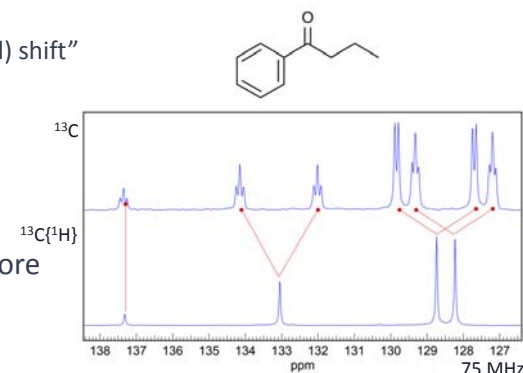


Resolving Complexity Pure Shift NMR

Will Kew
December 2017

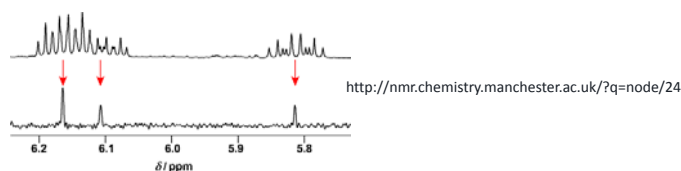
What is Pure Shift NMR?

- NMR spectra without coupling
 - Only chemical shift – “pure (chemical) shift”
- Decoupling of heteronuclear spins routinely possible!
- Homonuclear decoupling a little more complex...

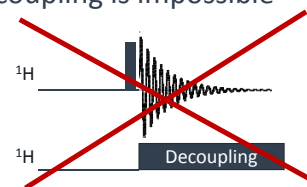
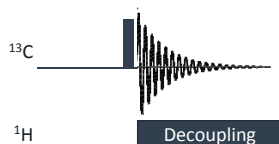


<https://www.chem.wisc.edu/areas/reich/handouts/NMR-Spectra/NMR-butyrophenone.pdf>

Homonuclear Decoupling



- Aim: Decouple homonuclear spins to increase resolution
- Reality: Perfect broadband homonuclear decoupling is impossible



Homonuclear Decoupling

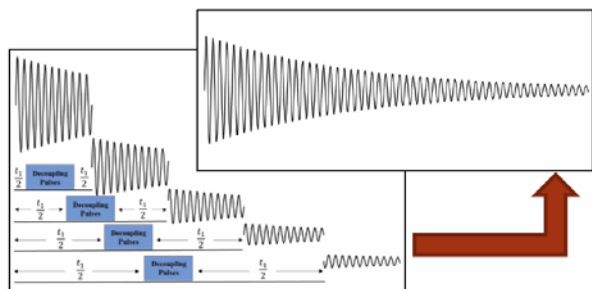
Selective Techniques

- Frequency Selective
 - Single frequency
- Band Selective (**BASHD/HOBS**)
 - Narrow range of frequencies
- Sensitivity >100%

Broadband Techniques

- Zangger-Sterk (**ZS**)
 - Real Time and Interferogram
 - Sensitivity worsens for larger sweep widths
- Bilinear Rotational Decoupling (**BIRD**)
 - Relies on ¹H-X-¹H filter
 - Sensitivity loss for natural abundance of X
 - ¹³C = 1.1% abundance (thus sensitivity)
- Pureshift Yielded by Chirp Excitation (**PSYCHE**)
 - Interferogram only in 1D NMR
 - In general, the best option for broadband decoupling
- Sensitivity 1-20%

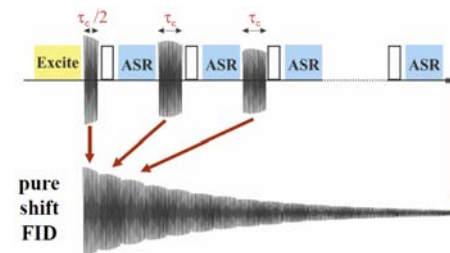
Interferogram – Pseudo-2D NMR



1D NMR experiment is repeated multiple times with variable delays
Pseudo 2D NMR dataset is concatenated into a single 1D FID

Time taken is significantly longer than a real-time experiment!

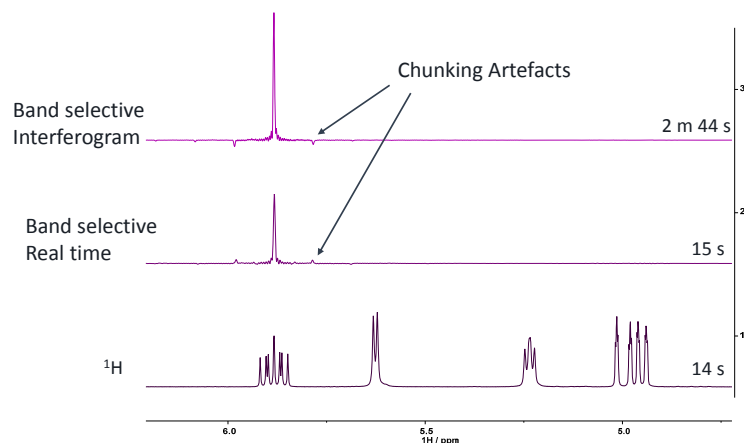
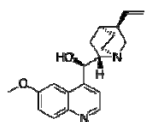
Real Time Pure Shift NMR



1D NMR experiment
Acquisition is repeatedly interrupted to refocus spins (decouple)
“Chunked” acquisition is stitched together into a single FID

No time penalty relative to a normal 1D experiment

Band Selective Approaches – 1D NMR



“Real time” takes no longer than a normal experiment

“Interferogram” takes considerably longer!

Quinine 50mM in DMSO
500MHz with room temp. probe

Band Selective in 2D NMR

Grey = Normal 2D TOCSY
Green = BASHD-TOCSY

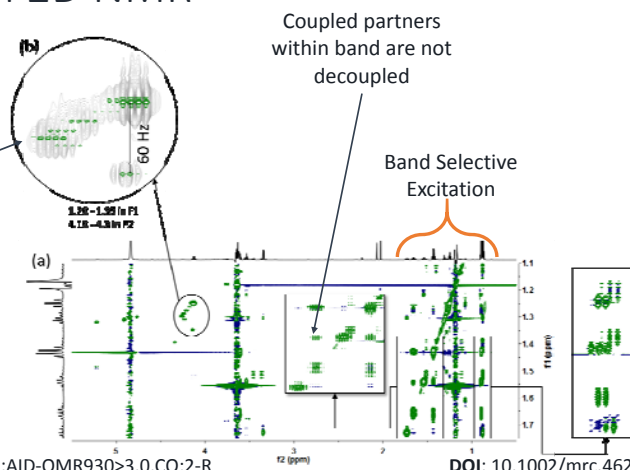
TOCSY cross peaks are decoupled in F1

BASHD experiments allow for substantial resolution increase

Resolve overlapping signals

No sensitivity loss

DOI: 10.1002/(SICI)1097-458X(199701)35:1<9::AID-OMR930>3.0.CO;2-R



DOI: 10.1002/mrc.4621

Broadband 1D Homodecoupling – Real Time

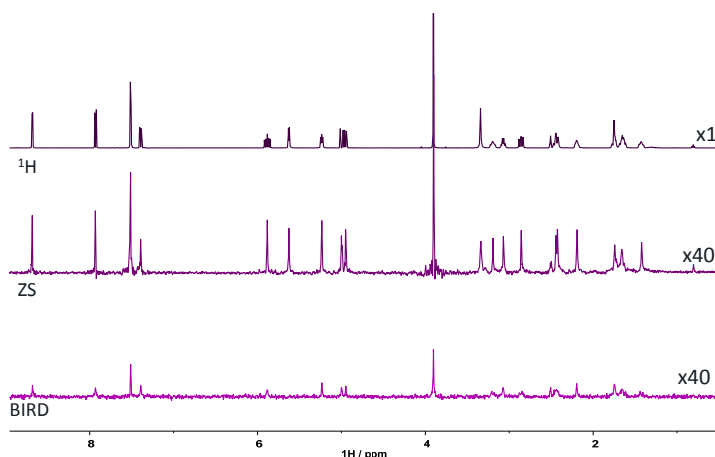
Broadband real time homodecoupling

Substantial sensitivity loss

Not-artefact free

Acceptable results for just 14s?

Quinine 50mM in DMSO
500MHz with room temp. probe



Broadband 1D Homodecoupling - Interferogram

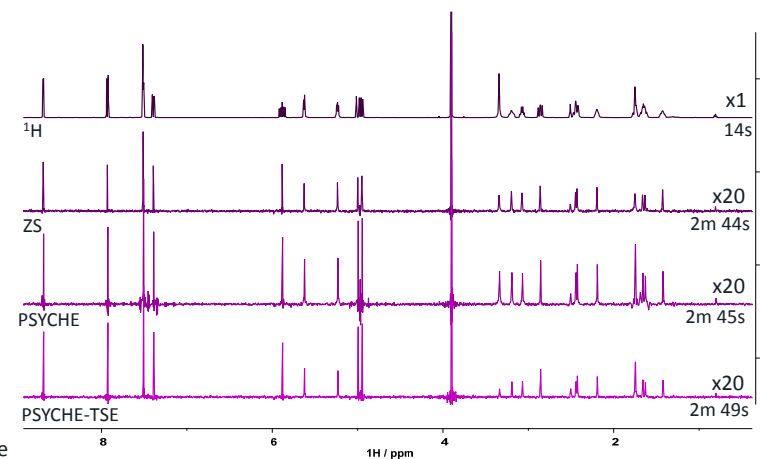
Fewer artefacts

Substantial sensitivity loss

Substantial time cost

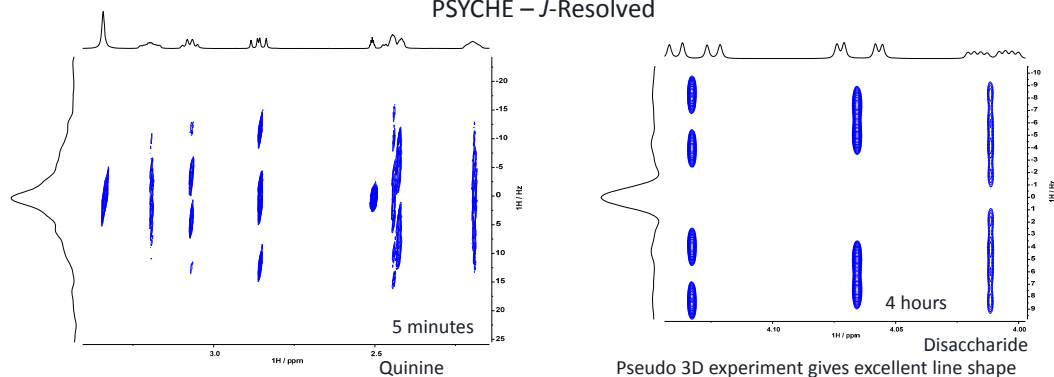
To get equivalent sensitivity would take >200x longer than normal 1D proton

Quinine 50mM in DMSO
500MHz with room temp. probe



Broadband Pure Shift in More Dimensions

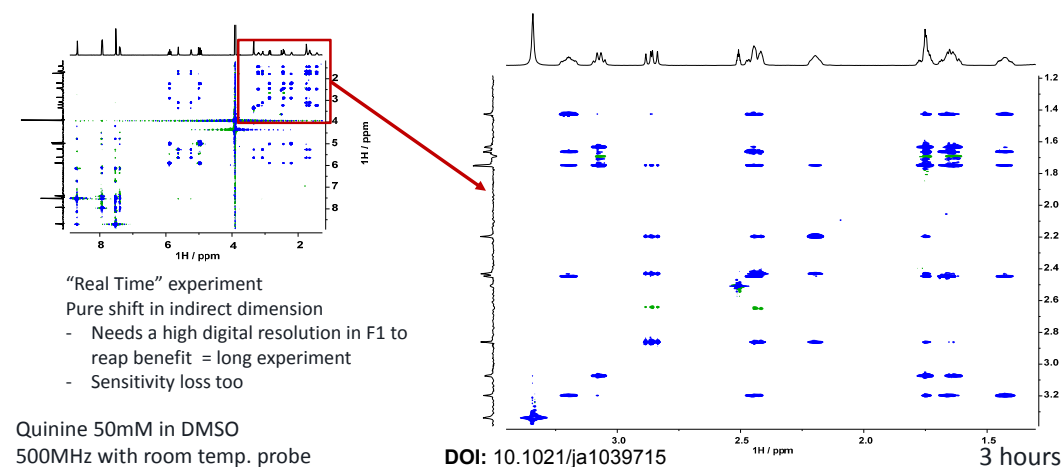
PSYCHE – J-Resolved



DOI: 10.1039/C5CC06293D

DOI: 10.1002/mrc.4671

F1-PSYCHE-TOCSY – 2D Broadband Pure Shift TOCSY



“Real Time” experiment

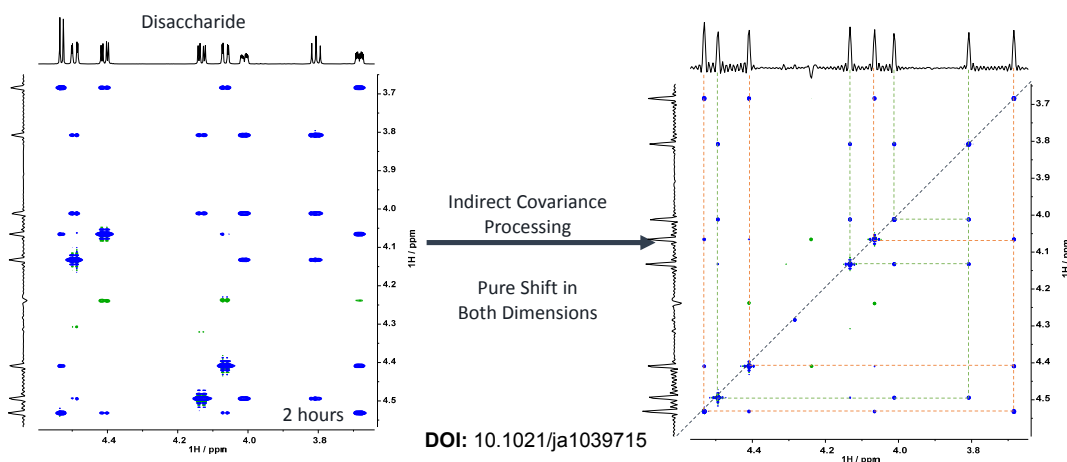
- Needs a high digital resolution in F1 to reap benefit = long experiment
- Sensitivity loss too

Quinine 50mM in DMSO
500MHz with room temp. probe

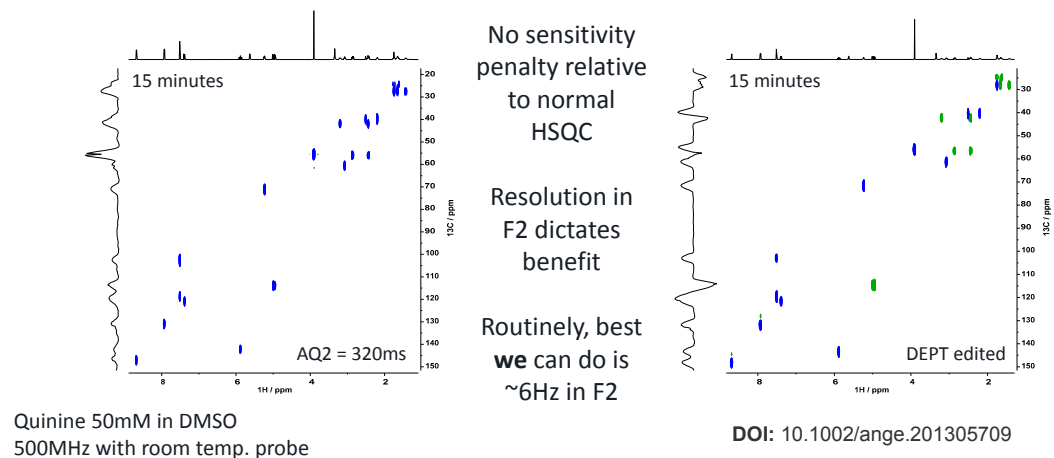
DOI: 10.1021/ja1039715

3 hours

Covariance NMR for Pure Shift – F1-PSYCHE-TOCSY

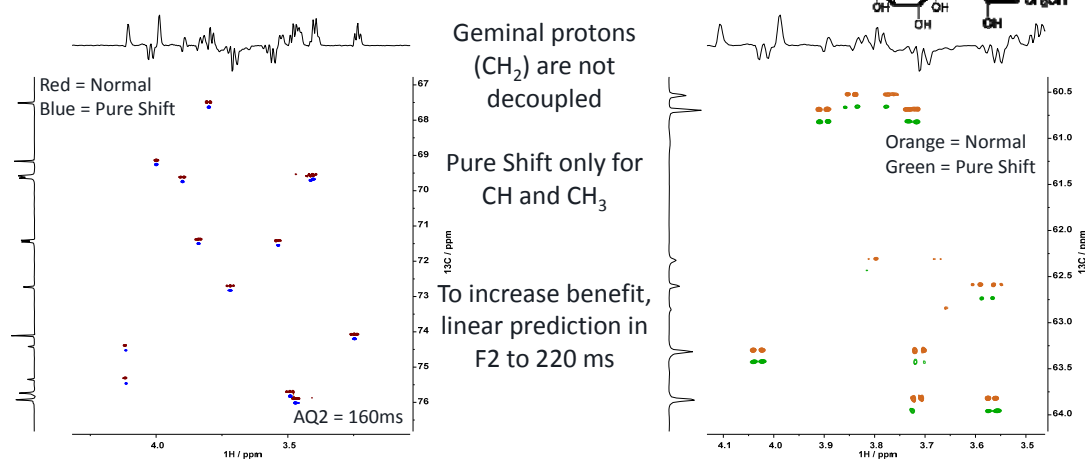


Pure Shift BIRD HSQC – Real time in F2

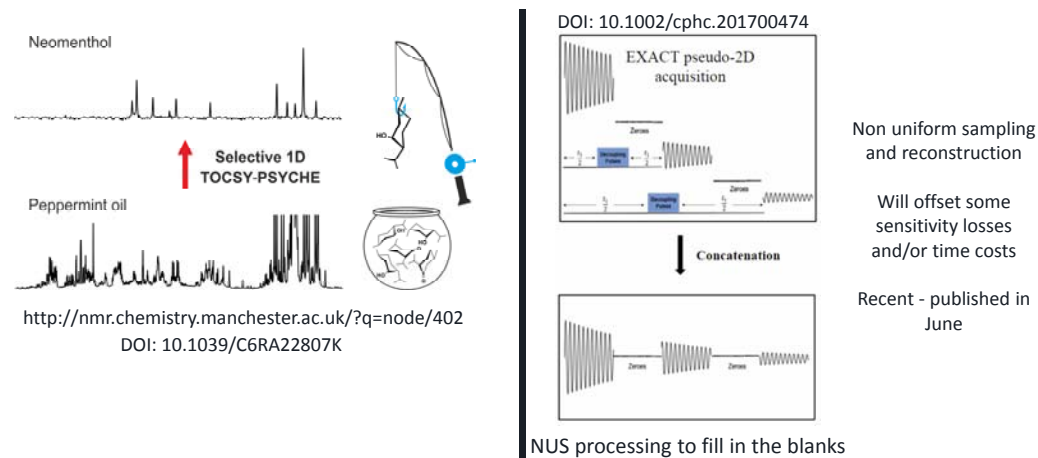


Note: spectra have been overlaid and shifted on y-axis for visualisation

Pure Shift BIRD HSQC - Real Time in F2



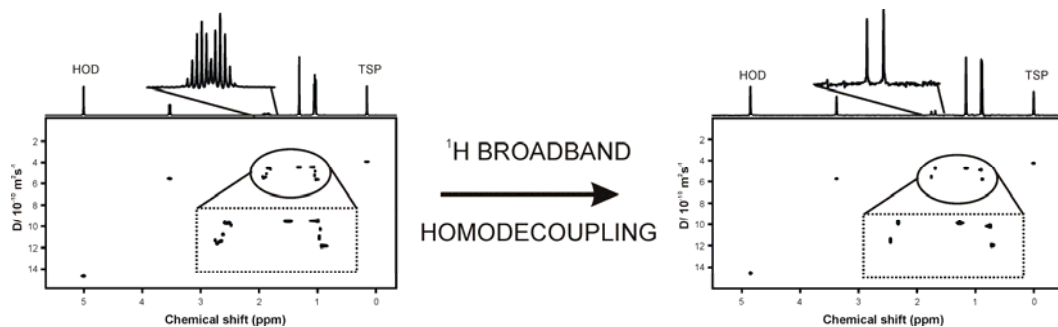
Other Pure Shift Advances





Pure Shift DOSY

DOI: 10.1039/b617761a



^1H BROADBAND
HOMODECOUPLING

PSYCHE-iDOSY

Loss of sensitivity due to PSYCHE element
Time increase due to being pseudo-3D experiment
Time = hours



Practical Aspects of Pure Shift NMR

- Automation at Edinburgh:
 - 1D PSYCHE
 - 2D BIRD HSQC
- Other techniques available upon request in manual
- See Juraj or Lorna
- Interferogram must be reconstructed
 - Automation will do that for you
- TopSpin use the "pshift" au script
- MestreNova automatically process 1D pure shift data
 - May struggle with 2D data
 - Unable to process pseudo-3D data

<http://nmr.chemistry.manchester.ac.uk/?q=node/24>