MRI PRACTICALS ON CIBM PRECLINICAL IMAGING SYSTEMS PROJECTS

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Master Course 2025-2026

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ORGANIZATION, EVALUATION

Expected student activities

Active participation in the theoretical courses with questions

Discussions/questions during the live demos

Supervised experimental manipulation of the MRI scanner

Processing of the acquired data

Work in teams for a joint project

Assessment methods

Report/mini project

- 6 groups in total – *2 by 2*
- Assessment:
  - Project: review of a theoretical topic
    - Subjects and groups allocated on 28th of October
    - Report submission by 2nd of December
    - Oral presentations on 16th of December
  - Evaluation during semester:
    - Presence is mandatory (min 80%)
    - Actively participate

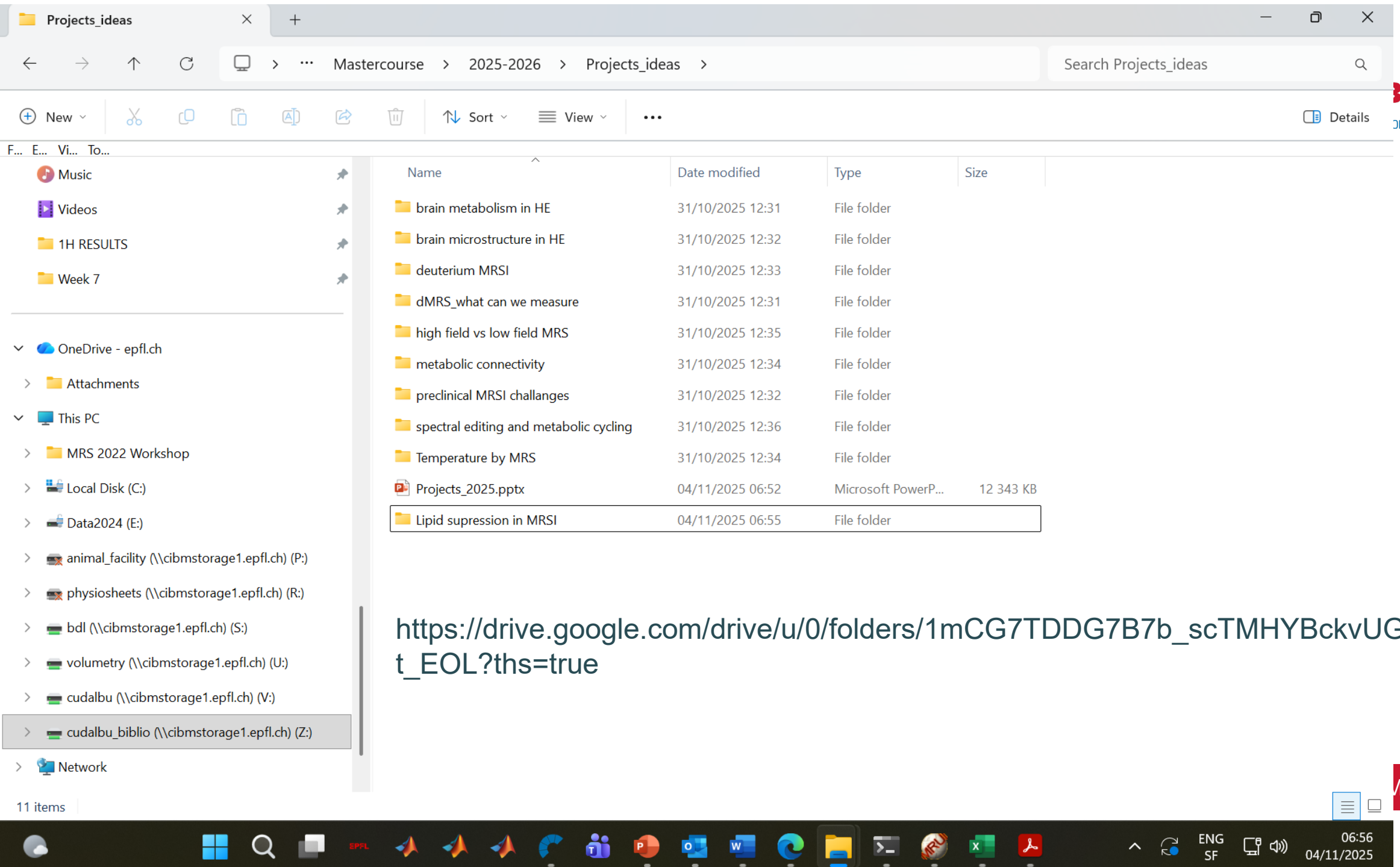
REPORT & ORAL REQUIREMENTS

Report (max. 15 pages, figures & references included):

- **Literature Review**
- **Single column** report
- Font Size : **12** / Linespacing : **1.15**
- To submit by : **2nd of December**

Oral Presentation (max. 15 minutes):

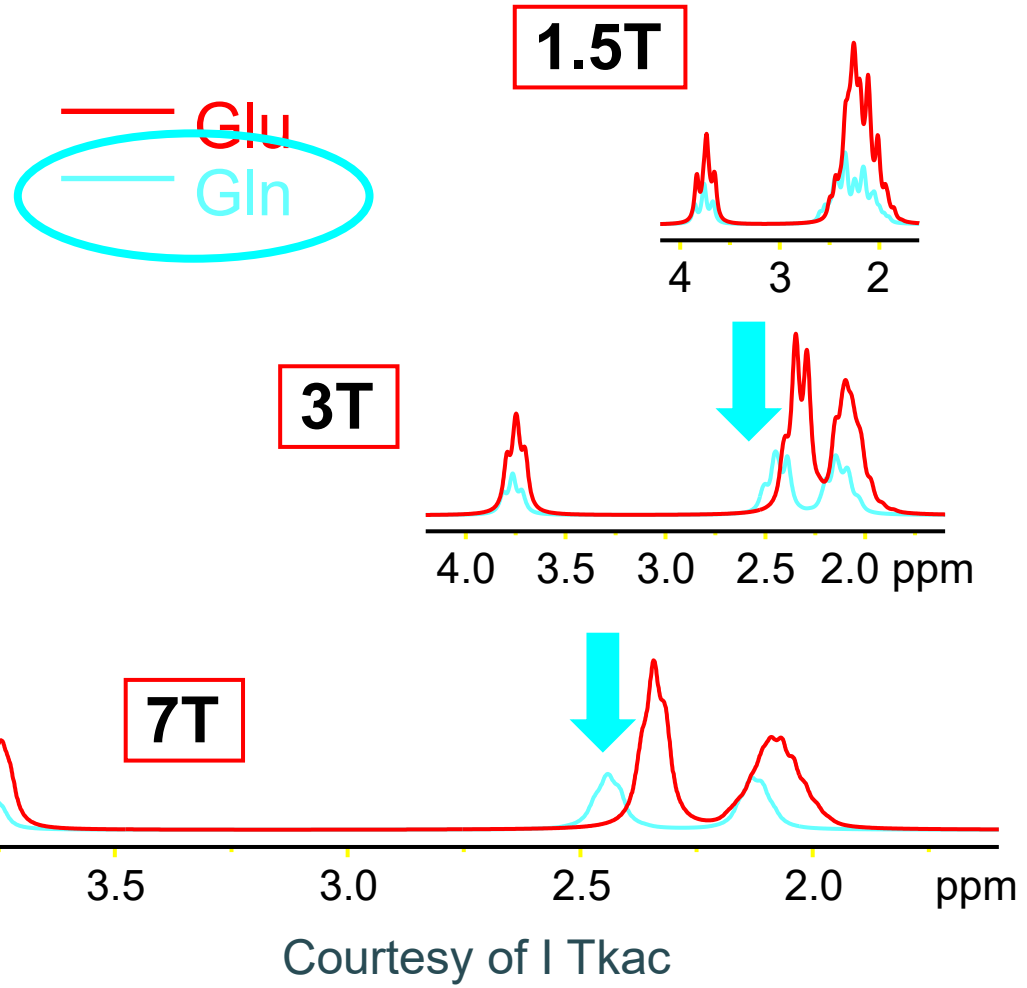
- **One presentation** per group (order to be determined…)
- Format : **15 minute presentation – 10 minutes questions**
- **Presence is mandatory through ALL presentations !**



https://drive.google.com/drive/u/0/folders/1mCG7TDDG7B7b_scTMHYBckvUG8-t_EOL?ths=true

HIGH B_0

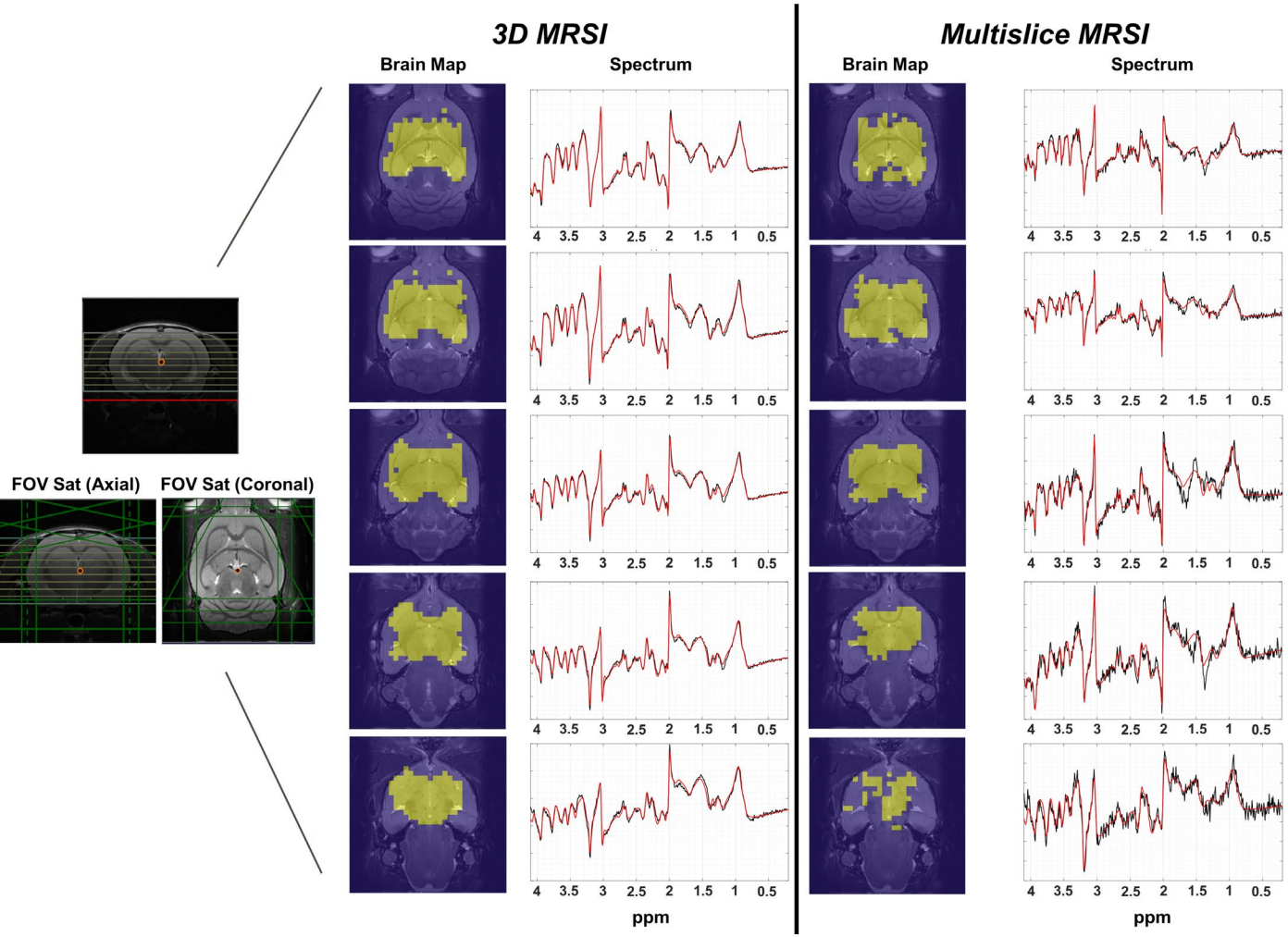
- Enormous progress
  - ↑ SNR
  - ↑ chemical shift dispersion – ↑ resolution
  - decreased strong J-coupling effects
  - Improve quantification precision and accuracy
  - ↓ T_2* - ↑ spectral lw in Hz

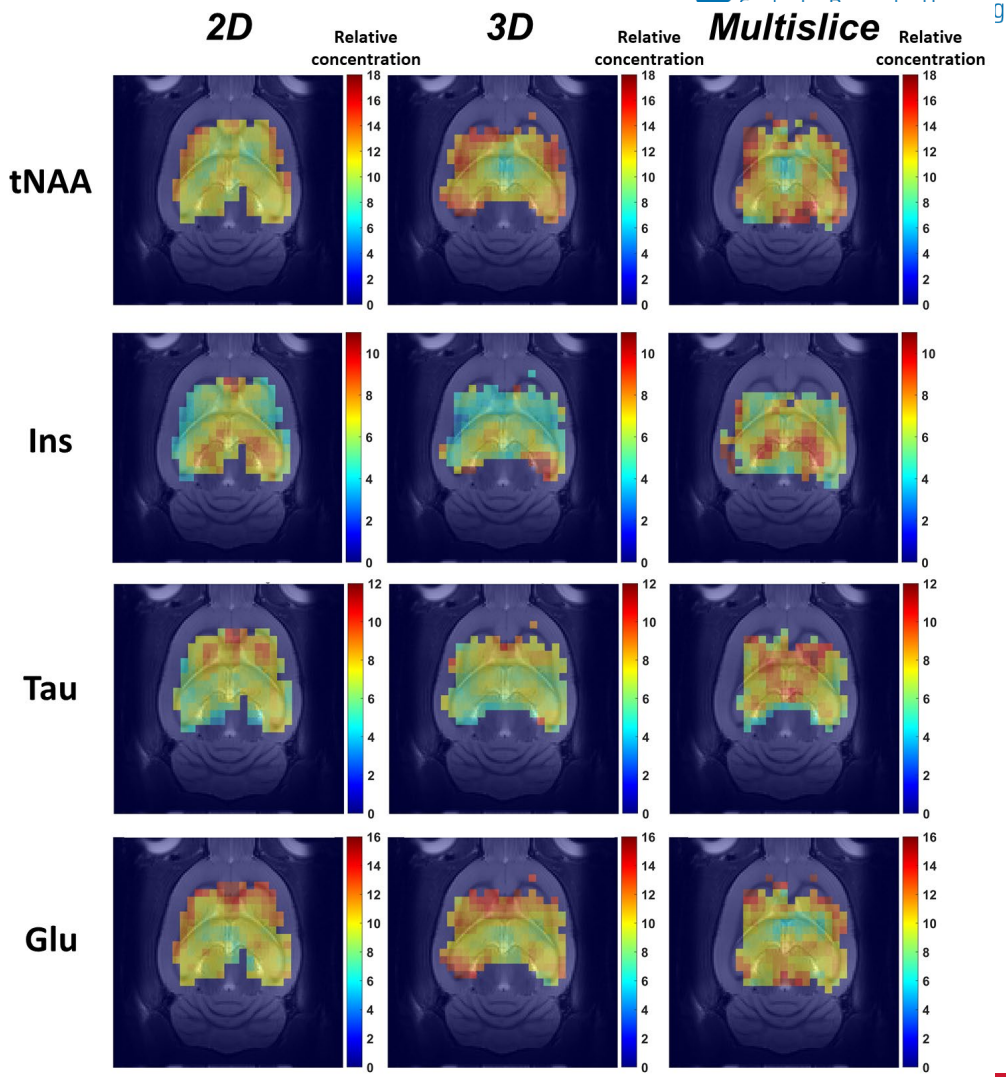


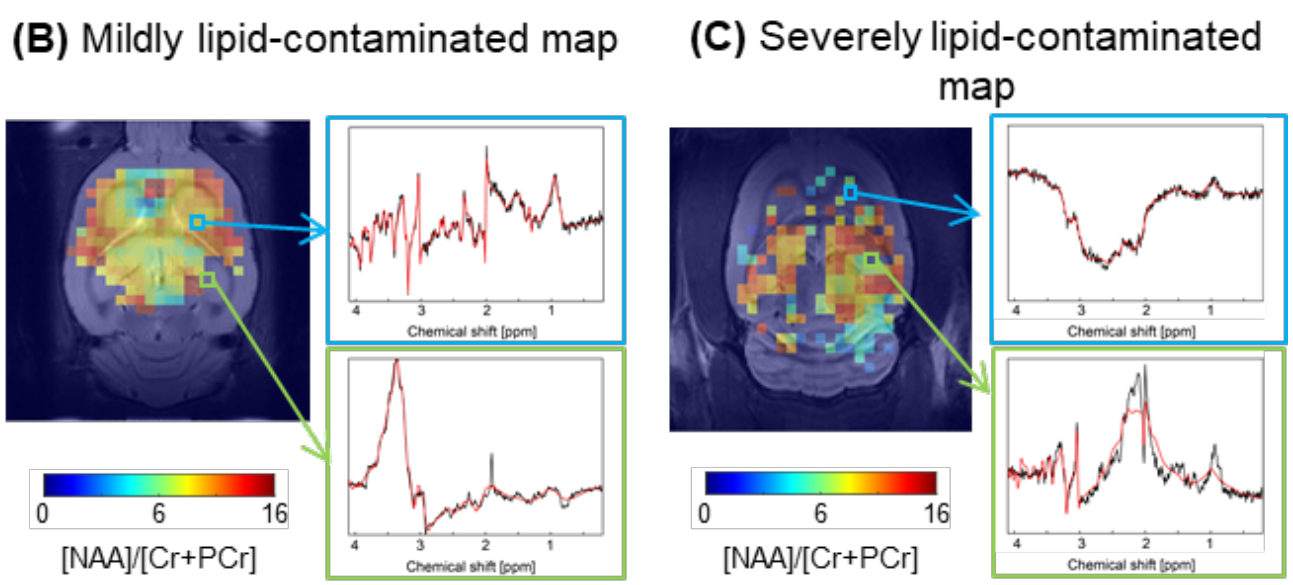
Courtesy of I Tkac

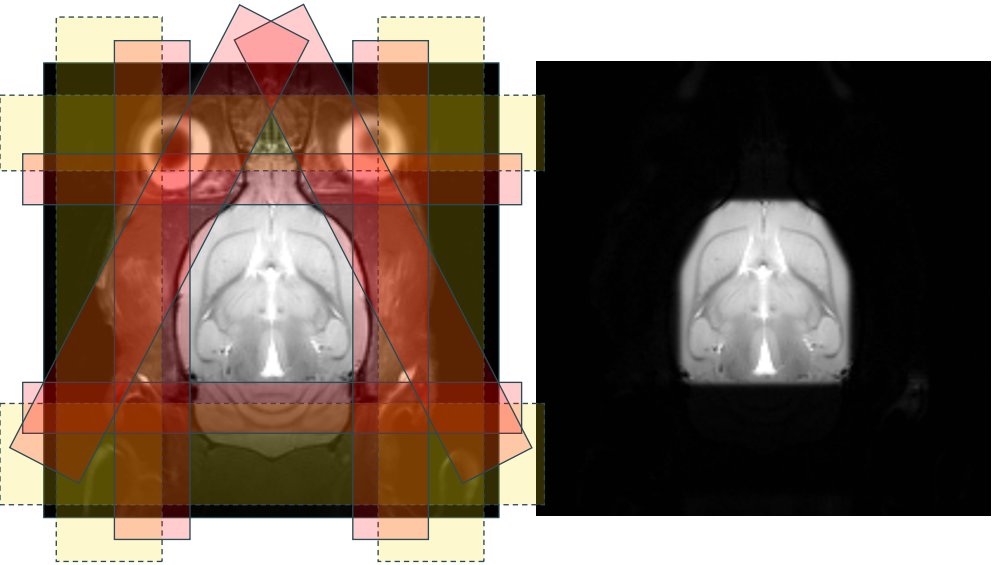
Oz G, et al., Clinical proton MR spectroscopy in central nervous system disorders. Radiology. 2014
Wilson M, et al., Methodological consensus on clinical proton MRS of the brain: Review and recommendations. Magn Reson Med. 2019

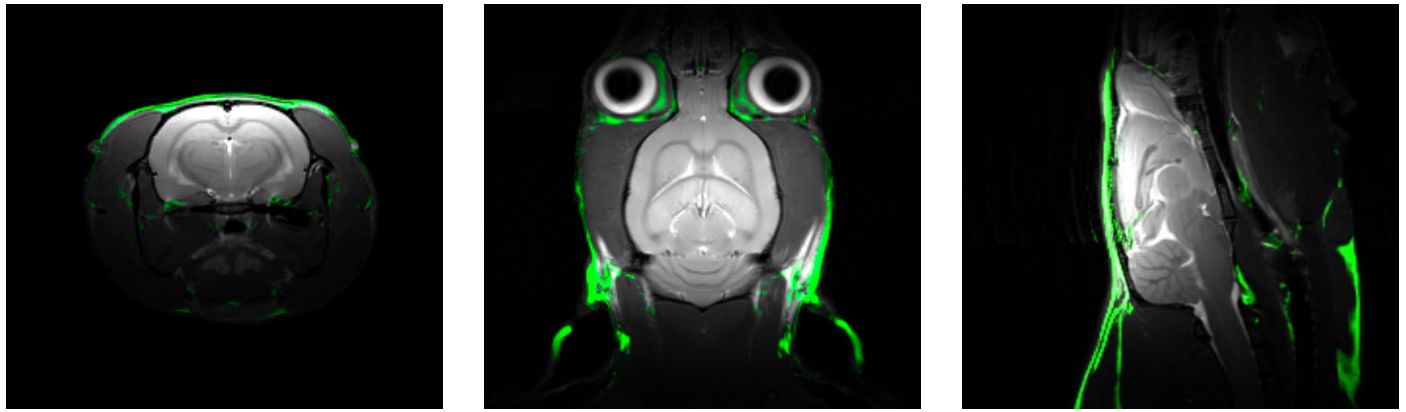
LIPID SUPPRESSION FOR 3D MRSI



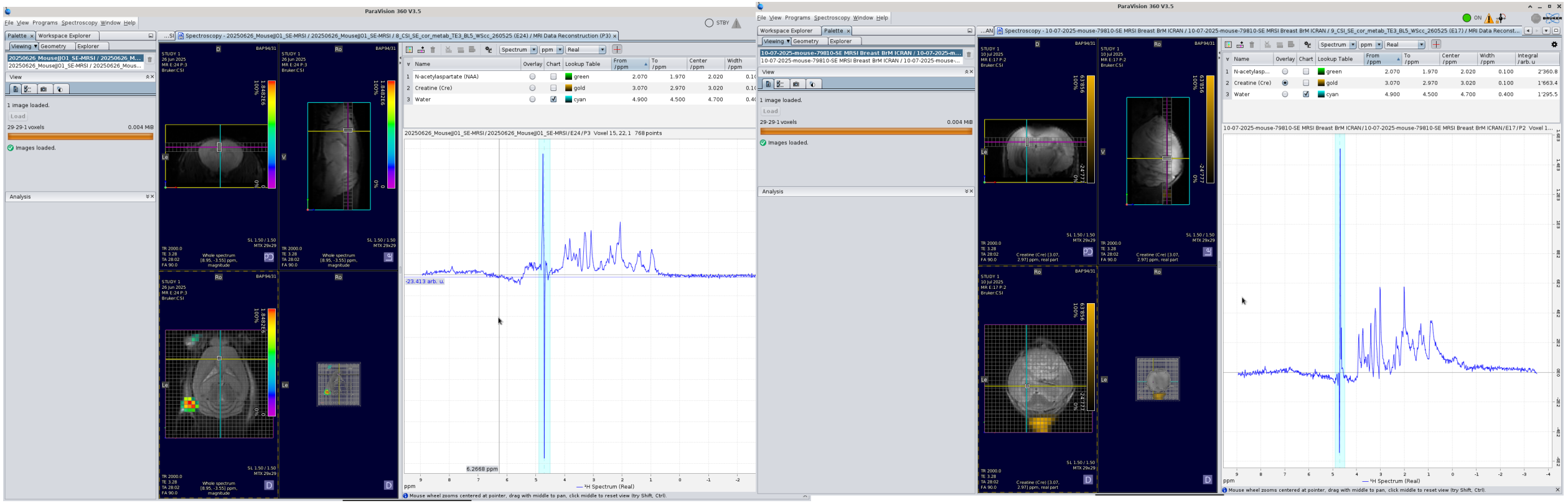








FID-MRSI - TEMPERATURE MEASUREMENT AND IMPLEMENTATION IN THE MRS4BRAIN TOOLBOX - *IN VIVO ACQUISITIONS AND DATA PROCESSING*

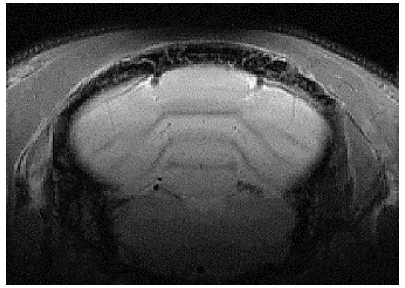


ADVANCED IMAGING OF THE BRAIN - MYELIN IMAGING OR DIFFUSION WEIGHTED IMAGING -*IN VIVO ACQUISITIONS AND DATA PROCESSING*

CIBM
Center for Biomedical Imaging

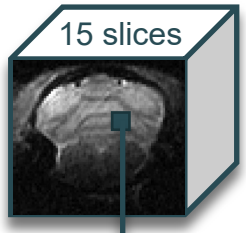
Diffusion Weighted MRI (dMRI)

MRI image



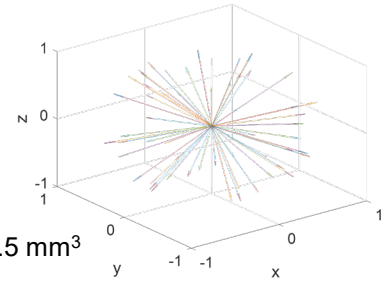
→ Water T_2 weighted image

dMRI



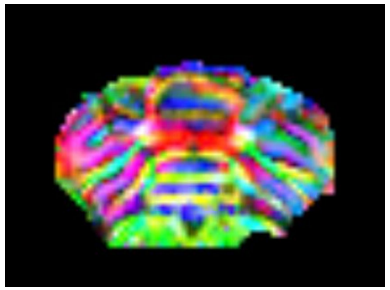
0.2x0.2x0.5 mm^3

Multiple gradient directions



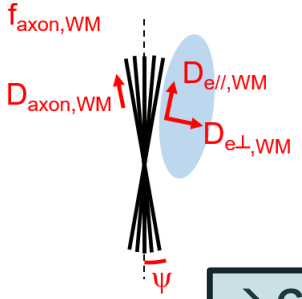
→ Probing the diffusion of water in different directions

Reconstruction - DTI



→ **Map** of macroscopic anisotropy

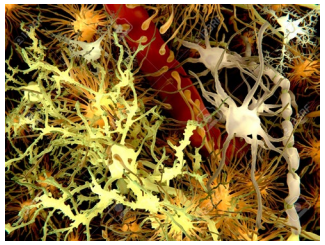
Tissue models

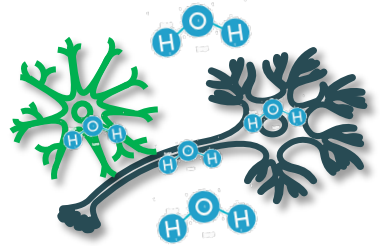


Assumptions on underlying biological geometry

→ **Geometric information**

1 **Water *is not* compartment *specific***





Water is everywhere!!!

With the help of D Simicic and J Mosso ☺

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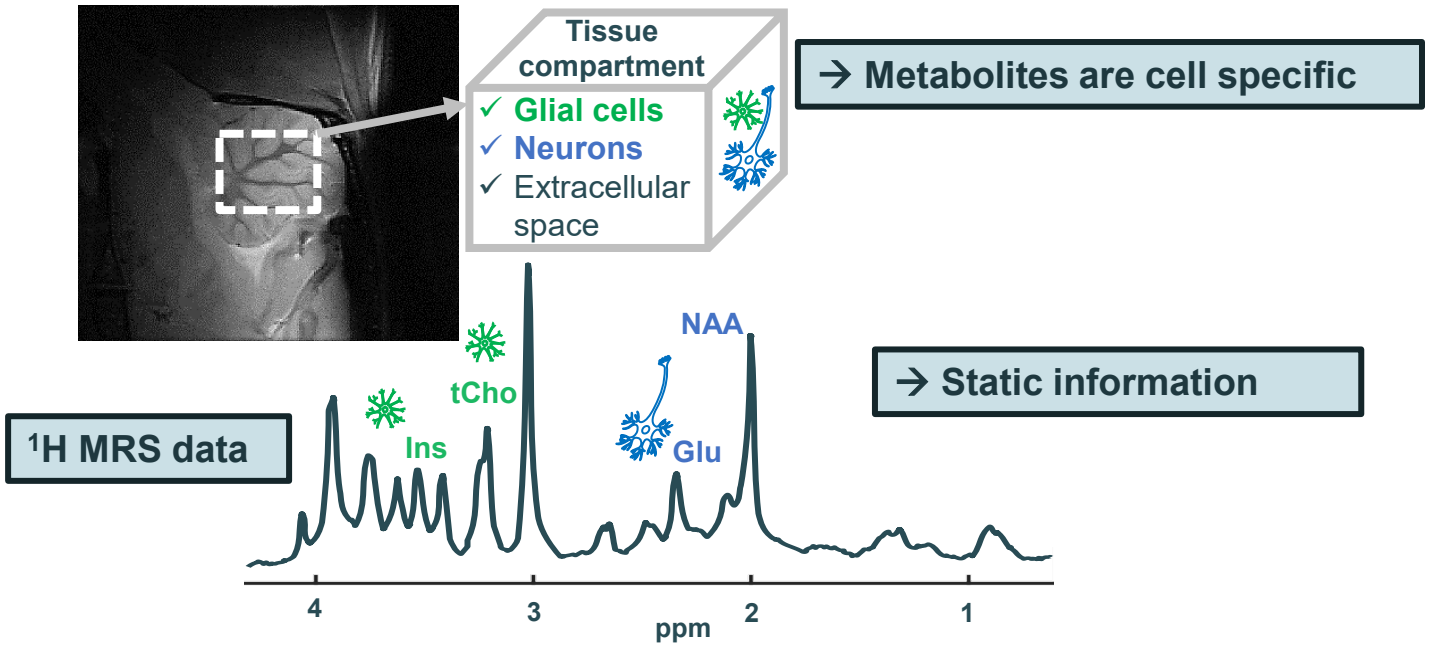
Magnetic resonance spectroscopy (MRS)

1 Metabolites are compartment *specific*



[Ins] ~ 3x higher in **astrocytes** compared to **neurons**[1]

[tCho] ~ 6x higher in **glia** compared to **neurons**[2,3]

[NAA] & [Glu], large consensus mostly in **neurons**

(1) Fisher S et al., J Neurochem 2002; (2) Urenjak J et al., J Neurosci. 1993; (3) Le Belle JE et al. NMR Biomed. 2002

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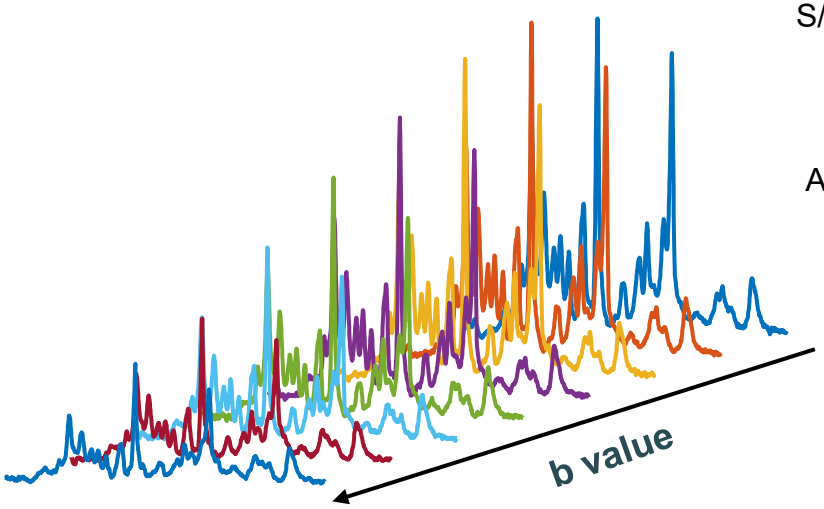
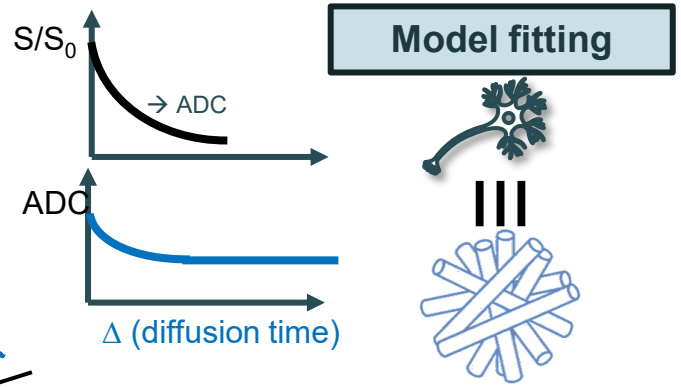
Diffusion Weighted MRS (dMRS)





Model fitting

→ Metabolite specific geometric information

! Metabolite = cell-specific information

- ✓ Cellular morphology
- ✓ Cytosol viscosity
- ✓ Tortuosity
- ✓ Exchange
- ✓ Compartmentation
- ✓ ……

J Mosso

Palombo et al. *Neuroimage* 2017; Mosso et al, MRM 2024 & Front Neurosci. 2024; Mougel et al MRM 2022 & J Magn Reson 2022

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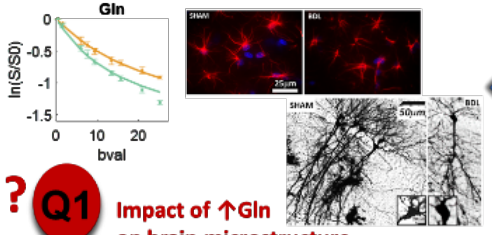
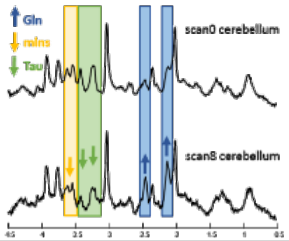
Chronic HE: Previous work and unknowns

Brain microstructure



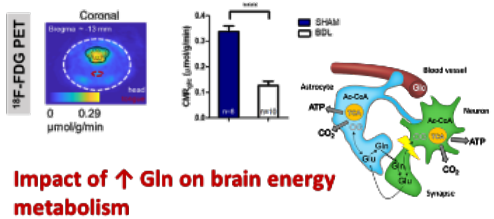
? **Q1** Impact of ↑Gln on brain microstructure

Brain Gln & Osmoregulation



MR Spectra
↑ Gln
↓ Osmolytes
↓ Energy metabolites

Brain energy metabolism



? **Q2** Impact of ↑ Gln on brain energy metabolism

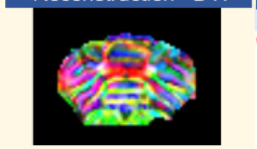
Current proposal : in animal models, organoids and children with type B and C HE

W1&3 Assess the effects of ↑ Gln on brain microstructure using:

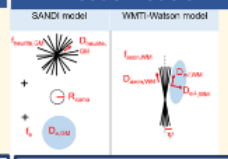
dMRI

→ Probing the diffusion of water in different directions

Reconstruction - DTI

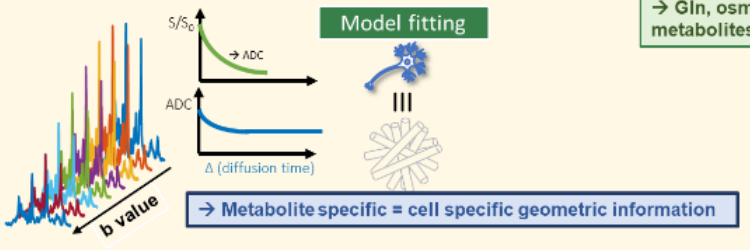


Tissue models



→ Macroscopic anisotropy → Geometric information

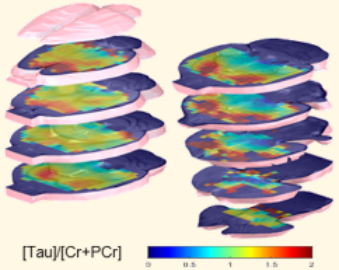
Diffusion Weighted MRS (dMRS)



→ Metabolite specific = cell specific geometric information

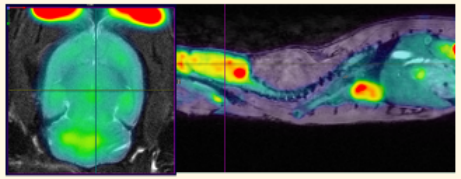
W2&3 Assess the effects of ↑ Gln on brain energy metabolism using:

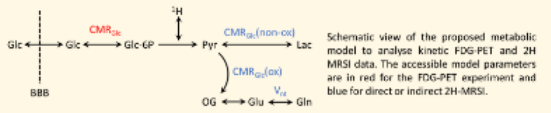
3D 1H-MRSI



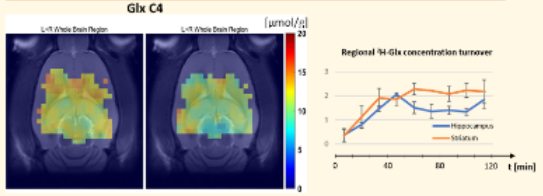
→ Gln, osmoregulation, Cr, energy metabolites

Dynamic PET-MR: Glc uptake

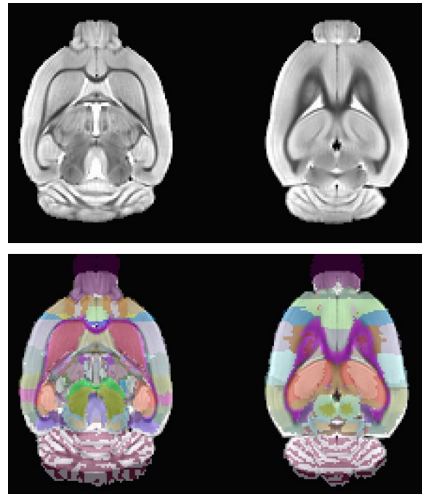




Dynamic 2H-MRSI: Glc metabolism

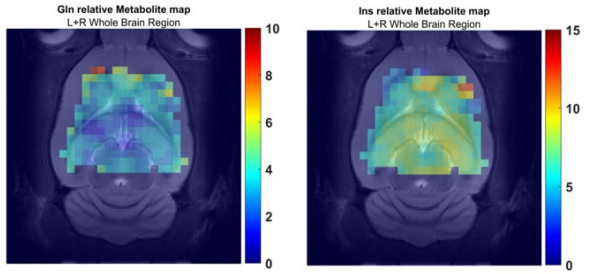


High resolution MRI: volumetry

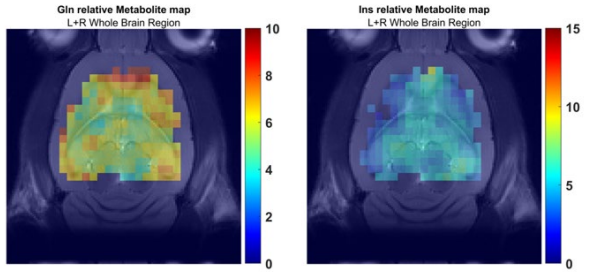


Courtesy of Tan Toi Phan

Sham



BDL



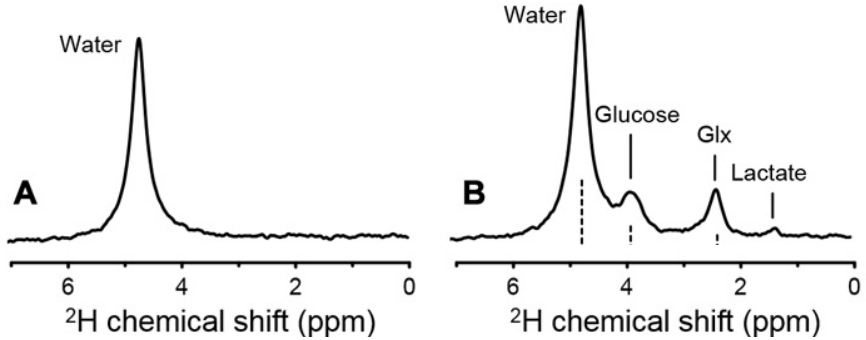
Courtesy of D Simicic and J Mosso

Courtesy of B Lanz and A Siviglia

Courtesy of Gianna Nossa

DIFFERENCES BETWEEN PROTON AND DEUTERIUM MRSI - *IN VIVO ACQUISITIONS AND DATA PROCESSING*

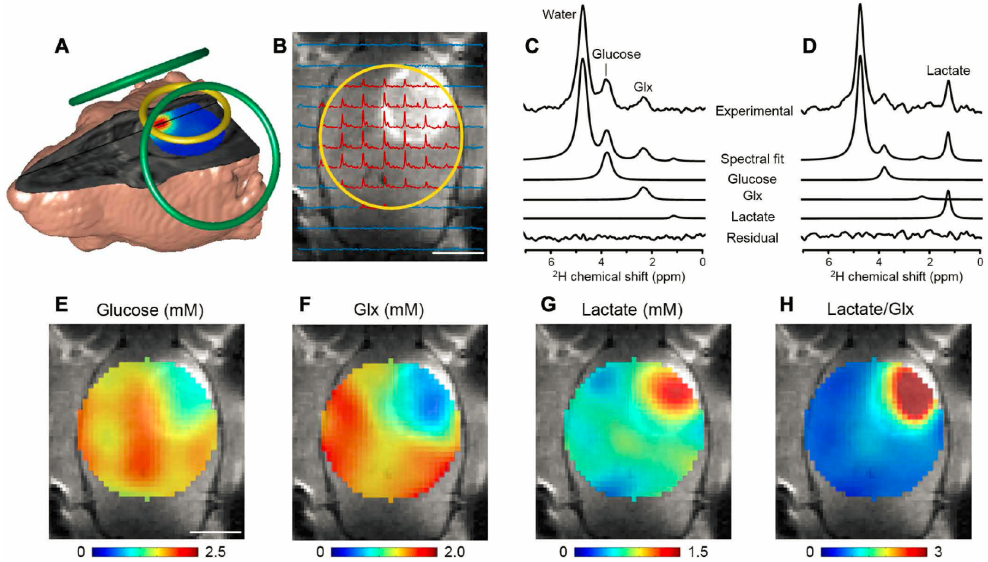
- Labelling experiment to study metabolic pathways
(like in FDG-PET or ^{13}C MRS)
- Low background signal (water lipids)
- Short relaxation times (T1 and T2)
-> faster temporal averages

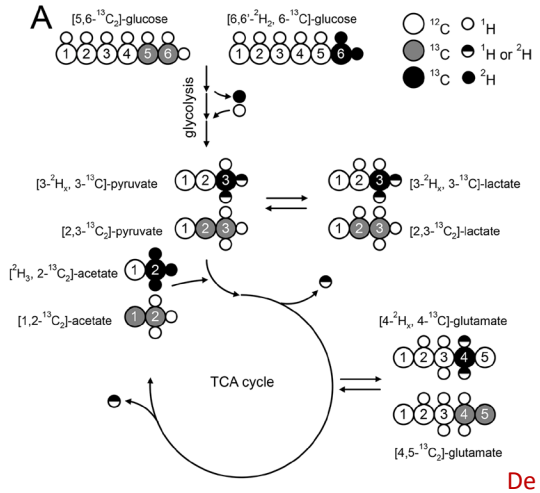


rat brain in vivo at 11.7 T before infusion of any ^{2}H-labeled substrate

rat brain after infusion of [6,6′-$^2H_2$]glucose in vivo

De Feyter *et al., Sci. Adv.* 2018





De Graaf *et al., ACS Chem. Neurosci.* 2021

CIBM
Center for Biomedical Imaging

THANK YOU FOR YOUR ATTENTION

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EPFL
UNIVERSITÉ DE GENÈVE
HUG Hôpitaux Universitaires Genève

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