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Human Brain Project

https://www.humanbrainproject.eu

Uniting Neuroscience and revolutionary Computing strengths to understand what makes us human and tackle brain diseases

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Uniting Neuroscience and revolutionary Computing strengths to understand what makes us human and tackle brain diseases

Index

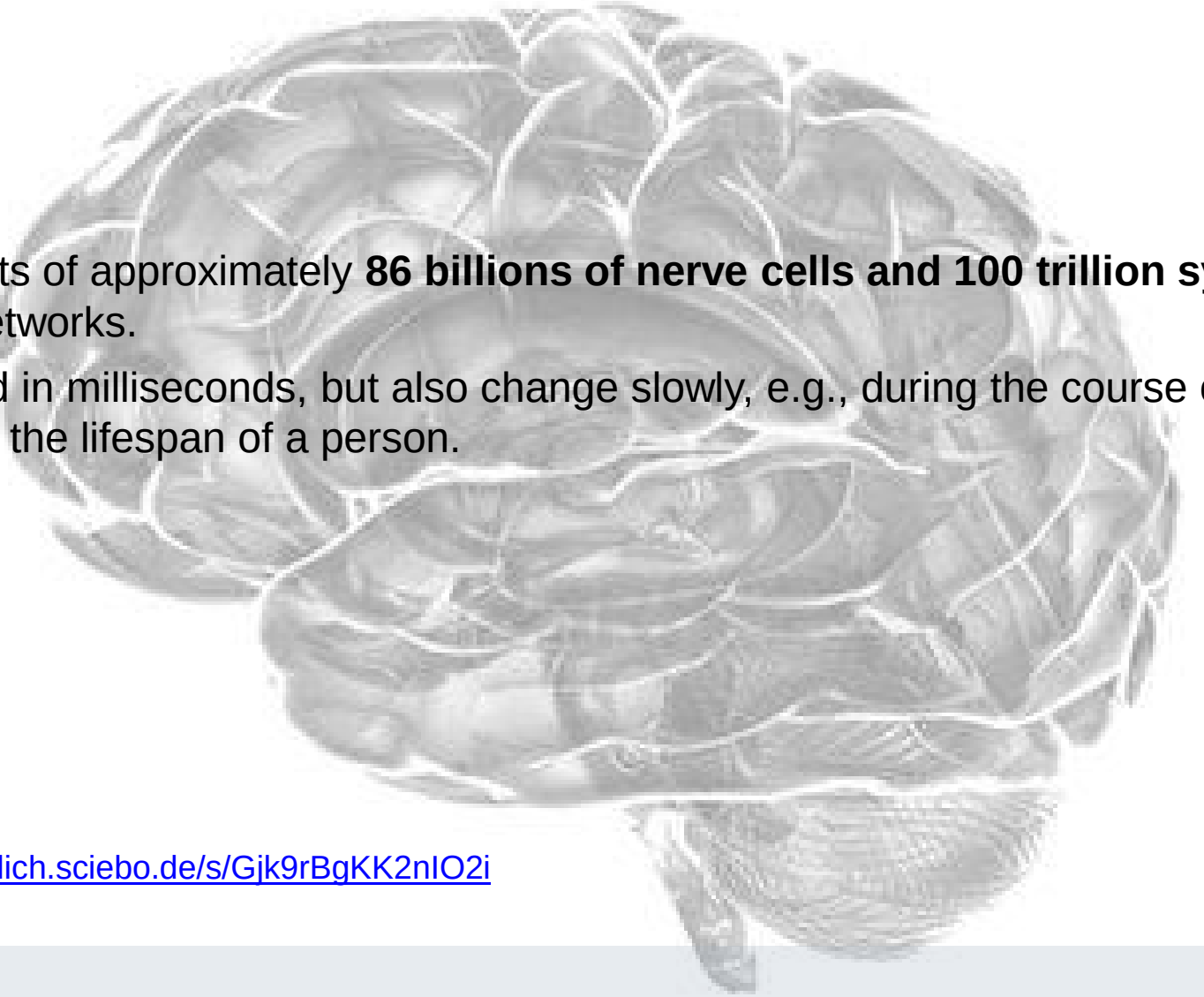
- **Introduction**
- **Project structure**
- **Towards a Research infrastructure**
- **Innovation in HBP**

Introduction

An intractable scientific enigma

Understanding the human brain is one of the greatest challenges facing 21st century science.
If we can rise to it, we can gain profound insights into **what makes us human**, build revolutionary **computing technologies** and develop new treatments for **brain disorders**.
Today, for the first time, modern ICT has brought these goals within reach.

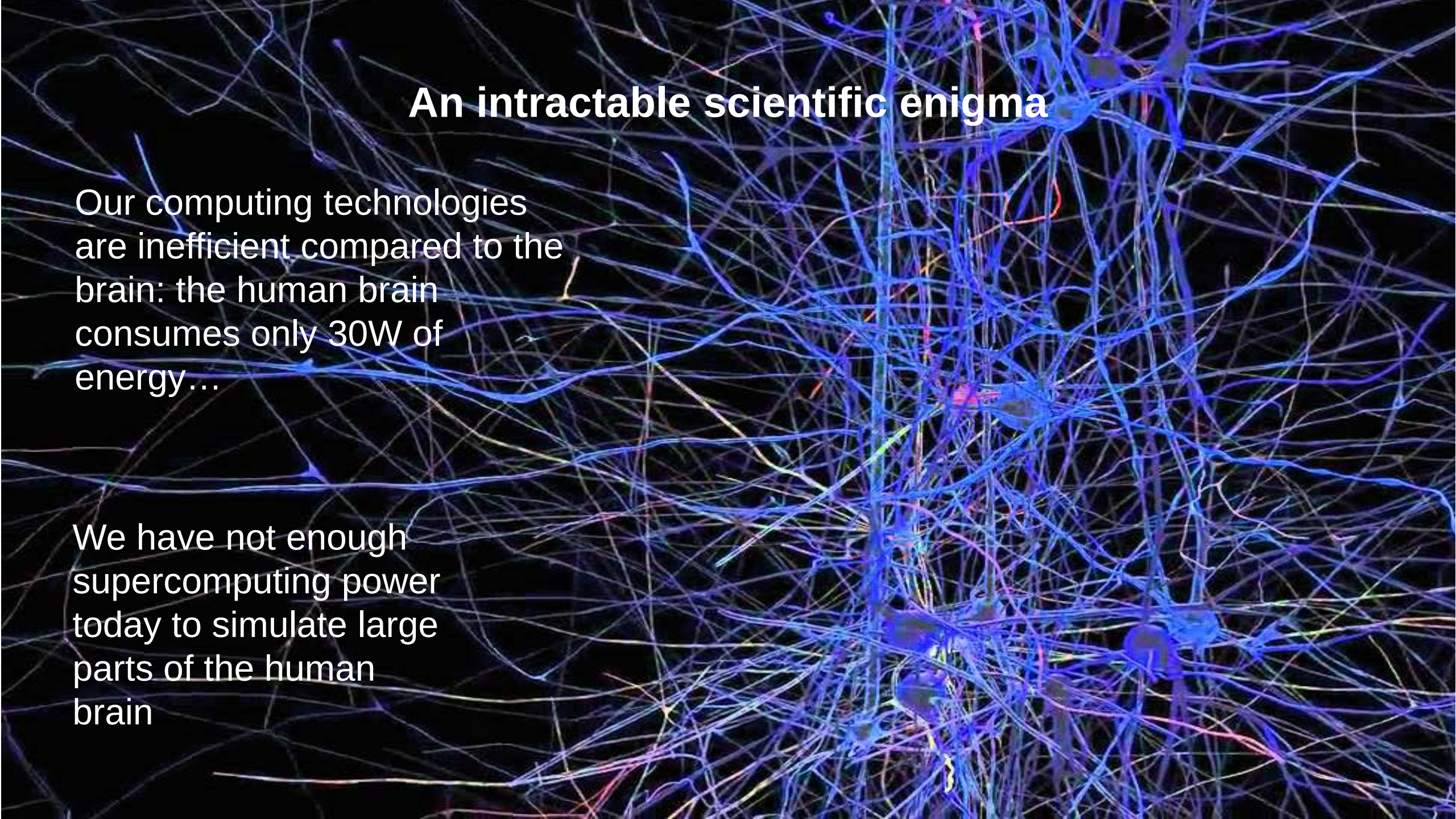
An intractable scientific enigma



The human brain consists of approximately **86 billions of nerve cells and 100 trillion synapses** that form local and global brain networks.

These networks respond in milliseconds, but also change slowly, e.g., during the course of a day, and over the months and years in the lifespan of a person.

https://fz-juelich.sciebo.de/s/Gjk9rBgKK2nIO2i



An intractable scientific enigma

Our computing technologies are inefficient compared to the brain: the human brain consumes only 30W of energy…

We have not enough supercomputing power today to simulate large parts of the human brain

An intractable scientific enigma

The Human Brain Project (HBP) is a major European scientific research initiative to improve our understanding of the brain and the role it plays in making us human, and to exploit the opportunities offered by the resulting knowledge.

An intractable scientific enigma

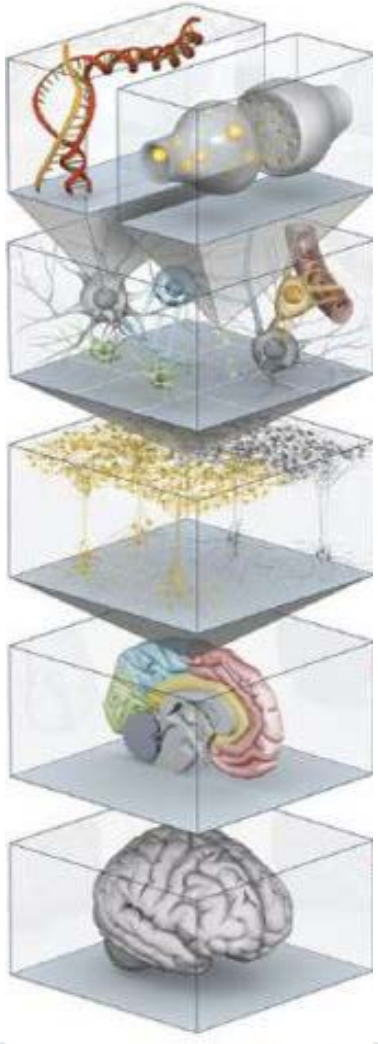
The HBP is one of several brain research initiatives and projects around the world, but it is unique in a number of ways.

Only the HBP has an explicit focus on both **neuroscience** and **computing**. It is also the broadest and most integrated brain initiative, and the only one aiming to build a research infrastructure to accelerate brain research.

An intractable scientific enigma

Understanding the **multilevel organization of the brain** requires bridging the **different scales in time and space**

This challenge is so extraordinary that not the even best-funded single research project could claim to provide the full picture



Molecular level

Cellular level

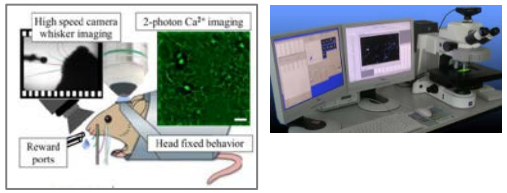
Circuits level

Regions level

Whole organ

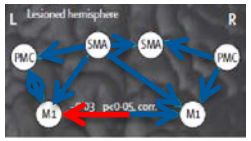
How to manage and process large volume of data at different levels?

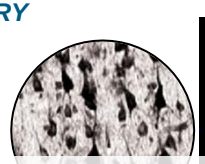
The Human Brain at Multiple Levels

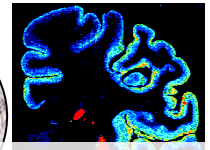


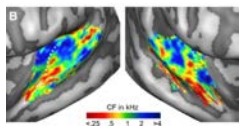
NEUROSCIENCE
EXPERIMENT & THEORY

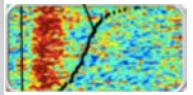
ETHICS & SOCIETY



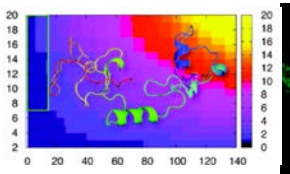


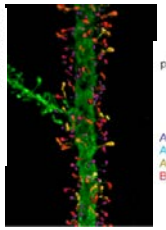


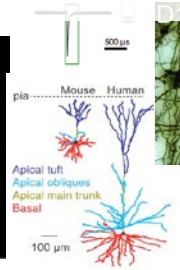


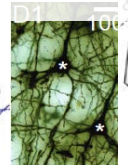


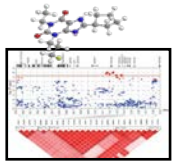
How to get access to multi-level brain organization?



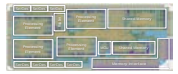








Multiscale in space and time, multimodal

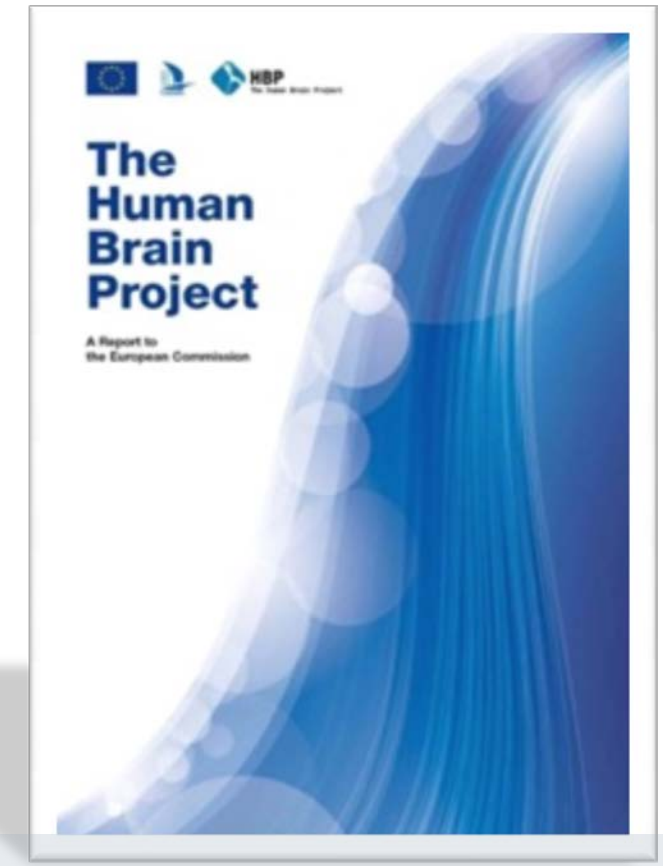


RESEARCH INFRASTRUCTURE
DATA ANALYTICS & SIMULATION

The origins of HBP: a FET- Flagship

Future and Emerging Technologies

- In 2009, the EU ICT Advisory Group recommended that the EC implement a new funding scheme to make Europe a major player in **BIG, HIGH-RISK, FOCUSED RESEARCH PROJECTS IN ICT**
- As the result of a competitive call for proposals, **23 proposals were submitted in December 2010**.
- In March 2011, **six candidates were selected for a pilot phase** for writing a full proposal – and two were finally selected in January 2013.
- **Submitted Proposals**:
  1) FuturICT – Knowledge Accelerator and Crisis-Relief System
  2) **Graphene Science and technology for ICT and beyond**
  3) Guardian Angels for a Smarter Planet
  4) **The Human Brain Project**
  5) ITFoM: The IT Future of Medicine
  6) RoboCom: Robot Companions for Citizens
- HBP started on **1 October 2013.**



https://www.humanbrainproject.eu/documents/10180/17648/TheHBPReport_LR.pdf

The origins of HBP: a FET- Flagship

After a long selection process the EC selected in 2013 two large Flagship projects

Graphene project

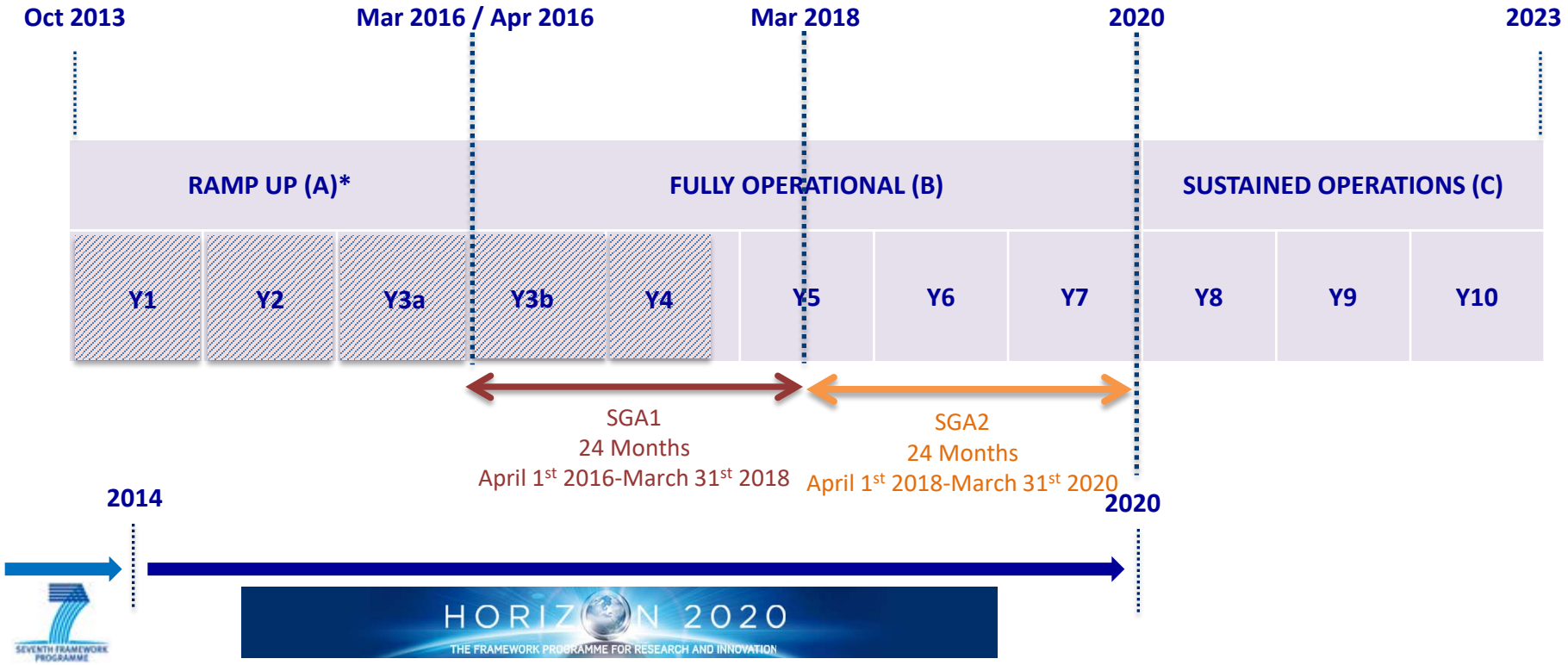
Human Brain Project (HBP)

Goal: ~ €100 million / year (EC + MS)
during a long period of time (~10 years)

The origins of HBP: a FET- Flagship

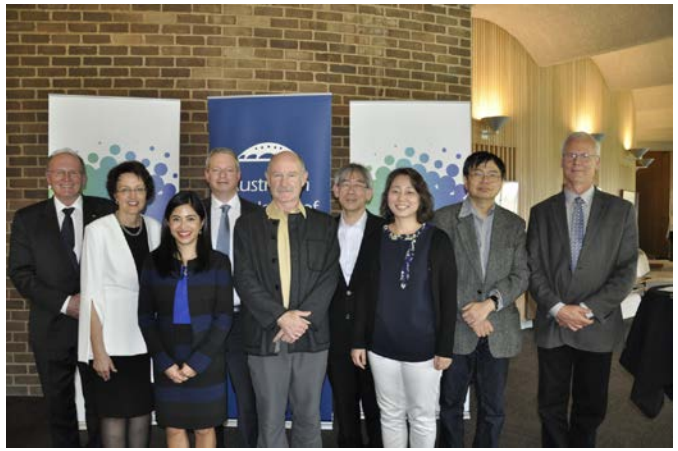
- **Bigger**: 116 Partners (typical EU project 5-10 Partners)
- **Richer**: €45 million/year (typical EU project €1-10 million/year)
- **Longer**: 10 years (typical EU project 1-2 years)
- **More complex**: 12 Subprojects (each size of typical EU project)
- **Broader**: computer science, neuroscience, medicine & many more
- **Well-justified**: progress review each year, new contract every 2 years

HBP phases


Oct 2013
Mar 2016 / Apr 2016
Mar 2018
2020
2023
RAMP UP (A)*
FULLY OPERATIONAL (B)
SUSTAINED OPERATIONS (C)
Y1
Y2
Y3a
Y3b
Y4
Y5
Y6
Y7
Y8
Y9
Y10
SGA1
24 Months
April 1st 2016-March 31st 2018
SGA2
24 Months
April 1st 2018-March 31st 2020
2014
2020
SEVENTH FRAMEWORK PROGRAMME
HORIZON 2020
THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

Other Brain research initiatives

- International Brain Initiative IBI
- Jointly announced in Dec 2017 by five large-scale national brain research projects in the “Canberra Declaration“
- The initial members are:
  Australian Brain Alliance
  Brain/MINDS project Japan
  Korea Brain Initiative
  Human Brain Project (EU)
  BRAIN Initiative (USA)



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Project structure

HBP at a glance

856 full-time research and staff positions

Over 700 scientific publications

31% positions filled by women

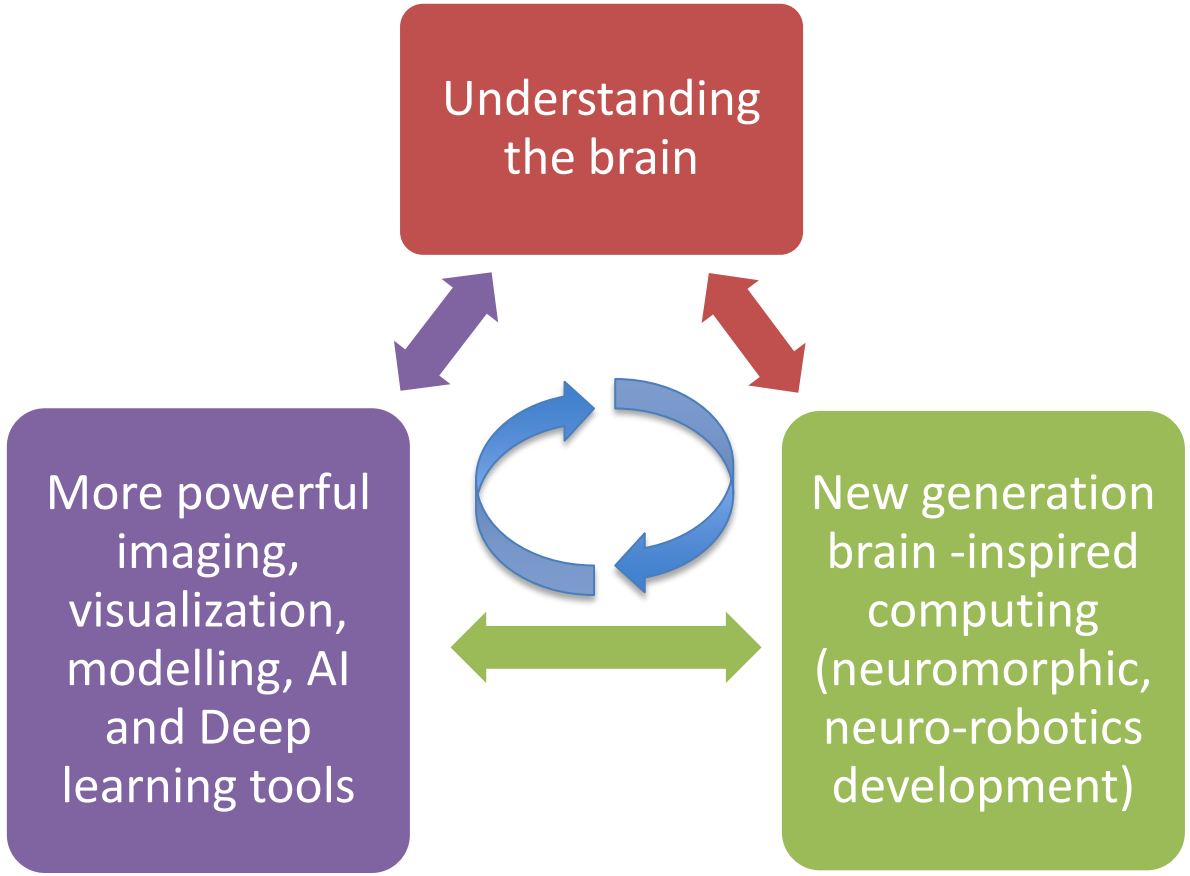
Funding Estimate 2013-2023:
EU → EUR 406 million
National → EUR 600 million

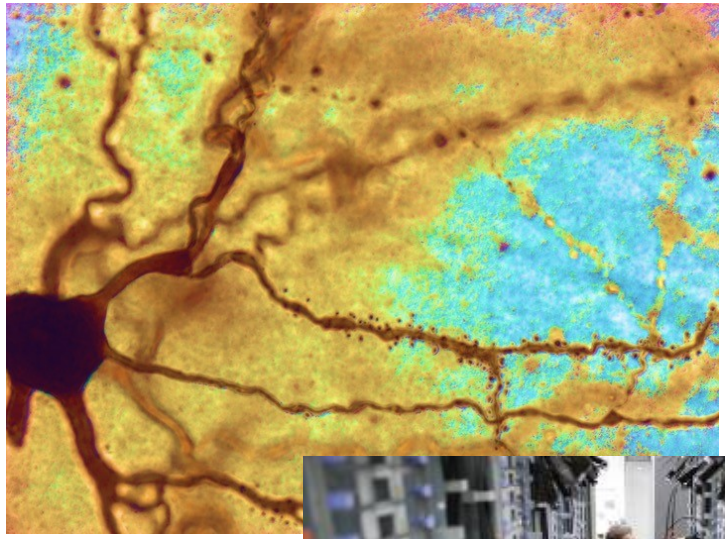
Embedded in previous and existing national and international initiatives: Blue Brain, BrainScaleS, Supercomputing and Modeling the Human Brain, SpiNNaker, PRACE (Partnership for Advanced Computing in Europe), etc.

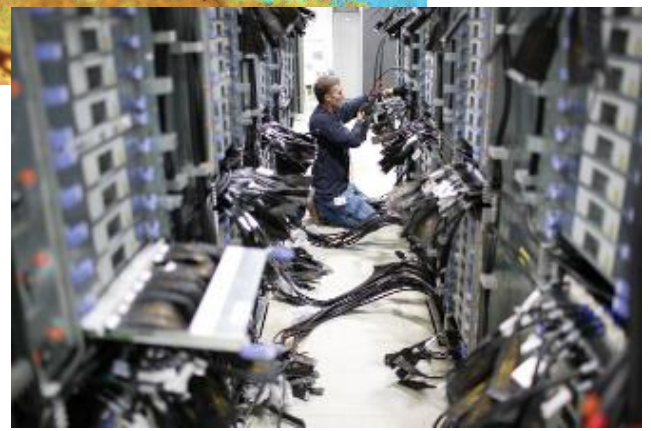
Co-funded by the European Union

Understanding HBP

A win-win situation of collaboration between Neuroscience and HPC







HBP structure

SUBPROJECTS

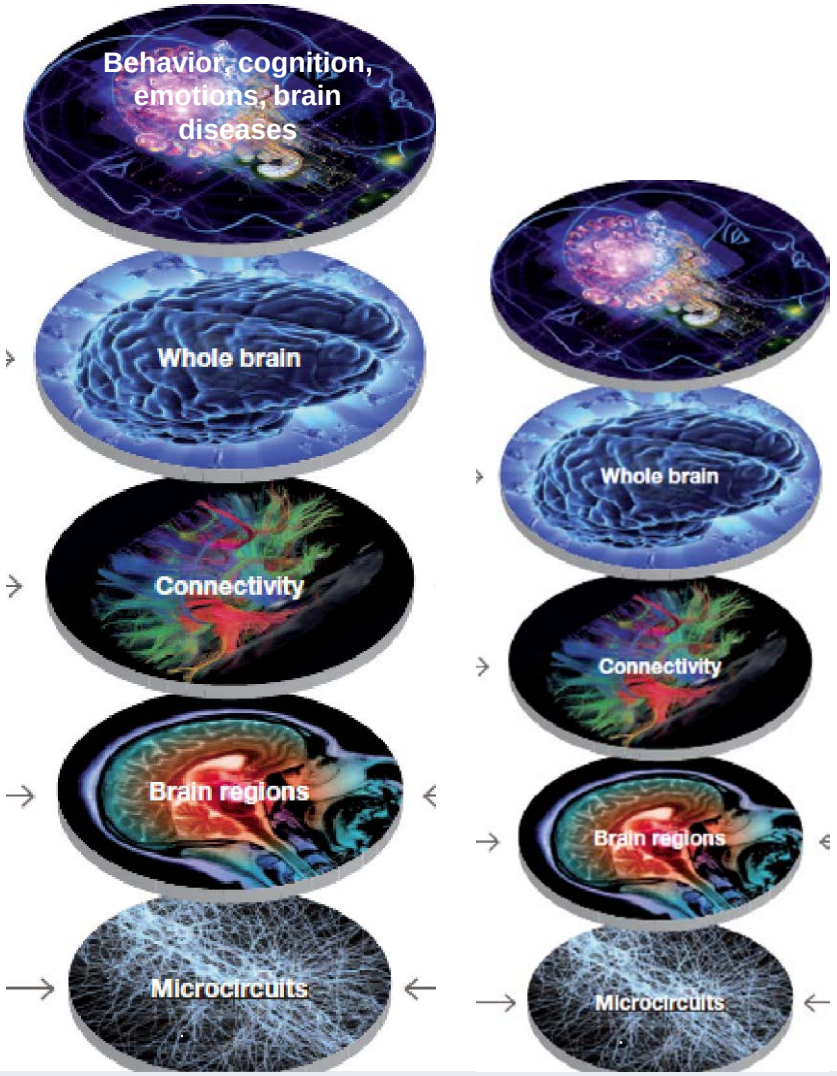
There are **12 Subprojects** in the HBPs that span the development of **6 ICT-based Platforms**, as well as data gathering, cognitive and theoretical neuroscience, ethics, and administrative services.

CO-DESIGN PROJECTS

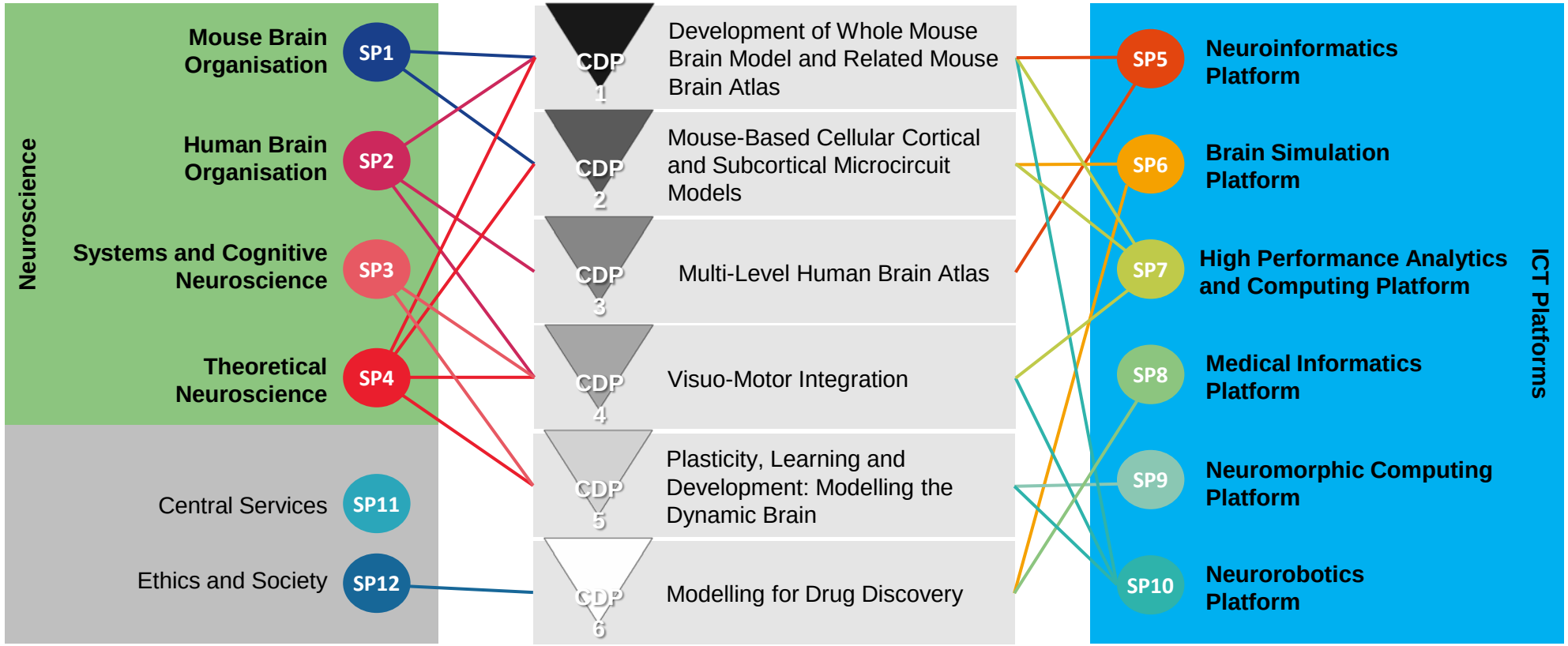
Co-design projects are multi-disciplinary and cross Subprojects. They are led by senior scientists from the HBP and are designed around **collaboration, data gathering and simulation between the HBP's Platforms**.

PARTNERING PROJECTS

Partnering Projects create synergies between the core HBP and activities receiving funding at regional, national or transnational level. The projects and their partners already **have their own funding** and join with the HBP to together make a new and significant contribution to the HBP's strategic research roadmap



Subprojects (SP) and co-Design Projects (CDP)



Towards a Research Infrastructure

- HBP unmatched computational resources
- The HBP Platform ecosystem
- HBP Joint platform
- HBP Research infrastructure

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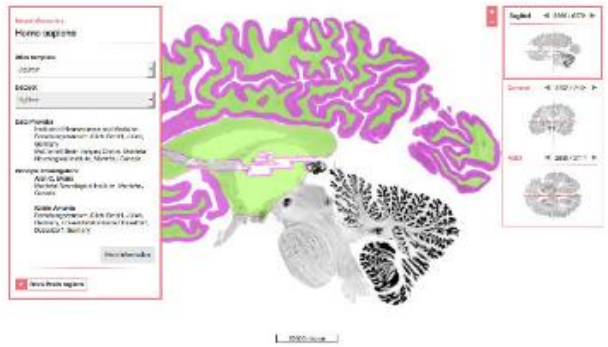
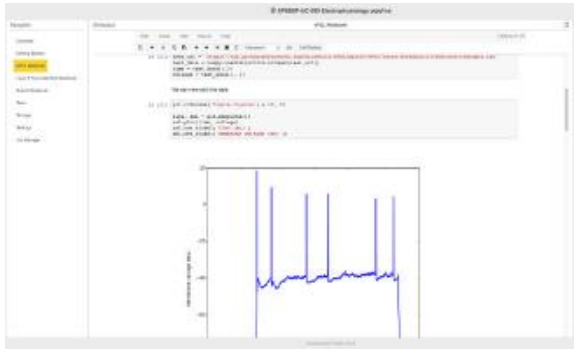
The HBP Platform Ecosystem

a fledgling distributed e-Infrastructure

NEUROINFORMATICS



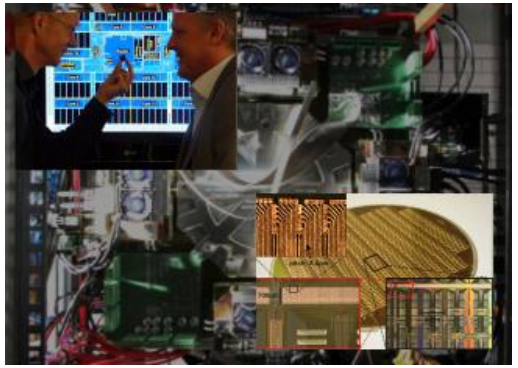
BRAIN SIMULATION



MEDICAL INFORMATICS

HIGH PERFORMANCE ANALYTICS AND COMPUTING (HPAC)

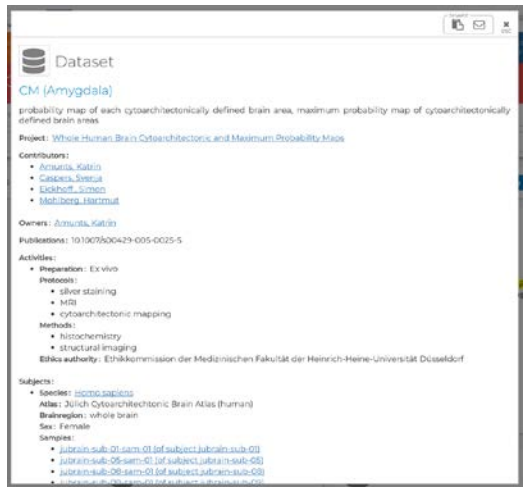
NEUROMORPHIC COMPUTING PLATFORM

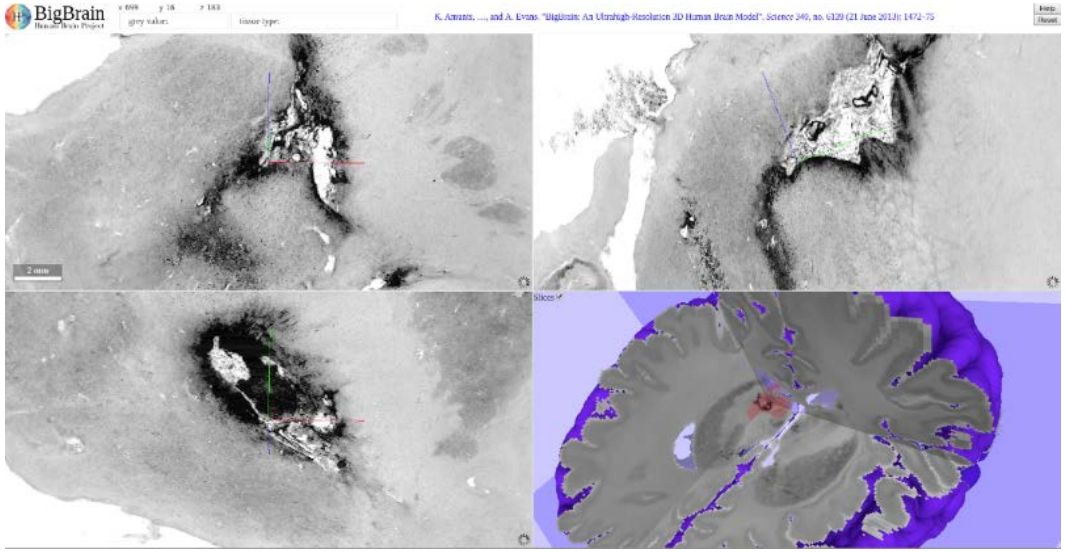


NEUROROBOTICS PLATFORM

NEUROINFORMATICS PLATFORM

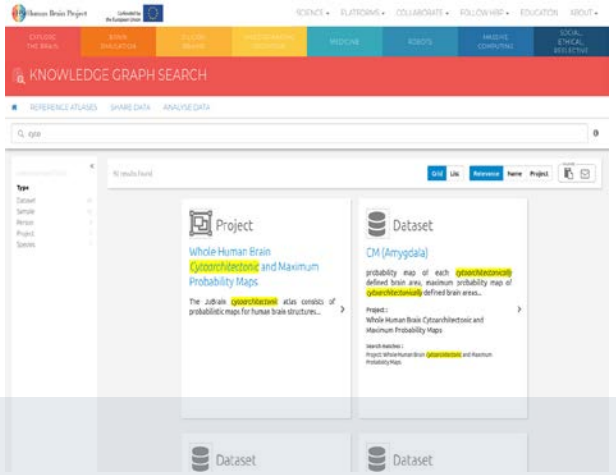
Open data = accelerated science





- Over 8 billion euro worldwide is spent annually on Neuroscience research
- 90% is spent on new data generation

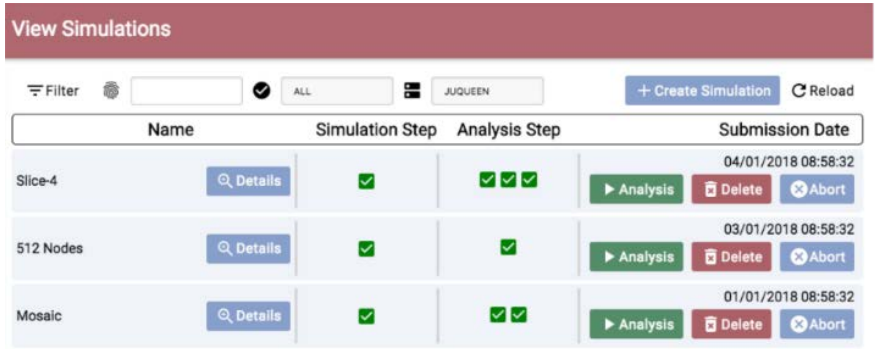
If only 1% of this data could be reused for new science
→ Over 60 million euro in annual cost savings

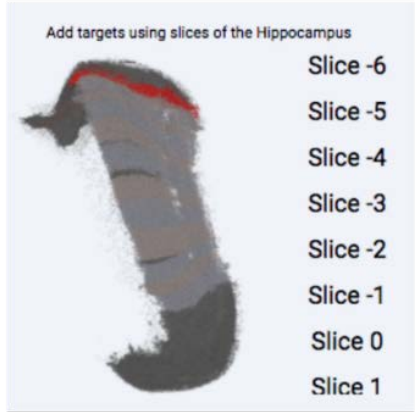


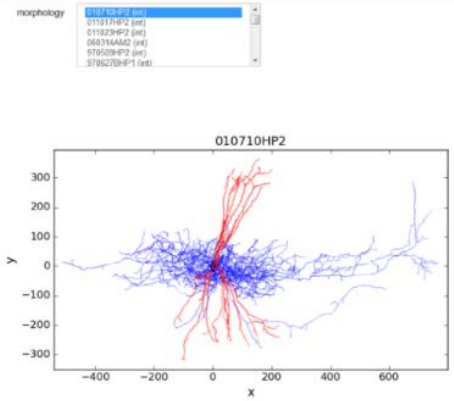
BRAIN SIMULATION PLATFORM

Build, simulate and analyze detailed models

- No install required, user-centric and user-friendly
- Custom built to enable the reconstruction and simulation of models of brain and brain tissue with a data-driven approach.
- Accessible to different neuroscientific and/or technical backgrounds and expertise levels
- Use the Platform's capabilities for scientific goals and curiosity
- Explore online functionality through guided Use-case Collabs and harness the power of in-silico neuroscience







HIGH PERFORMANCE ANALYTICS AND COMPUTING PLATFORM

Providing the supercomputer infrastructure

The human brain is so **complex** that a normal computer is not enough to simulate even a fraction of the human brain.

HBP uses powerful computers, capable of performing quadrillions of operations per second and have memory capacity measured in quadrillions of bytes.

The Human Brain Project not only makes this hardware available to the scientists, but also develops **software** that supports neuroscientists in their work

HBP **neuroscientists** collect a lot of data, then **develop brain models** based on this data and finally simulate these models

MEDICAL INFORMATICS PLATFORM

Helping EU patients beyond drugs

Medical challenges

Improved prevention

More precise and timely diagnosis

More performant treatment decision-making

More effective neuro-rehabilitation

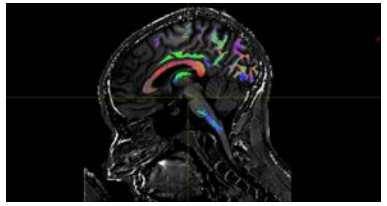
More shared knowledge about brain diseases

More shared knowledge about clinical practice

More efficient clinical studies

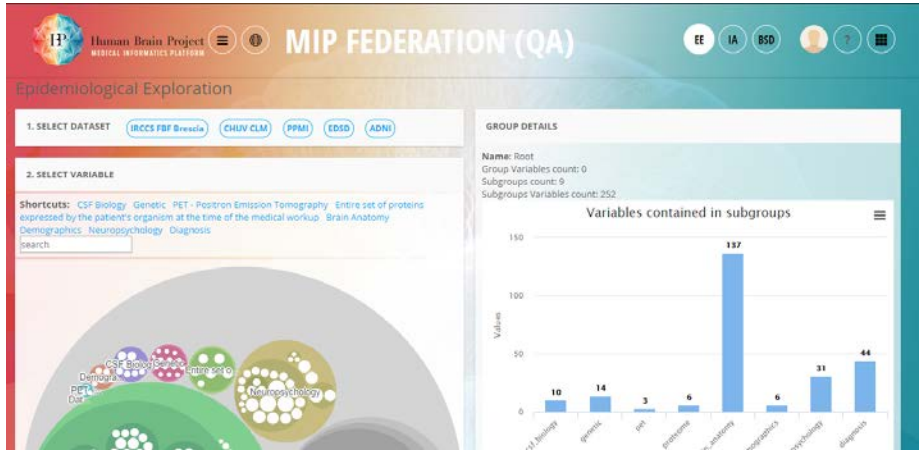
Facilitators

- More predictive & validated biomarkers
- AI-based diagnostic & decision making tools
- Open-access big research & clinical data
- GDPR compliant interoperability
- Scaled-up clinical/research EU network
- Mobile health technologies
- *Other Neurotechnologies (VR, Brain Computer interf, …)*



Anonymized, privacy sensitive queries
No data leaves the hospital
GPDR compliant

Machine and deep learning models with deep data access
No data leaves the hospital
GPDR compliant



MEDICAL INFORMATICS PLATFORM (CONT´D)

MIP offers a unique interoperability solution

SGA1

MIP installed in 7 hospitals

CLM – CHUV *LAUSANNE, SWITZERLAND*
699 PATIENT RECORDS

IRCCS FATEBENEFRATELLI, BRESCIA , *ITALY*
1960 PATIENT RECORDS

CENTRE HOSPITALIER REGIONAL UNIVERSITAIRE, *LILLE, FRANCE*
1436 PATIENT RECORDS

→ Datasets from 6345 individuals in the MIP

ASST GRANDE OSPEDALE, *NIGUARDA, ITALY*
MIP installed - Data Curation in Process

UNIVERSITY CLINIC, *FREIBURG, GERMANY*
MIP installed - Data Curation in Process

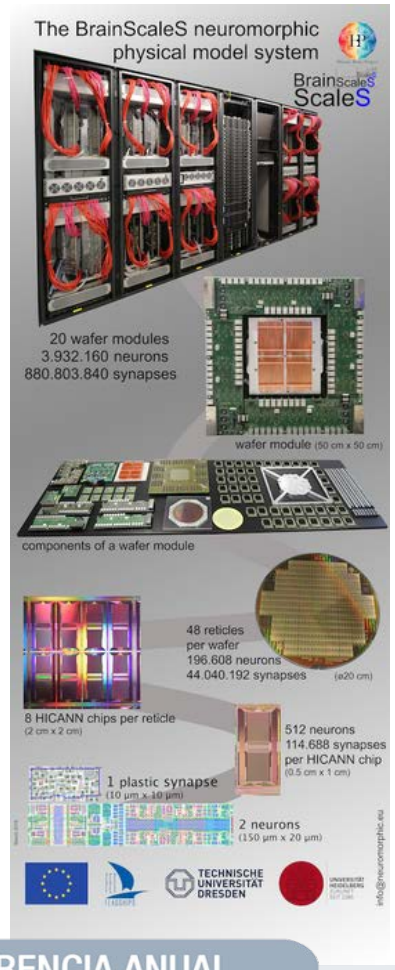
MEDICAL UNIVERSITY, *PLOVDIV, BULGARIA*
MIP installed - Data Curation in Process

SOURASKY MEDICAL CENTER, *TEL-AVIV, ISRAEL*
MIP installed - Data Curation in Process

SGA2

NEUROMORPHIC COMPUTING PLATFORM

Brain-like inspired computation

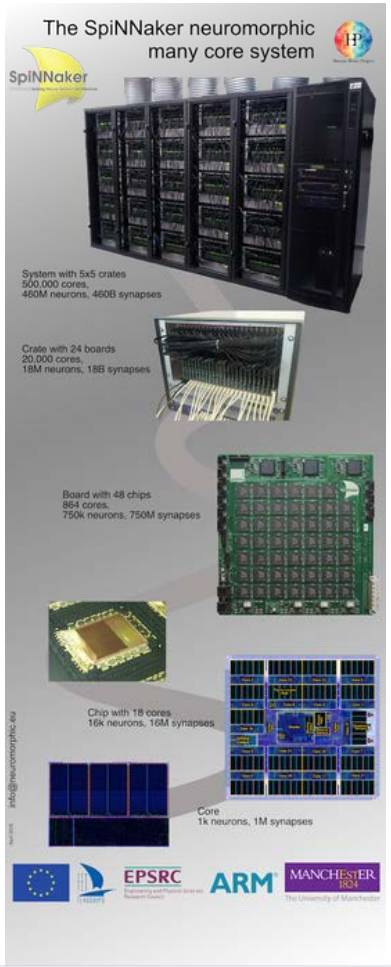


A better understanding of the functioning of the brain paves the way to **neuromorphic computing**, which promises to enhance traditional supercomputers with processors built on radically new approaches, based on **interconnected artificial neurons** or on **digital representations of neurons**.

Neuromorphic computing will be key in developing the next generation of **extreme-scale computing**, i.e., modular supercomputing.

In the medium term we may expect neuromorphic technologies to deliver a range of applications more efficiently than conventional computers, for example to deliver **speech** and **image recognition** capabilities in smart phones.

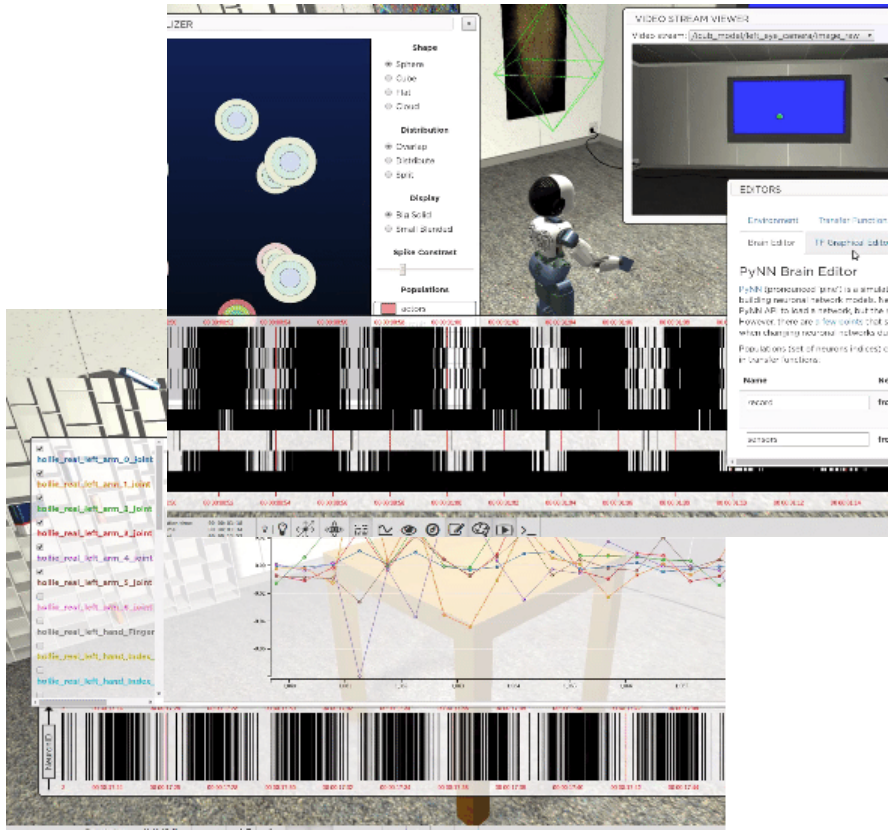
In the long term there is the prospect of using neuromorphic technology to integrate energy-efficient intelligent cognitive functions into a wide range of consumer and business products, from **driverless cars** to **domestic robots**.



NEUROROBOTICS PLATFORM

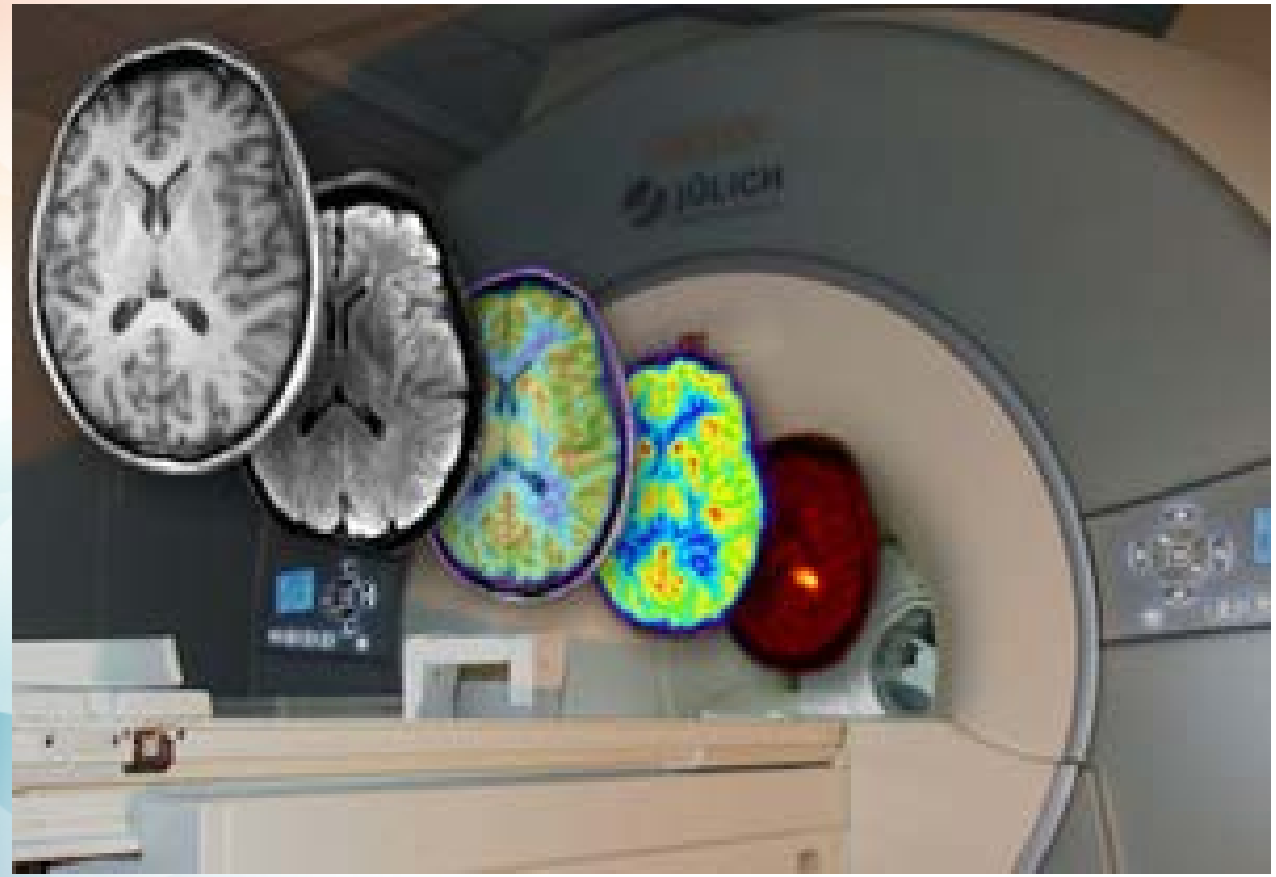
Simulation environments to build better robots

- Run simulations from anywhere without any installation
- Choose from the predefined robot models and environments to then edit them and the brain models you use as controllers.
- Desktop version for offline experimentation
- Connect your brain models to 3D bodies and let it explore one of our many simulation environments that you can customize with our environment designer



A key platform for the development of therapeutic experiments and robotics capabilities in HBP

Towards a Research infrastructure that supports Science, Technology, Innovation and Medical impact



The focus now is to **further progress the base infrastructure** and **connect the platforms** into a high-level infrastructure

EBRAINS

Innovation in HBP

The Innovation and Technology transfer Node of HBP

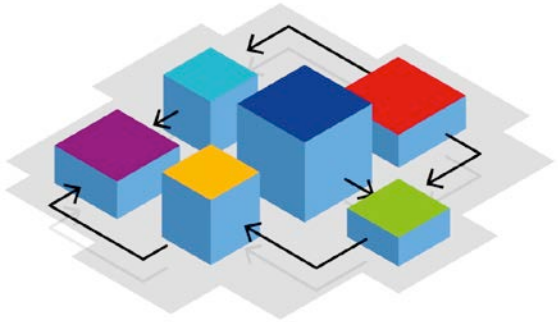
Universidad Politécnica de Madrid

The objective of the ITTN is to offer a set of innovation and technology transfer services for the whole HBP community and to accelerate its impact in society.

1. Identifying **emerging brain technologies** with market potential
2. Performing **technology and market watch reports**
3. Supporting the evolution of **prototypes** into industrial proofs of concept to bring TRLs closer to international markets
4. Training people on brain **innovation and technology transfer**
5. Promoting the creation and scale-up of **start-ups** on brain technologies
6. Helping the creation of **INDUSTRIAL HUBS** in participating countries.

The Innovation and Technology transfer Node of HBP

DO YOU WISH TO BE A MEMBER OF OUR INDUSTRIAL HUBS?



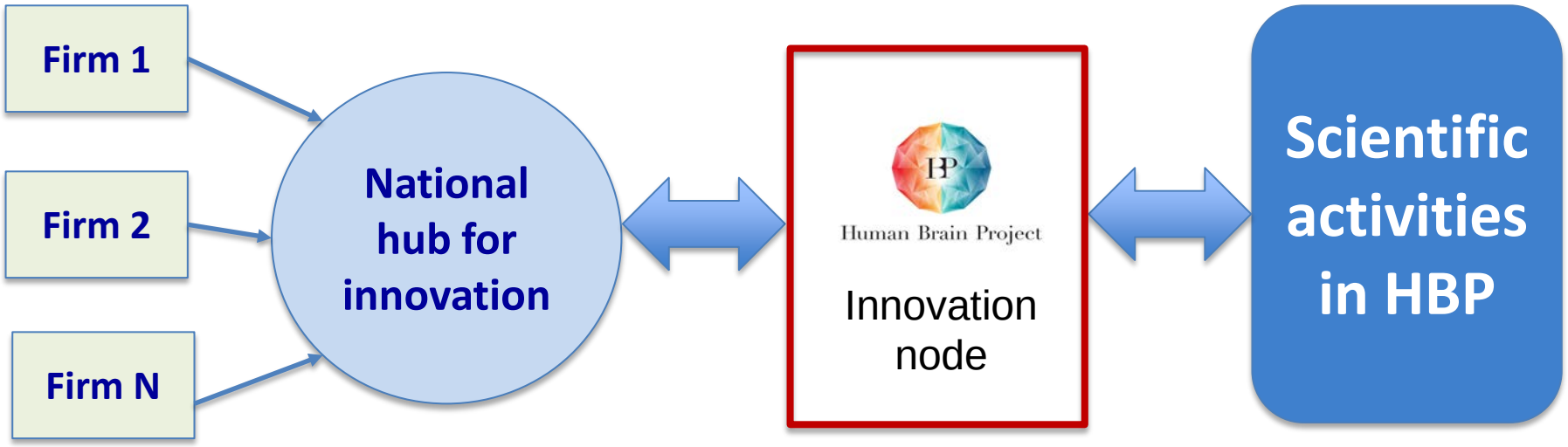
We are selecting **members** to participate in our **National Hubs for Innovation** (NHI)

Hub members will have fluent **access** to relevant HBP **knowledge** and will be early informed on new **HBP technologies**

Through NHIs HBP offers industries a real opportunity to capture **early research results** in Neuroscience, Computing and Brain medicine

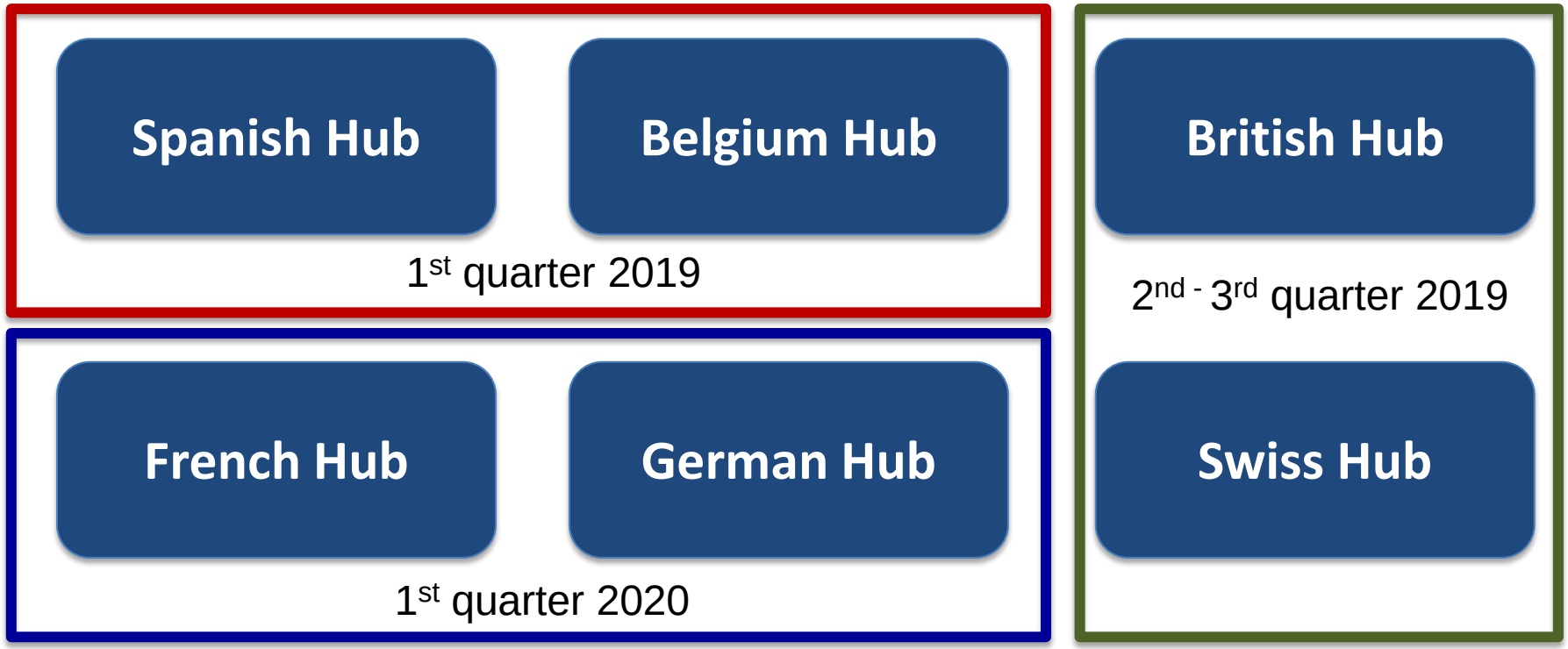
HBP NATIONAL HUBS FOR INNOVATION

HBP-NHIs *are conceived as voluntary associations of national industries (with or without legal personality) created at national level but coordinated at European level by the HBP ITTN as a bridge between the HBP consortium and firms' interests.*



HBP NATIONAL HUBS FOR INNOVATION

Progressive launching of National Hubs in the main countries participating in HBP

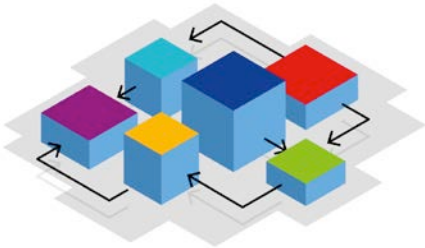


HBP NATIONAL HUBS FOR INNOVATION

OBJECTIVES

Facilitate the access to HBP technologies and platforms to industries participating in industrial hubs

- To **disseminate** within the industry members of each NHI information of **knowledge and technology** generated in HBP with potential industrial interest.
- To facilitate the **early access to HBP platforms** to test the applicability of their embedded tools in industrial settings

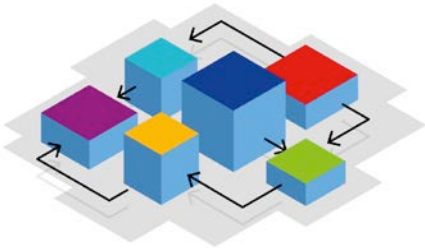


HBP NATIONAL HUBS FOR INNOVATION

OBJECTIVES

Industrial influence on the future direction of HBP objectives

- To identify **scientific and technological areas** with potential industrial interest at national level.
- To identify **possible innovation projects**
- To support the **definition of national positions** on industry interest
- To help in the definition of **complementary and partners' programmes**, or other public-private partnership schemes to support brain applied research.



WHO COULD BE A MEMBER OF A HBP NATIONAL HUBS FOR INNOVATION?

- **SMEs**, **start-ups**, and **large companies** (not belonging to the HBP consortium) are welcomed to the Hubs
- Industry **associations** are also welcomed
- Governance and operational rules are defined by a **MoU**
- Internally, each NHI can create "**groups of interest**" (as working groups on selected themes) on temporal or permanent bases.

How to engage with HBP?

If you are interested in our HBP technologies or in taking part of the HBP hubs, please do not hesitate to contact the HBP Innovation team by:

1. asking for information in this event

2. Or leaving your contact data and we will get in touch with you soon,

3. Or sending an email telling us your interest: ***innovation@humanbrainproject.eu***

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Thanks

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