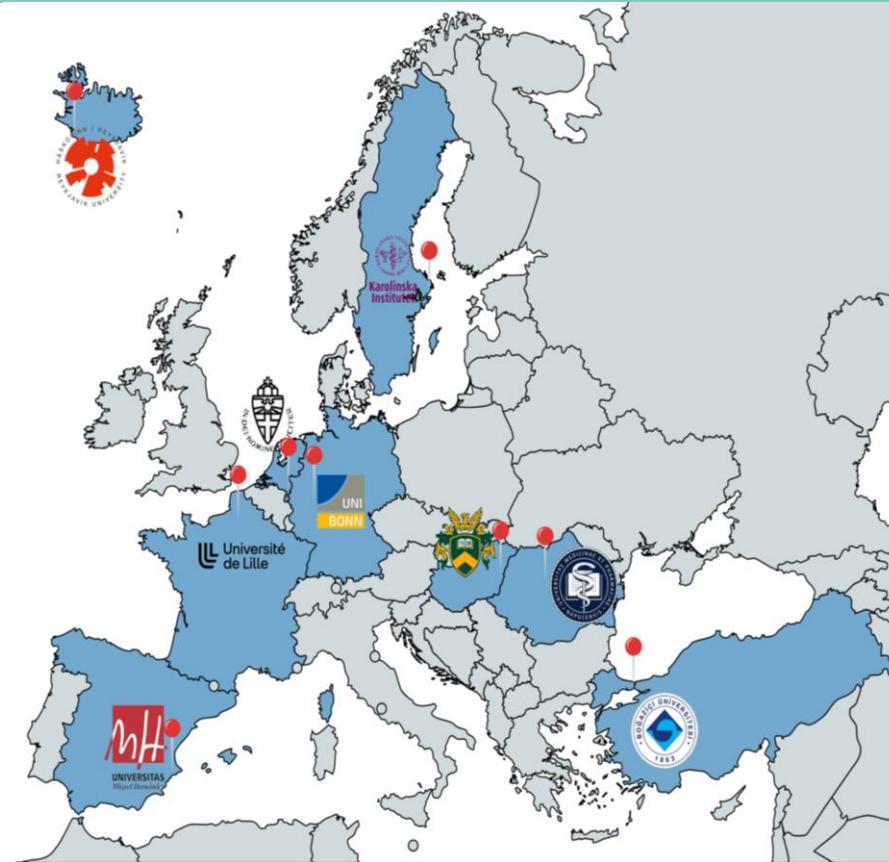




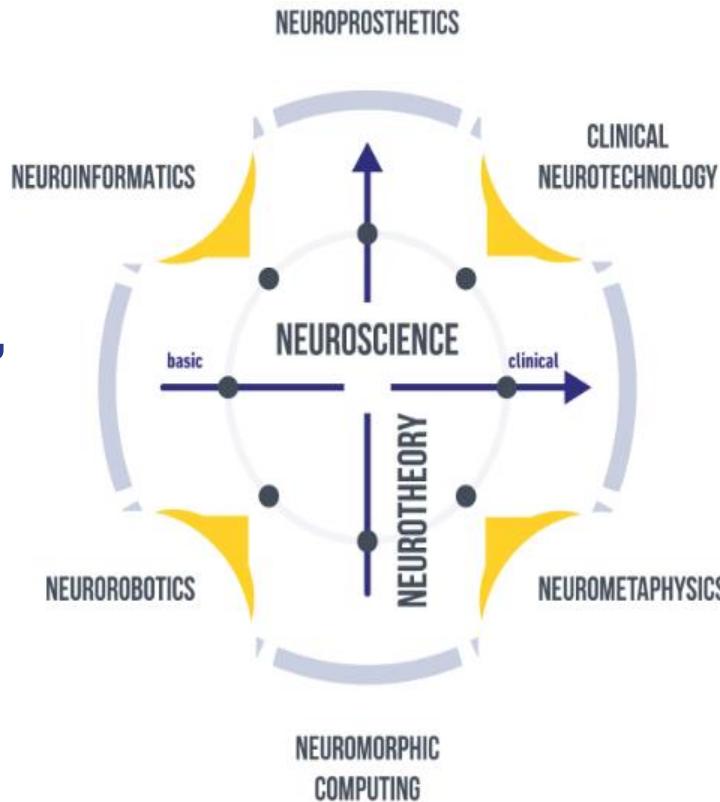
Co-funded by the  
Erasmus+ Programme  
of the European Union



Université  
de Lille

## 8 dimensions

“Technology **FROM,**  
**FOR,**  
**WITH**  
the brain”



Departments of Radiology



# A triple mission



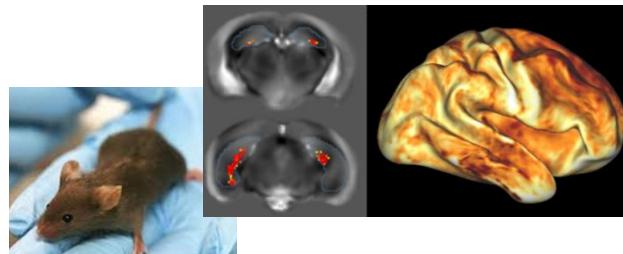
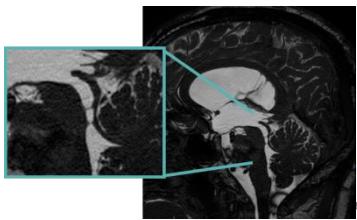
## Diagnostic Neuroradiology



## Research



## Innovation in Education



### Department of Neuroradiology

- ✓ Neurodegenerative disorders
- ✓ Neurovascular disorders
- ✓ Advanced MR techniques
- ✓ Regional network - ARIANES

### UMR1172 Lille Neuroscience & Cognition

- ✓ Degenerative and Vascular cognitive disorders

### UAR2014-US41 LiiFE

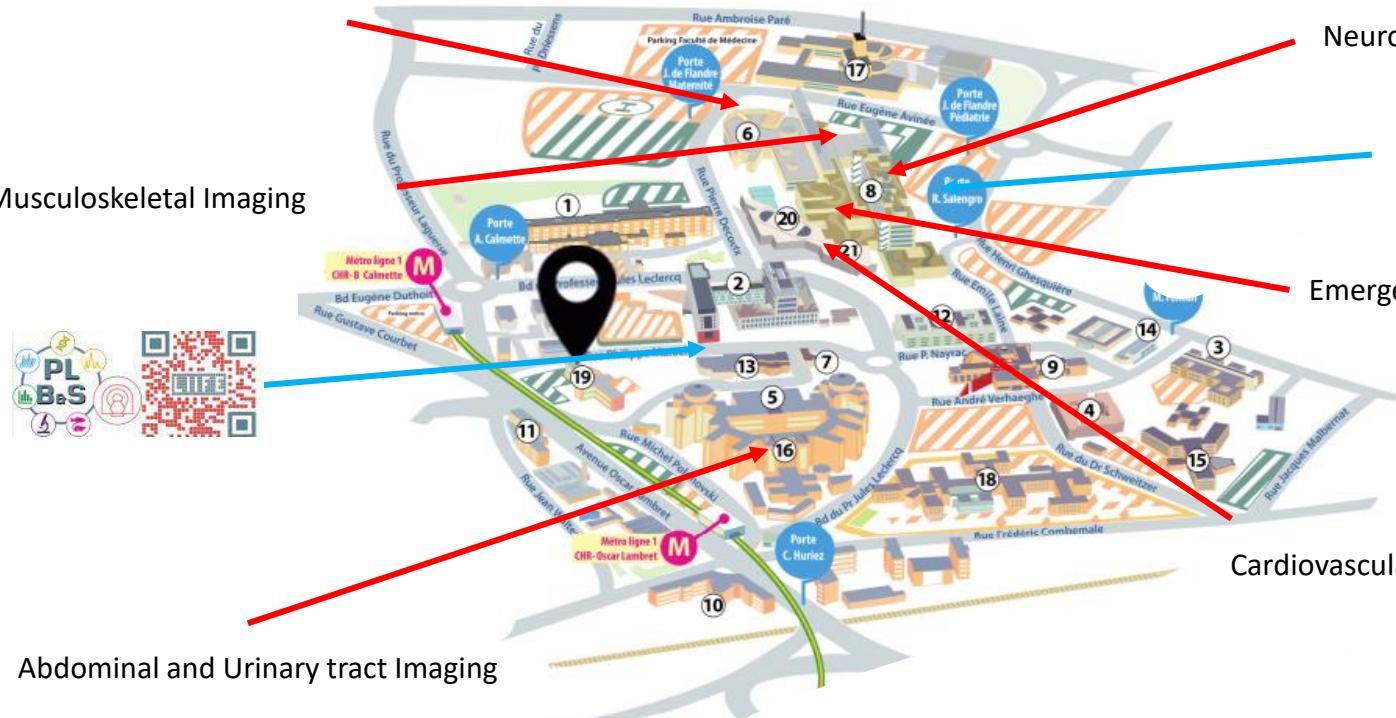
### Lille In-vivo Imaging and Functional Exploration

- ✓ Quantification of brain metabolic load
  - ✓ Brain connectivity
  - ✓ Artificial Intelligence

- ✓ Simulation-based learning
- ✓ Multidisciplinary approach
  - ✓ Eye-tracking system
- ✓ Continuing education - ARIANES

# Departments of Radiology

Pediatric and Women's Imaging



Neuroscience – Head and Neck Imaging



Emergency Imaging

Cardiovascular and Chest Imaging



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de Lille



# Department of Neuroradiology

## G Kuchcinski - JP Pruvo

### Diagnostic Neuroradiology

#### Medical Experts

- ✓ Neurovascular: M. Bretzner
- ✓ Psychiatry: R. Hanafi – JP Pruvo
- ✓ Neuroinflammatory: O. Outteryck
- ✓ Neurodegenerative: G. Kuchcinski
- ✓ Neuropediatrics: G. Soto-Ares
- ✓ Neuro-oncology: Q. Vannod-Michel
- ✓ Head & Neck: B. Pertuzon, M. Ayachi, M. Nobile, F. Dubrulle

### Interventional Neuroradiology

- ✓ L. Estrade : head of the unit
- ✓ N. Bricout, T. Personnic, M. Bretzner: Senior Practitioners

# Department of Neuroradiology

<b>MRI</b>	<b>2022</b>
1.5T MRI	4658 (1150 general anesthesia)
3T MRI	5698
Peroperative MRI	2017
MRI Emergency	8505
MRI Research	3306

<b>CT</b>	<b>2022</b>
CT Neuro / H&N	5413
CT Emergency	11509
CT Intensive Care	2507

<b>Interventional NR</b>	<b>2022</b>
Mechanical thrombectomy	506
Aneurysms	237
AVM, DAVF, Angioplasty	95

# Our projects for clinical care



## 2024 : 3T MRI fully dedicated to research

- Scientific partnership with Siemens

## 2025 : 7T MRI installation

- Staff Recruitment (physicist, engineer, radiographers)
- MR safety
- New clinical applications => Epilepsy
- Scientific partnership with Siemens

## 2030 : New Hospital

- Refine patients' experience (Neuro emergencies, outpatient)
- Strengthen Head&Neck and Psychiatry
- Integrate new digital tools and AI



# Education: « Acute Stroke» Simulation Program



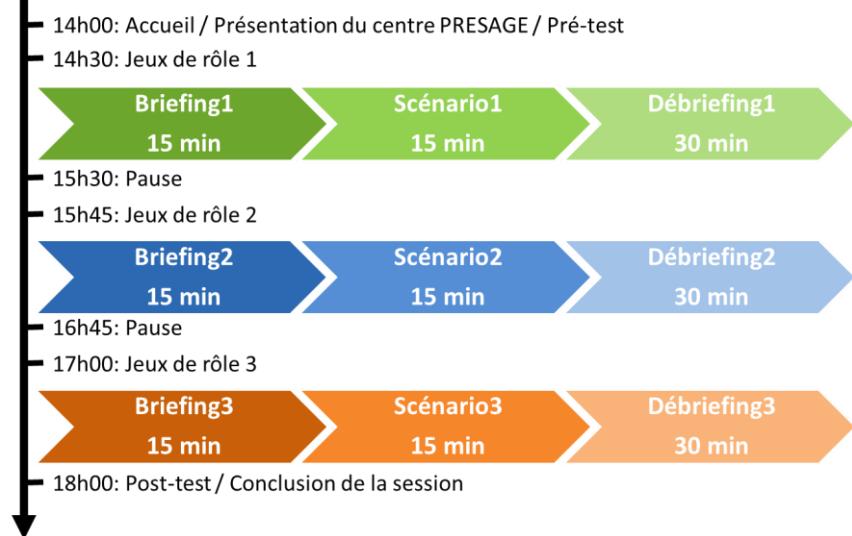
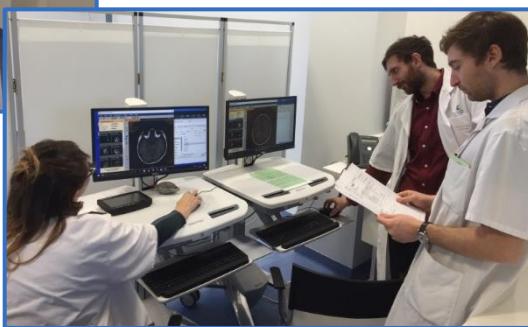
**OBJECTIVES:** Communication / Organisation / Decision-making

**METHODS:** Role-playing game

**PRE-REQUISITES:** e-learning about stroke management

**STUDENTS:** 80 between 2017 et 2019

Radiology Residents / Neurology Residents / Radiographers students / Nurse students



# Education: « Acute Stroke» Simulation Program



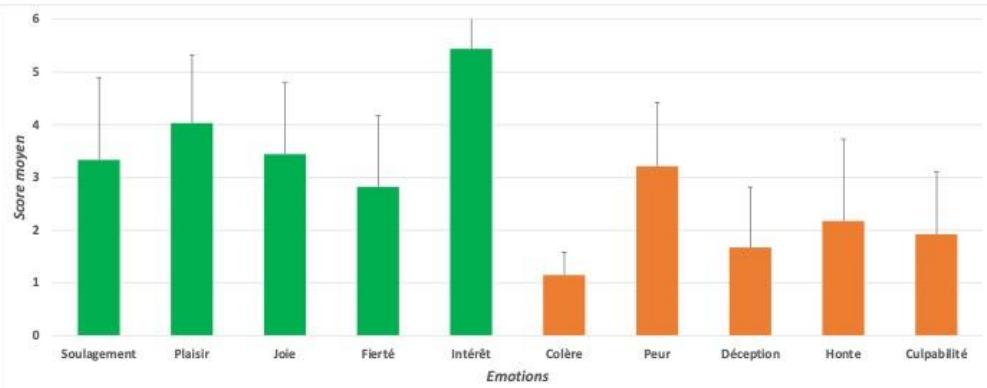
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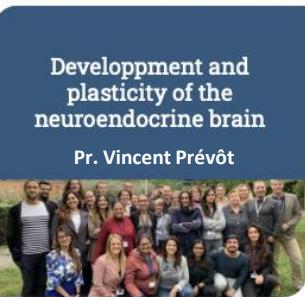
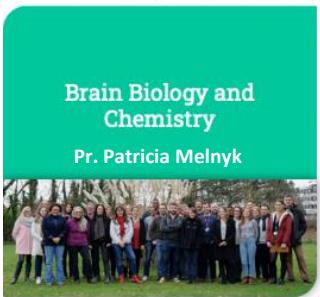
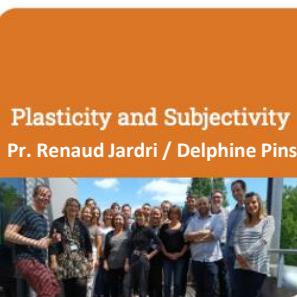
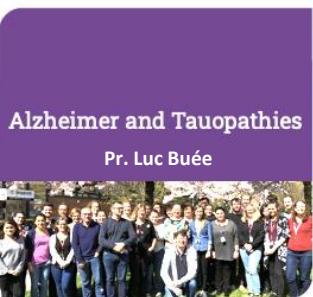
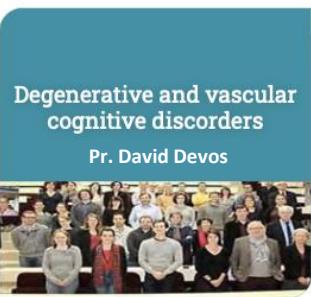


Essentiel  
Organisation  
Rapidité  
Anticipation  
Connaissance  
**Communication**  
Collaboration  
Efficacité  
**Temps** Optimisation Clinique  
Urgence  
Gain Gestion  
Expérience  
Confrontation

# Research Environment

## Lille Neuroscience & Cognition

Director: Pr. Luc Buée



Lille  
Neuroscience  
& Cognition

<http://lilncog.eu/>

## Lille In-vivo Imaging and Functional Exploration

Director: Pr. Pruvo / Dr. Lopes



Humain Imaging  
3T MRI

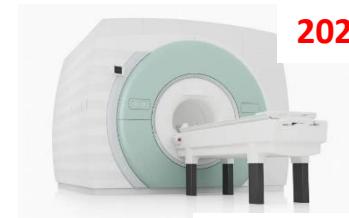


Animal Imaging  
7T Micro-MRI / 0.2T MRI  
Micro-PET



Animal  
Behaviour

7T MRI  
2025



### Staff

Research assistant – 1 FTE  
Research engineers – 4 FTE  
Engineers – 1 FTE  
Assistant engineers – 1 FTE  
Secretary – 1 FTE  
Technicians – 2 FTE  
Neuroradiologists – 1.4 FTE  
Nuclear medicine – 0.2 FTE



# Research collaborations

Prognosis in FEP  
Master 2 Simon Bernard

« PSY Plasticity and Subjectivity»  
U1172 R Jardri

« Development and plasticity of  
the neuroendocrine brain »  
U1172 V Prévot, P Giacobini

Tanycytes in AD and FTD  
*ERC-WATCH*

Team « Degenerative and Vascular  
Cognitive Disorders» U1172, D Devos

Iron chelation in PD  
H2020 FAIRPARK 2

Movement Disorders Clinic  
L Defebvre, C Moreau

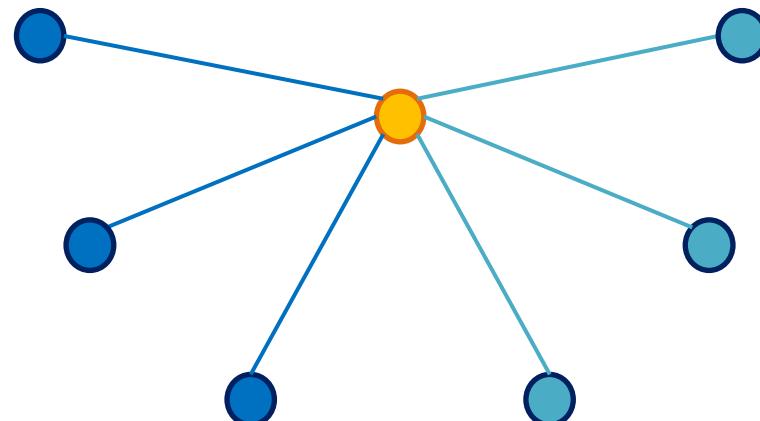
Vascular Neurology Clinic  
C Cordonnier, L Puy

Haemostasis in ICH  
*ANR ERANET COHDICH*

Team « Alzheimer and Tauopathies »  
U1172, L Buée, D Blum

Memory Ressources and Research  
Centre F Pasquier, T Lebouvier

Alzheimer and Caffeine  
*PHRCI CAFCA*



# Research collaborations



Pr Alexandre Vignaud, *CEA Neurospin, Paris Saclay*

Pr Maxime Guye, *CMRBM Marseille*

**7T MRI – French Ultra-high field Network (FUN)**

Dr Loïc Duron, Dr Augustin Lecler, Pr Laure Fournier  
*INSERM UMR-S970 – PARCC, Paris*

**Radiomics**

Pr Thomas Toudias – *INSERM U1215, Bordeaux*  
**Advanced imaging of post-stroke cognitive disorders**

Pr Catherine Oppenheim - *INSERM UMR 1266, Paris*  
**Advanced imaging of stroke and tumors**



Prof. Natalia Rost

*J. Philip Kistler Stroke Research Center*

*MGH, Boston, USA*

**Stroke / Martin Bretzner PhD**

Prof. Yi Wang

*MRI research Institute Radiology*

*Cornell University, New-York, USA*

**Quantitative susceptibility mapping**



Prof. Pia Sundgren,

*Lund University Bioimaging Centre*

*Lund, Sweden*

**7T MRI**

# Research topics

## Team « Degenerative and Vascular Cognitive Disorders » U1172, D Devos

### 3 main research topics

- ✓ Pathophysiological mechanisms of neuronal degeneration (vascular & ferroptosis)
- ✓ Multiple dimensions of cognition & related biomarkers
- ✓ Innovative symptomatic & disease-modifying treatments

### Keystone project LiIMIND

- ✓ Multimodal Imaging and Network analyses in Neurological Disorders
- ✓ PI: Renaud Lopes / Grégory Kuchcinski



# Research topic

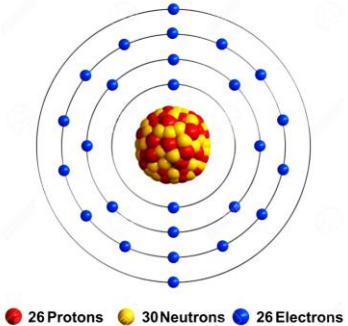
## One aim:

To develop **MRI biomarkers** to improve the understanding of **normal aging** and **age-related disorders**

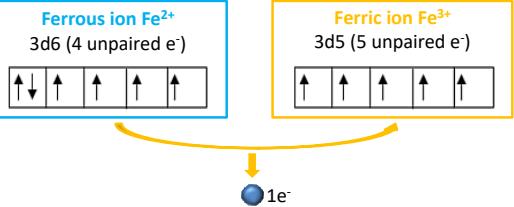
## Two strategies:

1. Developing **advanced MR sequences** => quantification of neuropathological process
  - ✓ Iron mapping in MRI and neurodegeneration
  
2. Advanced post-processing (AI) of standard MR sequences
  - ✓ Radiomics and WMH
  - ✓ BrainAGE

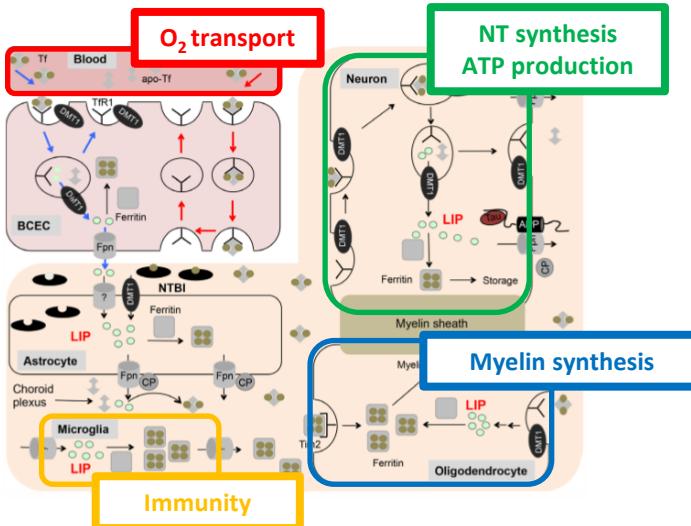
# Iron mapping with MRI and neurodegeneration



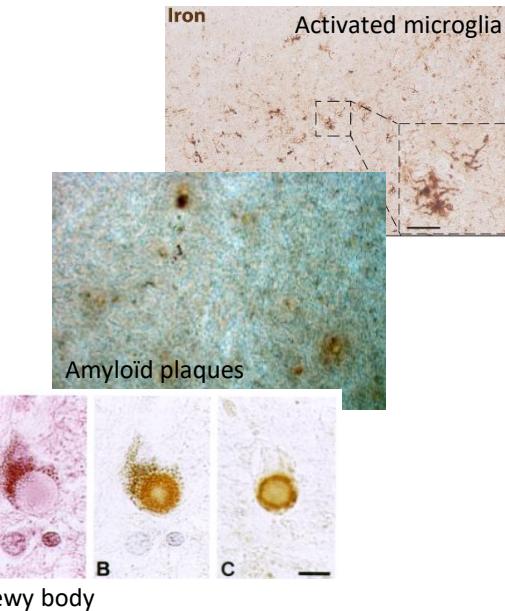
● 26 Protons ● 30 Neutrons ● 26 Electrons



A natural MRI contrast agent



Key role in brain physiology



Associated with histological hallmarks of neurodegeneration

# Iron mapping in Alzheimer's disease

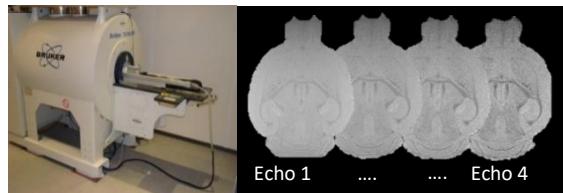


PhD 2018 – 2021, supervisor: Prof. JP Pruvo , co-supervisor: Dr. S Verclytte

## Optimized MRI acquisition 3D multiecho GRE

7T μMRI / In-vivo and ex-vivo / 4 - 6 echos

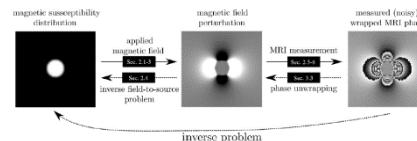
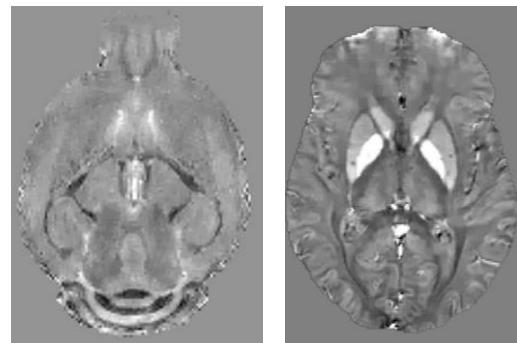
TE = 4 to 22 - 34 ms / Voxel = 100 – 125  $\mu\text{m}^3$  / 1,5 – 4h



3T MRI / 8 echos

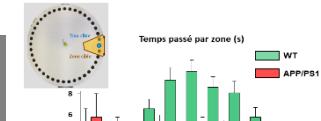
TE = 4 – 41 ms / Voxel = 1x1x2 mm / 10 min

## Harmonized post-processing pipeline

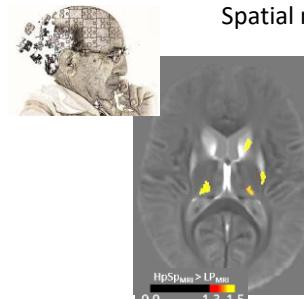


QSM reconstruction

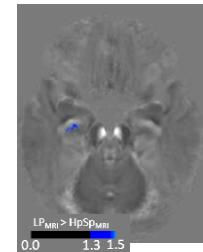
## Application Alzheimer's disease



APP/PS1 (n=15) vs WT (n=25) M9  
Iron accumulation (dentate/subiculum)  
Spatial memory impairment



COMAJ cohort (Early-Onset AD) n=68  
Different patterns of iron accumulation  
Limbic predominant => hippocampus  
Hippocampal sparing => deep gray nuclei



# Research topic

## One aim:

To develop **MRI biomarkers** to improve the understanding of **normal aging** and **age-related disorders**

## Two strategies:

1. Developing advanced MR sequences => quantification of neuropathological process

- ✓ Iron mapping in MRI and neurodegeneration

2. **Advanced post-processing (AI)** of standard MR sequences

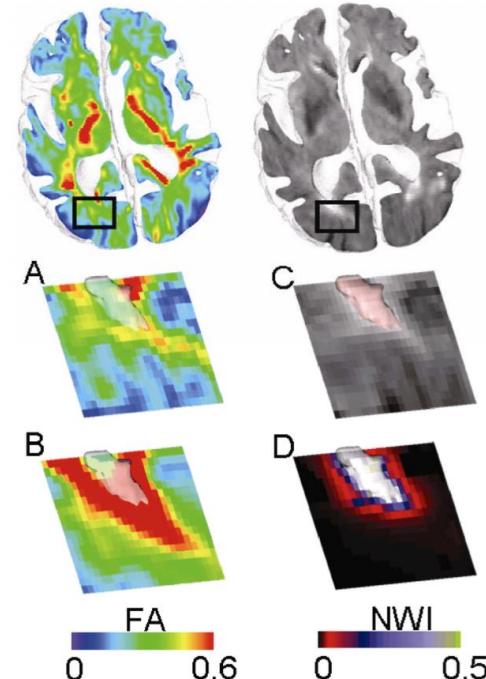
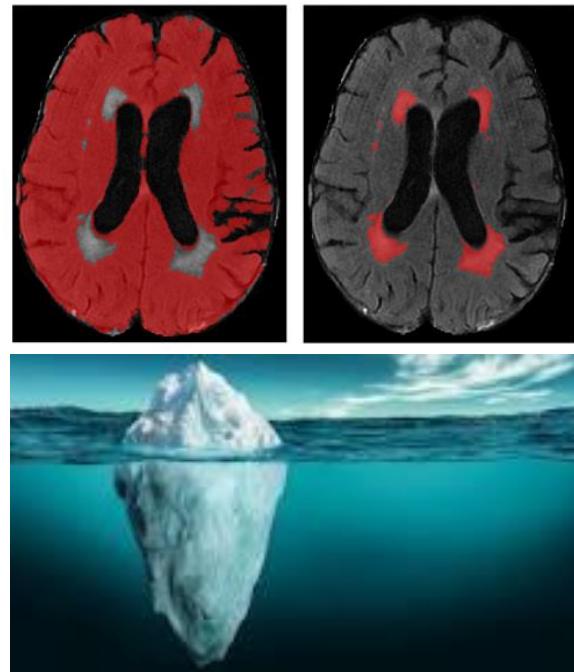
- ✓ Brain connectivity
- ✓ Radiomics and WMH
- ✓ BrainAGE
- ✓ Segmentation of hypothalamus



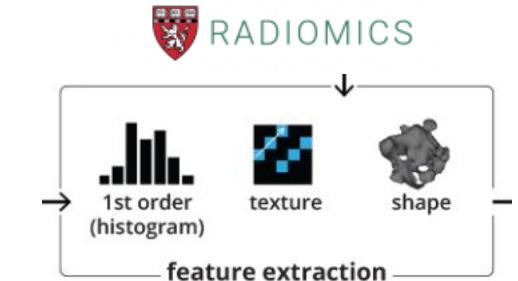
# Radiomics and WMH



- ✓ PhD Martin Bretzner, « Radiomics analysis of infarct and underlying brain parenchyma in stroke patients », Supervisor: Prof. X. Leclerc, Co-supervisor: G. Kuchcinski, defense in may 2023
- ✓ Collaboration with Pr Natalia Rost, J.P. Kistler Stroke Research Center, MGH Boston
- ✓ MRI-GENIE database of 4000 ischemic stroke patients



Maillard et al. Stroke 2011. doi: 10.1161/STROKEAHA.110.609768



Example: Gray-level co-occurrence matrix (GLCM)

$$I = \begin{bmatrix} 1 & 2 & 5 & 2 & 3 \\ 3 & 2 & 1 & 3 & 1 \\ 1 & 3 & 5 & 5 & 2 \\ 1 & 1 & 1 & 1 & 2 \\ 1 & 2 & 4 & 3 & 5 \end{bmatrix} \quad P = \begin{bmatrix} 6 & 4 & 3 & 0 & 0 \\ 4 & 0 & 2 & 1 & 3 \\ 3 & 2 & 0 & 1 & 2 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 3 & 2 & 0 & 2 \end{bmatrix}$$

Intensity matrix

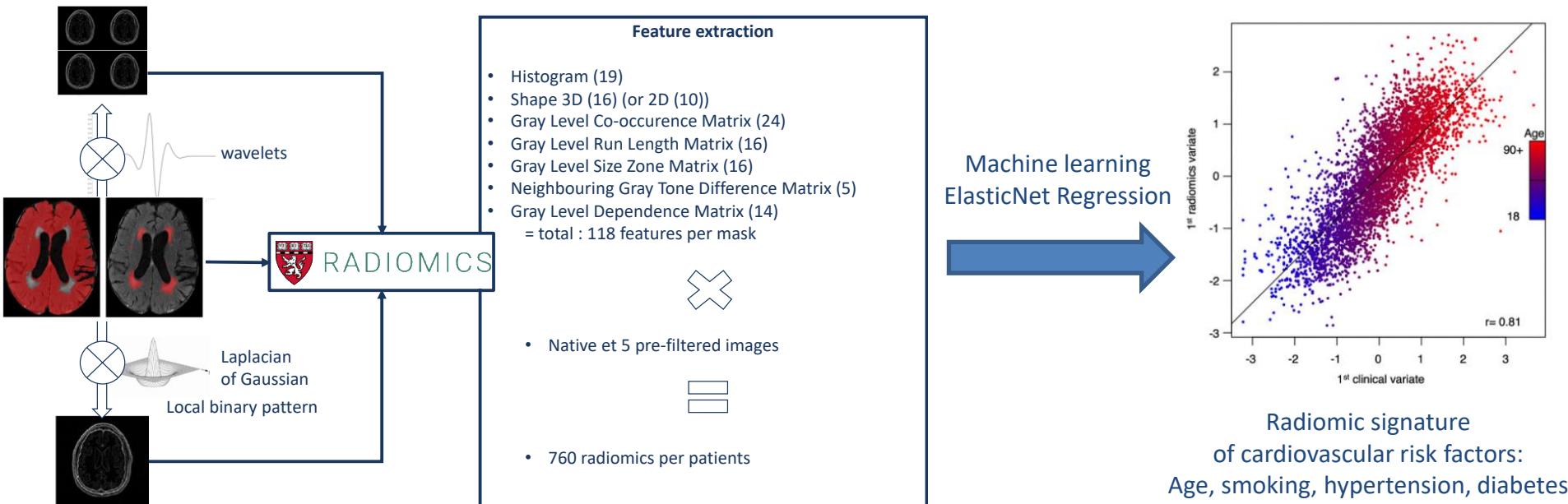
GLCM (distance 1, angle 0°)

<https://pyradiomics.readthedocs.io/>

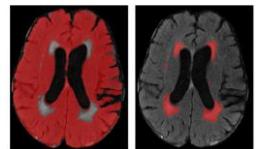
# Radiomics and WMH



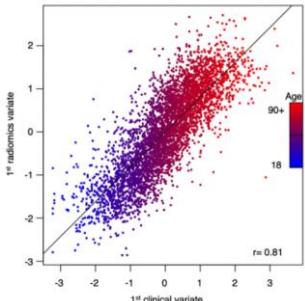
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# Perspective – Federated learning

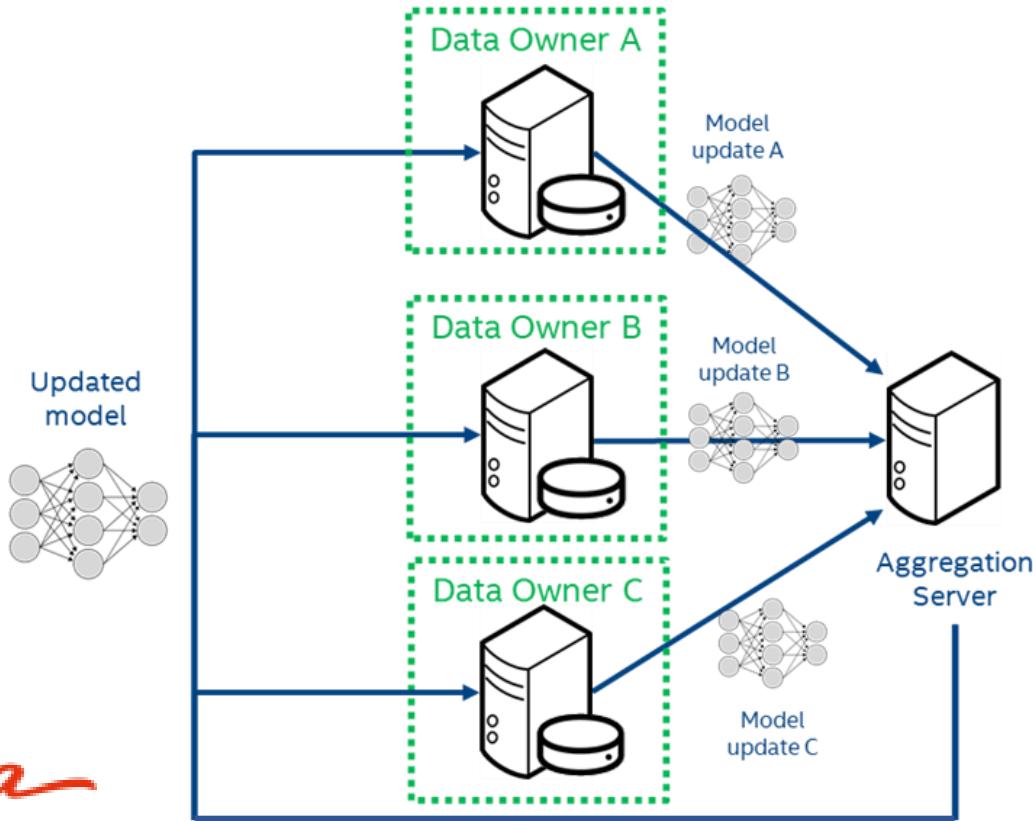


Machine learning  
ElasticNet Regression

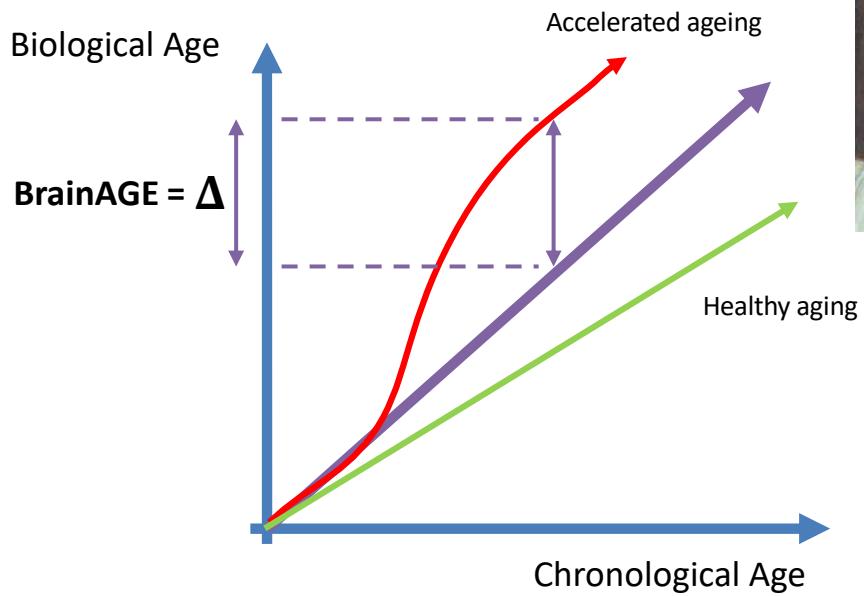


Inria

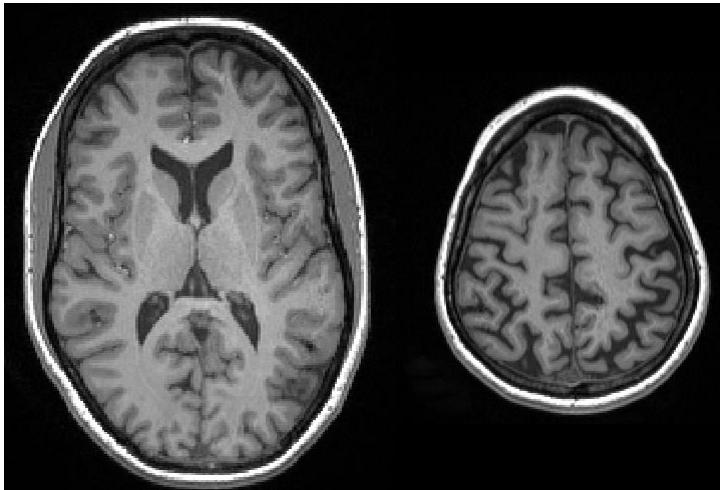
## Federated Learning Architecture



# BrainAGE



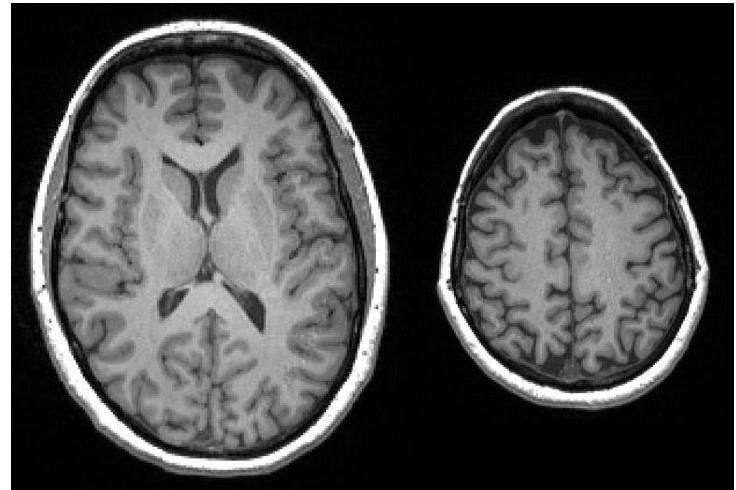
## How old is my brain ?



45 y ?

Chronological age = 41 y

BrainAGE = +4



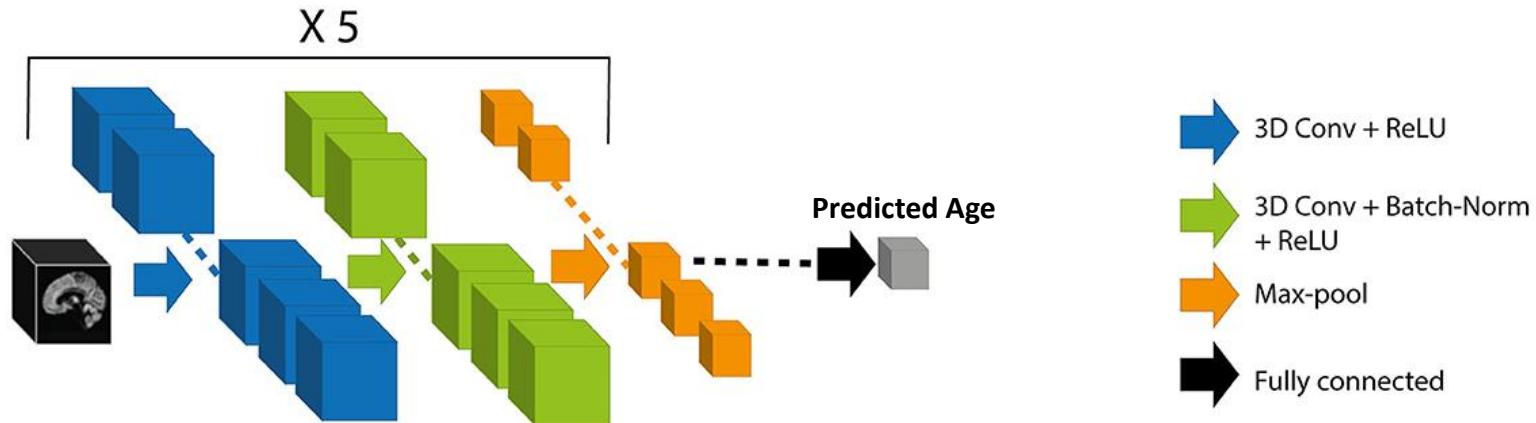
35 y ?

Chronological age = 43 y

BrainAGE = -8

# BrainAGE

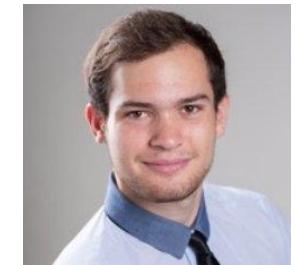
**Input = 3D T1 images**  
• Skull stripping  
• Bias field correction  
• Intensity normalization  
• Spatial normalization



## 3D convolutional neural network

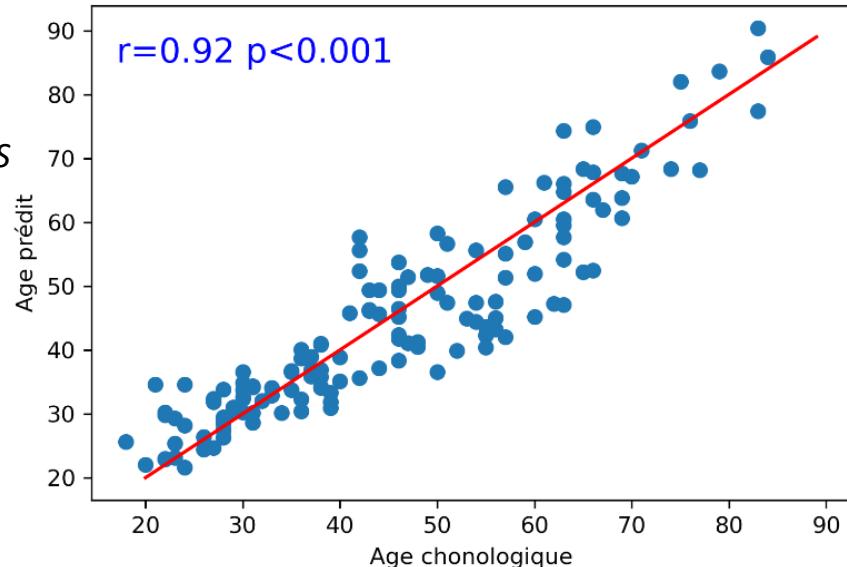
**Cost function:** Mean Absolute Error  
(predicted age – chronological age)

**Data augmentation:** rotation + translation

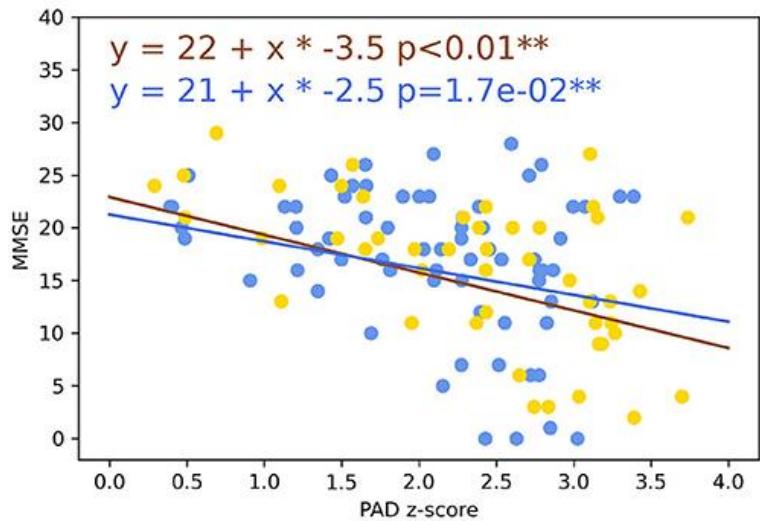


# BrainAGE

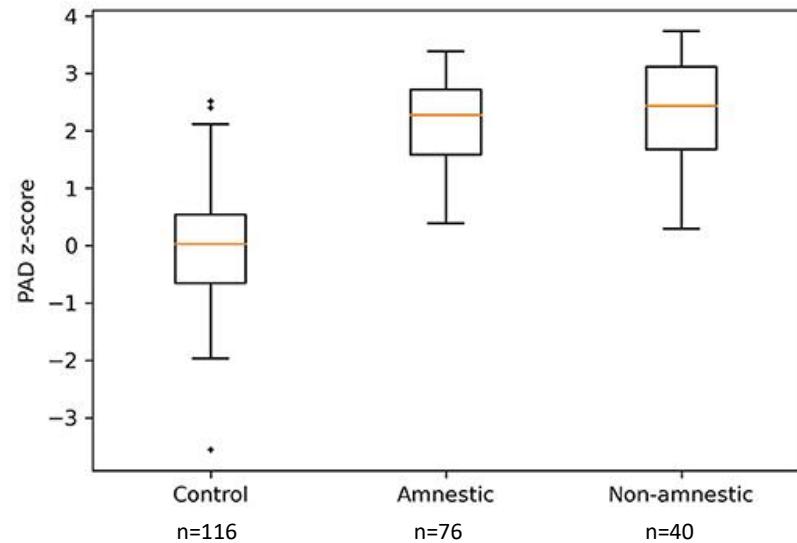
- Training on 2000 healthy subjects  
*open-source data bases: IXI, HCP, COBRE, MCIC, NmorphCH, NKIRS*
- Validation on 150 healthy subjects
- Mean absolute error = 4.5 y



# BrainAGE in Alzheimer's disease

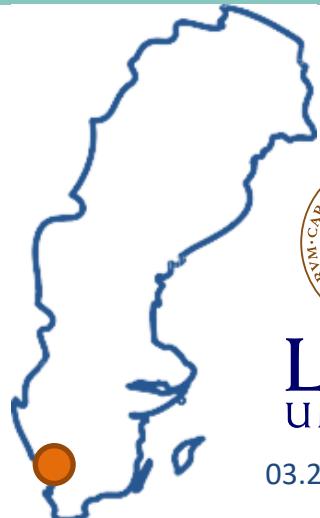


A marker of disease severity ...



... but not typicality

# BrainAGE in Lupus



LUND  
UNIVERSITY

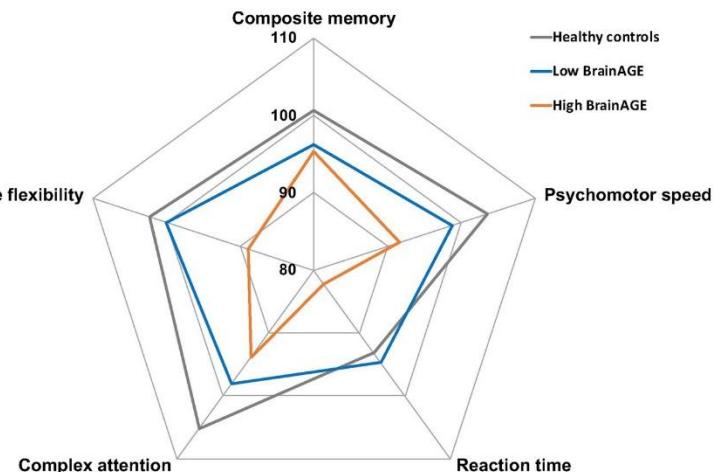
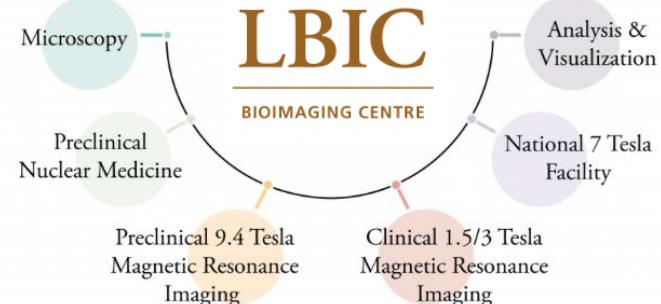
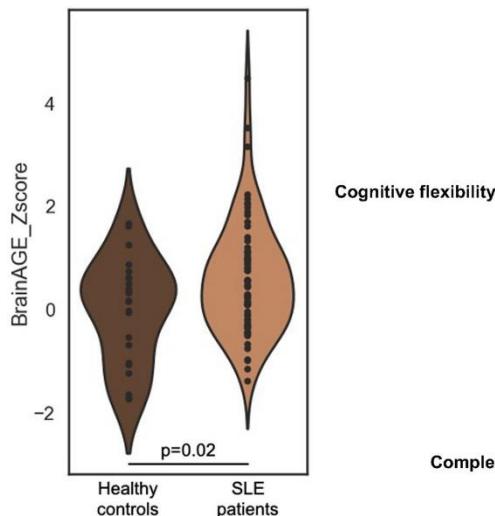
03.2022 – 06.2023



Karin Markenroth  
Bloch

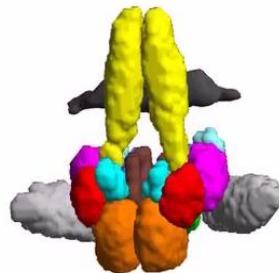
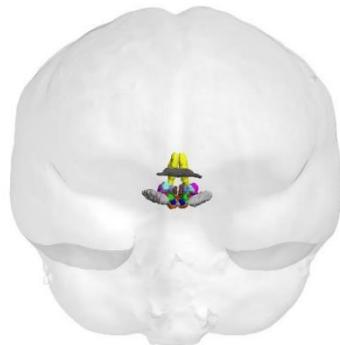


Prof. Pia Sundgren



# Atlas and segmentation of hypothalamus subnuclei

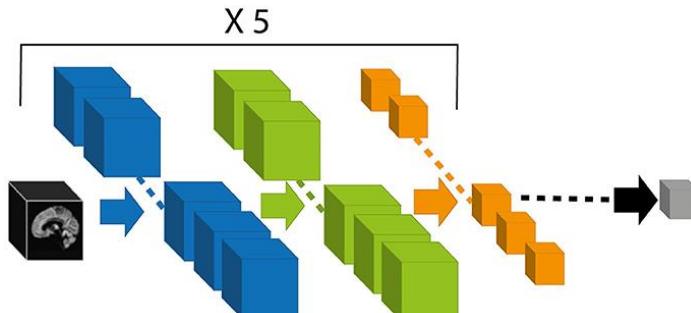
7T MRI



V. Prévot



C. Rahm



3D convolutional neural network

# Research perspectives

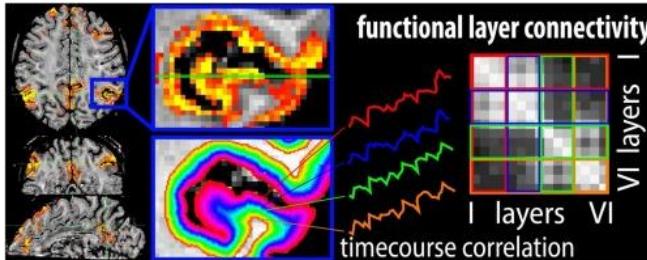


## 7T MRI acquisition

CPER 2021 – 2027 Arianes : 10.5 M€

PI: Prof. Pruvost

French State / Region Hauts-de-France /  
Lille University Hospital / Inserm / Univ. Lille

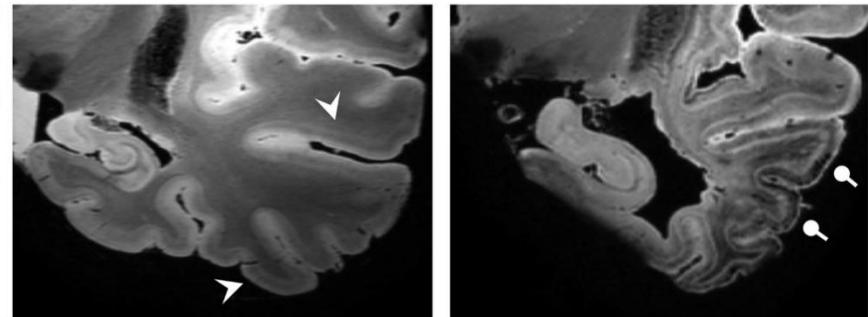


## Functional layer connectivity

Hubert et al. Process in Neurobiology 2021

## Iron sensitive techniques

Better spatial resolution + Increased susceptibility effect  
=> new imaging targets



Kenkhuis et al. NeuroImage Clinical 2019

## Hippocampus subfields and cortical layers in AD

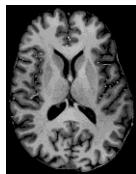
# Research perspectives



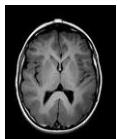
ARIANES PROJECT – [arianes.fr](http://arianes.fr)

## Research

Identification of new radiological  
and imaging markers



7T MRI



3T MRI



## Artificial Intelligence

Transfer the knowledge learned  
from 7T to resonate on 3T MRI

3T MRI      7T MRI      7T SYNTH

## Clinical

Application on a clinical network  
of 22 3T MRI

3T MRI network



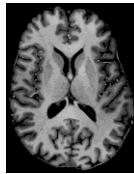
# Research perspectives



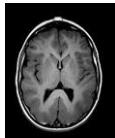
ARIANES PROJECT – [arianes.fr](http://arianes.fr)

## Research

Identification of new radiological  
and imaging markers



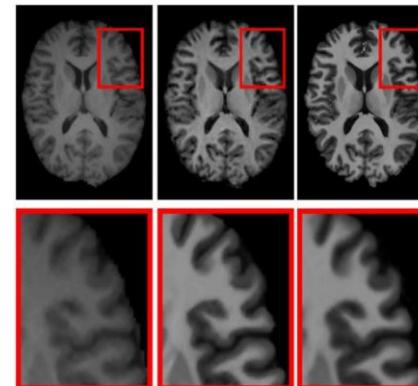
7T MRI



3T MRI



## Artificial Intelligence



## Clinical

Application on a clinical network  
of 22 3T MRI

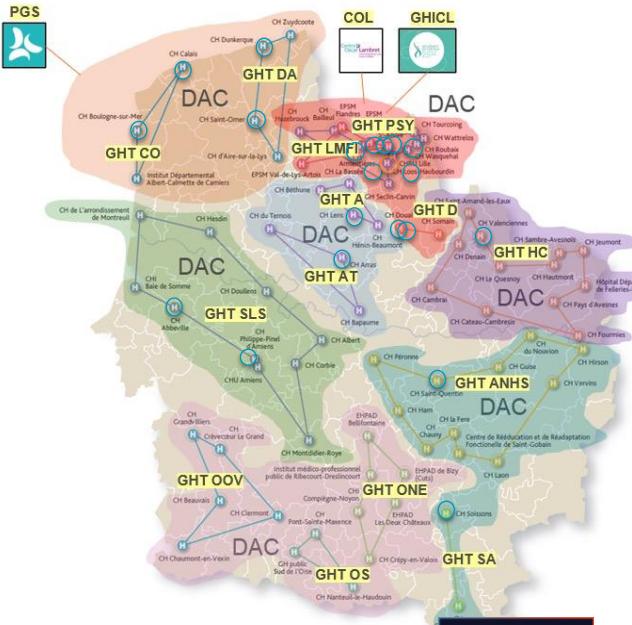
3T MRI network



# Research perspectives

## MRI regional network

ReactEU: 1 M€ / PI: Dr Lopes



Lille 7T MRI



Network of 3T MRIs

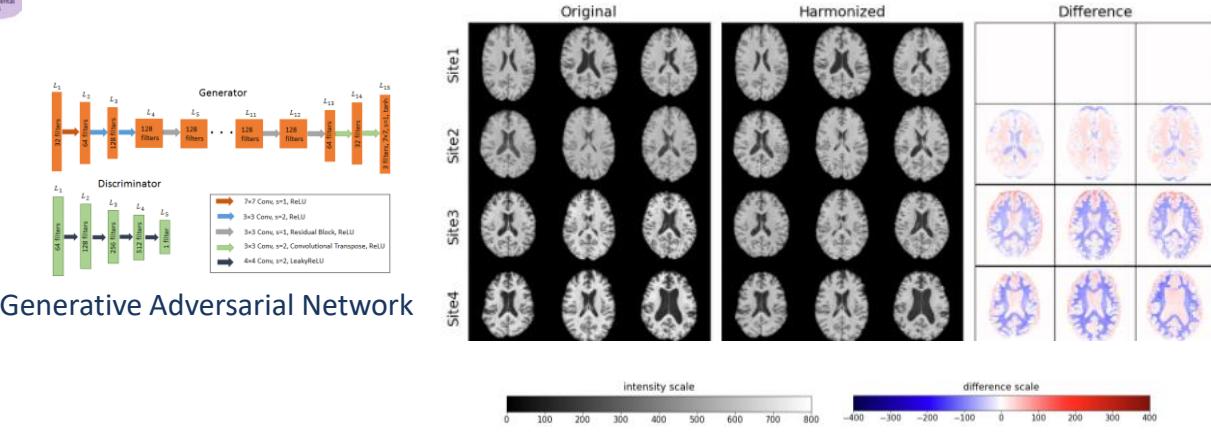


Roca et al. *Heliyon* 2023

## Enabling generalization of algorithms and biomarkers

- ✓ Large cohorts of patients
- ✓ « Real-life » settings
- ✓ Development of methods to correct for site-effects

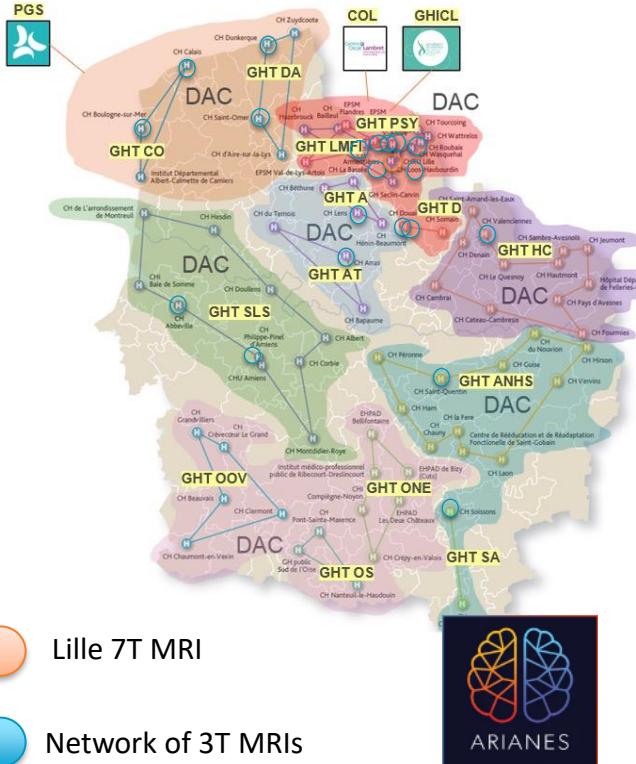
**PhD Vincent Roca**, « Deep Learning for inter-scanner harmonization in MRI »  
Supervisor: R. Lopes, Co-supervisor: G. Kuchcinski, Collaboration with Philips



# Research perspectives

## MRI regional network

ReactEU: 1 M€ / PI: Dr Lopes



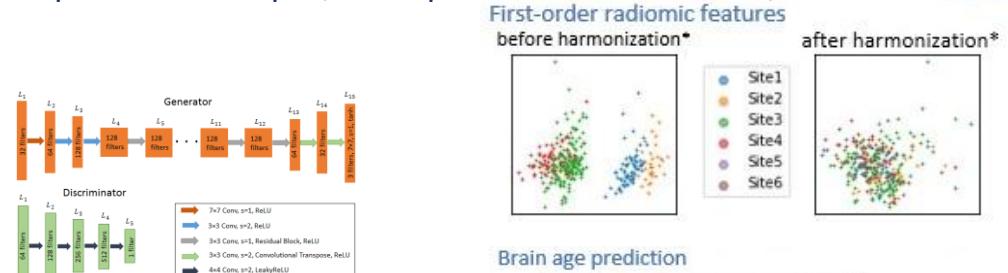
Lille 7T MRI

Network of 3T MRIs

## Enabling generalization of algorithms and biomarkers

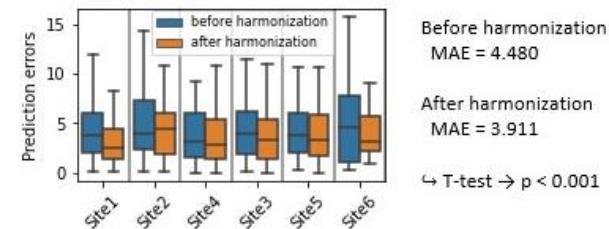
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Generative Adversarial Network

Brain age prediction

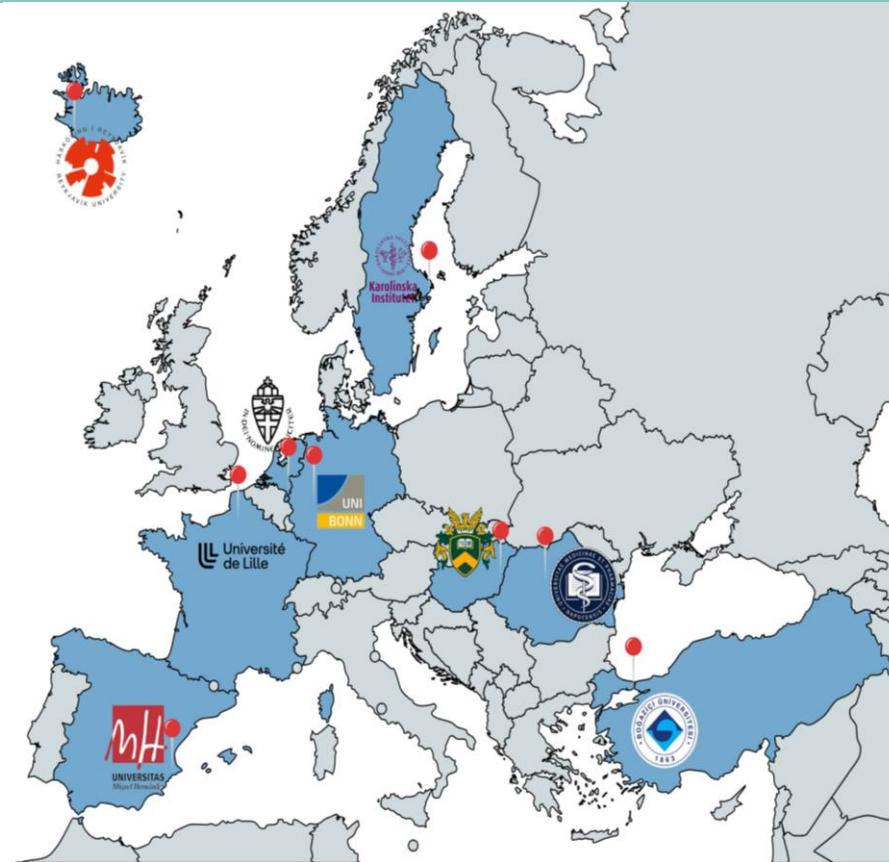


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