

Pulsed NMR in Target Material Research



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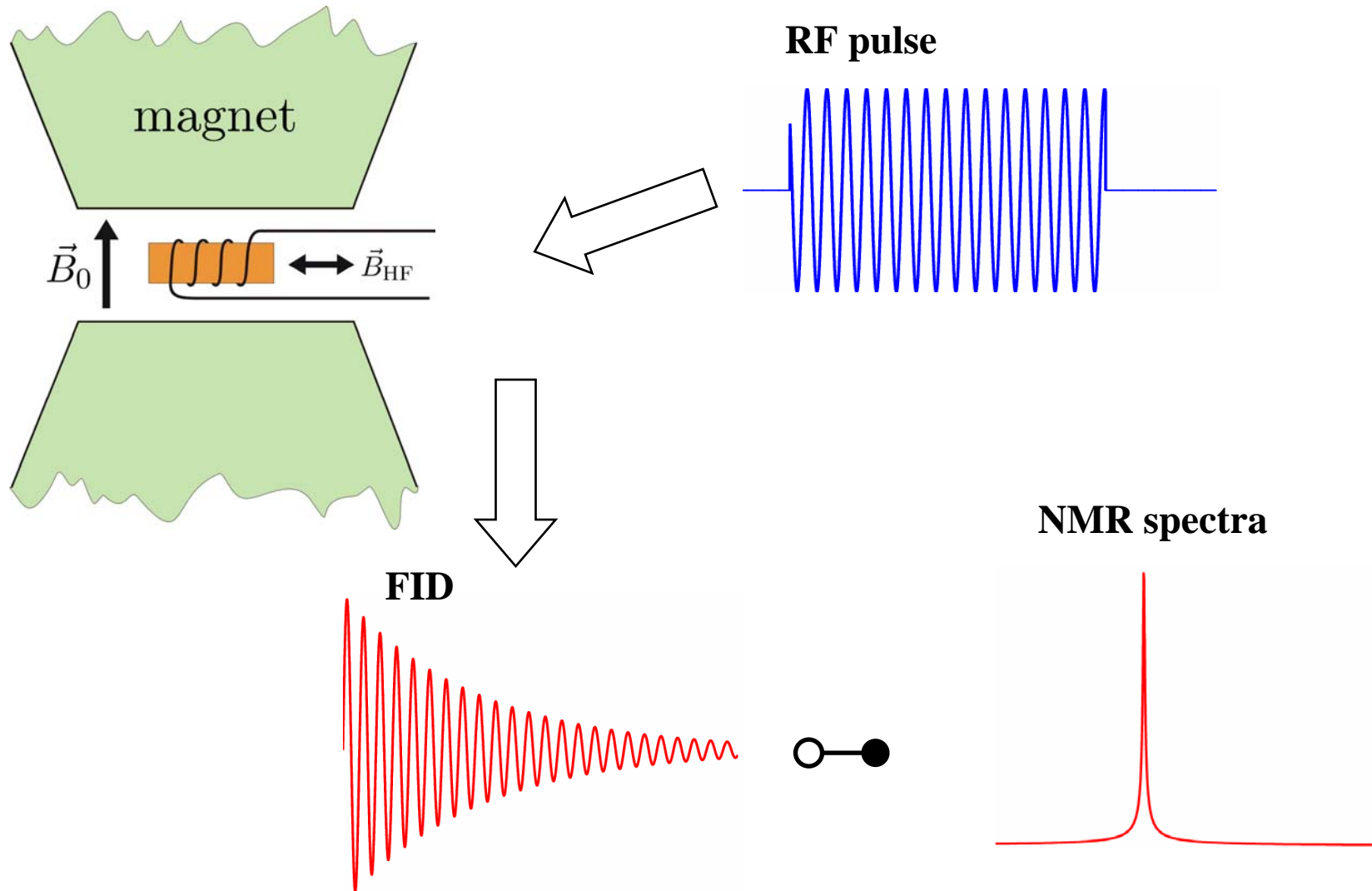
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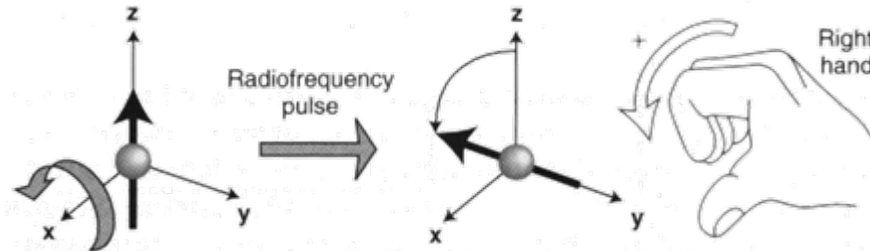
Outline of the Talk

- Principle of Pulsed NMR
- Excitation Spectra
- Experimental Setup
- Complex Fourier Transform
- NMR Measurements with ^6LiD
- Phase Transition in Frozen Butanol
- Summary and Outlook

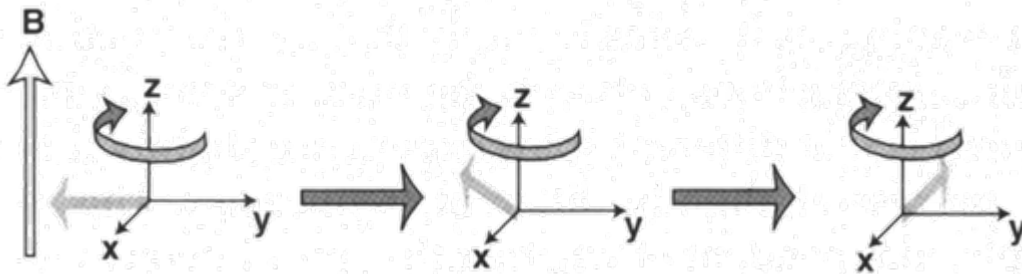
Principle of Pulsed NMR



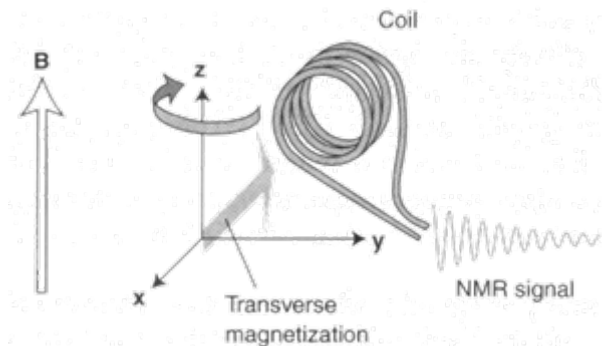
Principle of Pulsed NMR



By applying an rf pulse, every single spin is tipped out of the B_0 direction.
This causes a net transverse magnetization.



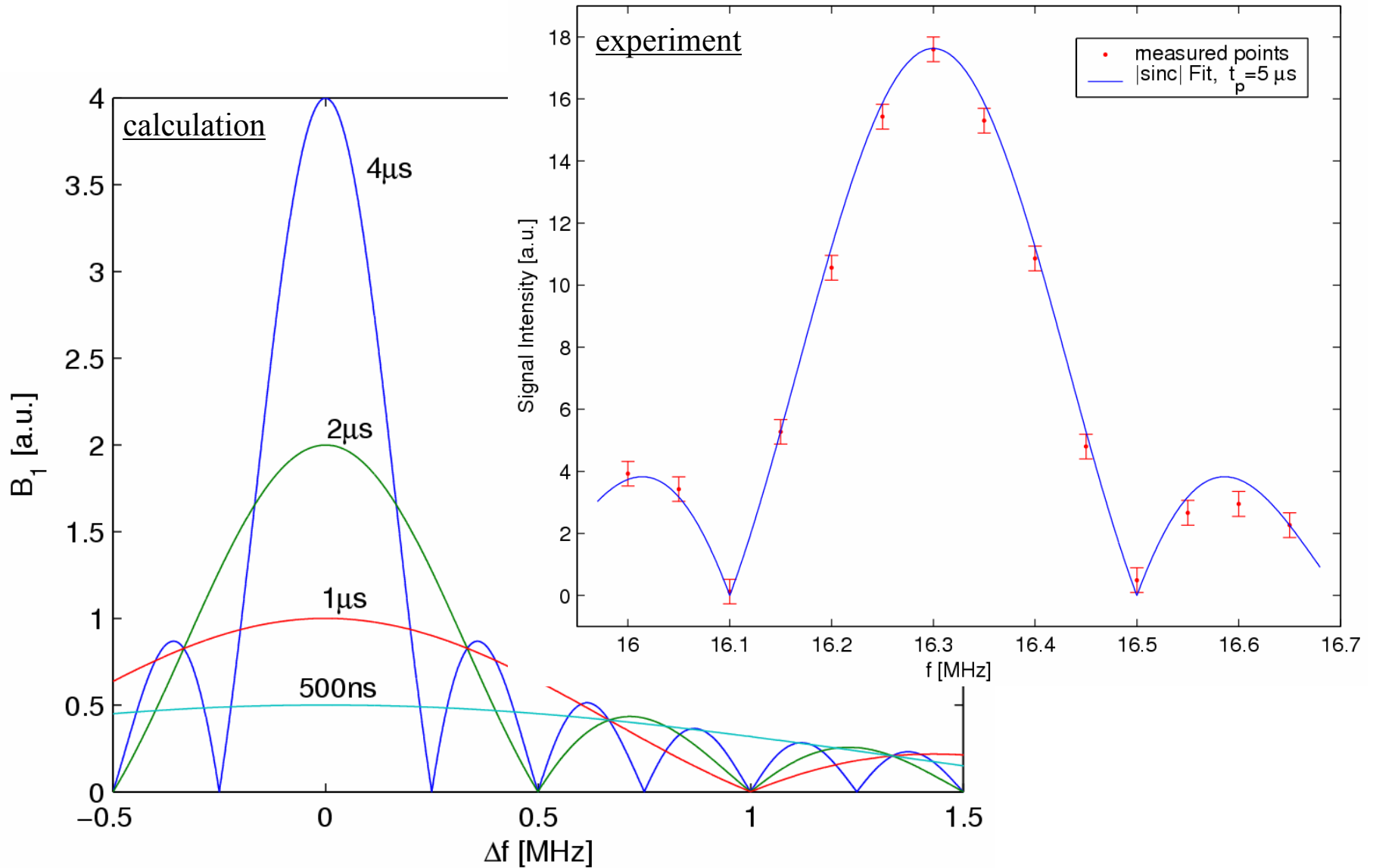
Because every single spin starts its precession motion, the transverse magnetization also precesses around the magnetic field.



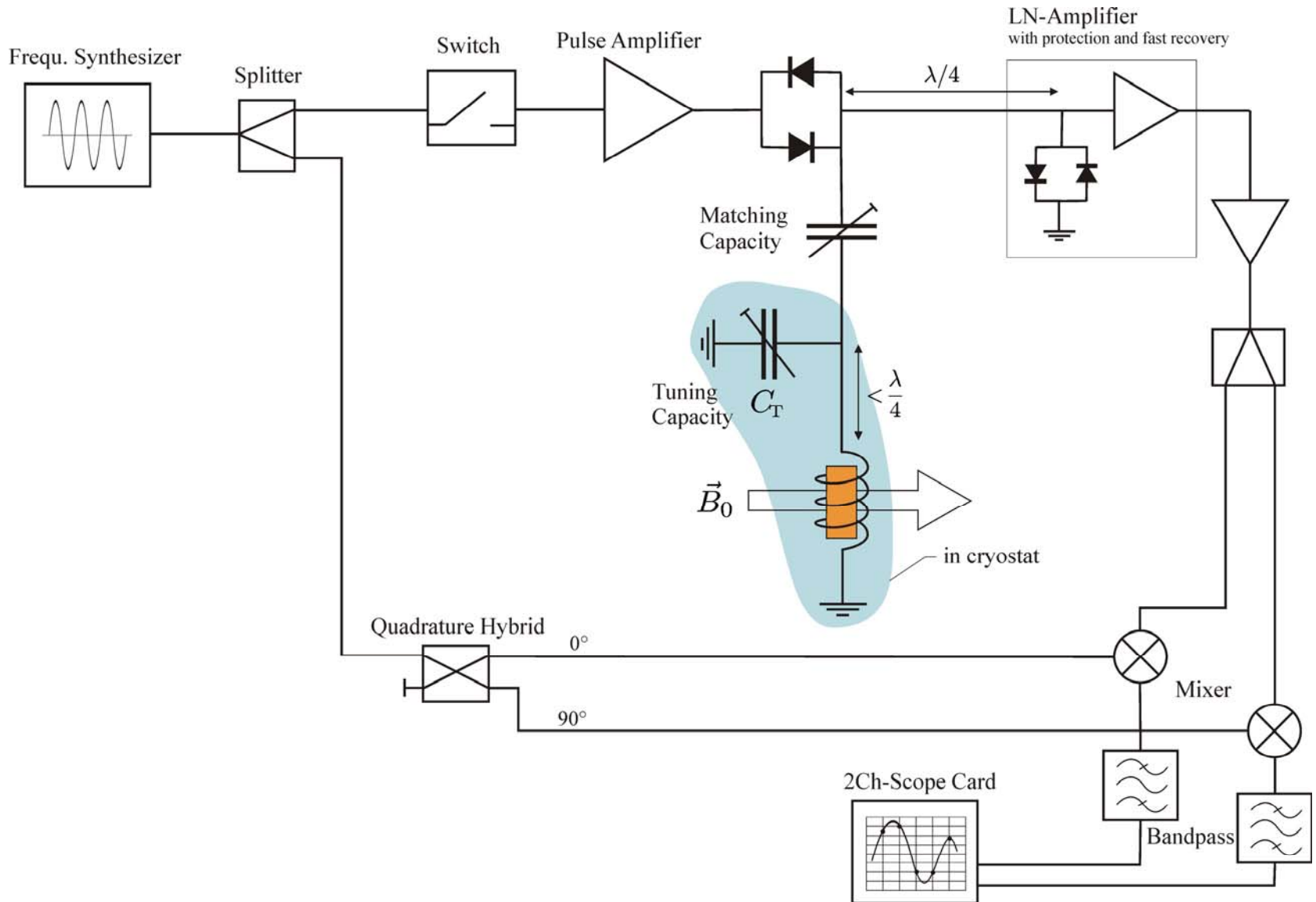
The rotating magnetic moment induces an oscillating signal in the receiver coil.

→ **free inductance decay (FID)**

Distribution of the Excitation



NMR Setup – Block Diagram



^4He Refrigerator

Liquid Helium
Supply

μw -Waveguide

He-Pumping
Flanges

Screen
Heat Sink

Separator

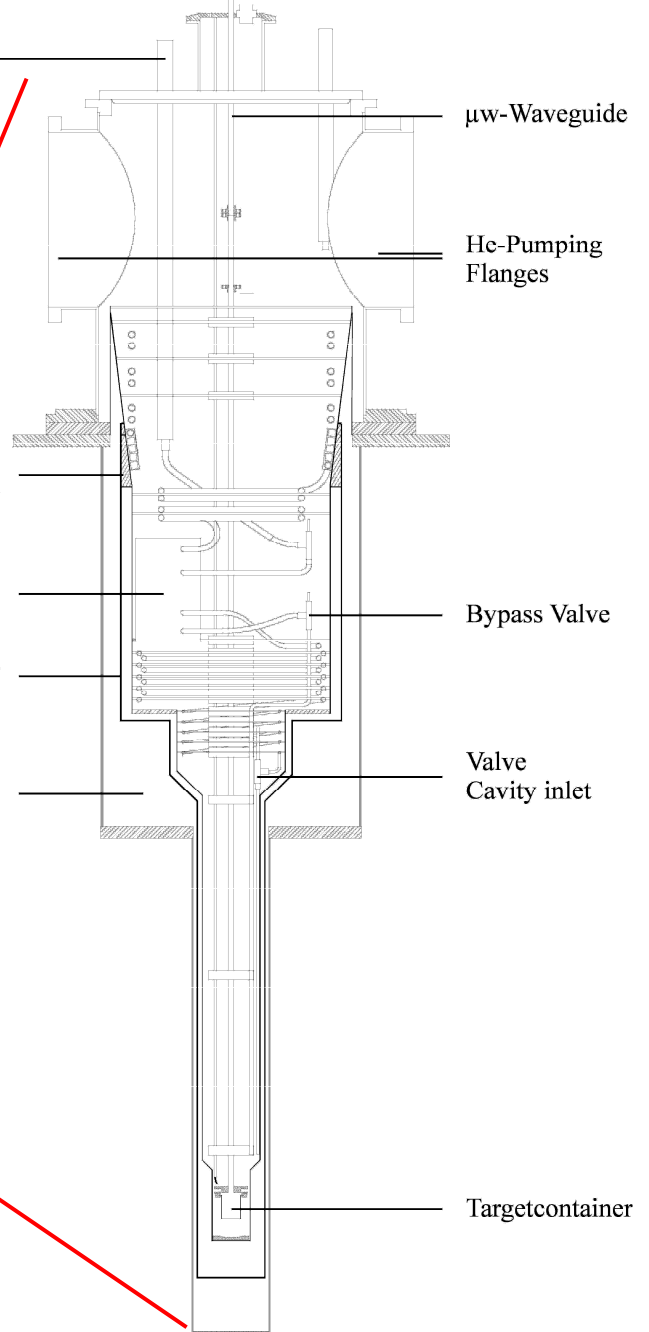
Radiation
Screen

Insulation
Vacuum

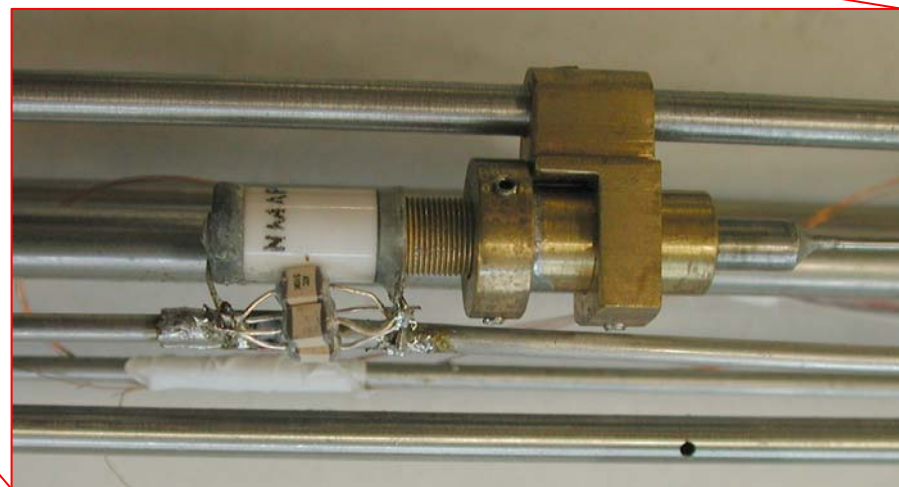
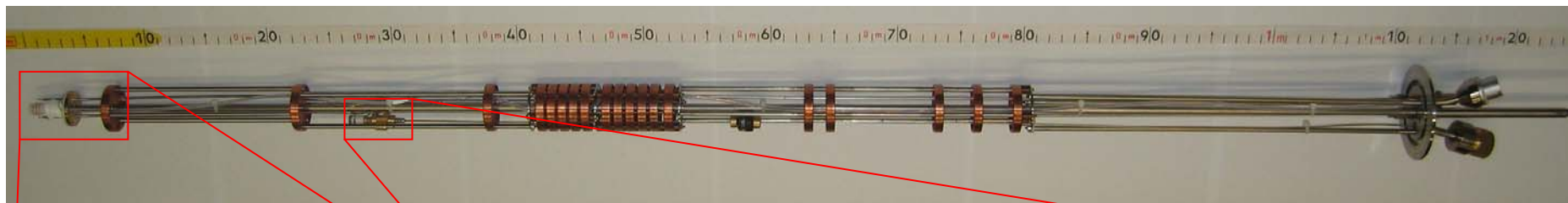
Bypass Valve

Valve
Cavity inlet

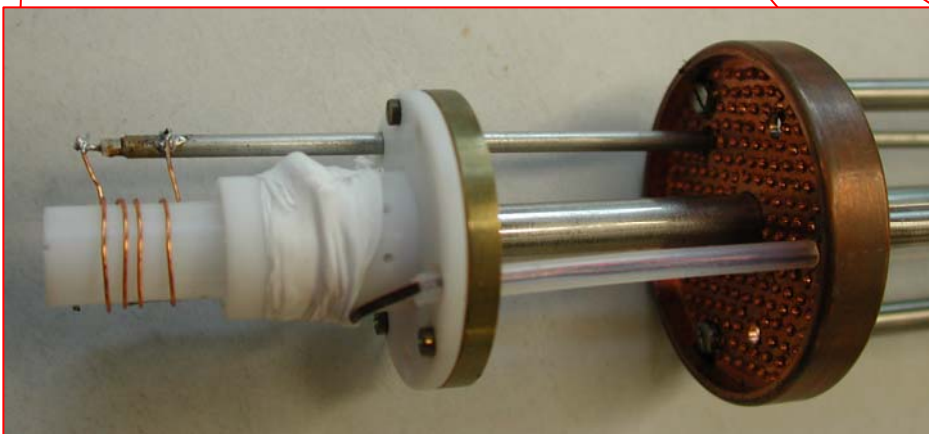
Targetcontainer



Cryostat Insert for Pulsed NMR

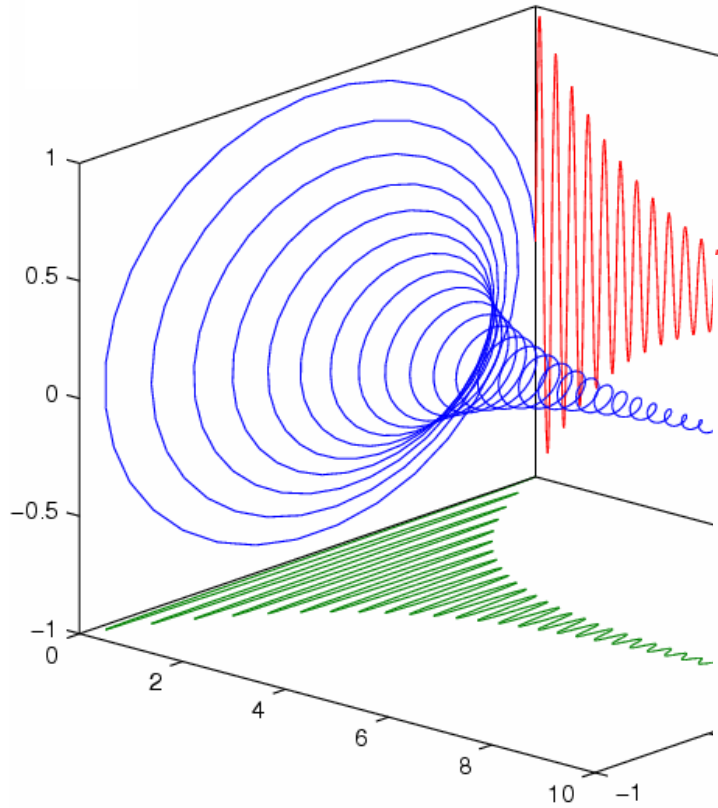


Tuning capacity:
Trimmer plus fix capacities

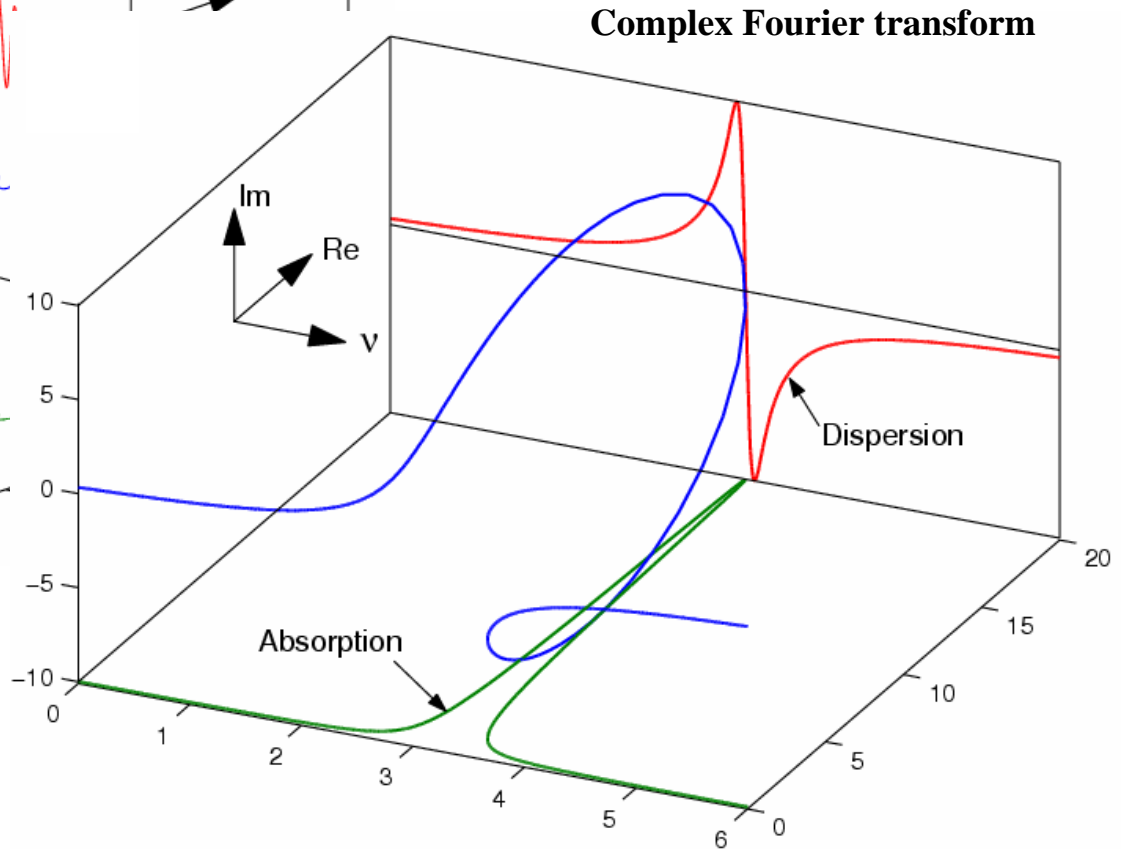


Sample in PTFE container
with NMR coil

Complex Fourier Transform

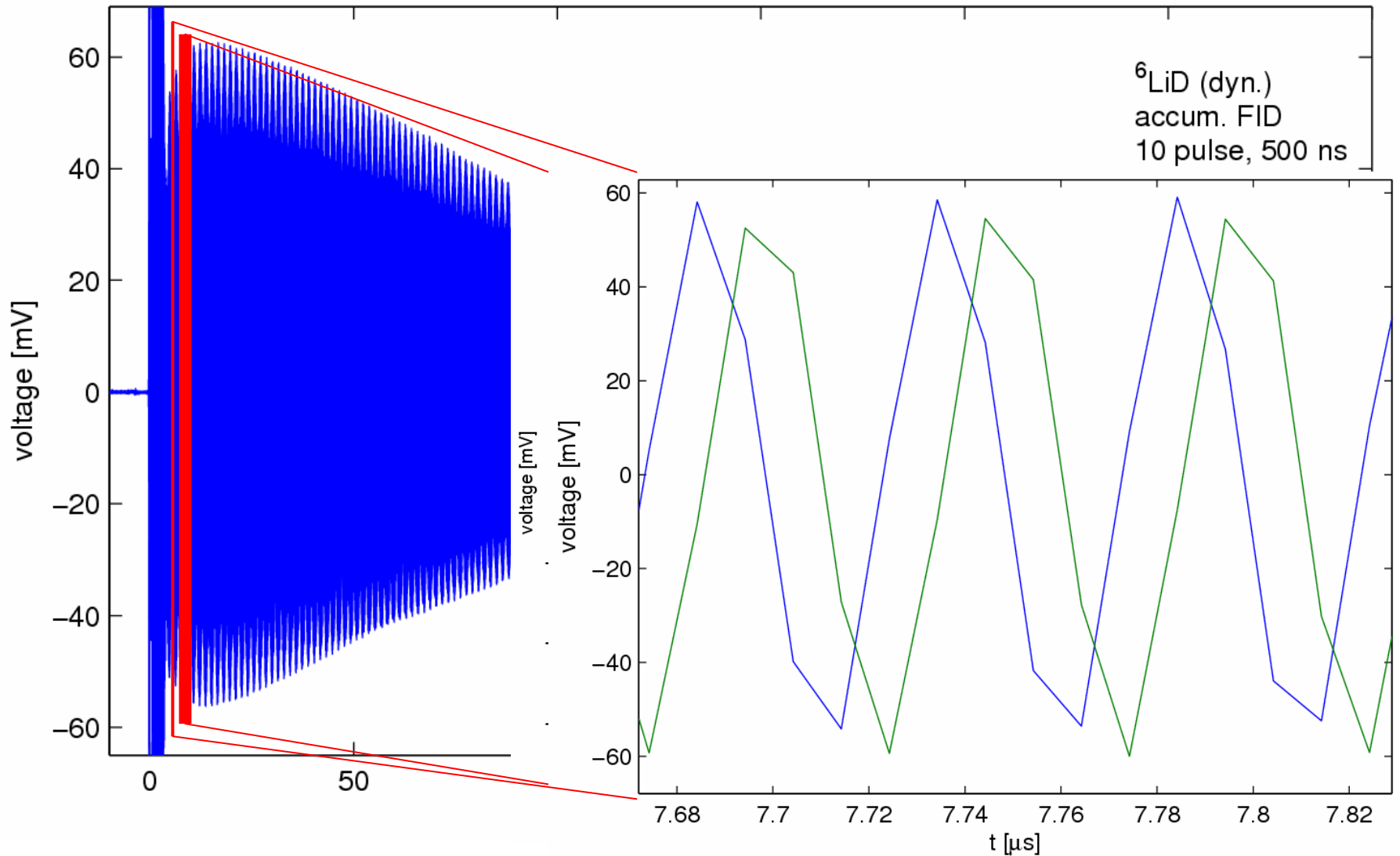


**Rotation of transverse magnetisation
in the complex plane**



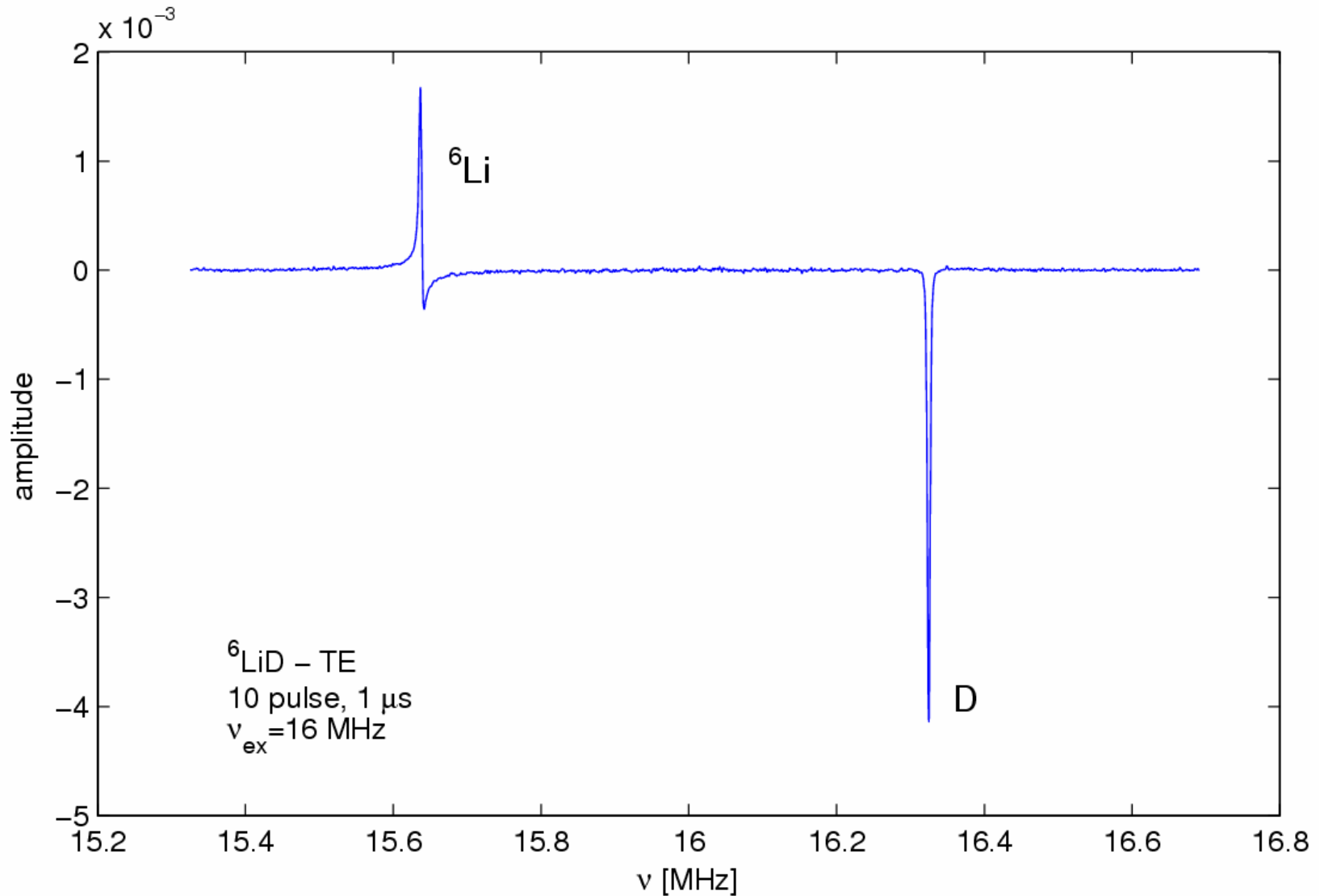
Measurement with ${}^6\text{LiD}$ @ 1K

- Free Inductance Decay -



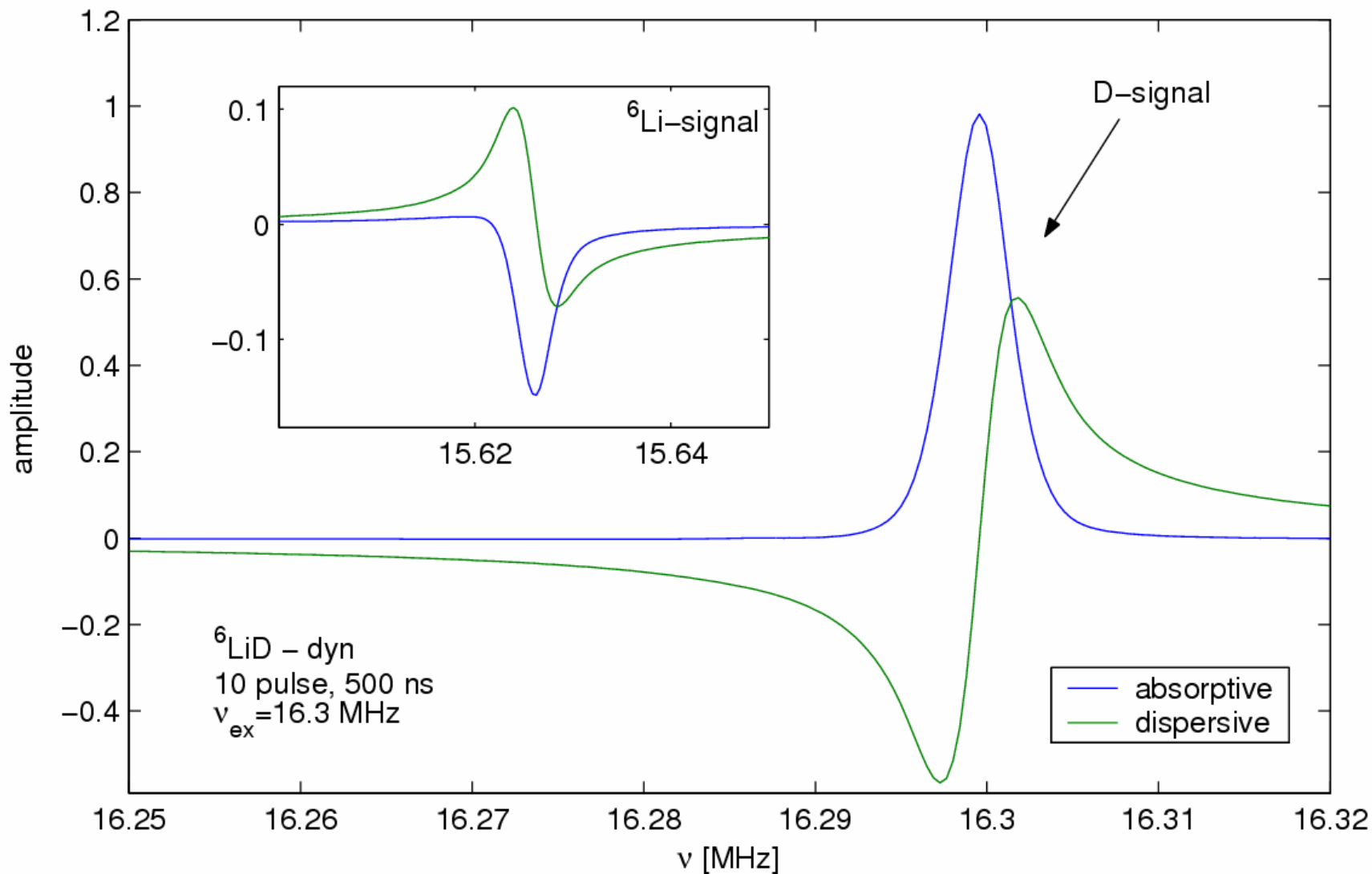
Measurement with ${}^6\text{LiD}$ @ 1K

- TE Spectra -

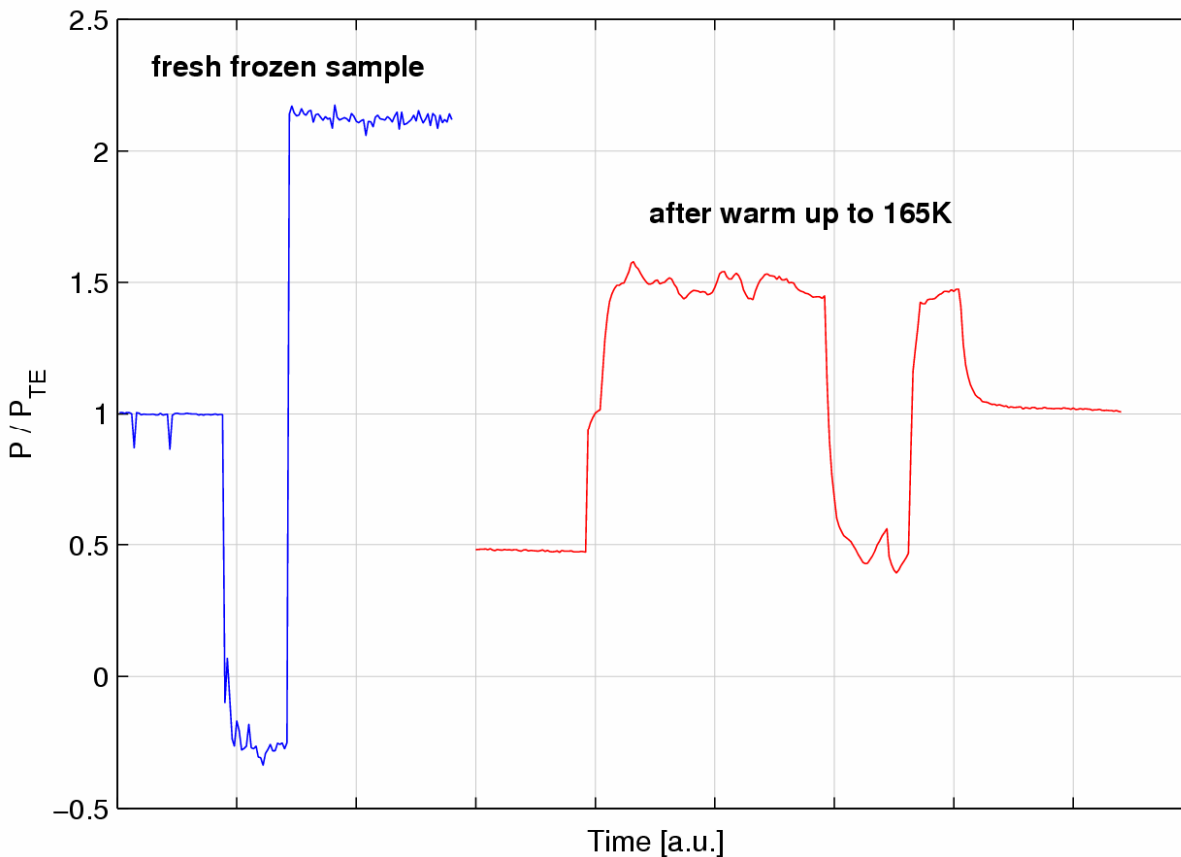


Measurement with ^6LiD @ 1K

- Dynamic Polarization Spectra -



Effect of Sample Warming on Polarization Ability



H-butanol (0.5% Tempo)
 $T=77K$

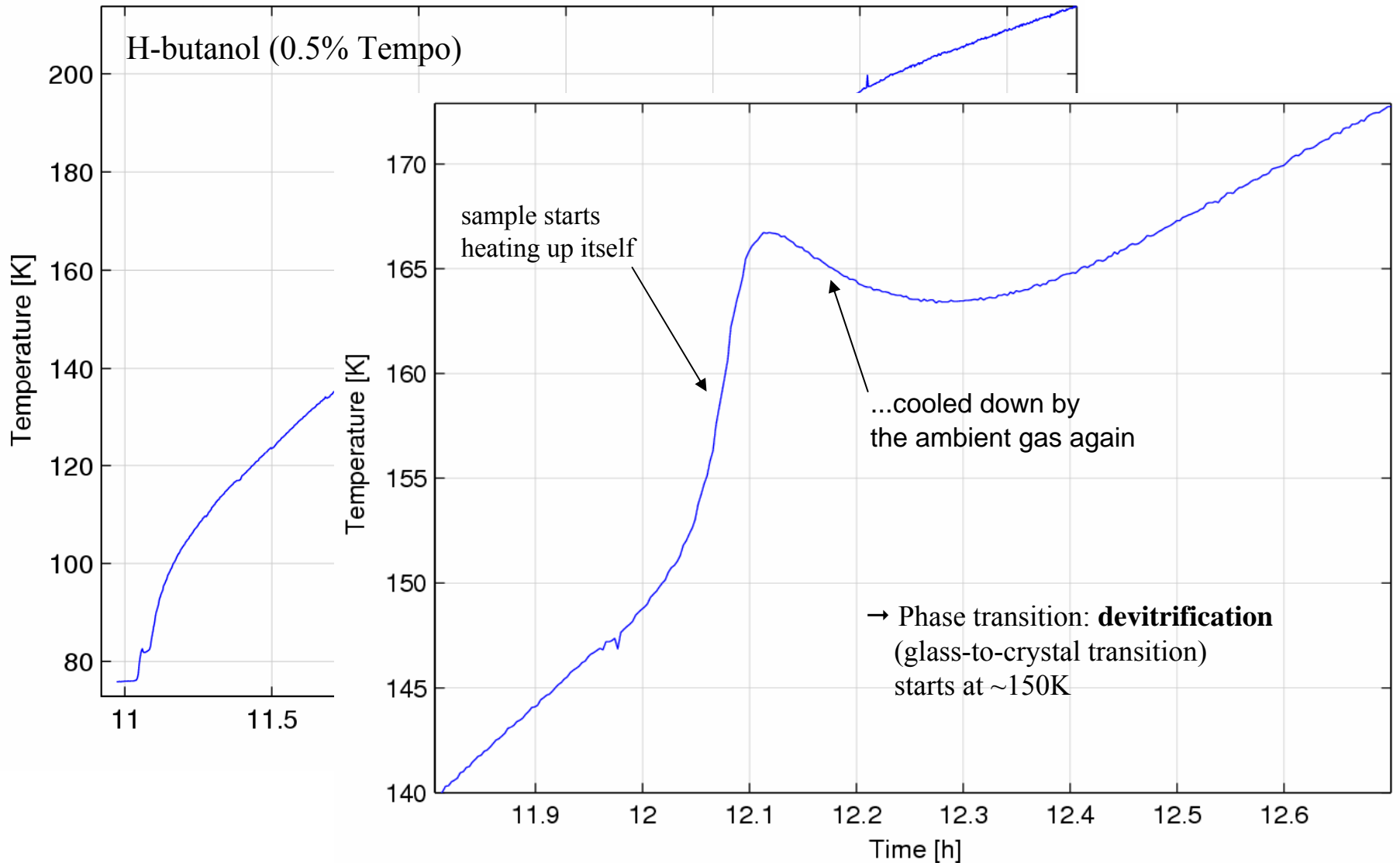
Define *enhancement* χ
to compare small dynamic effects

$$P_{\pm} = P_0(1 + \chi_{\pm})$$

| | χ_+ | χ_- |
|--------|----------|----------|
| fresh | 1.13 | -1.22 |
| warmed | 0.49 | -0.57 |

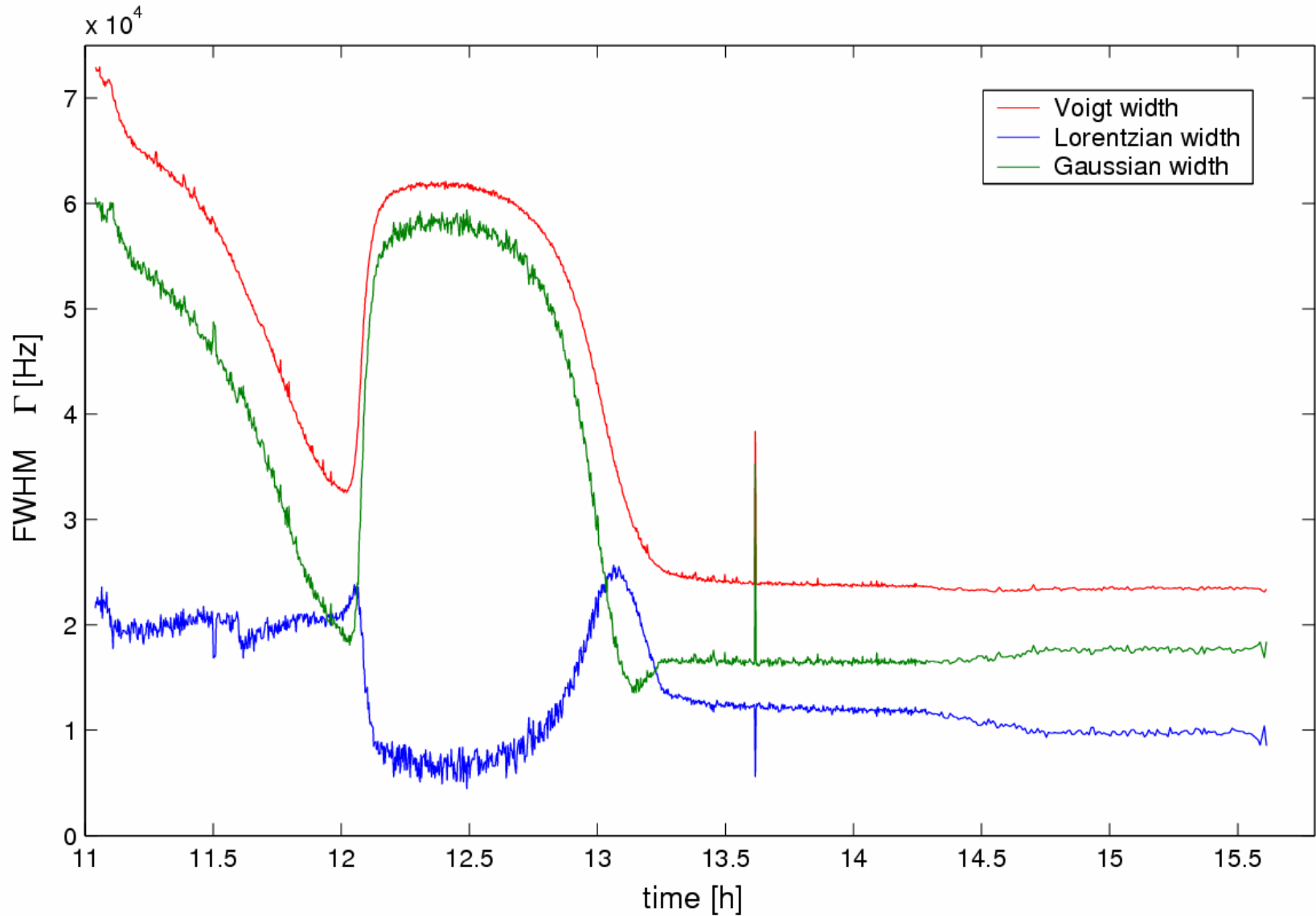
After warm up to 165K
enhancement meets 45%
of the primary performance
only

Abnormal warm up behaviour



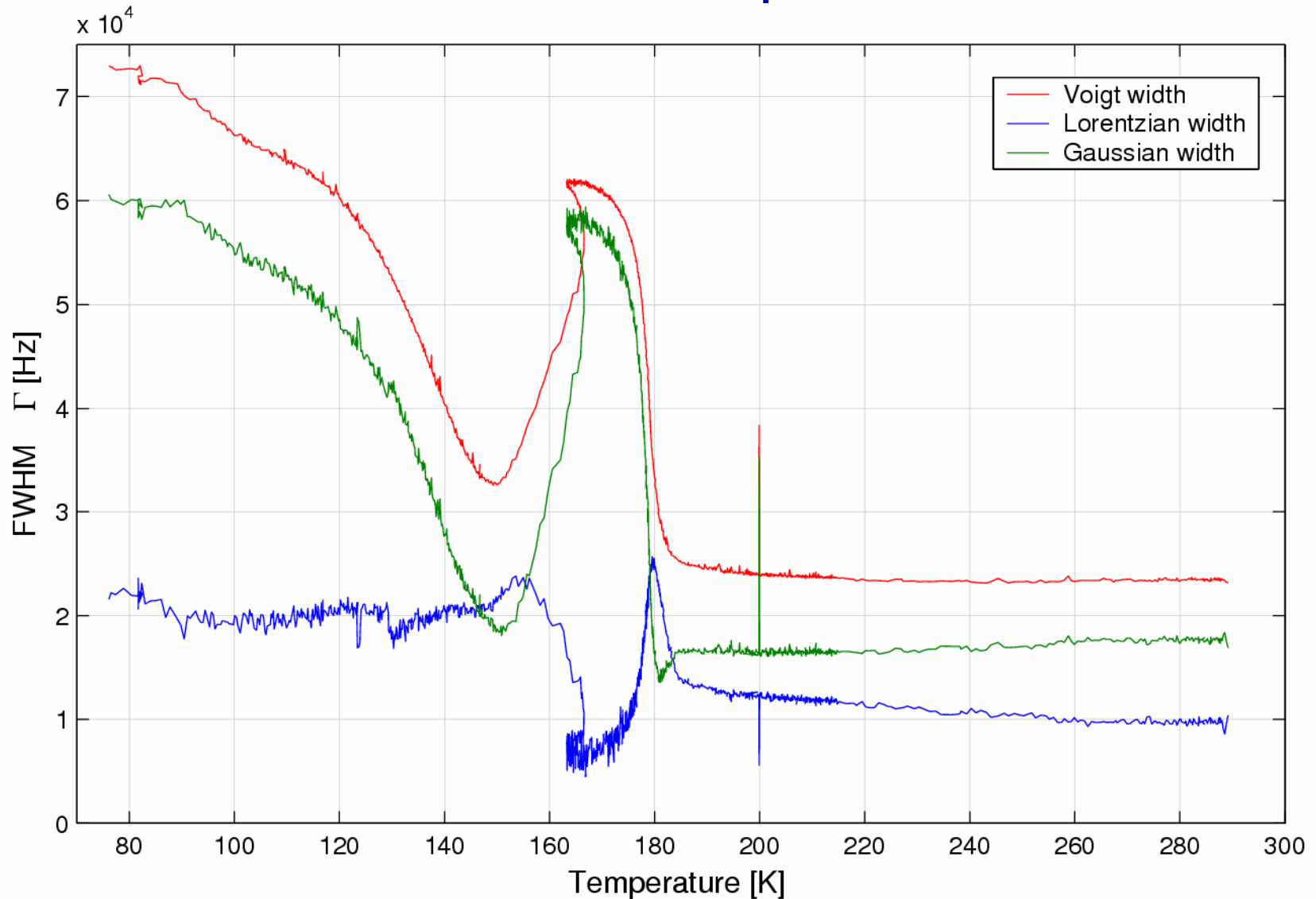
NMR monitoring of Devitrification

- Linewidth vs. Time -



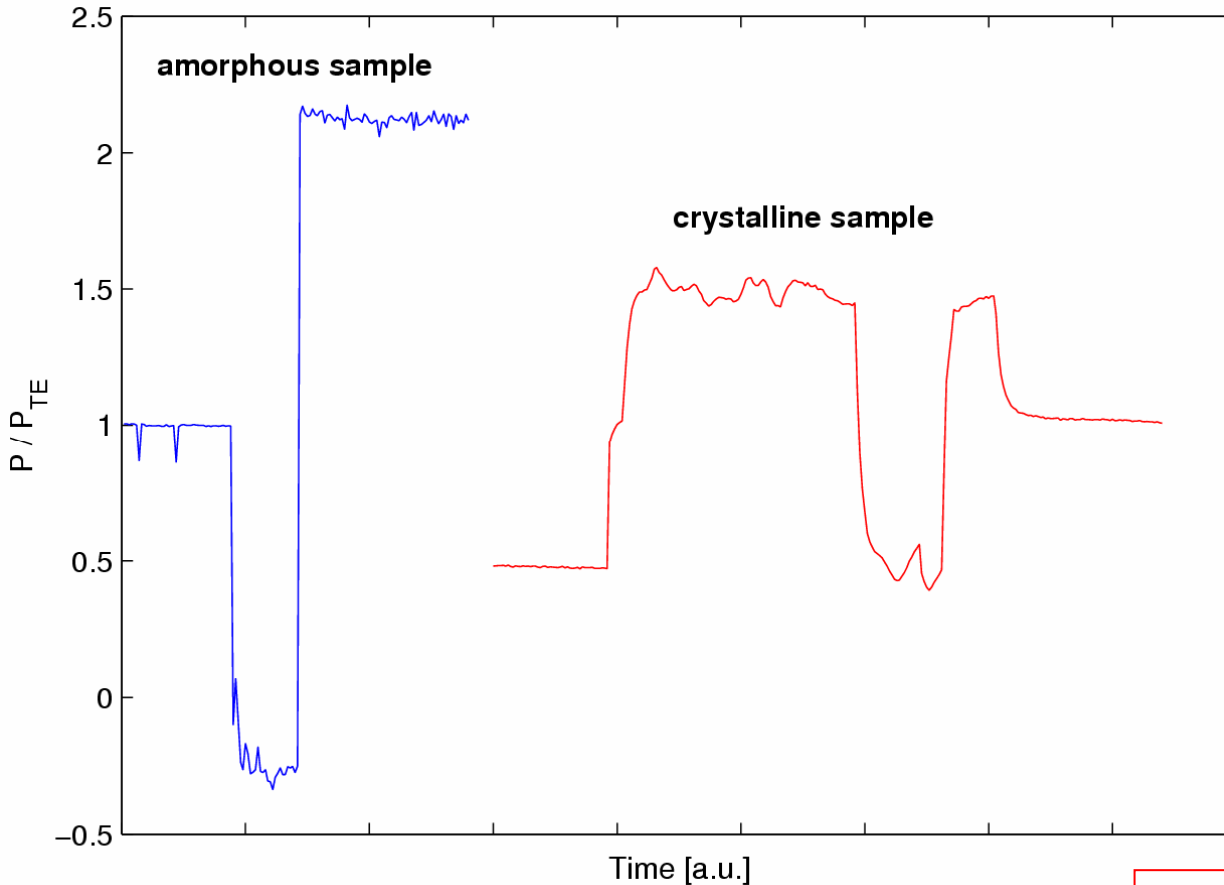
NMR monitoring of Devitrification

- Linewidth vs. Temperature -



Amorphous / Crystalline Sample

H-butanol (0.5% Tempo)
T=77K



amorphous sample
immediate response on μw

crystalline sample
build up- / relaxation
behaviour visible

Need of amorphous samples
to ensure good polarization ability

Summary and Outlook

- Pulsed NMR system for *top loading* ^4He refrigerator
- Wide range of sensitivity
 - TE / dynamic polarization @ 1K
 - TE polarization up to 300K
- Very fast technique (100 spectra in less than half a second)
 - Observe fast processes by their effects on the NMR line
- Simultaneous NMR detection of D- and ^6Li -nuclei in ^6LiD
- Need of amorphous samples to ensure good polarization ability
 - Devitrification in butanol starts at $T \sim 150\text{K}$
- Improve sensitivity for quadrupol broadened T_1 signals
- Measurement of electron relaxation time