NMR practical course

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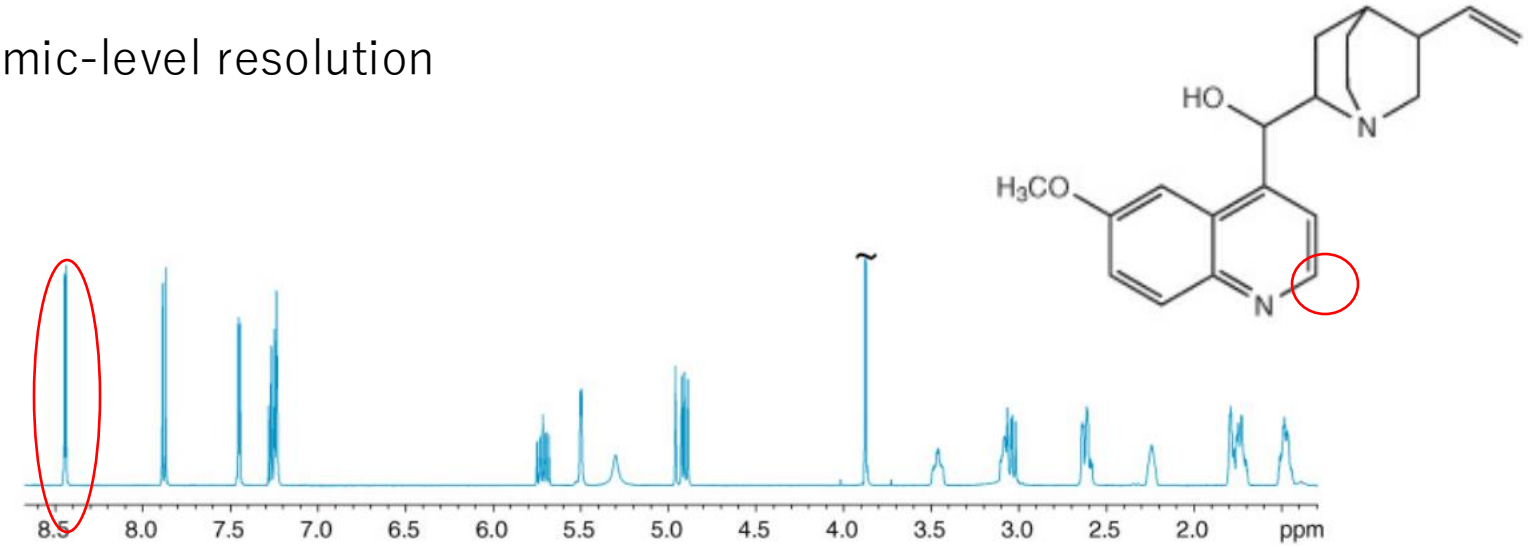
Advantage of using NMR

Atomic-level resolution



The chemical structure and ^{1}H-NMR spectrum of ‘quinine’ in $CDCl_3$ solution.
The hydrogen atoms in the red circles in the structure are observed
in the red circles in the spectrum.

The hydrogen atoms in the structure can be observed in pieces.

Disadvantage of using NMR

Worst sensitivity in the industry
Expensive equipment and maintenance costs

UV spectrometer：¥1,000,000~
Detectable from pM order
Measurement time: a few seconds

NMR：¥50,000,000~
Detectable from uM
Maintenance cost per year
：¥1,000,000

Measurement time:
several minutes to hours

CT scan
a few seconds

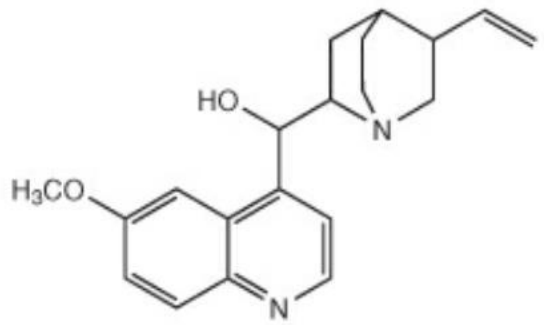
MRI scan
More than 30 mins

NMR applications

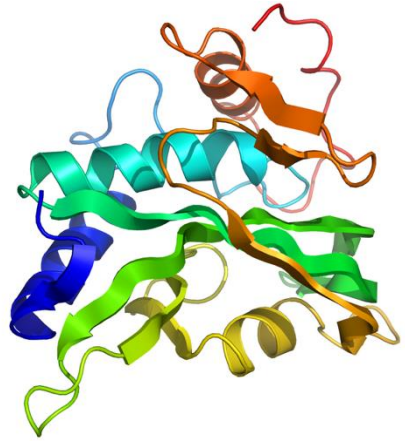
Structure determination of small molecule compounds

Structure determination and
acquisition of structural information of biomolecules

Quality control
- Drugs, proteins, lipids, rubber, plastics, etc.
- Regardless of the state of matter (liquid, semi-solid, solid).
- Metabolomics of wine
  - Know the raw materials, the region, the domaine,
    even the year of production! (No need to be a sommelier)



Quinine



Protein glutaminase

https://www.bruker.com/ja/products-and-solutions/mr/nmr-food-solutions/wine-profiling0.html

NMR can tell us a lot of things !

Sample preparation – for small molecule compounds

Use a deuterium (^2H=D) solvent
D_2O, CD_3Cl, d6-DMSO (=$(CD_3)_2SO$), CD_3OD, etc.

Not interfere with the observation
of proton signals in the compounds.

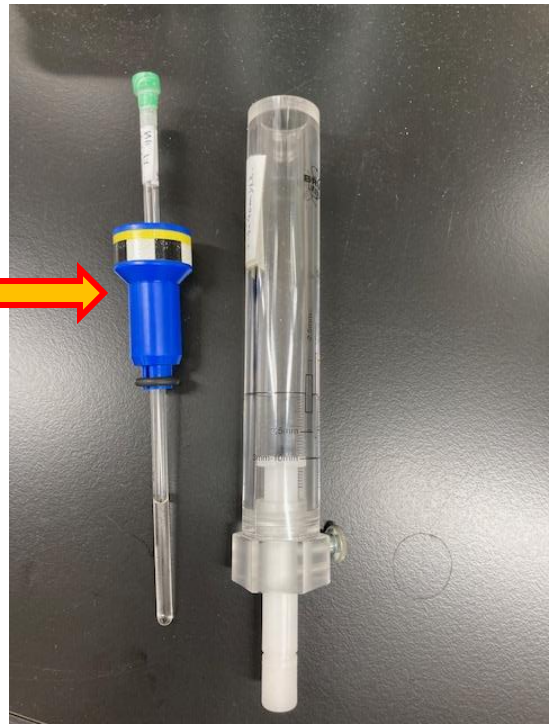
Volume : 500 μL
Dissolve a few mg of sample.
** Solubility is important. **

The solvent height is at least 4 cm.

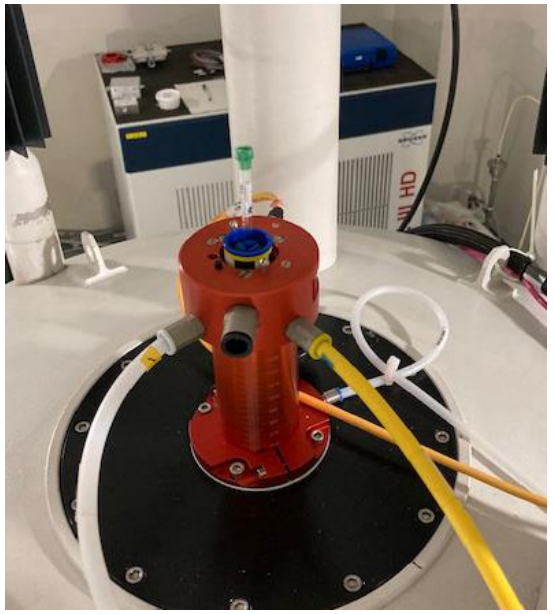
5 mm NMR tube and
human right hand.

Sample tube insertion to NMR magnet

Holder
(spinner)



Adjust the sample position
with a gauge.



Float the sample with air.
Insert the sample by closing the air valve.

Procedures after sample insertion

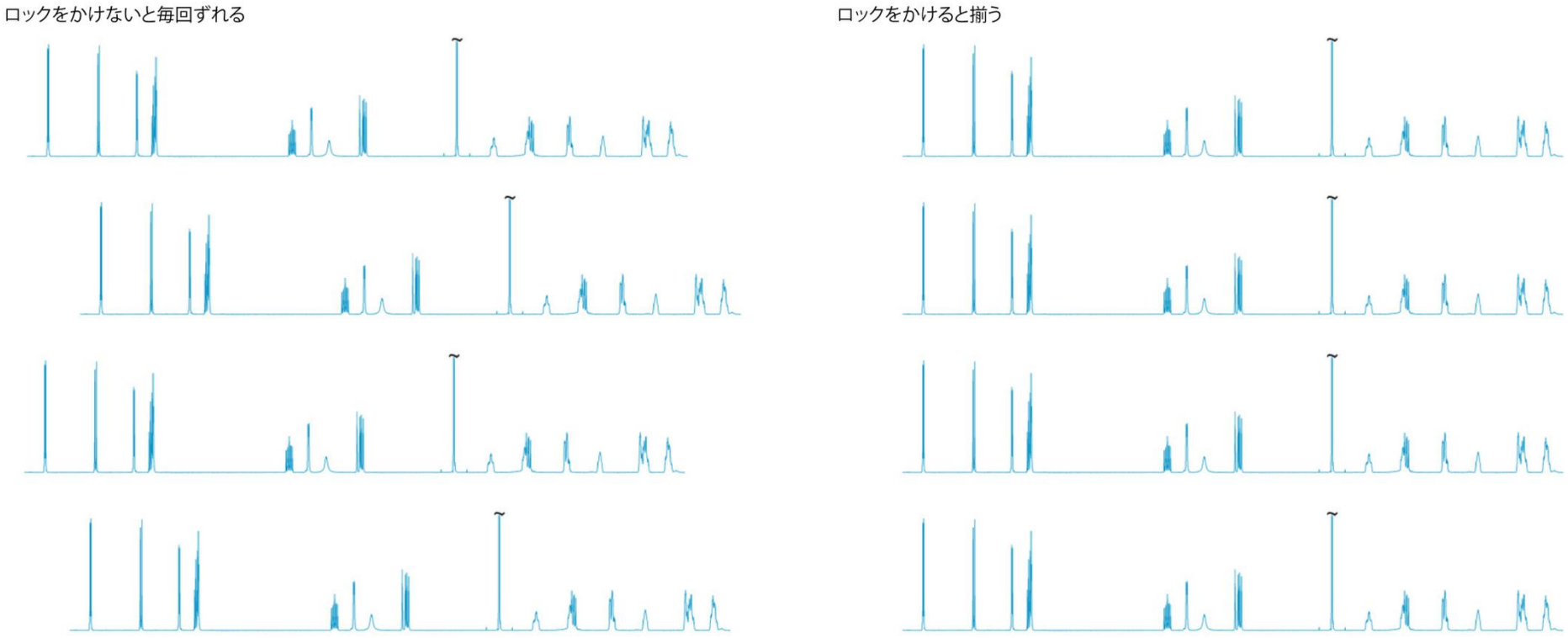
1. Lock
2. Tuning
3. Shimming
4. Parameter setting

For students in the practical course,
4 is a term you can easily understand.
2 is a term you may have encountered somewhere before.
But 1 and 3 may be new to you.

1． Lock

Lock is applied using the frequency of deuterium in the solvent.

Worst sensitivity in the industry => Needing stack of scans
Atomic-level resolution => NMR frequency accuracy required for correction

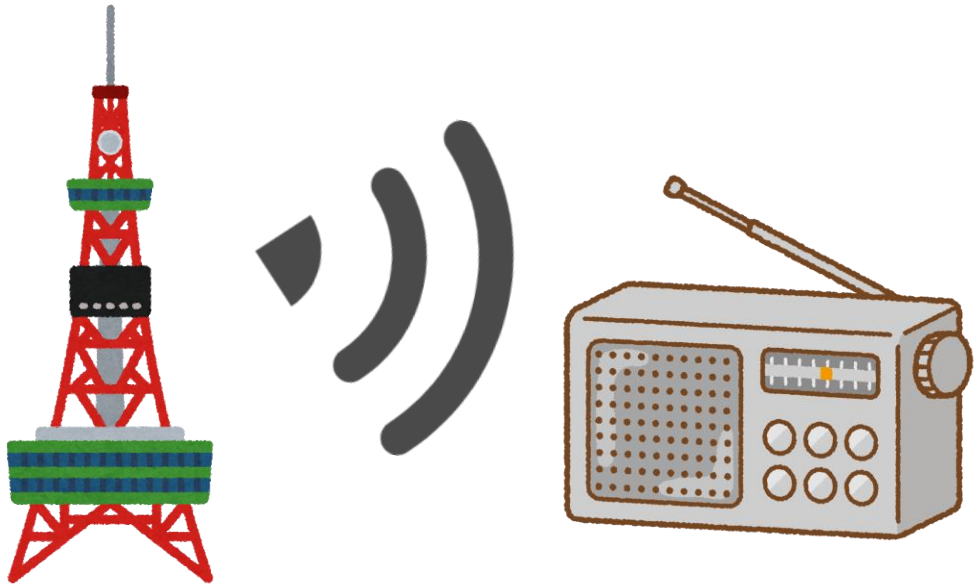


Lock off

Lock on

2． Tuning

Almost the same meaning as tuning a radio.
To tune the frequency to the channel (nuclear type) you want to listen to.
To make a clear sound (input pulse or output signal).

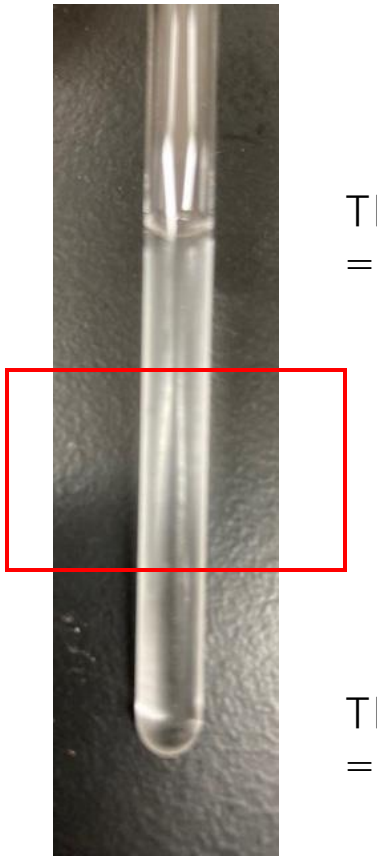


Almost constant as it passes through the air

Since it passes through a solution and glass of tube,
fine adjustment is required if the sample change.

3. Shimming

To improve the uniformity of the magnetic field.
The electromagnet coil for adjusting the uniformity is called “shim coil”.



The magnetic field is easily disturbed at the gas-liquid interface.
=> Keep at least 1 cm away from the detection area.

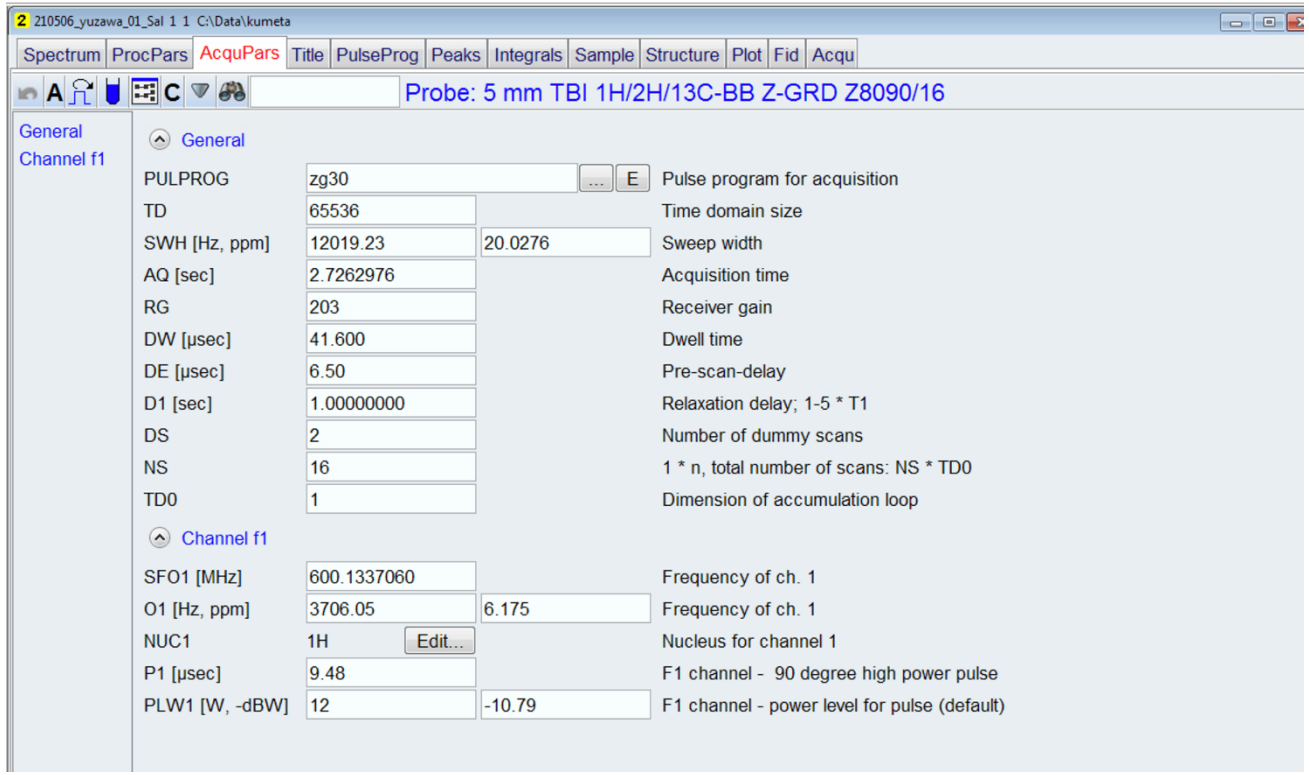
Detection area (about 1.6 cm).

The magnetic field is also easily disturbed at bottom of the NMR tube.
=> Keep at least 1 cm away from the detection area.

4. Parameter setting

OK by default setting

There are too many unfamiliar terms,
so do not change the settings until you have a deep understanding of these terms.



Acquisition parameters in the simplest 1D-proton NMR experiment.

Demonstration

Step	command
0. Sample Insertion	ej/ij
1. Lock	lock CDCL3
2. Tuning	atma
3. Shimming	topshim 1d rga
4. Parameter setting	edc
5. Acquisition	zg

Procedures after acquisition

1. FT
2. Phase correction
3. Analyse

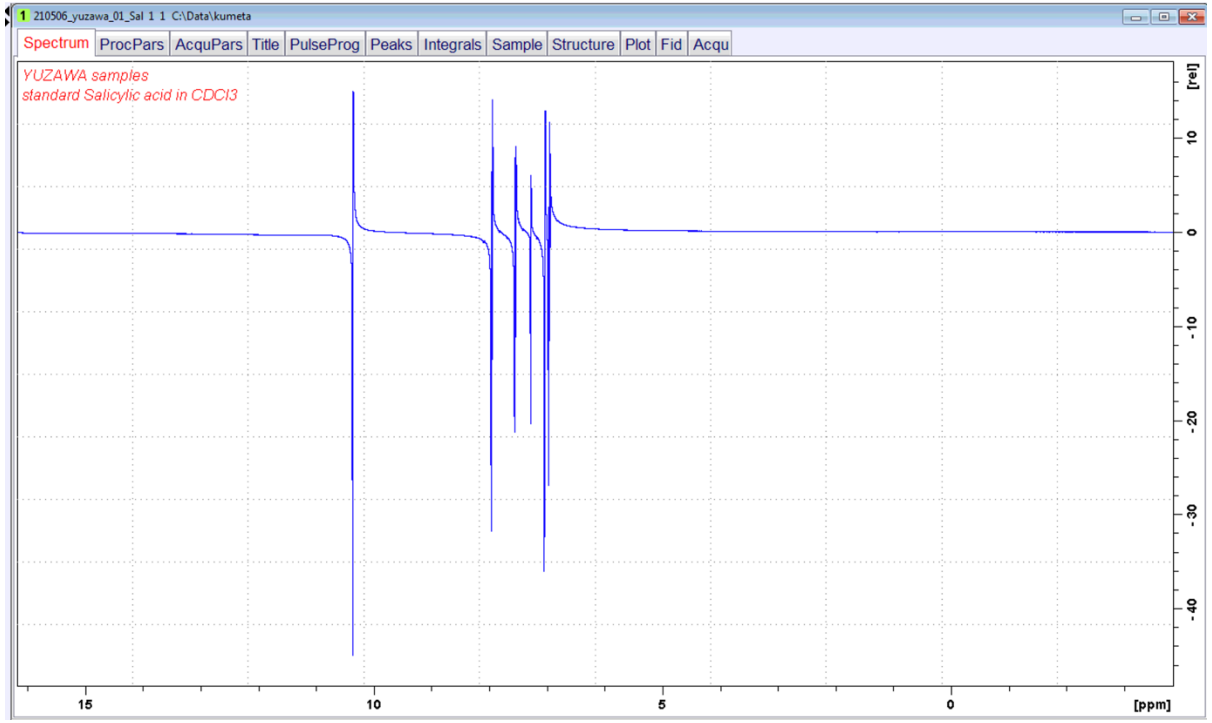
1．FT, Fourier Transform

generate the spectrum from FID data

FolderName (Sample Name)
ExpNo (Experiment Number)
ProcNo （Process Number）

Double click on ProcNo
efp　FT with exponential window function
.all　show full spectrum

There is a signal in negative region.
＝”Phase” not aligned
need to compensate



2． Phasing

”Phase correction” to get the “absorption” spectrum.

apk0	Zero-order automatic phase correction
.ph	Change to phase correction mode
.sret	Return, and save spectrum

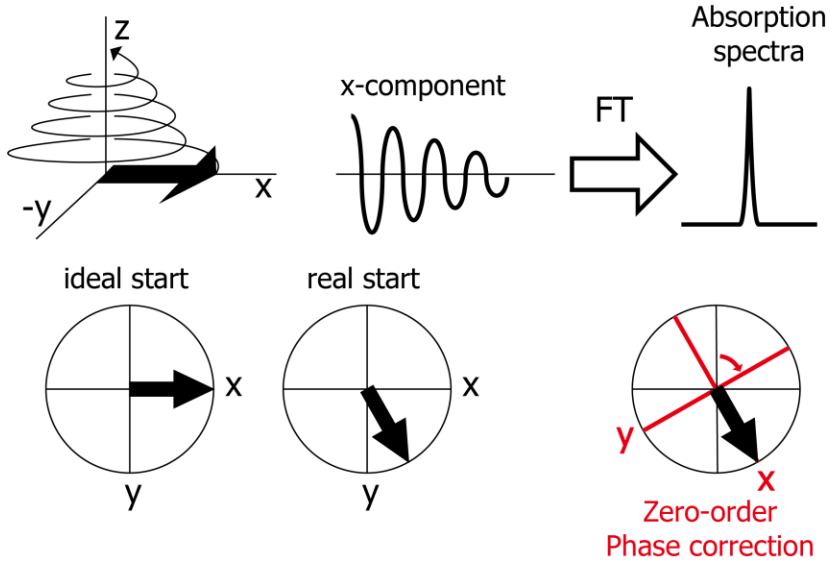
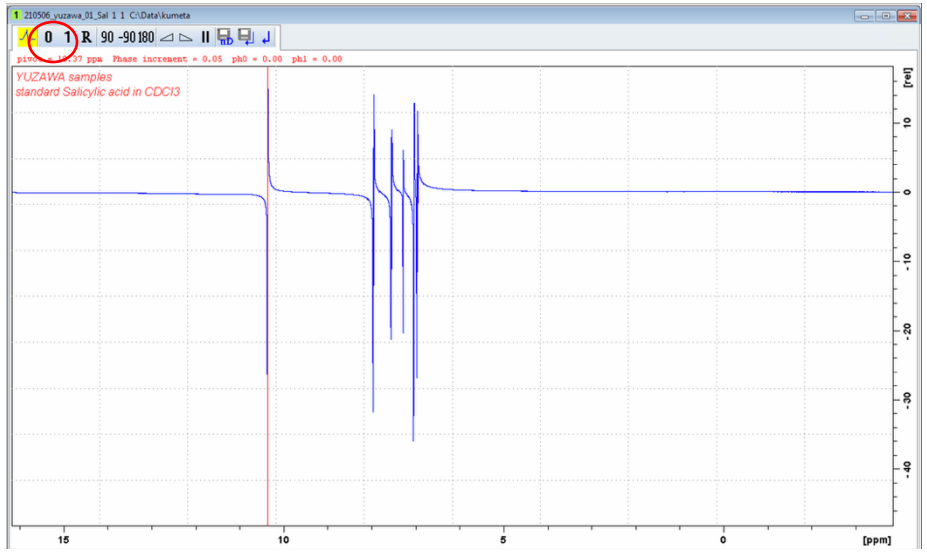
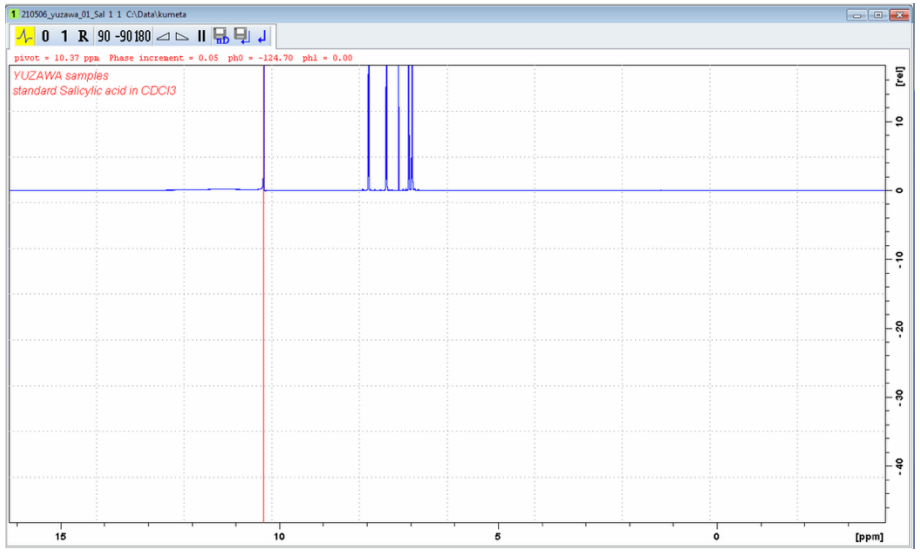


Image of zero-order phase correction

Drag the "0" icon, and mouse up and down.



“dispersion” spectrum



“absorption” spectrum

3． Analyse

Overlay and compare spectral data

.md　Change to multiple spectrum mode

Demonstration

1. FT	efp
2. Phase correction	.ph / .sret
3. Analyse	.md