

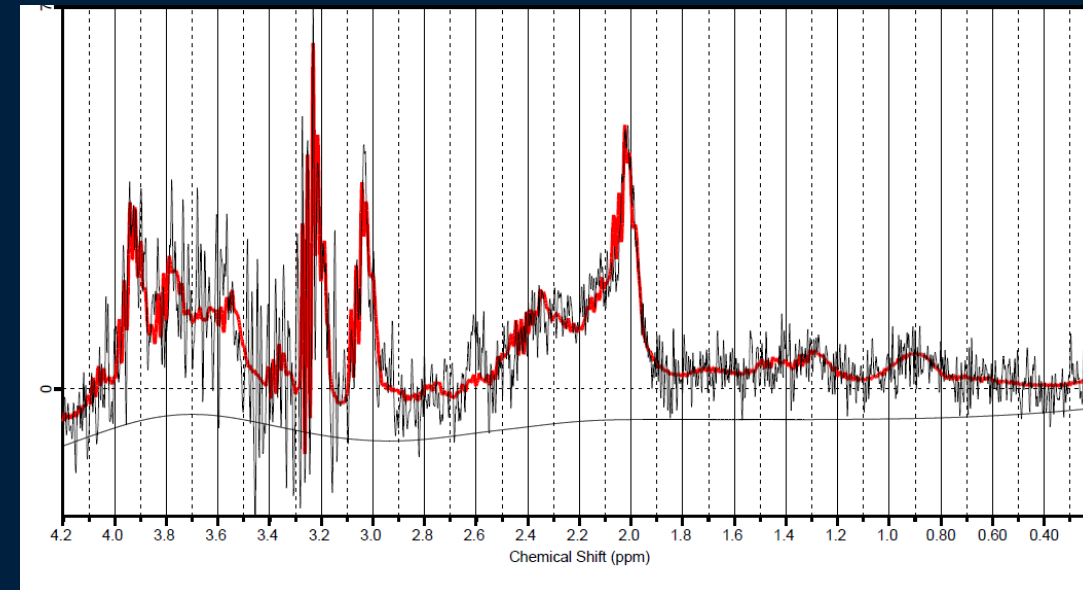
IN VIVO MRS: A GALLERY OF ARTIFACTS REVISITED



Erin MacMillan

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SFU ImageTech Lab, Simon Fraser University, Surrey, BC,
Canada





Declaration of Financial Interests or Relationships

Speaker Name: **Erin MacMillan**

I have the following financial interest or relationship to disclose with regard to the subject matter of this presentation:

Company Name: **Philips Canada**

Type of Relationship: **Salary Support**

WHAT IS A GALLERY OF ARTIFACTS?



NMR IN BIOMEDICINE
NMR Biomed. 2004;17:361–381
Published online in Wiley InterScience (www.interscience.wiley.com). DOI:10.1002/nbm.891

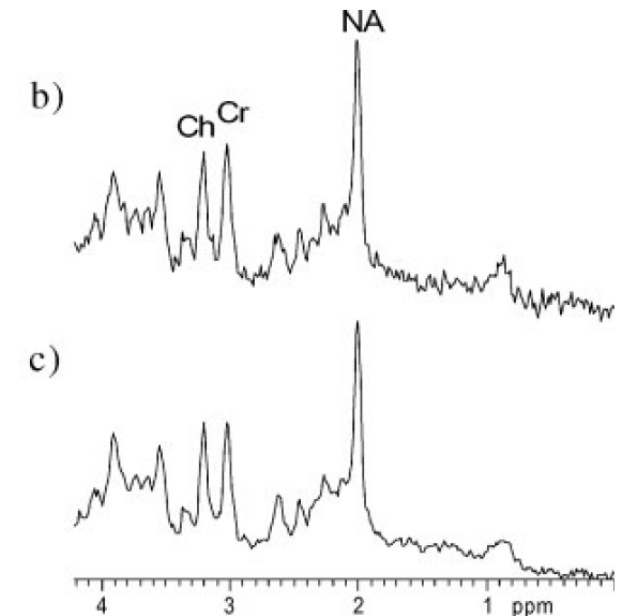
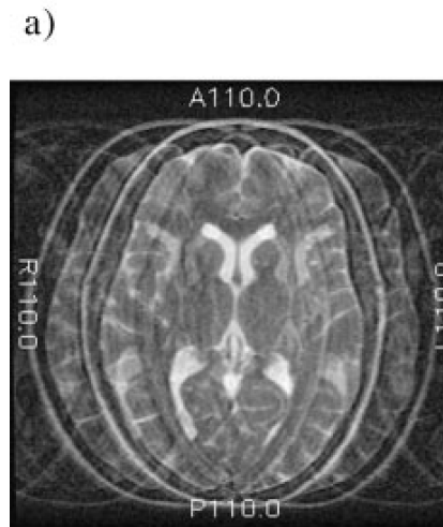
Review Article

Issues of spectral quality in clinical ^1H -magnetic resonance spectroscopy and a gallery of artifacts

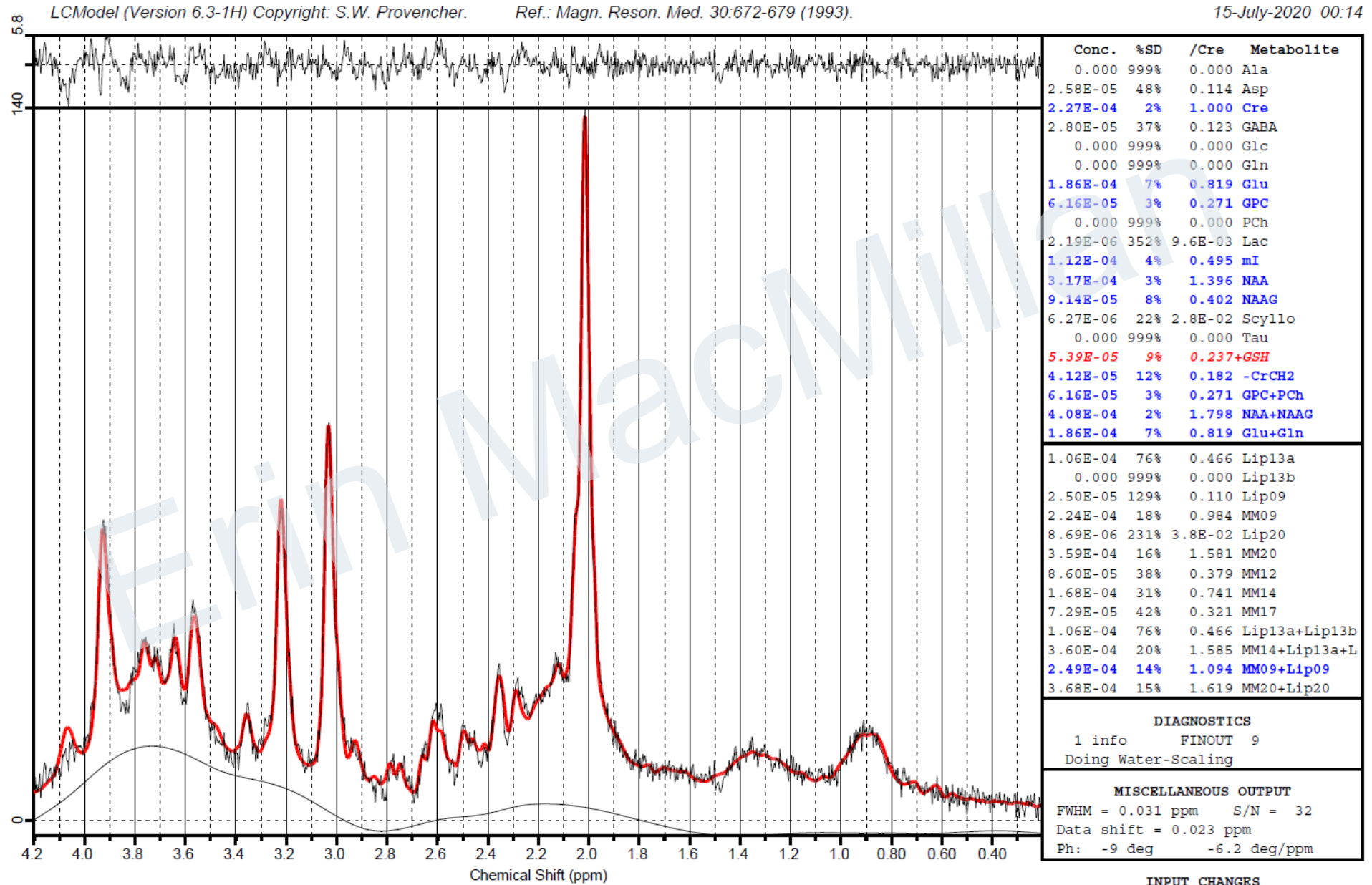
Roland Kreis*

Department of Clinical Research, Unit for MR Spectroscopy and Methodology, University Berne, Switzerland

Garbage In
↓
Garbage Out



WHAT IS A GALLERY OF ARTIFACTS?



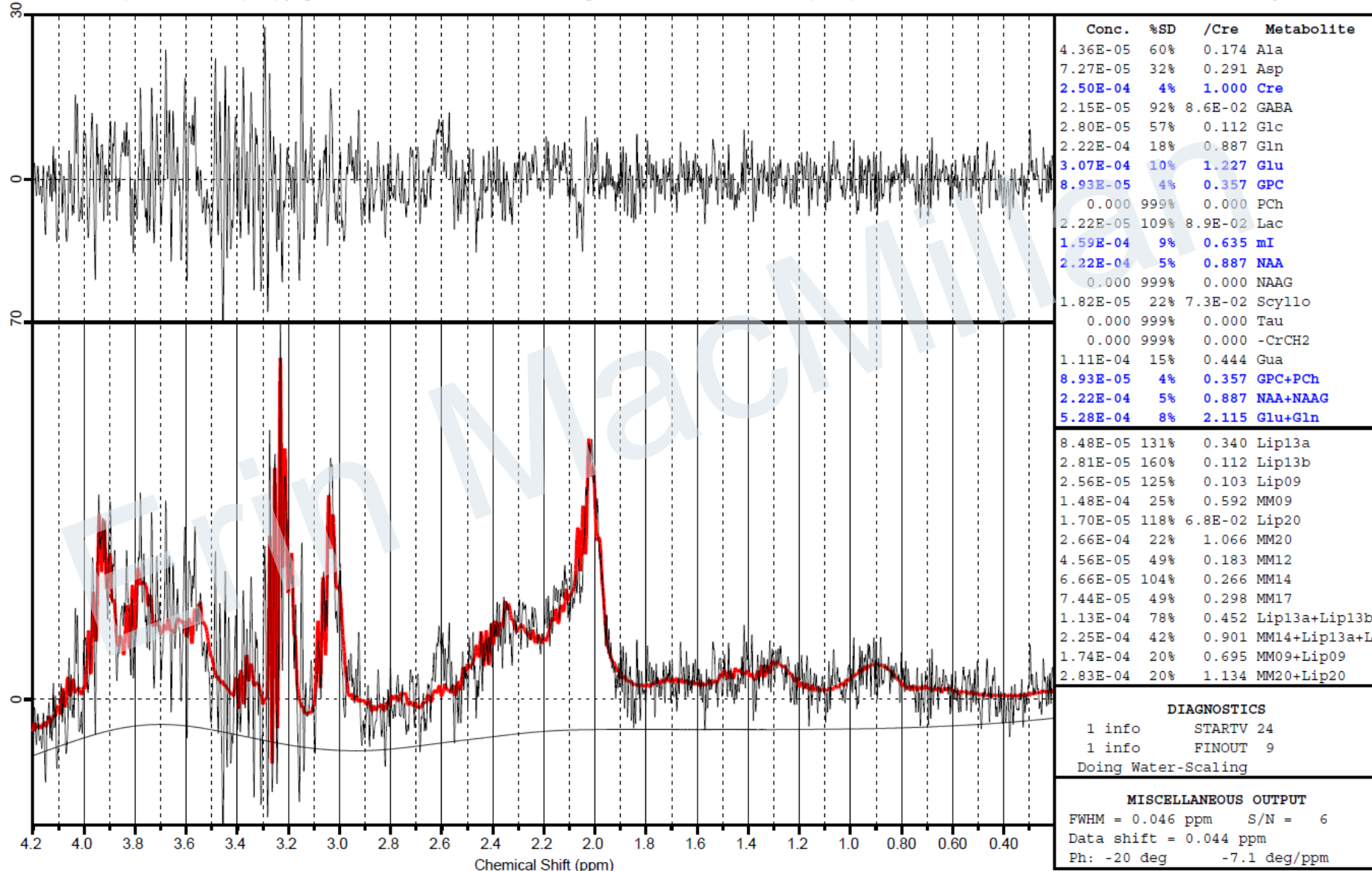
WHAT IS A GALLERY OF ARTIFACTS?



LCModel (Version 6.3-1H) Copyright: S.W. Provencher.

Ref.: Magn. Reson. Med. 30:672-679 (1993).

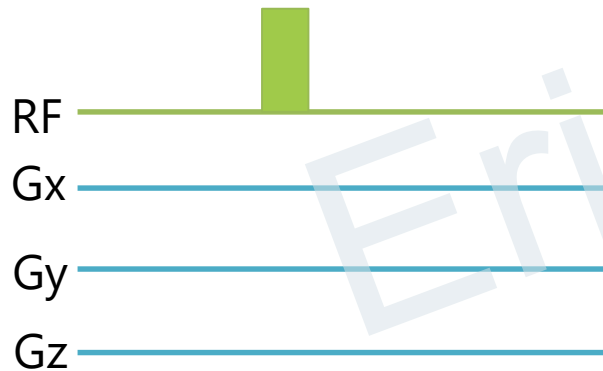
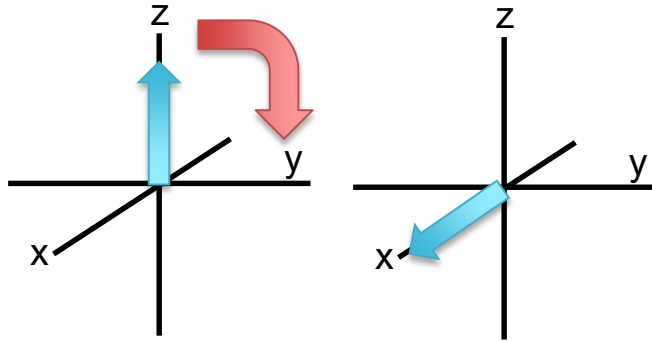
28-July-2017 16:25



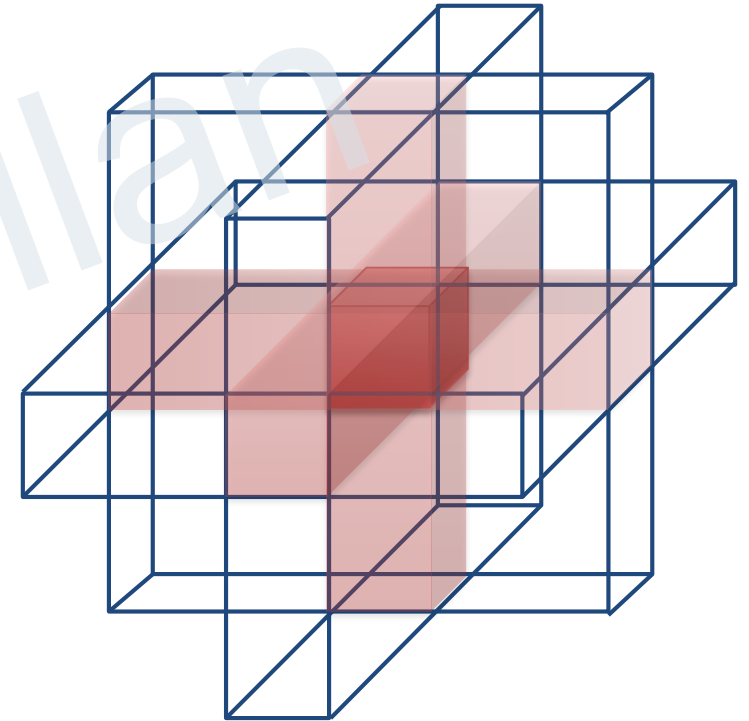
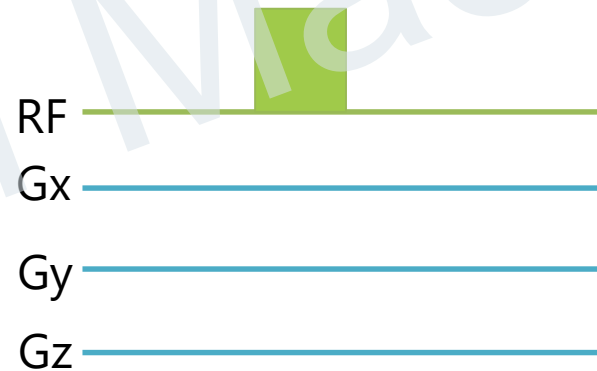
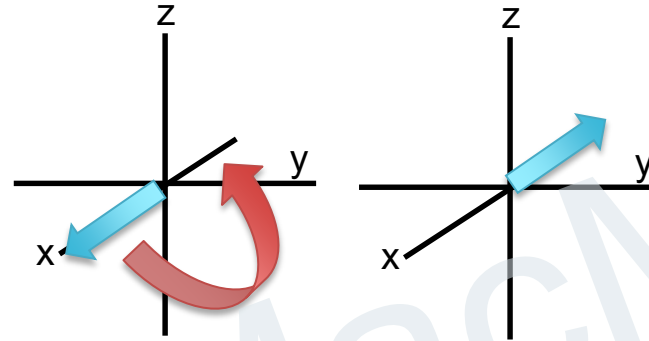
MRS ACQUISITION TOOLKIT



90° Excitation



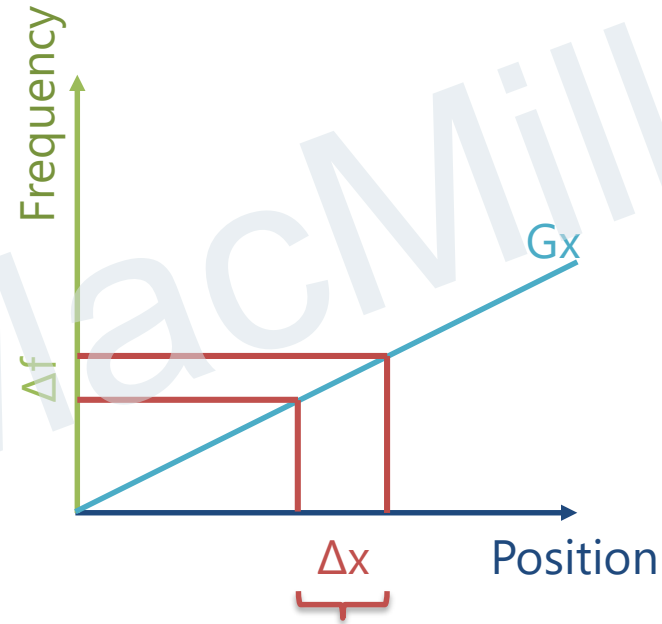
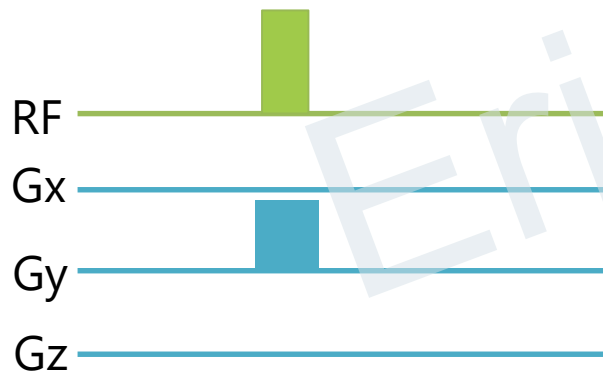
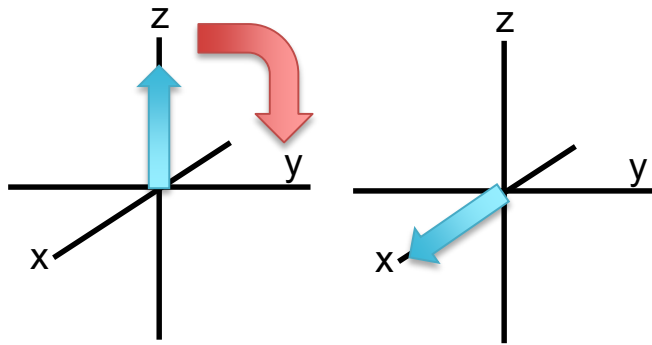
180° Refocus



MRS ACQUISITION TOOLKIT



Slice Selection

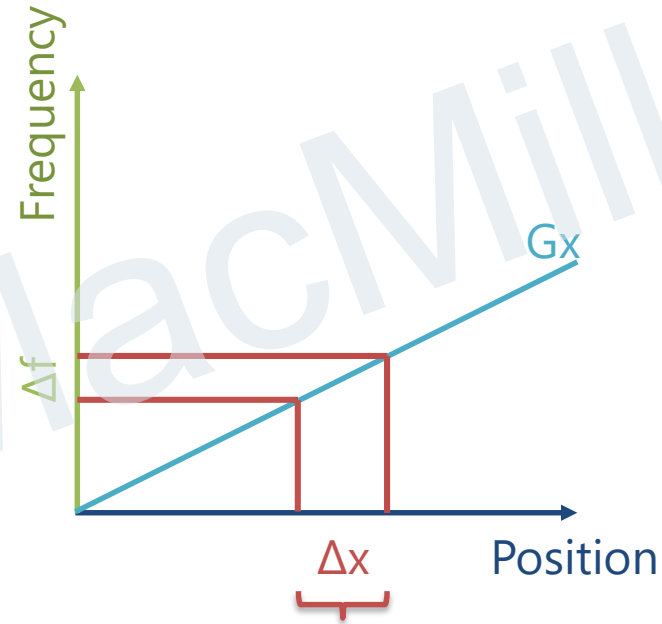
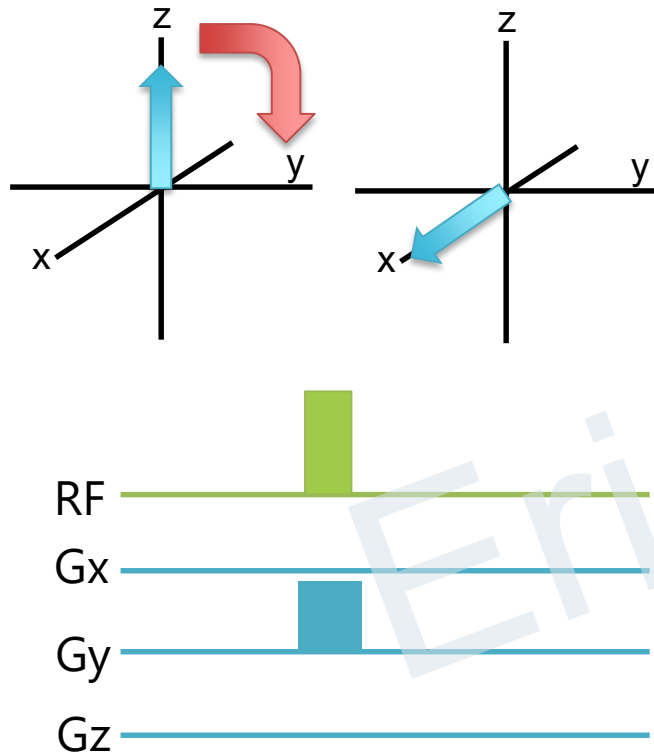


Slice Thickness

MRS ACQUISITION TOOLKIT – UNINTENDED CONSEQUENCES

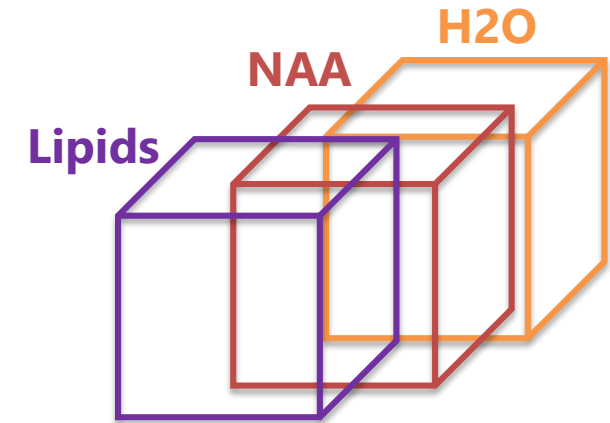


Slice Selection



Slice Thickness

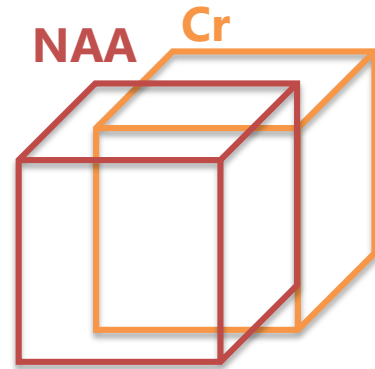
Chemical Shift Displacement Artifact



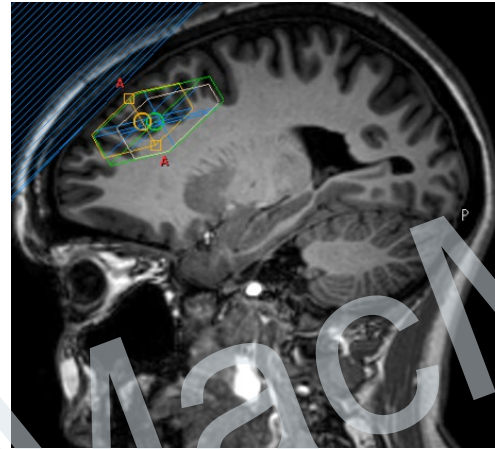
GALLERY OF ARTIFACTS



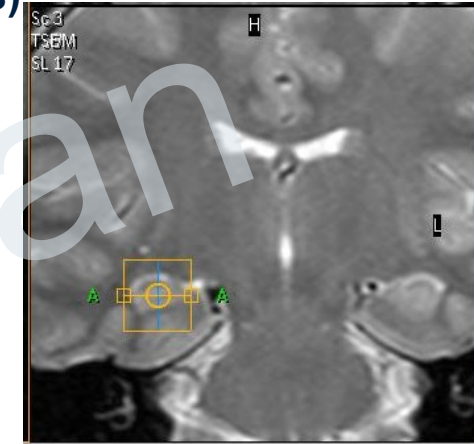
Chemical Shift Displacement Artifact



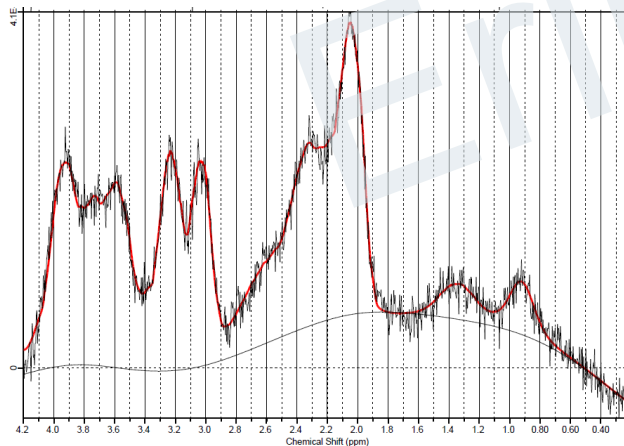
Outer Volume Signal Bleed



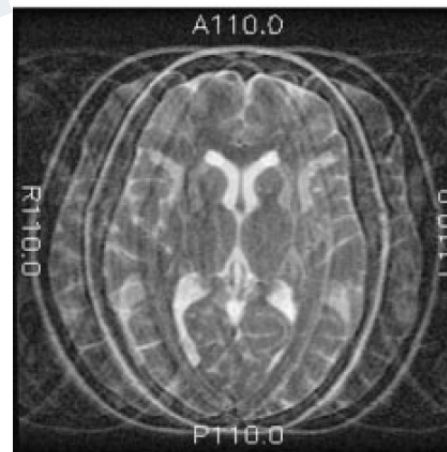
Outer Volume Spurious Echoes (Ghosts)



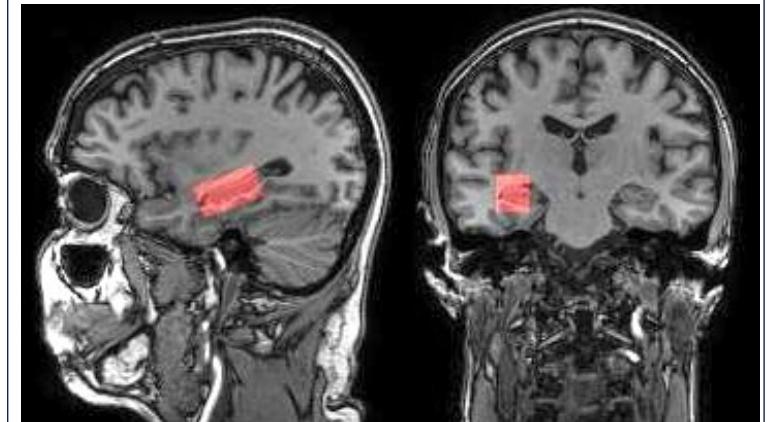
Poor Shimming



Motion Artifacts



Challenging Locations – All of the above!



CHEMICAL SHIFT DISPLACEMENT ARTIFACTS: PROBLEMS

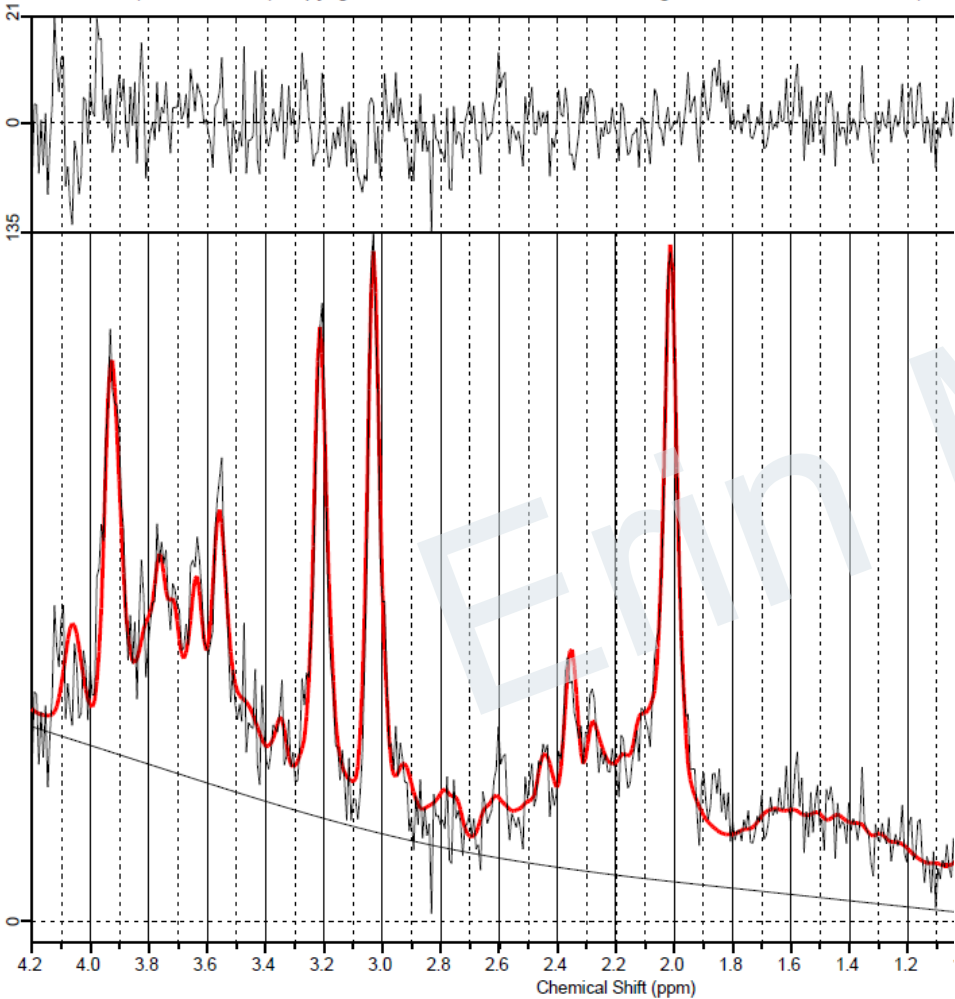


6.75e+00 mL, TE/TR/NS=35/2000/128

(FEM MRS SVS3 HC LT)

Data of: Radiology Research, The University of British Co

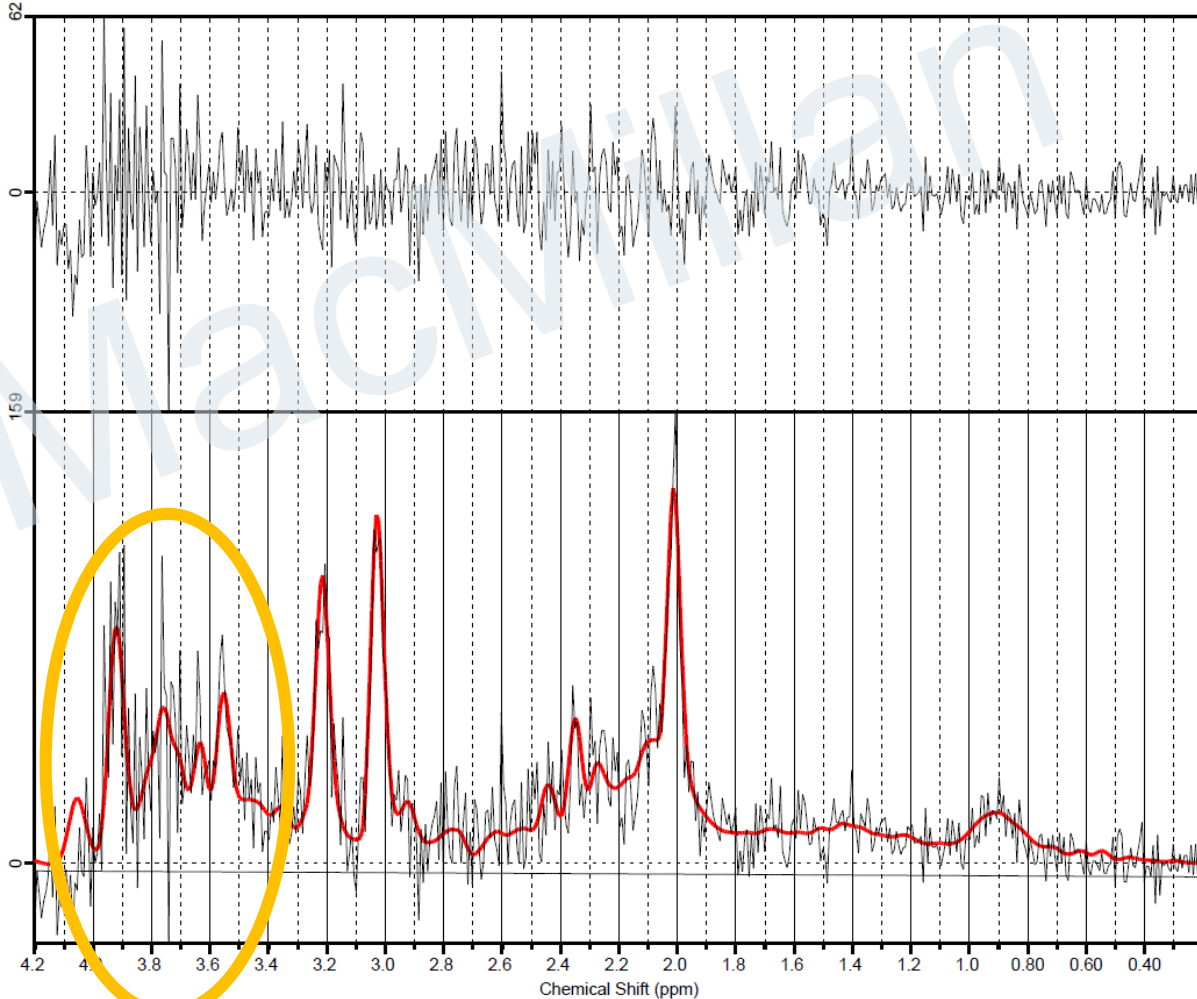
LCModel (Version 6.3-0L) Copyright: S.W. Provencher. Ref.: Magn. Reson. Med. 30:672-679 (199



(FEM MRS SVS3 HC RT)

Data of: Radiology Research, The University of British Columbia, Vancouver

LCModel (Version 6.3-0L) Copyright: S.W. Provencher. Ref.: Magn. Reson. Med. 30:672-679 (1993).



Conc.	%SD	/Cr+PCr	Metabolite
5.72E-06	861%	2.0E-02	Ala
8.01E-05	49%	0.282	Asp
1.43E-04	36%	0.504	Cr
1.41E-04	37%	0.496	PCr
2.37E-05	104%	8.3E-02	GABA
5.31E-05	43%	0.187	Glc
2.60E-04	36%	0.913	Gln
4.16E-04	18%	1.464	Glu
8.37E-05	8%	0.294	GPC
0.000	999%	0.000	PCh
1.11E-04	28%	0.391	GSH
2.56E-04	12%	0.901	Ins
0.000	999%	0.000	Lac
2.51E-04	9%	0.884	NAA
0.000	999%	0.000	NAAG
1.05E-05	61%	3.7E-02	Scyllo
8.08E-05	34%	0.284	Tau
0.000	999%	0.000	-CrCH2
8.37E-05	8%	0.294	GPC+PCh
2.51E-04	9%	0.884	NAA+NAAG
2.84E-04	6%	1.000	Cr+PCr
6.76E-04	12%	2.377	Glu+Gln
1.11E-06	330%	3.9E-03	Lip13a
0.000	999%	0.000	Lip13b
2.59E-07	409%	9.1E-04	Lip09
6.46E-06	30%	2.3E-02	MM09
1.81E-07	340%	6.4E-04	Lip20
9.95E-06	33%	3.5E-02	MM20
1.90E-06	51%	6.7E-03	MM12
6.45E-06	50%	2.3E-02	MM14
2.84E-06	61%	1.0E-02	MM17
1.11E-06	330%	3.9E-03	Lip13a+Lip13b
9.45E-06	37%	3.3E-02	MM14+Lip13a+L
6.72E-06	25%	2.4E-02	MM09+Lip09
1.01E-05	31%	3.6E-02	MM20+Lip20

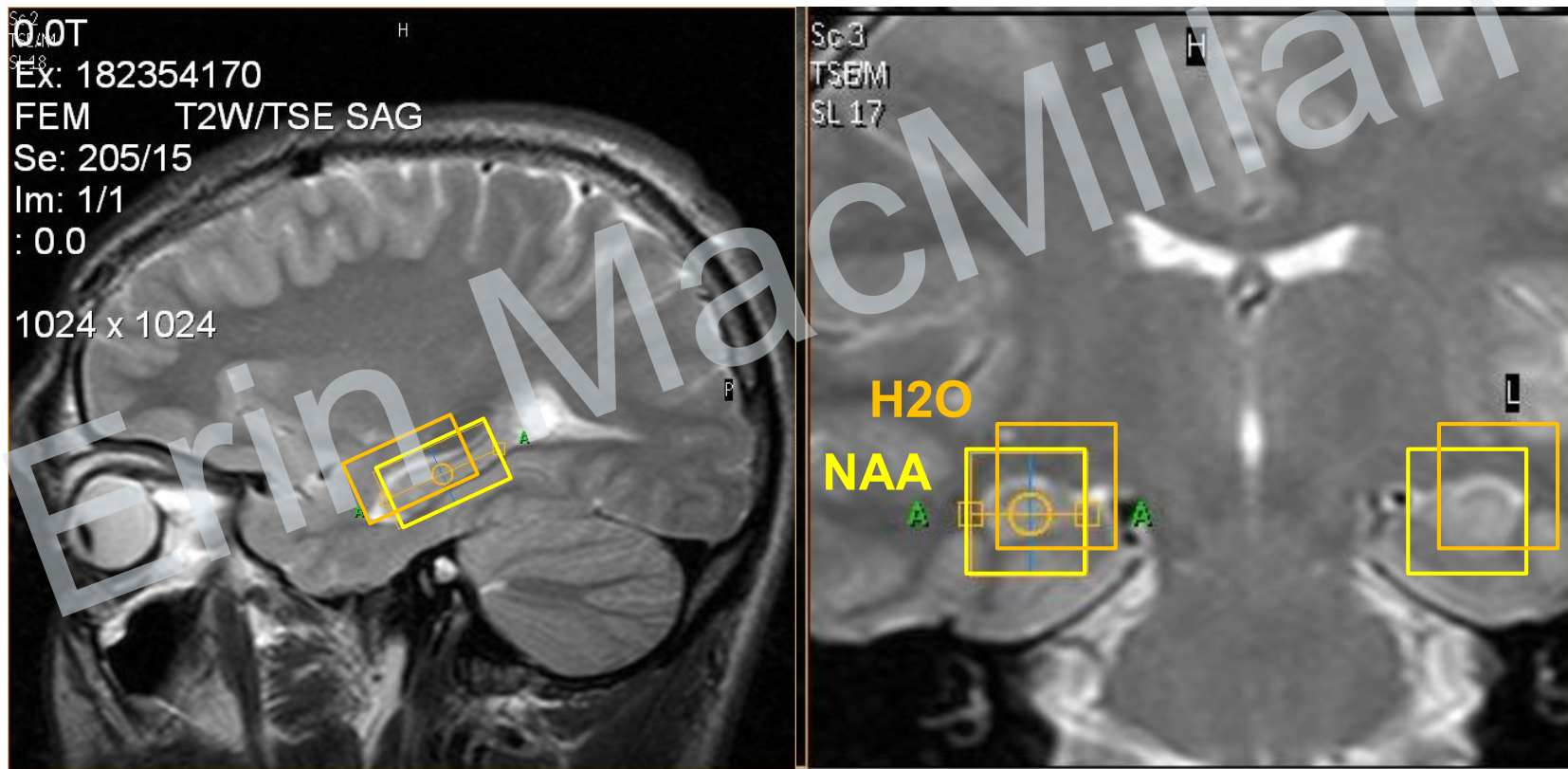
DIAGNOSTICS		
2 info's	RFALSI	11
2 info's	RFALSI	4
1 info	RFALSI	12
Doing Water-Scaling		

MISCELLANEOUS OUTPUT
FWHM = 0.046 ppm S/N = 5
Data shift = 0.031 ppm

CHEMICAL SHIFT DISPLACEMENT ARTIFACTS: PROBLEMS



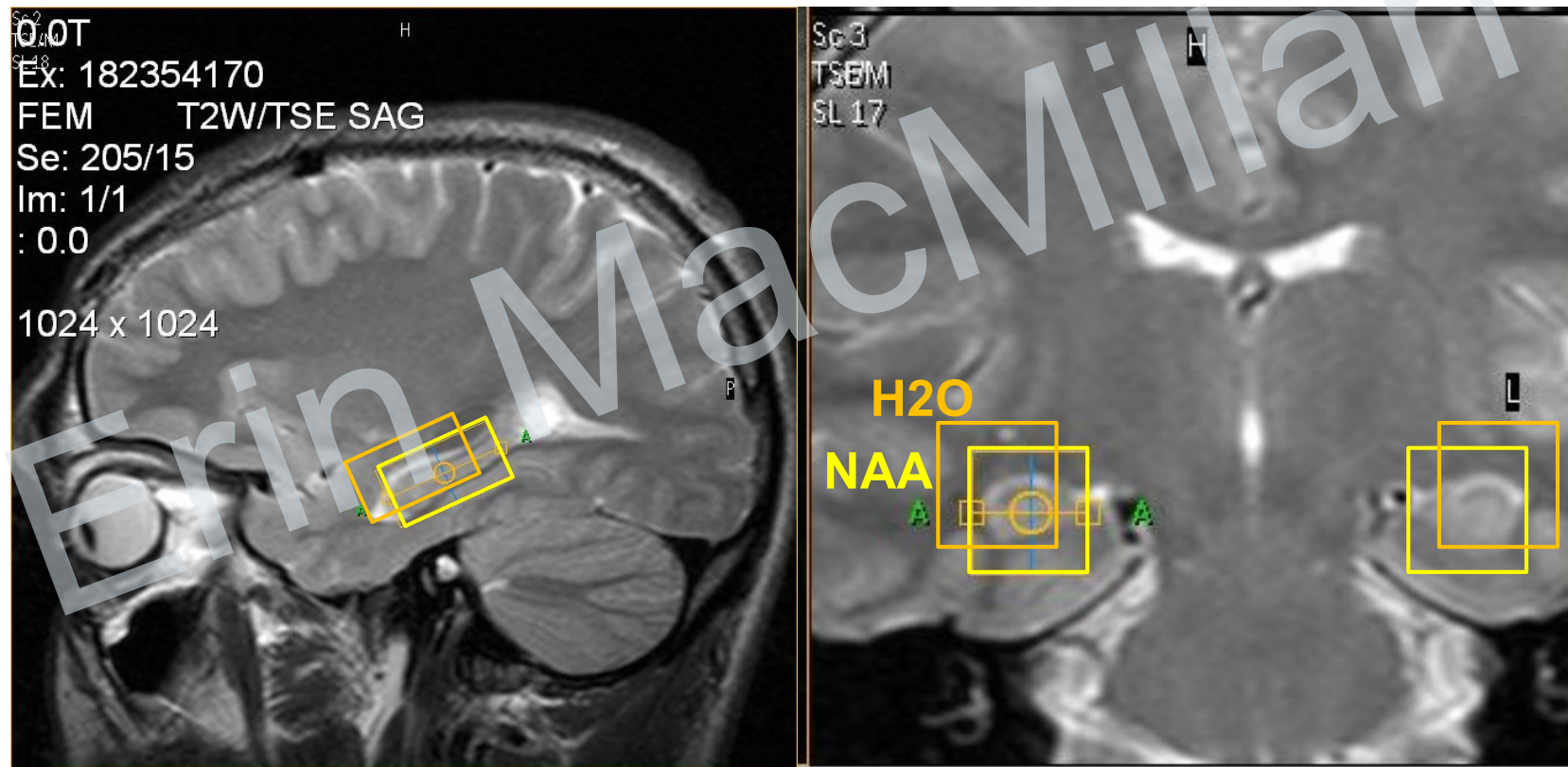
- Chemical shift directions kept the same for L and R voxels



CHEMICAL SHIFT DISPLACEMENT ARTIFACTS: SOLUTIONS



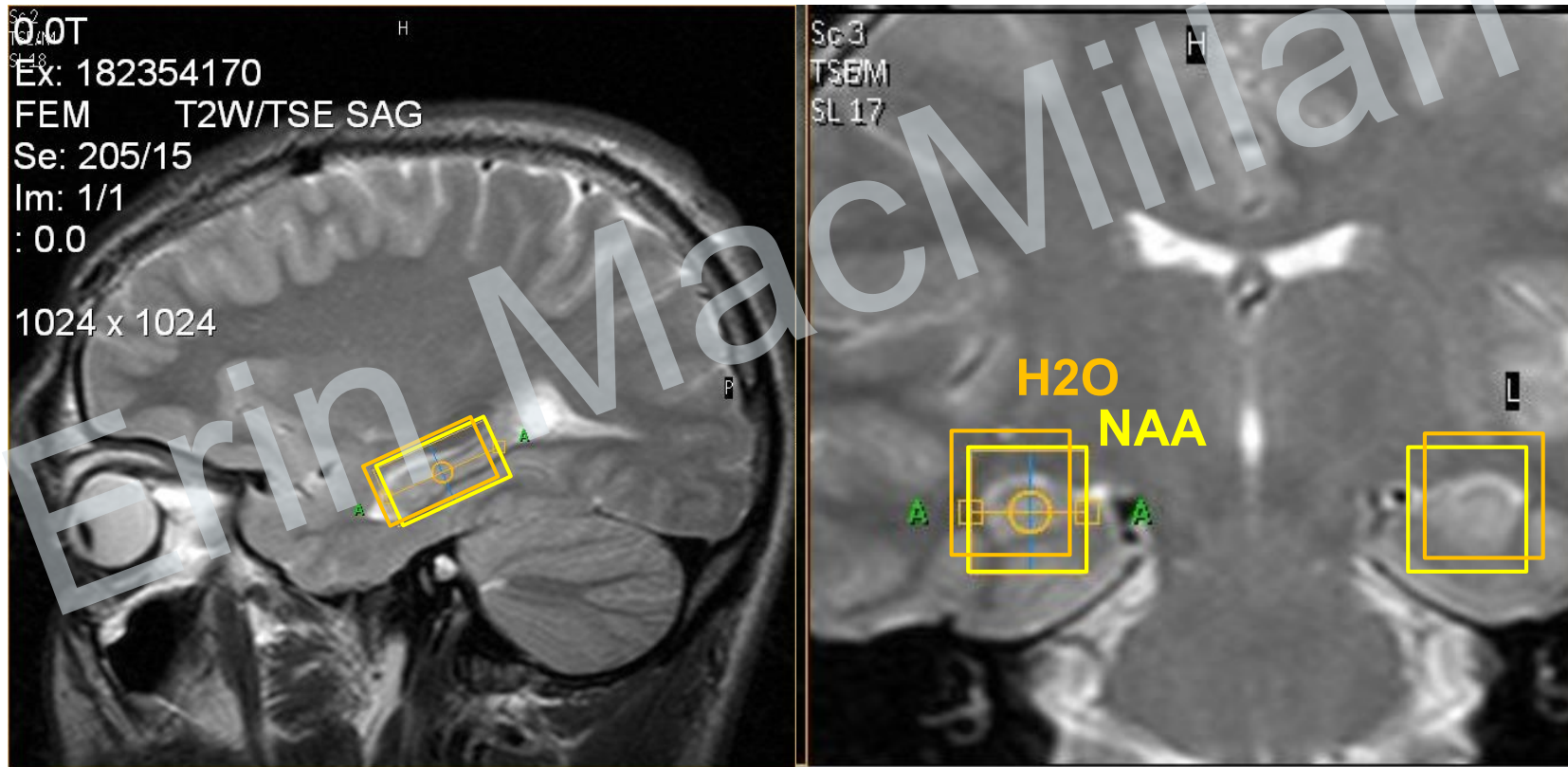
- Optimize chemical shift directions for voxel location



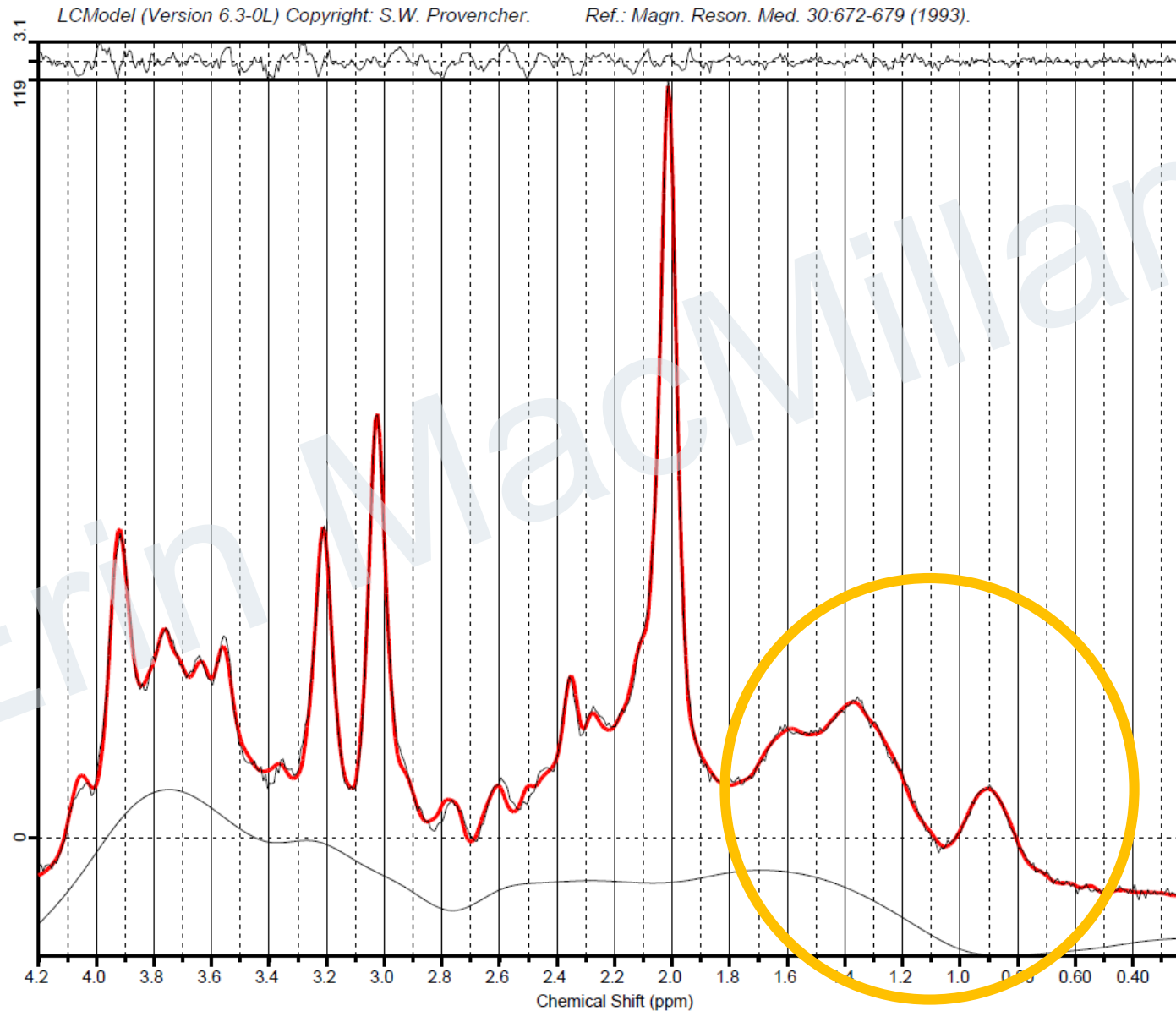
CHEMICAL SHIFT DISPLACEMENT ARTIFACTS: SOLUTIONS



- Semi-LASER for reduced CSDA



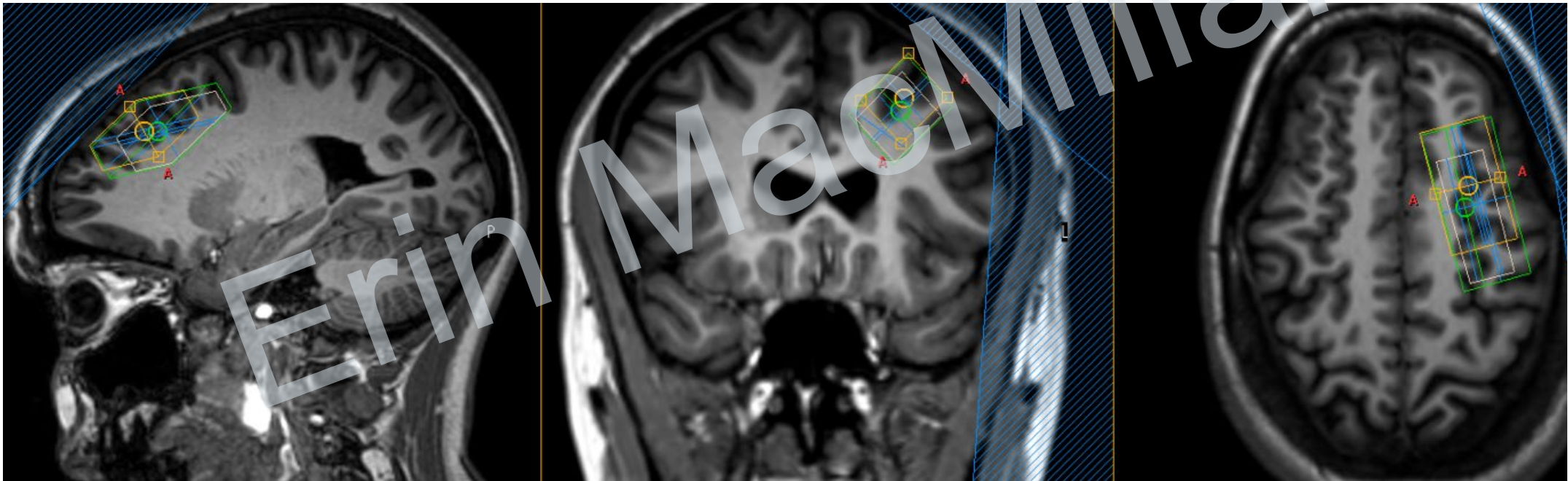
OUTER VOLUME SIGNAL BLEED: PROBLEMS



OUTER VOLUME SIGNAL BLEED: SOLUTIONS



- Chemical Shift Direction: lipids away from the skull
- REST / SAT bands to saturate skull lipids (blue hatched areas)
- Saline bags beside the head to improve shim optimization



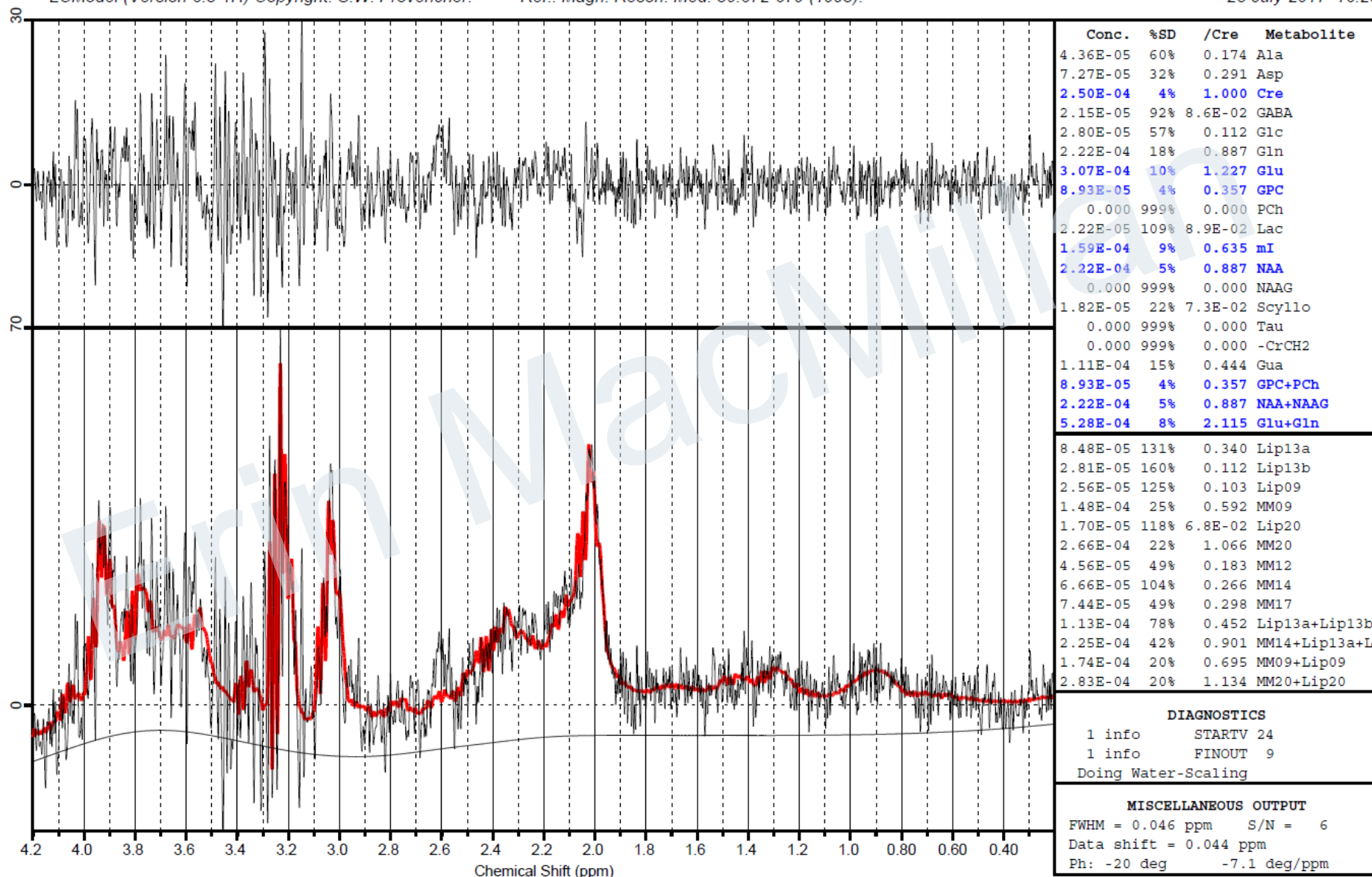
SPURIOUS ECHOES: PROBLEMS



LCModel (Version 6.3-1H) Copyright: S.W. Provencher.

Ref.: Magn. Reson. Med. 30:672-679 (1993).

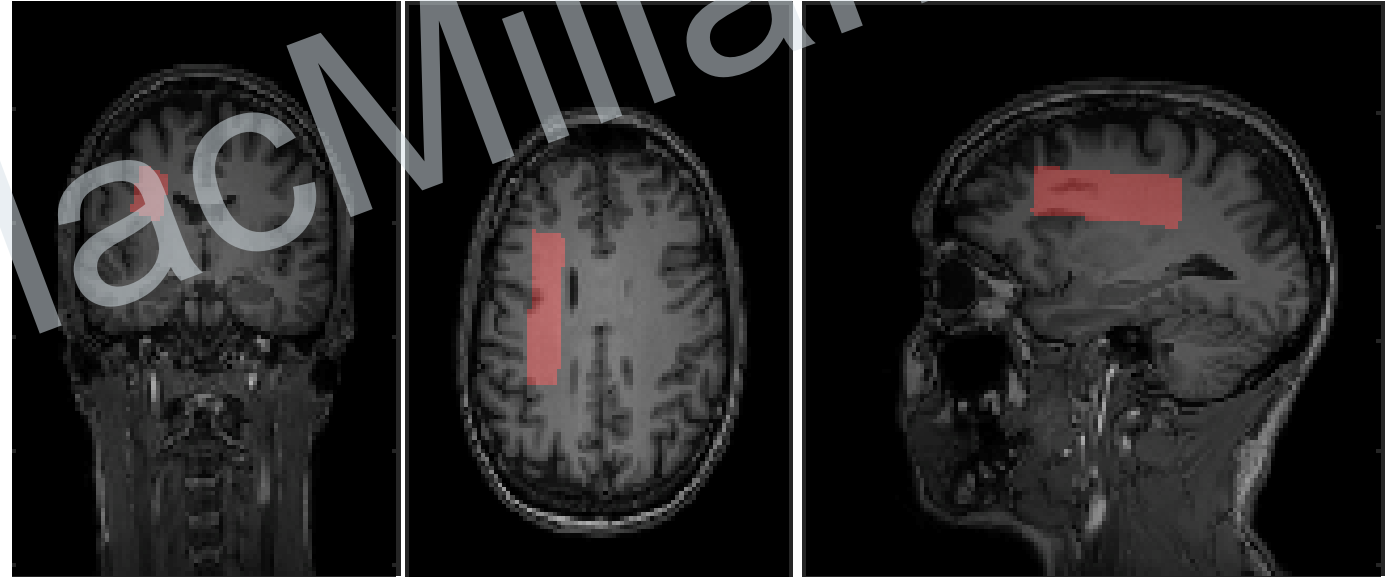
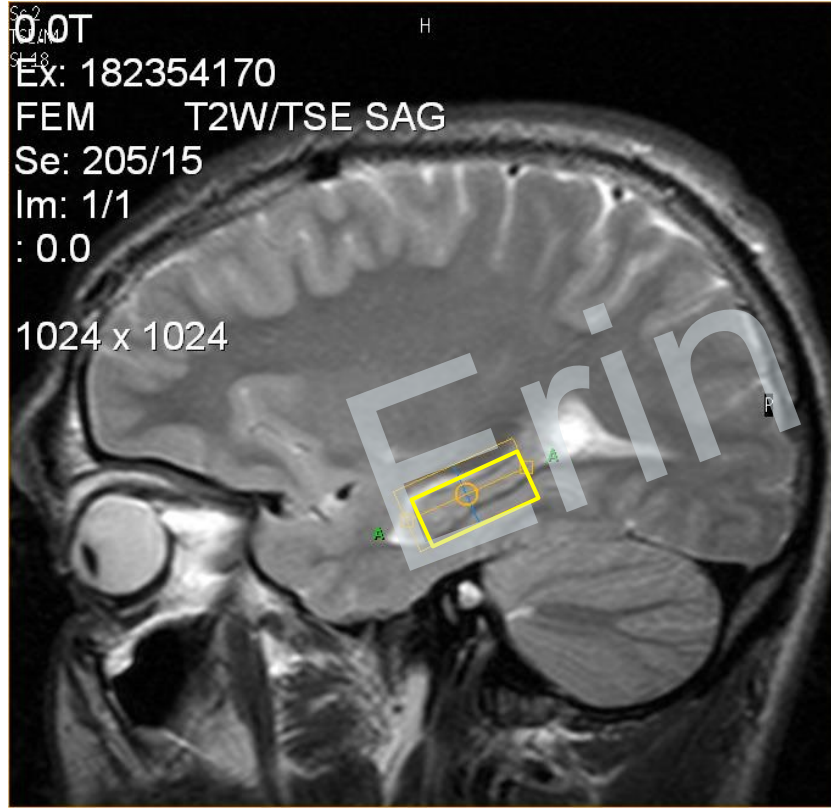
28-July-2017 16:25



SPURIOUS ECHOES: SOLUTIONS



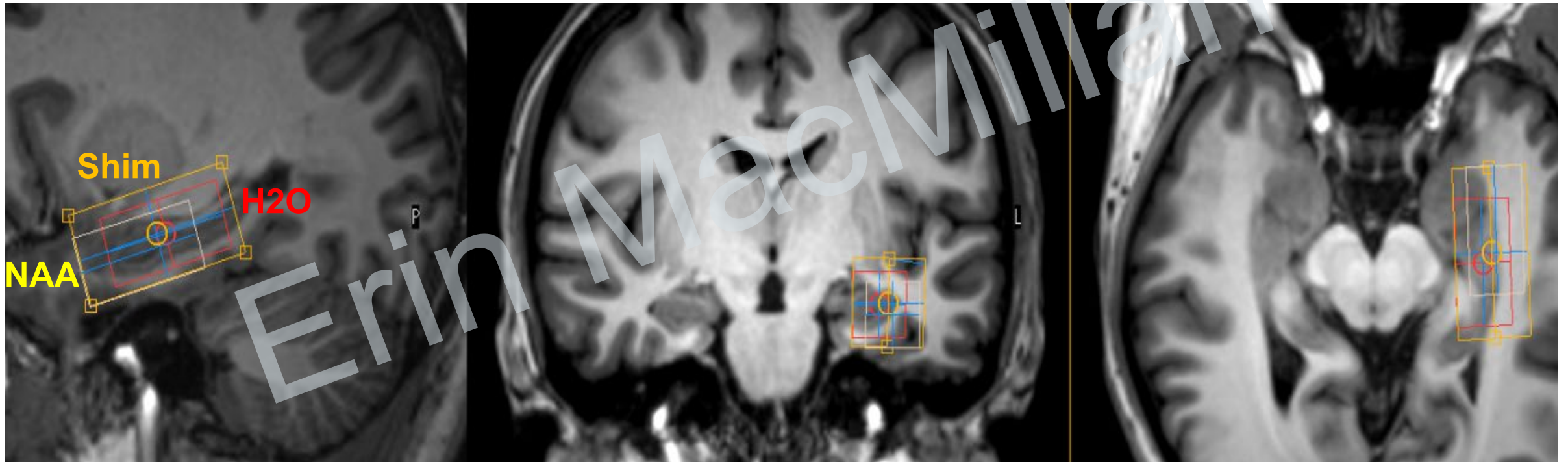
- Avoid exciting/refocusing ventricles!
 - Reduce voxel size
 - Shift away from ventricles



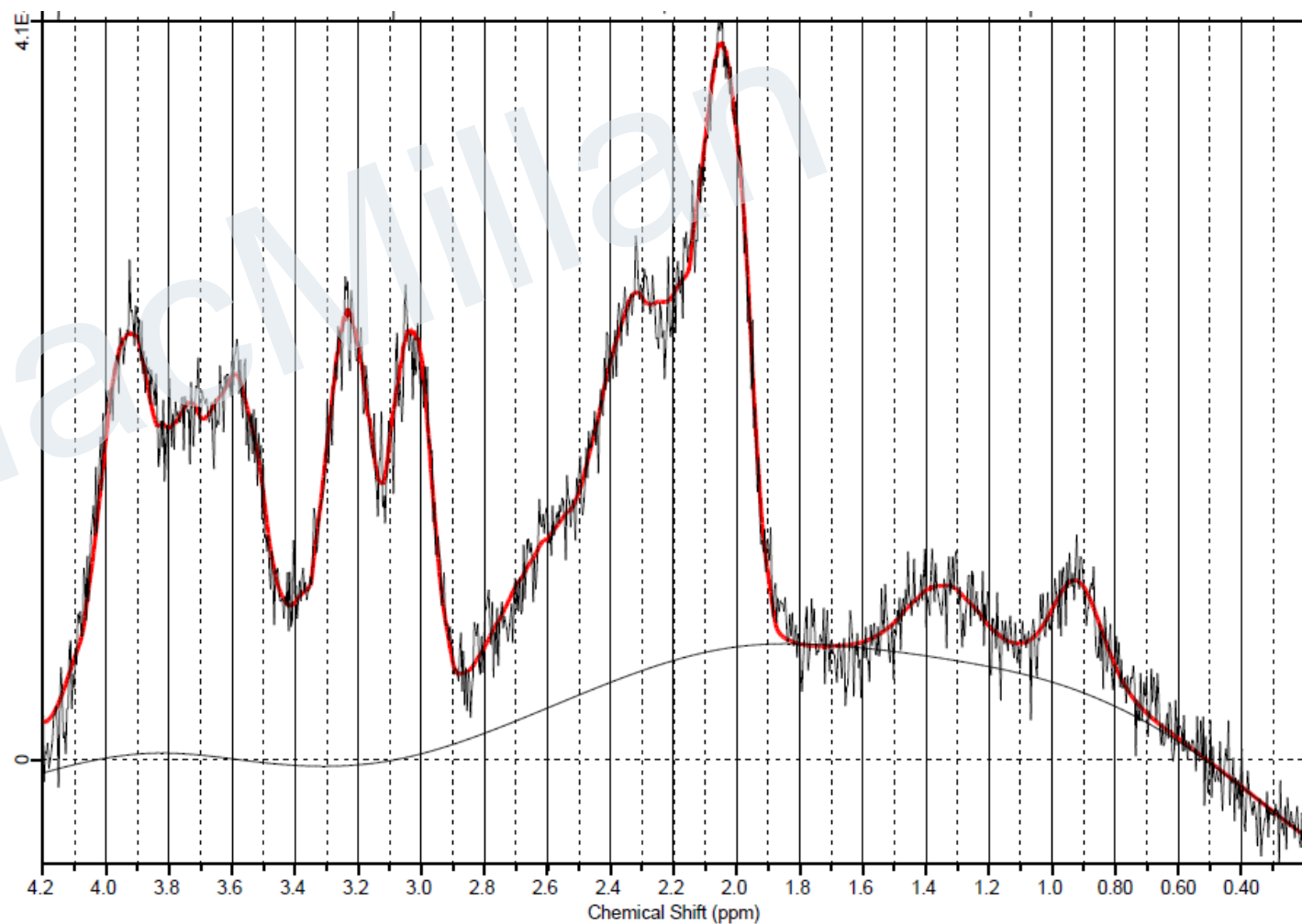
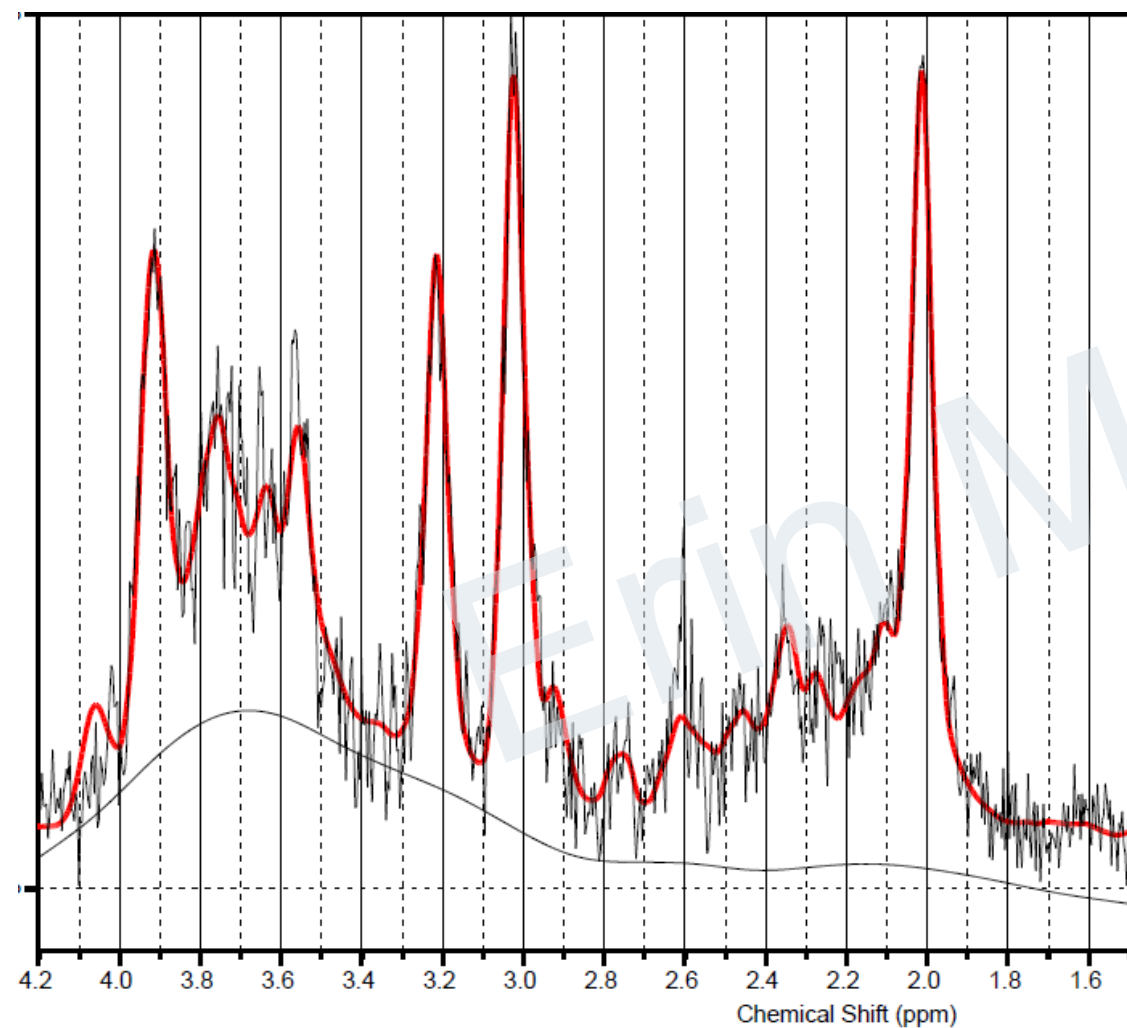
SPURIOUS ECHOES: SOLUTIONS



- Improved outer voxel water suppression:
 - Shim box over regions excited from NAA to H₂O



POOR SHIMMING: PROBLEMS



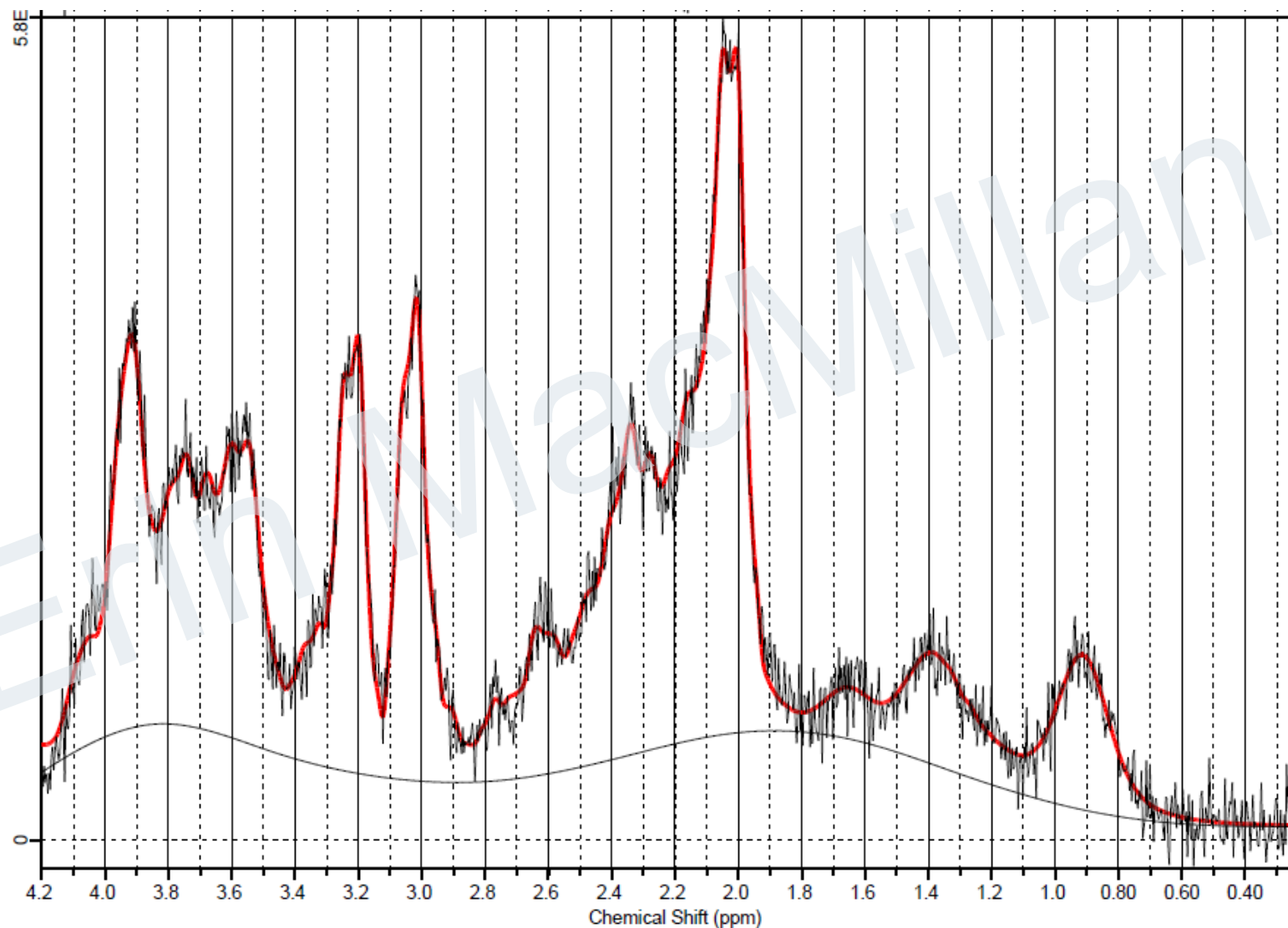
POOR SHIMMING: SOLUTIONS



- Prescribe shim box separately
 - Try to avoid tissue boundaries
- Saline bags outside the head for DLPFC
- Check first few shots before acquiring all the data

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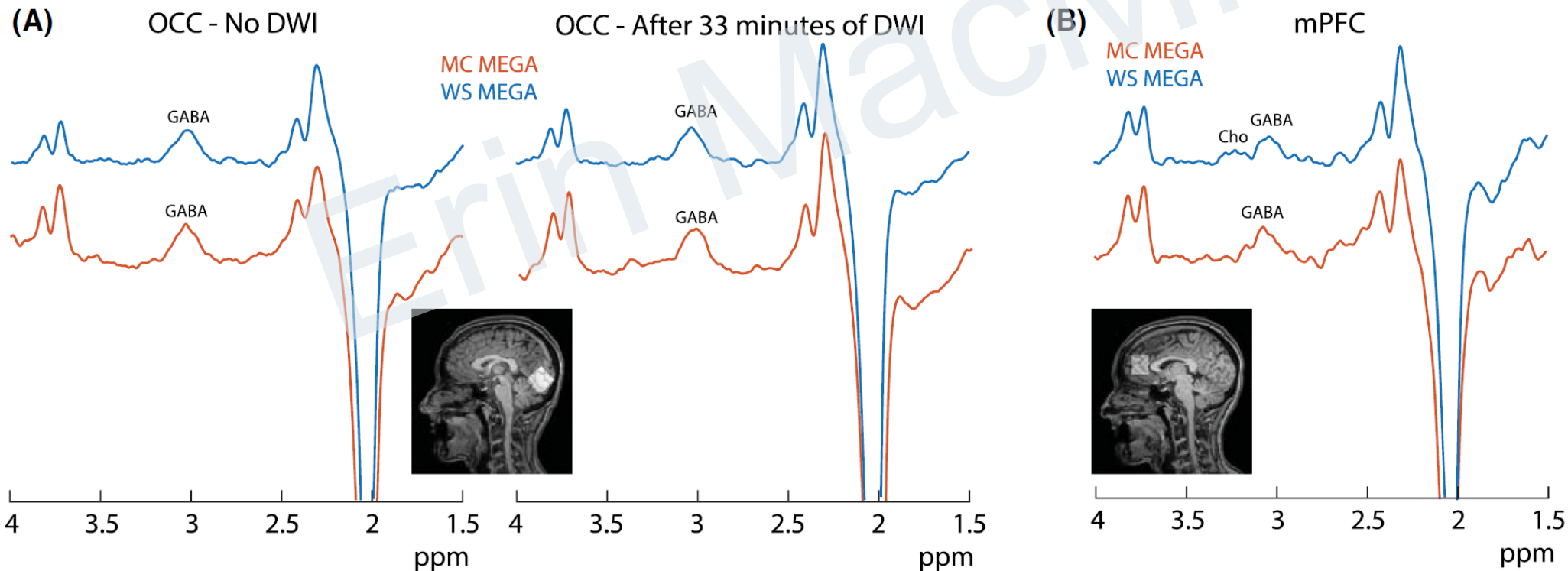
MOTION ARTIFACTS: PROBLEMS



MOTION ARTIFACTS: SOLUTIONS



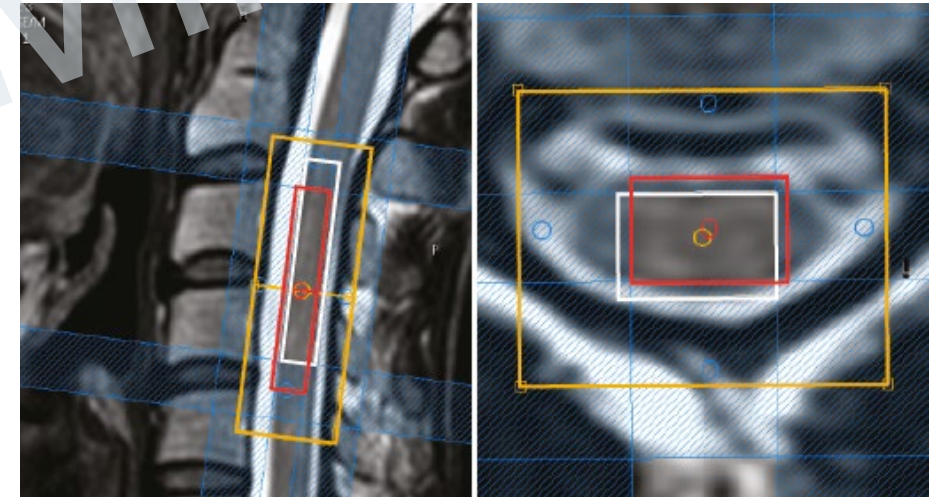
- Participant comfort
 - Lots of padding
- Export individual shots for frequency alignment
- Prospective frequency correction with metabolite cycling



CHALLENGING LOCATIONS: ALL OF THE PROBLEMS



- CSDA – difficult to avoid tissue boundaries
- Outer Volume – challenging to avoid exciting water
- Poor Shim – small volume, tissue boundaries
- Motion – physiologic, small volume



CHALLENGING LOCATIONS: SOME PARTIAL SOLUTIONS



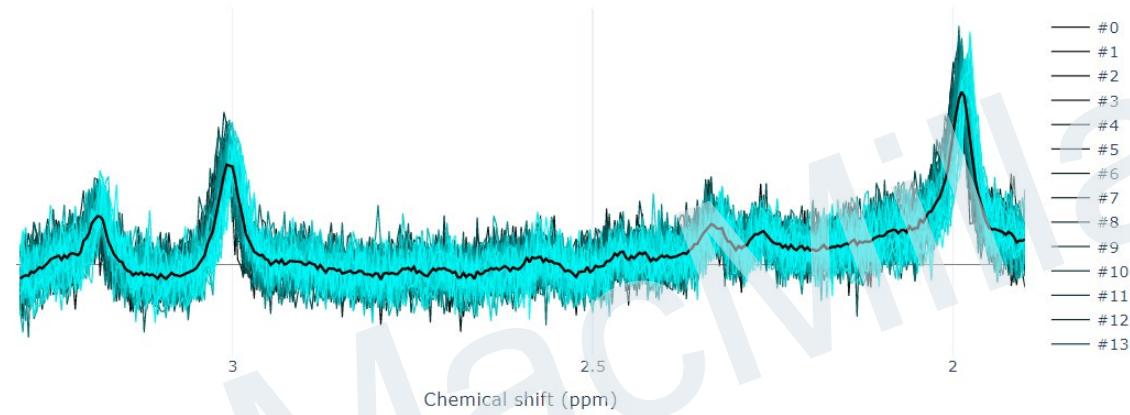
- Semi-LASER to reduce CSDA
- Small voxels to avoid ventricles
- Metabolite cycling:
 - Prospectively update centre frequency
 - Post-acquisition correction for frequency changes due to motion

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INSPECT ALL FREQUENCY ALIGNMENT

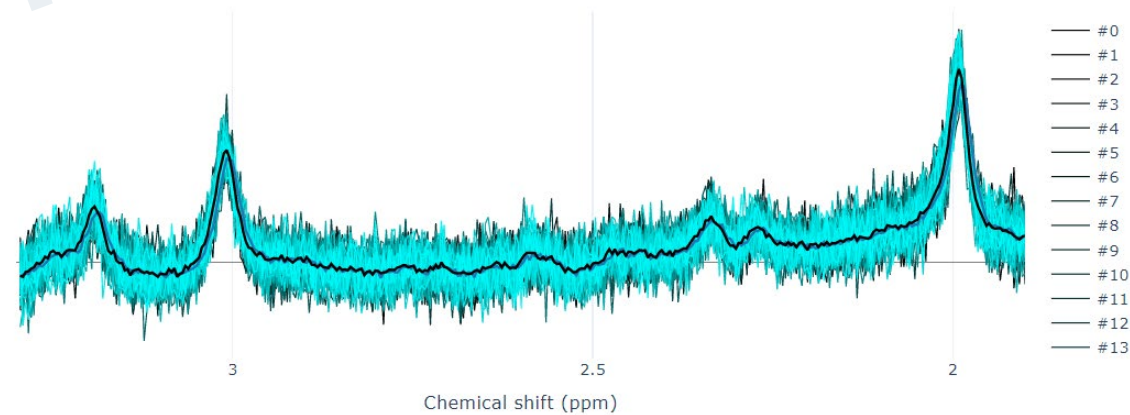


Unaligned



Transients after alignment.

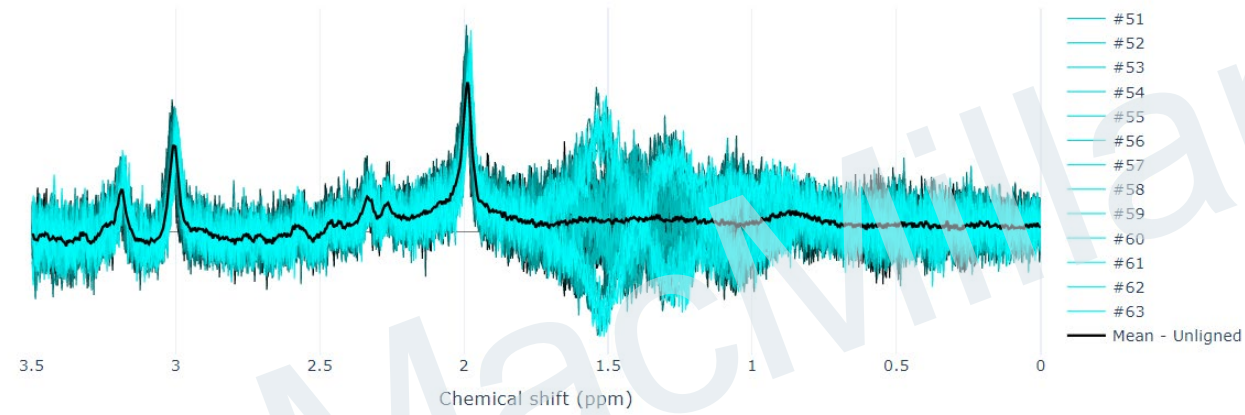
Aligned



INSPECT ALL FREQUENCY ALIGNMENT

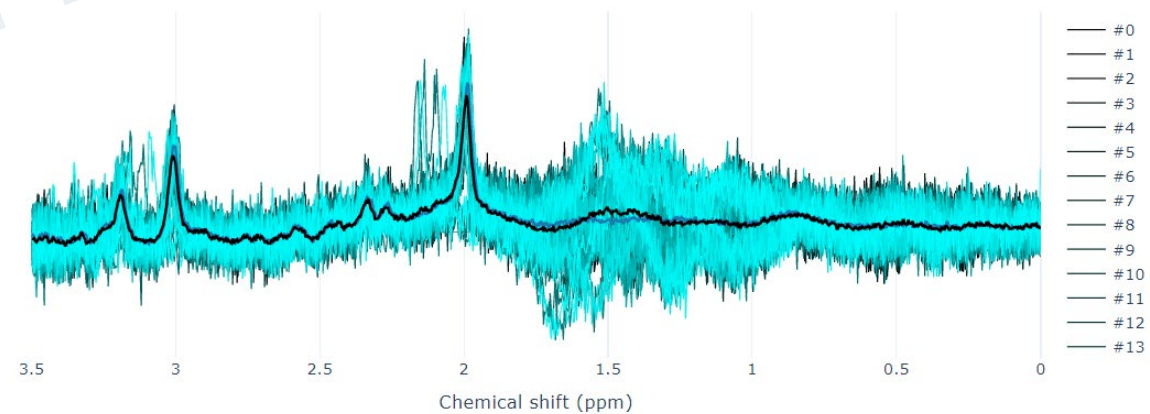


Unaligned

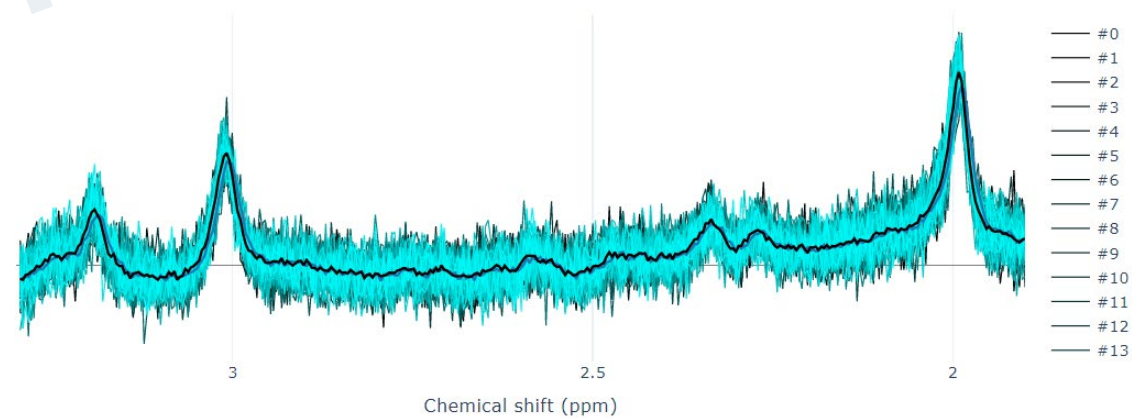
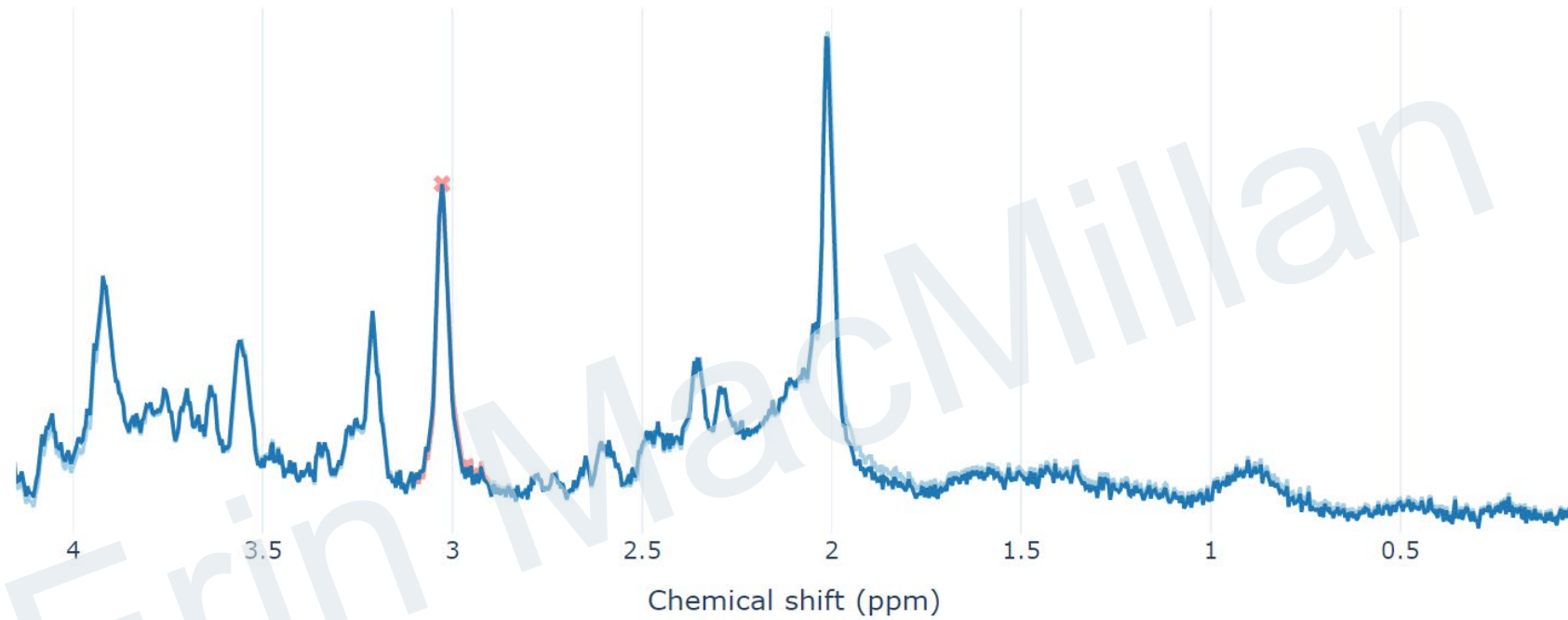


insients after alignment.

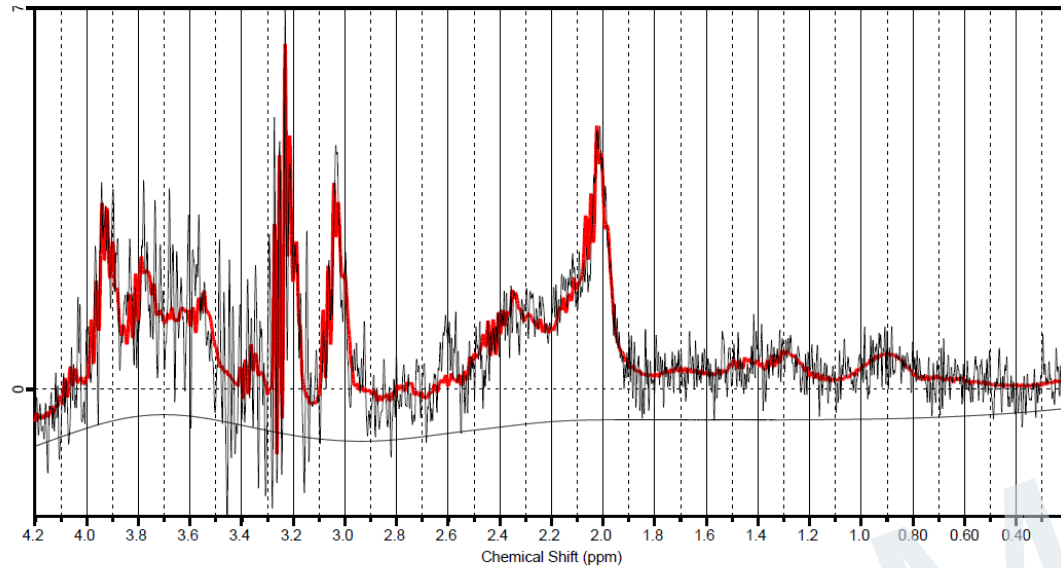
Aligned



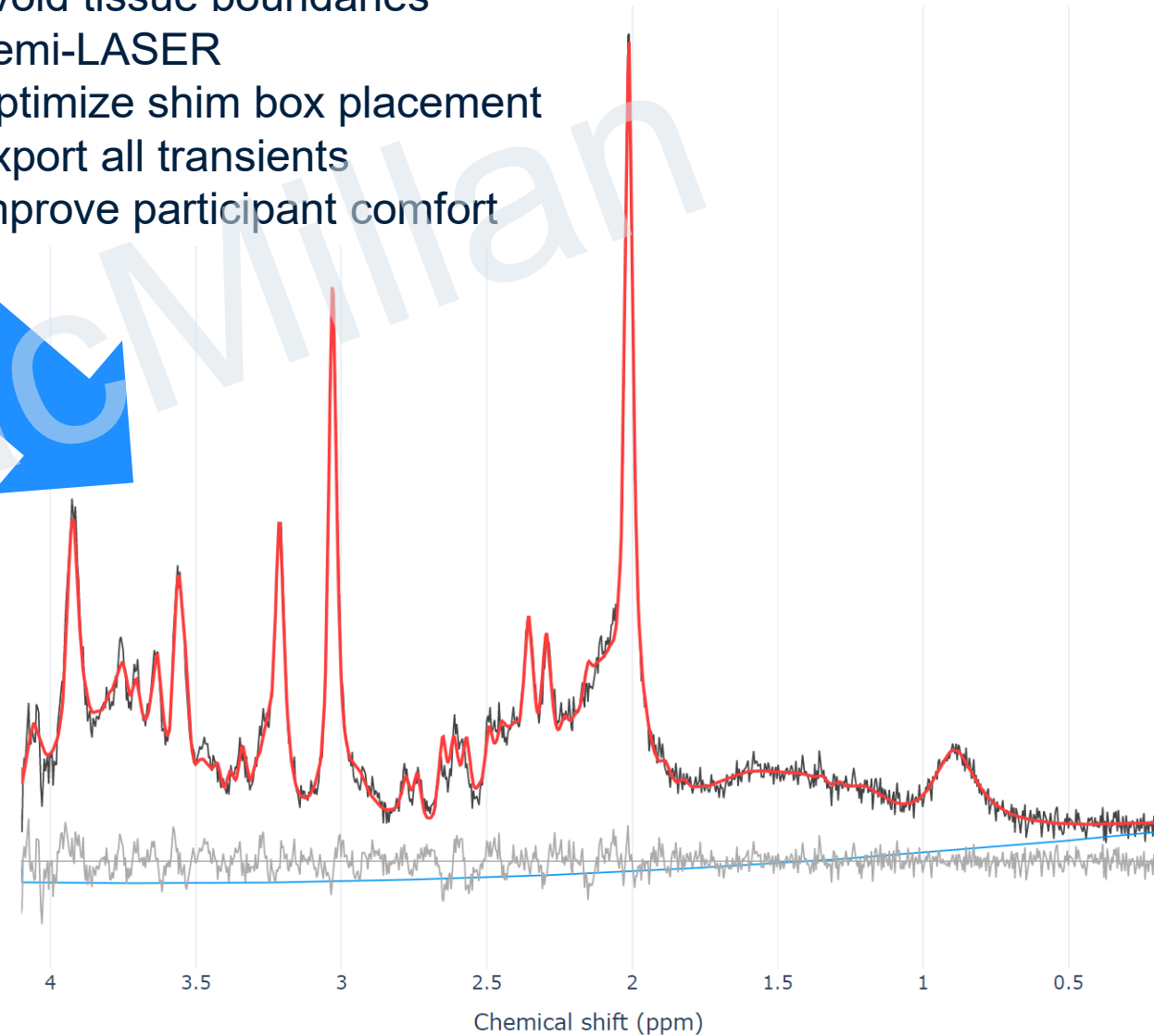
INSPECT ALL FREQUENCY ALIGNMENT



BRINGING IT ALL TOGETHER



Avoid tissue boundaries
Semi-LASER
Optimize shim box placement
Export all transients
Improve participant comfort



STANDARDIZED QUALITY ASSESSMENT



MRS QC Report
UBC MRI Research Centre
Version: 1.1.3
Last Edited: 2021-03-18

Study ID	
Site ID:	
Subject ID:	
Timepoint:	
Rescan (Y/N):	
Original Scan Date:	
Scan Date:	
Notification Date:	
MRS QC Analysis	
Completion Date:	
Completed By:	
Overall QC Grade:	
<input type="checkbox"/> PASS <input type="checkbox"/> FAIL <input type="checkbox"/> ADVISORY	
RESCAN Required:	
<input type="checkbox"/> YES <input type="checkbox"/> NO <input type="checkbox"/> ADVISORY <input type="checkbox"/> NA	
Comments:	
Voxel	
Spectrum Output:	
Screenshot:	
UBC Voxel Placement Determination:	
tNAA Useable: <input type="checkbox"/> YES <input type="checkbox"/> NO	Follow-up QC: <input type="checkbox"/> YES <input type="checkbox"/> NO Date:
ml Useable: <input type="checkbox"/> YES <input type="checkbox"/> NO	Follow-up QC: <input type="checkbox"/> YES <input type="checkbox"/> NO Date:
FWHM:	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL <input type="checkbox"/> ADVISORY
SNR:	<input type="checkbox"/> PASS <input type="checkbox"/> FAIL <input type="checkbox"/> ADVISORY
Overall QC Grade: <input type="checkbox"/> PASS <input type="checkbox"/> FAIL <input type="checkbox"/> ADVISORY	
Comments:	

WHICH METABOLITES ARE DETECTABLE?



1. Analyze all spectra from the study
2. Calculate the CRLB in absolute mM values
3. Find a threshold (e.g. 30%) of the median metabolite concentration across all spectra
4. Accept metabolites where the absolute error (CRLB) is less than this threshold in the majority of scans

MINI-REVIEW

Magnetic Resonance in Medicine 00:00–00 (2015)

The Trouble With Quality Filtering Based on Relative Cramér-Rao Lower Bounds

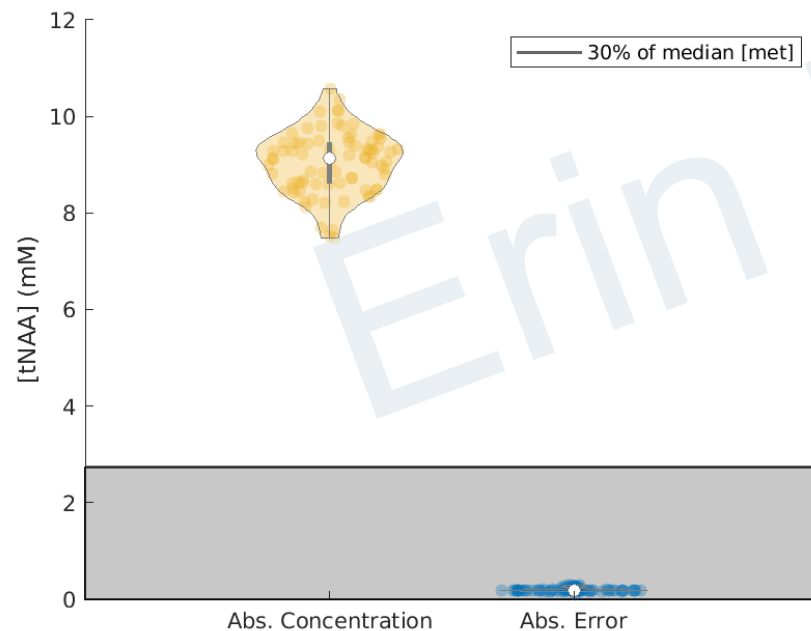
Roland Kreis*

WHICH METABOLITES ARE DETECTABLE?

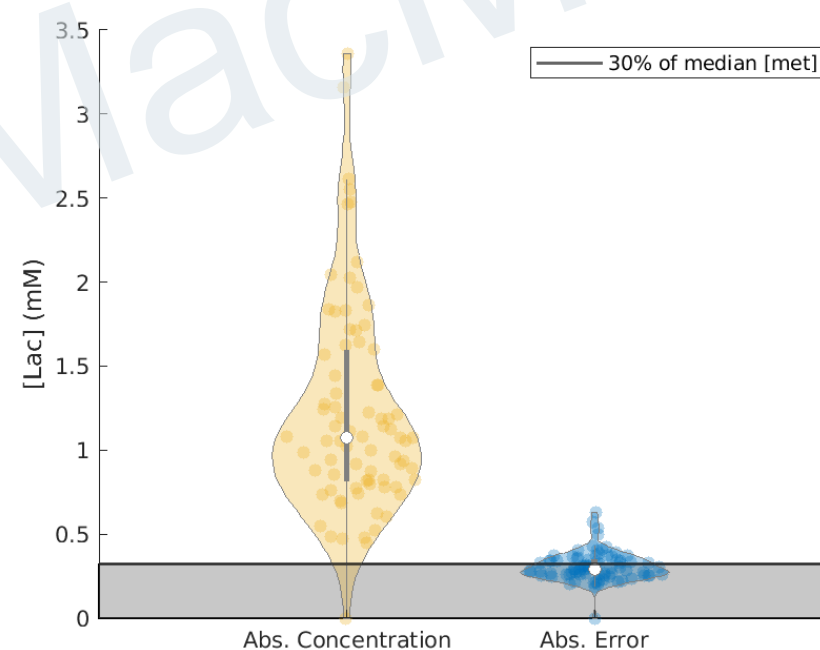


1. Analyze all spectra from the study
2. Calculate the CRLB in absolute mM values
3. Find a threshold (e.g. 30%) of the median metabolite concentration across all spectra
4. Accept metabolites where the absolute error (CRLB) is less than this threshold in the majority of scans

High detection confidence: tNAA



Detection unlikely: lactate



CONCLUSIONS

- Garbage in = garbage out!
- Ask questions!
- Mrshub.org Forum



ACKNOWLEDGEMENTS

- Dept of Radiology, University of British Columbia
- UBC MRI Research MRI Technologists

