# THE EU'S HUMAN BRAIN PROJECT (HBP) FLAGSHIP

**KATRIN AMUNTS**

CHAIR, SCIENTIFIC AND INFRASTRUCTURE BOARD OF THE HBP

RESEARCH CENTRE JÜLICH, C.&O. VOGT INSTITUTE FOR BRAIN RESEARCH, DÜSSELDORF
VICE-CHAIR, THE GERMAN ETHICS COUNCIL

Co Funded by
the European Union

Board of Funders, Brussels, 15. May 2015

Human Brain Project

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K. Amunts et al., Science, 2013.
BigBrain - an ultra-high resolution 3D human brain model

**JÜLICH** FORSCHUNGSZENTRUM

**DEEP Cluster**
**Prototypesystem funded by the European Union**

Human Brain Project
**K. Amunts**
(Jülich Research Centre, C. and O. Vogt-Institute of Brain Research, Düsseldorf)
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Co-funded by
the European Union
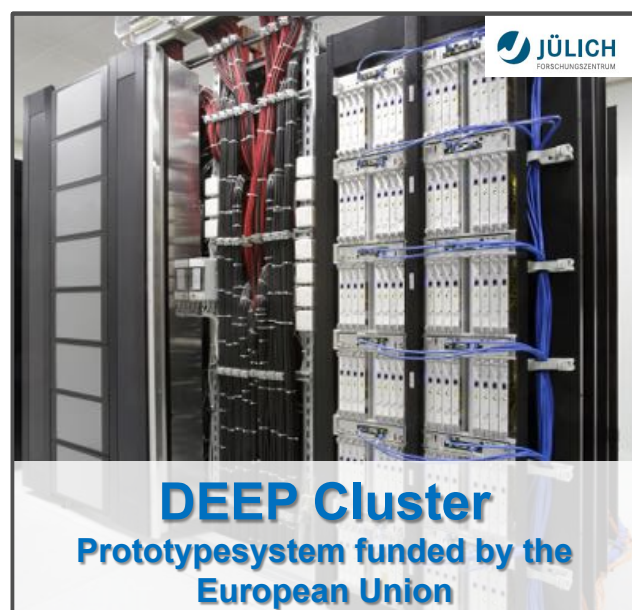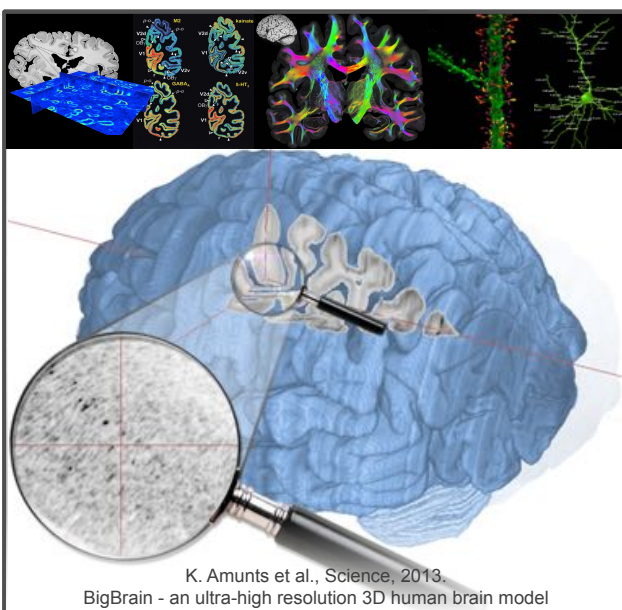
# HBP at a Glance

- 10-year, EUR 1 Billion Research Roadmap (50% Core Project, 50% Partnering Projects)
- 89 M Euros (Core Project, 2016-2018)
- Core project : 116 institutions, 19 countries
- 6 Platforms, released in March 2016
- Embedded in previous and existing national and international initiatives: Blue Brain, BrainScaleS, Supercomputing and Modeling the Human Brain, SpiNNaker, PRACE, etc.
- New governance in SGA1 established
- Science and clinical advisory boards installed
- Co-design projects (n=6) and use cases drive the development of the infrastructure



● HBP Partner

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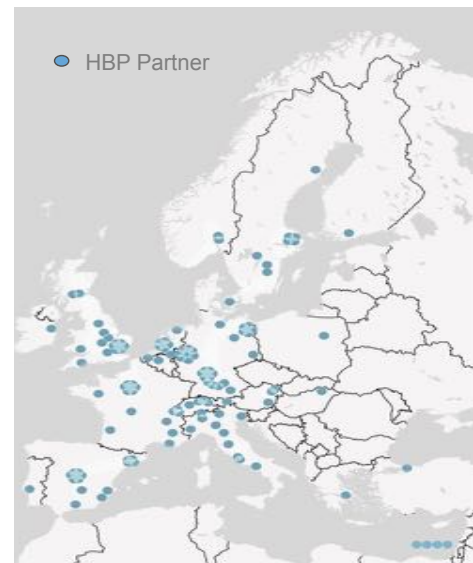
# The HBP Flagship Project



Sao Gabriel

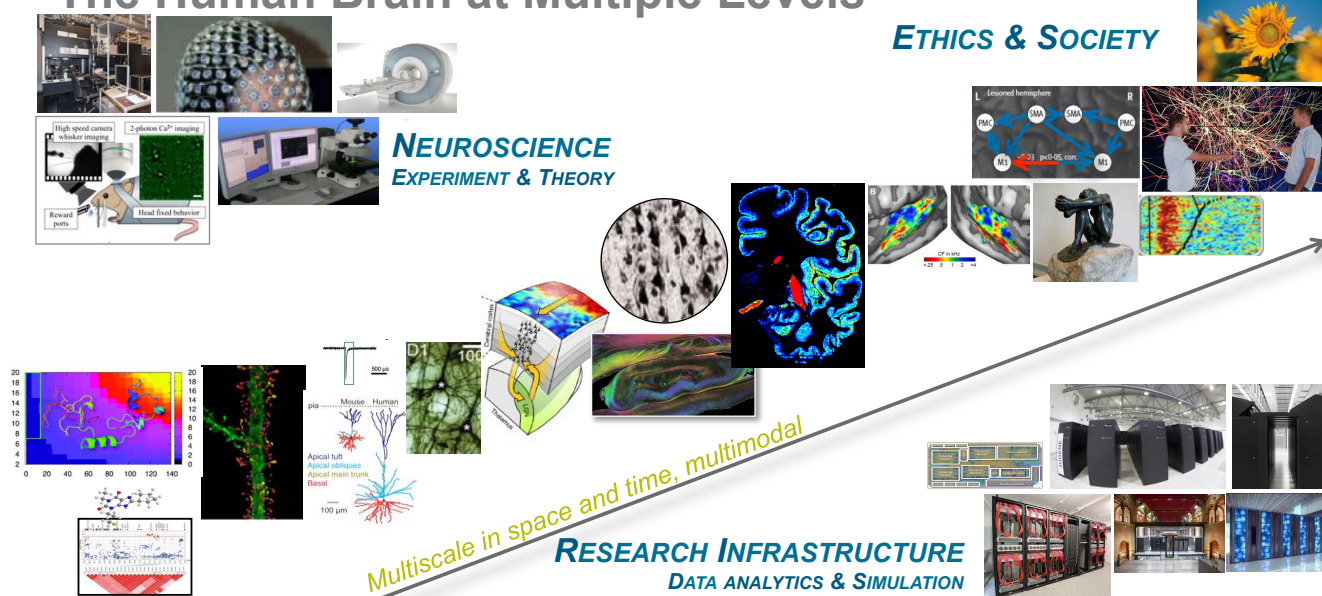**Vision of the HBP according to the FPA:**

Understanding the human brain is one of the greatest challenges facing 21$^{st}$ 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.
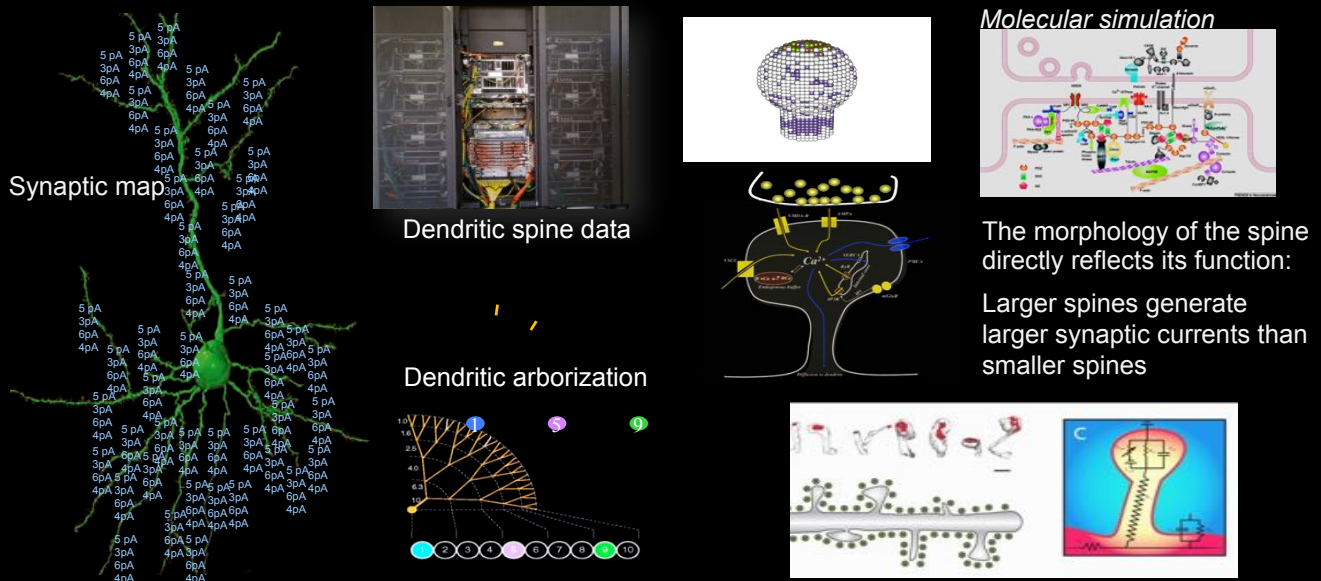
**Focus in SGA2:**

Development of a European Infrastructure for brain research that aims at bridging the scales of the brain's multiscale organisation

# Objectives of the HBP

- Create and operate a European scientific research infrastructure for brain research, cognitive neuroscience, and other brain-inspired sciences
- Gather, organize and disseminate data describing the brain and its diseases
- Simulate the brain
- Build multi-scale scaffold theory and models for the brain
- Develop brain-inspired computing, data analytics and robotics
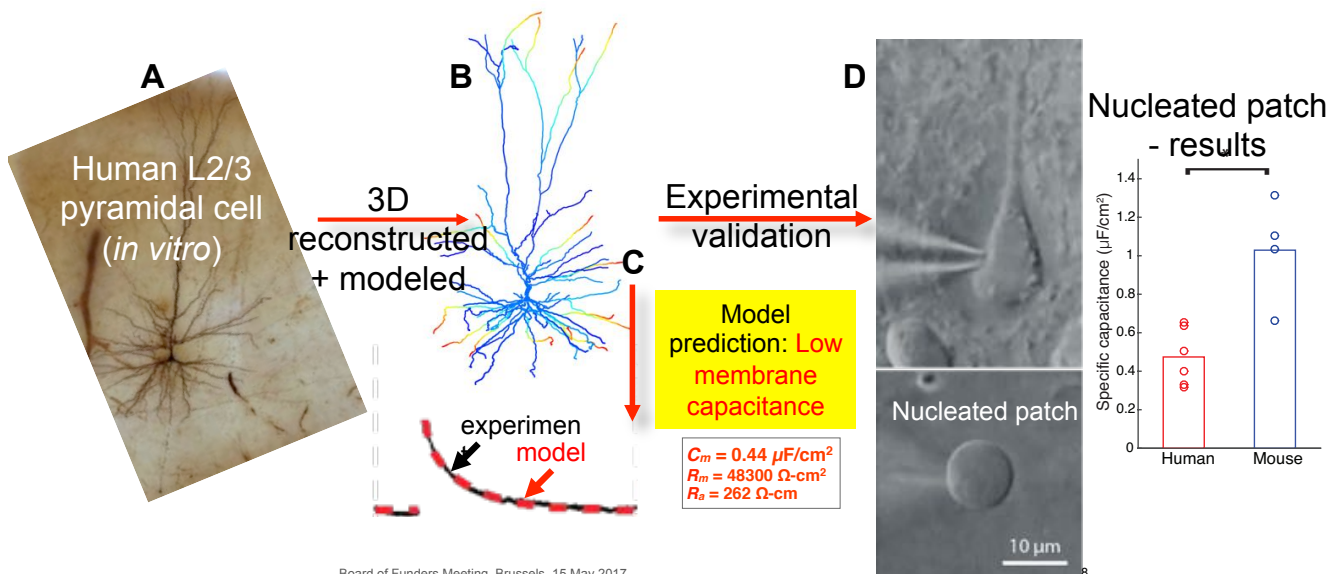- Ensure that the HBP's work is undertaken responsibly and that it benefits society

# The Human Brain at Multiple Levels



ETHICS & SOCIETY

NEUROSCIENCE
EXPERIMENT & THEORY

Multiscale in space and time, multimodal

RESEARCH INFRASTRUCTURE
DATA ANALYTICS & SIMULATION

# Mouse Brain: from Empirical Research to Simulation

Synaptic map

Dendritic spine data

*Molecular simulation*

The morphology of the spine directly reflects its function:

Larger spines generate larger synaptic currents than smaller spines

Dendritic arborization

*Javier de Felipe, Madrid & Henry Markram, Lausanne*  7

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# Modeling Human Neurons

**A** Human L2/3 pyramidal cell (*in vitro*)

**B** 3D reconstructed + modeled

experimen model

**C** Model prediction: Low membrane capacitance

$C_m = 0.44 \ \mu F/cm^2$
$R_m = 48300 \ \Omega\text{-}cm^2$
$R_a = 262 \ \Omega\text{-}cm$

**D** Experimental validation

Nucleated patch

10 µm

Nucleated patch - results

Specific capacitance ($\mu F/cm^2$)

Human  Mouse

Human Brain Project

*Huib Mansfelder, Amsterdam & Idan Segev, Jerusalem*

Co-funded by the European Union
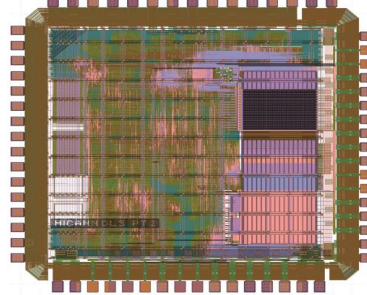
# Neuromorphic Computing

*SpiNNaker 2*
Power Management
Floating point precision
True random numbers

*BrainScales 2*
PowerPC plasticity processors
Flexible local learning rules
Improved parameter storage



- ➢ Chip prototypes designed, produced and tested during the ramp-up phase
- ➢ Major common emphasis : Strongly improved plasticity, learning capabilities
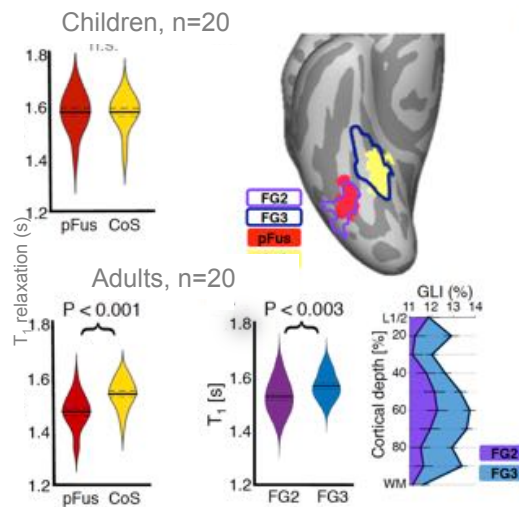- ➢ Getting ready for applications in cognitive computing

*Steve Furber, Manchester & Karlheinz Meier, Heidelberg*          9
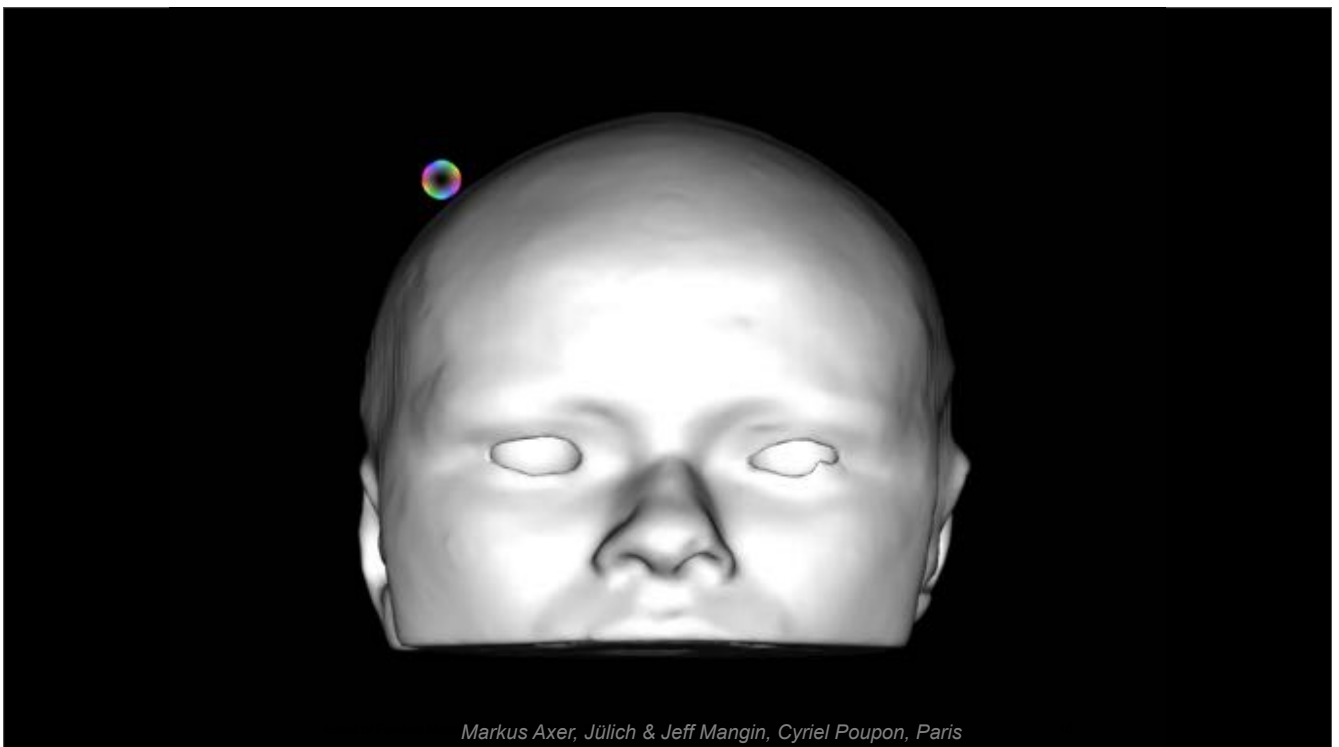


*Markus Axer, Jülich & Jeff Mangin, Cyriel Poupon, Paris*

# Face- and place selective regions differ in development

Children, n=20



> Microstructural developments are correlated with specific increases in functional selectivity to faces as well as improvements in face recognition

> Development of face-selective regions, but not place-selective regions, is dominated by tissue growth
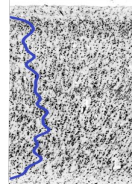
*Cross-Atlantic Collaboration:*

*Gomez, Barnett, Natu, Mezer, Palomero-Gallagher, Weiner, Amunts, Zilles, Grill-Spector: Growth of tissue in human cortex is coupled with the development of face processing. Science (2016, in press).*
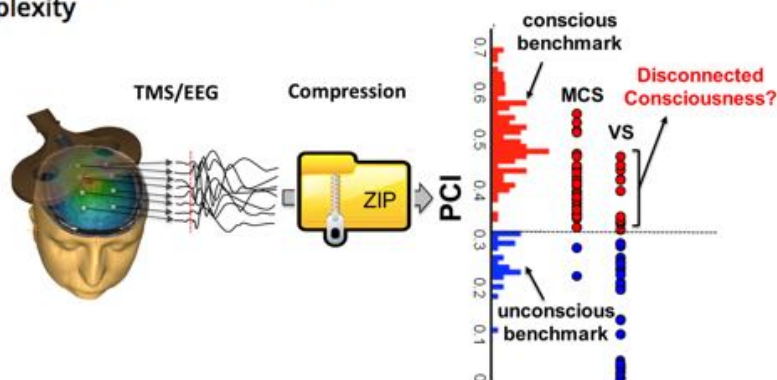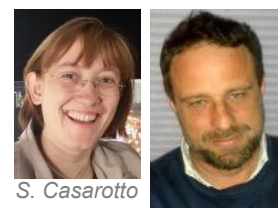
*Katrin Amunts, Jülich/Düsseldorf*

# Assessing Human Consciousness

*PCI: Pertubational Complexity Index*



Casarotto et al., Annals of Neurology 2016

*S. Casarotto*
*M. Massimini*
*Milan*

*S. Laureys O. Gosseries*
*M. Boly, Liege*

*Cyriel Pennartz, Amsterdam & Johan Storm, Oslo & Lars Muckli, Glasgow*

# Neurorobotics

- ➢ collaboratively design and run virtual experiments in cognitive neuroscience
- ➢ software and hardware tools to study how brain models can control robots in complex environments



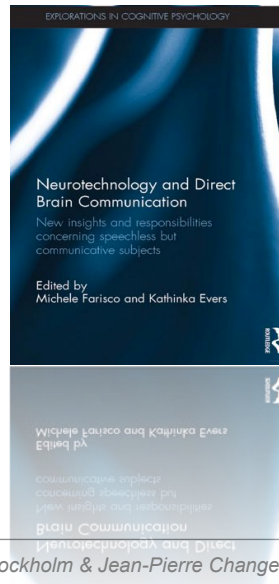*Alois Knoll, Munich & Mark-Oliver Gewaltig, Lausanne*    13

# Cross-species studies



**Behavior**    **Anatomy**    **Function**    **Connectivity**

**HOMOLOGY**

**mesoscale**
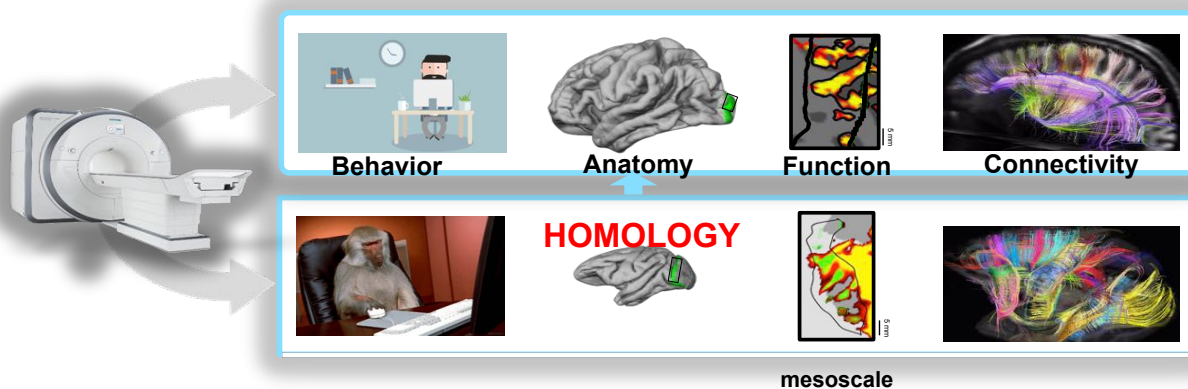
# Ethics & Society in the HBP

**Topics:**

- Ethical aspects in the field of global data sharing
- Foresight lab
- Researcher awareness and reflection
- Neuroscience and society
- Consciousness, self-awareness, human identity

EXPLORATIONS IN COGNITIVE PSYCHOLOGY

Neurotechnology and Direct Brain Communication

New insights and responsibilities concerning speechless but communicative subjects

Edited by
Michele Farisco and Kathinka Evers

*Science & Society*

**Proactive epigenesis and ethical innovation**
*A neuronal hypothesis for the genesis of ethical rules*
Kathinka Evers, Jean-Pierre Changeux

"*The brain progressively builds its adult connectivity through a constant dialogue between the genetic endowment of the child and her/his experience of the external world*"
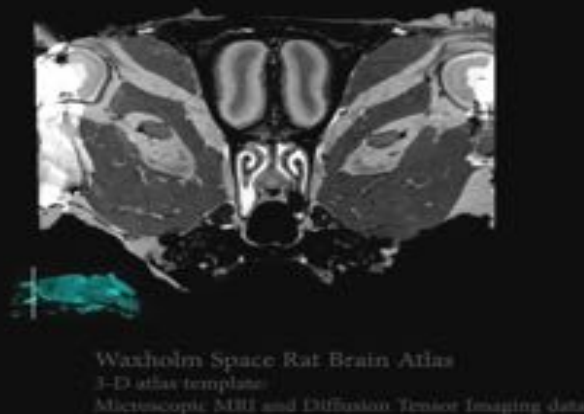
*Evers & Changeux, EMBO reports, 2016*

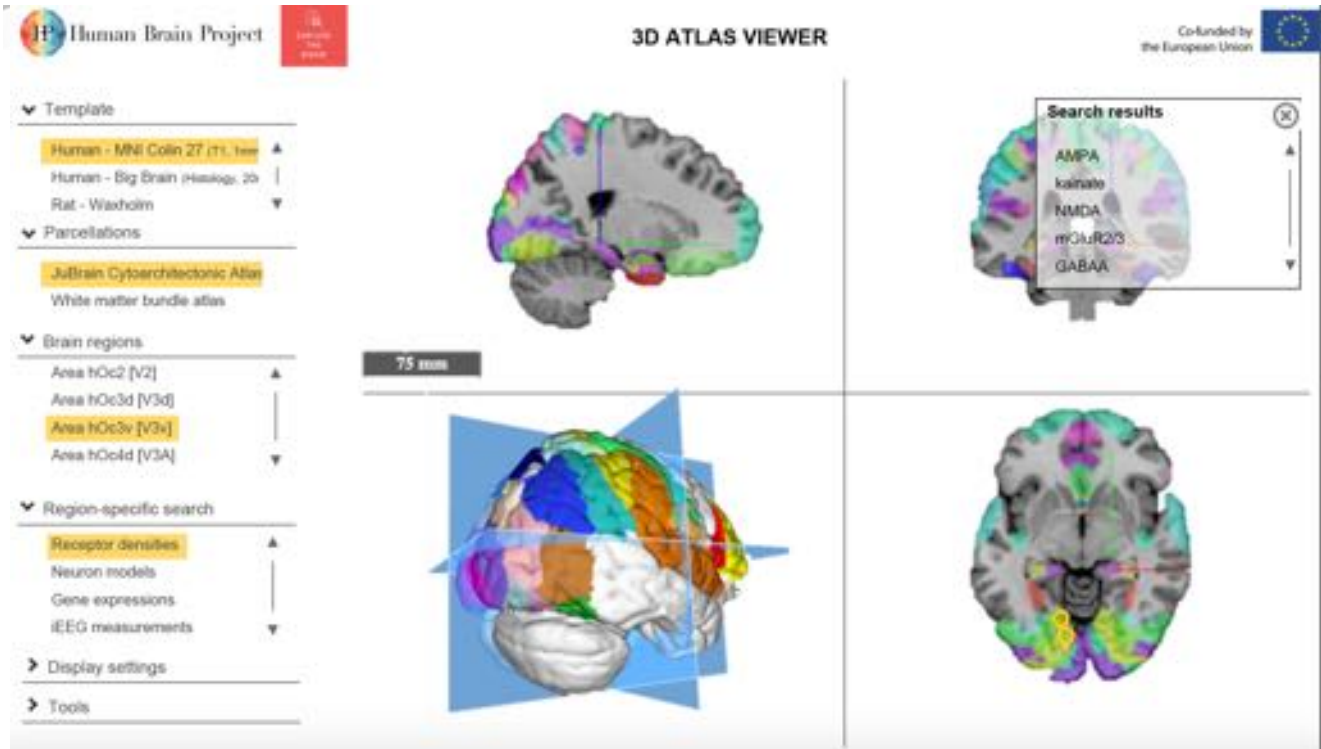*Kathinka Evers, Stockholm & Jean-Pierre Changeux, Paris*     15

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# Multimodal Rodent Atlas

▪ **Atlases of brain structures:**
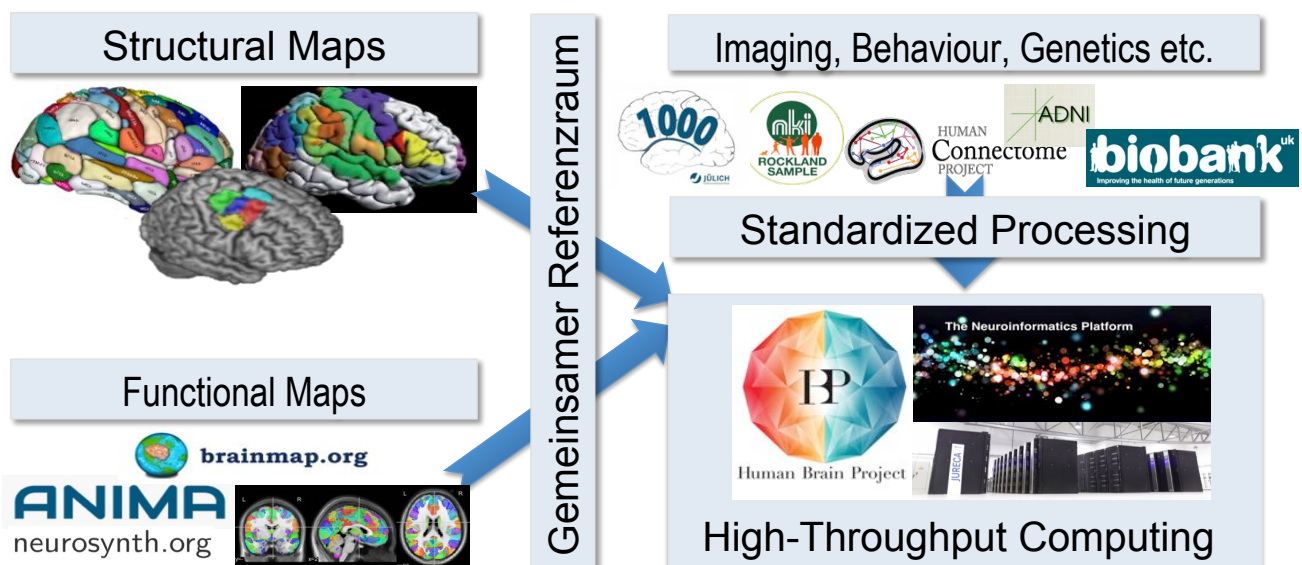
▪ **Tools for viewing and slicing of atlases**



Waxholm Space Rat Brain Atlas
3-D atlas template
Microscopic MRI and Diffusion Tensor Imaging data

Jan Bjaalie and team, Oslo

# HBP: INTEGRATING DATA & KNOWLEDGE



Structural Maps

Gemeinsamer Referenzraum

Imaging, Behaviour, Genetics etc.

Standardized Processing

Functional Maps

brainmap.org

ANIMA

neurosynth.org

The Neuroinformatics Platform

Human Brain Project

High-Throughput Computing

Simon Eickhoff, Düsseldorf

# The Status of the HBP Research Infrastructure

- The Ramp-up Phase between October 2013 and March 2015; and the first half of the SGA1 funding cycle have laid down a solid foundation for the HBP infrastructure and led to important lessons and insights.

- The focus now is to build the base infrastructure ("compute, storage, networks") and connect the elements to the high-level infrastructure and into our "one HBP platform" concept ("software, service")

- SGA2 (2018-20) will work as a more consolidated System of Systems with a strong focus on openness and support.

- Demand-side measures and targeted high level support are built into SGA2 to foster a user ecosystem of co-designer projects inside and outside the HBP

# Infrastructure roadmap
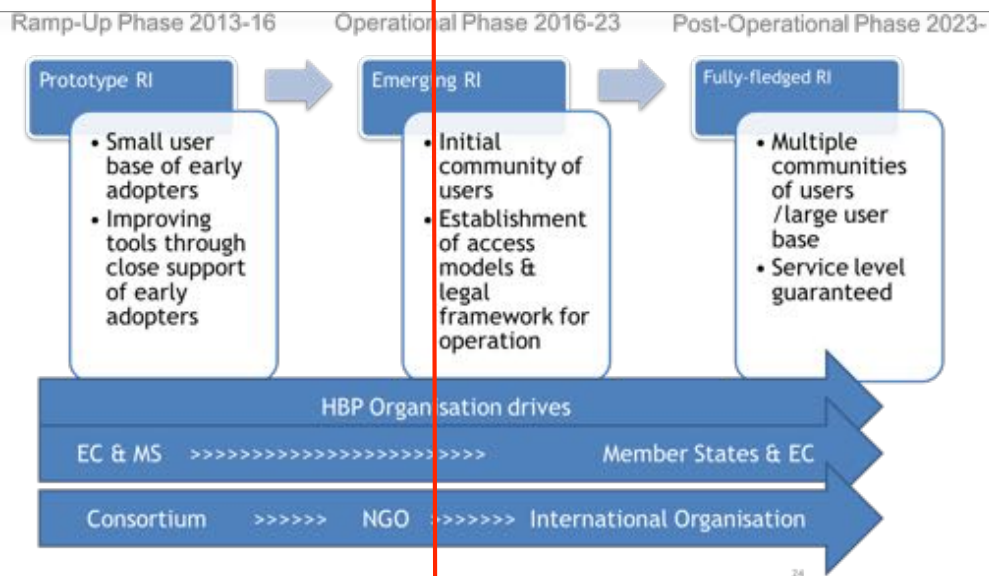
# HBP Service-based Research Infrastructure (SRI)
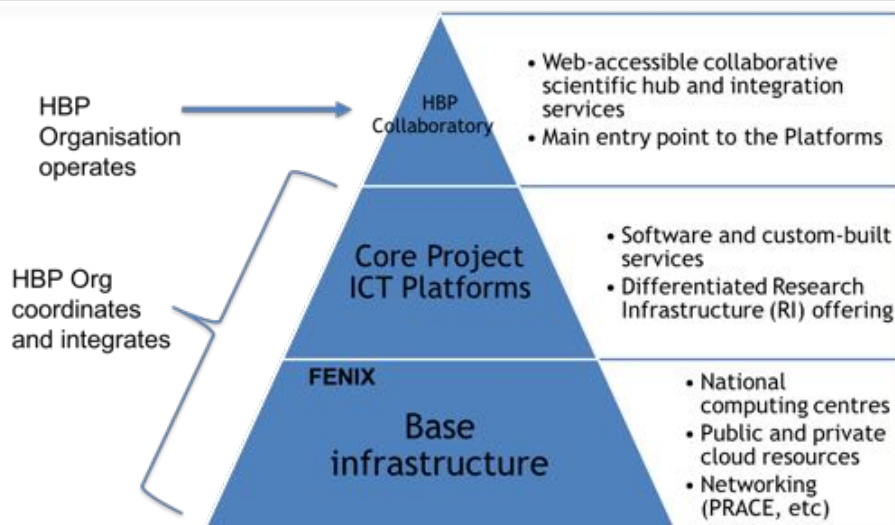
# Pre-Commercial Procurement: JULIA & JURON



*Thomas Lippert, Jülich*

# Fenix: Consortium of Supercomputing Centers

- Barcelona Supercomputing Center
- CEA Computing Centre TGCC
- Italian supercomputing centre CINECA
- CSCS in Lugano (Switzerland)
- JSC at Forschungszentrum Jülich

## Goal

Provide services for federated data infrastructure tightly coupled to supercomputers for HBP and other scientific communities



Human Brain Project

*Thomas Lippert, Jülich & Thomas Schulthess, Lugano/Zürich*

Co-funded by the European Union

# Architectural approach to Fenix

## Federated data infrastructure

Key feature: tight integration with supercomputers

## Interactive compute services

Compute nodes optimised for interactive work on large data volumes (includes, e.g., use of Jupyter notebooks)
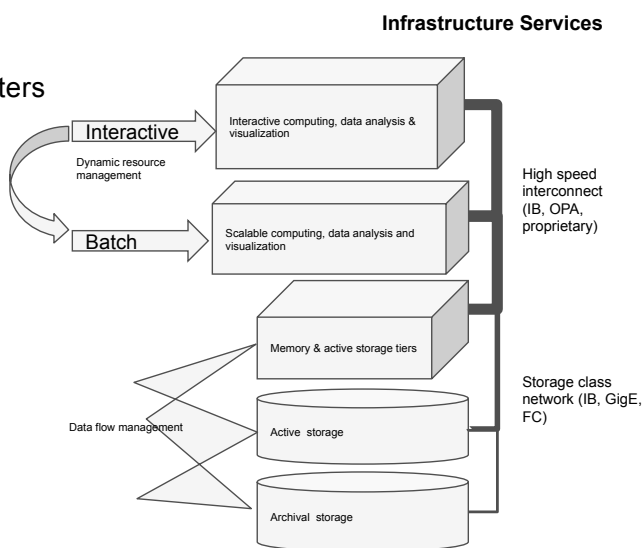
Integrated dense memory

Flexible and portable software deployment through light-weight virtualisation (containers)

Support for visualisation

## Elastic access to HPC resources

Seamless integration with supercomputers



**Infrastructure Services**

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# Human Brain Project SGA "ICEI"

## ICEI = Interactive Computing E-Infrastructure for the HBP

- Executed under the FPA of the Human Brain Project
- EUR 25M budget, EC expects >50% in-kind contribution

## Objectives

- Procure equipment and maintenance, licences for software components, and R&D services for the Fenix e-infrastructure
- Design a generic e-infrastructure for the HBP driven by its scientific use-cases and usable by other scientific communities
- Build the e-infrastructure with key characteristics
  - Interactive Compute Services
  - Elastic access to scalable compute resources
  - Federated data infrastructure
- Establish suitable governance and allocation mechanism

# Concept of the Joint Platform: Plans for SGA2
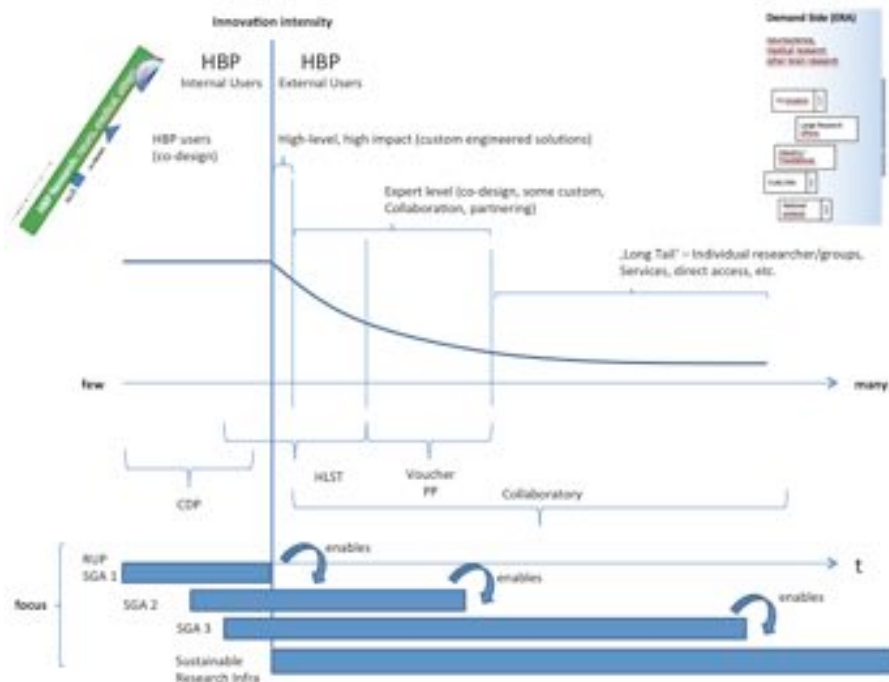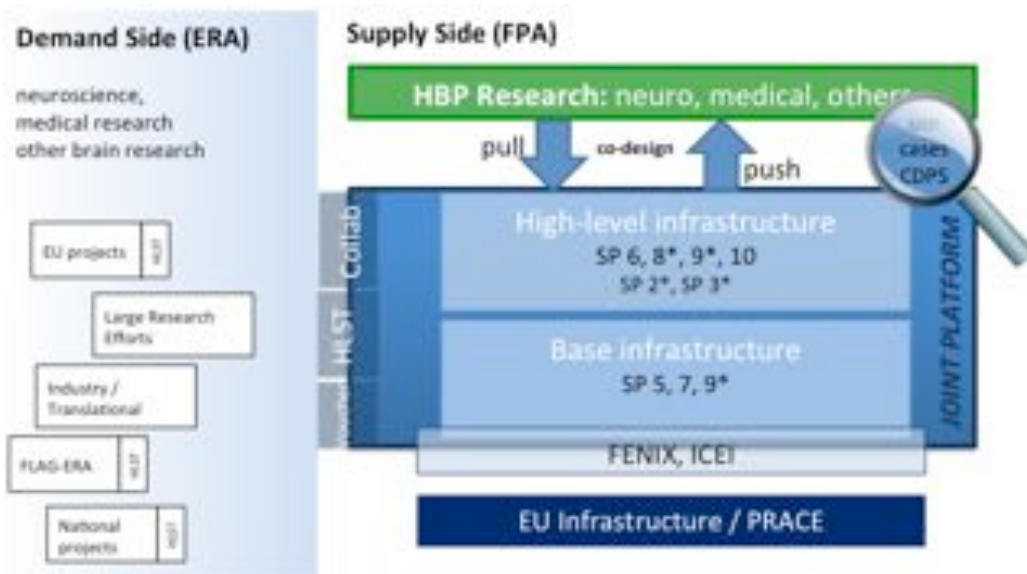
# A portfolio of outreach activities

**Levels of collaboration:**

- Direct collaboration including the platforms and the collaboratory (e.g., through HLST)
- Call for Expression of Interest
- Partnering Projects (e.g., FLAG ERA, MoUs)
- Collaboration with Global Brain Initiatives and other large-scale private, national and international organisations
- Education (e.g., HBP School, HBP Student Conference, Trainings, )
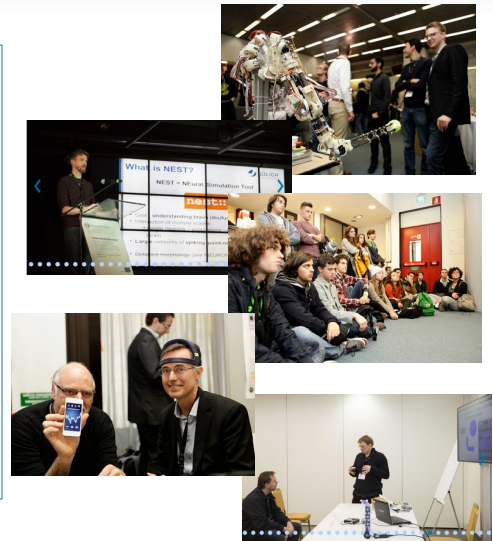


*Amunts, Ebell, Muller, Telefont, Knoll, Lippert: The Human brain Project: Creating a European Infrastructure to Decode the Human brain. Neuron, 2016*

# Current Partnering

Total number of institutions involved in a PP (24)

- 9 Associated Members (non HBP) brought into Consortium
- 15 institutions involved in HBP, on the institution level, not labs/PI

Countries represented in PPs (France 8, Netherlands 4, Spain 4, Hungary 2, Belgium 2, Italy 1, Canada 1, USA 1, Germany 1)

Type of institutions involved in PP (University 10, Research Performing Organization 13, SME 1)

Links to HBP: SP1, SP2, SP4 and SP10

Over 100 bottom-up individual project collaborations with HBP on institutional lever

# Partnering: current activities and next steps

Integration:
- Individual calls with the PP to inform them about SCOPE, discuss with them their current integration, inform them of upcoming actions and events
- Setting up of the procedure for the election of a Partnering Project Representative
- Planning of PP active participation in HBP events (Young Researcher Event, Summit) in collaboration with SCOPE
- Setting up of procedure for SCOPE travel grant supporting PPs' participation in HBP meetings and events

Communications:
- Revision of the Partnering Project page on the HBP website
- Setting up of the communications plan to disseminate PP activities in collaboration with SCOPE

FLAG-ERA JTC2019: Collaboration with FLAG-ERA to elaborate the process for the selection of the JTC2019 topics

# HBP Legal Entity Update

The HBP is creating a legal entity to coordinate the project and build and sustain the infrastructure.

A Working group has been formed prepare the implementation proposal:

- Is composed of legal experts from the major Partner institutions and a Swiss law firm.
- Will work to carefully ensure the questions of the Stakeholder Board are answered sufficiently.
- Members have been selected and the first meeting is due to take place on 16 May.

# Scientific Achievements

**546 publications (XI/16)**

**Platform Release
March 30, 2016**



Henry Markram:
New Bell Labs
Shannon
Visionary
Award, 2016

Jean-Pierre
Changeux:
Olav Thon Award,
2016

www.humanbrainproject.eu

/TheHumanBrainProject

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Please send your questions to: k.amunts@fz-juelich.de