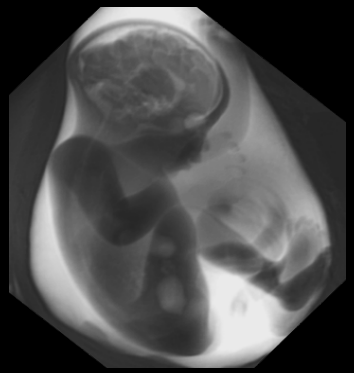

Improved Fetal Brain Magnetic Resonance Spectroscopy Using Selective Combination

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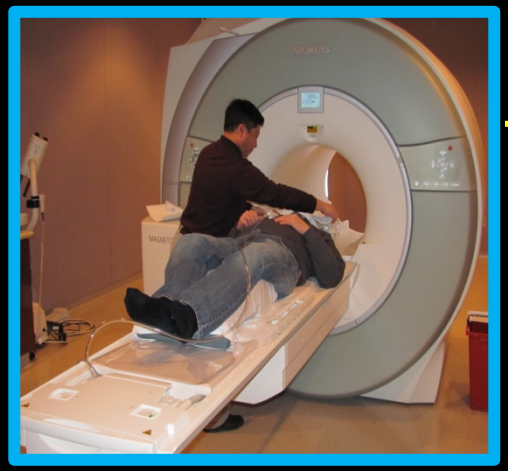
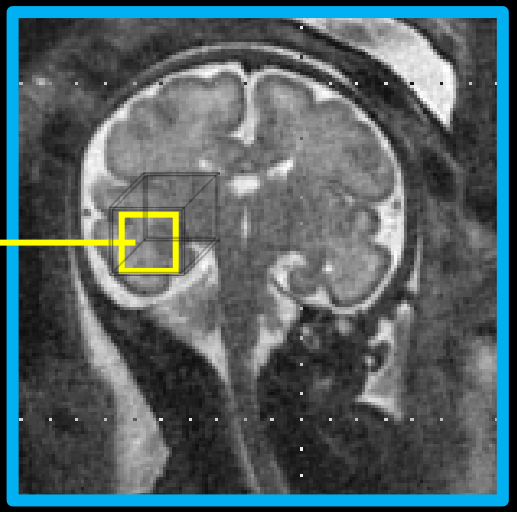
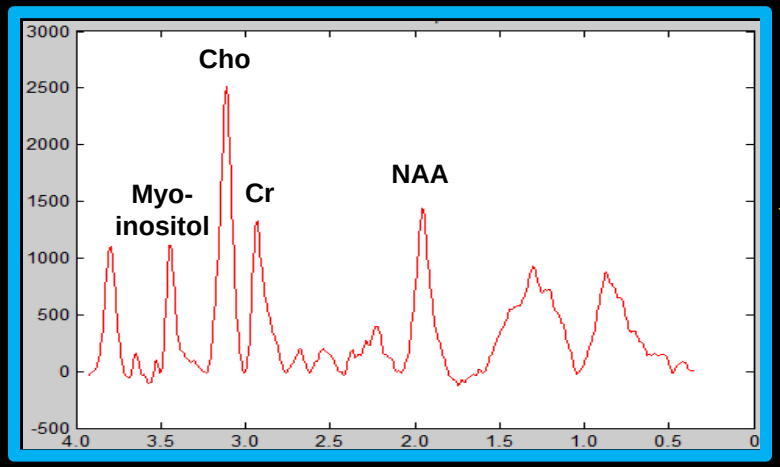
Magnetic Resonance Spectroscopy



MRI Scanner

(voxel)





Chemical Shift in *ppm

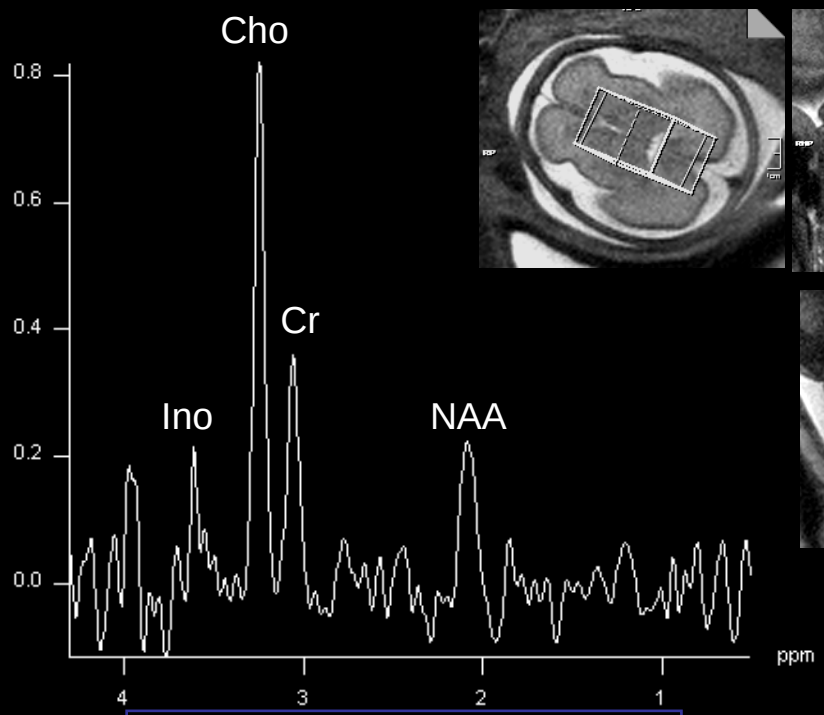
Relative concentrations of brain metabolites

*ppm – parts per million

Uses differences in magnetic resonance frequencies (chemical shift) between various metabolites

Magnetic Resonance Spectroscopy (MRS) in the Fetal Brain

- **Provides non-invasive method to identify and quantify biological metabolites in the tissue**
- **Assess fetal brain metabolic status in-utero[1]**

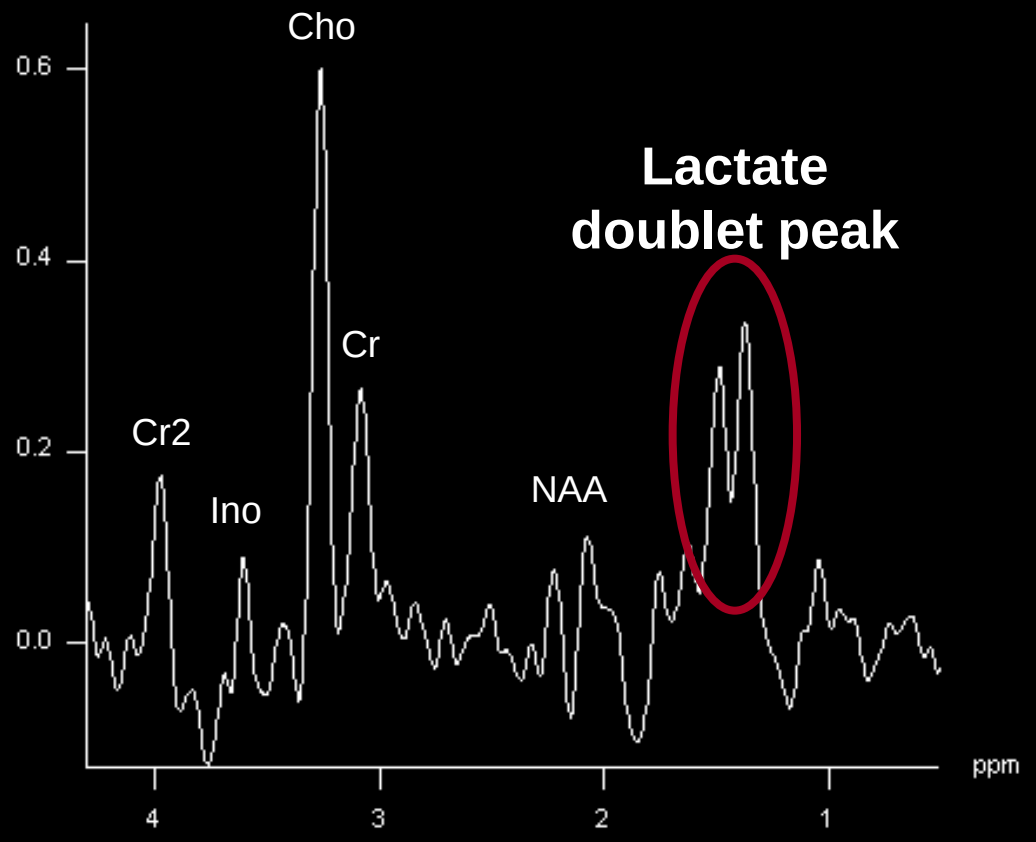


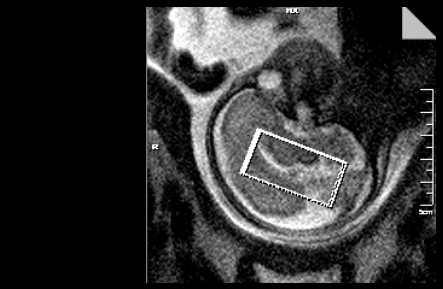
Normal fetal brain spectrum (25 weeks)

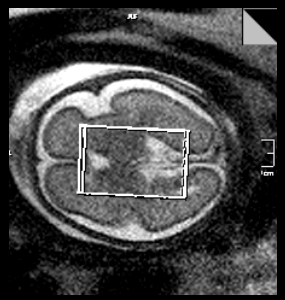
- **<u>Myoinositol</u>: lipid synthesis**
- **<u>Choline</u>: cell membrane stability and myelination**
- **<u>Creatine</u>: metabolic activity**
- **<u>NAA</u>: neuronal or axonal marker**

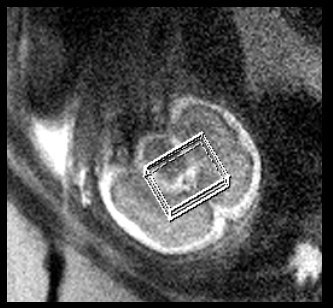
Fetal Brain MRS – Clinical Relevance

25 week old fetus - IUGR with Complete Heart Block









Presence of lactate indicates metabolic acidosis

Fetal Brain MRS: Challenges

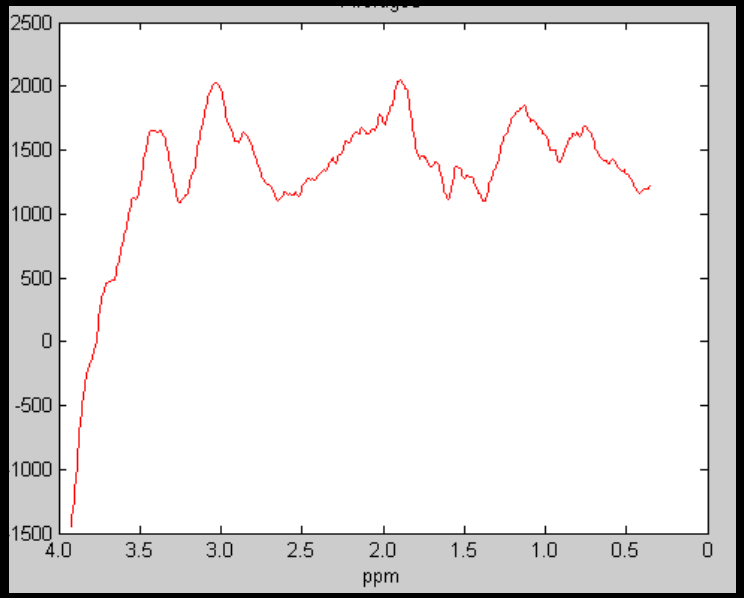
Motion

GA - 24 4/7 weeks

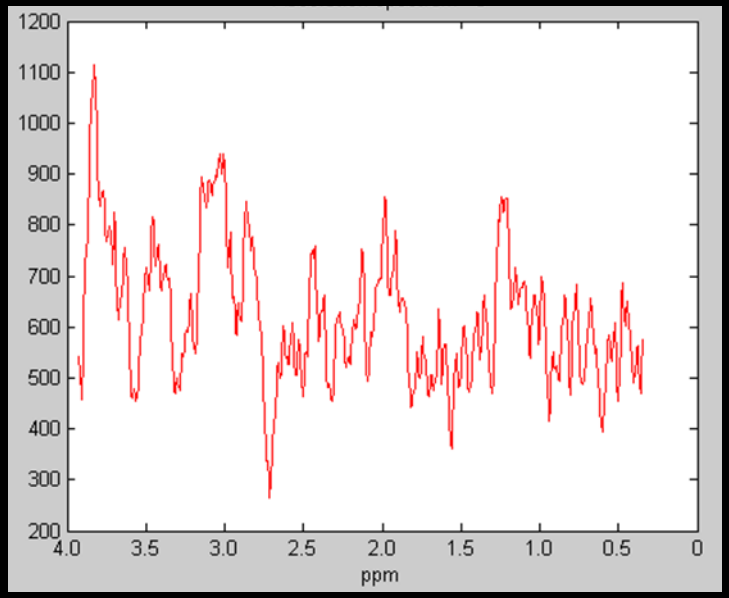
GA - 28 5/7 weeks

Fetal Brain MRS: Challenges

Motion <u>severely</u> affects the quality of the acquired spectra



GA - 23 5/7 weeks



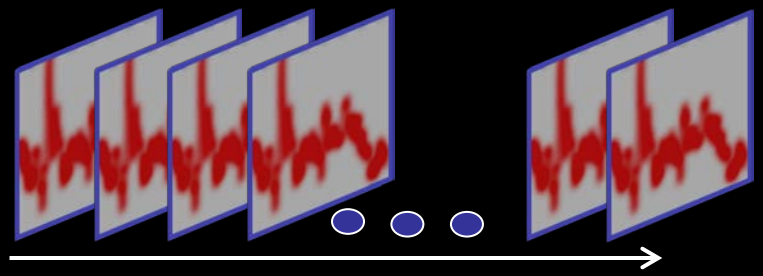
GA - 20 6/7 weeks

Fast and/or motion-insensitive methods are warranted for fetal MRS

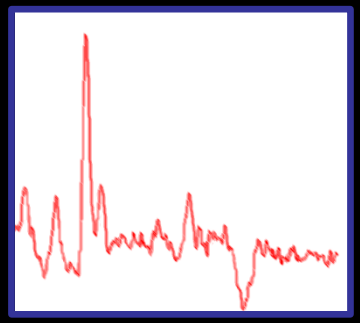
Motion in MRS

Typical MRS acquisition

N (~96) individually acquired spectra

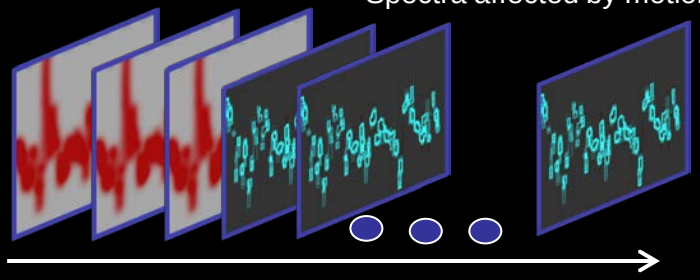


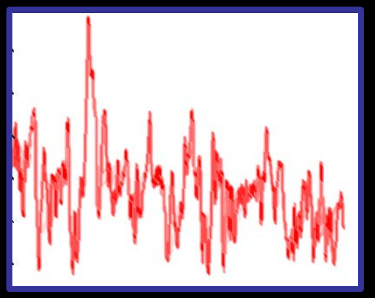
Average of the N acquisitions



In case of fetal movement during such MRS acquisition

Spectra affected by motion



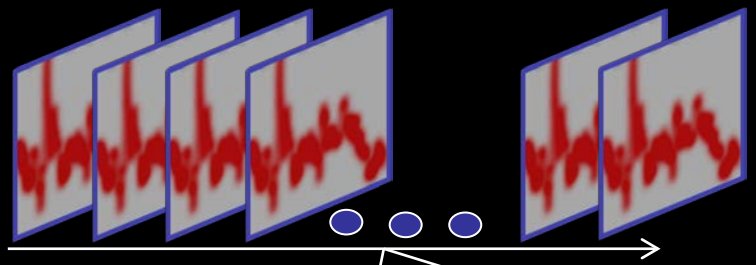


… the resulting averaged spectrum is a noisy and precludes any measurement

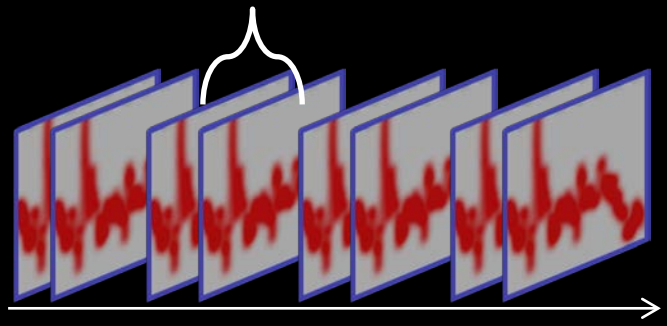
A novel approach

Piece-wise acquisition

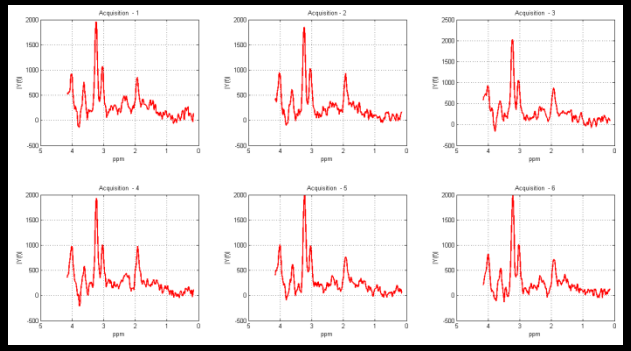
N (~96) individually acquired spectra



Every 16 individual acquisitions are averaged to provide an individual output



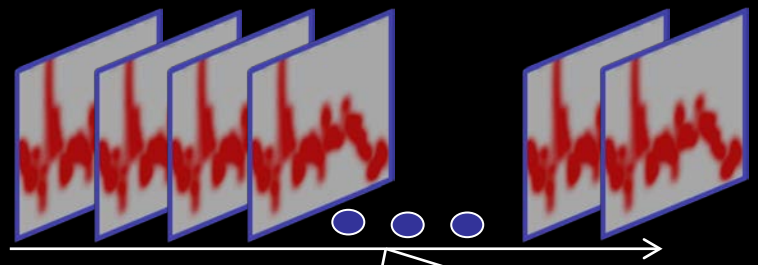
The result is N/16 (96/16=6) individual spectra (instead of a single output)



A novel approach

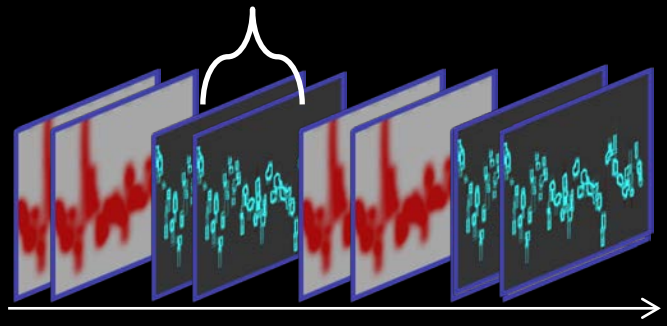
Piece-wise acquisition

N (~96) individually acquired spectra

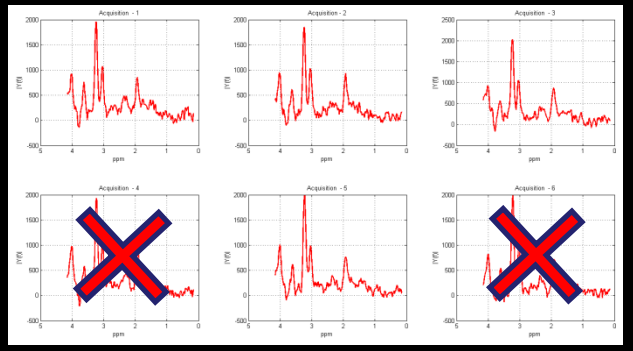


The part of data affected by motion can be discarded in selective averaging

Every 16 individual acquisitions are averaged to provide an individual output



The result is N/16 (96/16=6) individual spectra (instead of a single output)



Fetal Brain MRS @ 3.0T with Piece-wise acquisition and selective averaging

- We applied the piece-wise MRS data acquisition with selective averaging in N=55 pregnant subjects
  - gestational age 20 5/7 to 38 1/7 weeks, mean-30.25 weeks; std- 4.8 weeks
- No sedation

Fetal Brain MRS @ 3.0T with Piece-wise acquisition and selective averaging

- **Acquisition Parameters:**
  - PRESS (spin-echo) sequence – TR=1200 ms, TE=144 ms; (PRESS -point resolved spectroscopy)
  - 6 acquisitions – each measurement is an average of 16 measurements
  - Single voxel spectroscopy - Voxel placed in the central basal ganglia region of the fetal brain
  - sequence time - 2 minutes;
    - including shimming total acq time approximately 3.5 to 4 minutes

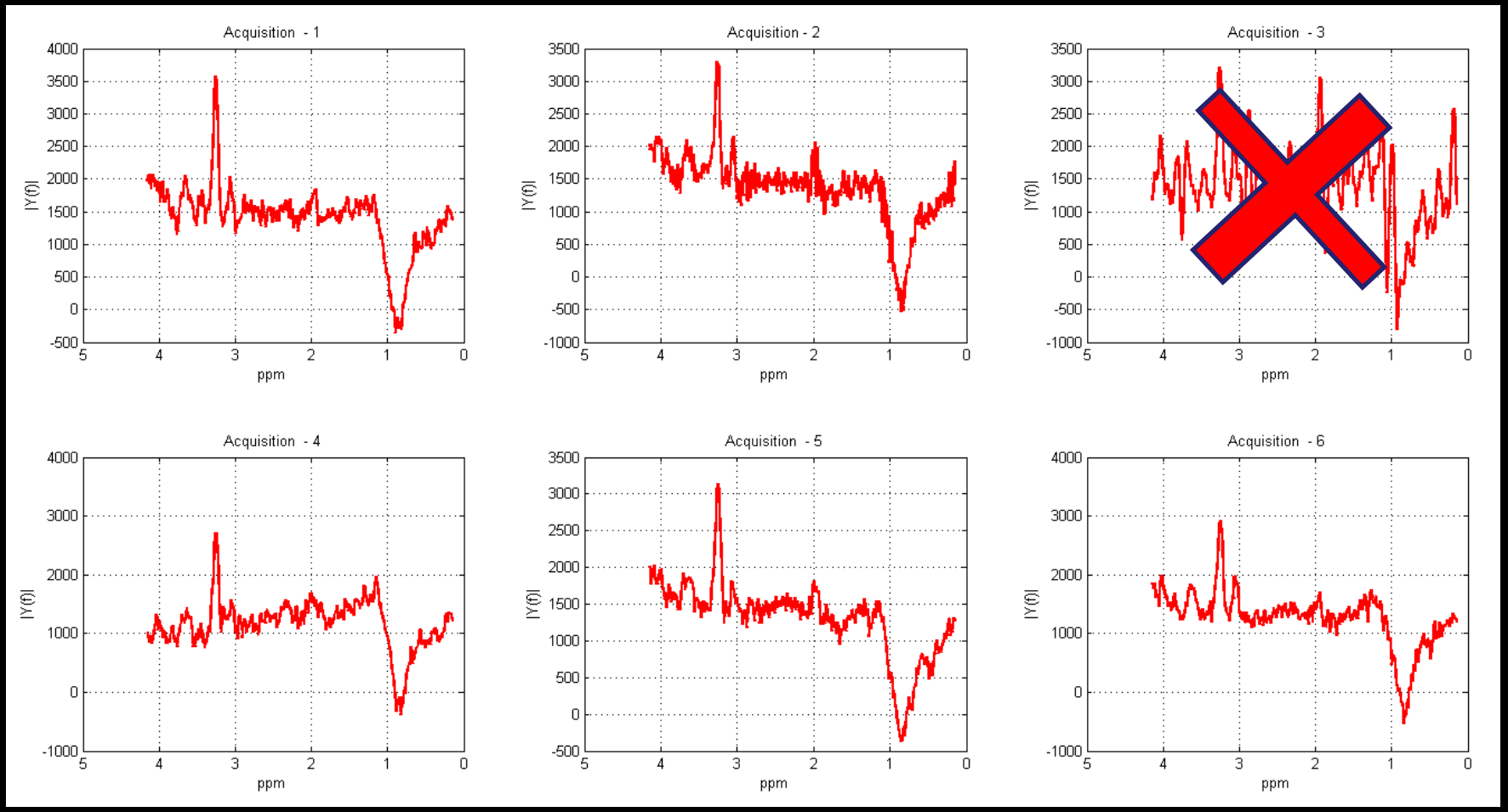
Fetal Brain MRS @ 3.0T with Piece-wise acquisition and selective averaging

Quality evaluation

- Signal to Noise Ratio (SNR) of three metabolite peaks – NAA, Cho, Cr were evaluated.
- SNR > 2:1, for all three metabolites was considered good quality

Results

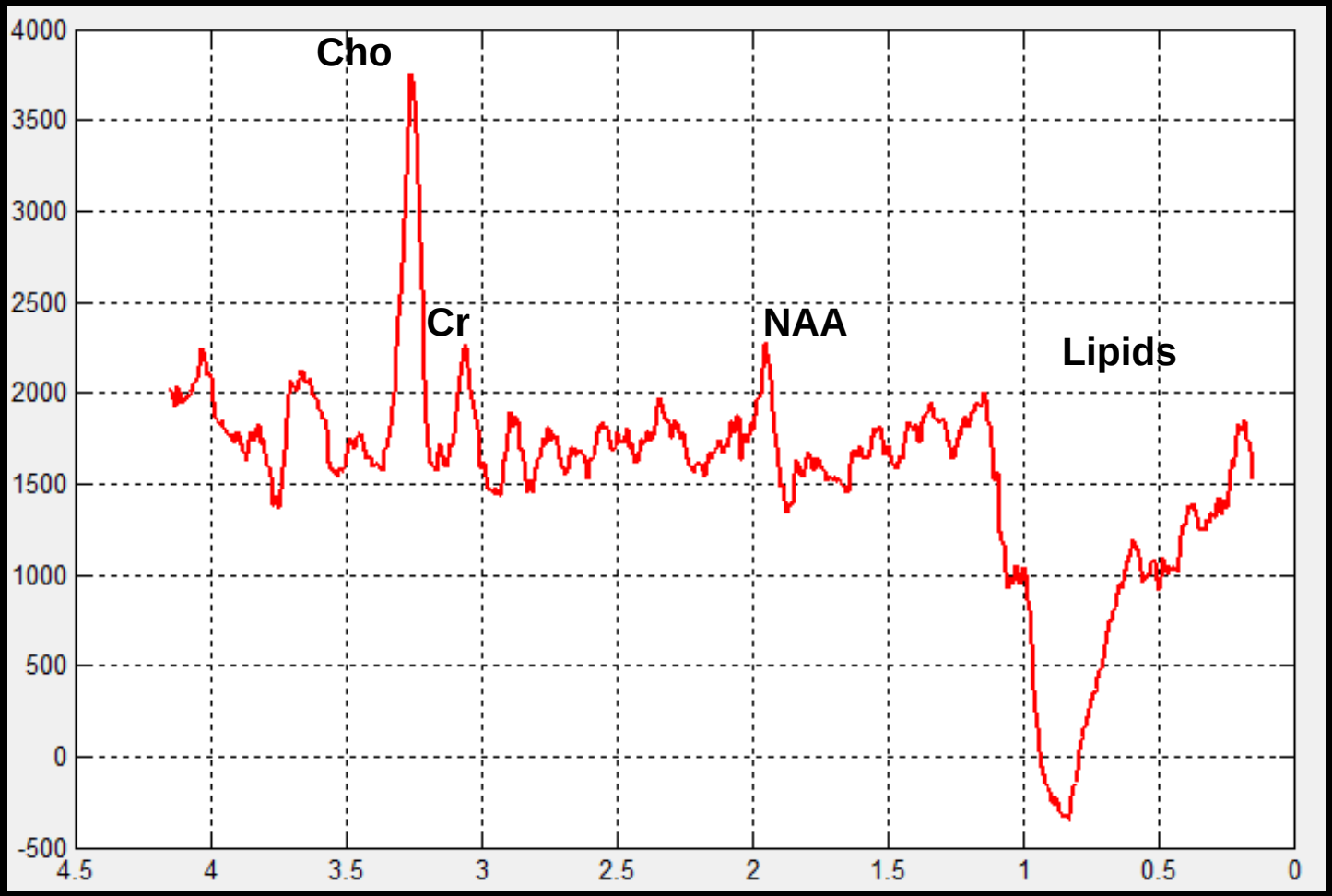
Example of MRS acquisition at gestational age 22 2/7 weeks



Significant noise in Acquisition 3

Results

Averaged (1,2,4,5,6) spectra with acquisition 3 discarded

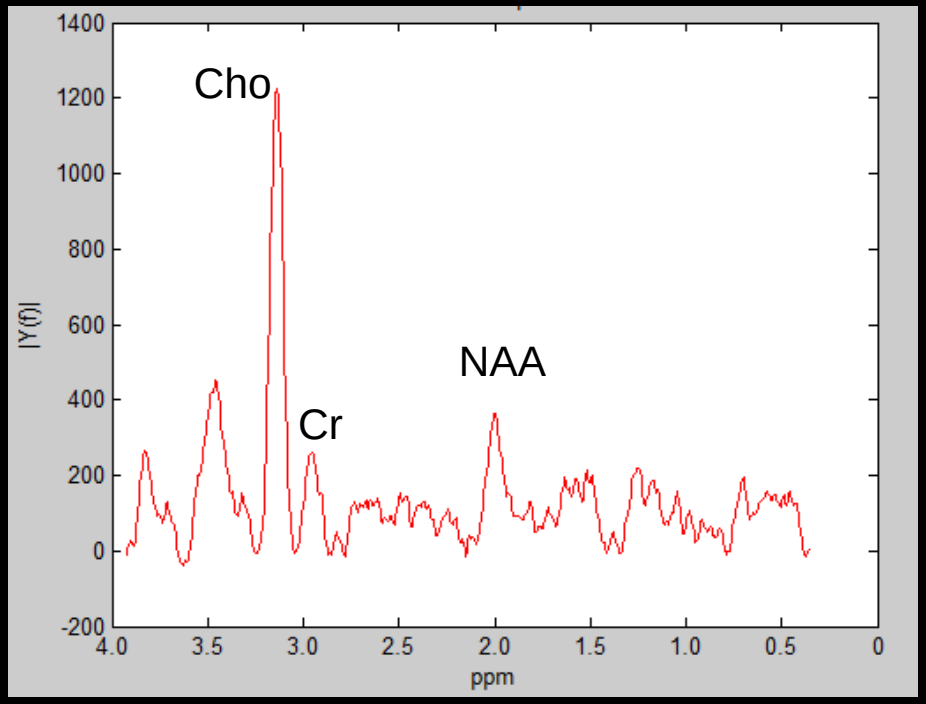


GA - 22 2/7 weeks

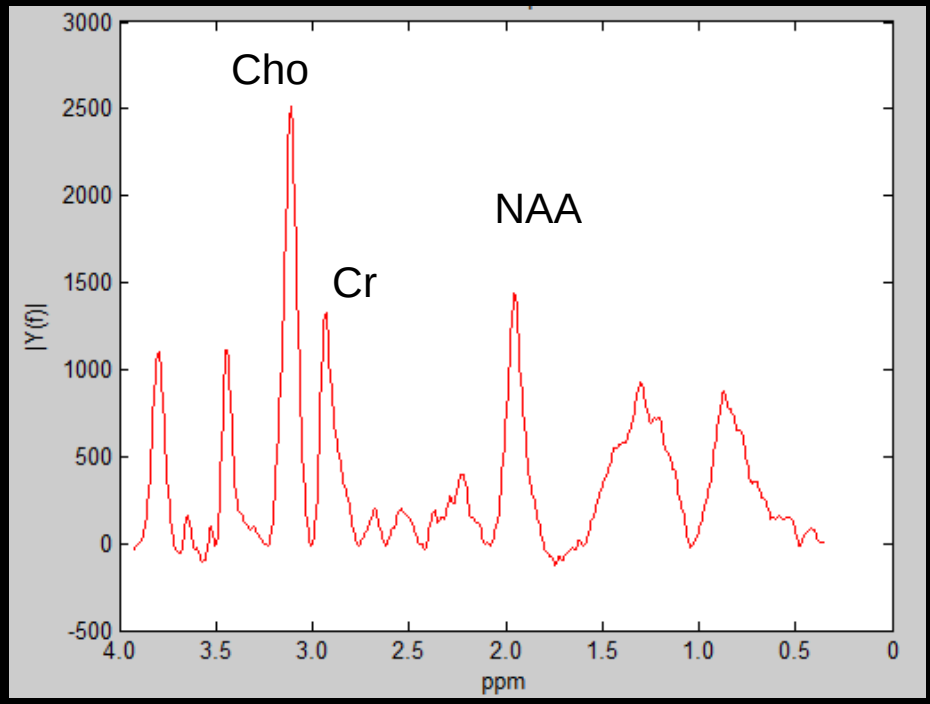
Results

An offline post processing tool was developed in-home for this selective combination of the acquired spectra

Results



GA = 20 5/7



GA = 35 4/7

Good quality spectra were obtained from fetuses with gestational ages ranging from 20 5/7 to 38 1/7 weeks

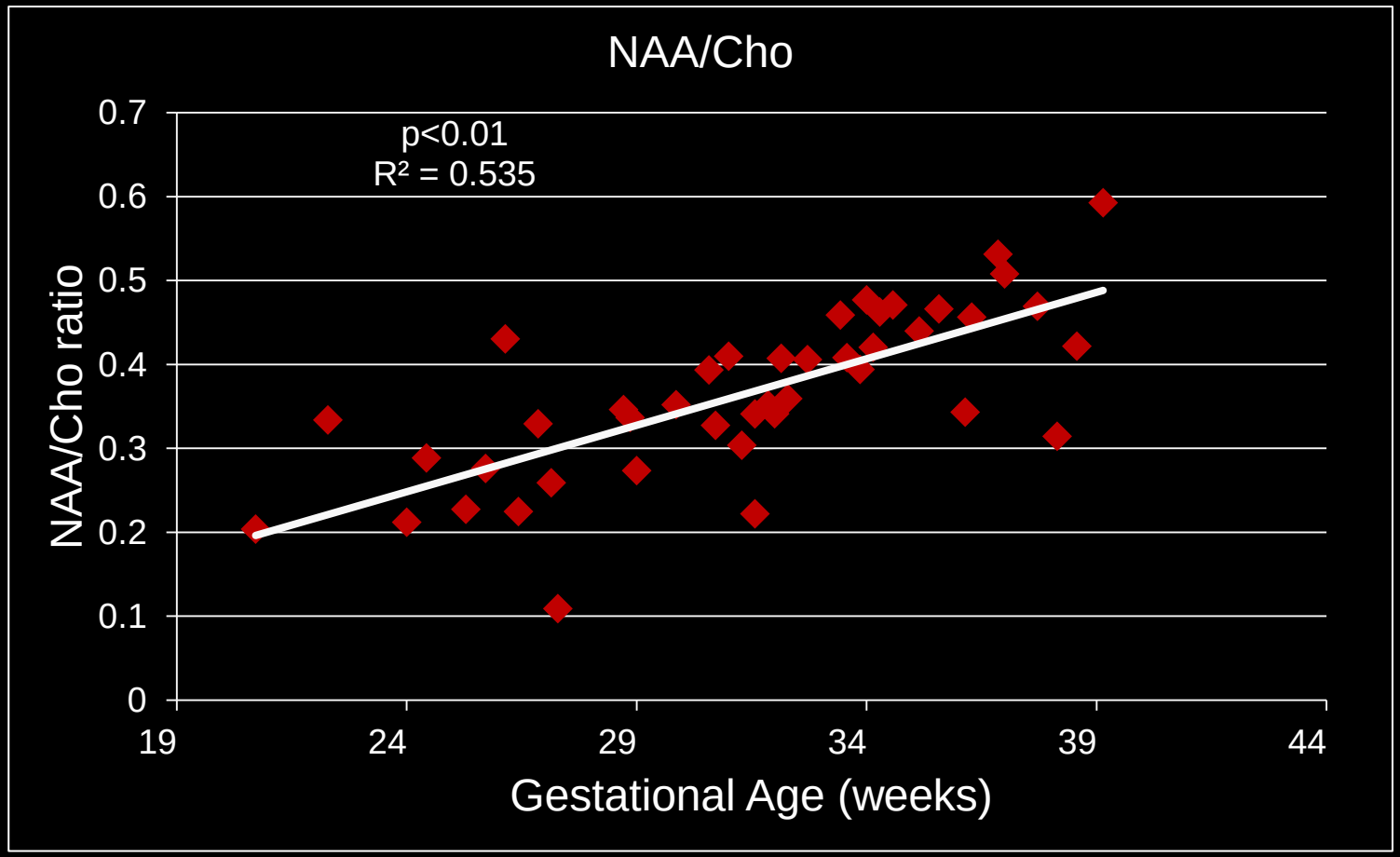
Results

Good quality spectra (SNR>2:1) were obtained in 40 of 55 fetuses

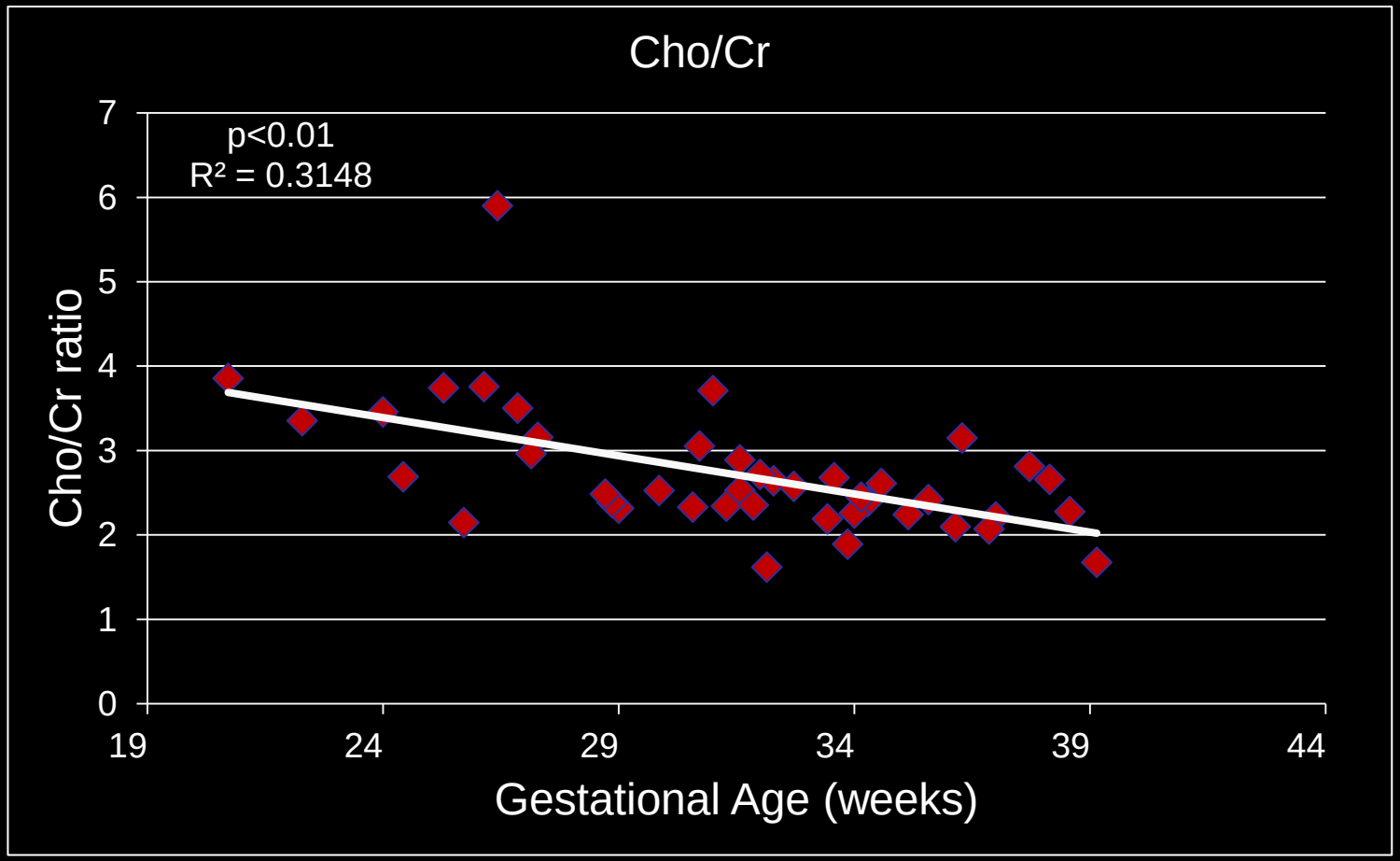
This corresponds to a success rate of 73%

This is improved compared to success rate reported in the literature[2]

Results


NAA/Cho
p<0.01
R² = 0.535
NAA/Cho ratio
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
19
24
29
34
39
44
Gestational Age (weeks)

Results



The increase of NAA/Cho ratio and decrease of Cho/Cr ratio with gestation are in good agreement with previously reported trends[3-6]

Comments

- Piece-wise acquisition and selective combination helps in discarding data corrupted by motion

- Practically, piece-wise acquisition also helps visualize the quality of spectra online on the magnet and one can stop measurement if the spectra quality is seen to be affected by motion

- To take full advantage of this method, individual acquisitions should have a minimum # of averages that ensures the SNR in individual spectra themselves is high enough for quantification

Comments and conclusion

- In our study, performing MRS at 3.0T helped in this aspect, providing a reasonably high SNR even in individual acquisitions, and in reducing acquisition time

- With this approach we also have reasonable success rate even for lower gestations

- We follow a more stringent quantitative criteria for defining quality of spectra. Despite this we obtain a success rate higher than that reported in literature

Conclusion

- In conclusion, piece-wise acquisition and selective combination approach could help in improving success rate of obtaining quality spectra from the fetal brain.

- This is easy to implement in the sequence and requires relatively simple post-processing of data

References

[1] Prayer, D. and SpringerLink (Online service) (2011). Fetal MRI. Medical radiology Diagnostic imaging. New York ; London, Springer.

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[3] Kok RD, van den Berg PP, et al., Magn Reson Med. 2002 Oct;48(4):611-6.

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[6] Story L, Damodaram MS, et al., Am J Obstet Gynecol. 2011 Nov;205(5):483.e1-8.;