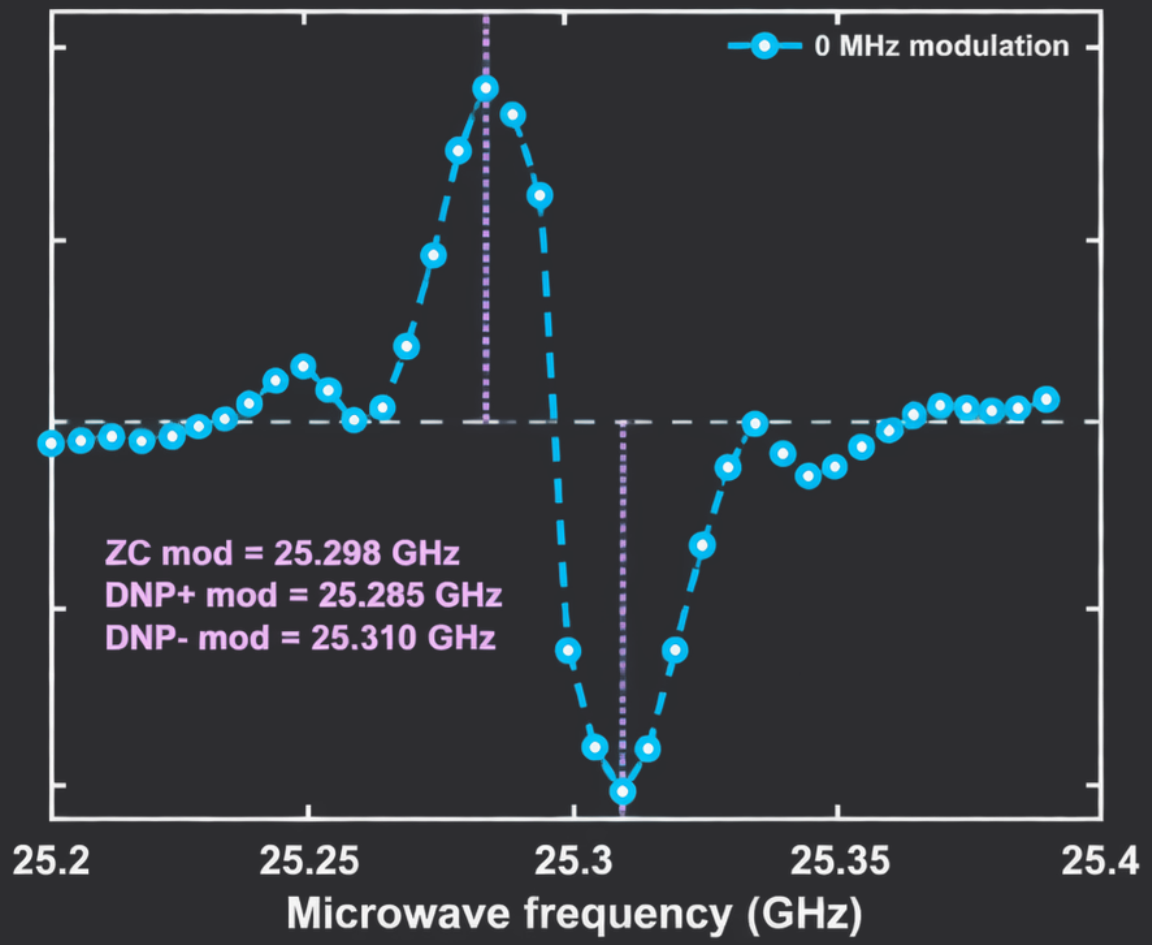
80 mM water polarized at 5%

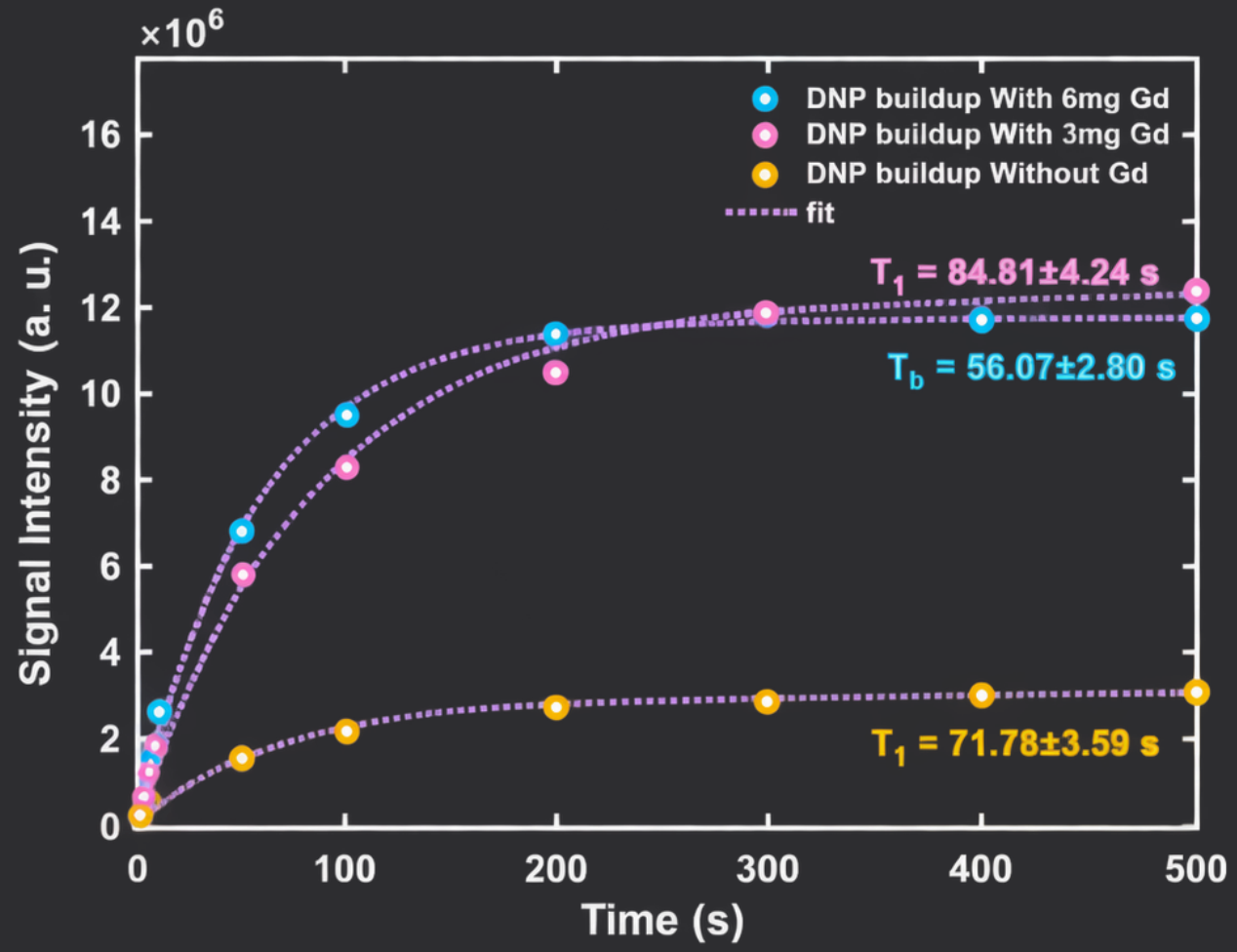


GRE sequence, FOV = 25 × 50 mm², resolution = 0.5 × 0.5 mm², FA = 5°, TE/TR = 2.0/6.0 ms, time per frame = 300 ms.

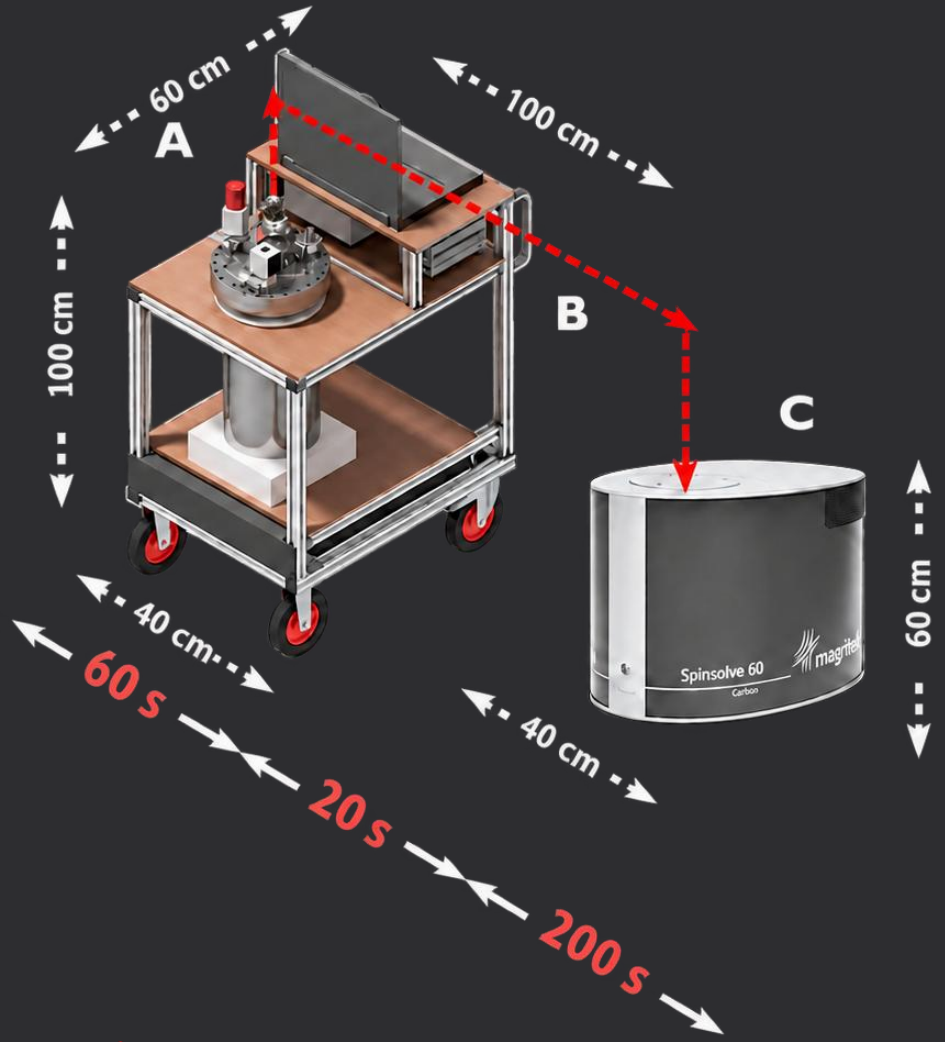
Polarizer performance: ^{13}C polarization

5 M[1-^{13}C, ^{15}N]urea + 20 mM OX063

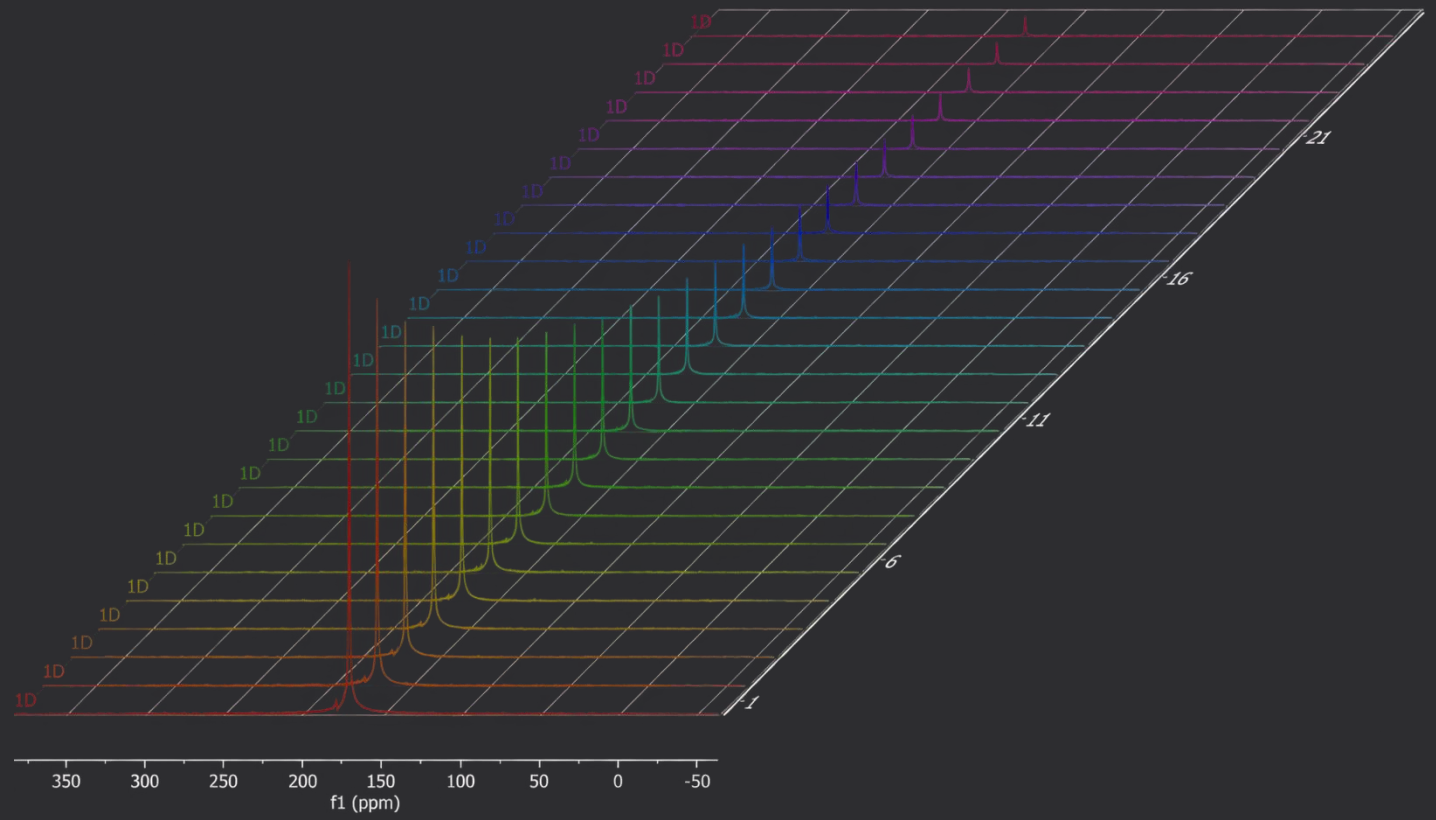




Polarizer performance: ^{13}C dissolution



[1-^{13}C]pyruvic acid + 20 mM OX063



Theoretical enhancement:

- At **4.2 K**: 15% polarization ($\boldsymbol{\varepsilon = 150k}$)

Measured enhancement:

- At **4.2 K**: 4.5% polarization ($\boldsymbol{\varepsilon = 50k}$)

POLARIZE

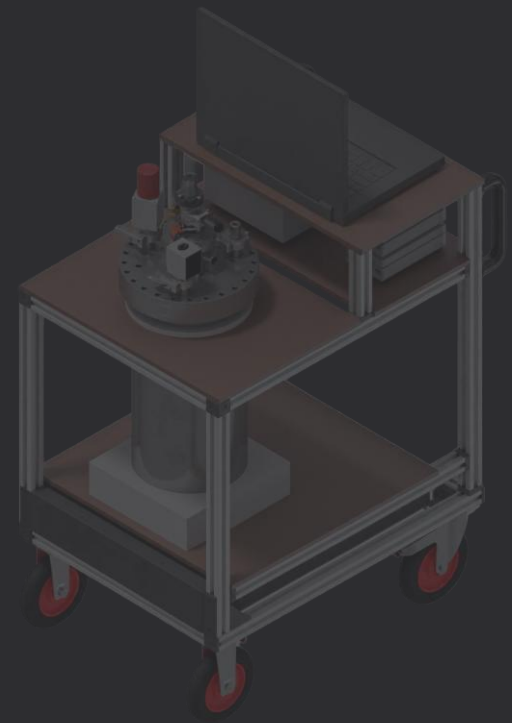
Can we increase the throughput?

...50% ^{13}C polarization is not always required...

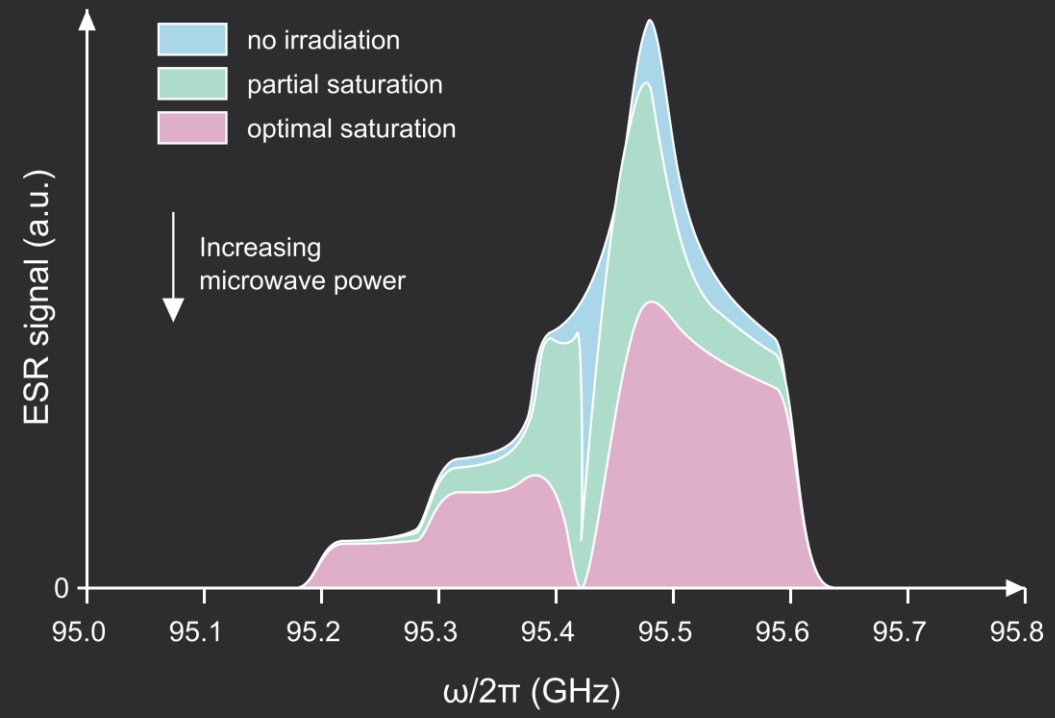
“take a traditional polarizer and dissolve beforehand”

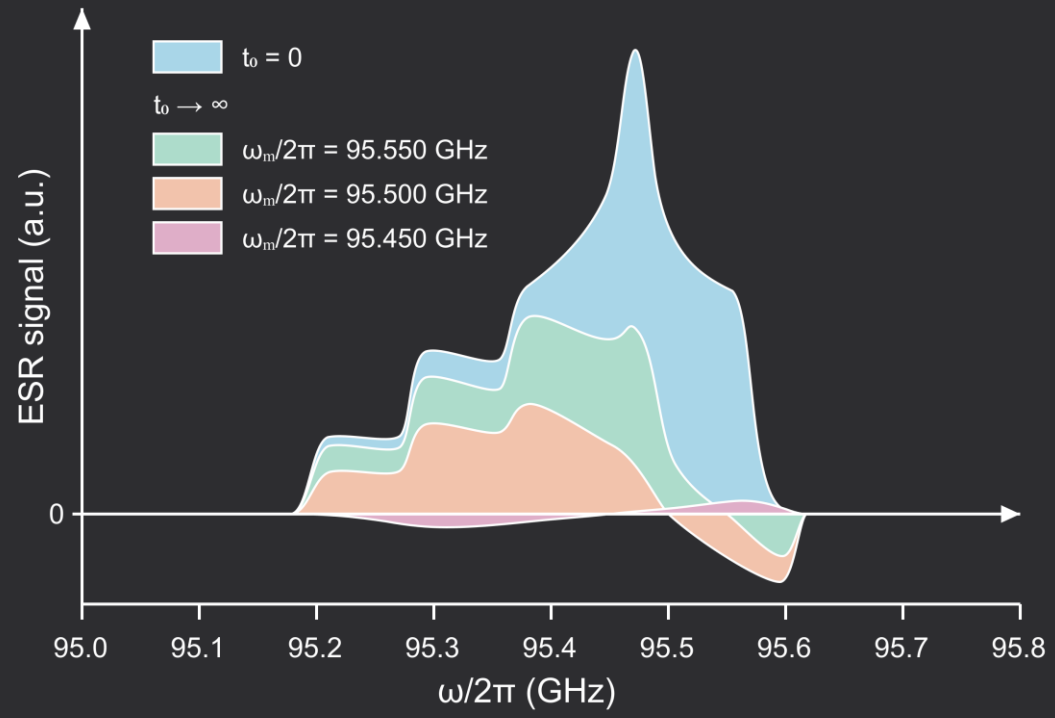


“relax the experimental conditions ”

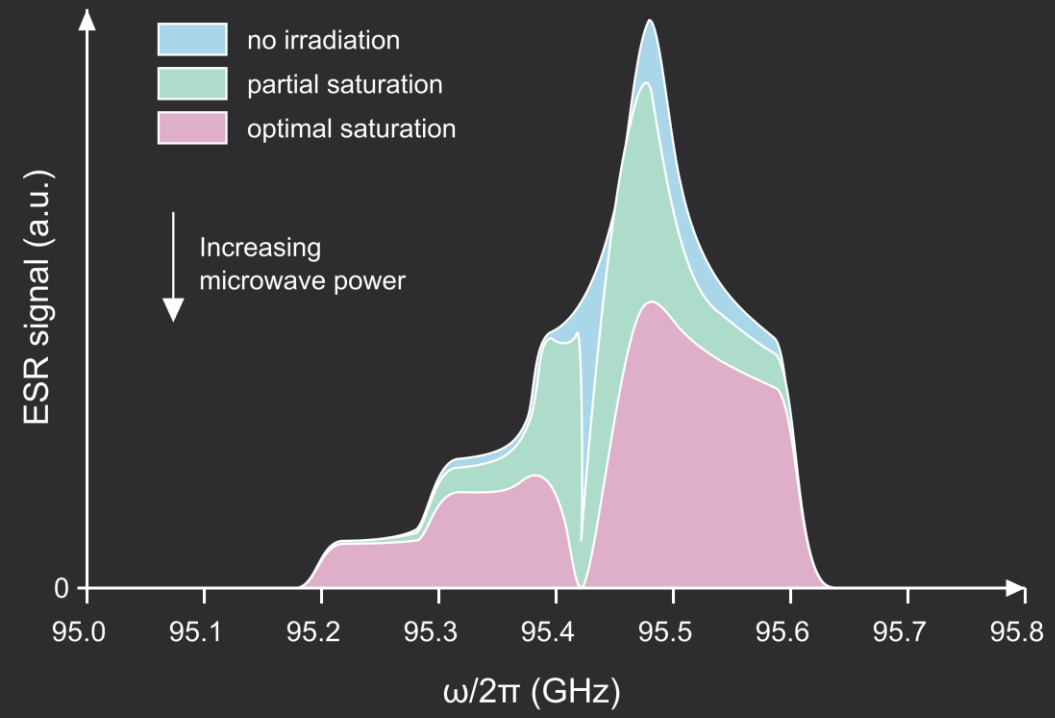


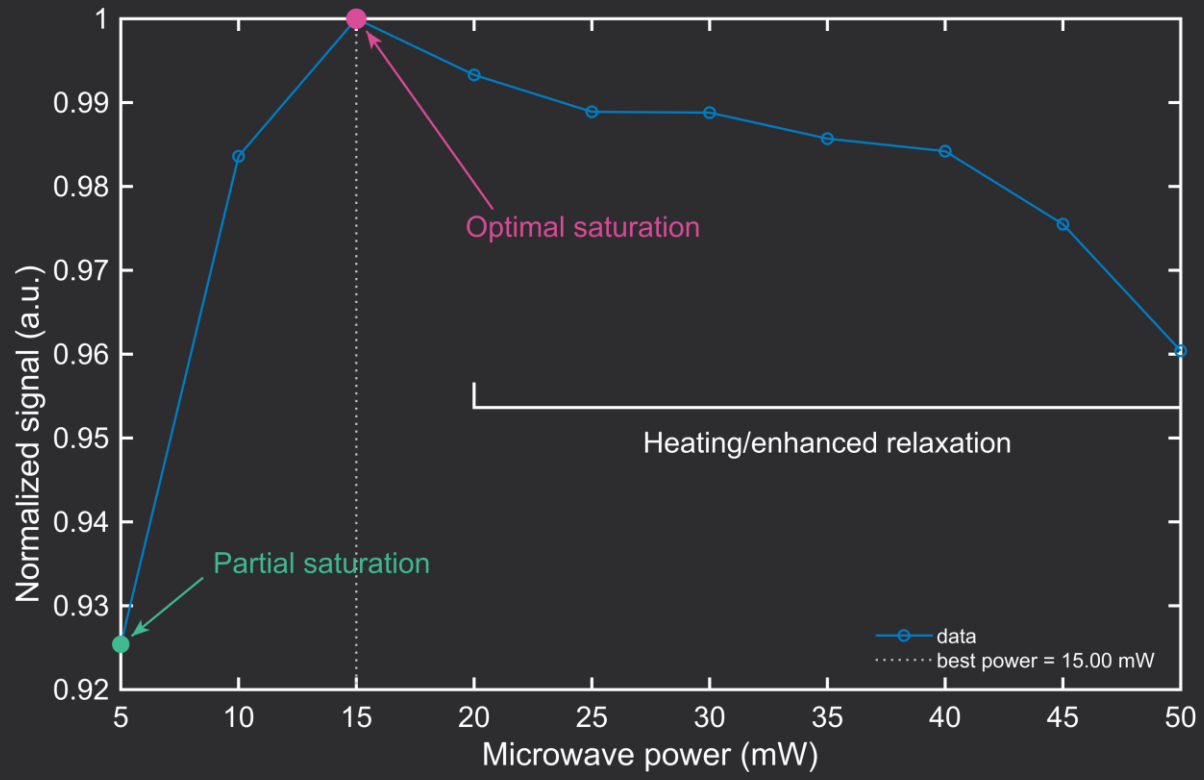
The buildup time constant is power- and frequency-dependent





The buildup time constant is power- and frequency-dependent

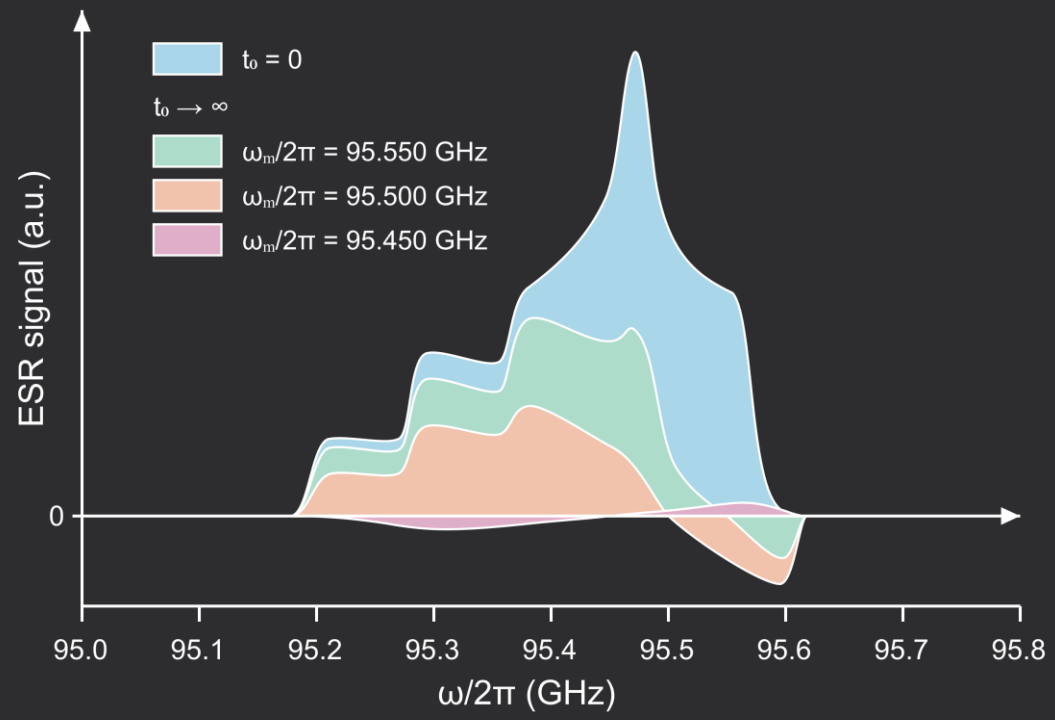




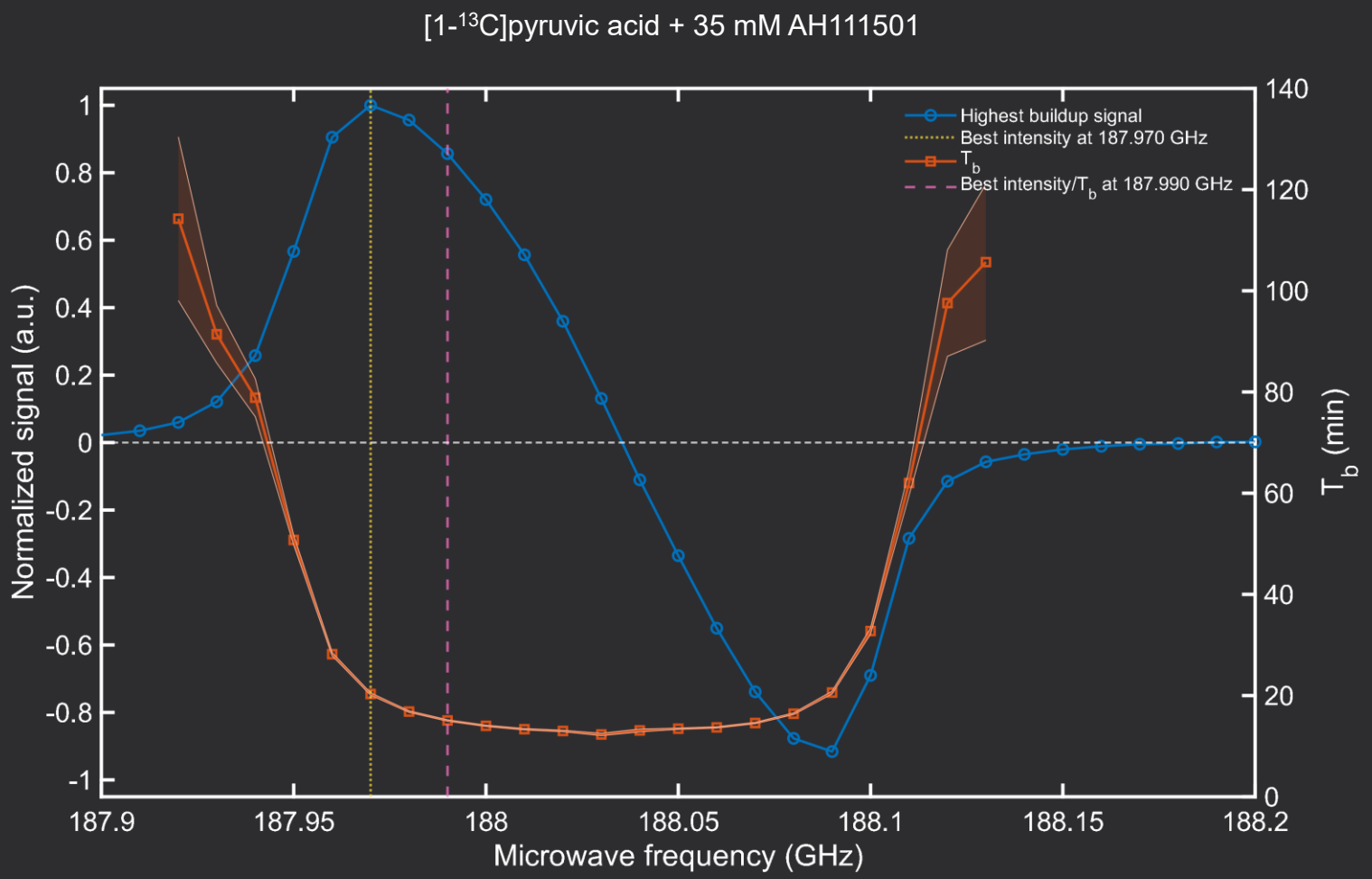
The buildup time constant is power- and frequency-dependent

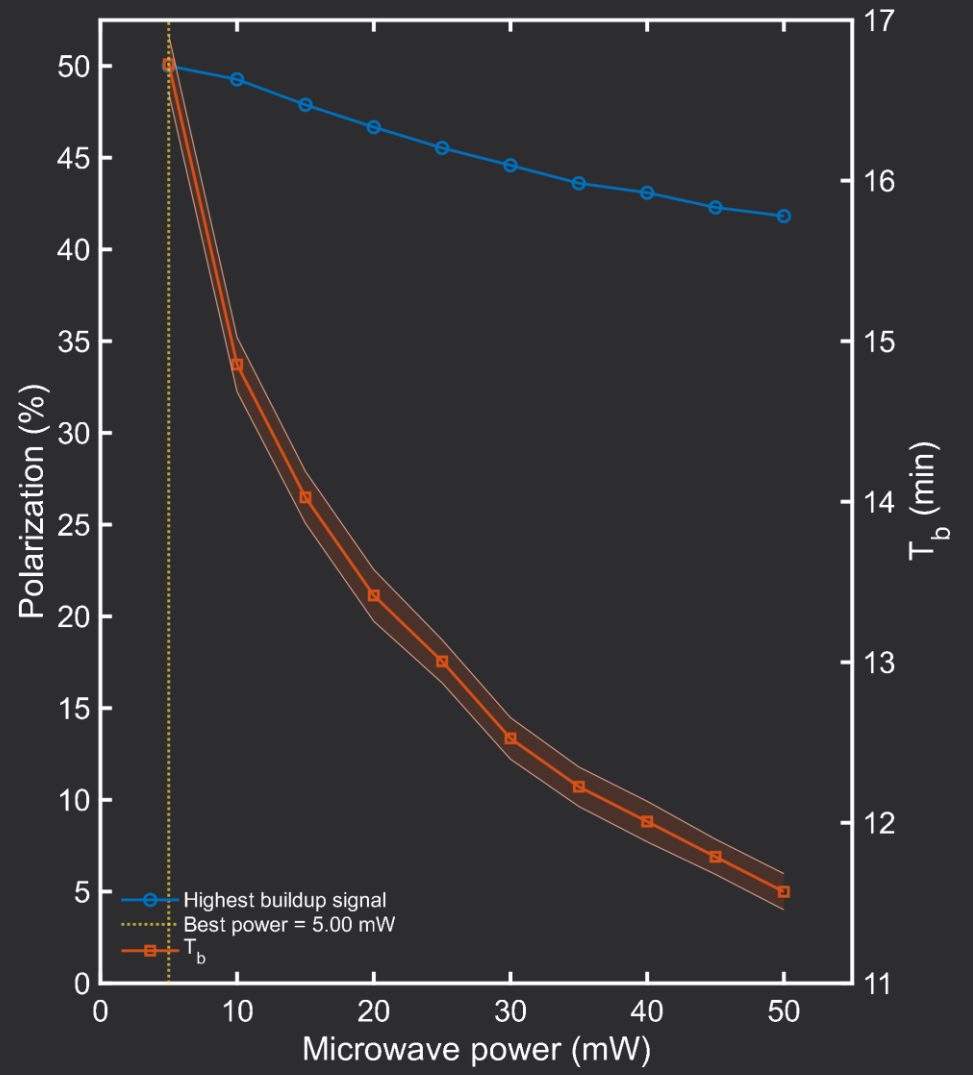
Towards the center of gravity $\omega_0 = \int \omega \cdot g(\omega) d\omega$

- microwave absorption is high (faster buildup)
- polarization transfer is smaller



Perform a full characterization of the sample

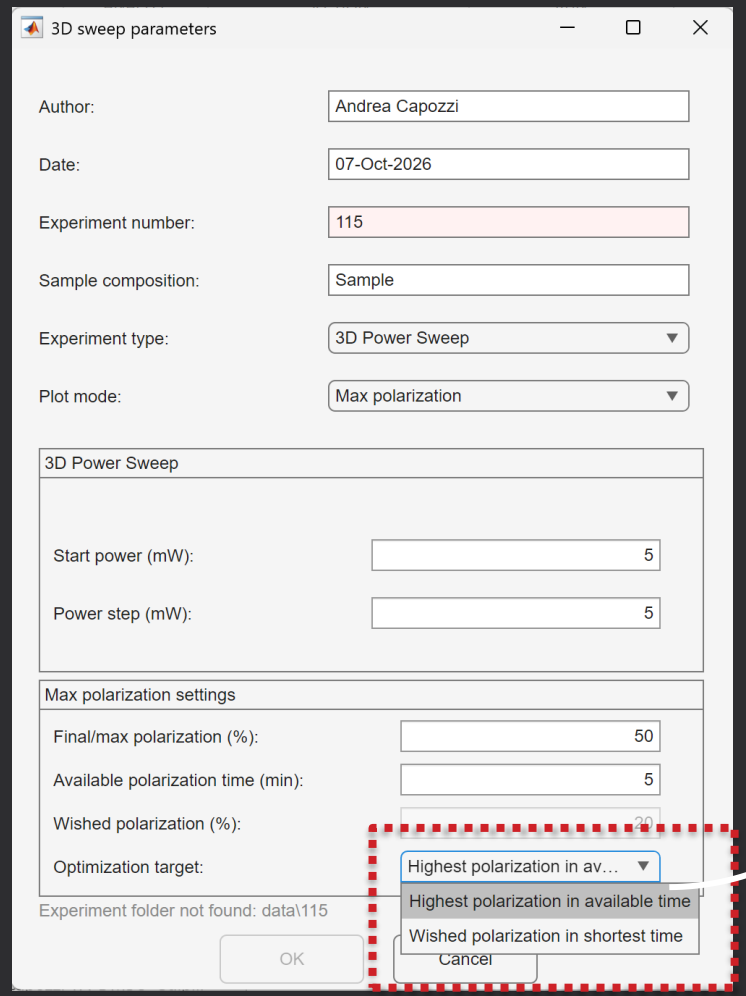




SA15 Heidelberg

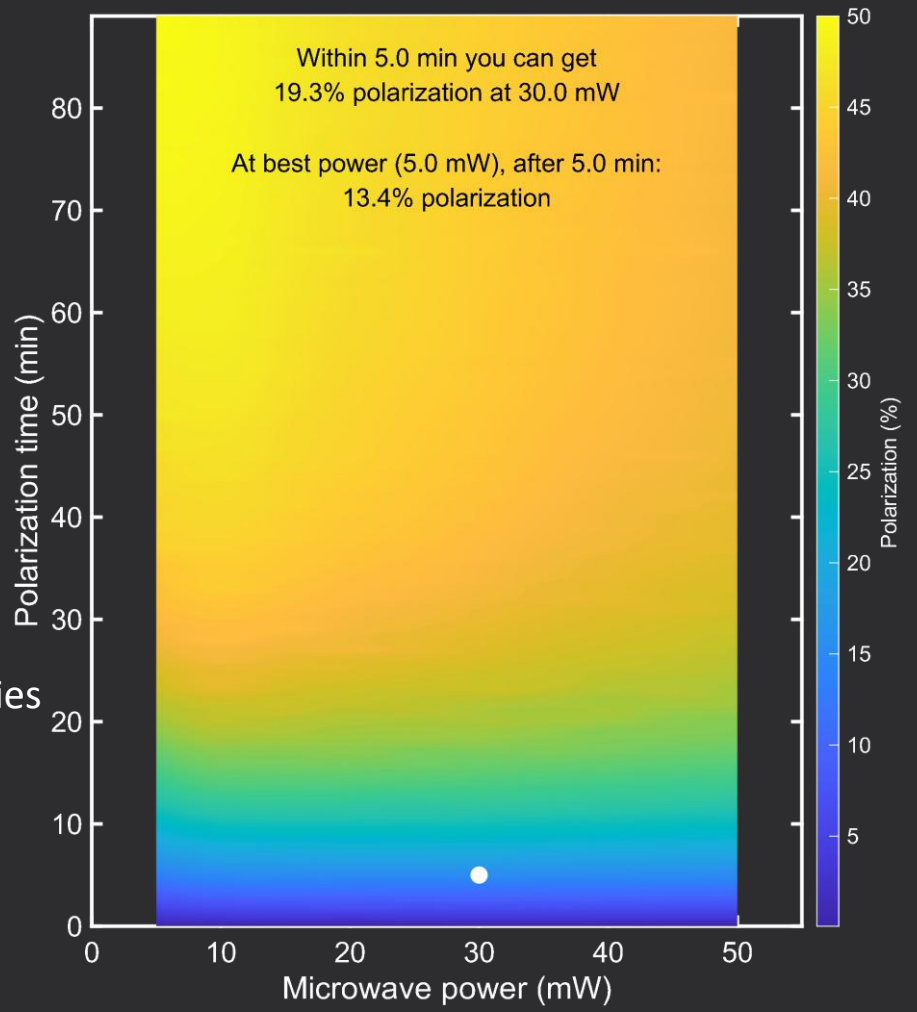
Interpolation of frequency and power data

MATLAB Toolbox extension

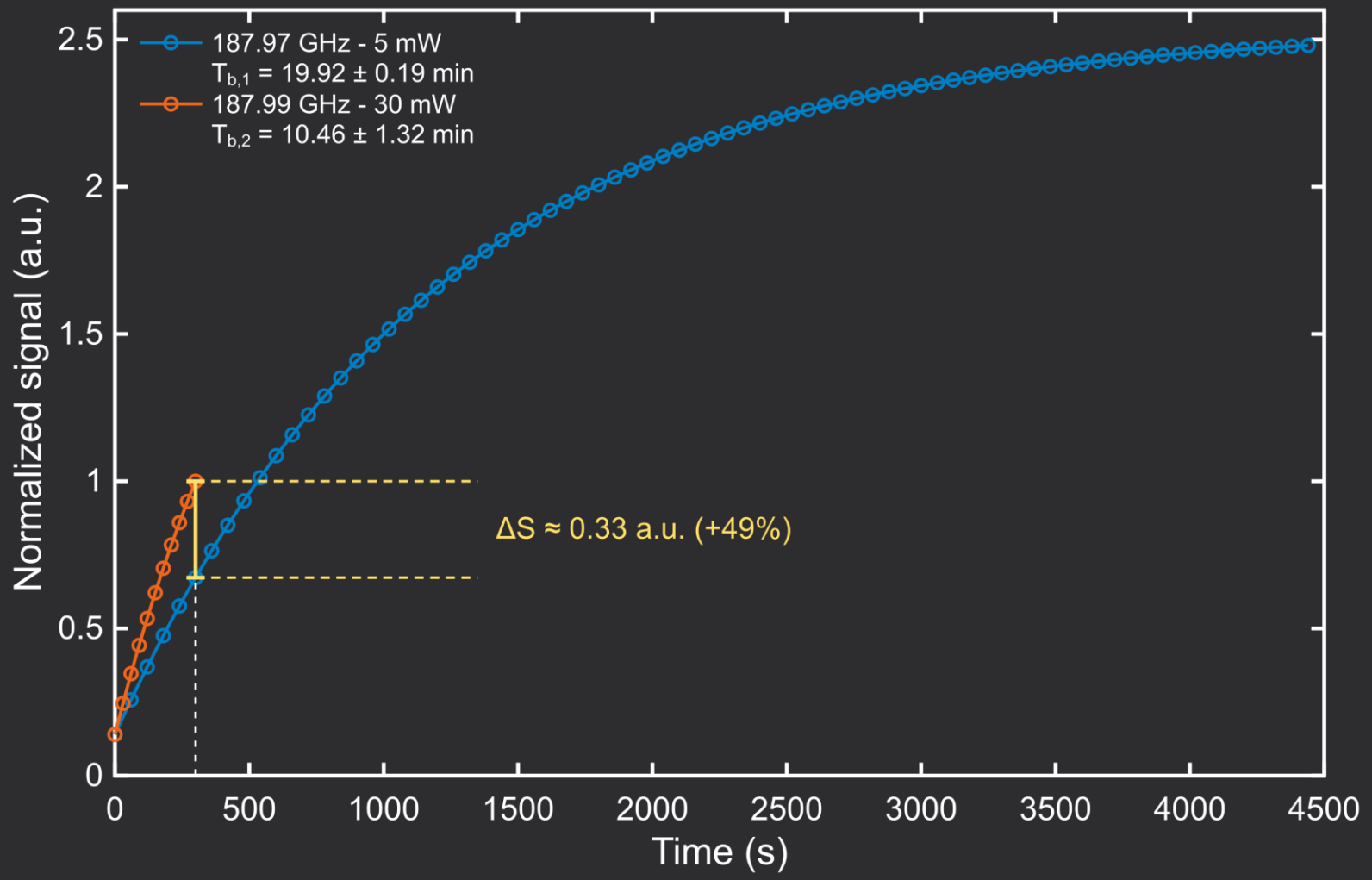


Two working modalities

Sample “heatmap”

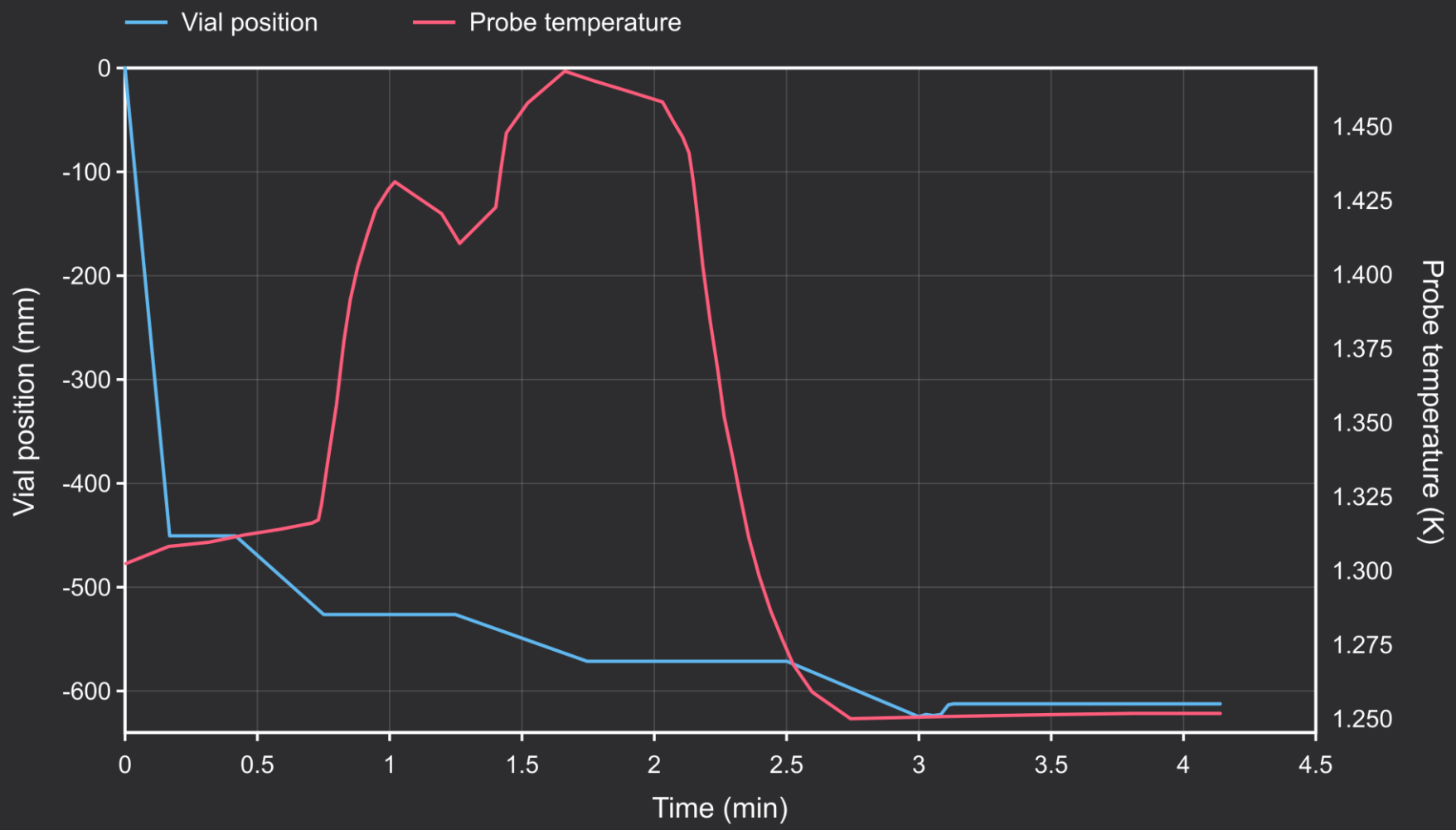


Fast buildup vs best buildup



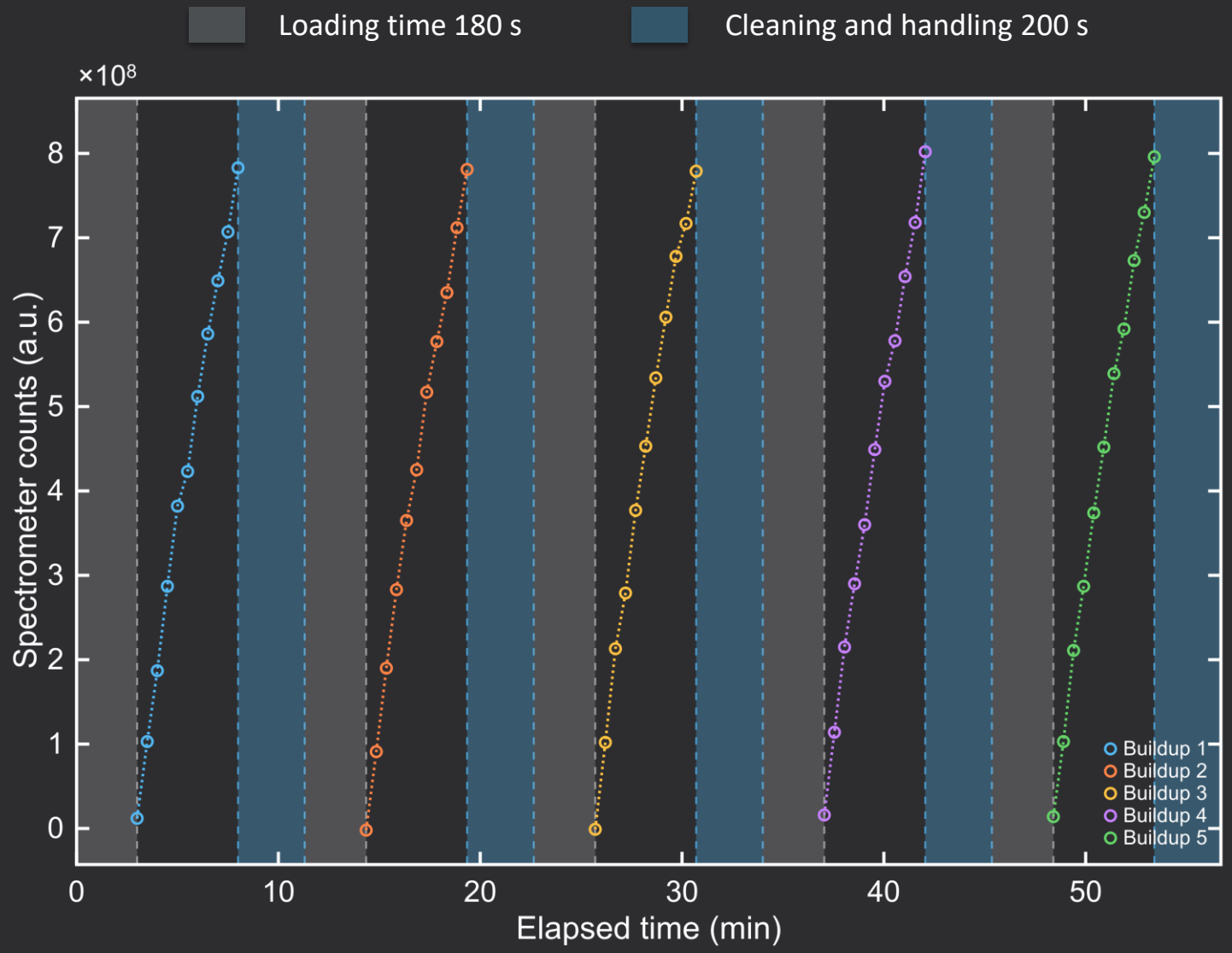
SA15 Heidelberg

Optimization of the sample loading profile



Five samples per hour polarized above 15%

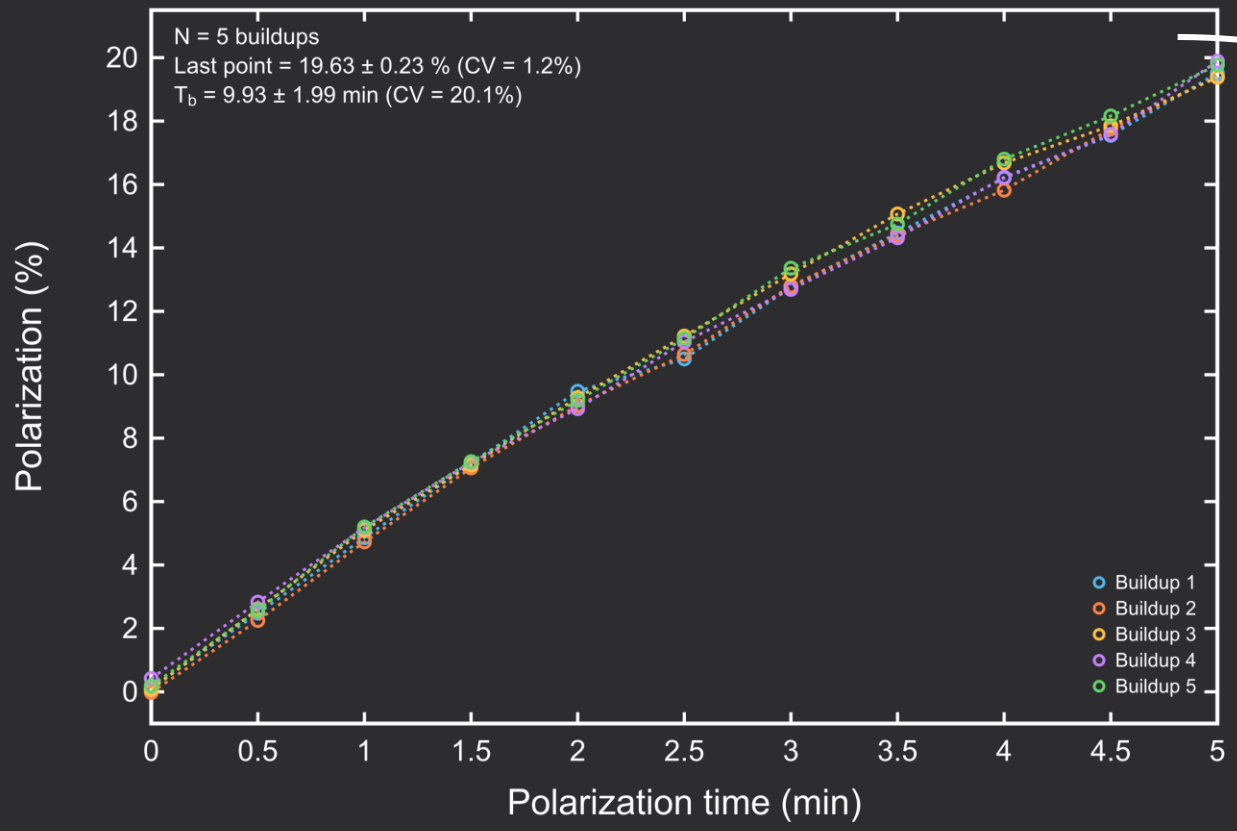
SA15 Heidelberg

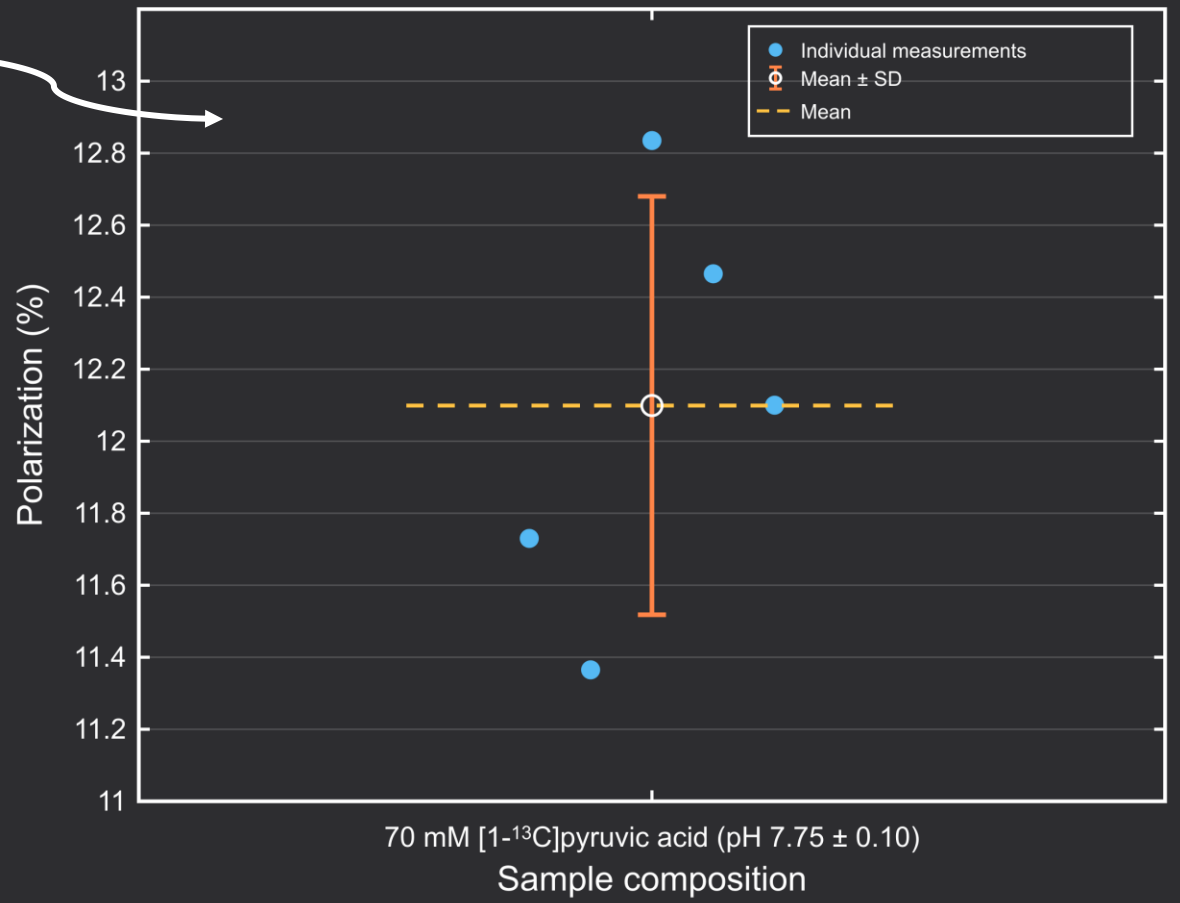


Five samples per hour polarized above 15%

SA15 Heidelberg

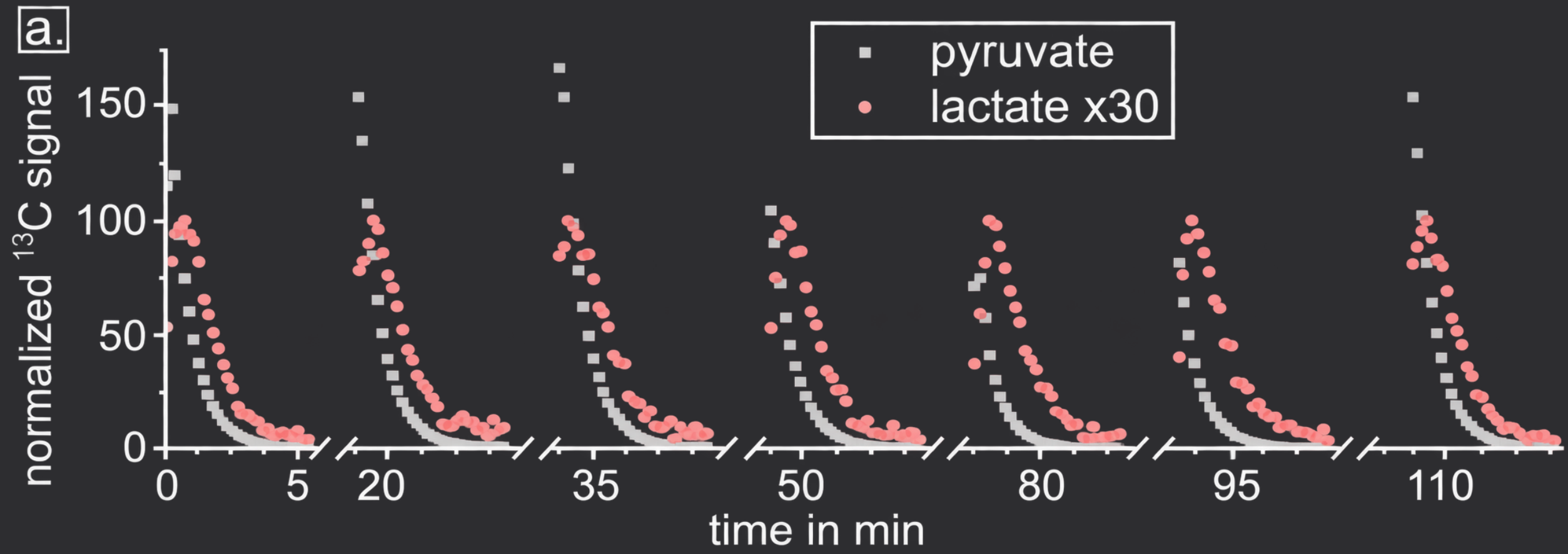
30 s transfer





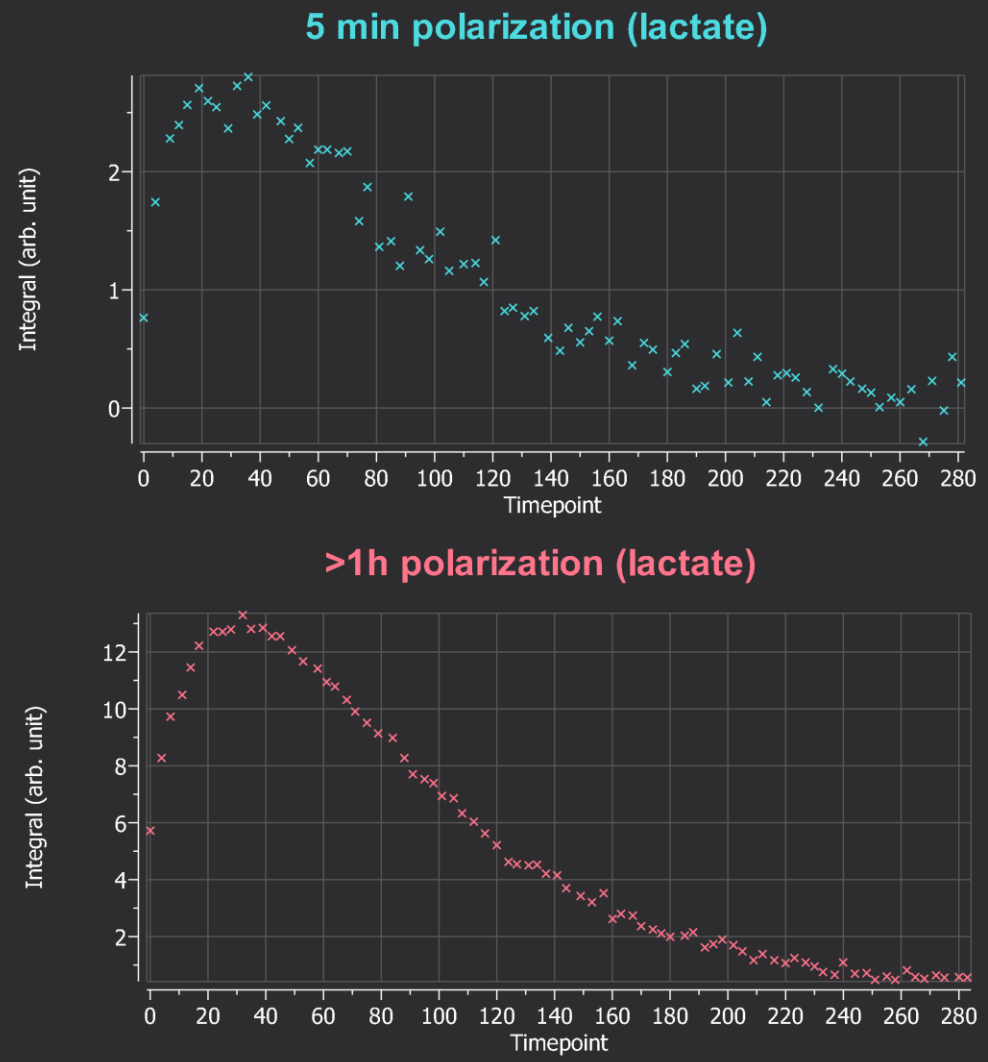
High throughput cells experiment (7.5 M in bioreactor)

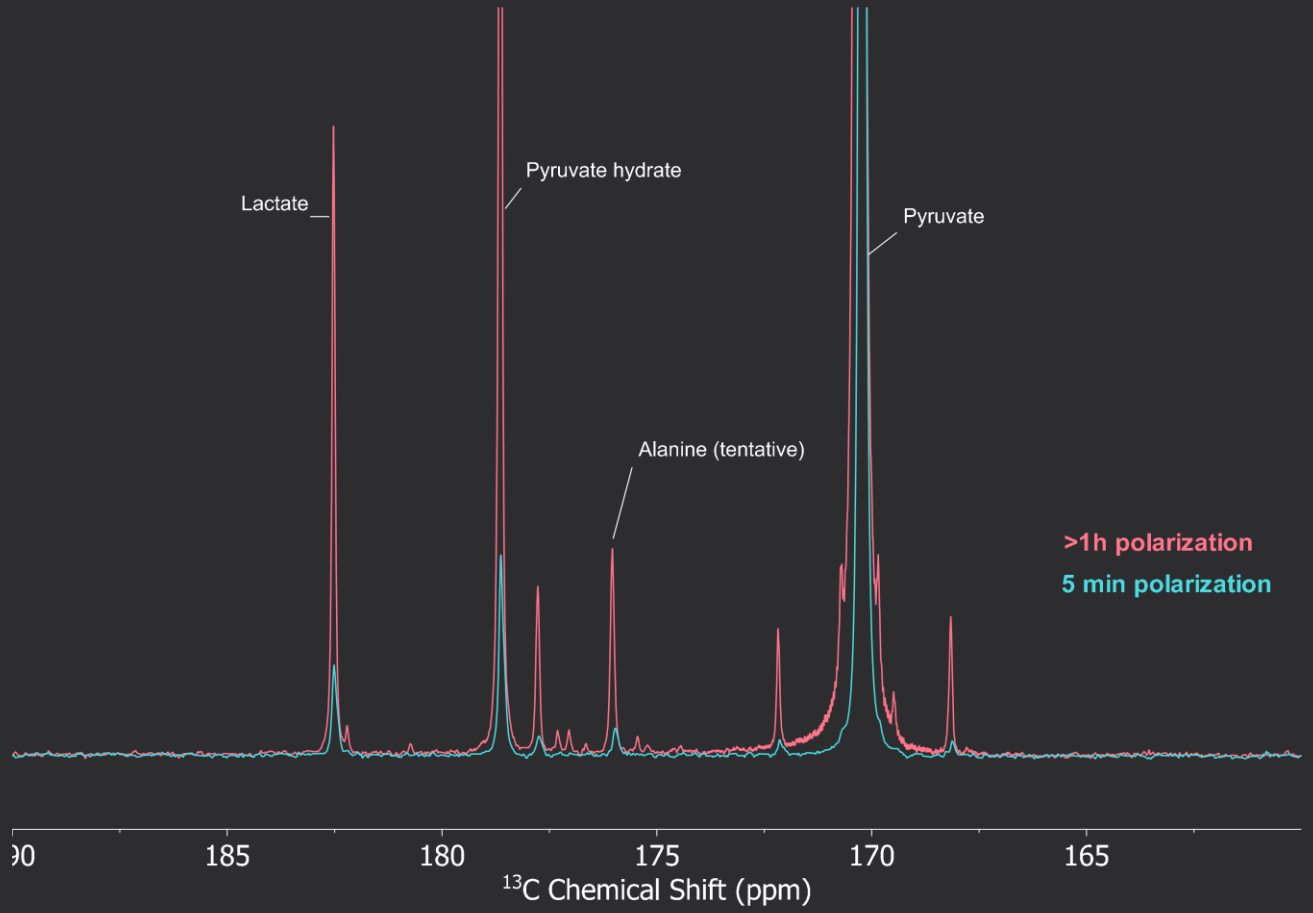
SA15 Heidelberg



High throughput cells experiment

SA26 Aarhus





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Research for a Life without Cancer

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Dr Helen Abeln

EPFL



Dr Jean-Noël Hyacinthe



Dr Sotirios Katsikis

Thanks for your attention!



AARHUS UNIVERSITY

Duy Anh Dang
Dr Nichlas Vous Christensen
Dr Esben Hansen
Prof. Lotte Bonde Bertelsen

Philipp Groß
Dr Andreas Schmidt

POLARIZE