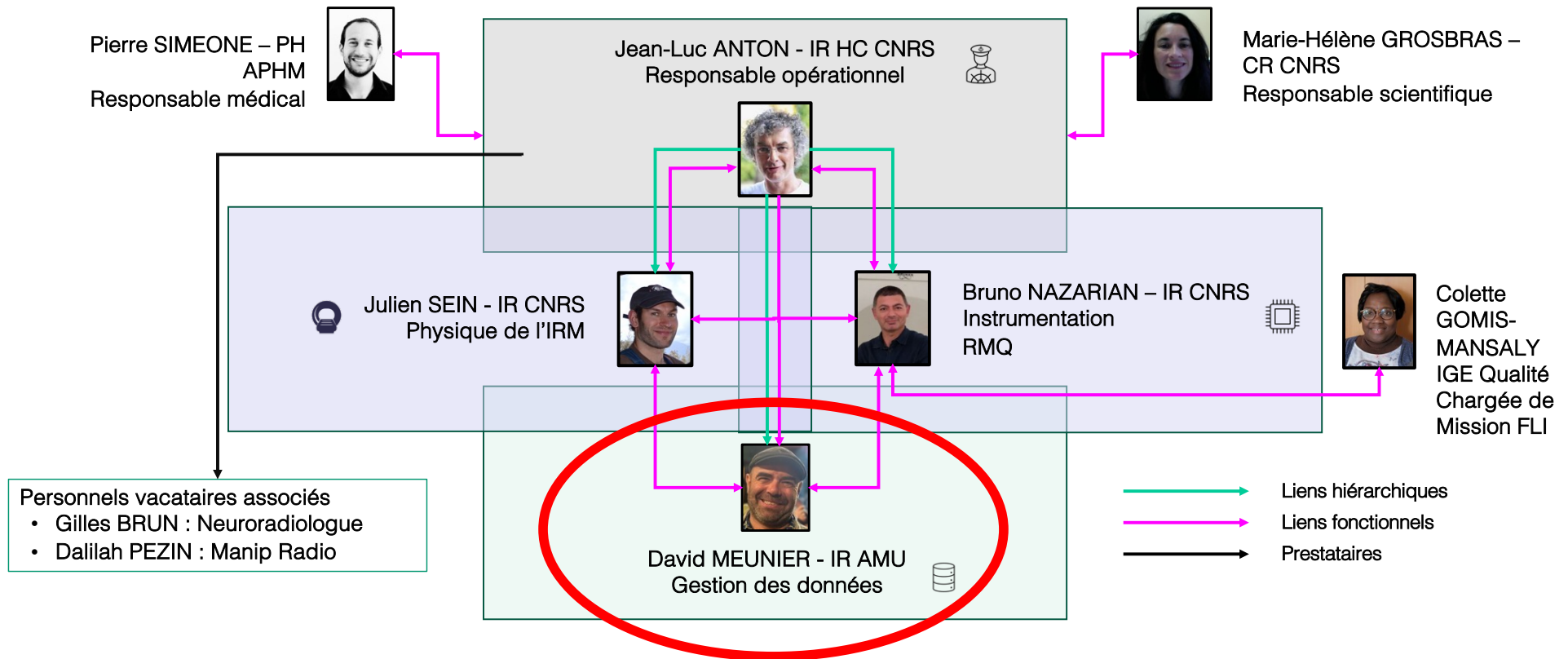


News of Centre IRM-INT@CERIMED

Jean-Luc Anton, David Meunier, Bruno Nazarian, Julien Sein

The most important : the TEAM !



**David Meunier joins us, coming from the NIT - INT:
Specialist in MRI Data Management and Analysis**

A new teammate : David Meunier aka Dave Miller

• 1997

• CPGE Aix
• Centrale Lyon

• 2002

• DEA Lyon

• 2003

• These Lyon

• 2007

• Post-doc Cambridge

• 2010

• Post-doc Cambridge 2

• 2011

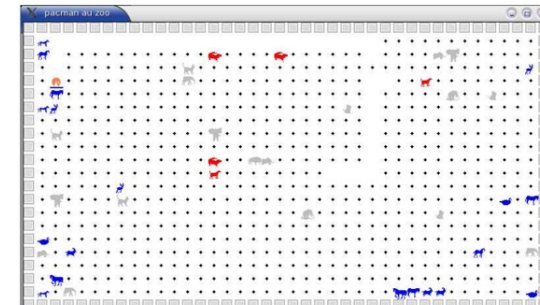
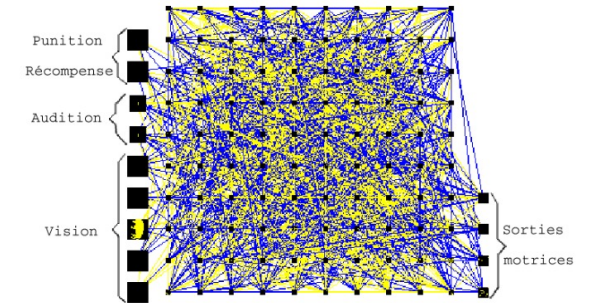
• Post-doc Orsay

• 2012

(AI)

(AI)

(Neuro-imaging and AI)



NeuroImage 44 (2009) 715-723



Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg



Age-related changes in modular organization of human brain functional networks

David Meunier^{a,b}, Sophie Achard^{a,b,c}, Alexa Morcom^d, Ed Bullmore^{a,b,*}

^a Brain Mapping Unit, University of Cambridge, Cambridge, UK

^b Behavioural and Clinical Neuroscience Institute, University of Cambridge, Cambridge, UK

^c Grenoble Image Parole Signal Automatique, Centre National de la Recherche Scientifique, Grenoble, France

^d Centre for Cognitive and Neural Systems, University of Edinburgh, Edinburgh, UK

+1500 citations

• 1997

• CPGE Aix
• Central Lyon

• 2002

• DEA Lyon

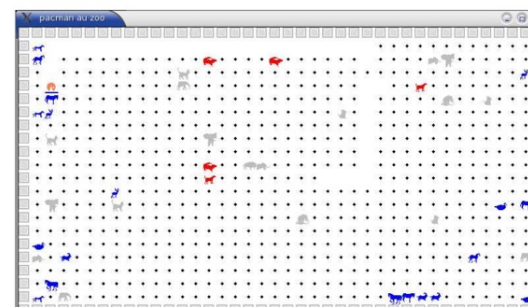
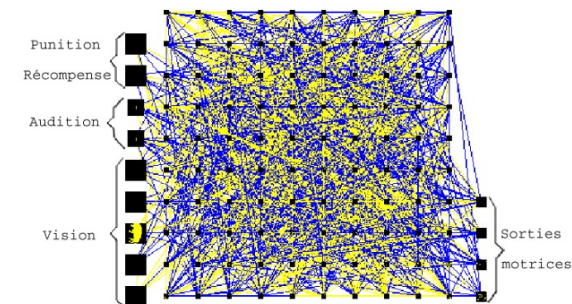
• 2003

• These Lyon

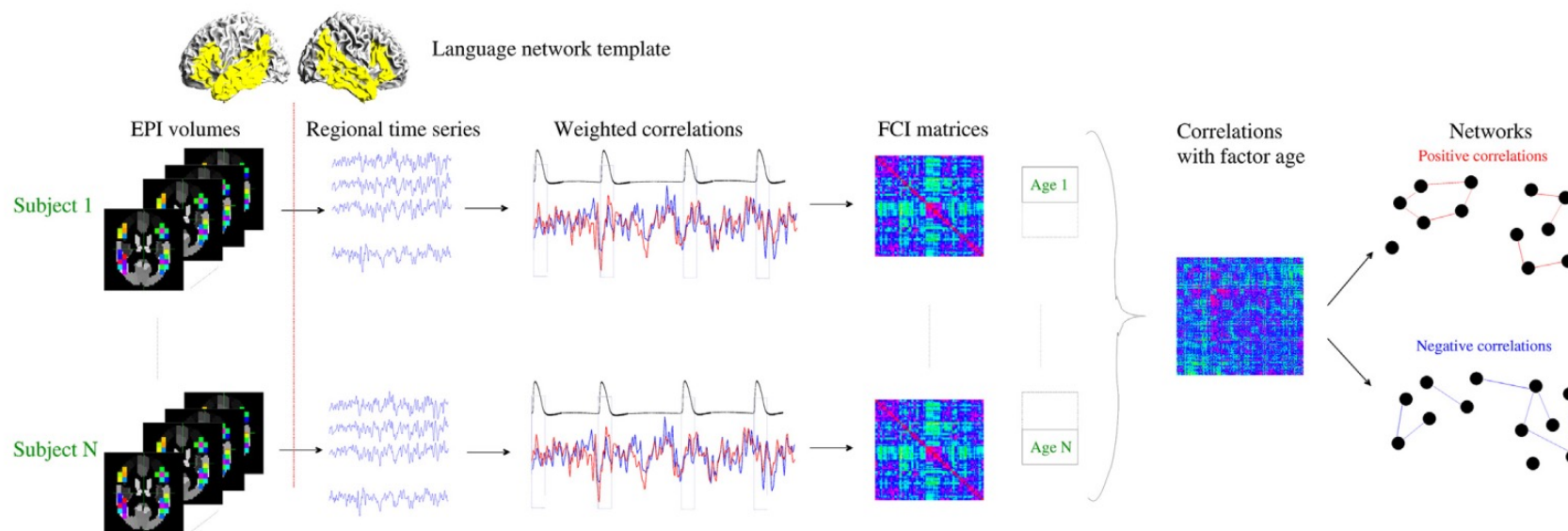
• 2007

(AI)

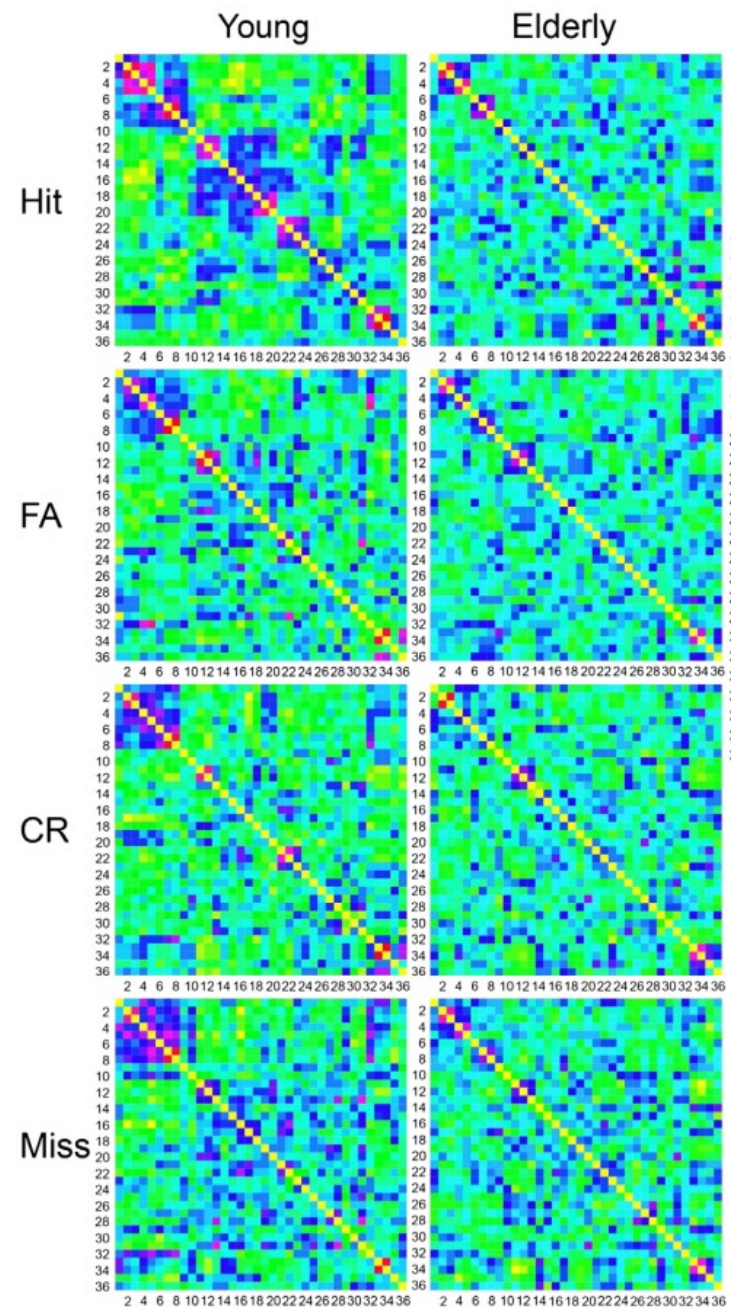
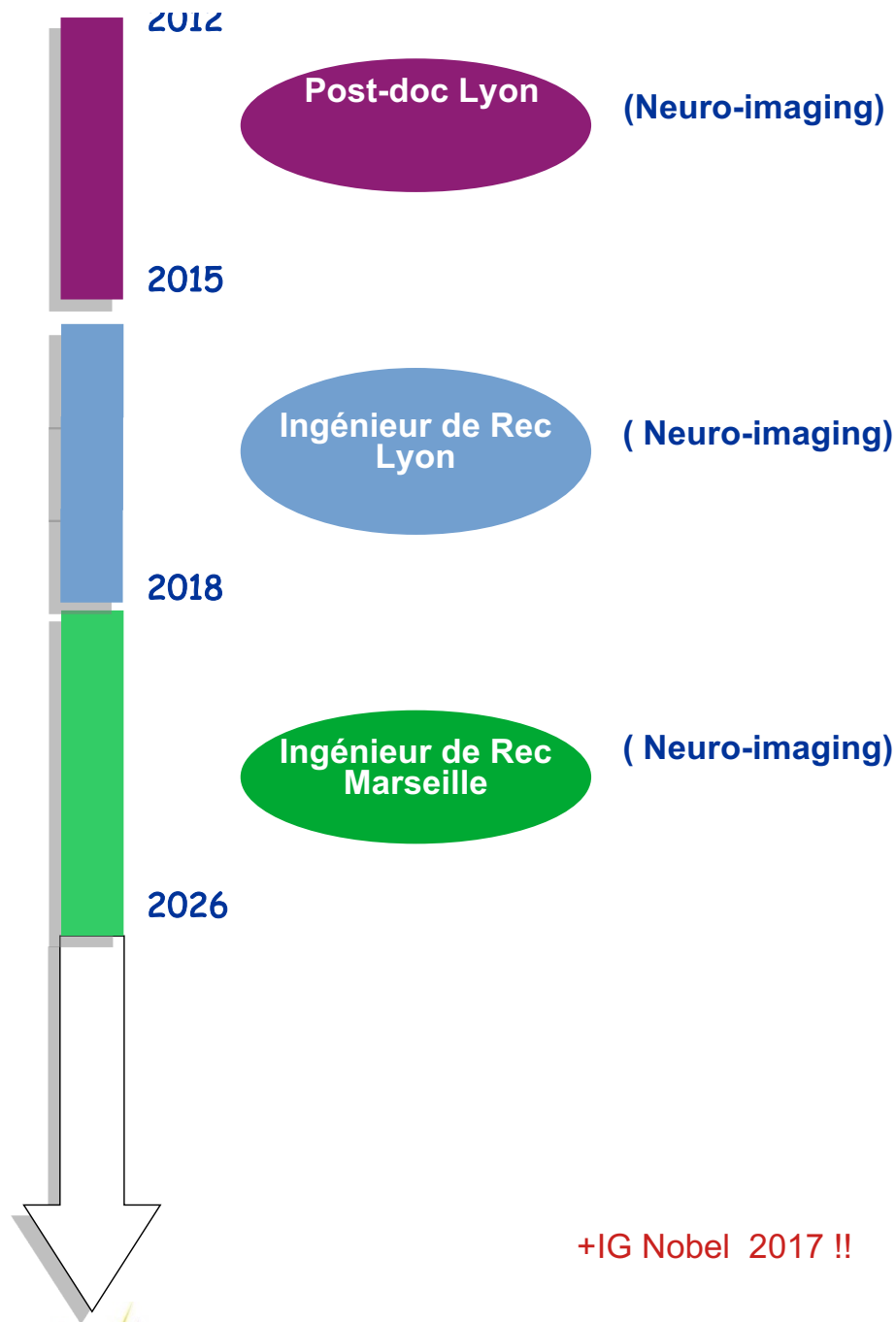
(AI)



NeuroImage 44 (2009) 715-723



(Meunier et al, Neurobio Aging, 2014)

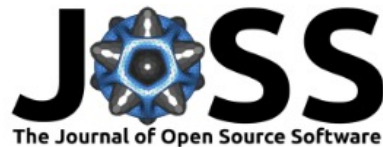


(Meunier et al, NeuroImage, 2014)

David : developpement @INT (since 2018)

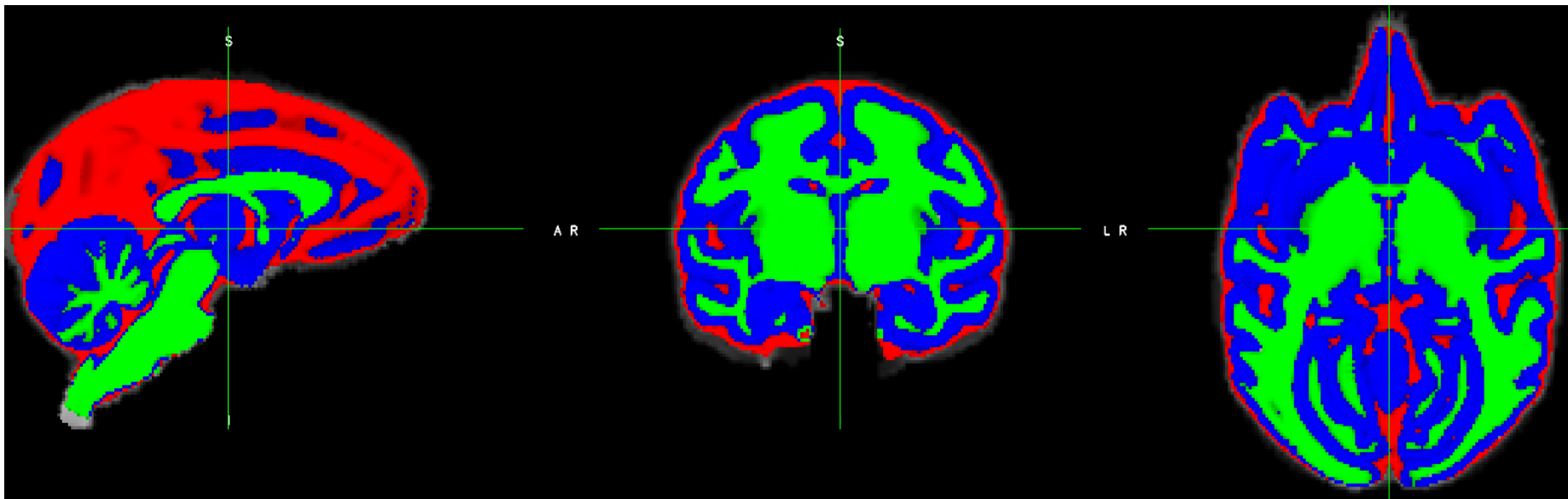
Macatype

- Performs pre-processing, brain extraction and segmentation of anatomical MRI (T1w, T2w) of different NHP species (macaque, marmouset, baboon)
- Available as python package `pip install macatype` or as container docker/singularity (dockerhub)
- **Publish in JOSS**



Macatype: An open multi-software framework for non-human primate brain anatomical MRI processing

David Meunier ¹, Kep Kee Loh ⁴, Bastien Cagna ^{2,3}, Regis Trapeau ¹, Julien Sein ¹, and Olivier Coulon ¹

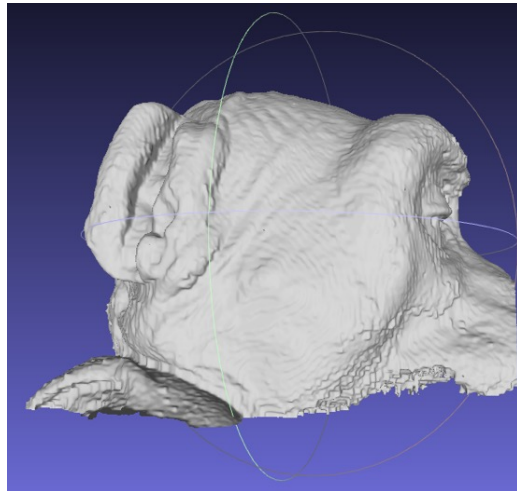


SkullTo3d

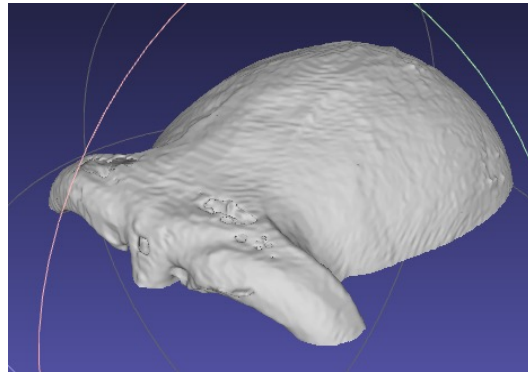
- Performs skull segmentation over specific MRI sequences (PDw petra, MEGRE) or other (CT-scan) on NHP
- Sub-layer of macapype: both skull and brain are registered in similar space
- « stereotaxic » space validation (thanks to Julien Sein, Luc Renaud and Banty Tia)
- Used mostly as tool to plan surgery and preparation of recording chamber and headplot



Plan to published dataset (15macaque + 15 marmosets) as data paper



Full Head mask (macaque)



Robust Petra skull mesh



3D printing skull (CT) and brain (macaque)



3D printing skull (Petra) and brain (marmoset)

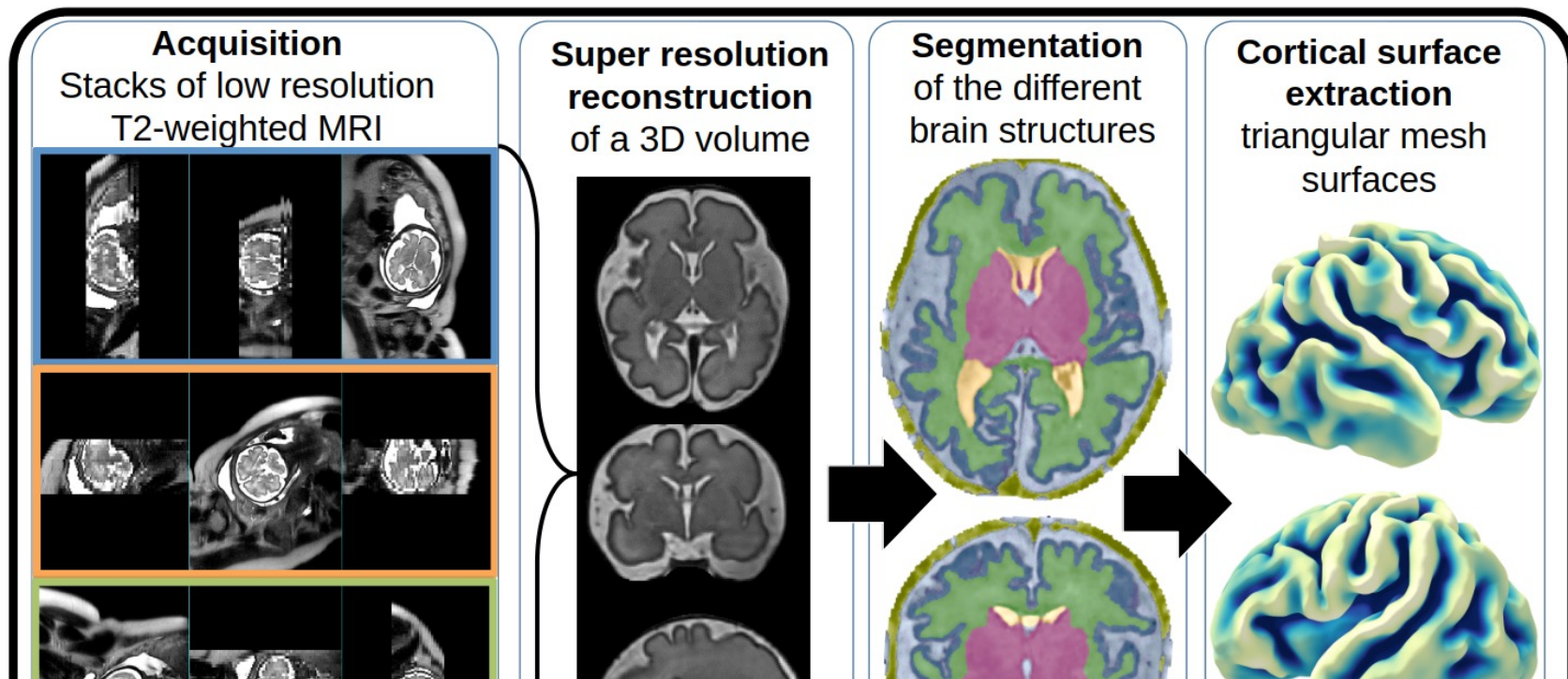
fetpype

- Developed in collaboration with Guillaume Auzias (MeCa-INT) and a fetal MRI consortium, in particular Thomas Sanchez from Lausanne)
- (Also) **published in JOSS**



Fetpype: An Open-Source Pipeline for Reproducible Fetal Brain MRI Analysis

Thomas Sanchez ^{1,2*}, Gerard Martí-Juan ^{3*}, David Meunier ⁴, Miguel Angel Gonzalez Ballester ^{3,5}, Oscar Camara ³, Elisenda Eixarch ^{6,7}, Gemma Piella ³, Meritxell Bach Cuadra ^{1,2}, and Guillaume Auzias ⁴



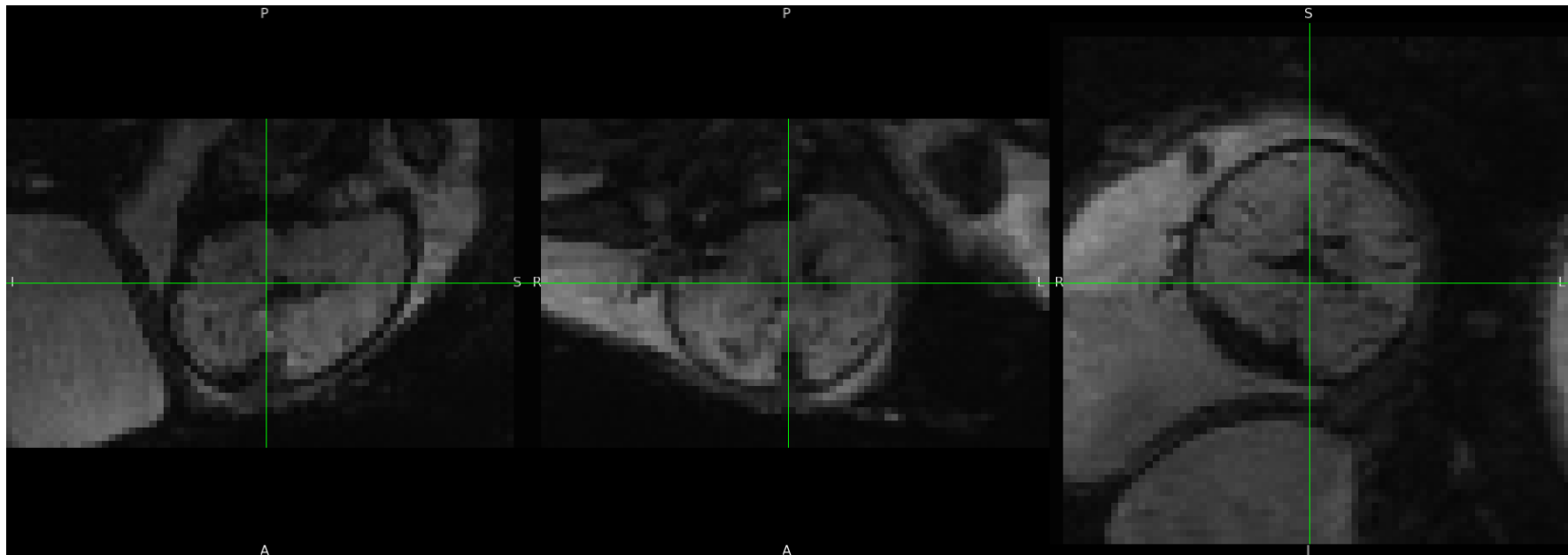
func_Babofet



- 10 longitudinal sessions of 10 baboon fetuses (PI: Olivier Coulon)
- **Aims at producing an open dataset with maximal preprocessing**
- Anatomical, diffusion and **functional MRI as Resting state**
- LOTS of movements (mostly due to breathing of the anest. Mother)



So far, best processing involves splitting image segment according to Framewise Displacement



Organization and Strategy

- **Administrative & Legal:**

- Renewal of ARS Accreditation (2025–2032)
- Renewal of the “technology platform” label: application due by Monday, October 12!

- **Investments & Equipment:**

- No hardware upgrade to CIMAX for scientific reasons (little benefit based on tests conducted using REMI), financial reasons (€1.7 M€ !), and environmental reasons
- Major software upgrade: XA60, new Mars reconstructor (with deep-learning capabilities for data-efficient acquisitions)
- replacement of our cooling unit with two new cooling units
- purchase of two ultra-flexible, multi-purpose antennas (18 channels) and one 24-channel antenna for large macaques
- software update contract for another 3 years (paid at the end of 2024: FLI): through the end of 2029
- renewal of the MRI system maintenance contract for 3 years (2026–2029): 117 k€ excl. tax/year

Infrastructure and Management

- Thermal Infrastructure: Level-Up
- The MRI Center Under Surveillance
- Quality Management: The Rise of the QMS

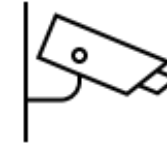
Thermal System: Triple check



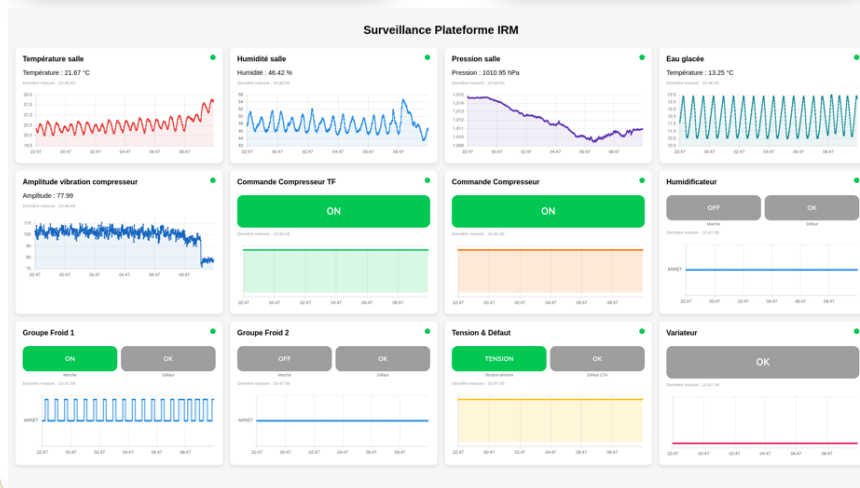
- Two cooling units are better than one
- Weekly failover
- Duplication / Redundancy / Backup



The MRI Center Under Surveillance

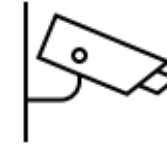


- A New Architecture Inspired by Home Automation
- Romain Poos's Senior Thesis Project

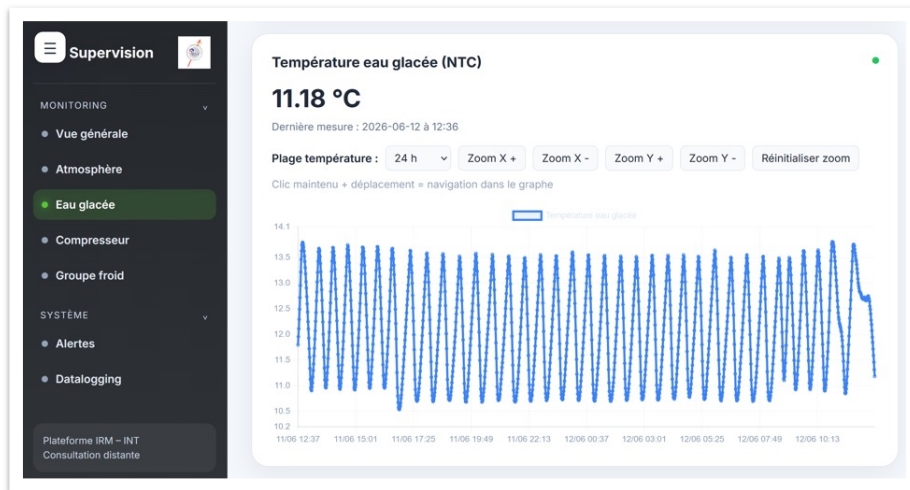


- Local Monitoring (Dashboard)
- Alerts
- Data Logging

The MRI Center Under Surveillance



- Remote Consultation
- Scalable



Groupe Froid 1

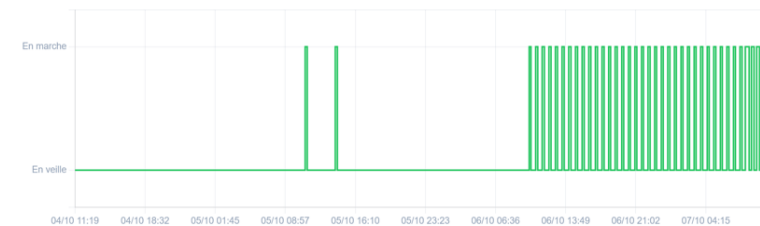


Dernière mesure : 2026-10-07 à 11:19

Plage : 3 jours Zoom X + Zoom X - Zoom Y + Zoom Y - Réinitialiser zoom

Clic maintenu + déplacement = navigation dans le graphe

État



Groupe Froid 2

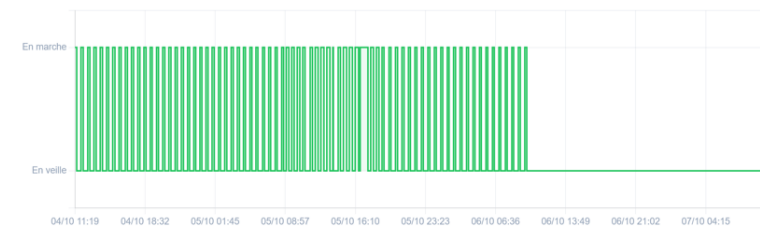


Dernière mesure : 2026-10-07 à 11:21

Plage : 3 jours Zoom X + Zoom X - Zoom Y + Zoom Y - Réinitialiser zoom

Clic maintenu + déplacement = navigation dans le graphe

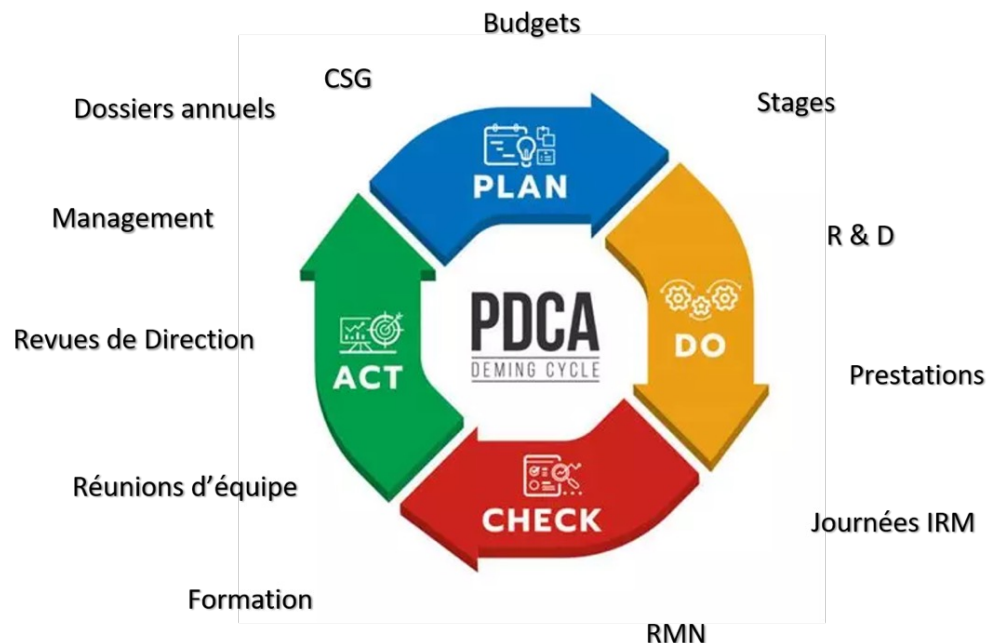
État



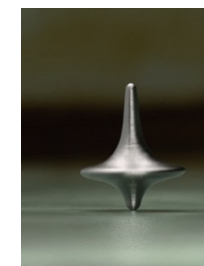
Quality Management: Year III



Continuous Improvement



Management of Internal and External Concerns



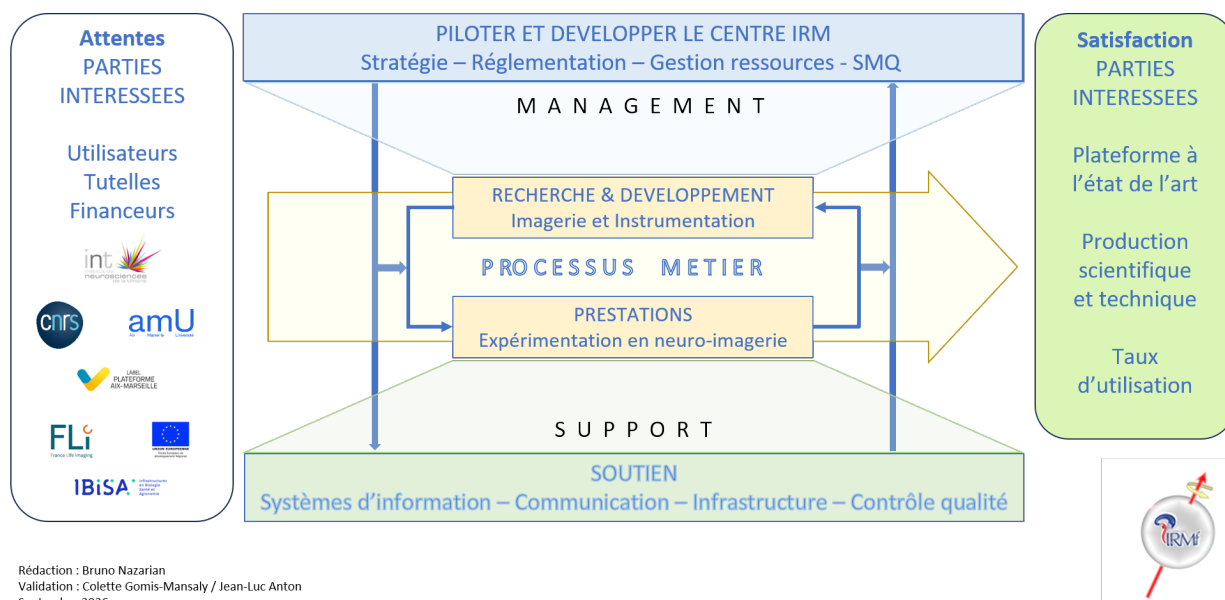
Quality Management: Year III



A Structured Policy

1. Maintenir un haut niveau d'expertise scientifique et technique
2. Maintenir une dynamique d'innovation en neuroimagerie
3. Valoriser les activités de la plateforme par son rayonnement scientifique et le transfert de ses compétences
4. Mettre en œuvre une organisation de qualité maîtrisée et efficace
5. Mettre en œuvre une organisation éco-responsable

CENTRE IRM – INT : CARTOGRAPHIE DES PROCESSUS



A Process-Based Approach

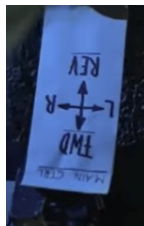
Rédaction : Bruno Nazarian
Validation : Colette Gomis-Mansaly / Jean-Luc Anton
Septembre 2026

Quality Management: Year III



Users Training

- Roadmaps
- Safety Training



Feedback



Dans le cadre de sa démarche qualité, le Centre IRM - INT souhaite connaître votre avis et votre retour d'expérience concernant votre dernière étude en IRM. Ce retour d'expérience permettra d'améliorer nos processus et la qualité de notre service.

Le questionnaire est divisé en 5 rubriques qui explorent les différentes étapes de la mise en oeuvre de votre étude au Centre IRM. A propos de l'étude Mise en place de l'étude (revue scientifique et technique, développements, ...) Passation de l'étude (accueil des participants, acquisition, ...) Mise à disposition des données Accompagnement au traitement des données

Partie A: A propos de votre étude
Tout d'abord, nous avons trois questions très simples, d'ordre général, relatives à votre étude.

A1. Quel est l'acronyme de votre étude ?
Convenez

A2. Etait-ce votre première étude en IRM ?
Oui ☐
Non ☒

A3. Etait-ce votre première étude au Centre IRM - INT ?
Oui ☐
Non ☒

Partie B: Mise en place de l'étude
Cette section traite de la préparation de votre étude avec les ingénieurs du Centre IRM, que ce soit sur le versant IRM que du point de vue Stimulation, le cas échéant.
Elle concerne tout ce qui précède la passation des sujets et l'acquisition de données, de la mise au point du protocole, en passant par les éventuels développements techniques ou méthodologiques mais également au niveau réglementaire et éthique.

B1. Avez-vous bien intégré les spécificités, risques, dangers du travail dans un environnement IRM ? (plusieurs réponses possibles)
Je connais déjà bien ces risques ☒

5 - Quels effets peuvent survenir en cas de mouvement rapide du corps entier dans un champ magnétique intense ?

Choisissez-en autant que vous voulez

☐ A Chaleur excessive.

☐ B Diminution de la concentration uniquement.

☒ C Sensation de vertige et phosphènes.

☐ D Effets neurologiques irréversibles.

Ok

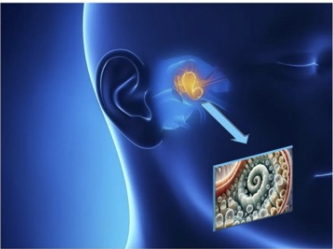
Powered by Typeform

"Quels effets peuvent survenir en cas de mouvement rapide du corps entier dans un champ magnétique intense ?

BRAVO : La bonne réponse est C : "Sensation de vertige et phosphènes."

En effet : Les mouvements rapides de la tête dans un champ magnétique intense peuvent induire de légers courants électriques au niveau des cristaux présents dans l'oreille interne et peuvent donc stimuler le système vestibulaire, créant une sensation de vertige, variable selon les individus.

A noter que l'intensité de tels courants n'est pas à même de créer une réelle sensation de chaleur. Tout comme il n'y a rien à craindre de conséquences neurologiques de tels effets



Continuer

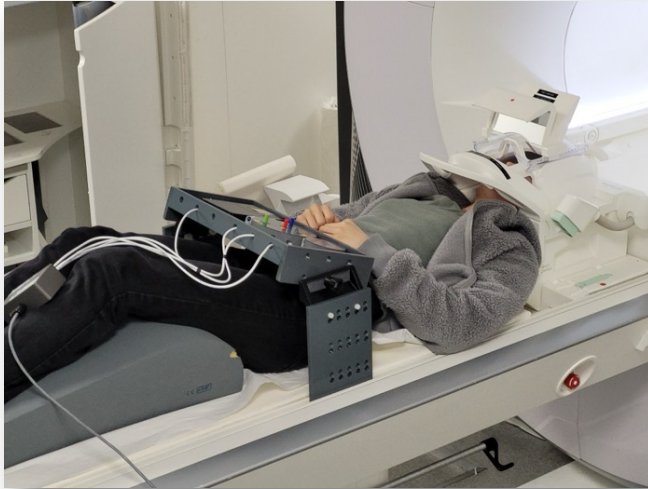
Powered by Typeform



Stimulation Environment

- Exciting new, complex studies to develop
- The audio system is becoming more powerful
- Electrophysiology in MRI: Well-established expertise

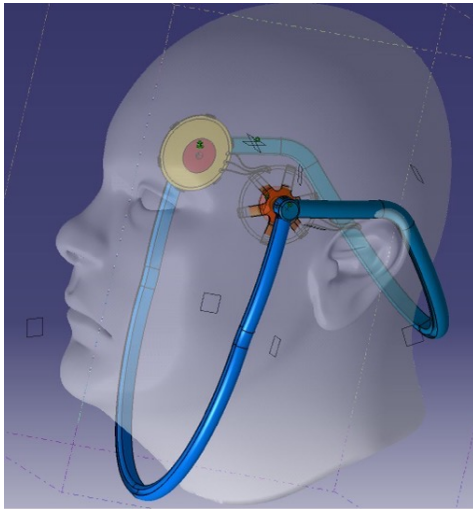
The major challenges raised by researchers



You talkin' to me ??

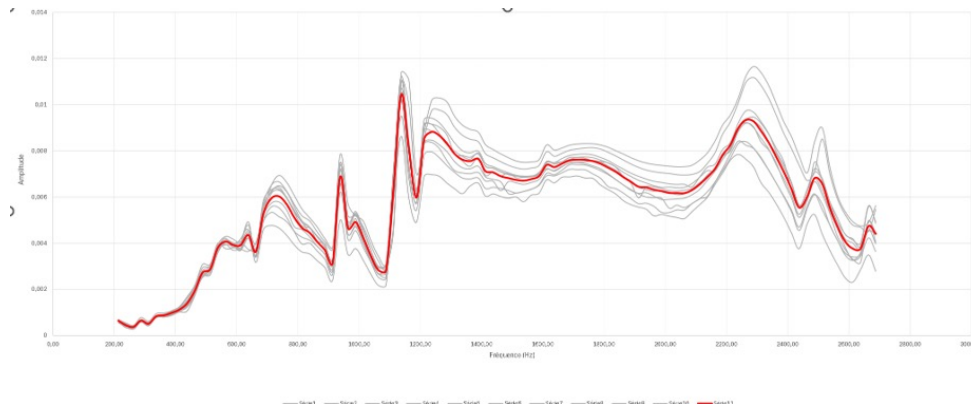
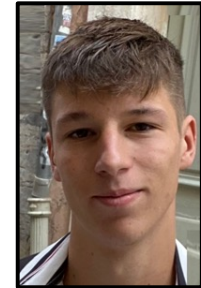
Thank you for a very enjoyable game,
Dave.

The audio system keeps getting better ... and better



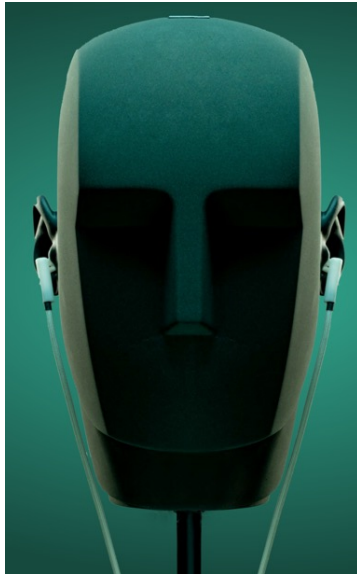
Bone-Conduction Headset

- Romain Poos's Internship
- Operational Prototype (H / NHP)
- Acoustic Validation



Groovy !!

The audio system keeps getting better ... and better



Active Noise Cancellation

- Back from HBM
- OptoAcoustic / OptoActive

New active noise-canceling ear tips



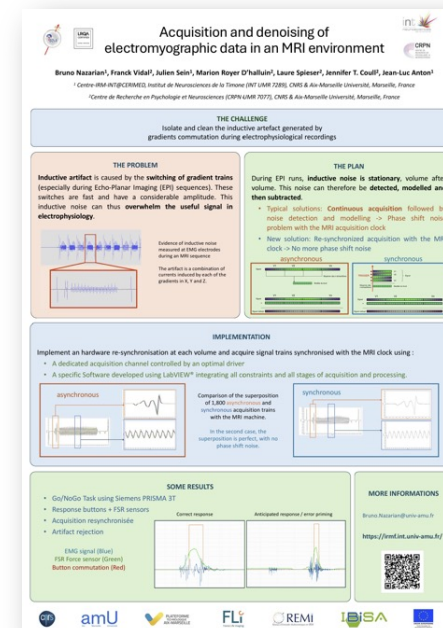
Electrophysiology: Electromyography



- HBM / ESMRMB / SFRMBM Poster
- Methodological Study
- Usable (two channels)



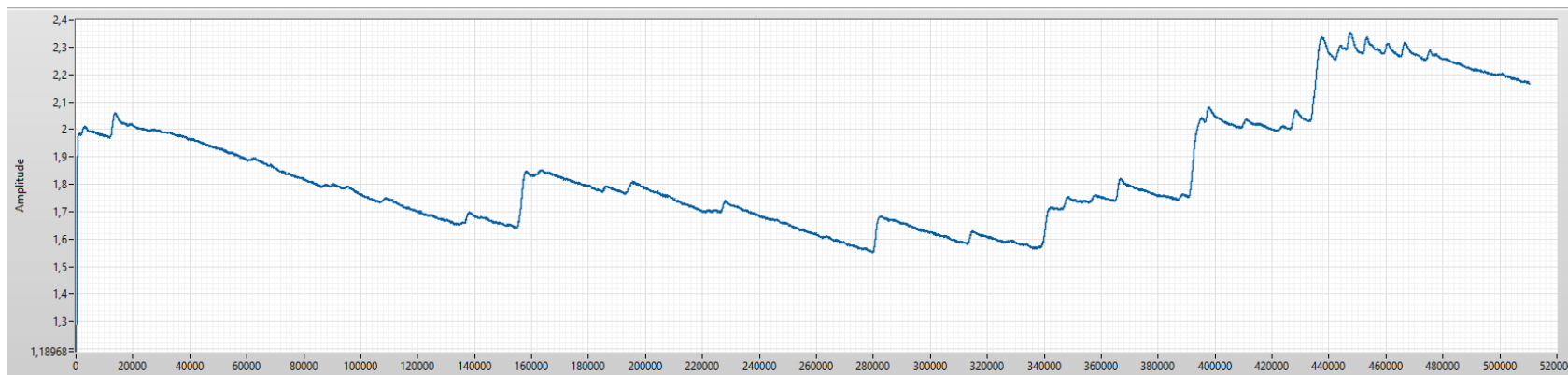
Use the Force ...



Electrophysiology: Electrodermal Response



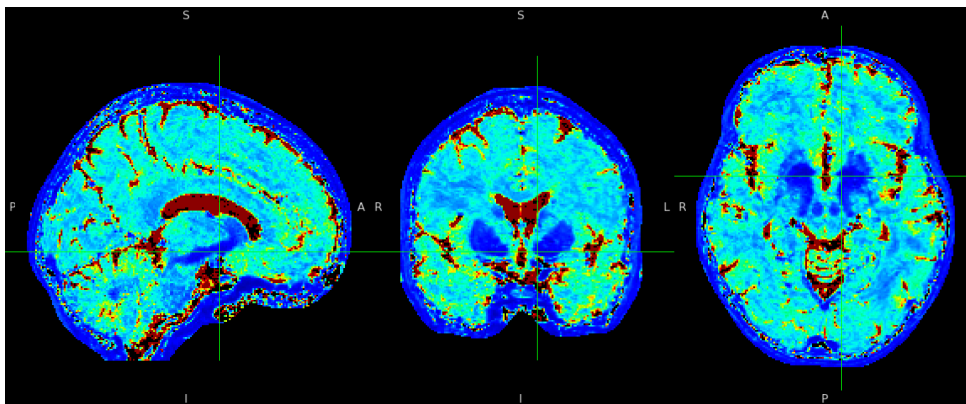
- Portable System
- Filtration via PPF
- In routine ProPsy / PEPR



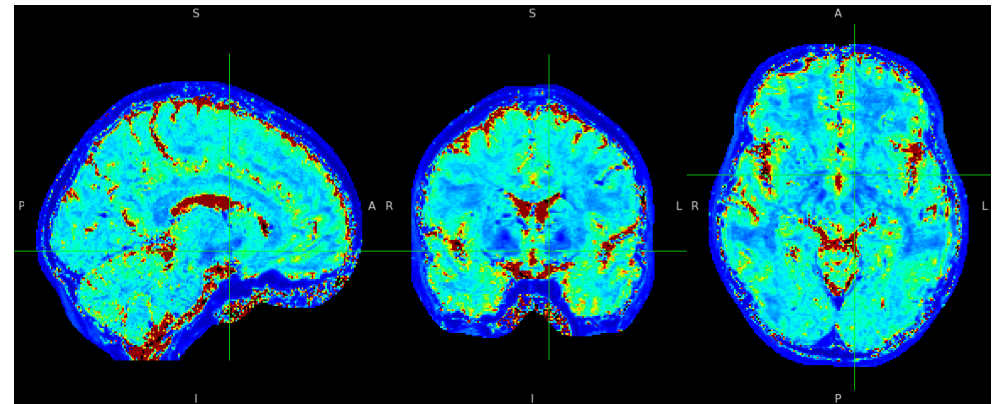
Activités méthodologiques : IRM

- BOLD Multi-echo EPI:
 - => Of interest due to variations in local $T2^*$ (particularly in the temporal, frontal, and subcortical regions)
 - => Age-related variations in $T2^*$ (development–aging)

Carte $T2^*$ (ms):



S01: 73ans



S02: 25 ans

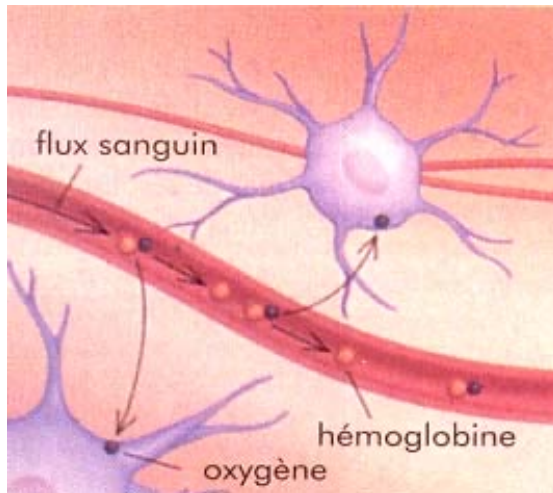
Callaghan et al. (2026)

Processed MPM qMRI aging data. OpenNeuro. [Dataset]doi:10.18112/openneuro.ds005851.v1.0.1

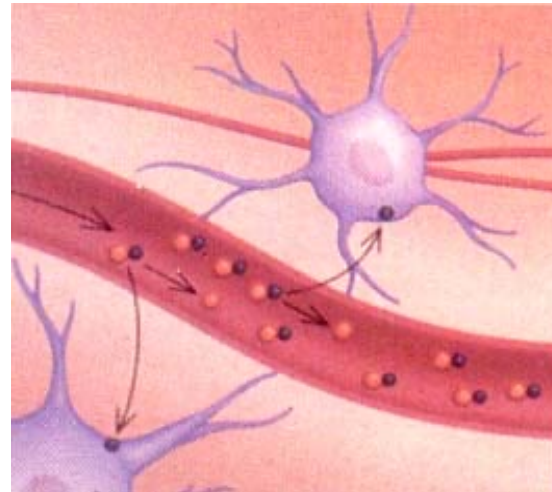
Why do we bother about T2*?

Hemodynamic activity

ACTIVATION



INCREASE OF CBV



● *Oxygen*

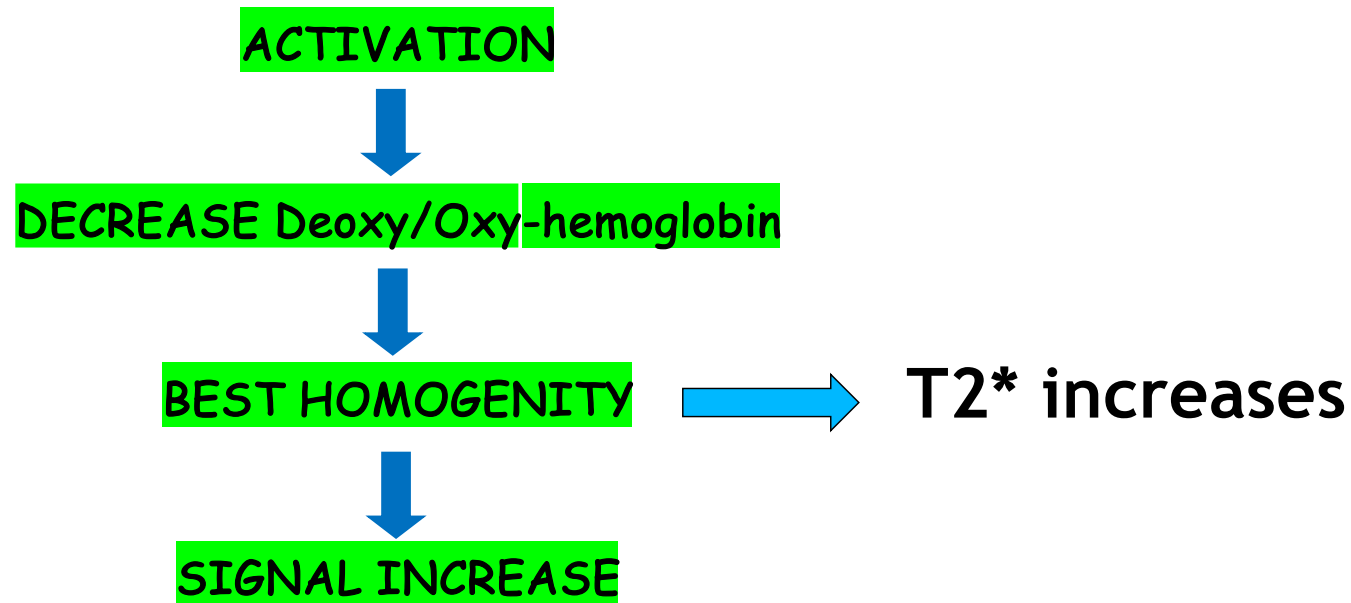
● *Hemoglobin*

Capillary

● *Paramagnetic
deoxy-hemoglobin*

● *Diamagnetic
oxy-hemoglobin*

Why do we bother about T2*?

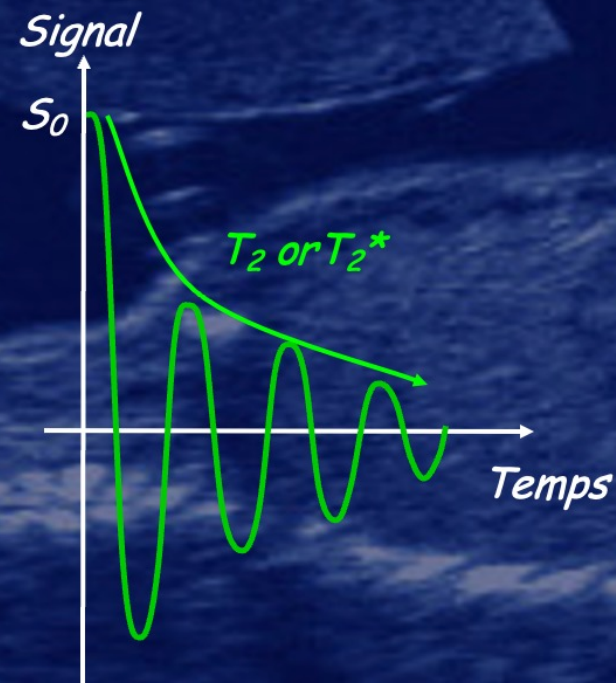


What is T2* ?

Recording of the NMR signal

The collected signal S is a FID
(Free Induction Decay)

$$S = S_0 \sin(2\pi f_0 t) \exp(-t/T_2)$$



What is T2* ?

T₂* Relaxation

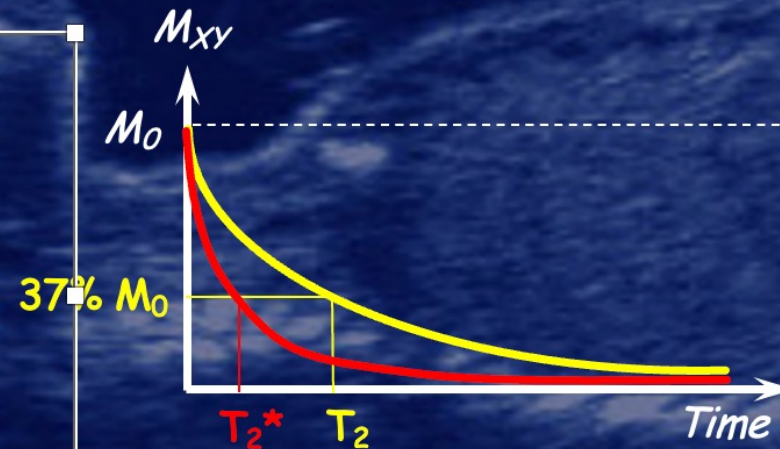
If there are field inhomogeneities in the sample, the spins will not precess at the same frequency f_0 .

=> Additional phase shift

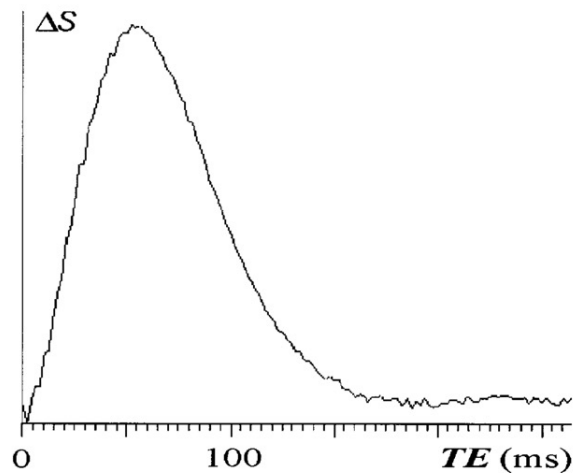
The decay of the transverse magnetization is then faster:

$$\frac{1}{T_2^*} = \frac{1}{T_2} + \frac{1}{T_2'}$$

where T_2' characterizes transverse relaxation related to field inhomogeneities.



Single echo vs multi echo fmri



This bell-shaped curve (the contrast) has its maximum value

$$\frac{S_0 \Delta T_2^*(t_r)}{e T_2^*} \approx 0.37 \frac{S_0 \Delta T_2^*(t_r)}{T_2^*} \quad [4]$$

at $TE_n = T_2^*$, which is typically 70 msec at 1.5 T (Fig.1).

=> But with different T_2^* , which TE is the best?

=> Multi-echo fMRI can help ...

Posse et al. Enhancement of BOLD-Contrast Sensitivity by Single-Shot Multi-Echo Functional MR Imaging, MRM, 1999

Quick overview on Multi-Echo fMRI

Acquisition:

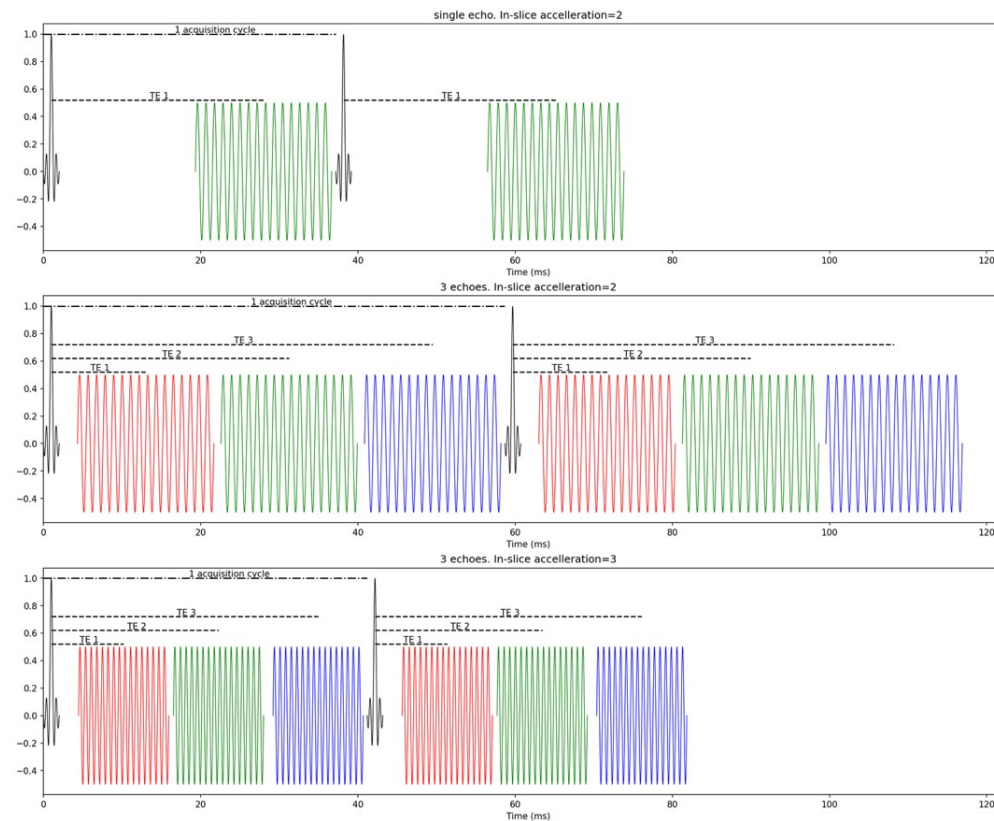


Fig. 2 A sample multi-echo fMRI pulse sequence. #

Quick overview on Multi-Echo FMRI

Images:

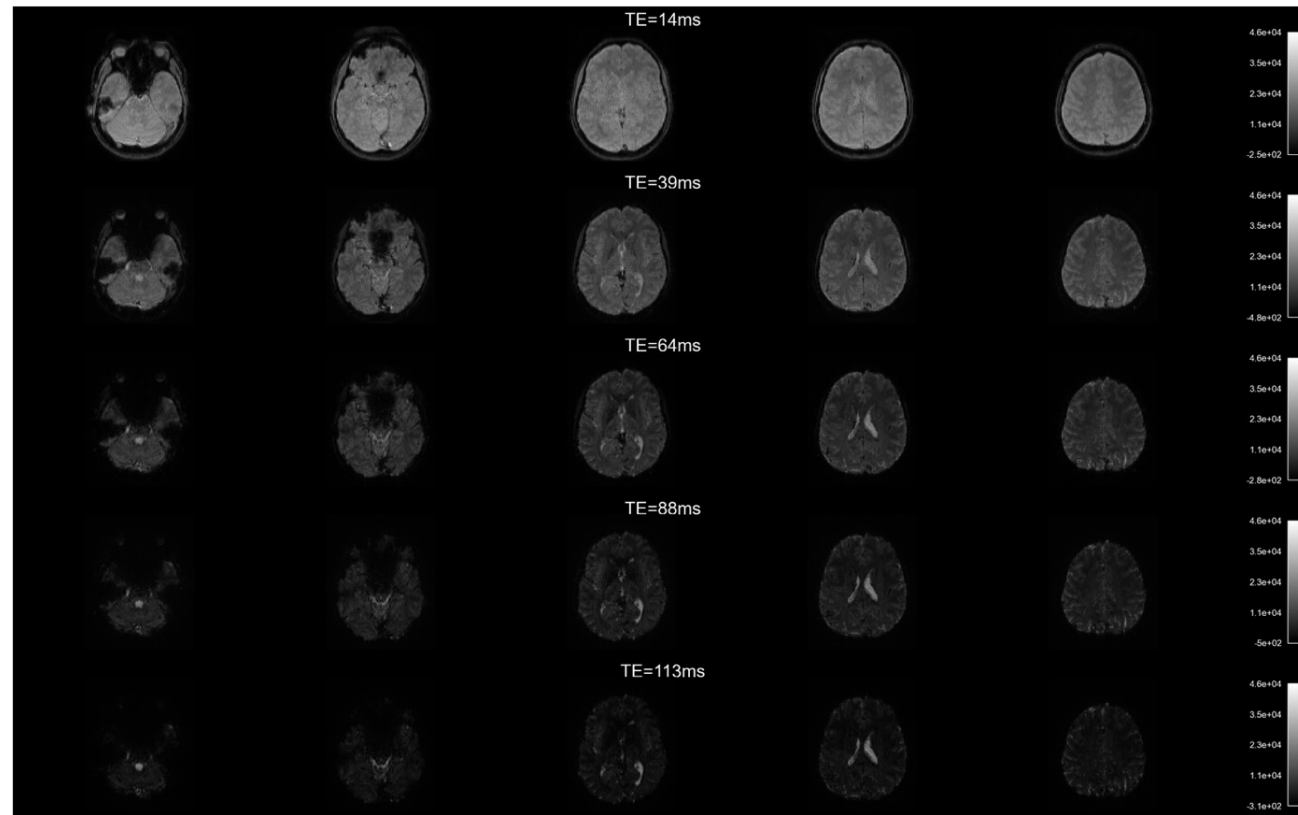
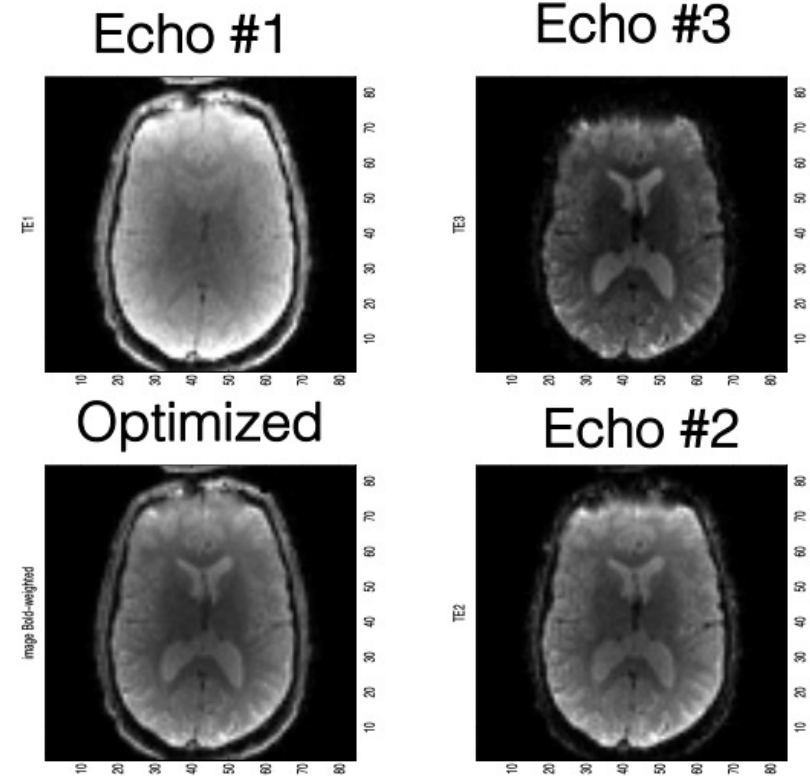
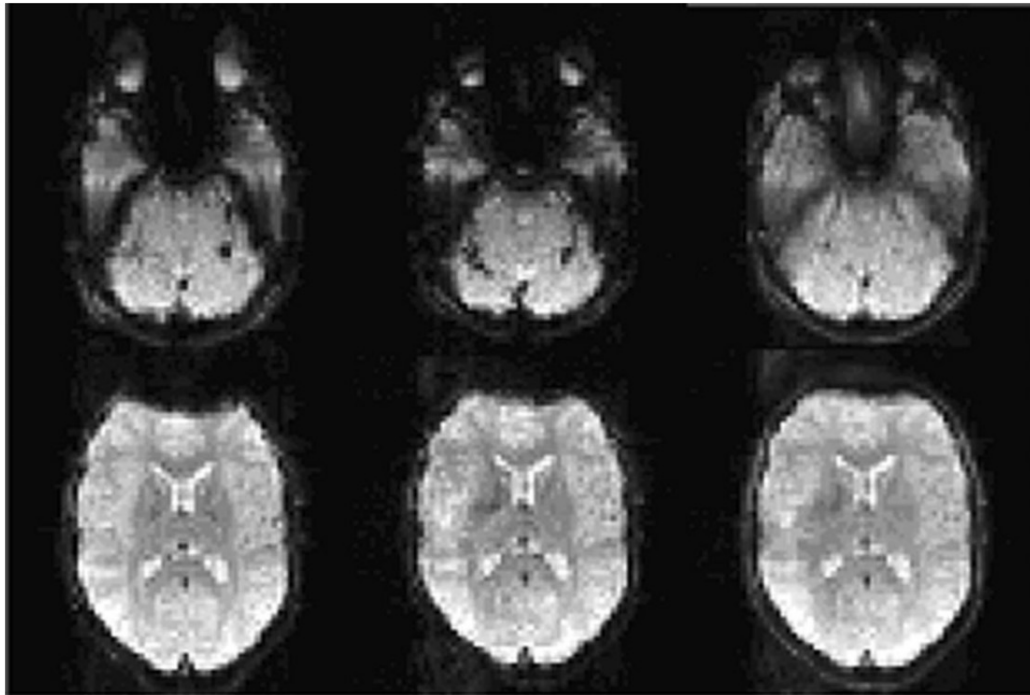


Fig. 3 Signal decay in the brain. #

Optimal combination

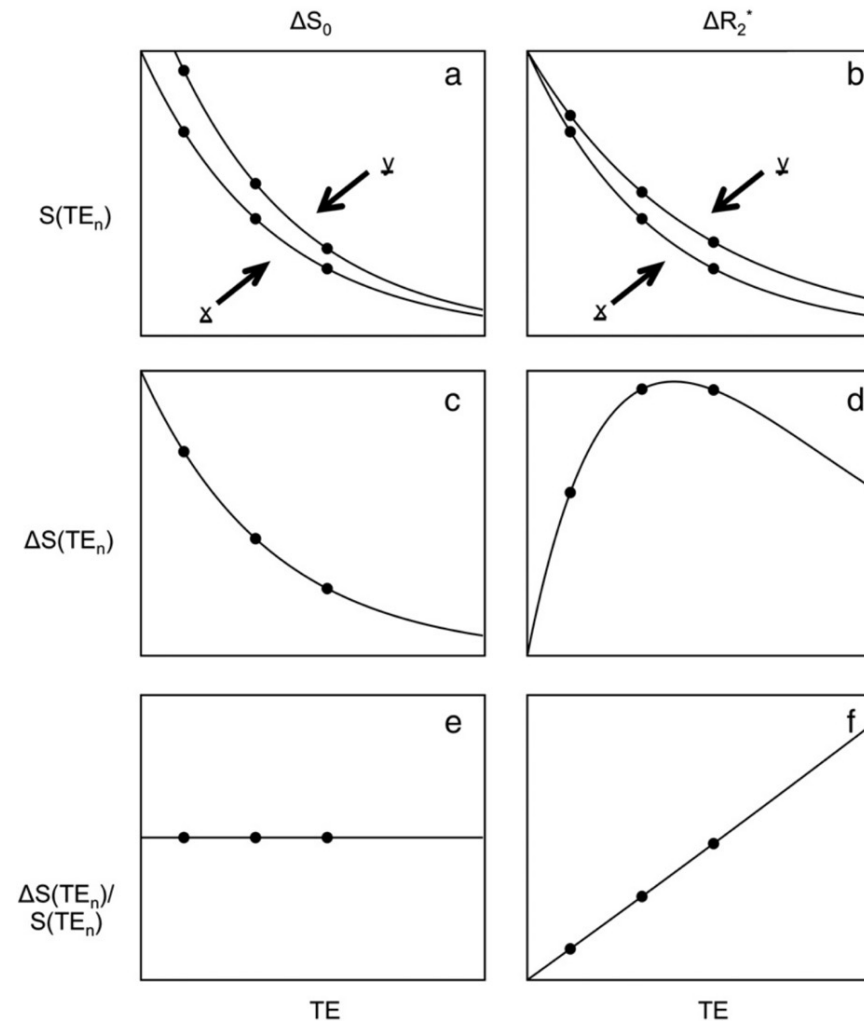


Activités méthodologiques : IRM

- EPI BOLD Multi-écho :

→ potentielles possibilités de débruitage via TEDANA (en cours de prise en main et de validation)

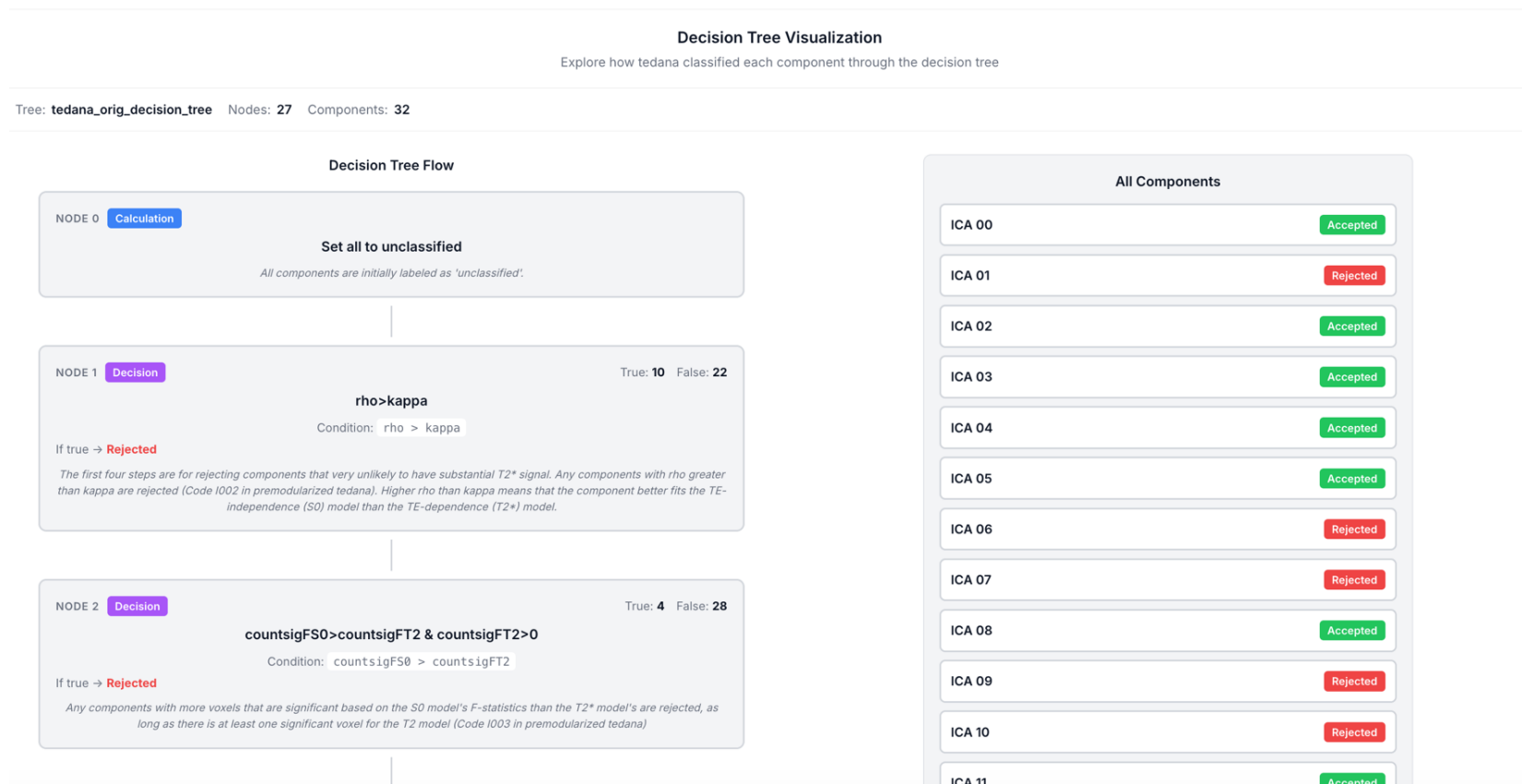
BOLD vs non BOLD



Activités méthodologiques : IRM

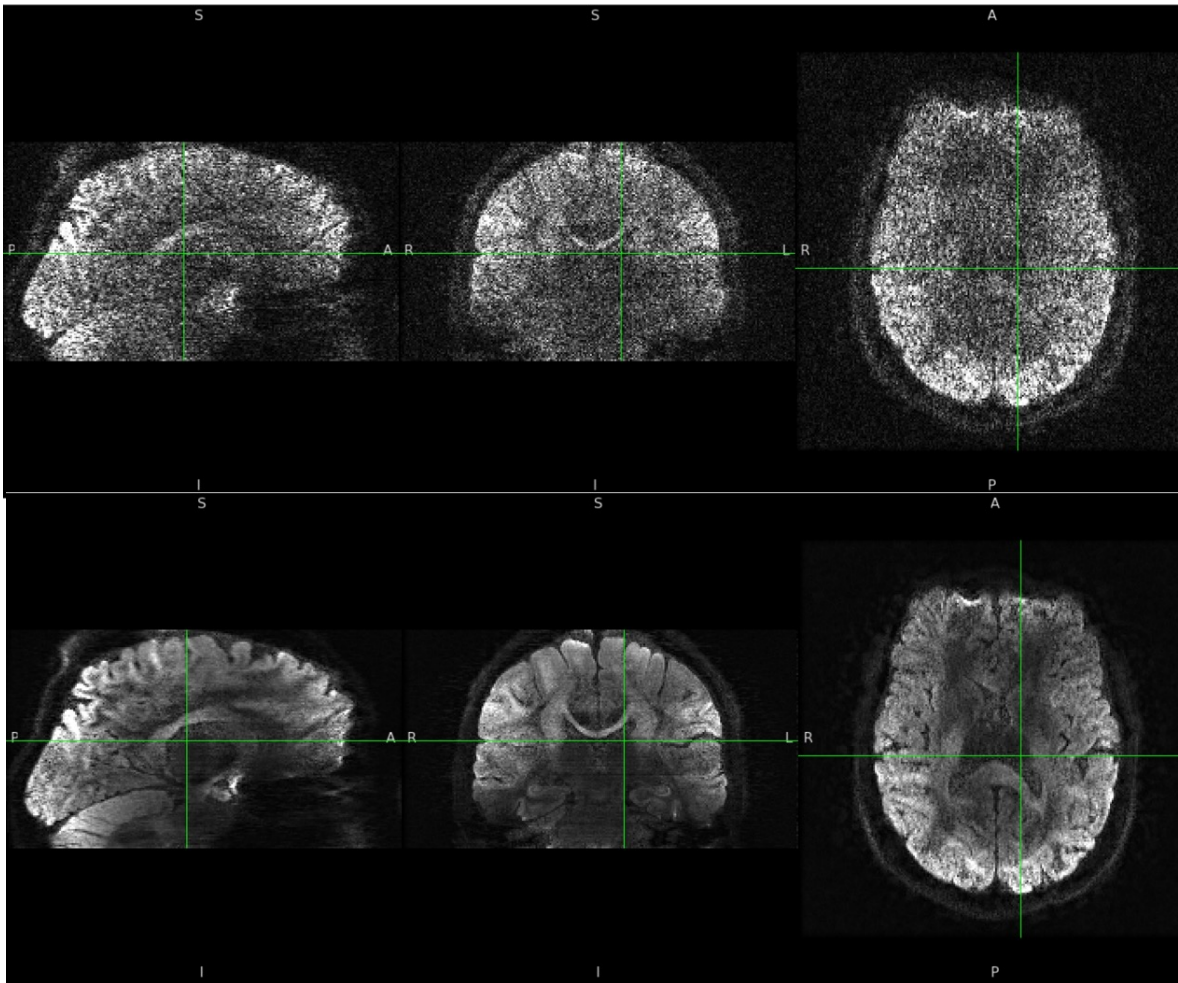
- EPI BOLD Multi-écho :

→ potentielles possibilités de débruitage via TEDANA (en cours de prise en main et de validation)



Denoising

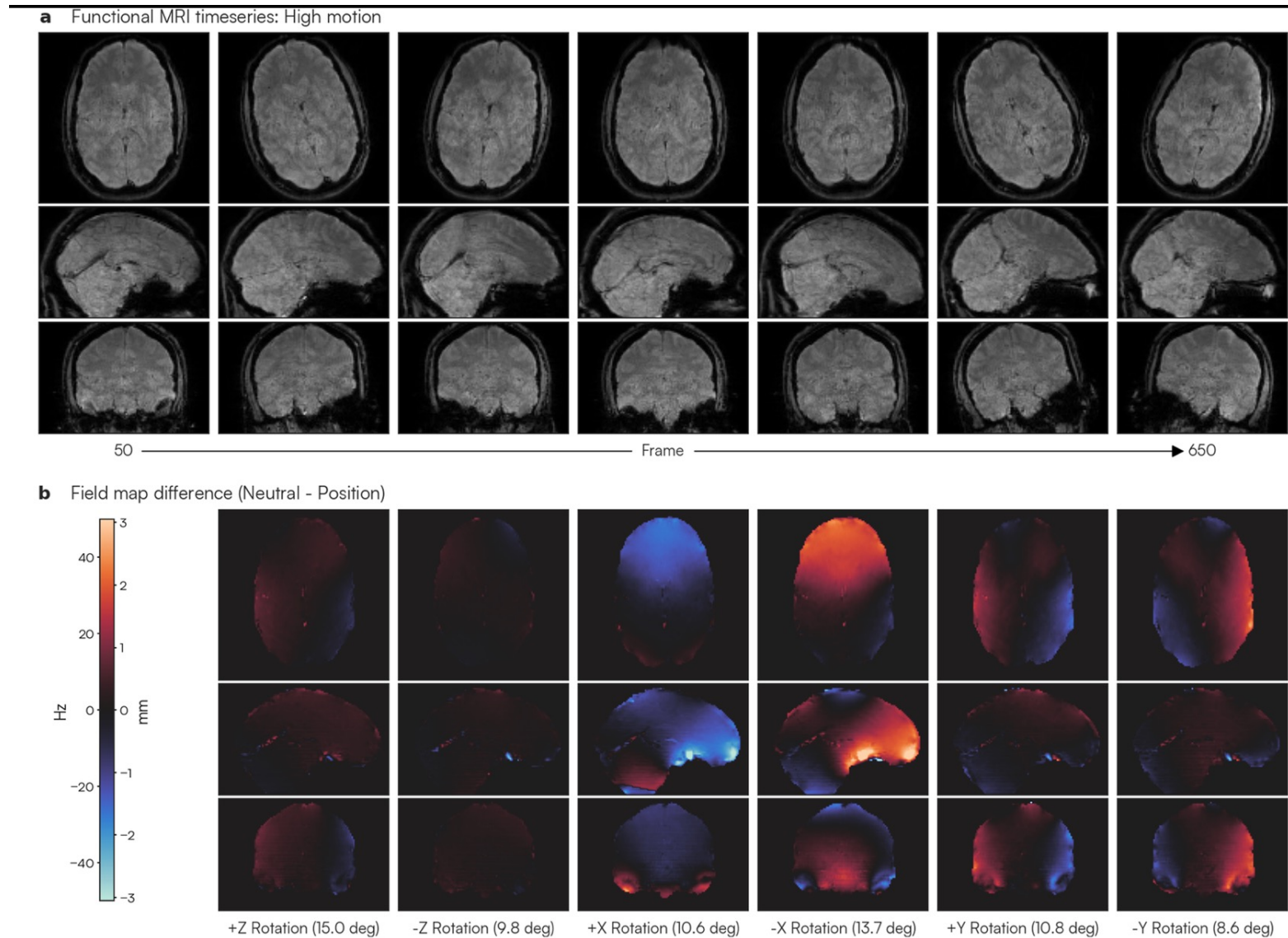
- Tests et validations en cours de NORDIC pour DWI et EPI-BOLD



**Native DWI
image, $b=1800$,
0.9mm voxel size**

**NORDIC-Denoised DWI
image**
⇒ Usable for multi-echo
fMRI
⇒ “Robust-Tedana”
framework
Tahayori et al. (2025)

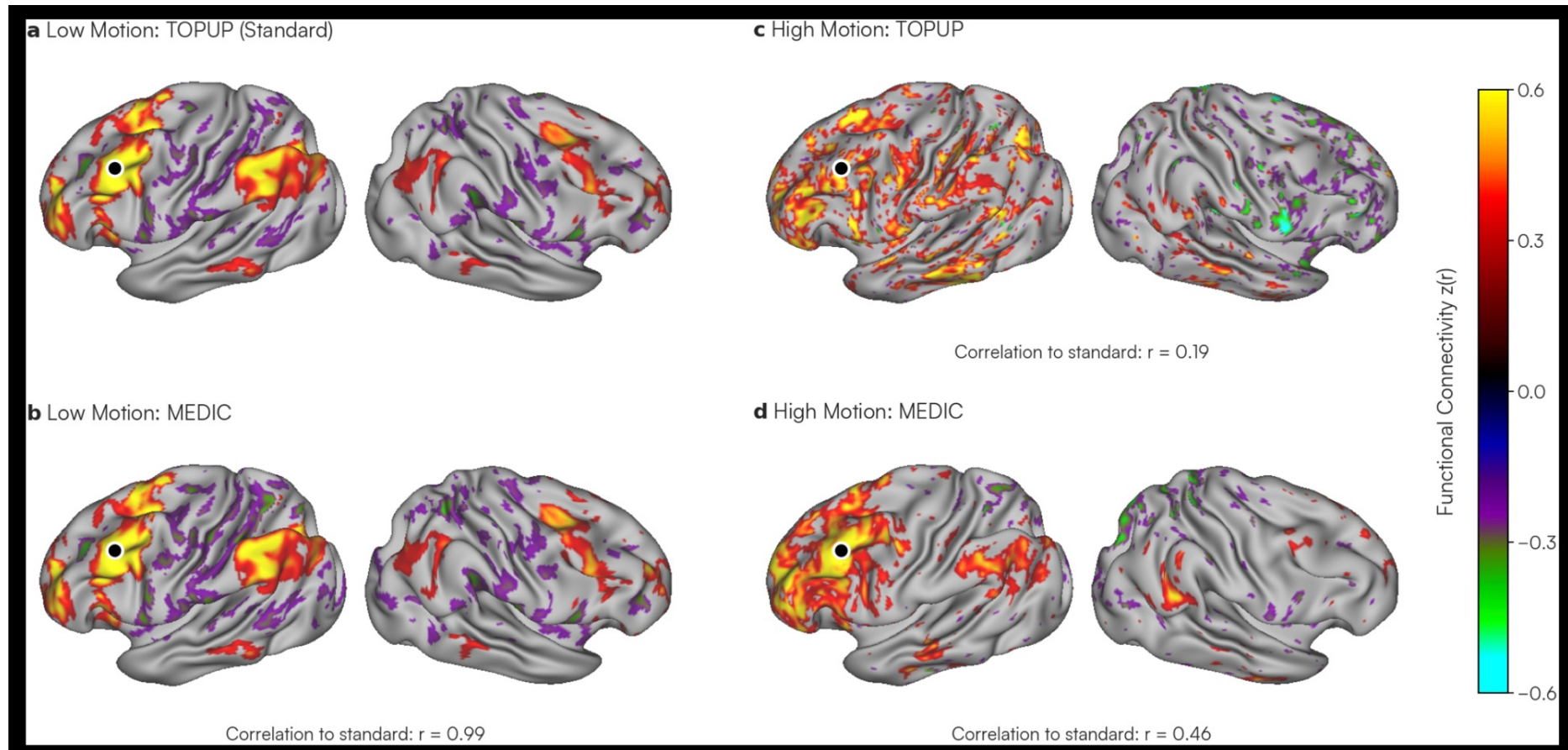
Susceptibility distortion correction for ME fMRI (MEDIC)



<https://github.com/vanandrew/warppkit>

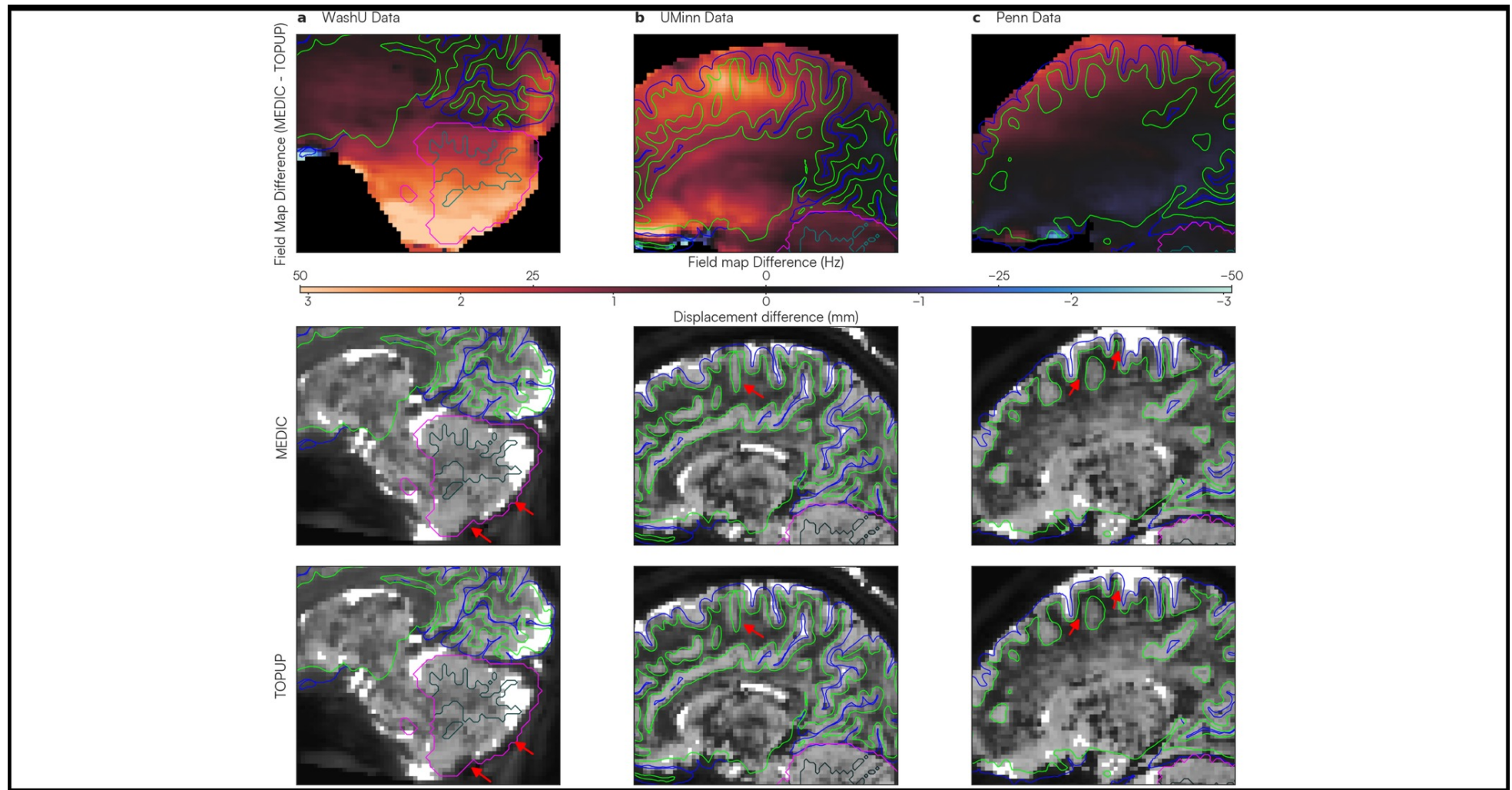
Van et al, Imaging Neurosciences, 2026

Susceptibility distortion correction for ME fMRI



<https://github.com/vanandrew/warpskit>

Susceptibility distortion correction for ME fMRI

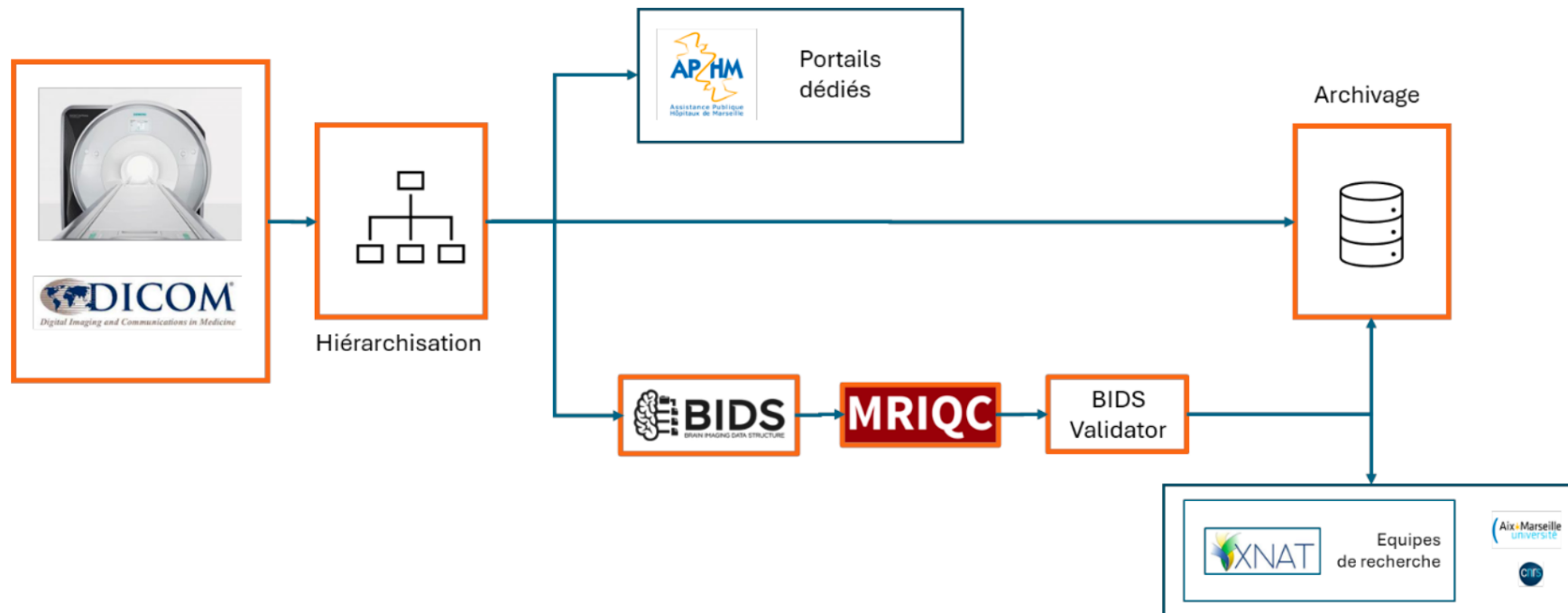


<https://github.com/vanandrew/warppkit>

Van et al, Imaging Neurosciences, 2026

Data Management

- « Glacier archiving on a RAID 5 NAS + daily backup to the 4D-OMICS DataCenter »



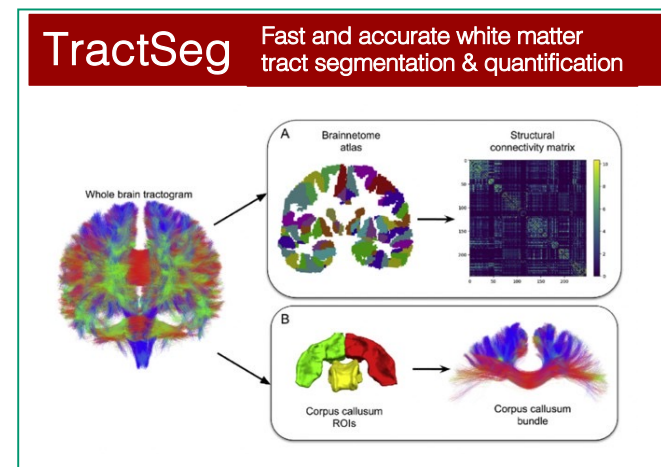
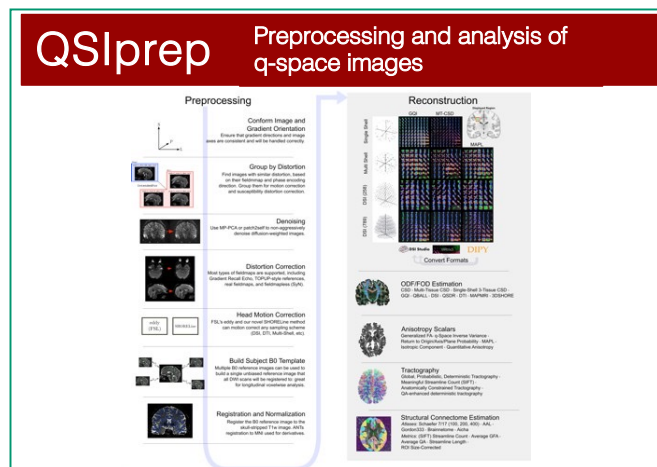
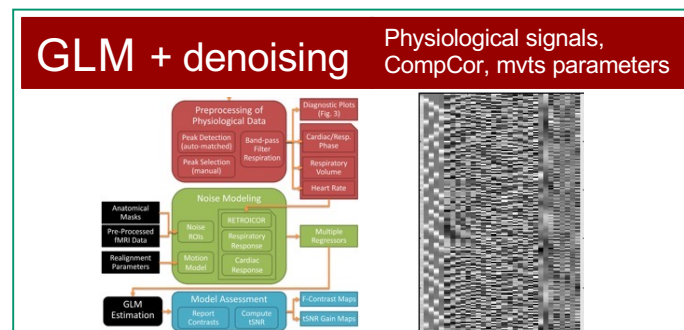
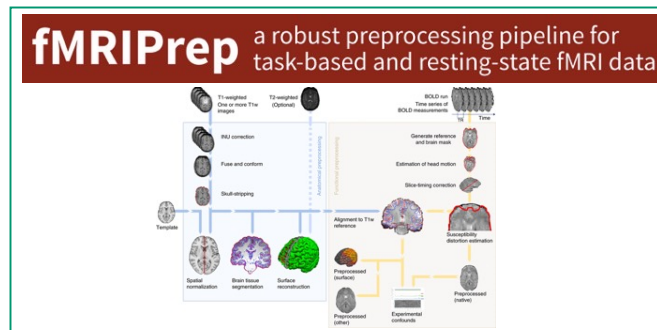
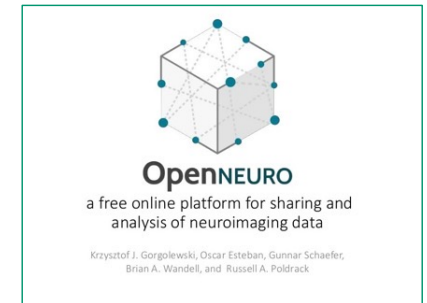
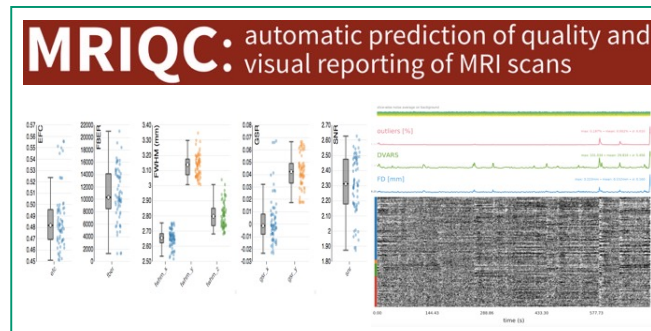
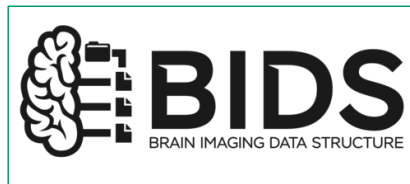
Data Management

- Learn how to use MRI console and instrumentation (redundancy with the team)
- Deploy a solution to distribute data to all users (including non-INT users)

XNAT or another system (Mistral Hugo Dary) at DataCenter Sud



Quality Analysis, Preprocessing, and Data Sharing



Développement permanent ...



Centre IRM-INT@CERIMED

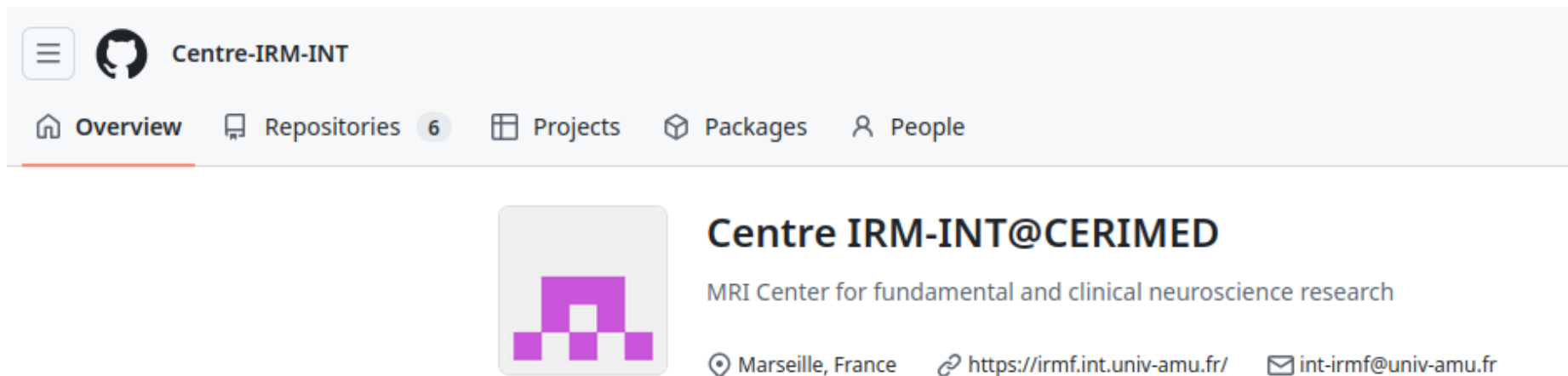


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Planning of pipelines / containers developpement

- Reorganize some internal processes (in particular the use of a centralized source code github repository)
- Rationalize some pre-processing and distribute them (chain of containers in particular) → « metatype » project



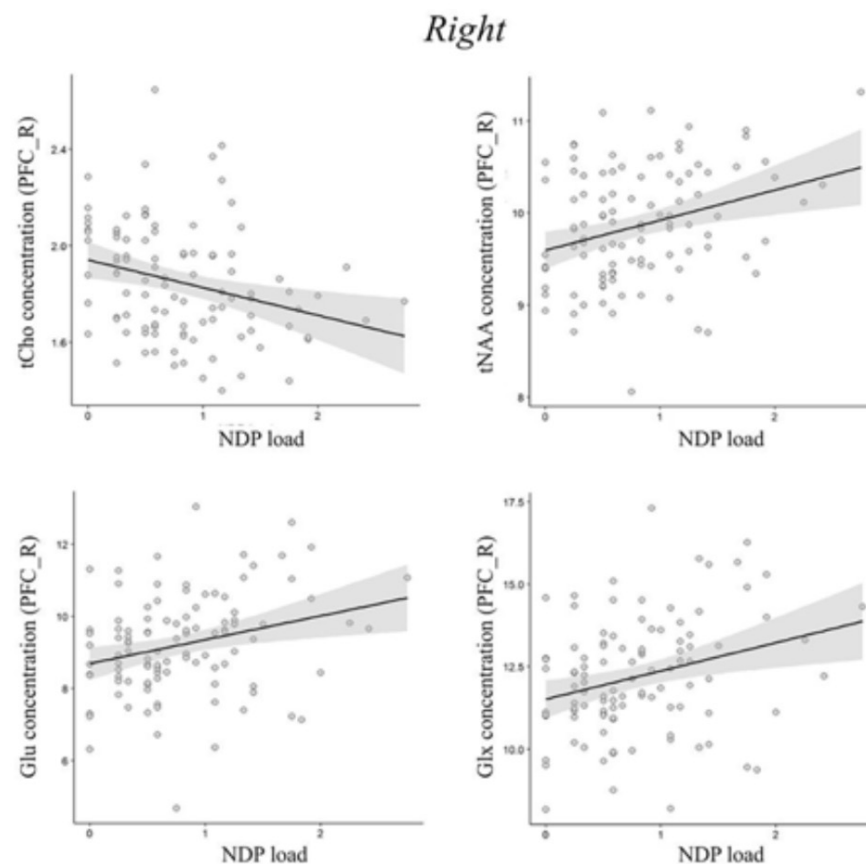
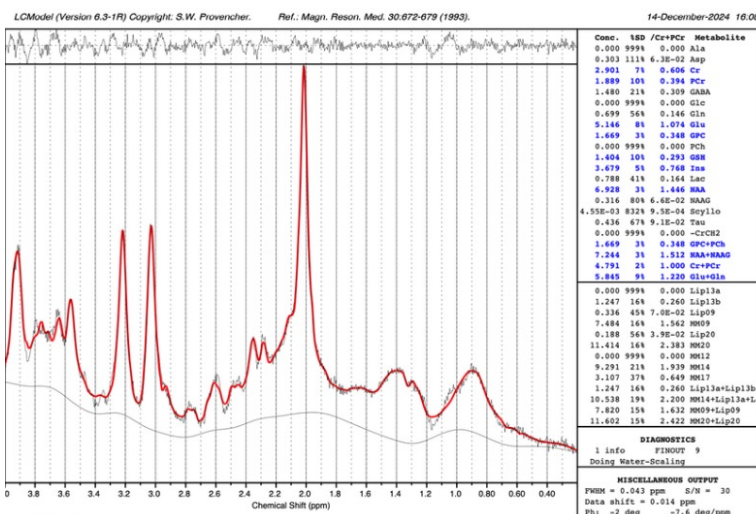
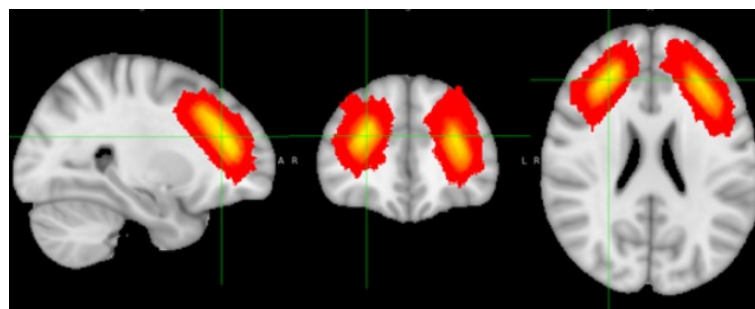
Scientific Activity

- MRI utilization remains consistently high ($\approx 60\%$ human subjects, $\approx 40\%$ PNH)
- Fundamental research projects
 - Healthy subjects (Interception, Timon, DeepMReye Wordlearning, ArtificialVoices, Motolang, Inhibition, BraINT, Duree, Soudscape, AinTalk, ModalChunk ...)
 - Patients: Parkinson's disease (Ecripark), dyslexia (Predys), bipolar disorder (Nemo), amputation (PhantomPain), addiction (Drugaddict), scoliosis (PrioprioAdo)
 - Non-human primates (PNH): Baboons (Babofet, Gestimage), macaques (Covoprim, Sociomonk)
- Clinical research projects (elderly patients: Prof. Ceccaldi & Félician's department)
- Launch of two major national projects:
 - PERPR ProPsy – FrenchMind (psychiatry)
 - Karavela – Céphalonauts (language decoding)
- Strong publication record by the scientific community: ≈ 15 high-impact articles / year
- 5 young researchers recruited over 2 years in Marseille in the field of MRI: Olga Kepinska (LPL), Florence Bouhali, Marie Chancel, Caroline Landelle, and Yannick Becker (CRPN)

Scientific Activity

- Spectroscopy:

Petitgas L ... Lefrere A : Reduced prefrontal total choline MRS levels characterize the neurodevelopmental phenotype of bipolar disorder. **Neuropsychopharmacology**

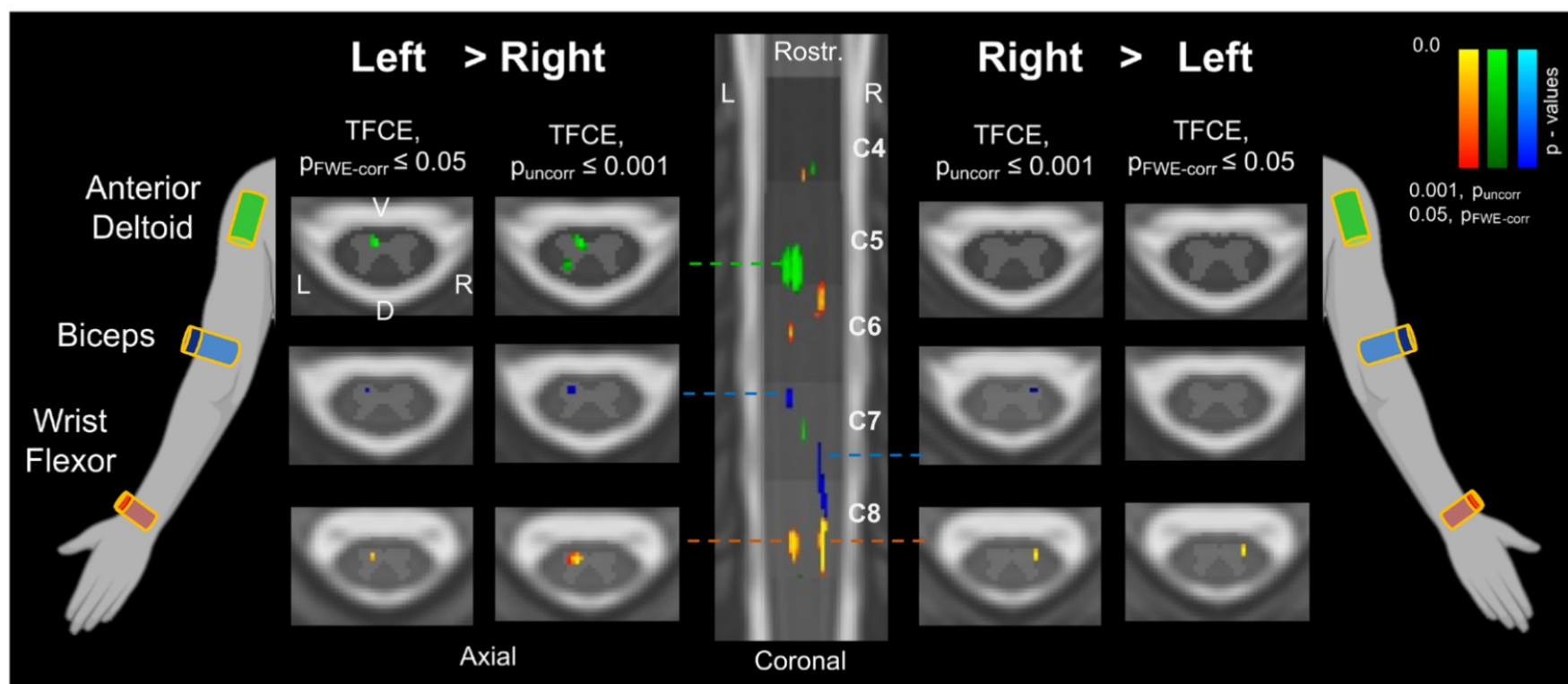


Scientific Activity

- Functional imaging of the spinal cord:

Schlienger R ... Kavounoudias A. Mapping Human Proprioceptive Projections of Upper Limb Muscles through Spinal Cord fMRI. **Human Brain Mapping**

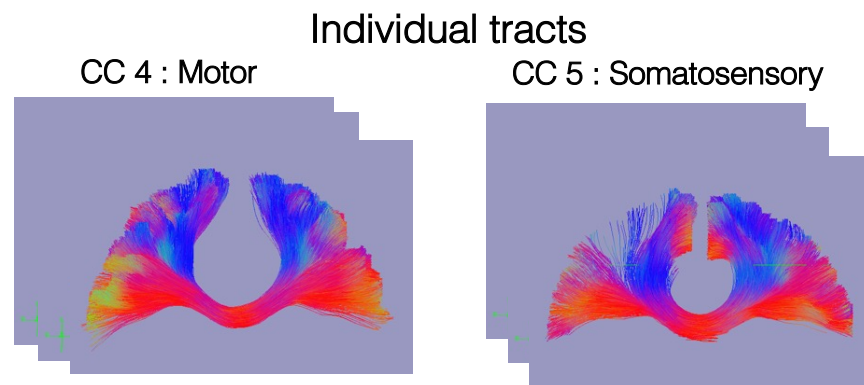
+ un autre article (moelle lombaire) en cours de révision



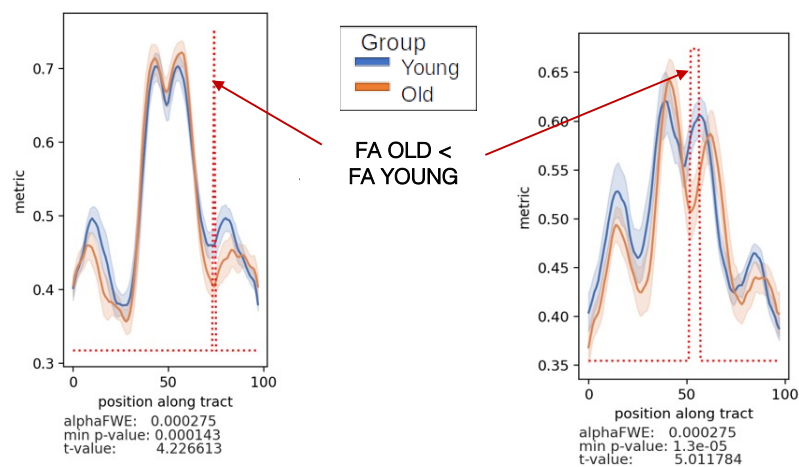
Scientific Activity

- Diffusion-Weighted Imaging (DWI) & Tractometry:

Pinzon D ... Kavounoudias A. White-Matter Integrity in Callosal Tracts Predicts Proprioceptive Discrimination Acuity, currently being submitted



Group difference analysis



Scientific Community Events

- Monthly Neuroimaging Meetings (RMN)
- Working Groups & Training Sessions (fMRI, Denoising, Connectivity, MVPA, DWI, Surface, ...)

- <https://irmf.int.univ-amu.fr>
- <https://github.com/Centre-IRM-INT>
- <https://remi.network/fr>



irmf.int.univ-amu.fr/en/home/ 90 %

Centre IRM - INT
The Magnetic Resonance Imaging research platform of the Institut de Neurosciences de la Timone (INT) located in the Centre Européen de Recherche en Imagerie Médicale (CERIMED - Campus Santé Timone, Marseille)

Home Facilities Research support Training & scientific animation Network & partnership Team & Contact

Home

16TH ANNUAL SCIENTIFIC DAY CENTRE IRM-INT
Quantitative MR Imaging and its Applications
Monday, May 4, 2026

News and events

- RMN of Thursday 9 April 2026
- Annual scientific Meeting : Monday, May 4, 2026
- RMN of Thursday 19 March 2026
- RMN of Thursday 12 February 2026
- RMN of Thursday 15 January 2026

Highlights

- LRQA CERTIFIED Quality
- The Center in pictures
- EyeTracking Data



RMN 08/10/2026

Scientific Community Events

Annual scientific Meetings

The collage features several overlapping posters for scientific events:

- 12th annual 'Centre IRM-INT' meeting** (21st November 2019): Focuses on LANGUAGE COMMUNICATION.
- 13th Annual Scientific Day of the MRI-INT Centre** (October 20th 2023): Theme: MRI NEUROIMAGING OF BRAIN DISORDERS.
- 14th Annual Scientific Day of the MRI-INT Center** (October 20th 2023): Focuses on Quantitative MR Imaging and its Applications.
- 15th Annual Scientific Day of the MRI-INT Center** (Monday, May 4, 2026): Focuses on Quantitative cartography and DWI Tractometry.
- 16th ANNUAL SCIENTIFIC DAY CENTRE IRM-INT** (Monday, May 4, 2026): Focuses on Quantitative MR Imaging and its Applications.
- Jou du Cen Mar** (FRIDAY 9 JUNE CAMPUS SAIN' AMPHI-CHARVE): Focuses on Adaptation Networks during Development.
- Imagerie Structurale** (Jeudi 11): Focuses on Structural Imaging.
- 8e Journée** (Vendredi 9): Focuses on Learning and control from a to adulthood.
- 7e Journée** (Jeudi 11): Focuses on Structural Imaging.

Logos for Aix-Marseille Université, CNRS, CERIMED, and the Institut de Neurosciences de la Timone are visible throughout the collage.

To be continued ...

- **New Developments in MRI**
 - Fetal Imaging in Humans
 - Ultra-Fast Acquisitions (3D EPI)
 - Silent Acquisitions (Looping Star)
- **Data Analysis & Training**
 - Getting Started with New Noise-Reduction Tools
 - Implementation of Standardized and Modular Pipelines
 - Working Group on Surface Analysis
- **Equipment:**
 - Long-term (3–4 years): replacement of the MRI system ($\approx$ €2 million HT)
- **Staff:**
 - Long-term (6–8 years): replacement of half the team

Thank you !