A large instrument for population neuroimaging

Jean-François Mangin

NeuroSpin

ICPerMed workshop, Siena, 2023

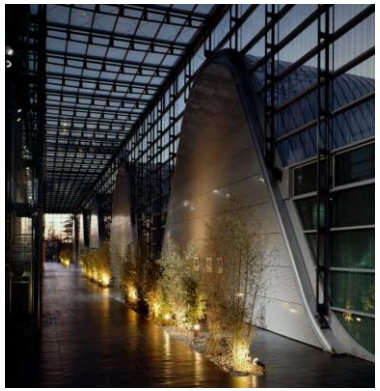
NeuroSpin

A research institute gathering the two dimensions of neuroimaging

cea université PARIS-SACLAY

Deep phenotyping

Push MRI technology to the limits



Clinical 11.7T
(World record)

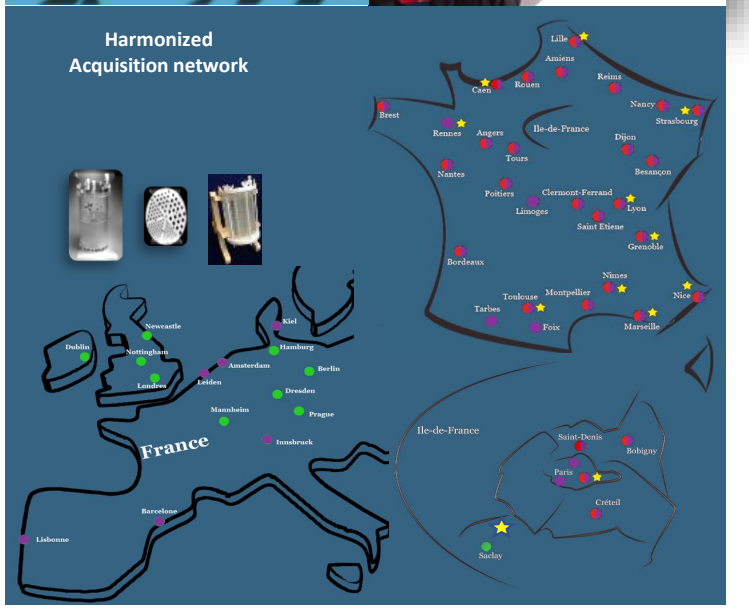
5000 acquisition
hours (C. Poupon)

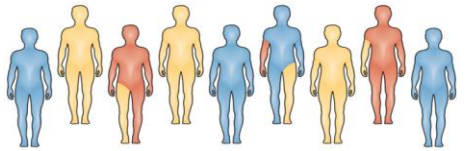
Wide phenotyping

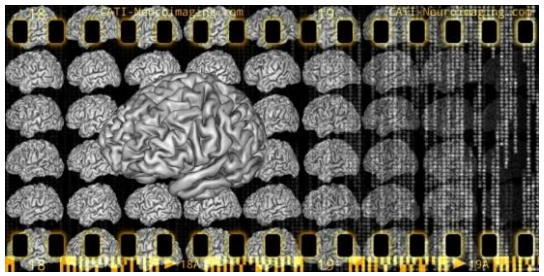
Push the size of the clinical research datasets

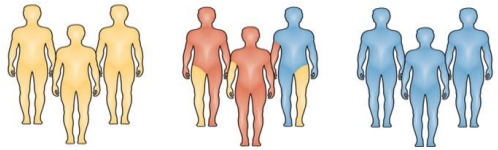
US 52 – UAR 2031

CATI







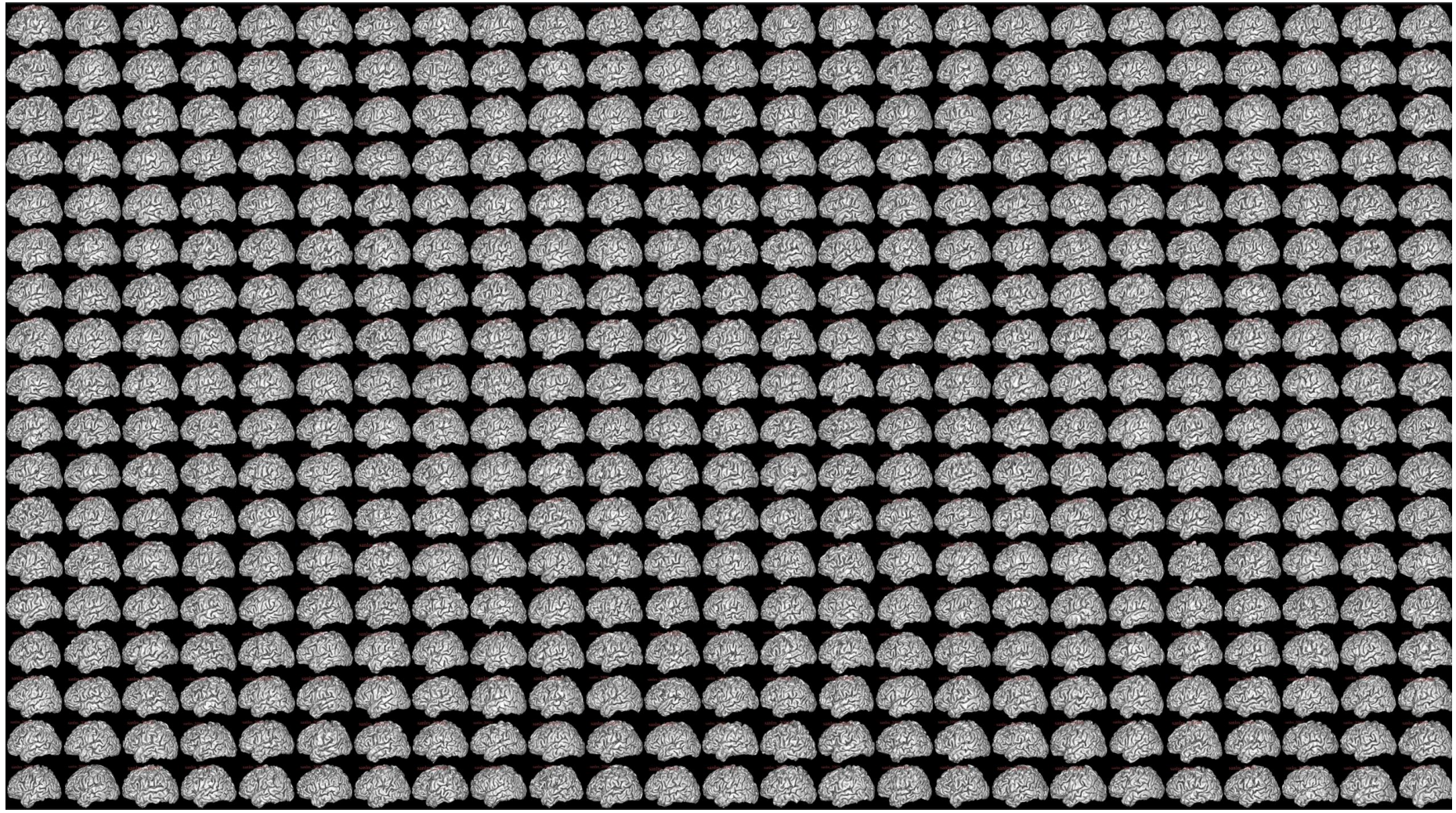


Neurospin is the nest of

scikits learn
machine learning in Python

Let's imagine a medical consultation of the future

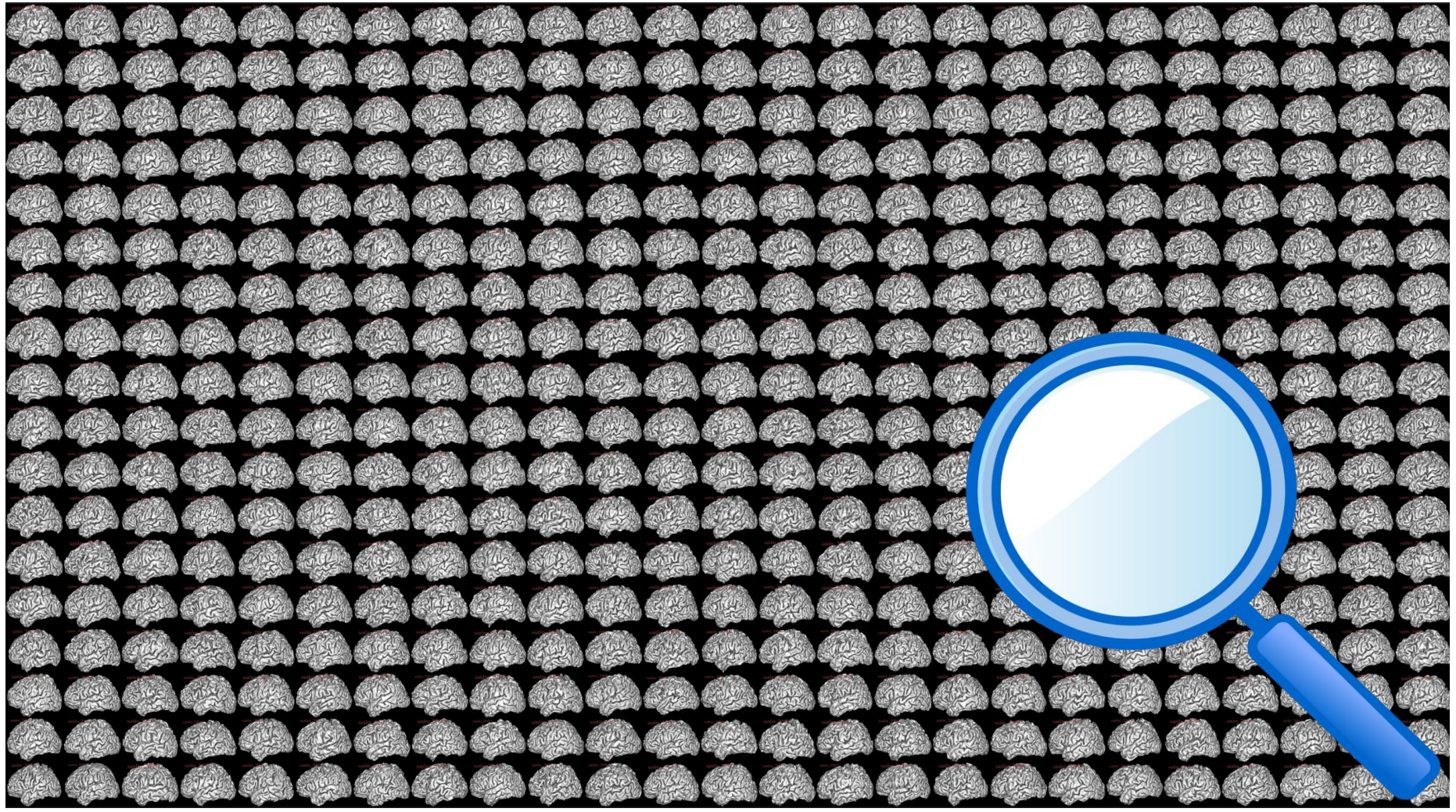
The doctor has access to an extensive library of medical records



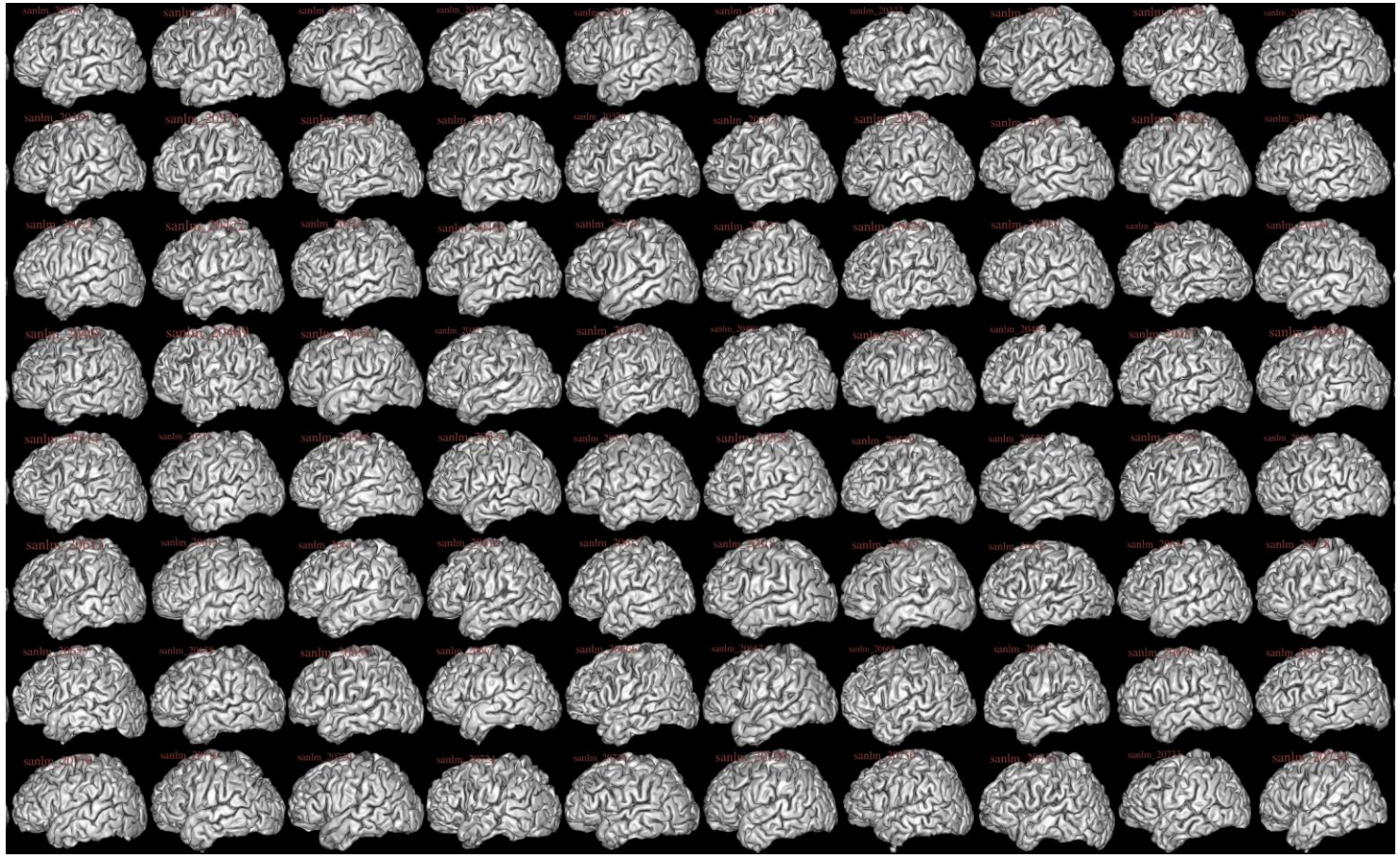
He looks for similar patients in the records of the past

The nearest neighbors strategy

New patient

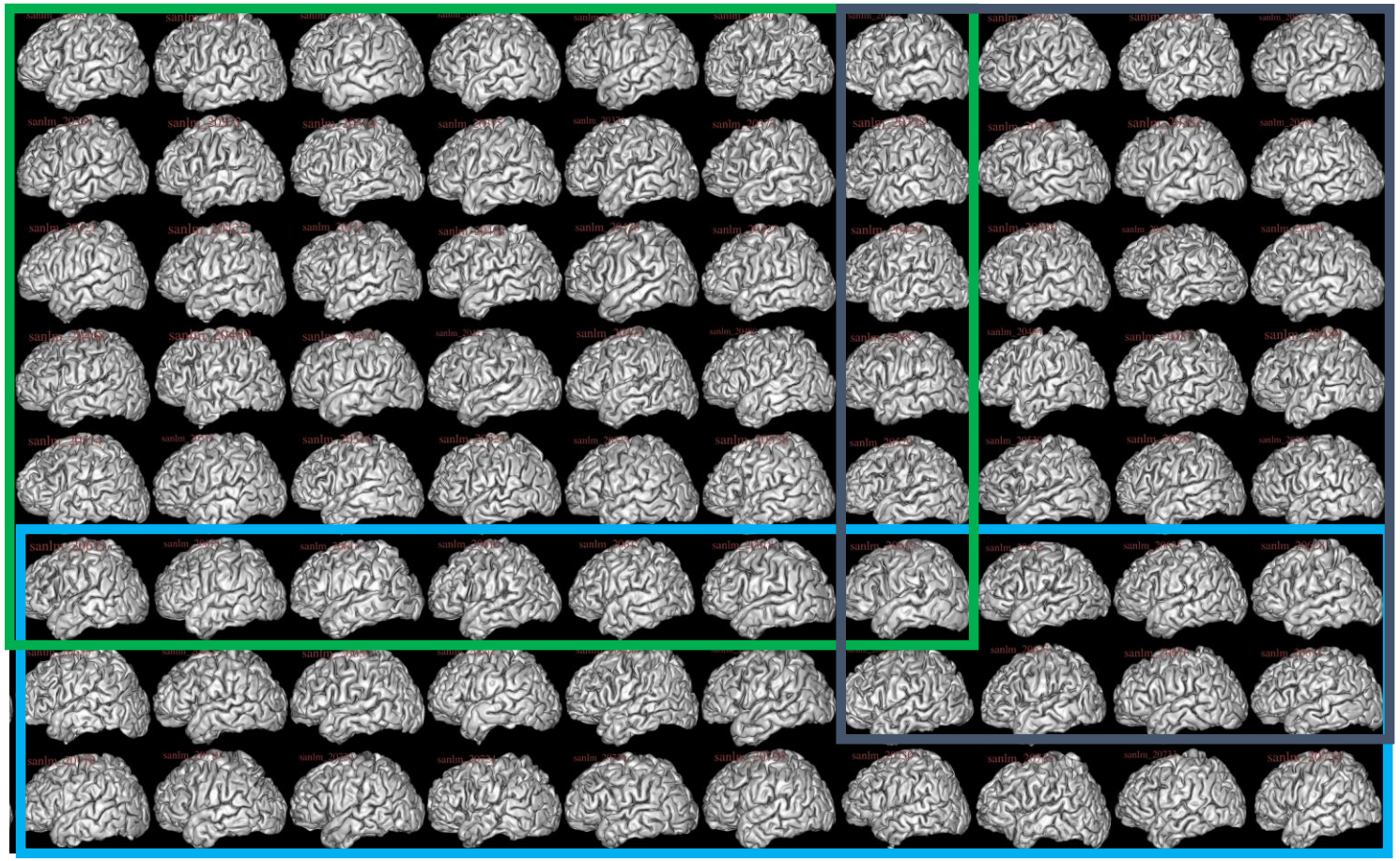


First request leads to a subset of similar patients



The doctor has access to the patient's care path

Therapy A



Therapy B

Therapy C

The doctor finally gets some support

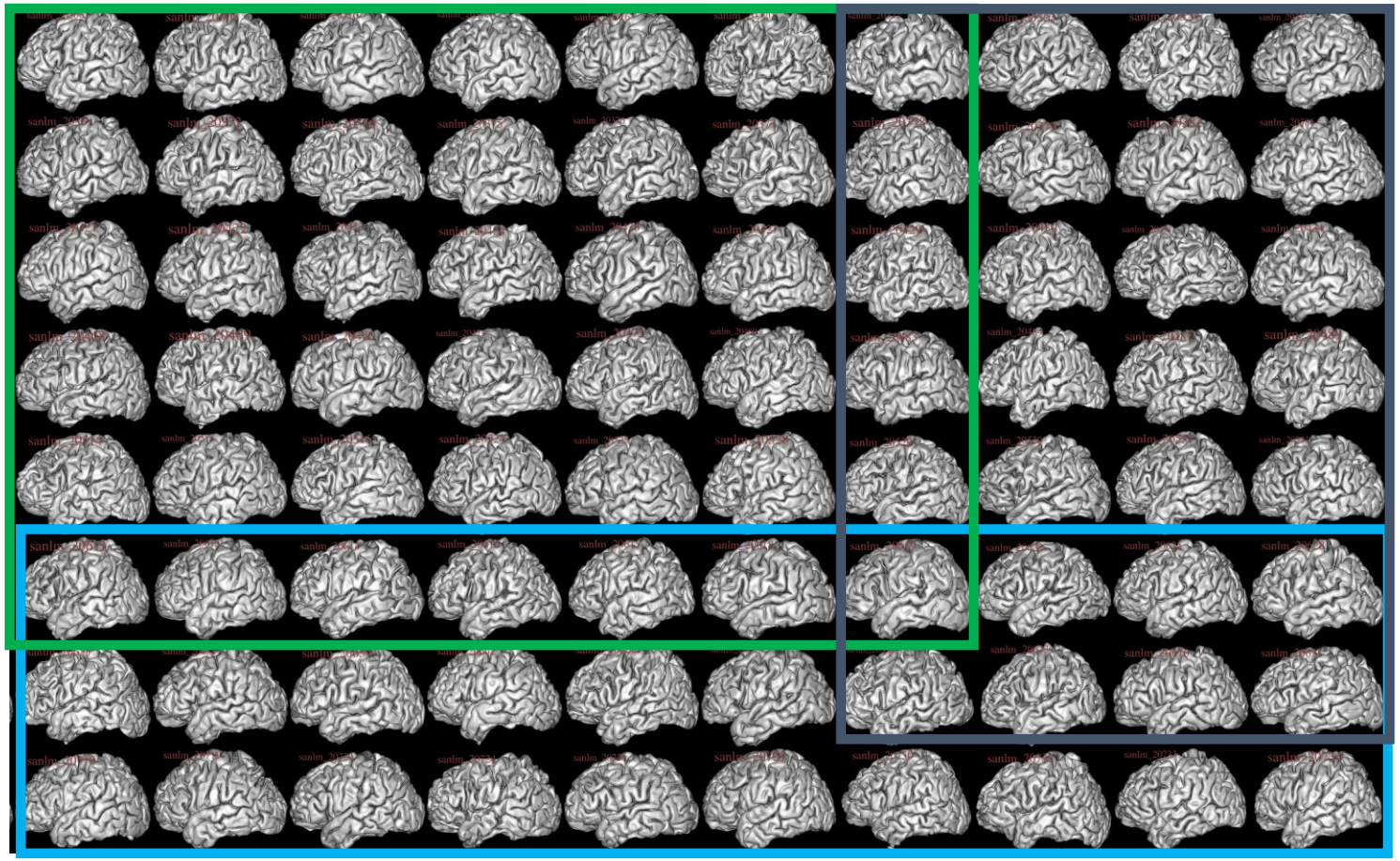
Therapy A

Decision support:

Therapy A is the most efficient

Outcome of therapy A can be predicted with a missing biomarker X

Ask for additional exam



Therapy B

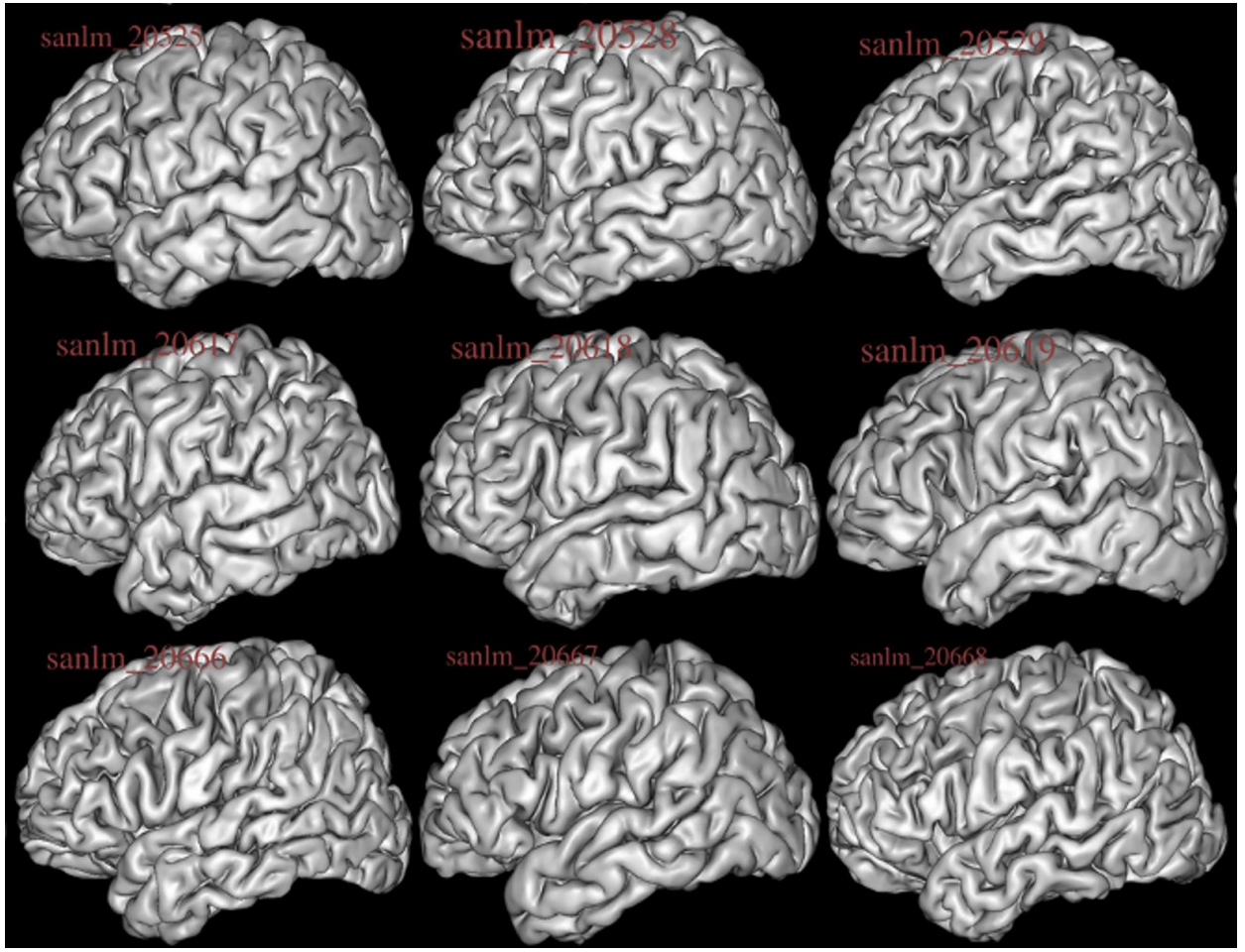
Therapy C

Nearest neighbors after complementary exams

Decision support

Chances of success

1. Therapy B
2. Therapy A
3. Therapy C



Which metrics?
Standardisation required

Which neighbors?
Stratification

A very large instrument for the neuroimaging of cohorts

Built in the context of a cohort dedicated
to the natural history of AD (2300 subjects)

MEMENTO

déterMinants et Évolution de la Maladie d'alzhEimer débutaNte et des déficiTs cOgnitifs

FONDATION PLAN ALZHEIMER

FONDATION DE COOPÉRATION SCIENTIFIQUE
POUR LA RECHERCHE SUR LA MALADIE D'ALZHEIMER
& LES MALADIES APPARENTÉES

Kick-off grant (2011-2015) : 9 millions € for 5 years

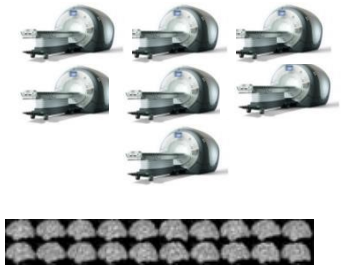
To make multicenter neuroimaging affordable

Now a pay for service business model

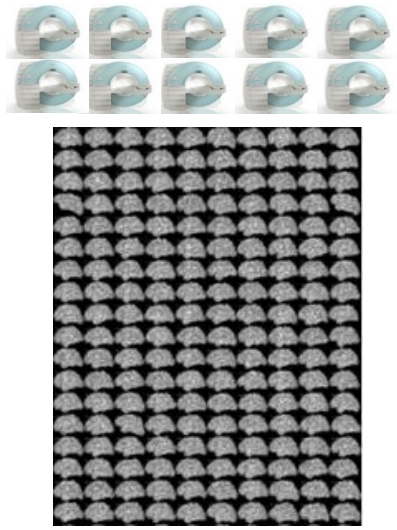
+40 funded projects supported: AD, Parkinson, ALS,
Bipolar disorder, Schizophrenia, prematurity, neuro-oncology, etc.

+10000 subjects already collected (15000 MRI, 5000 PET)

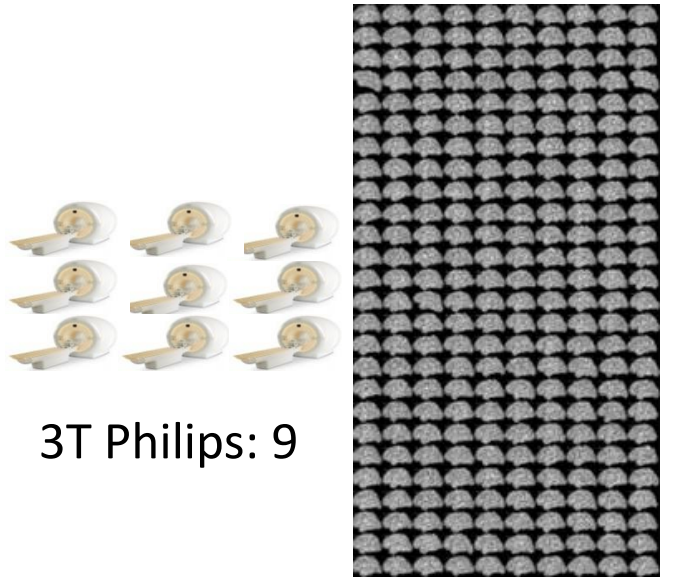
MRI network for MEMENTO cohort



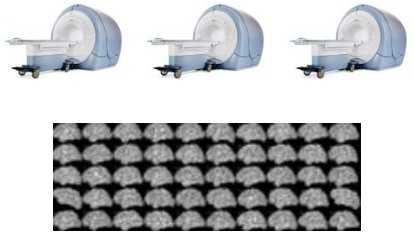
3T GE: 7



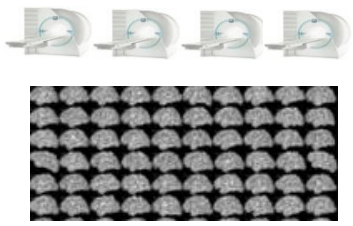
3T Siemens: 10



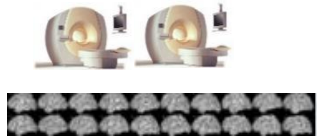
3T Philips: 9



1.5T GE: 3



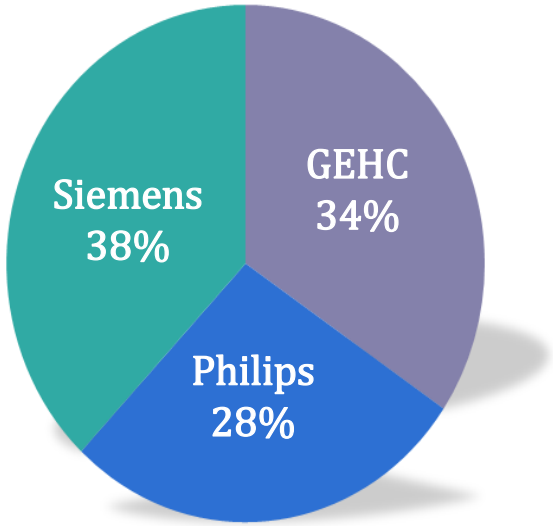
1.5T Siemens: 4



1.5T Philips: 2

PET network for MEMENTO cohort

29 MACHINES….



SIEMENS

Modèles	Année Installation	Nombre Sites
Biograph mCT	2012	3
Biograph mCT	2009	1
Biograph Hirez TruePoint	2008	1
Biograph 6 True V	2006	1
Biograph 6	2005	1
Biograph LSO DUO	2004	1
Biograph 16	2004	1
Biograph 6	2004	1
Biograph LSO DUO	2003	1

GE

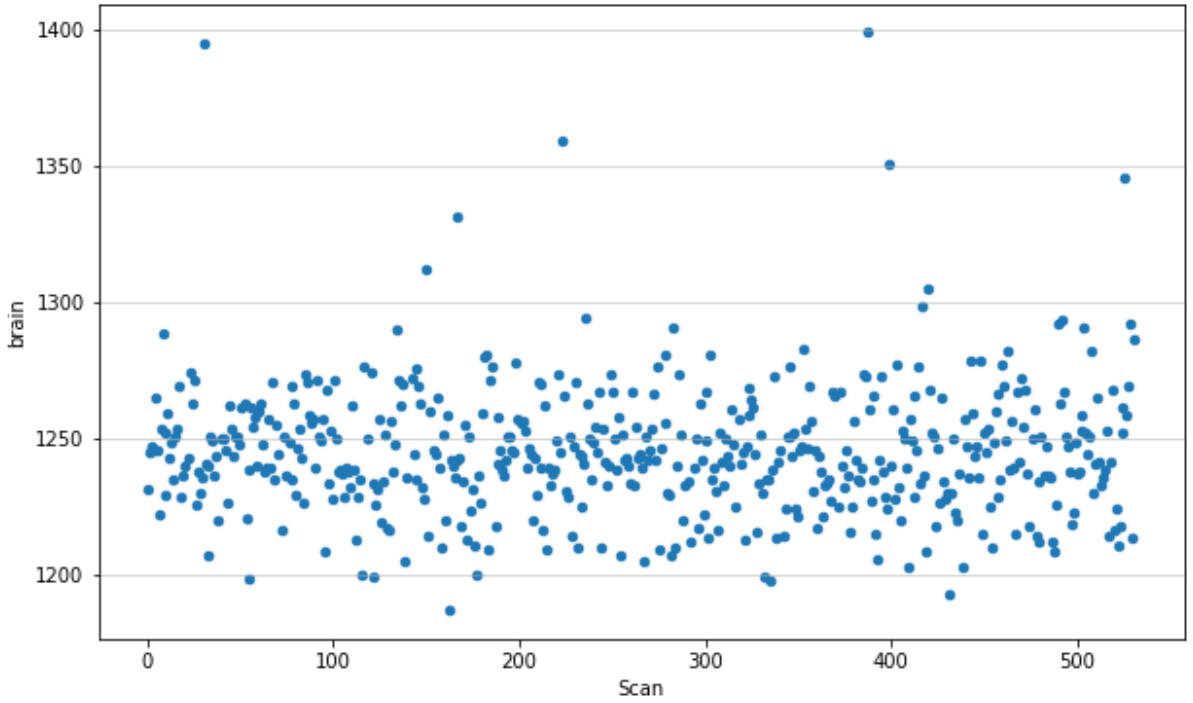
Modèles	Année Installation	Nombre Sites
Discovery 690	2011	1
Discovery 690	2010	1
Discovery 690	2009	1
Discovery RX	2009	2
Discovery VCT HD	2008	1
Discovery ST	2004	1
Discovery DST - E	2004	1
Discovery ST 4	2004	1
Discovery ST	2003	1

PHILIPS

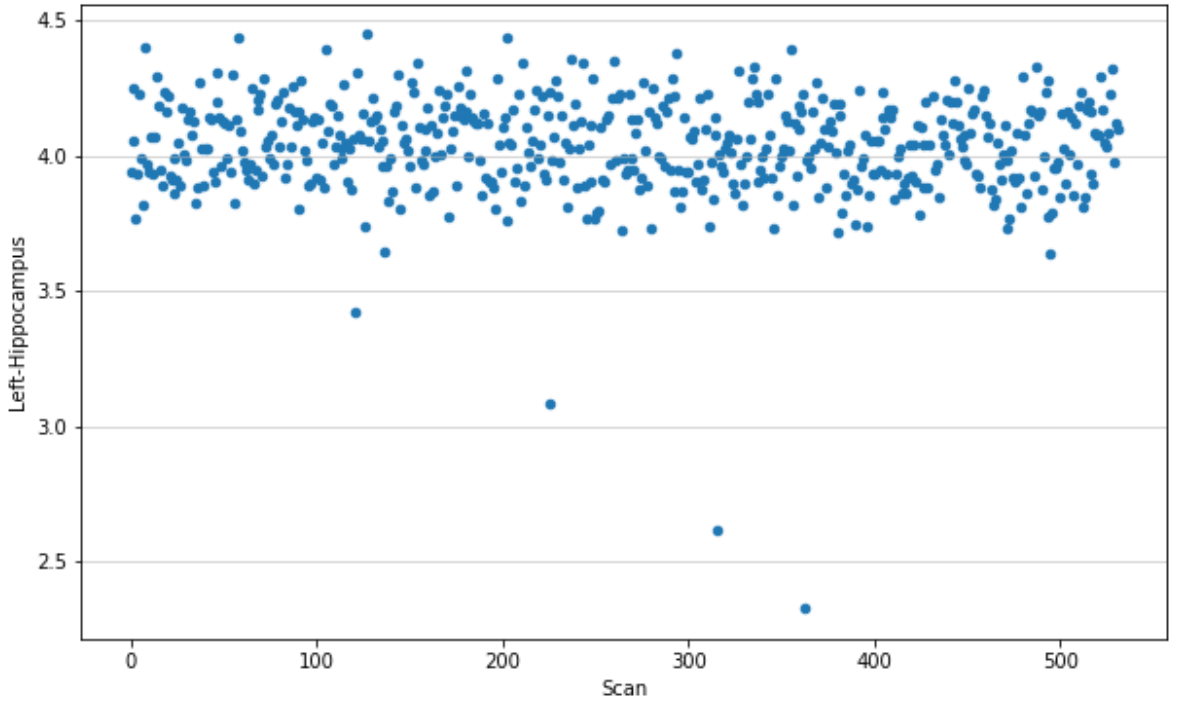
Modèles	Année Installation	Nombre Sites
Gemini TF	2010	1
Gemini TF	2008	1
Gemini GXL	2006	1
Gemini GXL	*2005*	*1*
Gemini Dual CT	*2004*	*1*
Gemini GXL	2003	1
Gemini Dual CT	2003	2

One subject, 100 machines, 500 acquisitions (1T to 3T)

Brain volume

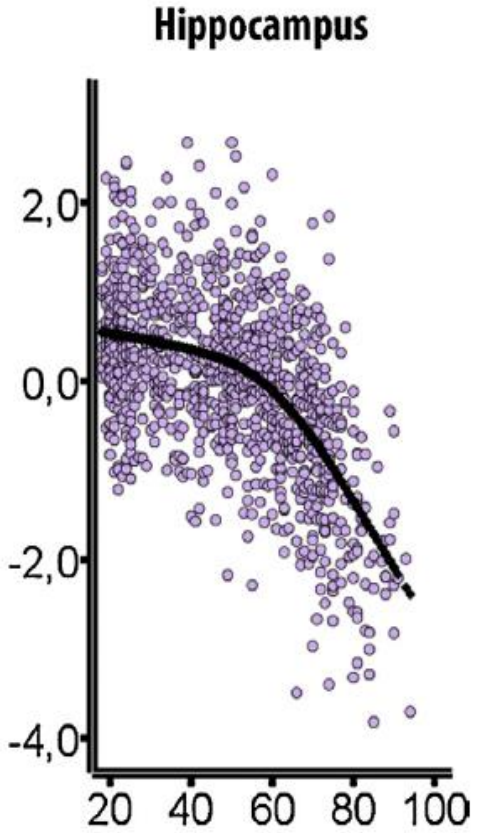


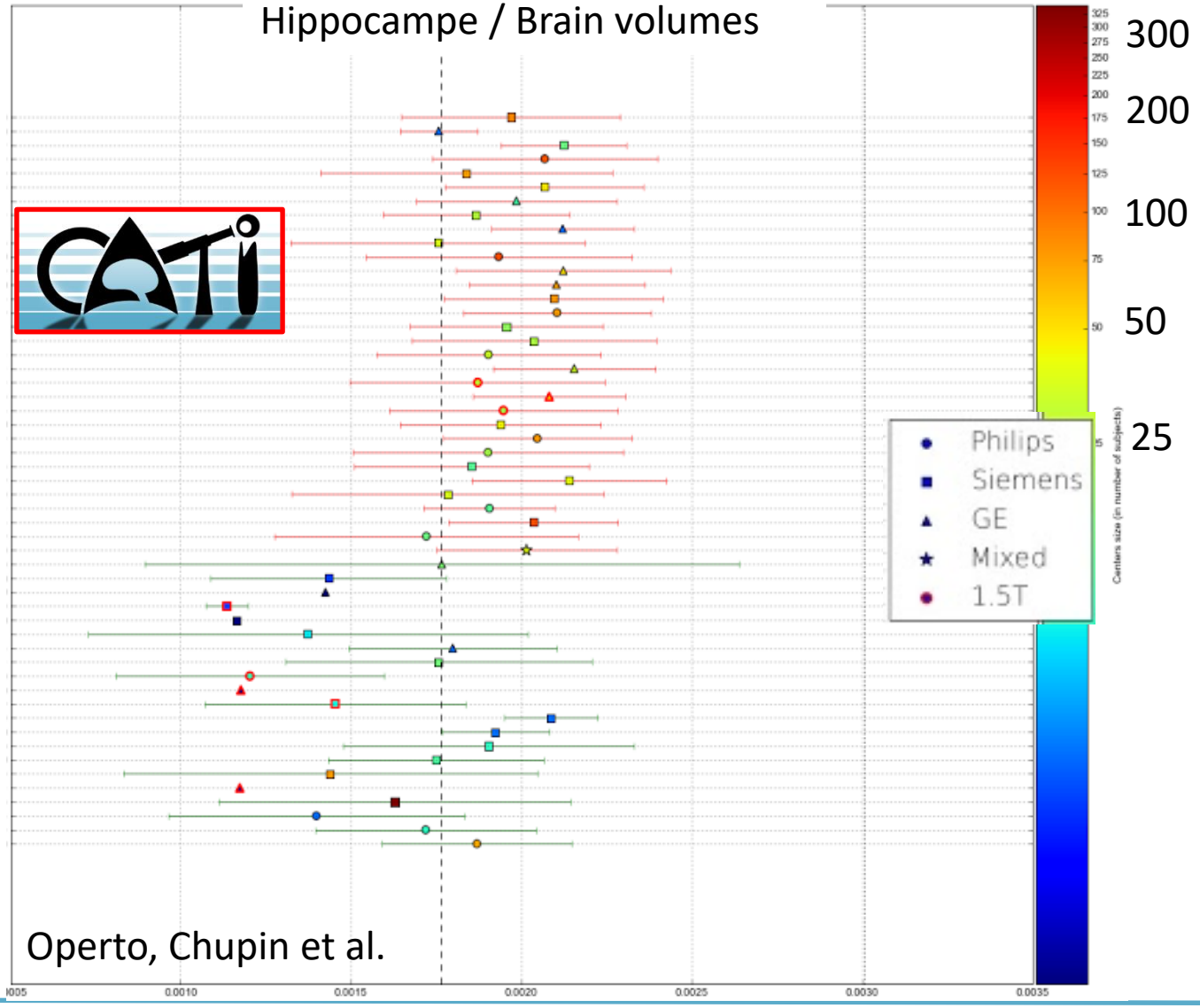
Hippocampus



A standardisation issue ?

A must for multicenter imaging: standardisation



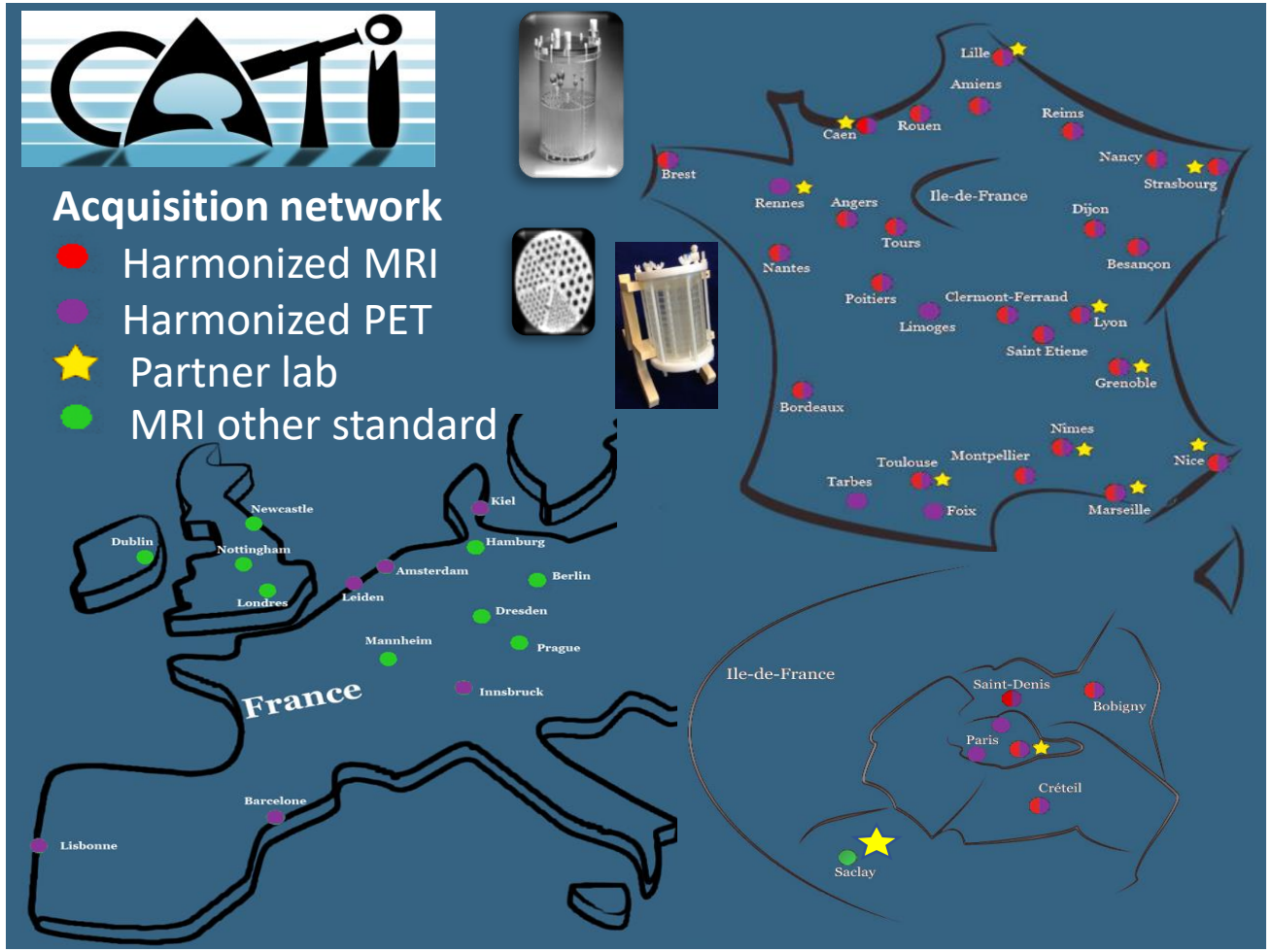


Early MCI subjects
CATI harmonisation

Alzheimer and MCI patients
Light harmonisation

A large instrument for population imaging (14 years old)

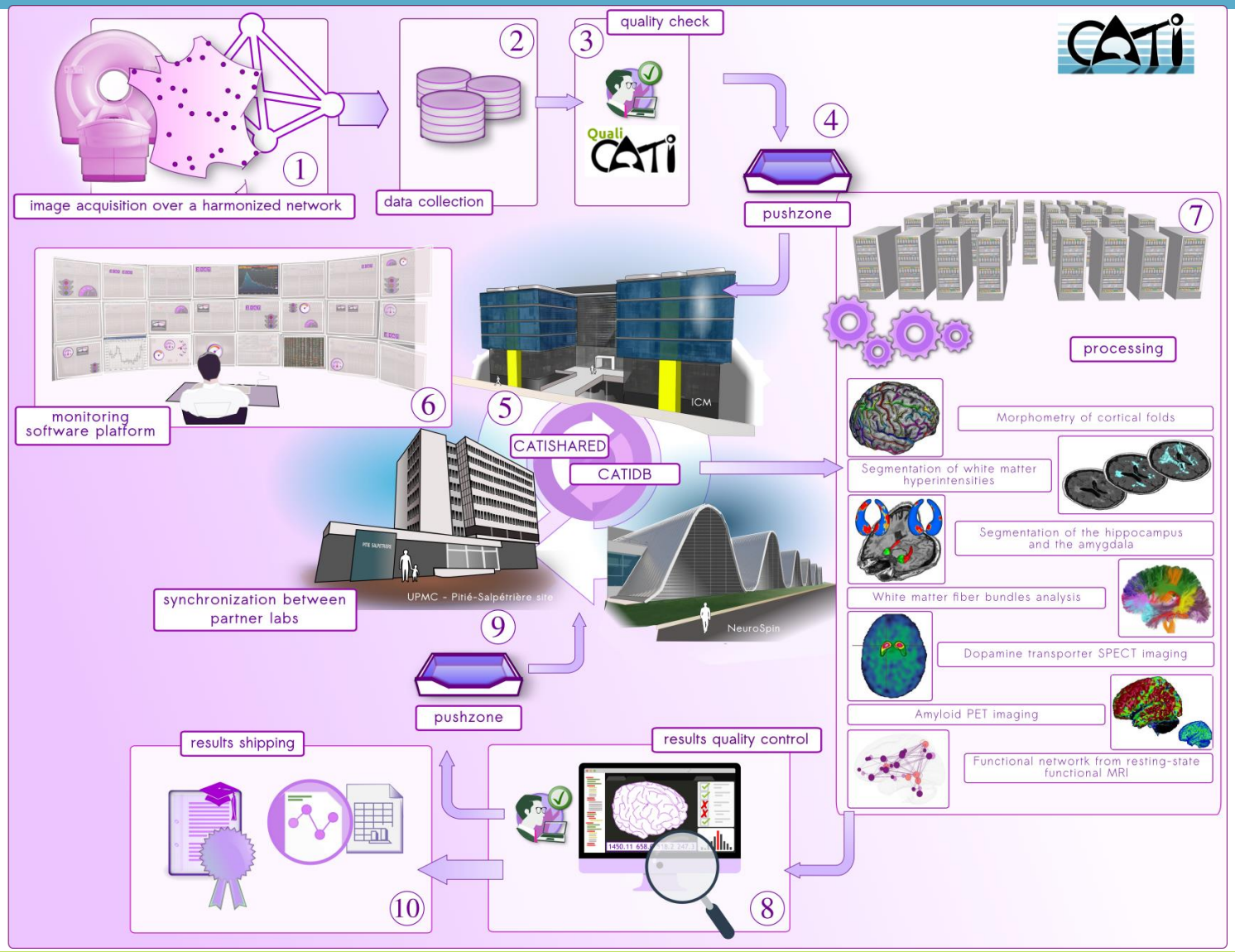
Support of more than 40 French and European clinical studies



A wide dataset to feed machine learning

Pathology	Study number	Subject number
Alzheimer's disease and related dementias	18	8000
Parkinson's disease and related dementia	6	2500
Huntington	3	200
Hypertension	1	800
ALS	1	1000
Psychiatry	5	3900
Aging	2	2400

Data acquisition and analysis, quality controls

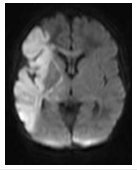


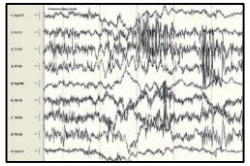
ENSEMBLE: a typical project supported by CATI

Predicting outcome in infants at risk of Cerebral Palsy

FONDATION PARALYSIE CÉRÉBRALE

8 clinical sites





GMA

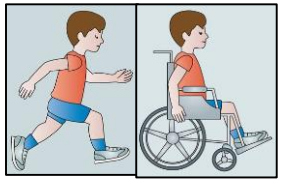
HINE

MRI

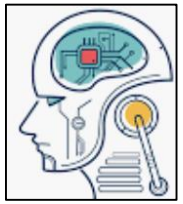
EEG

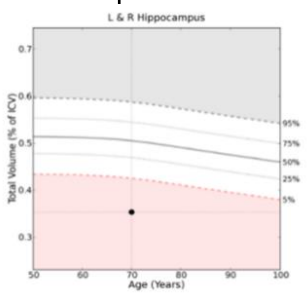
Standardisation

Machine Learning



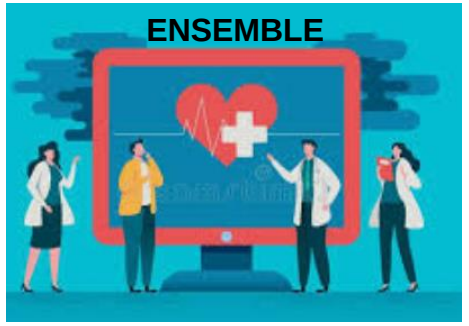
Prognosis





Automatic rating

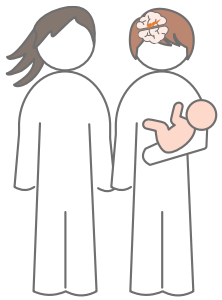
Deliverables



Web service

Open database

Family advisory council FAC



Harmonizing CATI's database with other datasets via algorithmic approaches

+ Setting standards in routine care

The data landscape (collected by CATI)

Size

100 000

10 000

1 000

Age

1

10

50

100

Adolescent Brain Cognitive Development®
Teen Brains. Today's Science. Brighter Future.

biobank uk

PPMI

French Minds

3C

MEMENTO

Imagen

ADNI

ABIDE

BABY a UNC / UMN collaboration Connectome Project

cVEDA

HUMAN Connectome PROJECT

1000BRAINS

ENSEMBLE

Mapt

Predistim

Baltazar

EU-AIMS Autism Research in Europe

Psycare

Insight

CogFrail

Pulse

RLink

Leopold

PrevDemAlz

ATRIL

MPIR2*

Clem

FAIR PARK

PredemPark

Stimz'O

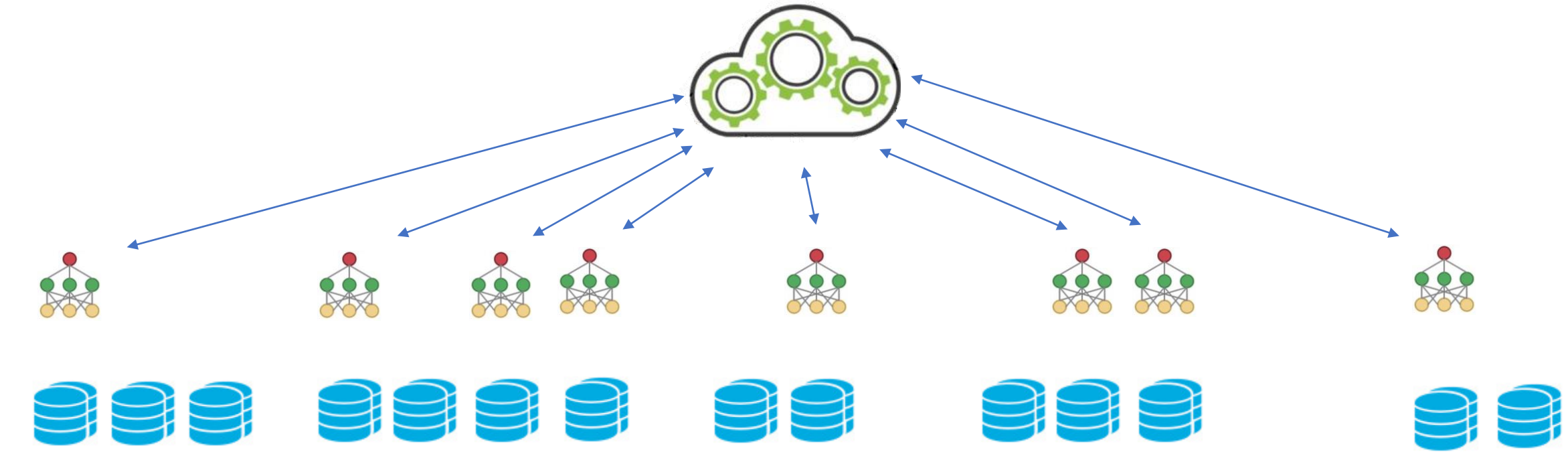
PredicPGRN

triHEP

CreamHD

revHD

Federated organization required (GDPR)



HEALTH DATA HUB

N4HCloud
Numerics for Health

France Cohortes
Données de recherche pour la santé publique

EBRAINS

Dementias Platform UK

CATI's French Ecosystem to be extended to health care system

Public organizations:

Trials

fcrin French Clinical Research Infrastructure Network

FORCEi

Imaging societies

SFMN Société Française de Médecine Nucléaire et Imagerie moléculaire

SFR Société Française de Radiologie

Research networks

REMI Réseau d'Intégration Multicentrique en IRM

FLI France Life Imaging

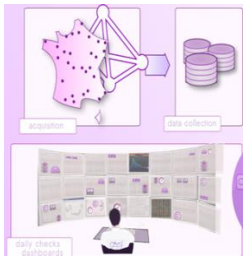
Public sphere:

Clinical research

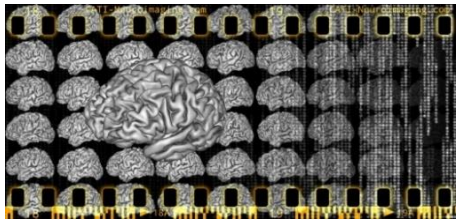
PredicPGRN PredictMA Mapt Comaj Capp
Biomage Imabio3 Imap Predistim PredemPark
MEMENTO
Baltazar Leopold Bipage
Fairpark Pulse Psymac

déterMinants et Évolution de la Maladie d'alzhEimer débutaNte et des déficiTs cOgnitifs

Public platform



CATI



Support PHRC, ANR, European project, etc.

National database, Big data, Biomarkers

Labs

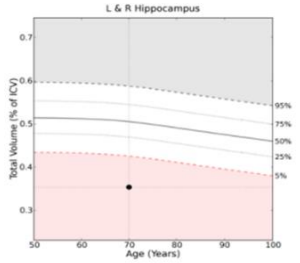
NeuroSpin
cea
Inria
ICM
Pitié-Salpêtrière
Inserm
cnrs
UPMC PARIS UNIVERSITAS

Private sphere (2 markets)

Licences Norms

Royalties

1) Diag / therapy Radiology (cloud)



Subcontracting

Innovative biomarkers

2) Clinical trials / CRO

Licences software

royalties

Certification

Qynapse

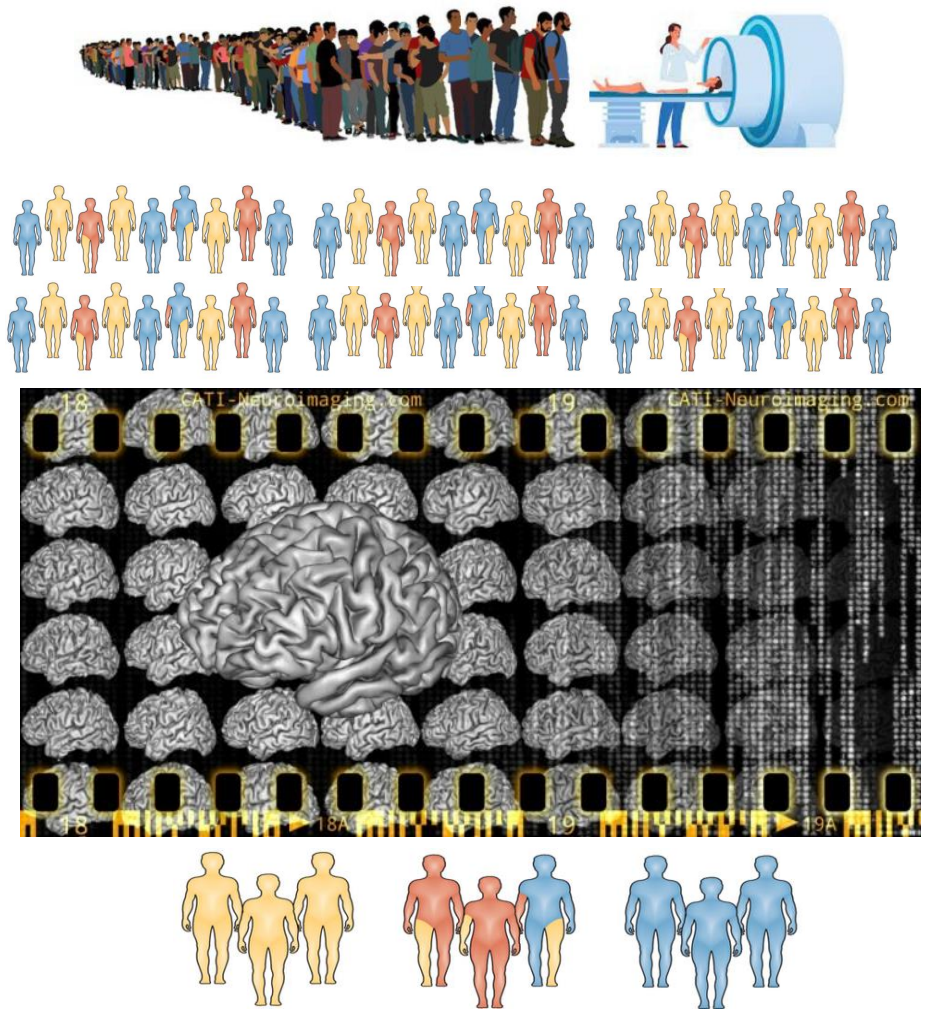
ventio

SORBONNE UNIVERSITÉ · cea · ICM · cnrs · Inserm · ASSISTANCE PUBLIQUE HÔPITAUX DE PARIS

Alzheimer PLAN 2008 › 2012 L'ENGAGEMENT DE TOUS

PLAN MALADIES NEURO-DÉGÉNÉRATIVES 2014 | 2019

The vision for the future



- **Push acquisition standard to routine care** compatible with normative scales and ML-based predictors from research, dedicated web service

- **Reinject routine care data into the research circuit to refine stratification, correct sampling bias in the research population, monitor sensor evolution, etc.**