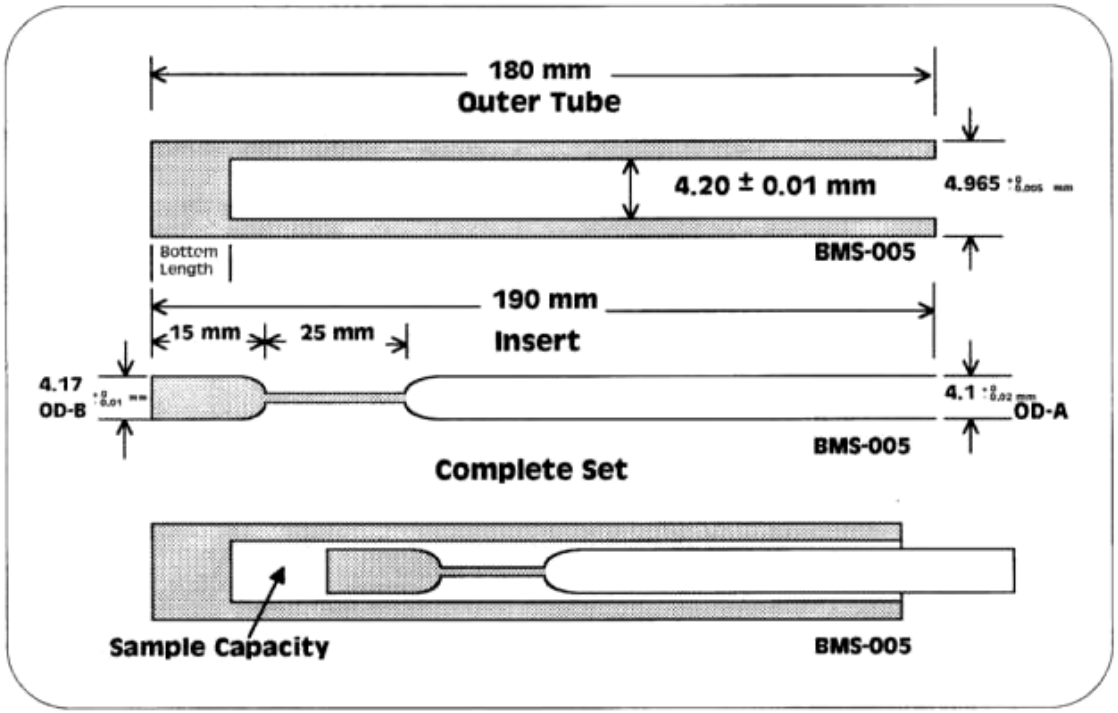
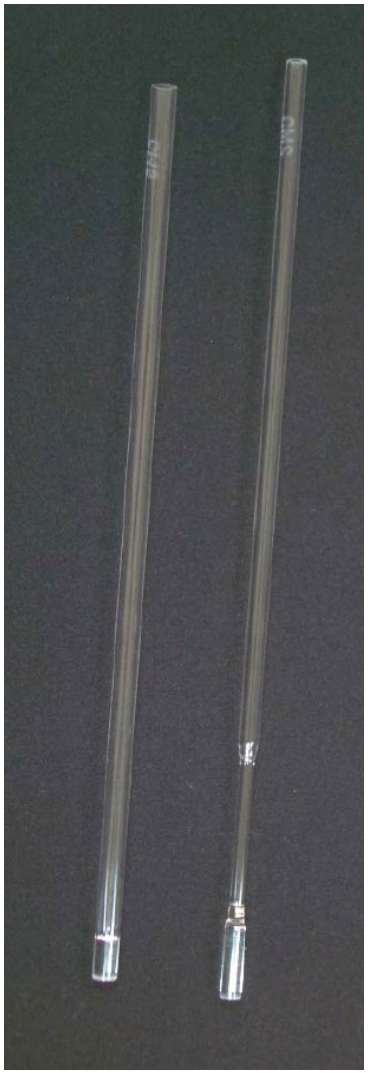
# Useful NMR Experiments for Nature Products

吳英彥 (Casper Wu)

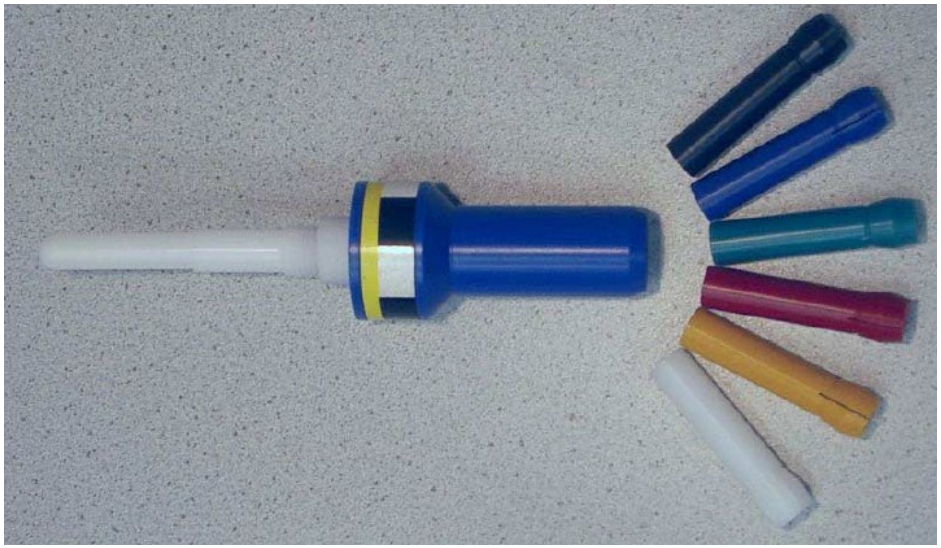
# SHIGEMI Tube



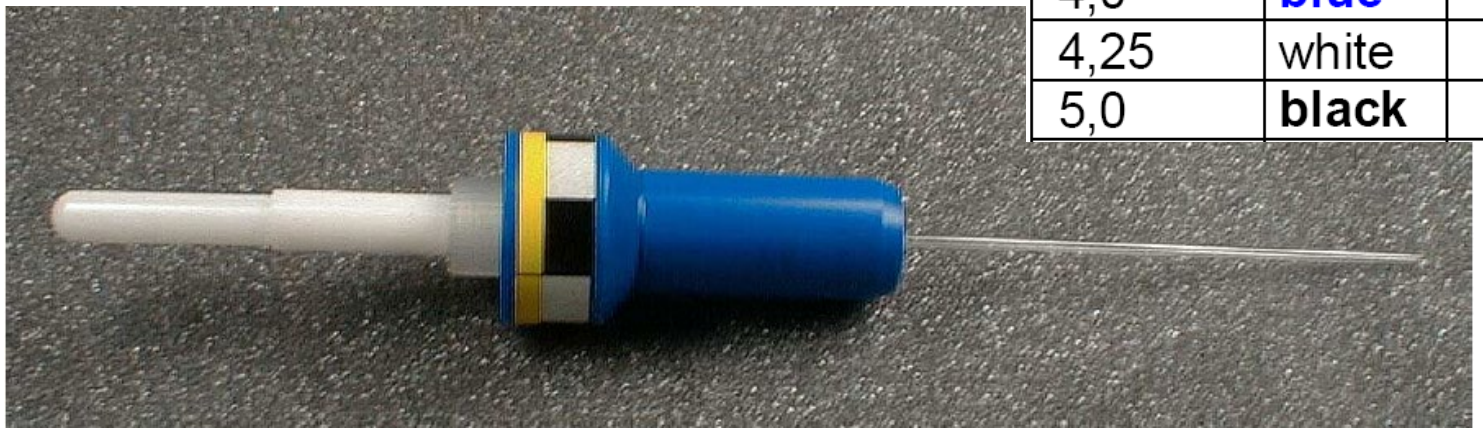



| Parts Name | Solvent |
|---|---|
| BMS | $D_2O$ |
| CMS | $CDCl_3$ |
| DMS | DMSO-d6, $C_6D_6$, $C_5D_5N$ |
| MMS | $CD_3OD$, $CD_3CN$ |
| AMS | Acetone-d6 |

# MATCH Tube



| Tube OD | Clamp Color Code | Ideal Sample Volume |
|---|---|---|
| [mm] | | µl |
| 1,0** | **black** | 12 |
| 1,7 | white | 45 |
| 2,0 | **yellow** | 70 |
| 2,5 | **red** | 120 |
| 3,0 | **green** | 160 |
| 4,0 | **blue** | 310 |
| 4,25 | white | 370 |
| 5,0 | **black** | 490 |



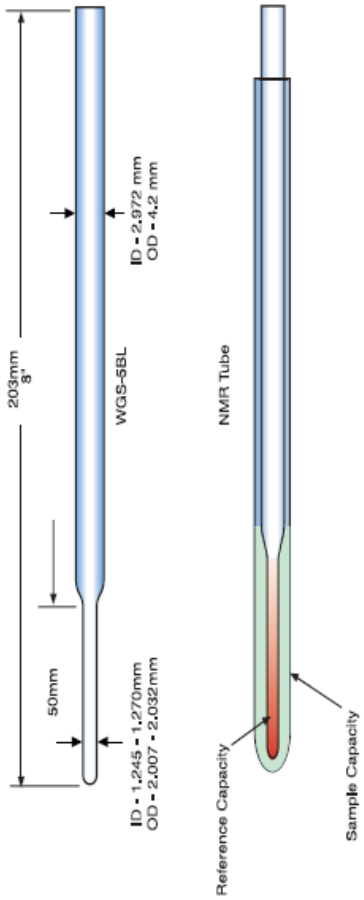
# Stem Coaxial Small Volume NMR Insert

The most versatile and reliable coaxial system available for NMR experiments is the Wilmad Stem Coaxial Small Volume NMR Inserts.

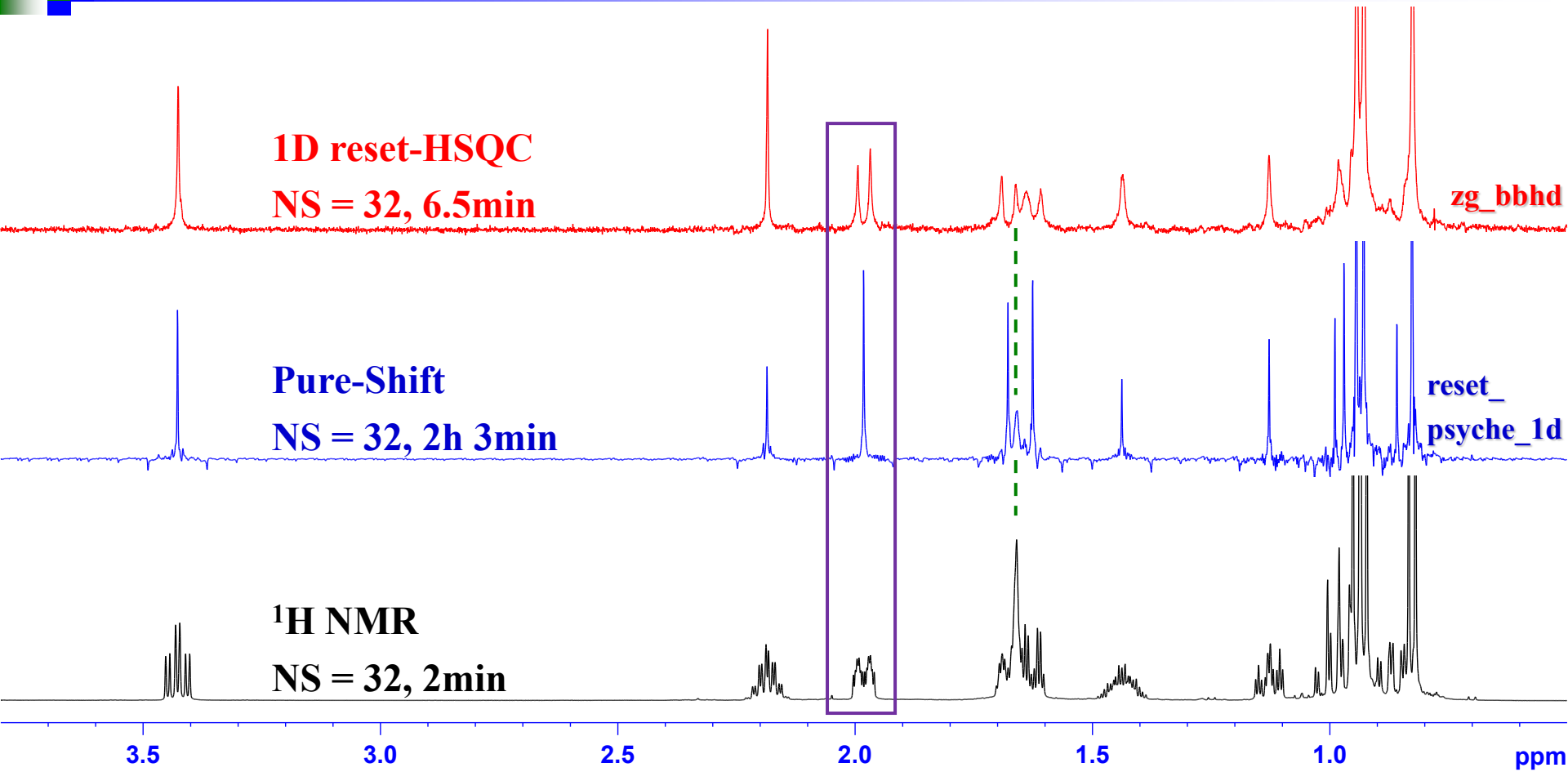
- General applications include small volume NMR, external referencing, external locking and magnetic susceptibility determination
- Manufactured from ASTM Type 1 class A glass, ideal for variable temperature studies
- Outer tube must be ordered separately depending on magnetic field strength

**Stem Coaxial Small Volume NMR Insert**

| Catalog No. | Fits Outer Tube with O.D. | Stem Height | Stem O.D. | Inner Capacity | Outer Capacity | Use with |
|---|---|---|---|---|---|---|
| WGS-4BL | 4mm | 25mm | 2mm | 30 µL | 124 µL | 406-PP, 427-PP |
| WGS-5BL | 5mm | 50mm | 2mm | 60 µL | 530 µL | 506-PP to 535-PP |
| WGS-5BL-SP | 5mm | 50mm | 3.3mm | 220 µL | 260 µL | 506-PP to 535-PP |
| WGS-8BL | 8mm | 50mm | 3mm | 190 µL | 1560 µL | 513A-XPP |
| WGS-10BL | 10mm | 50mm | 4mm | 410 µL | 2600 µL | 513-XPP |



# 1D reset-HSQC and Pure-Shift





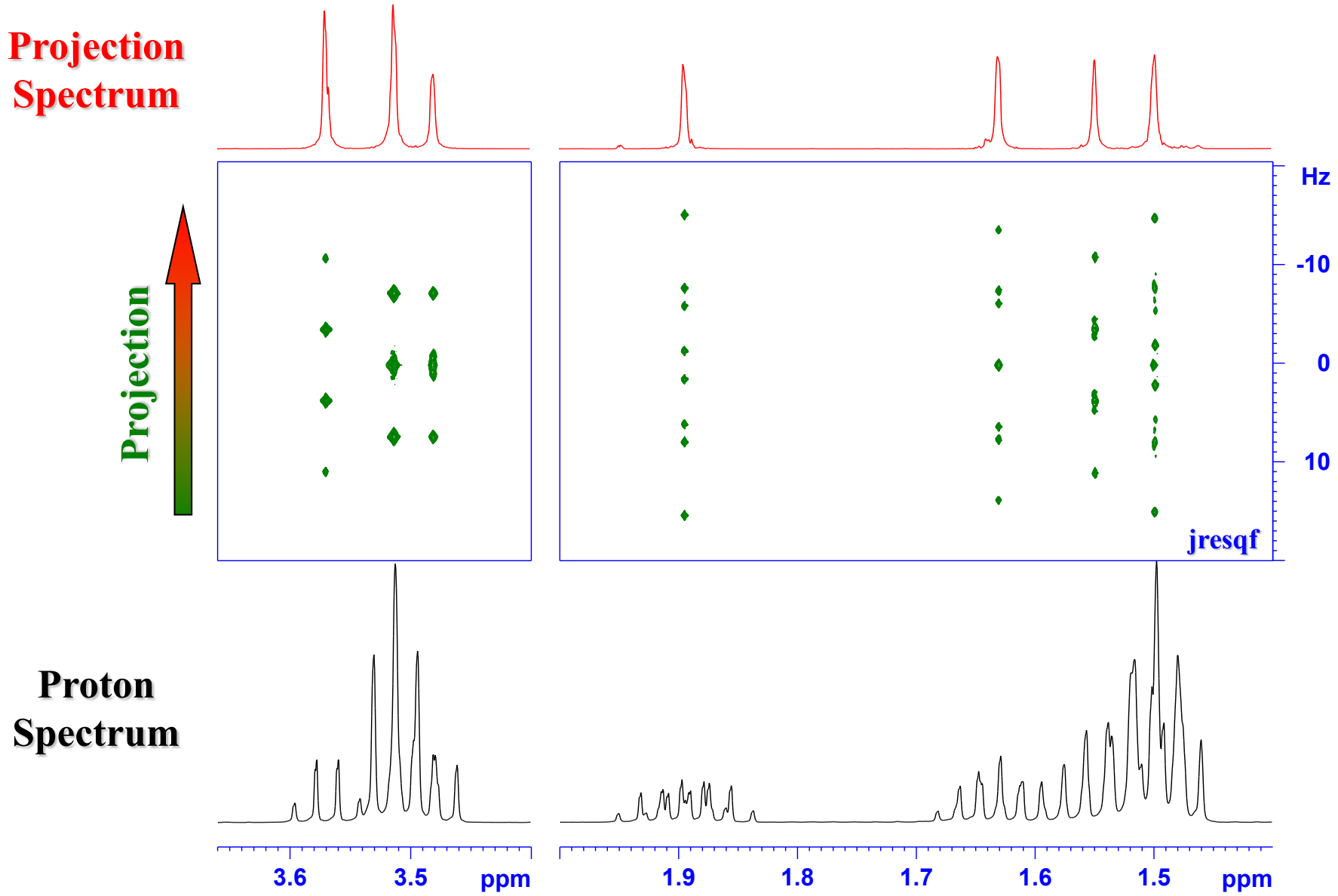
**1D reset-HSQC:**

1. L. Paudel, R. W. Adams, P. Kiraly, J. A. Aguilar, M. Foroozandeh, M. J. Cliff, M. Nilsson, P. Sandor, J. P. Waltho & G. A. Morris, Angew. Chem. 125, 11830-11833 (2013)
2. J. A. Aguilar, M. Nilsson & G. A. Morris, Angew. Chem. 123, 9716-9717 (2011)
3. P. Sakhaii, B. Haase & W. Bermel, J. Magn. Reson. 199, 192-198 (2009)

**Pure-Shift:** M. Foroozandeh, R.W. Adams, P. Kiraly, M. Nilsson and G.A. Morris, Chem. Commun. , 51, 15410, (2015)

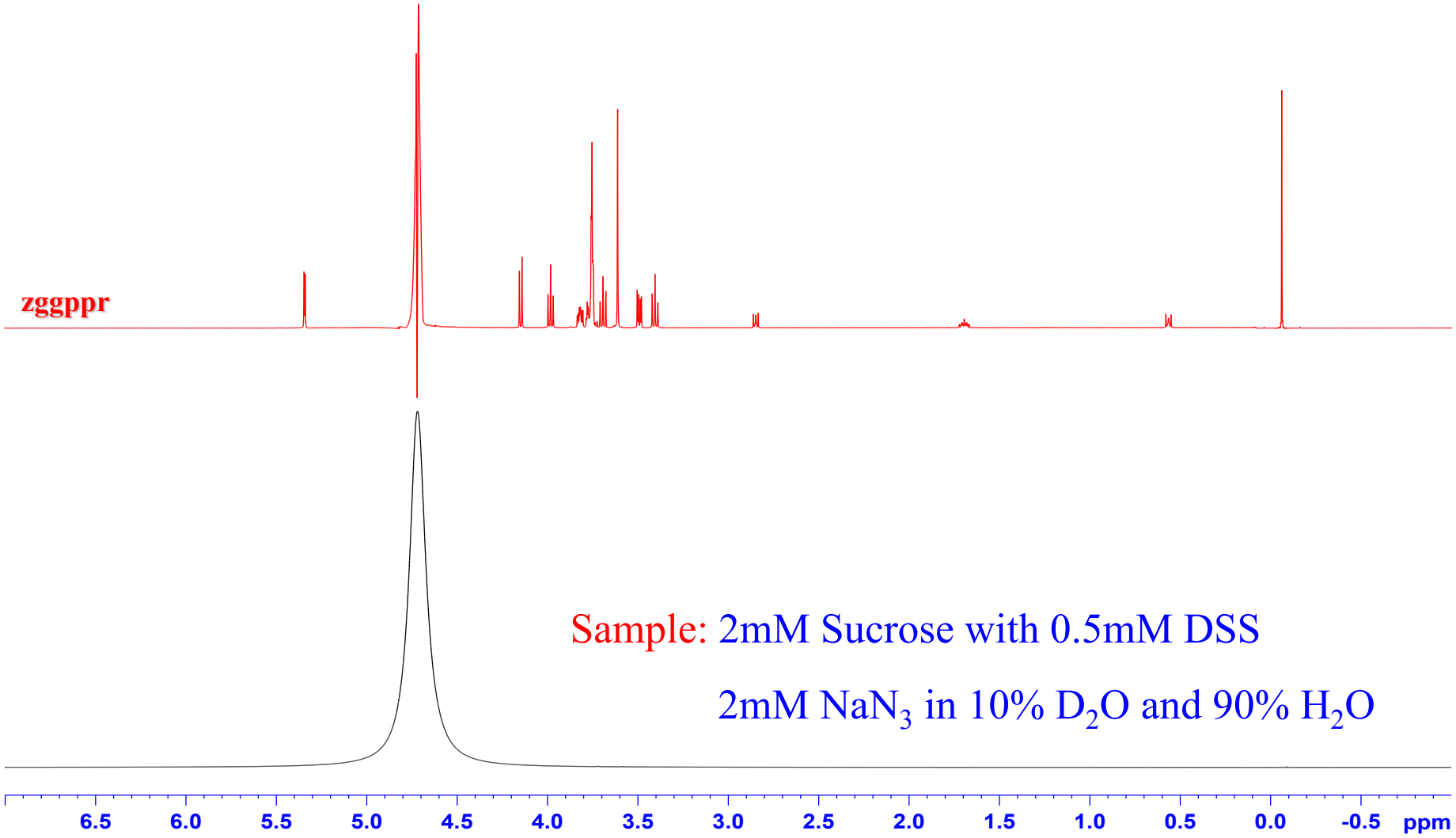
# Homonuclear J-resolved





# Solvent Suppression



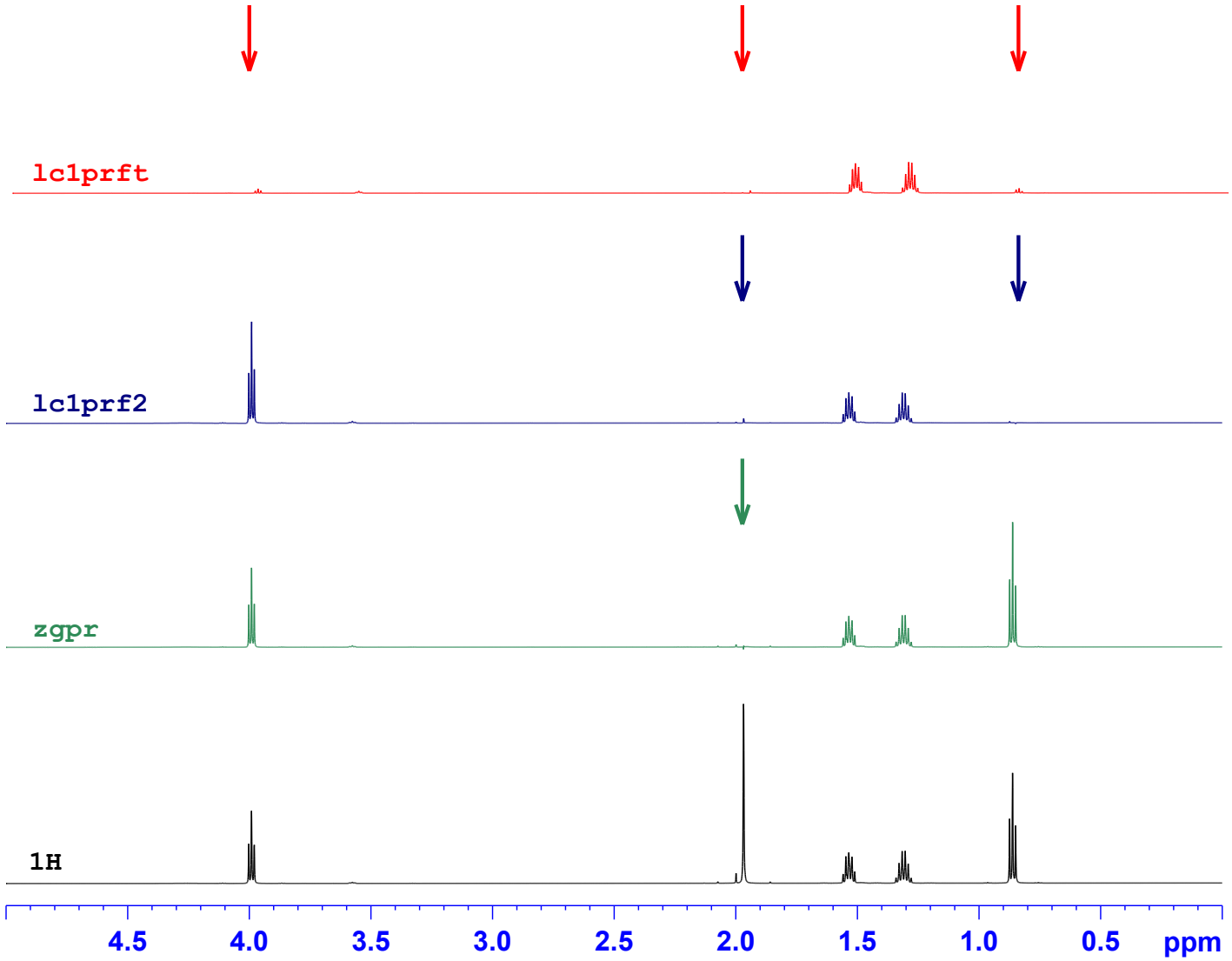



Sample: 2mM Sucrose with 0.5mM DSS

2mM $NaN_3$ in 10% $D_2O$ and 90% $H_2O$

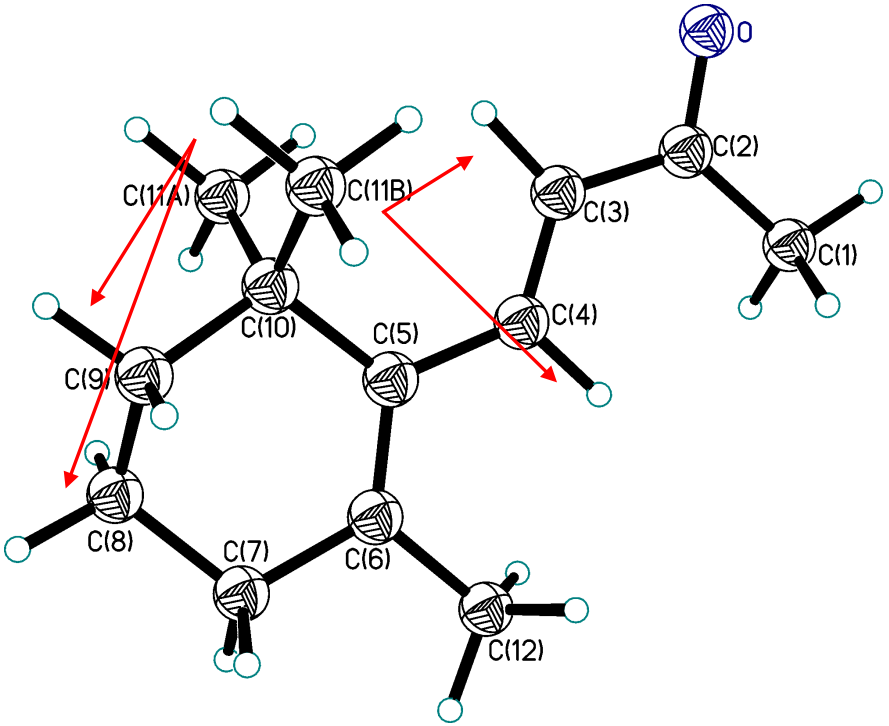
# Multiple Solvents Suppression

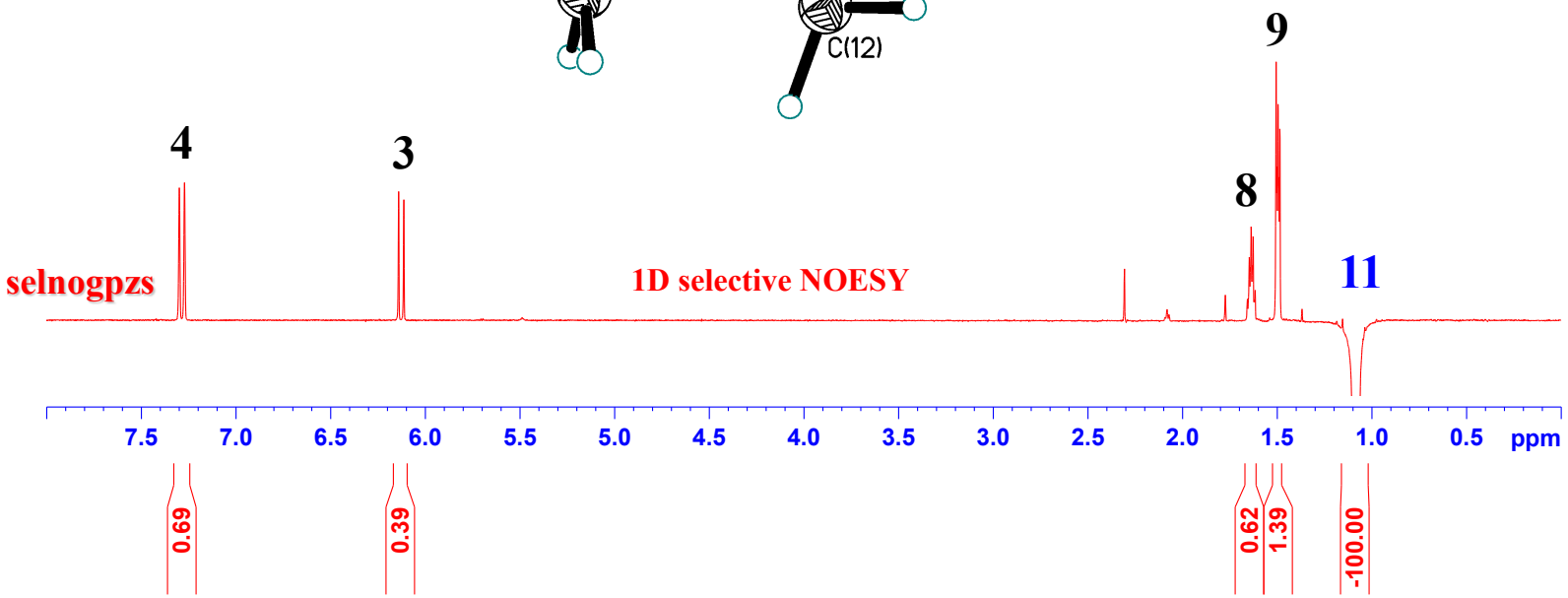
②



# Selective NOESY

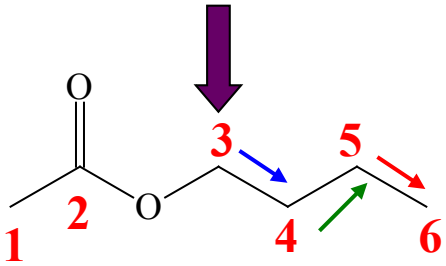




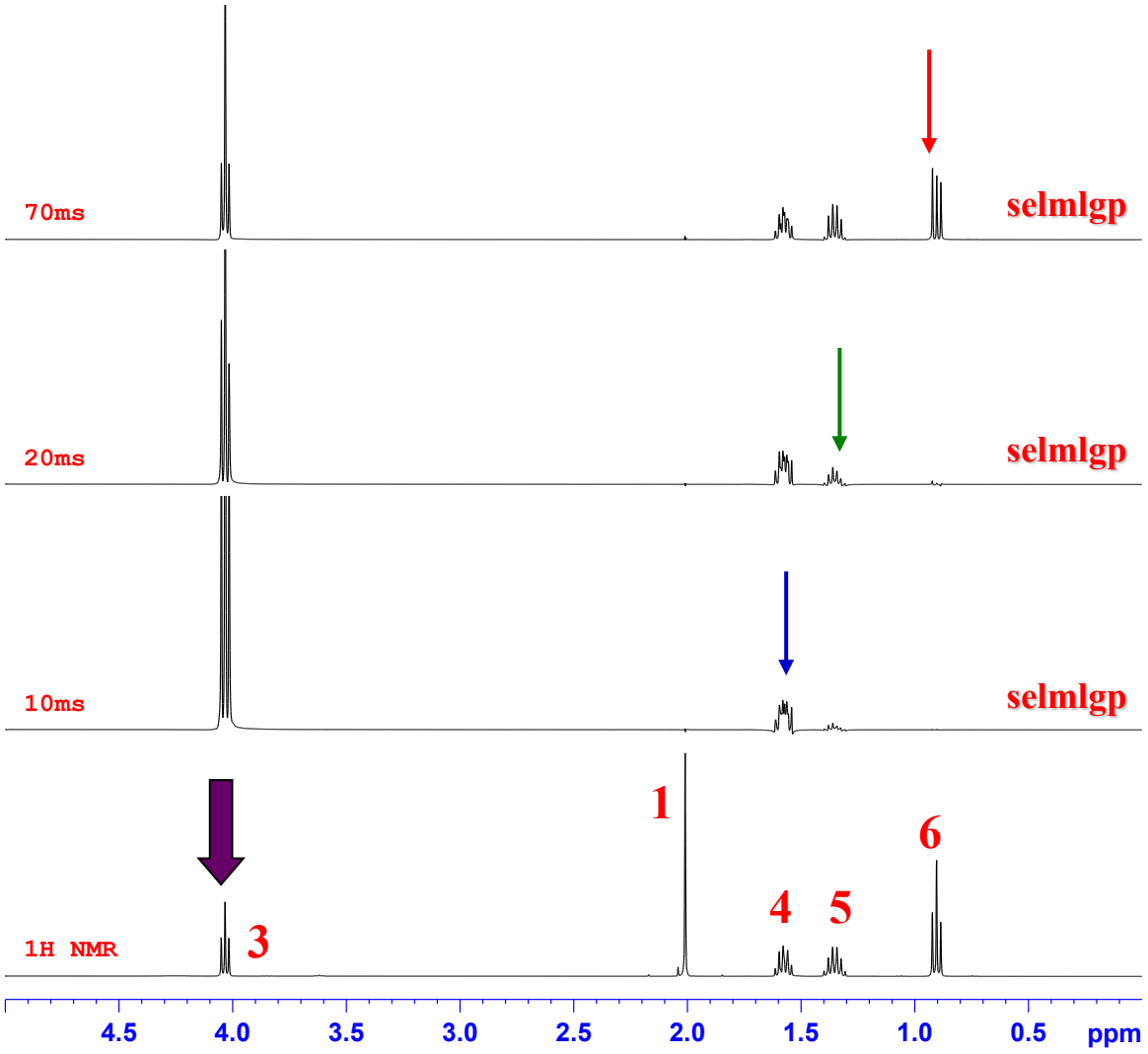



# Selective TOCSY

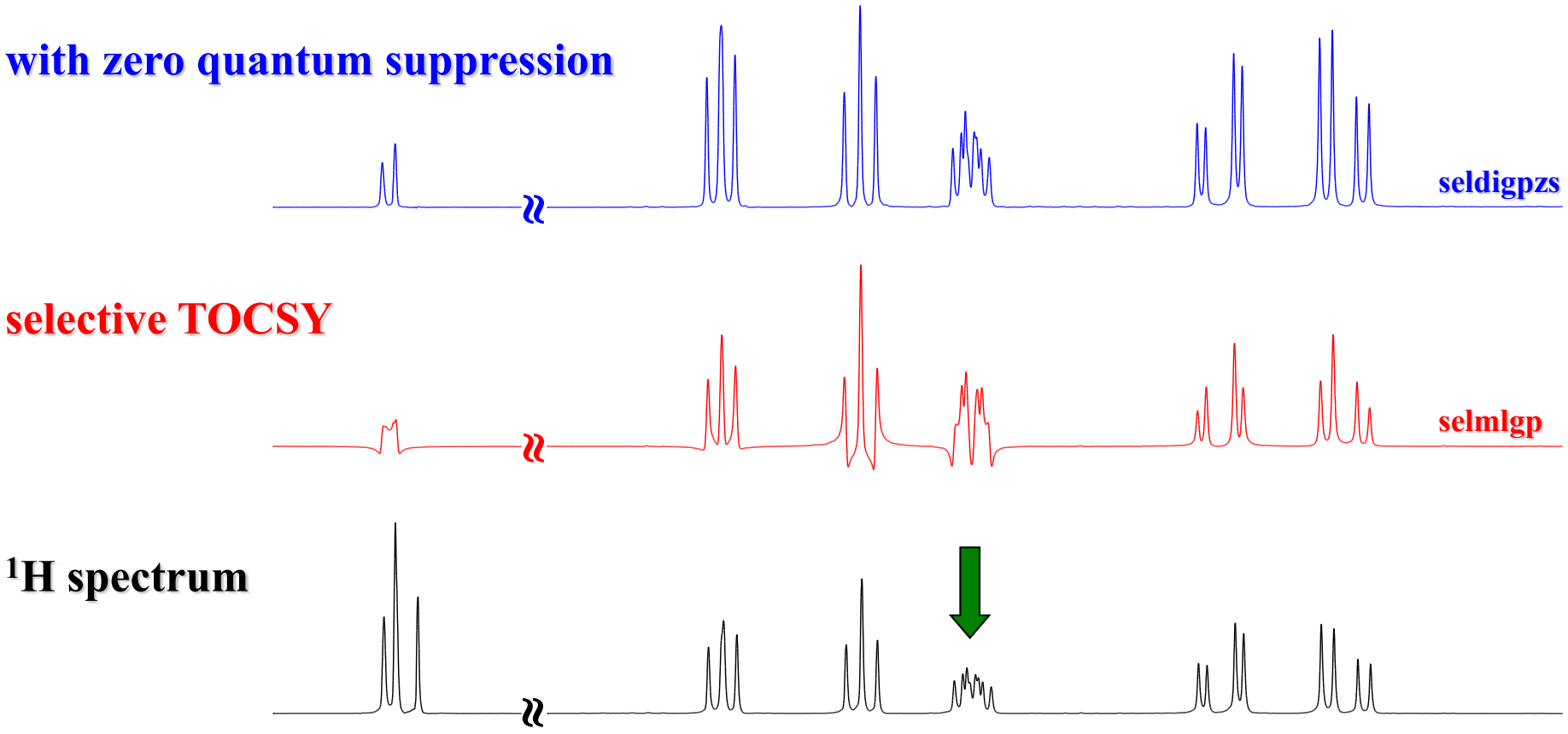





n-butyl acetate



# Selective TOCSY with Zero Quantum Suppression ②m





1. H. Kessler, H. Oschkinat, C. Griesinger, W. Bermel, J. Magn. Reson. 70, 106 (1986)
2. J. Stonehouse, P. Adell, J. Keeler, A. J. Shaka, J. Am. Chem. Soc. 116, 6037 (1994)
3. K. Stott, J. Stonehouse, J. Keeler, T. L. Hwang, A. J. Shaka, J. Am. Chem. Soc. 117, 4199-4200 (1995)
4. M. J. Thrippleton, J. Keeler, Angew. Chem. Int. Ed. 42, 3938-3941 (2003)

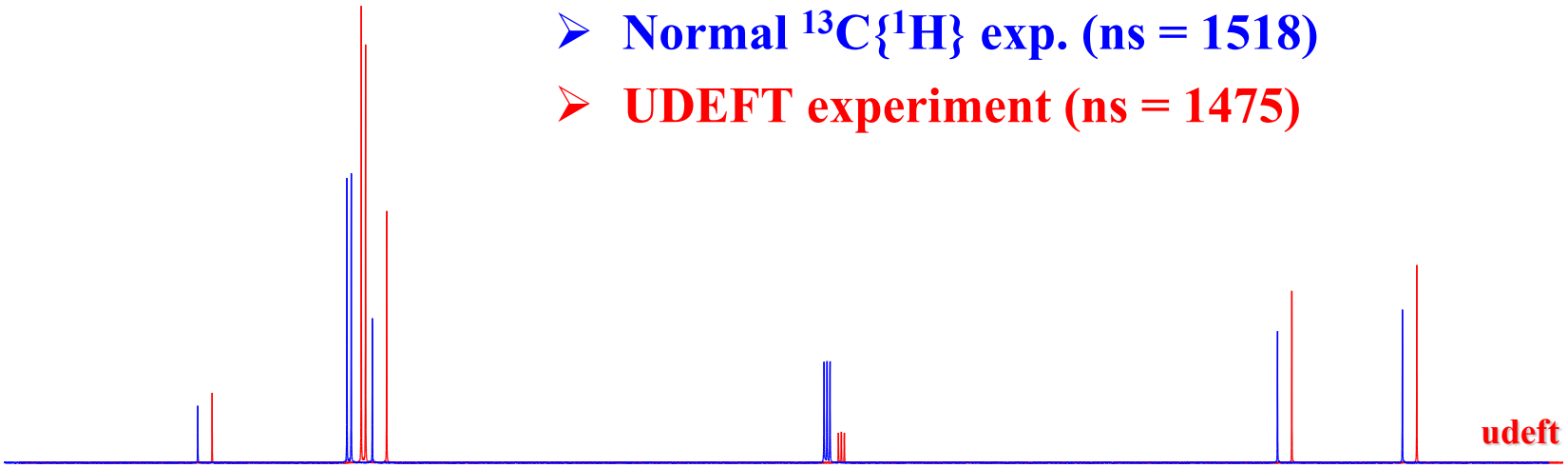
# UDEFT



## Uniform Driven Equilibrium Fourier Transform
## -increase sensitivity of long relaxation time nuclei

- Sample: 10% ethylbenzene
- Experiment time: 2 hr

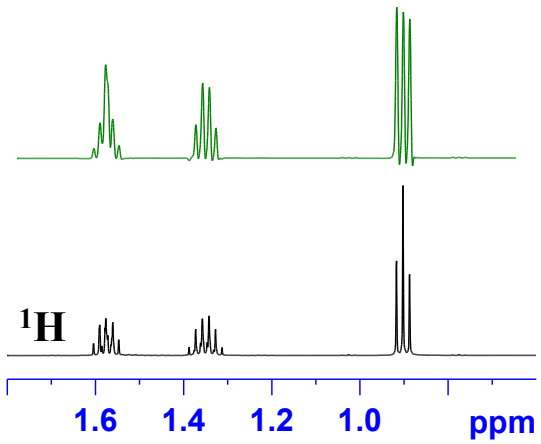
- Normal $^{13}C\{^{1}H\}$ exp. (ns = 1518)
- UDEFT experiment (ns = 1475)

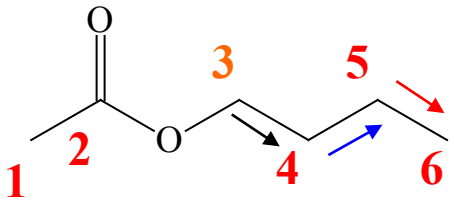



M. Piotto, M. Bourdonneau, K. Elbayed, J.-M. Wieruszeski, G. Lippens, Magn. Reson. Chem. 44, 943-947 (2006)

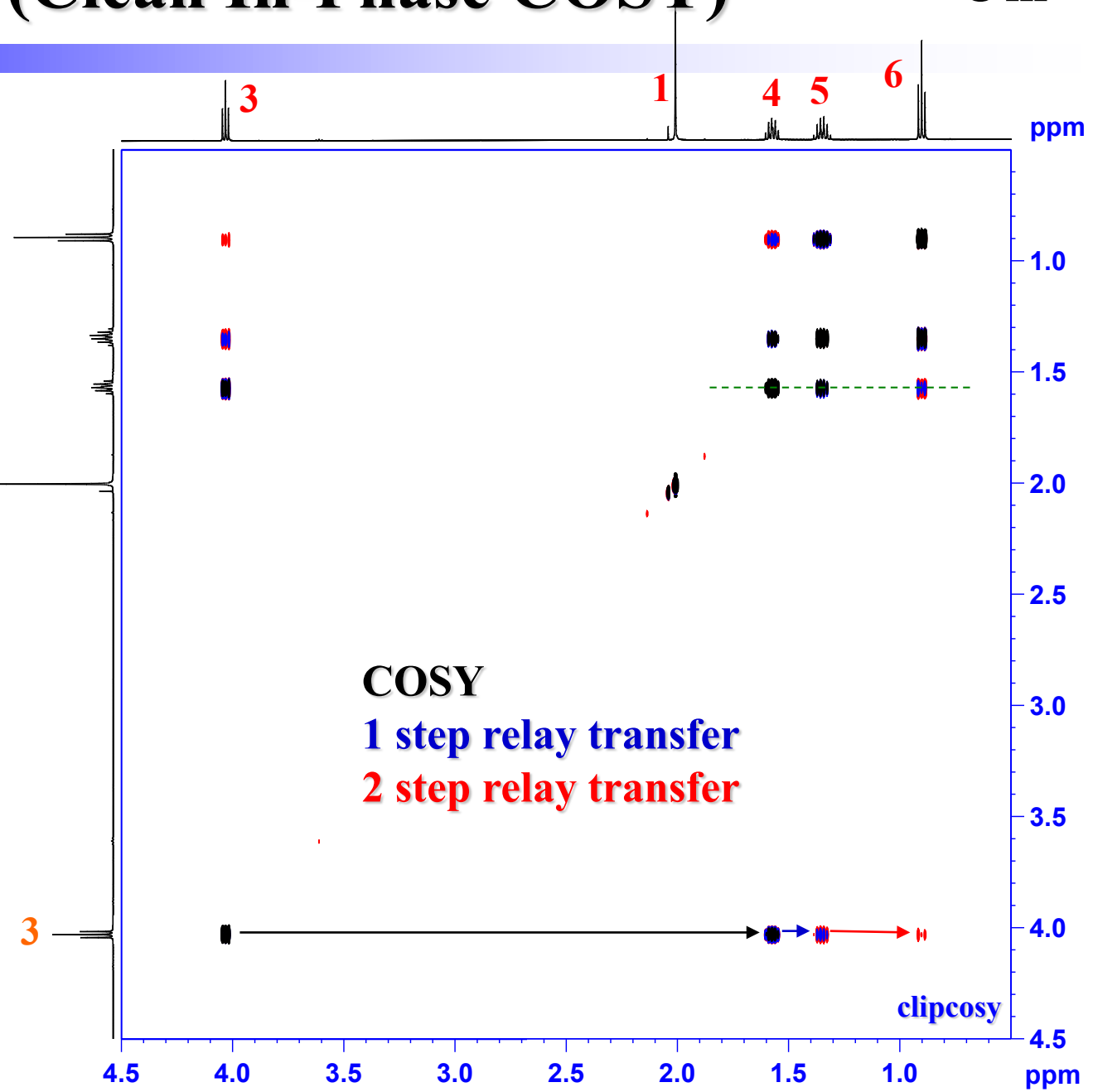
# CLIP-COSY (Clean In-Phase COSY)

②m



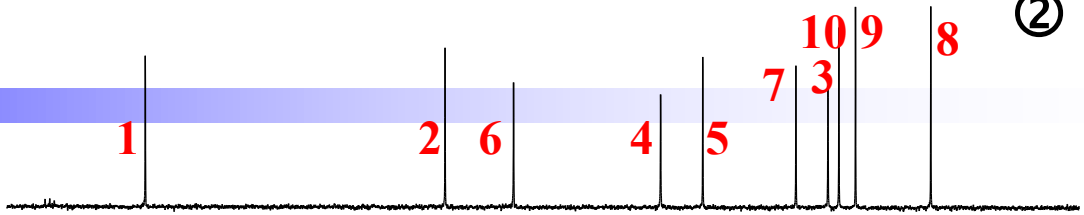



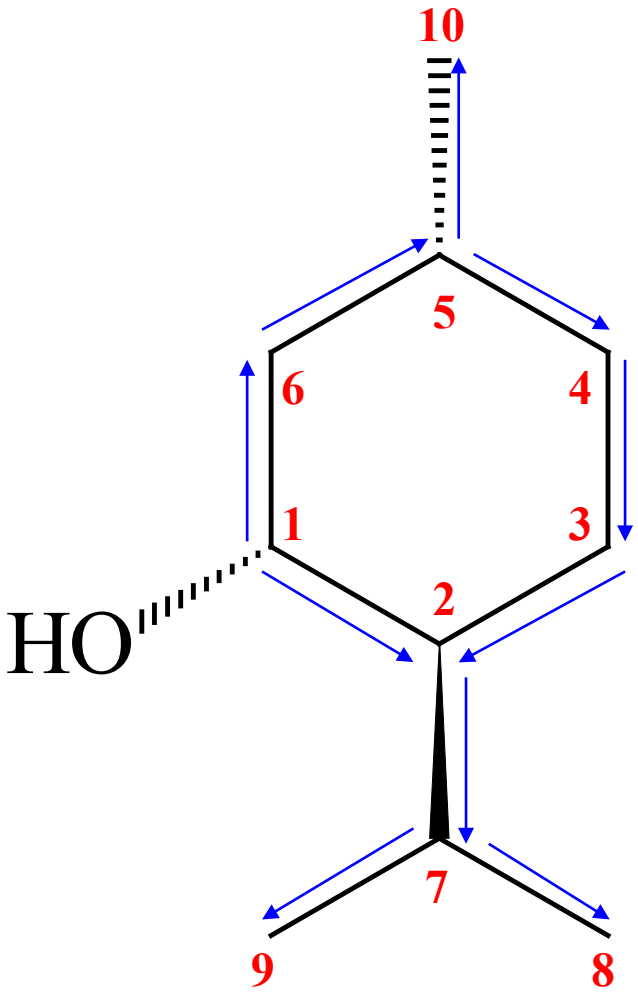

n-butyl acetate



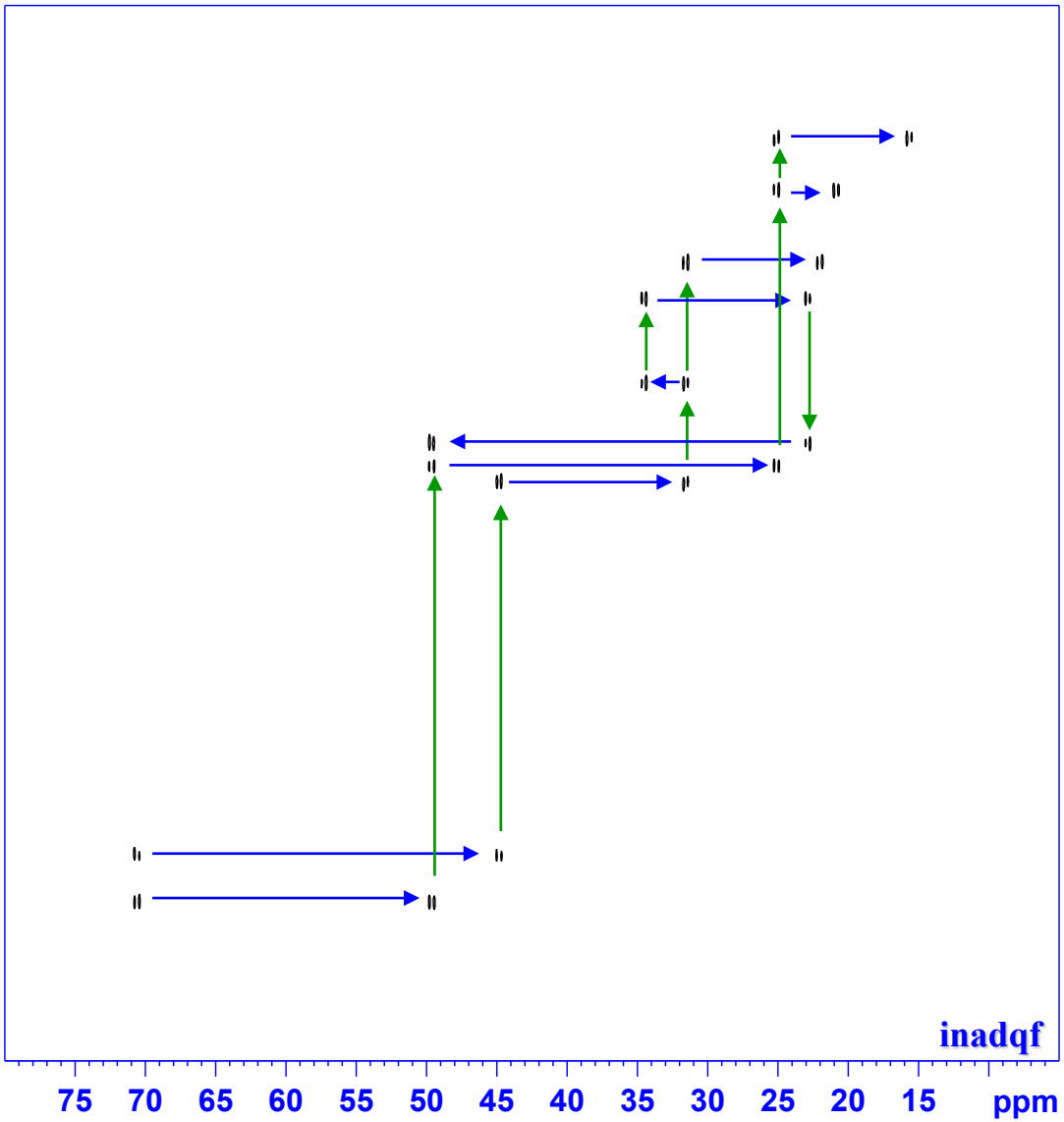

M. R. M. Koos, G. Kummerlöwe, L. Kaltschnee, C. M. Thiele & B. Luy, Angew. Chem. Int. Ed. 55, 7655-7659 (2016)

# INADEQUATE




(L)-Menthol



# Phase Sensitive-INADEQUATE

- Phase sensitive
- Increase sensitivity
- Reduce phase cycle
- Reduce relaxation delay

➢ **PS-INADEQUATE**

NS = 96, D1 = 2sec

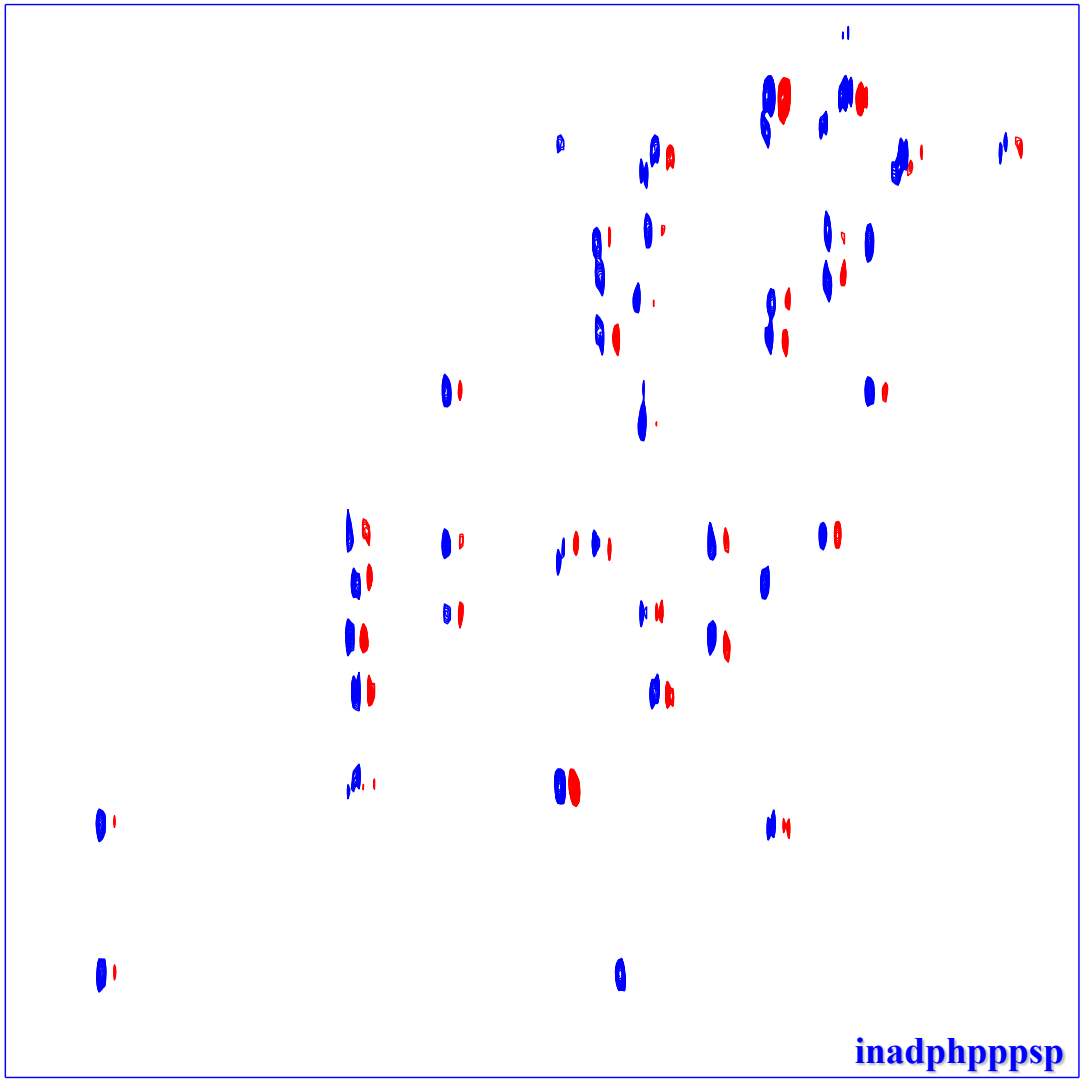
EXPT = 7hr 11min

➢ **INADEQUATE**

NS = 96, D1 = 5sec

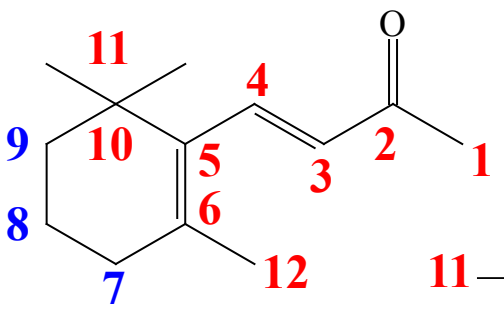
EXPT = 17hr 20min

1g Cholestererly Acetate (MW = 428.7) in $CDCl_3$



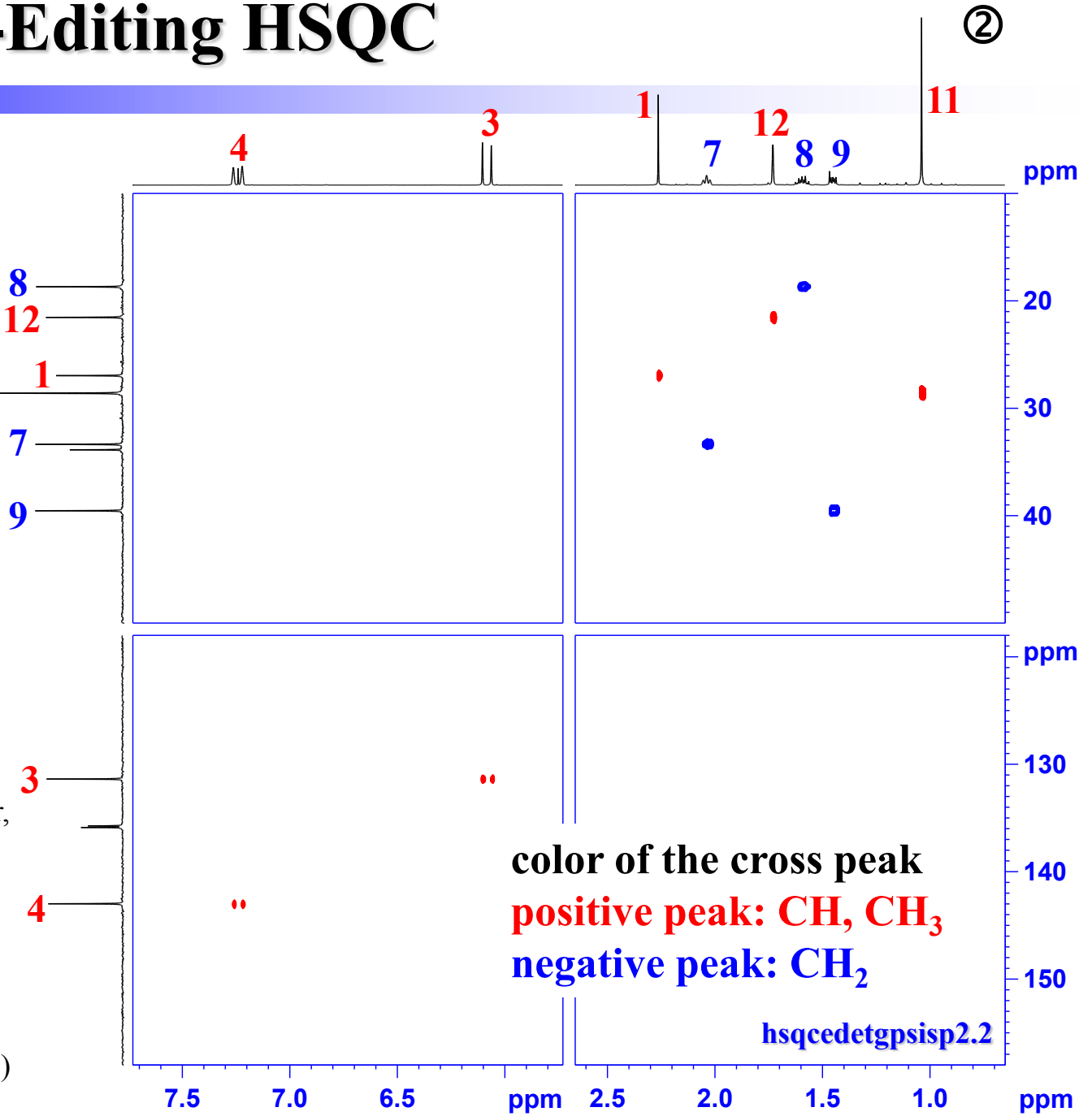
# Multiplicity-Editing HSQC



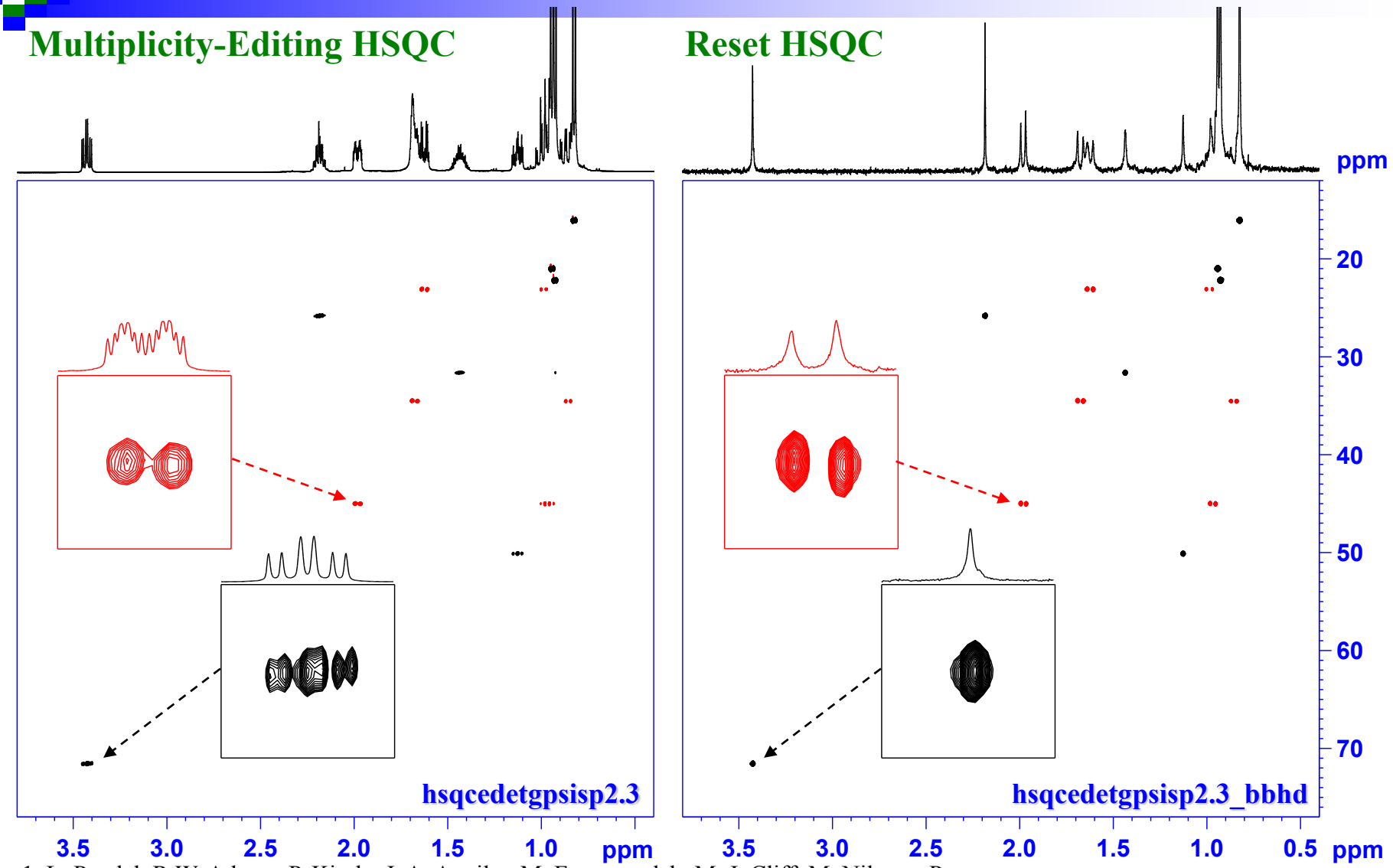



β-ionone


1. A.G. Palmer III, J. Cavanagh, P.E. Wright, M. Rance, J. Magn. Reson. 93, 151-170 (1991)
2. L.E. Kay, P. Keifer, T. Saarinen, J. Am. Chem. Soc. 114, 10663-5 (1992)
3. J. Schleucher, M. Schwendinger, M. Sattler, P. Schmidt, O. Schedletzky, S.J. Glaser, O.W. Sorensen & C. Griesinger, J. Biomol. NMR 4, 301-306 (1994)
4. W. Willker, D. Leibfritz, R. Kerssebaum,W. Bermel, Magn. Reson. Chem. 31, 287-292 (1993)

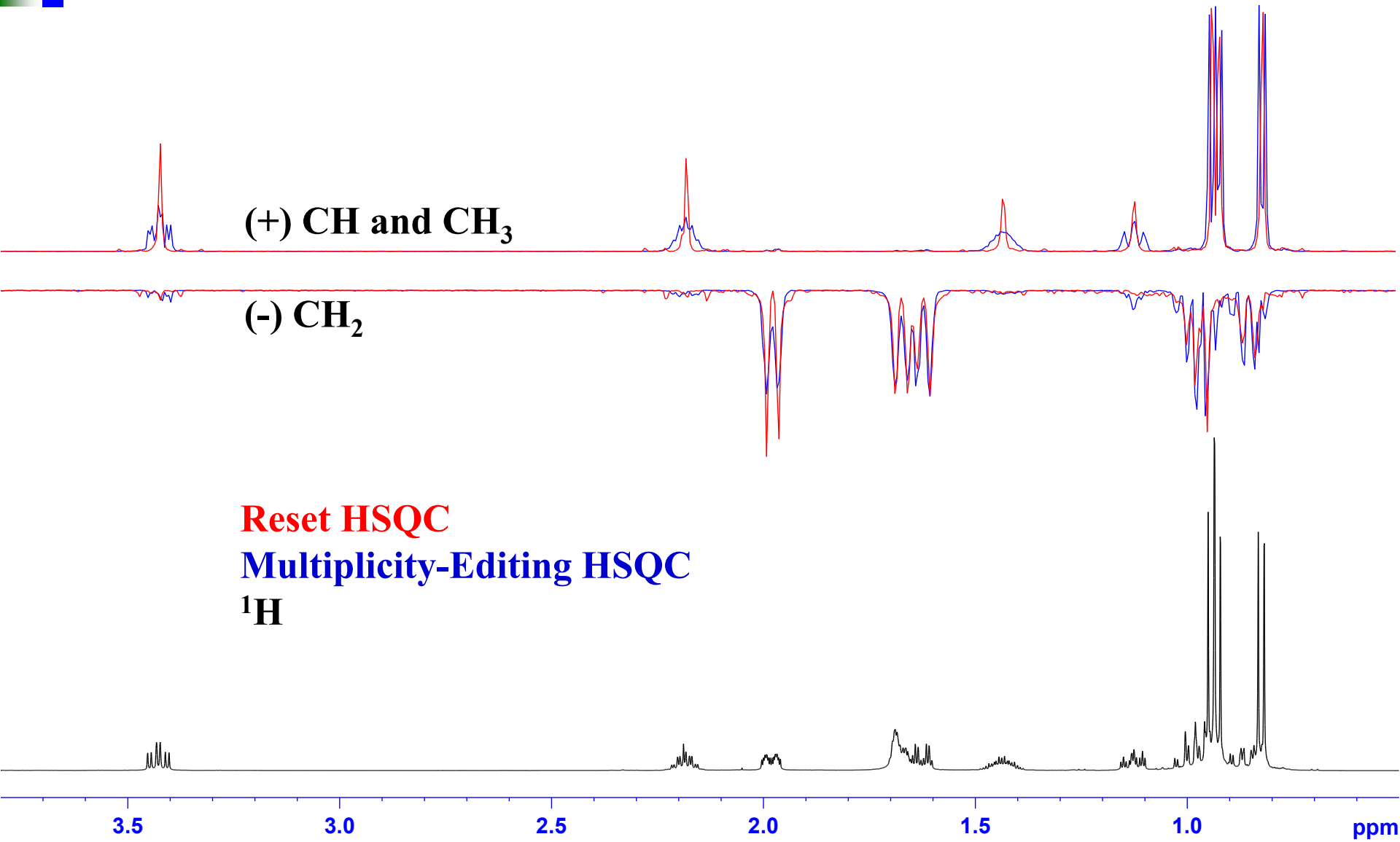
# Reset-HSQC (Pure-shift HSQC)



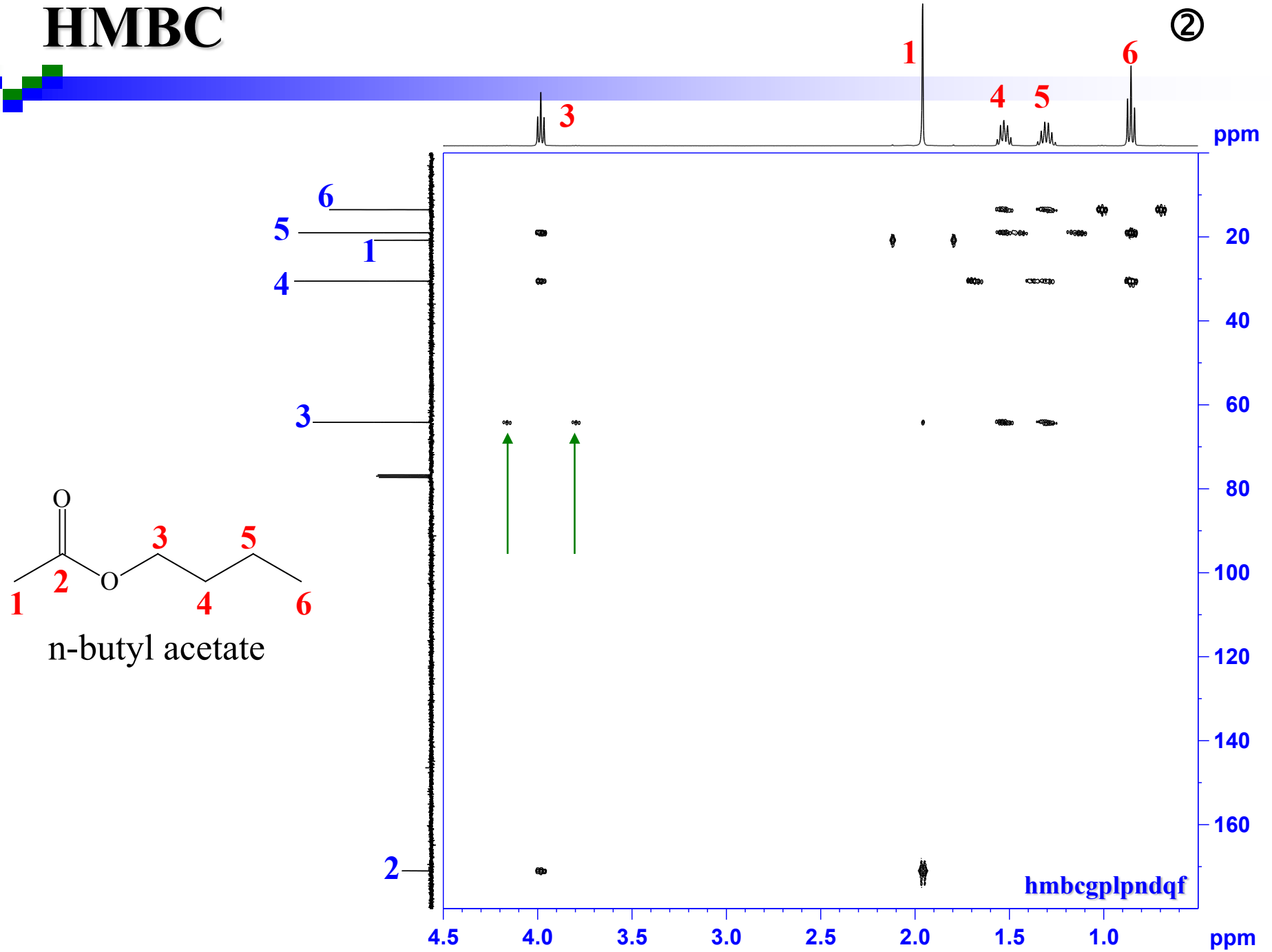


1. L. Paudel, R.W. Adams, P. Kiraly, J. A. Aguilar, M. Foroozandeh, M .J. Cliff, M. Nilsson, P. Sandor, J. P. Waltho, G.A. Morris, Angew. Chem. 125, 11830-11833 (2013)
2. P. Sakhaii, B. Haase & W. Bermel, J. Magn. Reson. 199, 192-198 (2009)
3. R.D. Boyer, R. Johnson & K. Krishnamurthy, J. Magn. Reson. 165, 253-259 (2003)

# Reset-HSQC (Pure-shift HSQC)

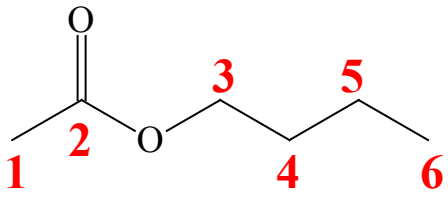


# HMBC


②
1
6
4
5
3
ppm
6
5
1
4
3
2
20
40
60
80
100
120
140
160
hmbcgplpndqf
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
ppm
O
O
1
2
3
4
5
6
n-butyl acetate

# Clean-HMBC

②m

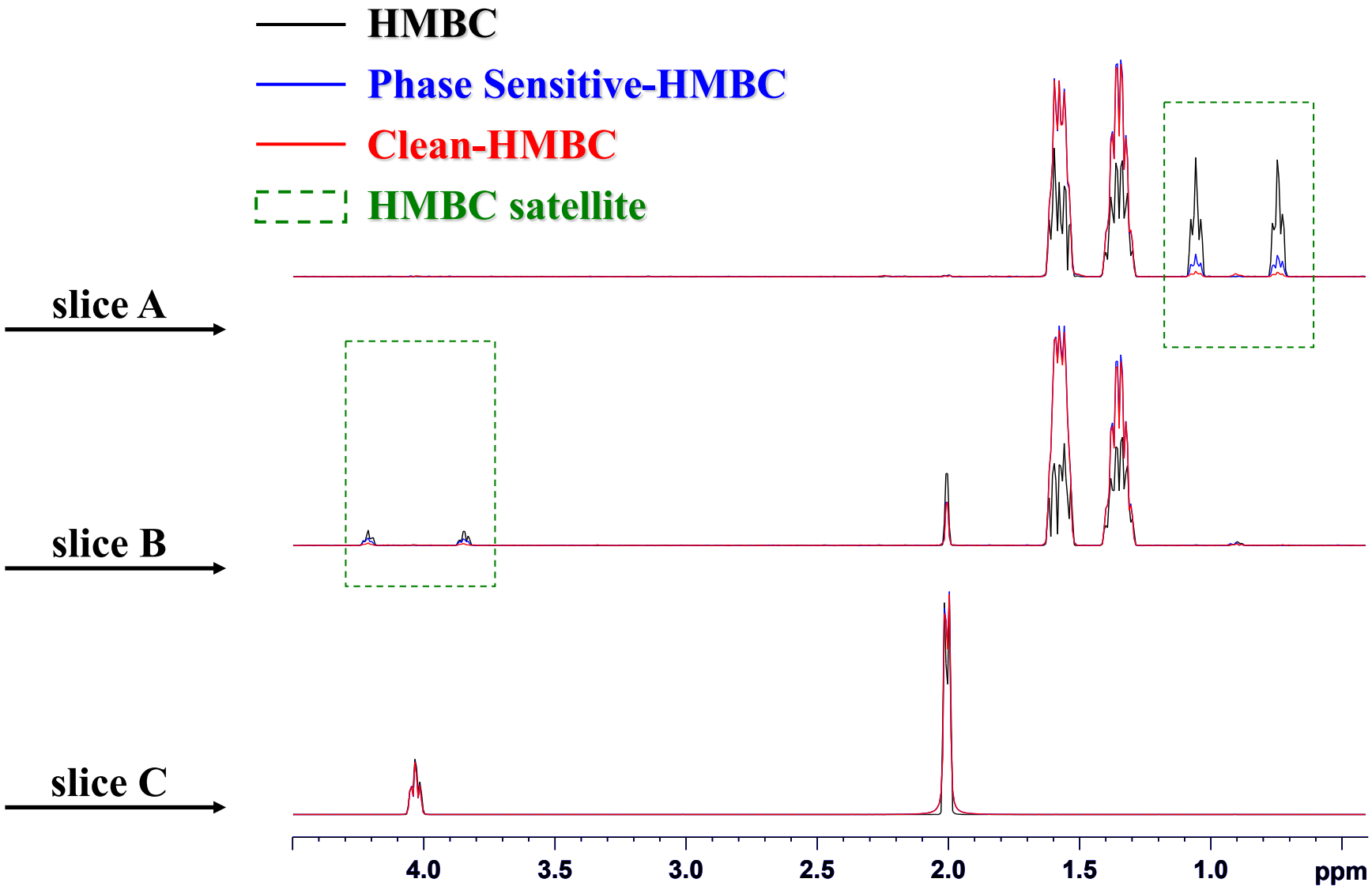



n-butyl acetate


1. P. Wuertz, P. Permi, N.C. Nielsen & O.W. Soerensen, J. Magn. Reson 194, 89-98 (2008)
2. D.O. Cicero, G. Barbato & R. Bazzo, J. Magn. Reson. 148, 209-213 (2001)

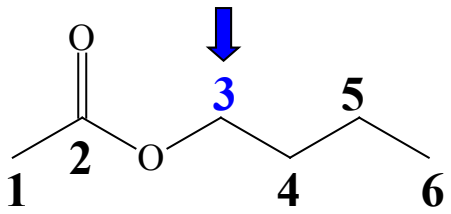
# Signal and Satellite

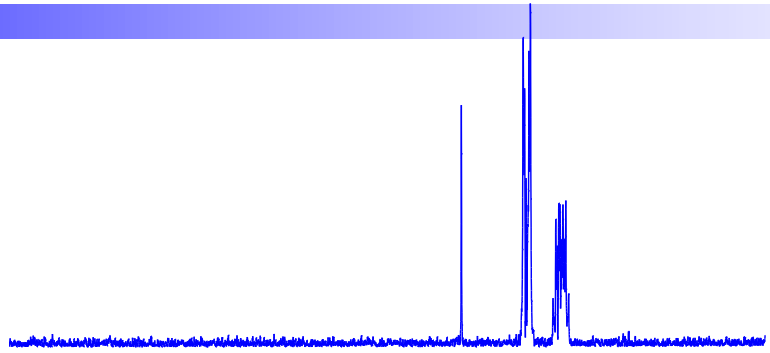
②m

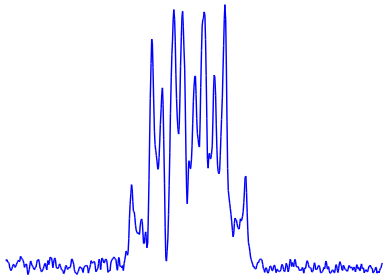


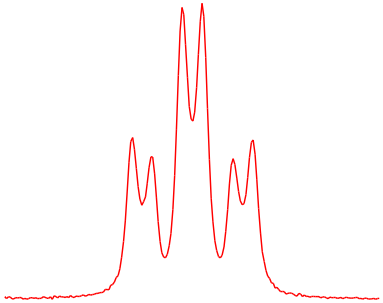
# 1D Selective Clean-HMBC

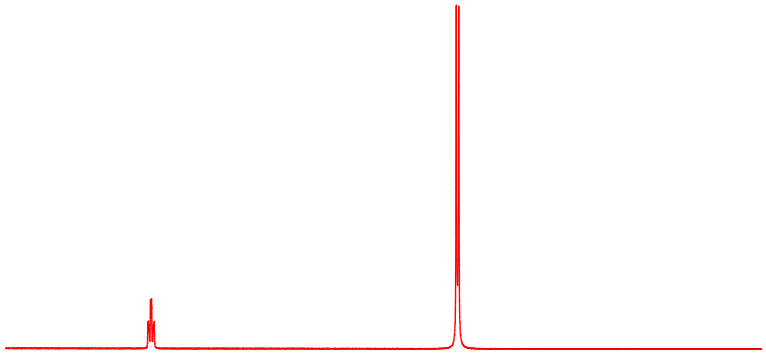
②m

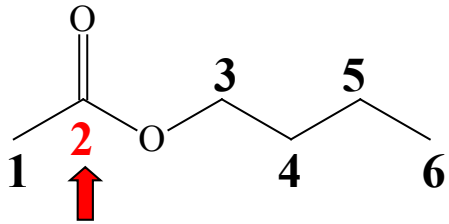


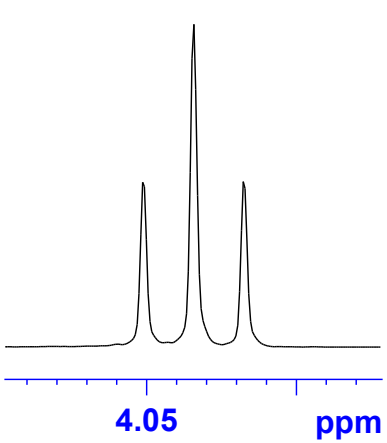



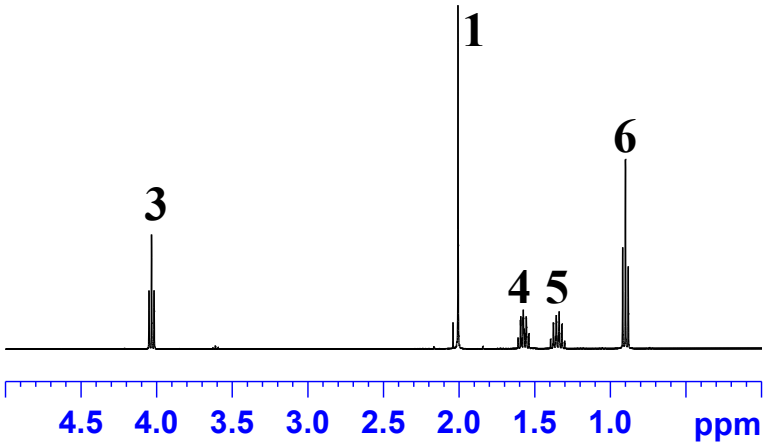


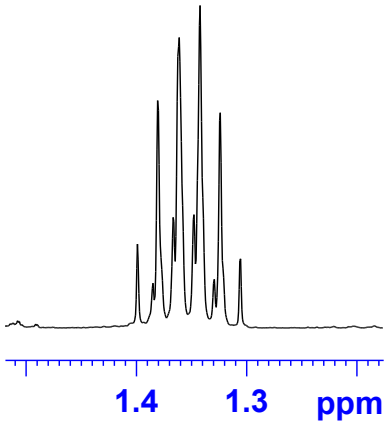






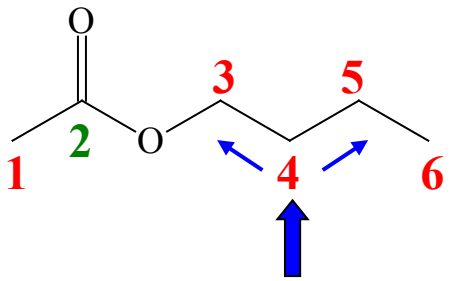



# H2BC



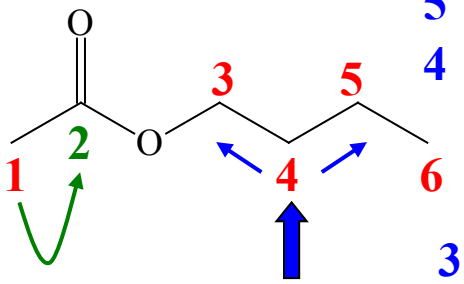



n-butyl acetate

N.T. Nyberg, J.O. Duus & O.W. Soerensen, J. Am. Chem. Soc. 127, 6154-6155 (2005)

# 1,1-ADEQUATE





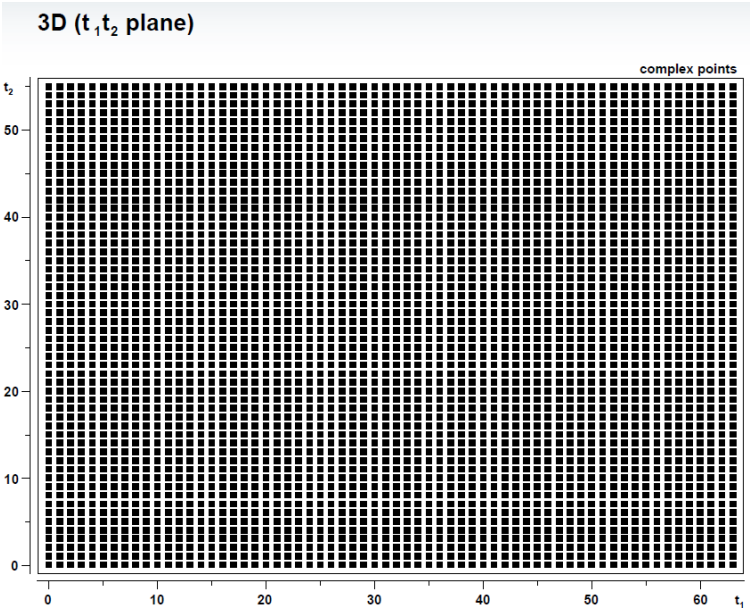

n-butyl acetate

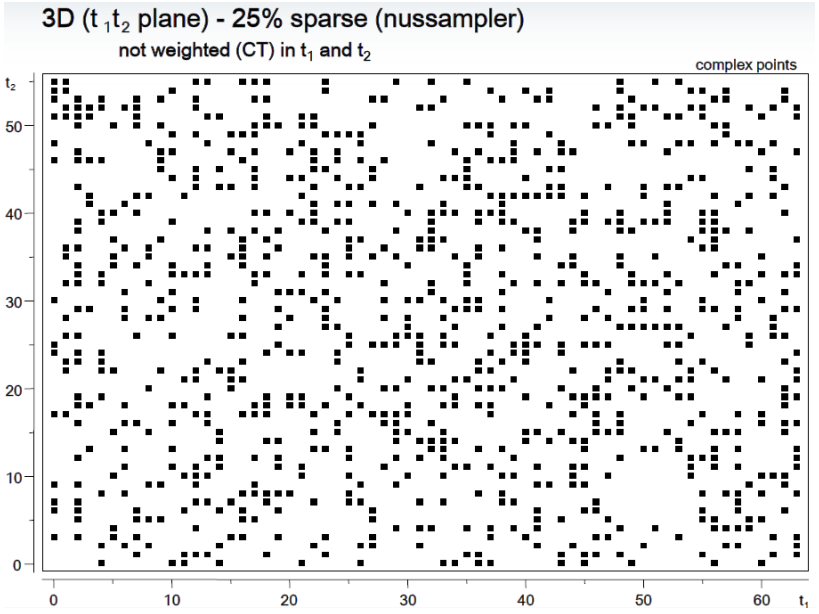
1. B. Reif, M. Koeck, R. Kerssebaum, H. Kang, W. Fenical & C. Griesinger J. Magn. Reson. A118, 282-285 (1996).

2. M. Koeck, R. Kerssebaum & W. Bermel, Magn. Reson. Chem. 41, 65-69 (2003)

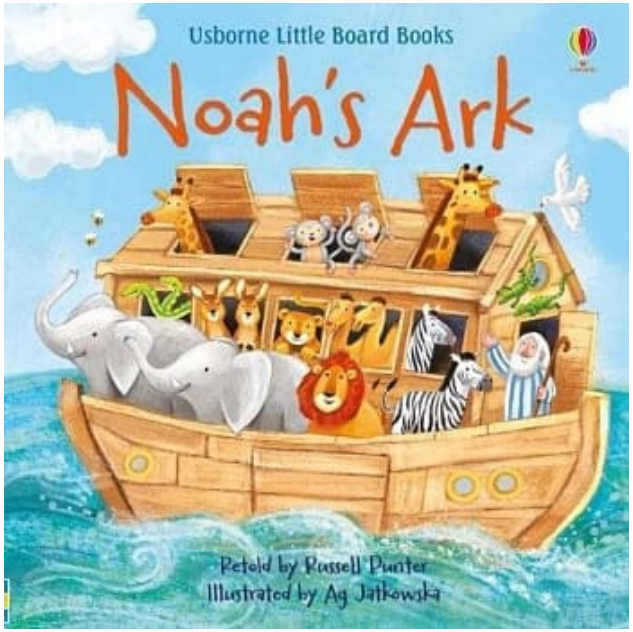
# NUS (Non Uniform Sampling)

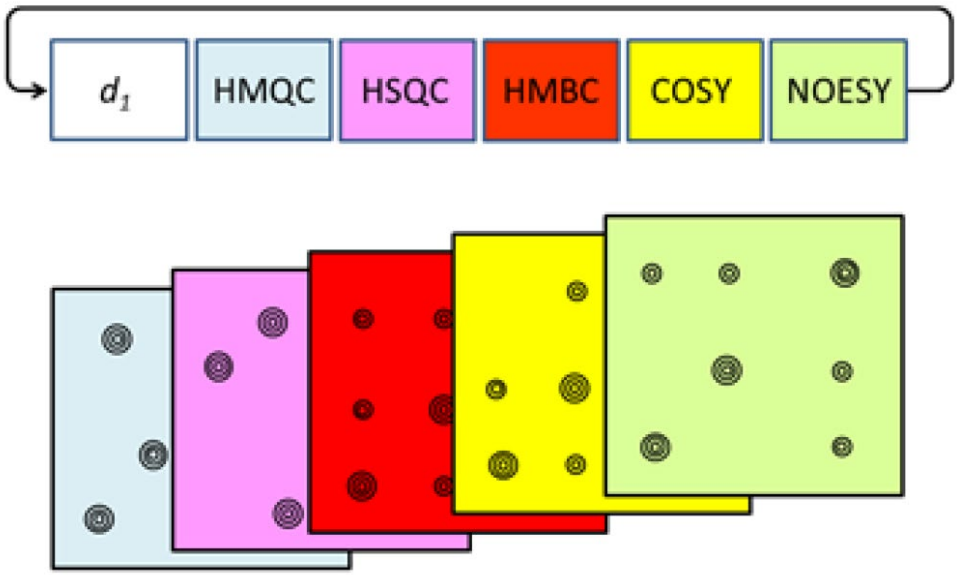
**NUS is sparse sampling method, samples a sub-set of the indirect dimension in a random (or weighted random) manner and then predicts the uncollected data based on the data sampled. The reconstructed data is then used for the indirect Fourier transforms. Usually, It will save more than 50% acquisition time in 2D experiments and get almost the same quality spectra.**



# NOAH (NMR by Ordered Acquisition using $^1$H-detection)





1. E. Kupce and T. D. W. Claridge, Angew. Chem. Int. Ed., 56, 11779-11783 (2017)
2. E. Kupce and T. D. W. Claridge, Chem. Commun., 54, 7139-7142 (2018)
3. T. D. W. Claridge, M. Mayzel, and E. Kupce, Magn Reson Chem. 57:946-952 (2019)
4. E. Kupce and T. D. W. Claridge, J. Magn. Reson. 307, 106568 (2019)

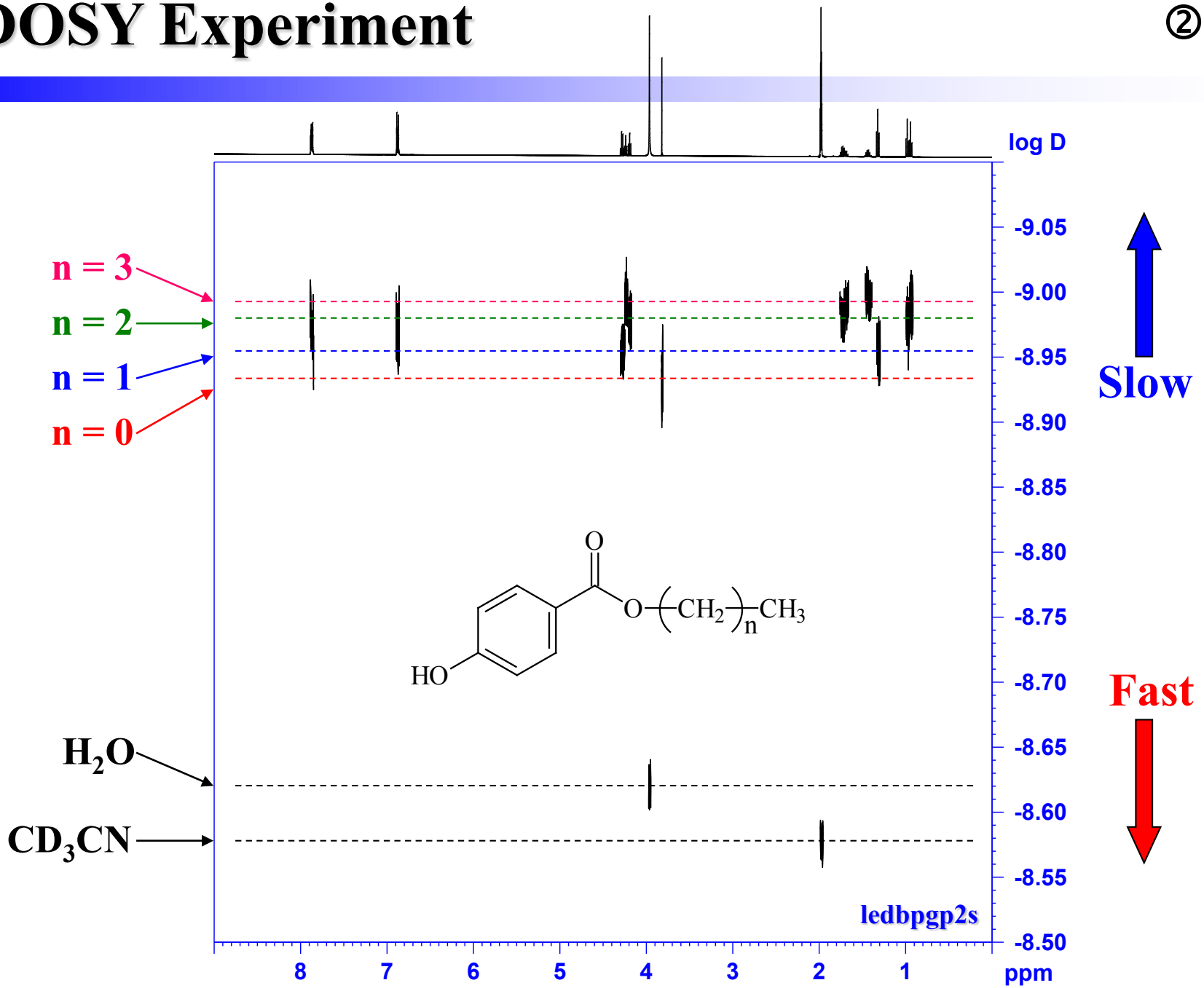

**NOAH2: BS, SC, MB...**

**NOAH3: BSC, BSN, BST...**

**NOAH4: BSCN, MSCN...**

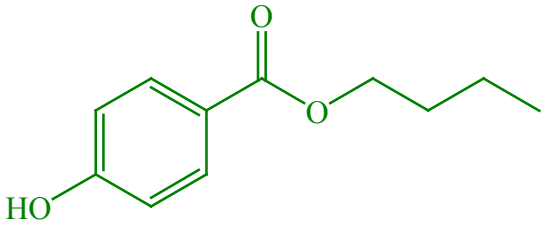
# DOSY Experiment





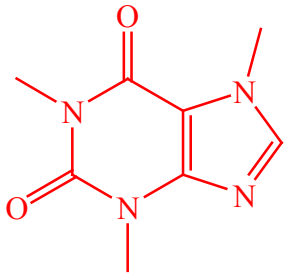
# DOSY Experiment





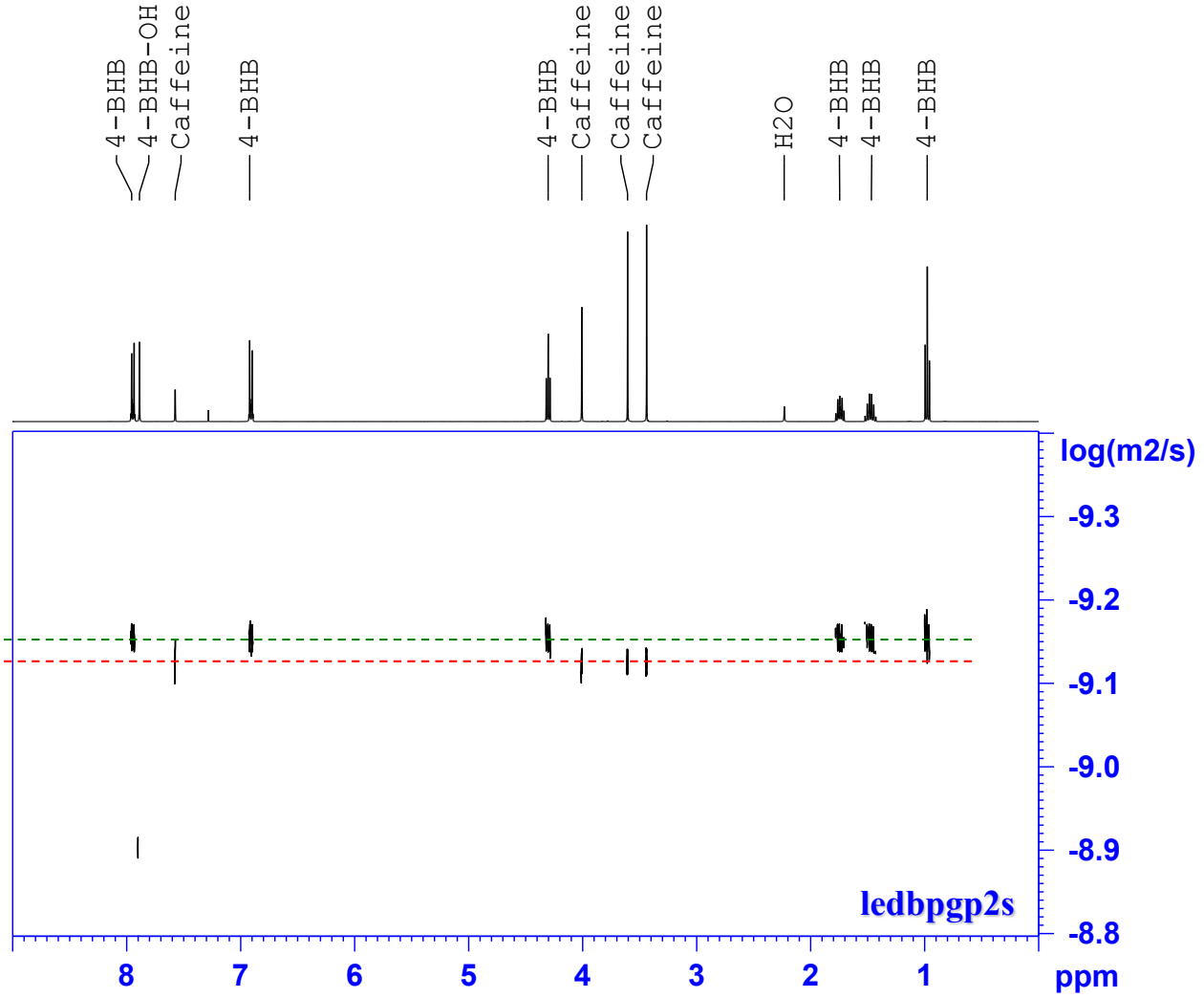

**Butyl-4-HydroxyBenzoate**

**(Mw = 194.23)**




**Caffeine**

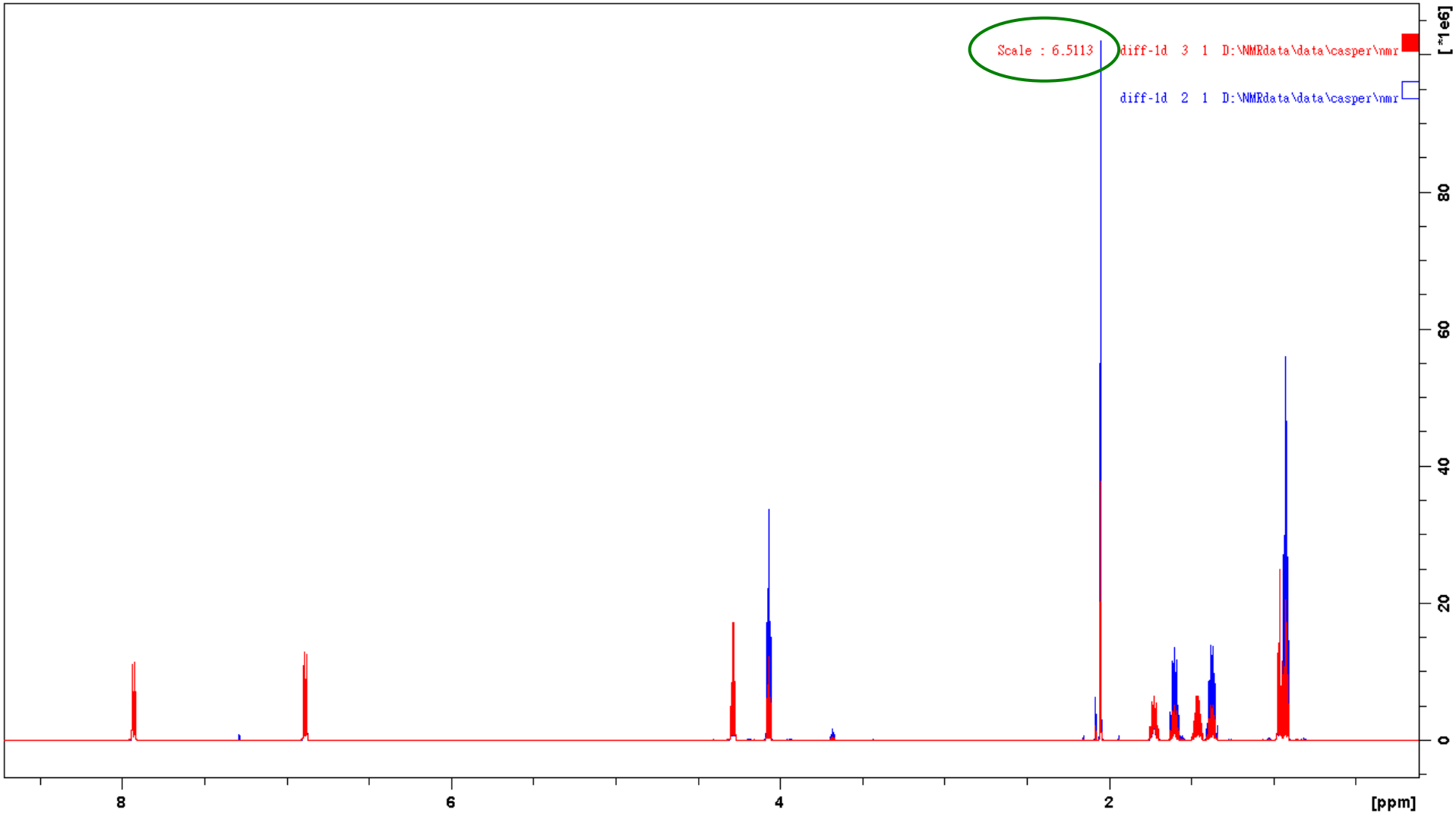
**(Mw = 194.19)**



# DOSY Experiment Setup

②

## adjust p30(δ) and d20(Δ)



**Thank you !!**