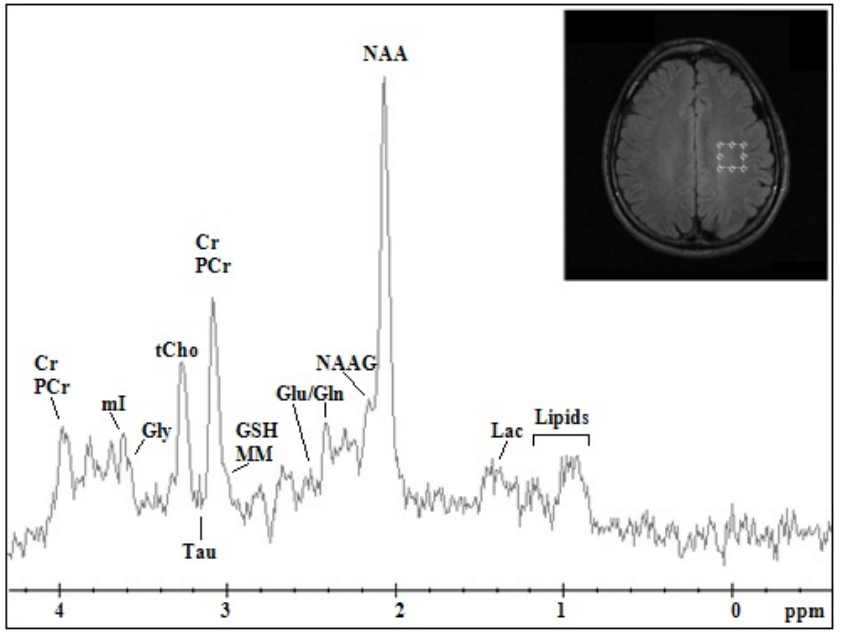
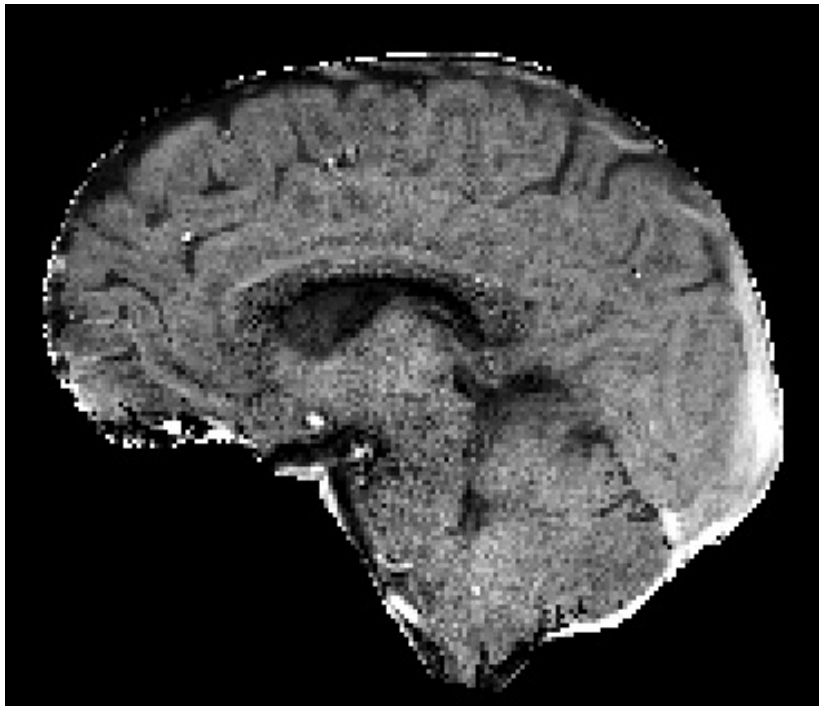
MRS and GluCEST:

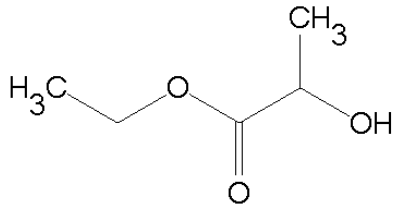
Acquisition and Analysis

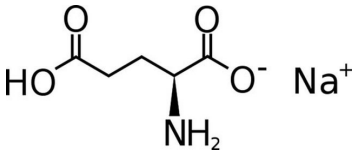


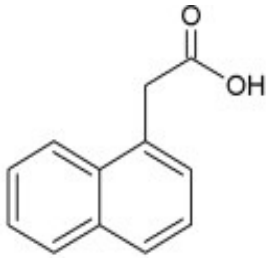


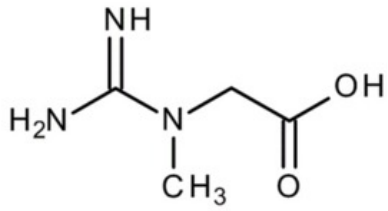
Magnetic Resonance Spectroscopy

- Method for studying neurochemicals/neurometabolites *in vivo*





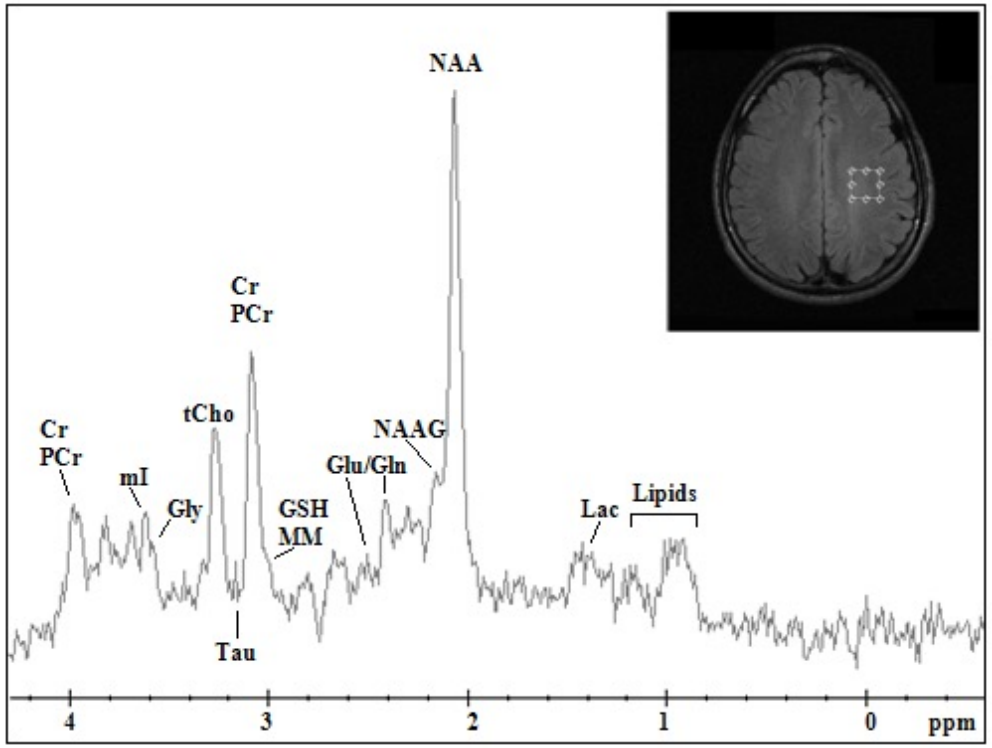




Magnetic Resonance Spectroscopy

- Method for studying neurochemicals/neurometabolites *in vivo*

- The output of processed MRS data is a **spectra**

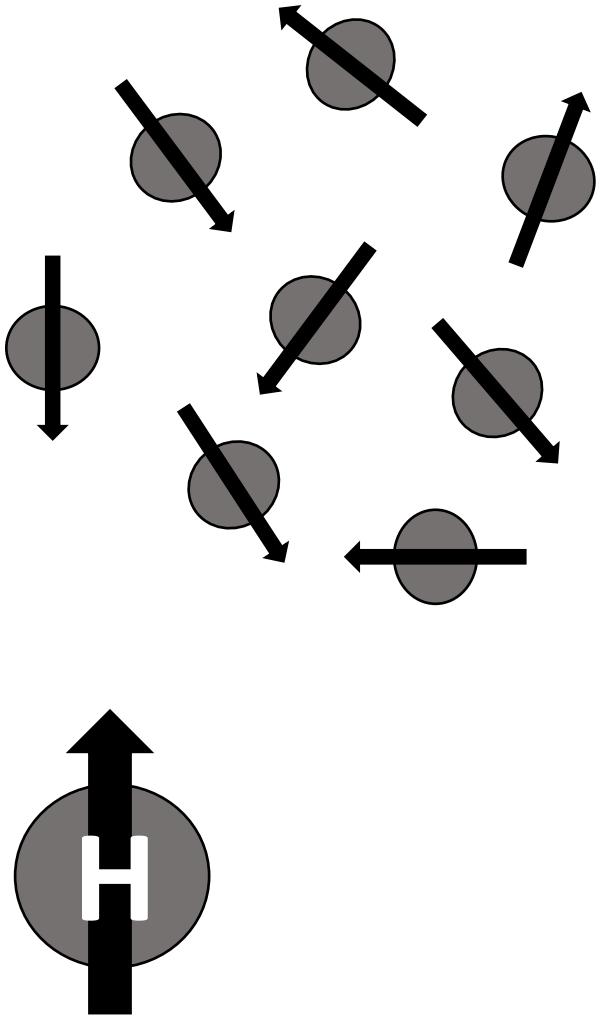


Magnetic Resonance Spectroscopy

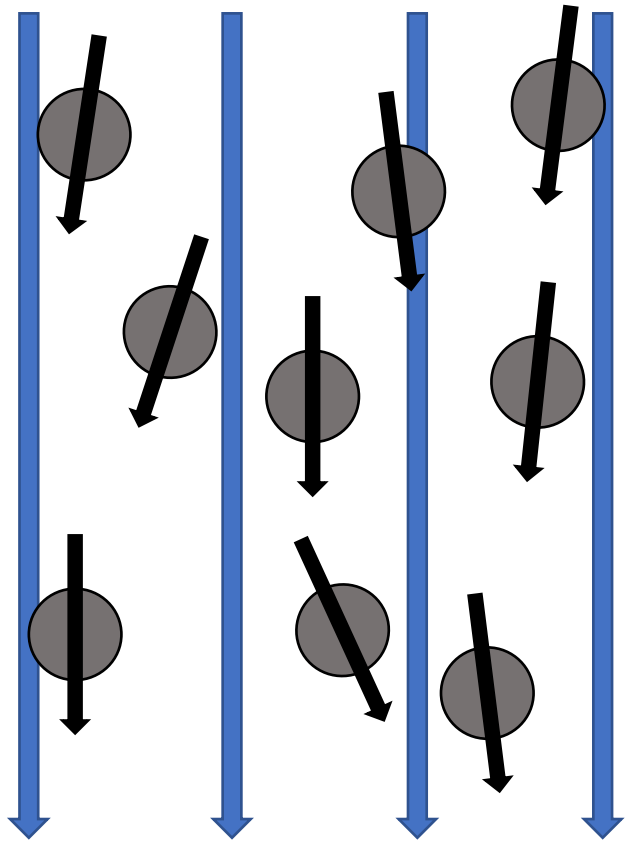
- Method for studying neurochemicals/neurometabolites *in vivo*
- The output of processed MRS data is a **spectra**
- Neurochemicals/metabolites we can measure:
  - **N-acetylaspartate (NAA)**
  - Choline
  - Creatine/phosphocreatine
  - Myo-inositol
  - Lactate
  - Glutathione
  - Glutamate/Glutamine

Proton (H) MRS Acquisition

No Magnetic Field

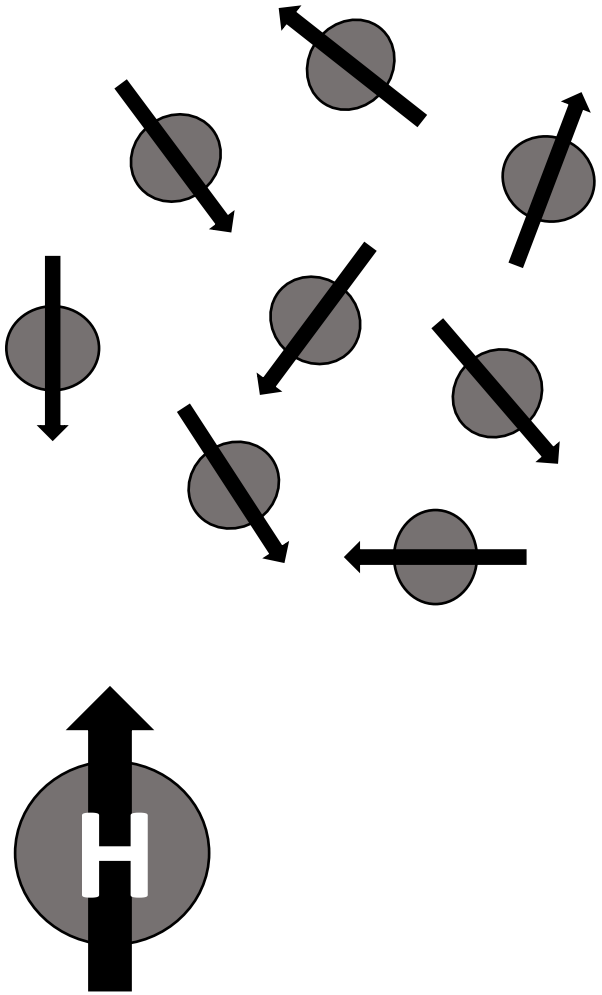


Applied Magnetic Field (B0)

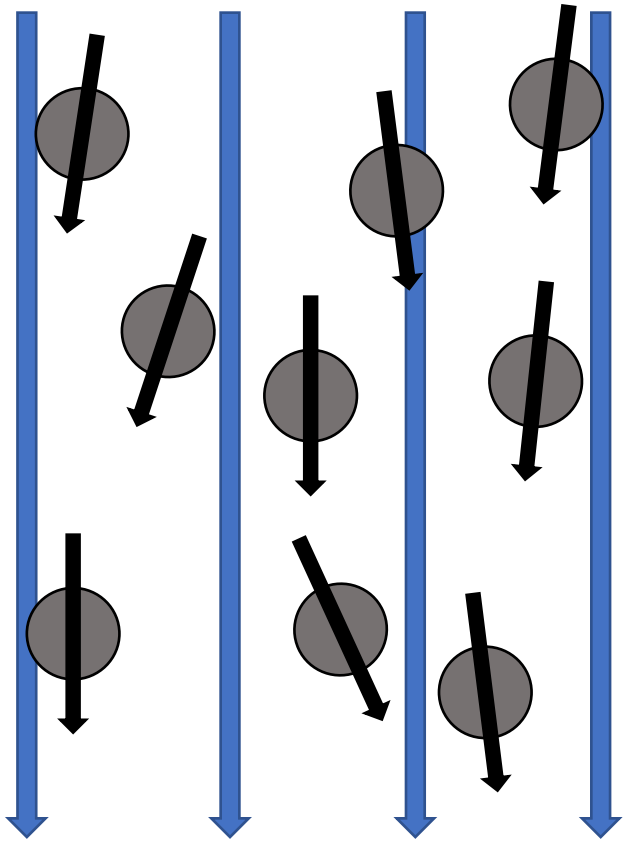


Proton (H) MRS Acquisition

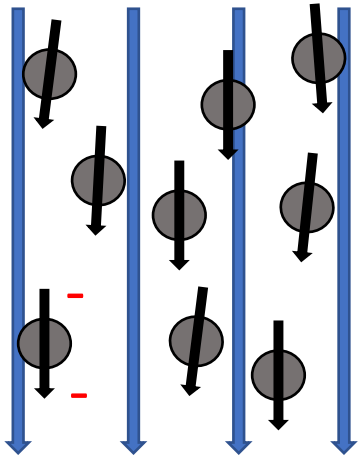
No Magnetic Field



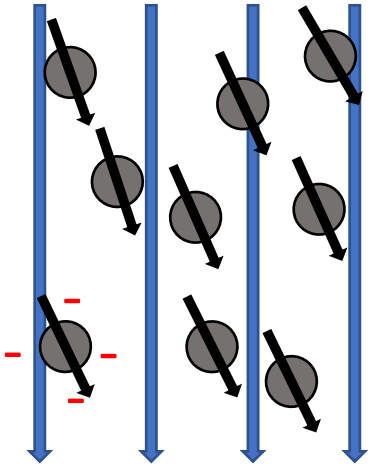
Applied Magnetic Field (B0)



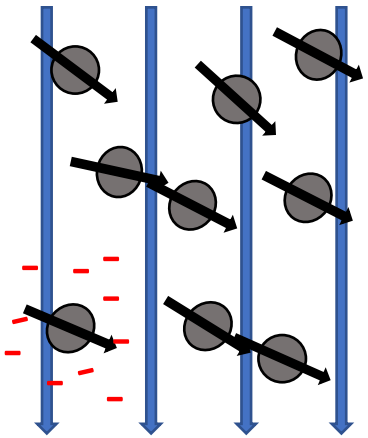
Choline



Glutamate/Glutamine

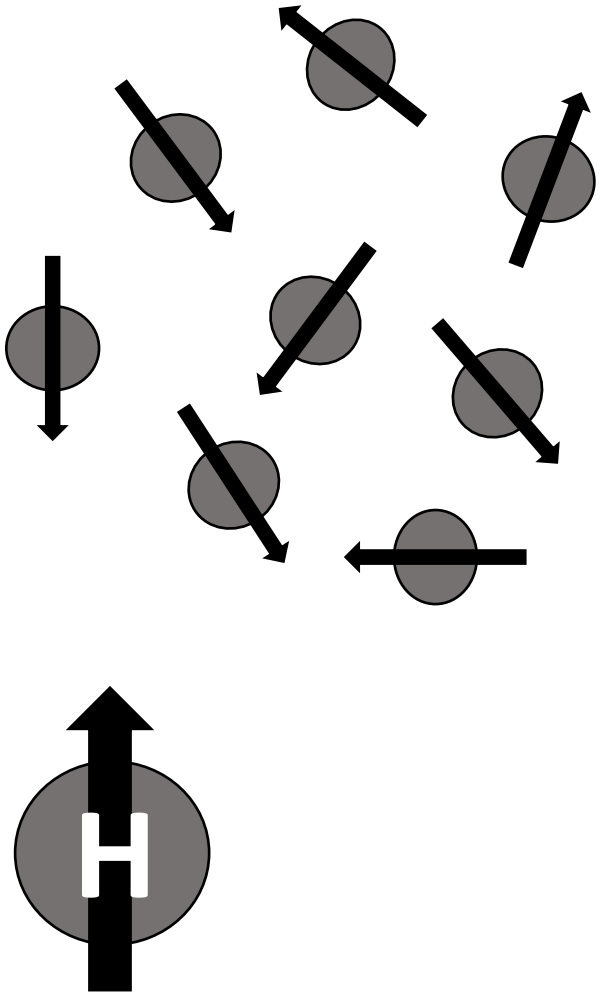


NAA

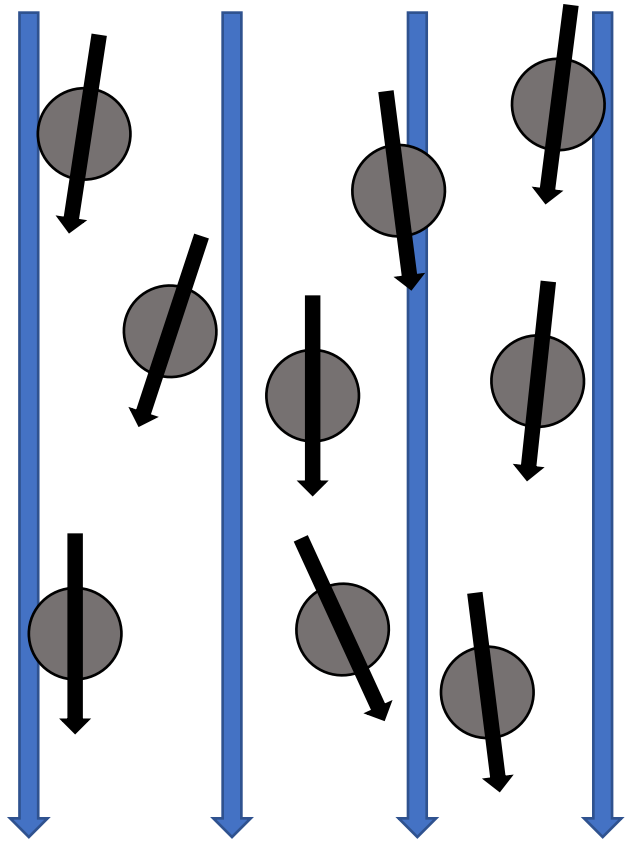


Proton (H) MRS Acquisition

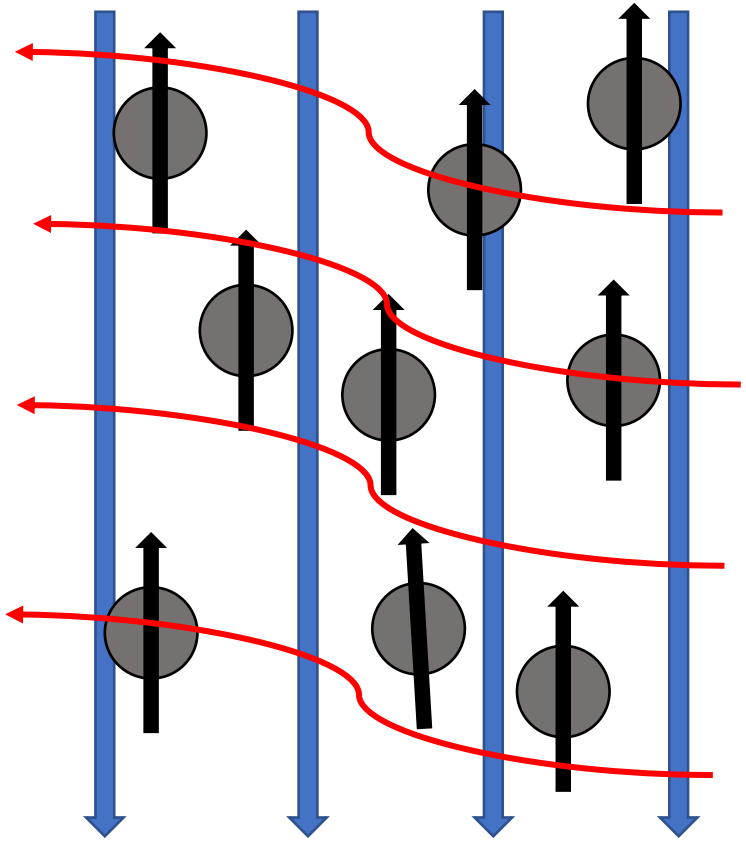
No Magnetic Field



Applied Magnetic Field (B0)



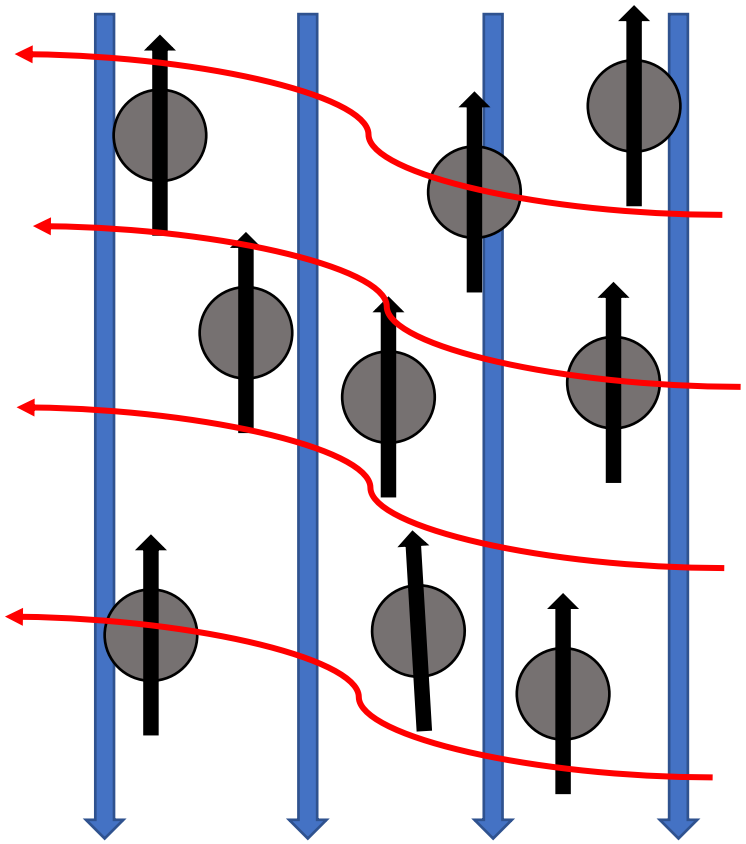
Radiofrequency Field (B1)



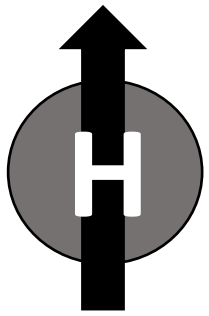
SPIN FLIP

Proton (H) MRS Acquisition

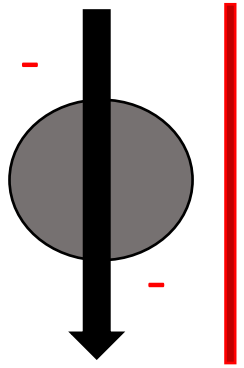
Radiofrequency Field (B1)



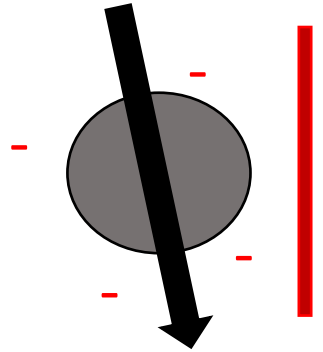
SPIN FLIP



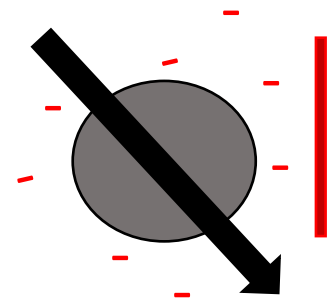
Choline



Glutamate/Glutamine



NAA



ΔE

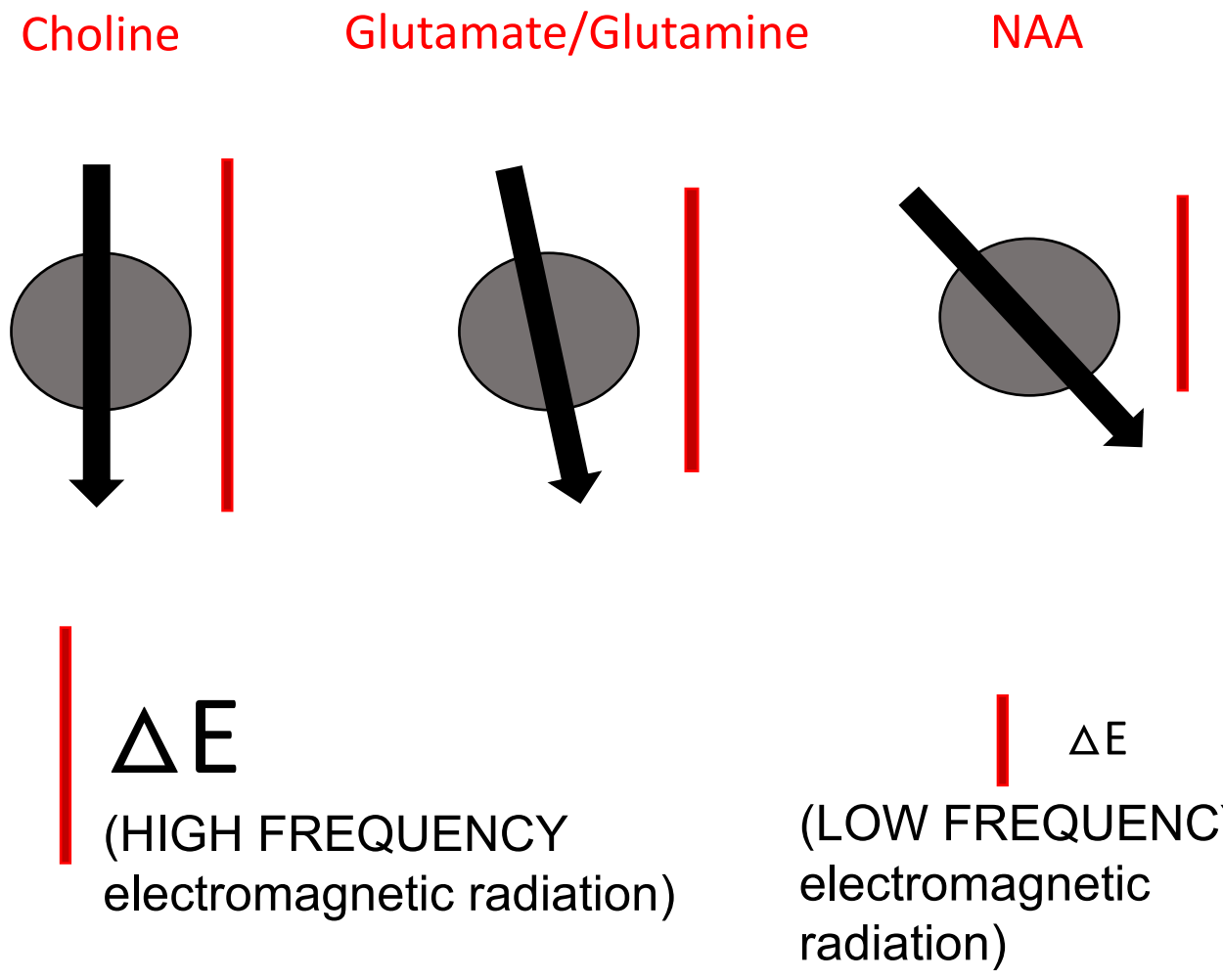
(HIGH FREQUENCY electromagnetic radiation)

ΔE

(LOW FREQUENCY electromagnetic radiation)

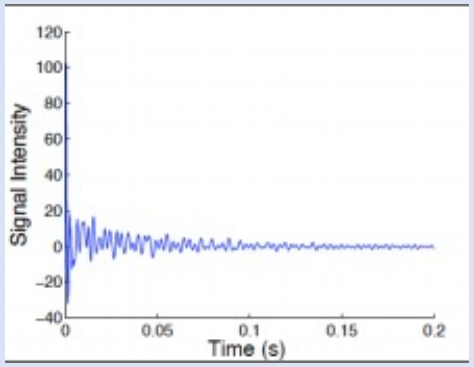
Proton (H) MRS Acquisition

- Protons in different chemicals absorb electromagnetic radiation of different FREQUENCIES
- When we turn off the B1, protons in different chemicals therefore EMIT RADIATION OF DIFFERENT FREQUENCIES
- These emitted frequencies are what we measure in MRS!

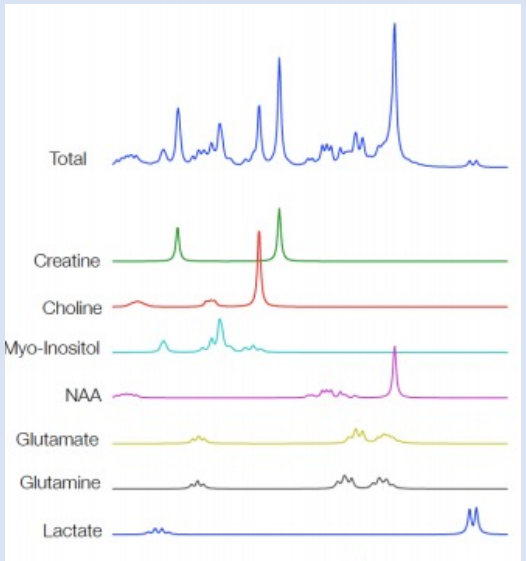


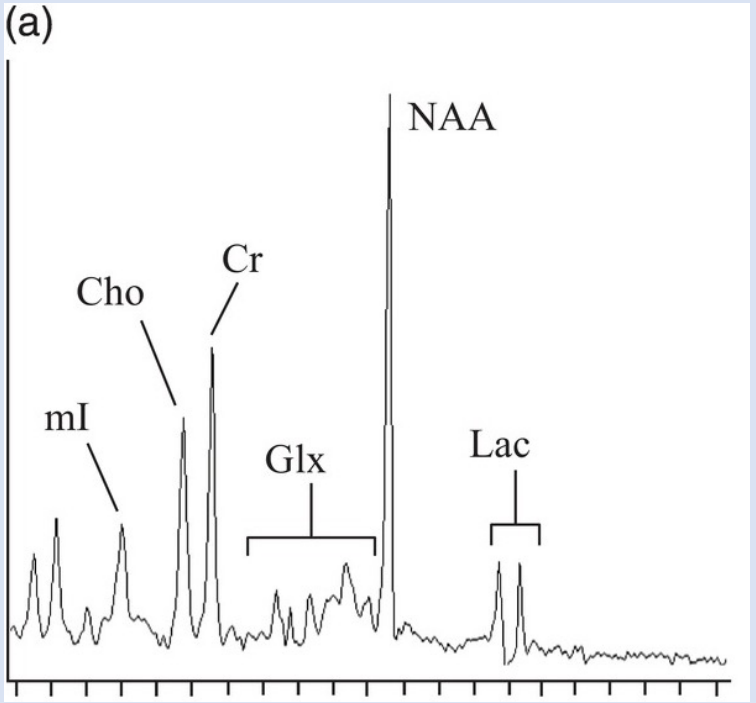
Proton (H) MRS Acquisition

Free Induction Decay Signal



Fourier Transform

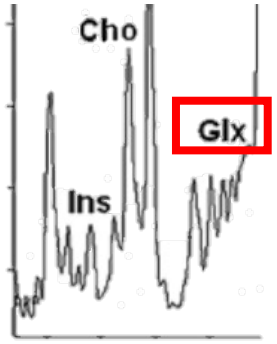




Magnetic Resonance Spectroscopy

Concentrations estimated in one brain region per study

Cannot differentiate between gray matter, white matter, and CSF signal

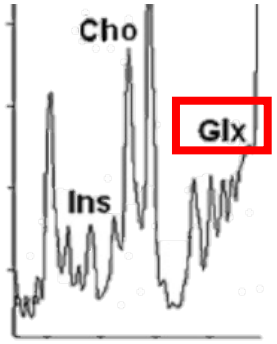


Glutamate + Glutamine = GLX

Magnetic Resonance Spectroscopy

Concentrations estimated in one brain region per study

Cannot differentiate between gray matter, white matter, and CSF signal



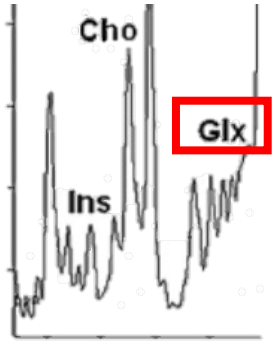
Glutamate + Glutamine = GLX

- Is glutamate actually disrupted in these disorders?
- Is it disrupted early or late in the disorder (or both)? Are alterations different at different stages in the disorder?
- How does glutamate level relate to clinical symptoms?
- Is glutamate abnormal in all individuals with a disorder or in a subset of them only?
- Can glutamate measures be used to target individuals to glutamate-modulating treatments?

Magnetic Resonance Spectroscopy

Concentrations estimated in one brain region per study

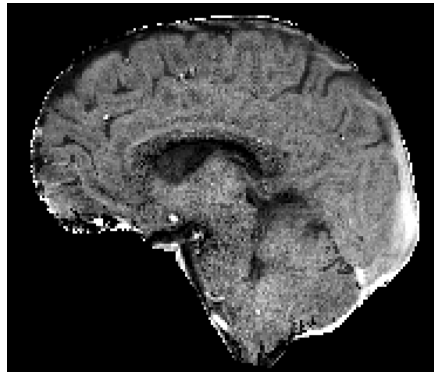
Cannot differentiate between gray matter, white matter, and CSF signal



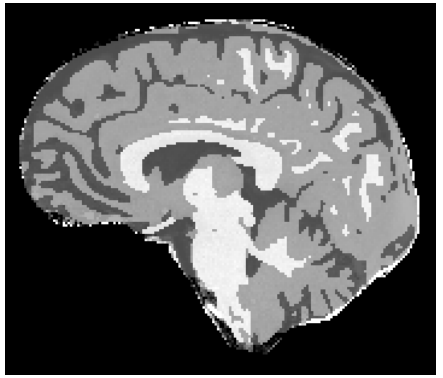
Glutamate + Glutamine = GLX

GluCEST

Glutamate level estimated across an entire 2D brain slice

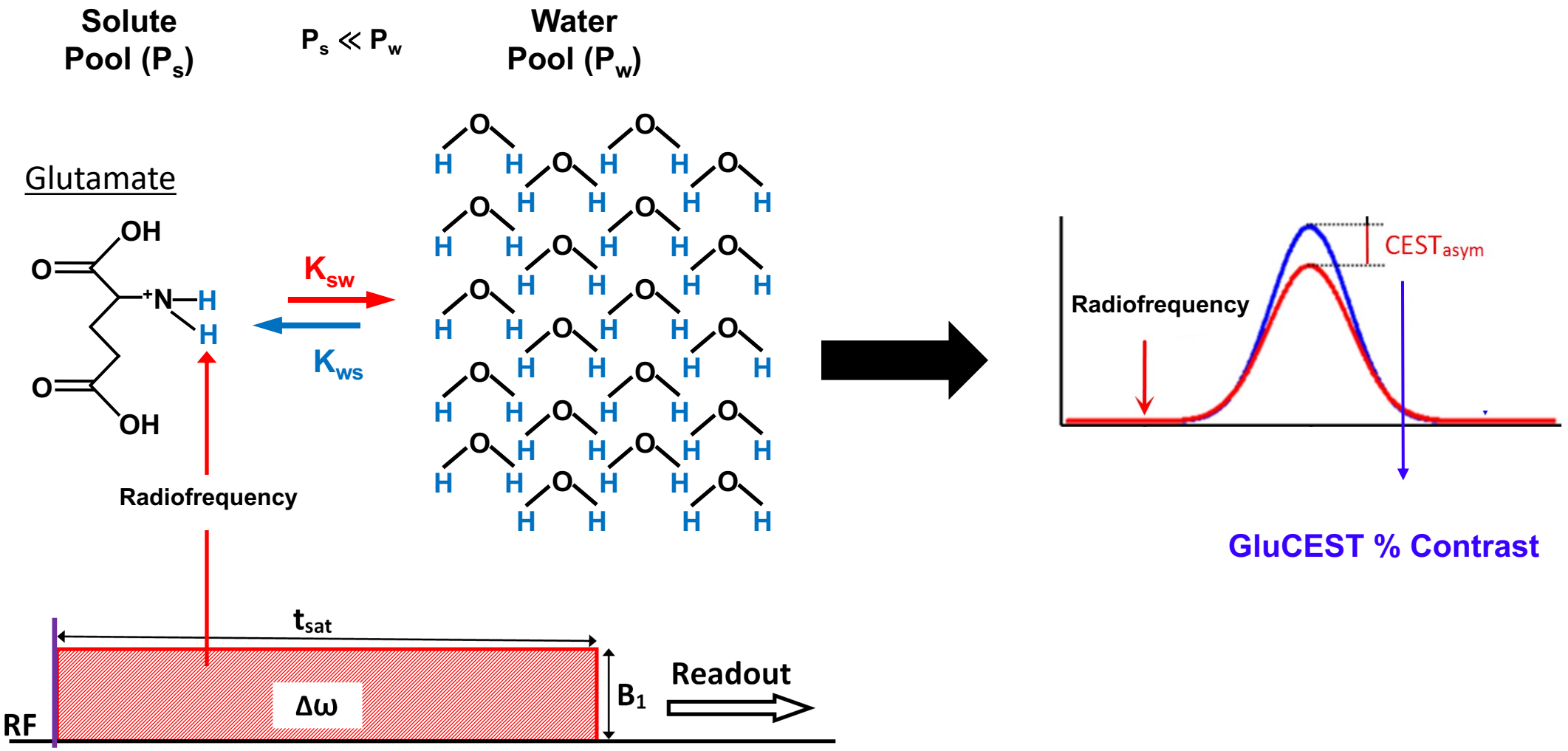


Can differentiate between gray matter, white matter, and CSF glutamate



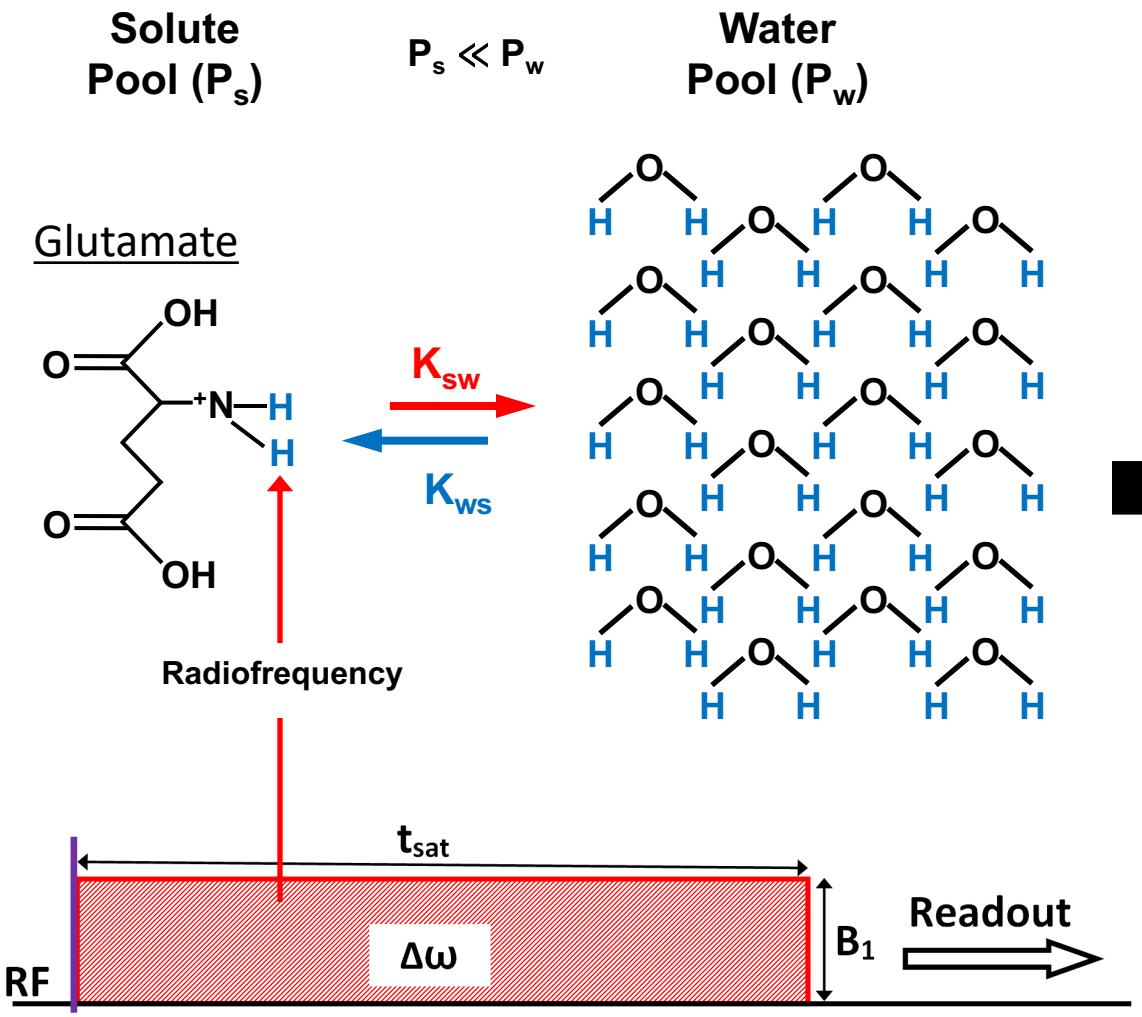
Only sensitive to glutamate

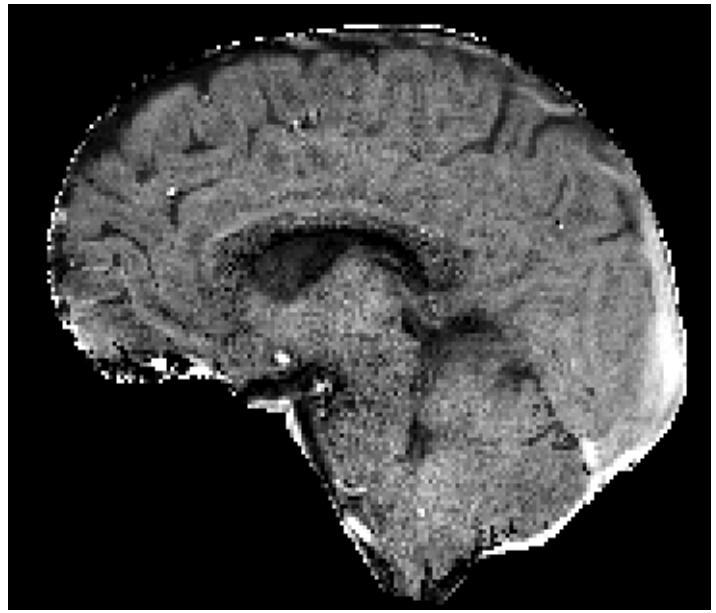
Glutamate Chemical Exchange Saturation Transfer Imaging (GluCEST)



Wolff S, Balaban R. NMR imaging of labile proton-exchange. *J Magn Reson* 1990; 86(1):164-169.

Glutamate Chemical Exchange Saturation Transfer Imaging (GluCEST)

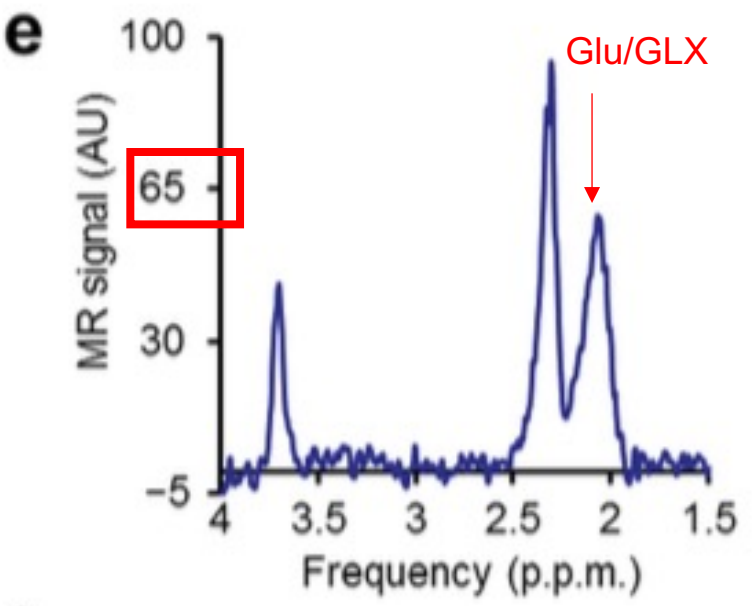




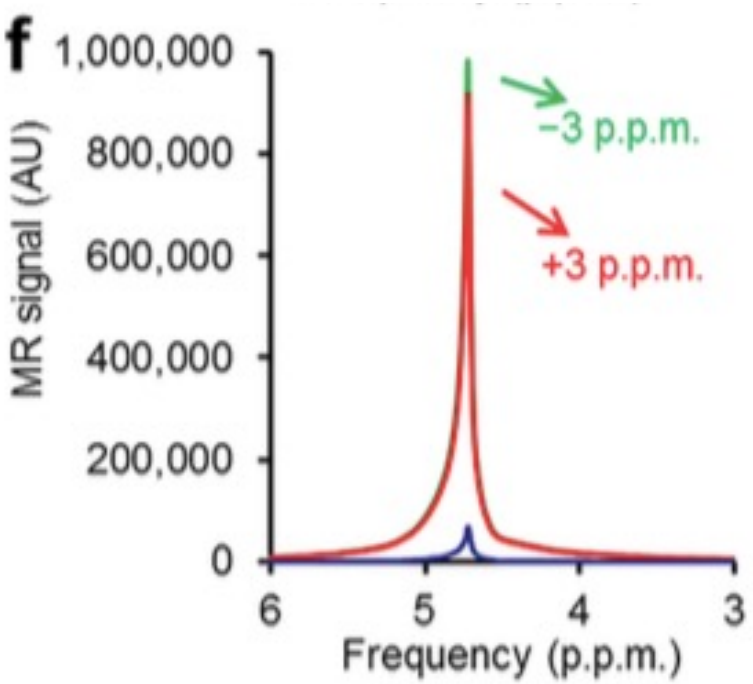
Wolff S, Balaban R. NMR imaging of labile proton-exchange. *J Magn Reson* 1990; 86(1):164-169.

*700 FOLD INCREASE IN SENSITIVITY TO GLUTAMATE

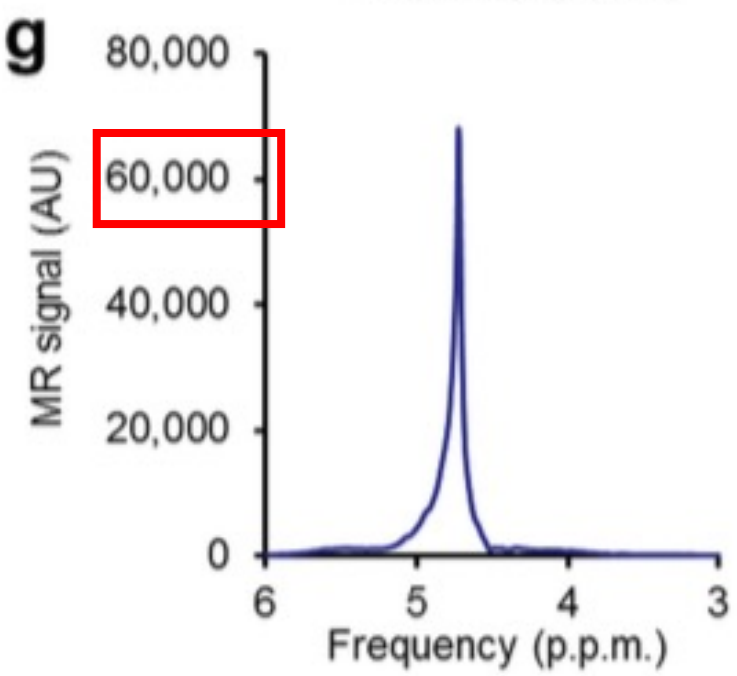
MRS



CEST Effect
(change in water signal)



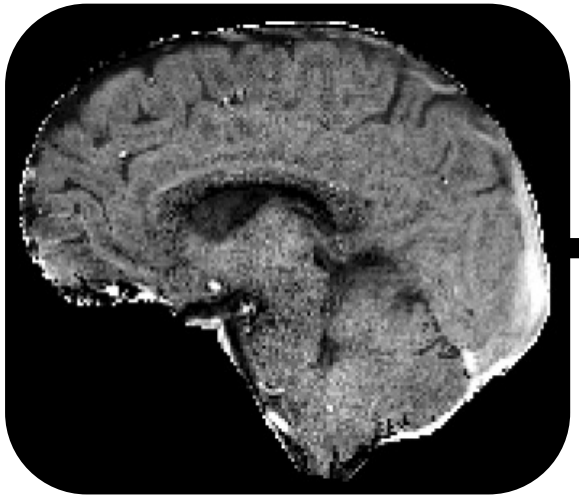
CEST Effect
(RESCALED)



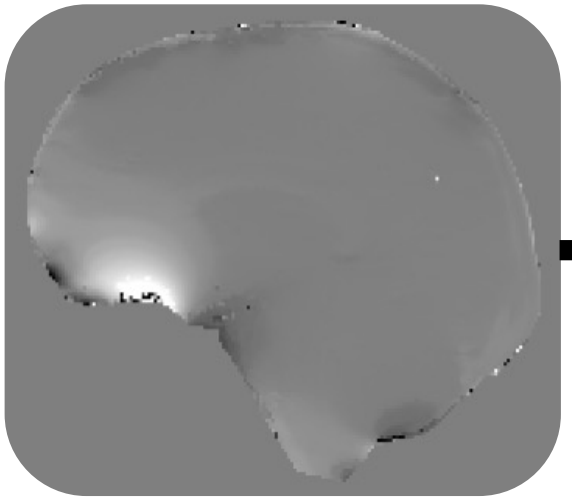
Cai et al. *Nature Medicine* 2012

GluCEST Analysis

Raw GluCEST Data



B0 Correction



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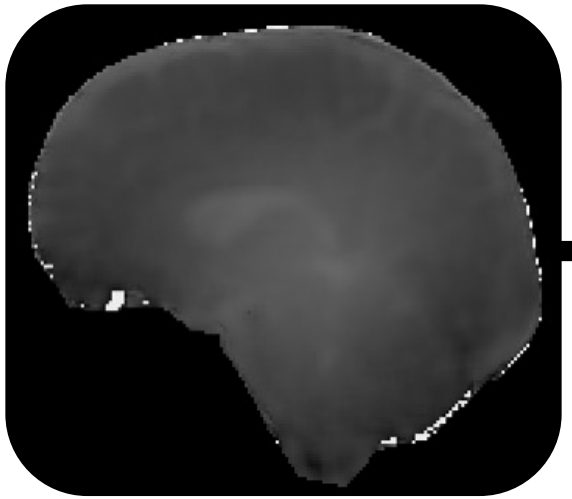
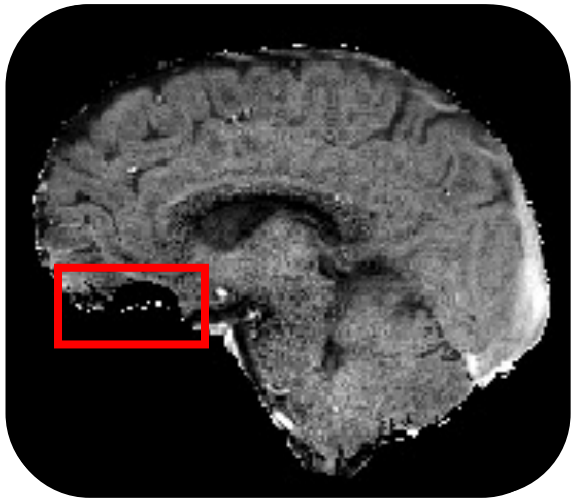
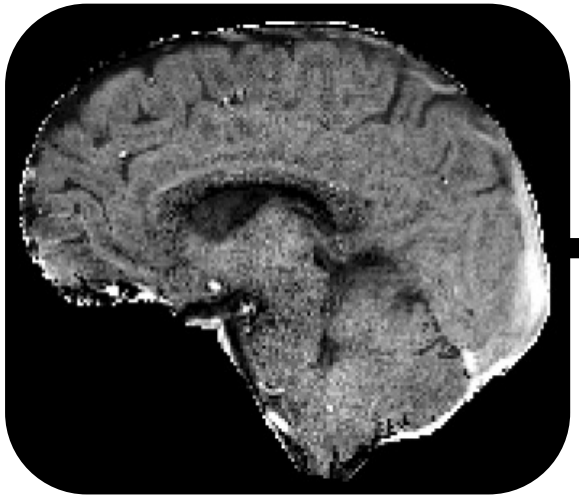


Threshold Data

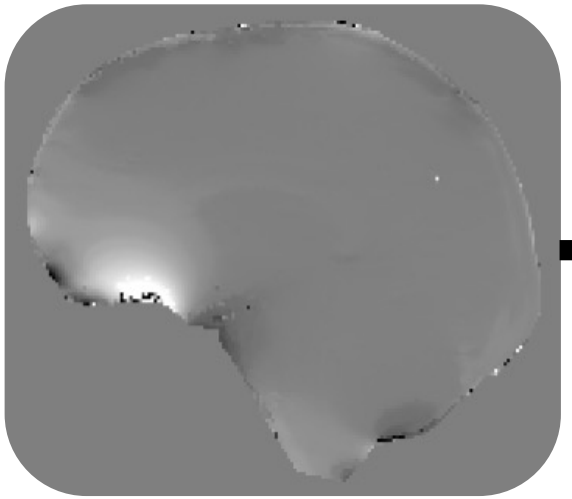


GluCEST Analysis

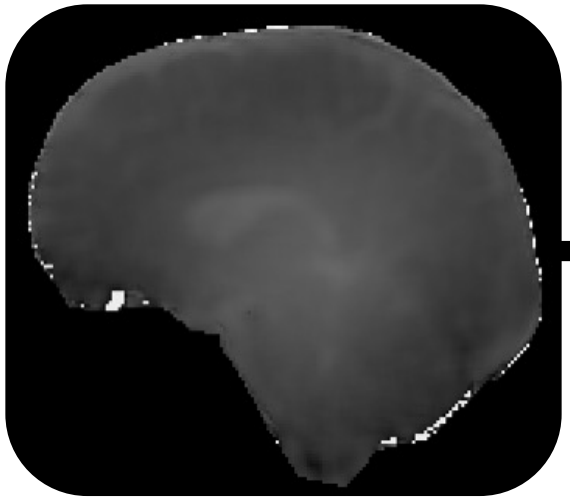
Raw GluCEST Data



B0 Correction



B1 Correction



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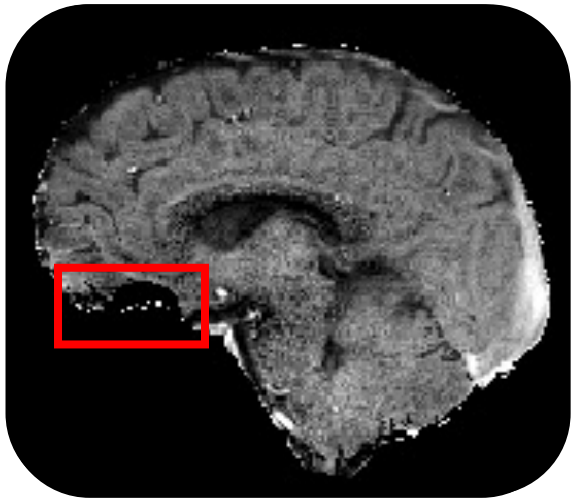
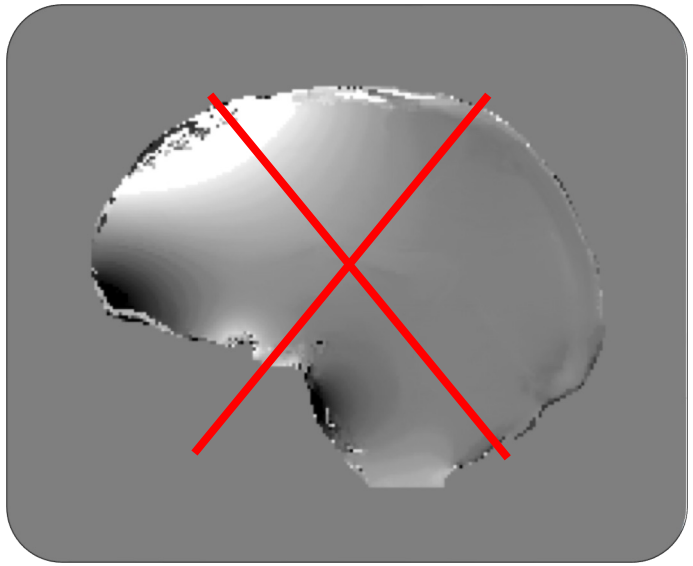
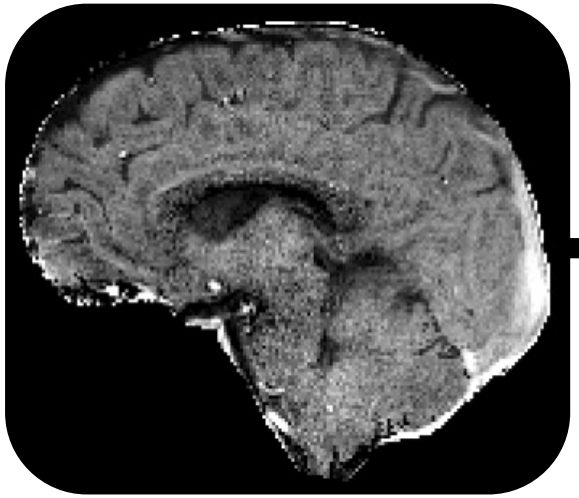


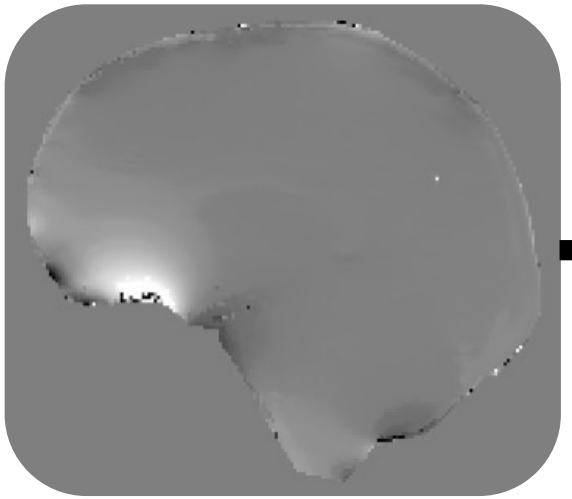


GluCEST Analysis

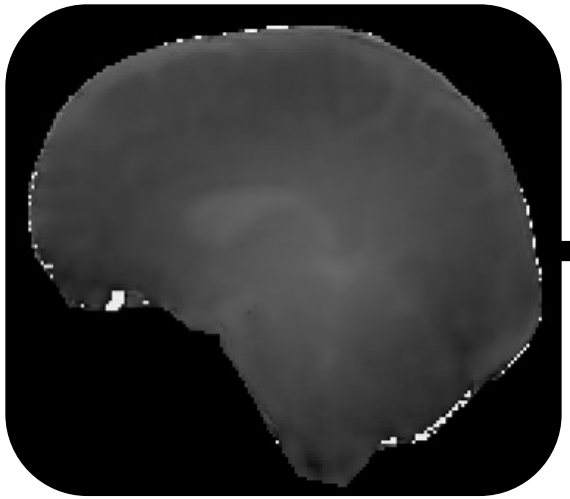
Raw GluCEST Data



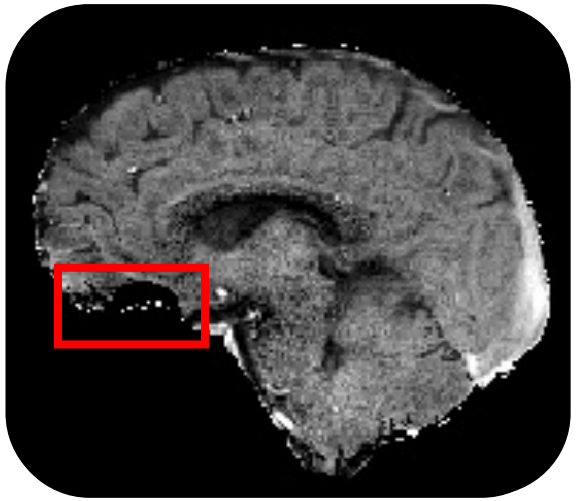
B0 Correction

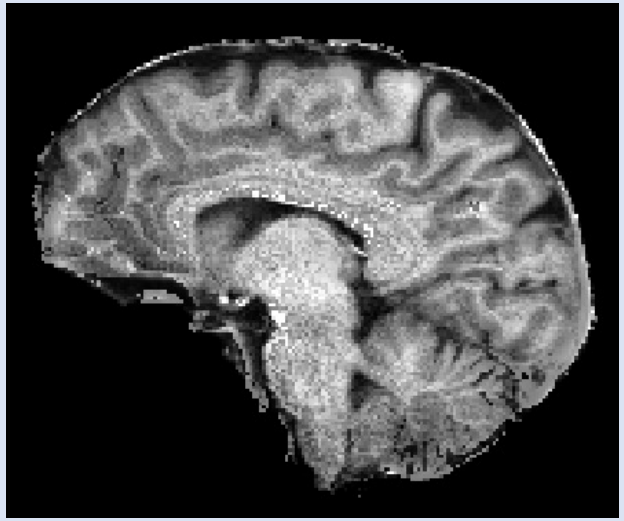


B1 Correction



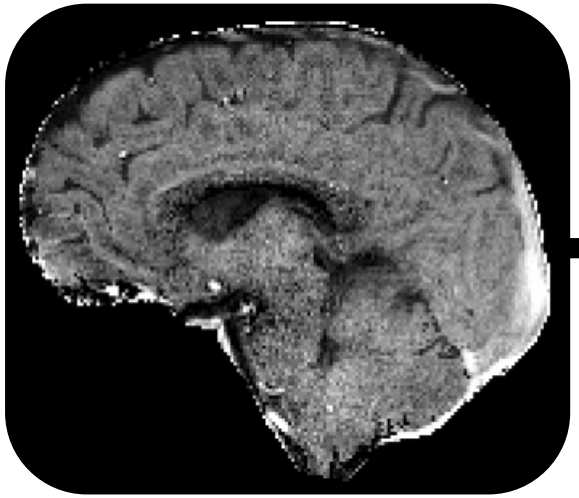
Threshold Data





GluCEST Analysis

Raw GluCEST Data



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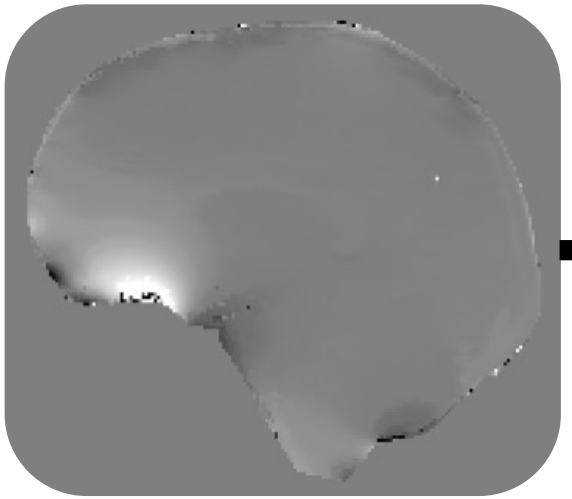

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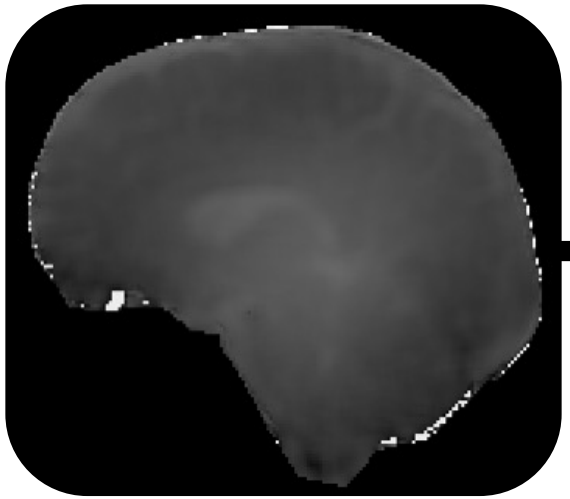

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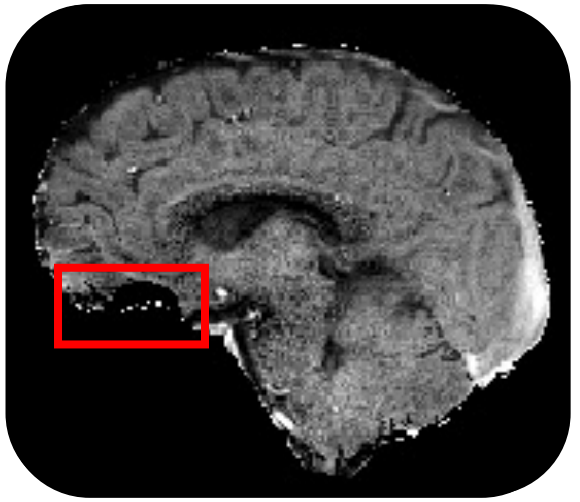
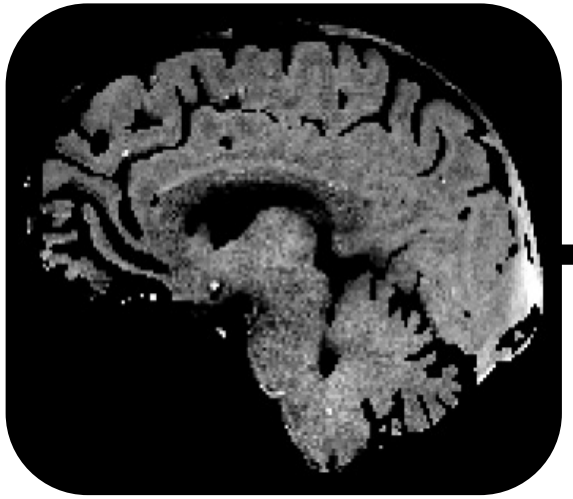


Tissue Segmentation

CSF Removal



Mask Generation

Atlas Registration