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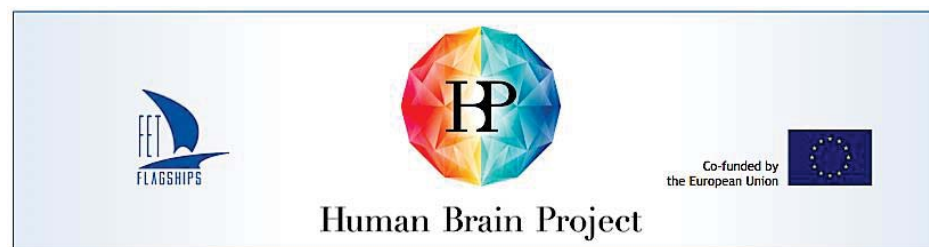


Modeling the Brain: The Human Brain Program at a glance Platforms & Ethics

Jean-Pierre CHANGEUX

Deputy-leader SP 12 Ethics and society





New scientific board July 2016

SIB Members	SP2 Leader / Scientific Research Director (SIB chair)	Katrin AMUNTS (KA)
	SP10 Leader / Software Development Director (SIB vice-chair)	Alois KNOLL (AK)
	SP9 Leader / Infrastructure Operations Director (SIB vice-chair)	Karlheinz MEIER (KM)
	SP1 Leader	Javier DEFELIPE (JD)
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	SP6 Leader	Henry MARKRAM (HM)
	SP7 Leader	Thomas LIPPERT (TL)
	SP8 Leader	Ferath KHERIF (FK)
	SP12 Leader	Kathinka EVERS (KE)
Guests	Minutes Taker / SP2 Manager	Sabine BRADLER (SB)
	SP11	Martin TELEFONT (MT)

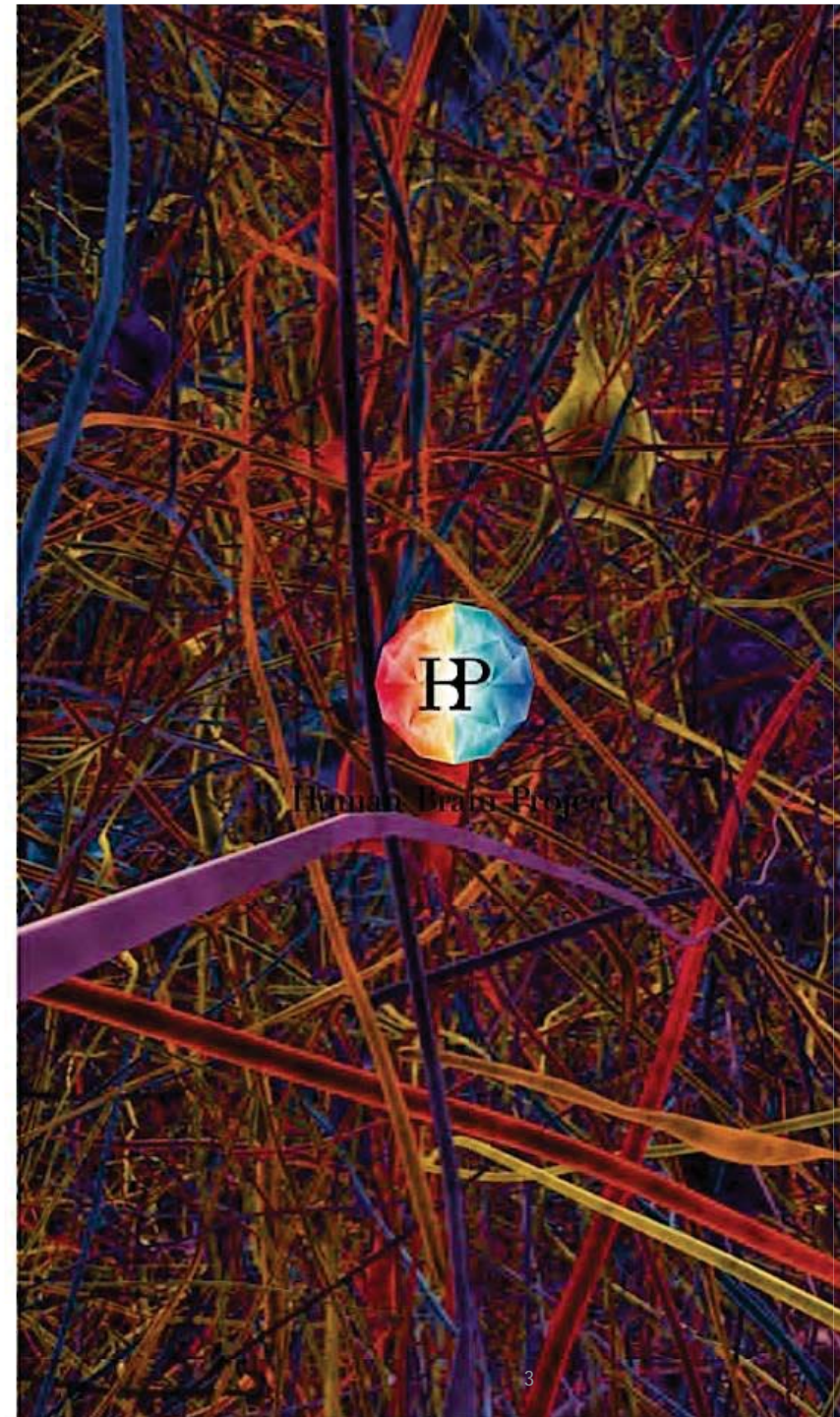
Human Brain Project Vision

Understanding the human brain is one of the greatest challenges facing 21st century science.

If we can rise to the challenge, we can **gain profound insights into what makes us human**, develop **new treatments** for brain diseases and build **revolutionary new** computing and robot technologies.

Today, for the first time, modern ICT has brought these goals within sight.

HBP is a European Flagship project to **create** and **operate** collaborative research tools for brain research, and brain-inspired technologies



HBP at a glance

Future Emerging Technology (FET) Flagship

10-year, **EUR 1 billion** Research Roadmap

50% Core Project, 50% Partnering Projects

Biggest EU ICT project: HBP uses ICT funding

Focus

future neuroscience, medicine, computing/robotics

Ramp-up Phase (2 ½ years)

FP7 (54 million EUR)

750+ scientists,

114 institutions,

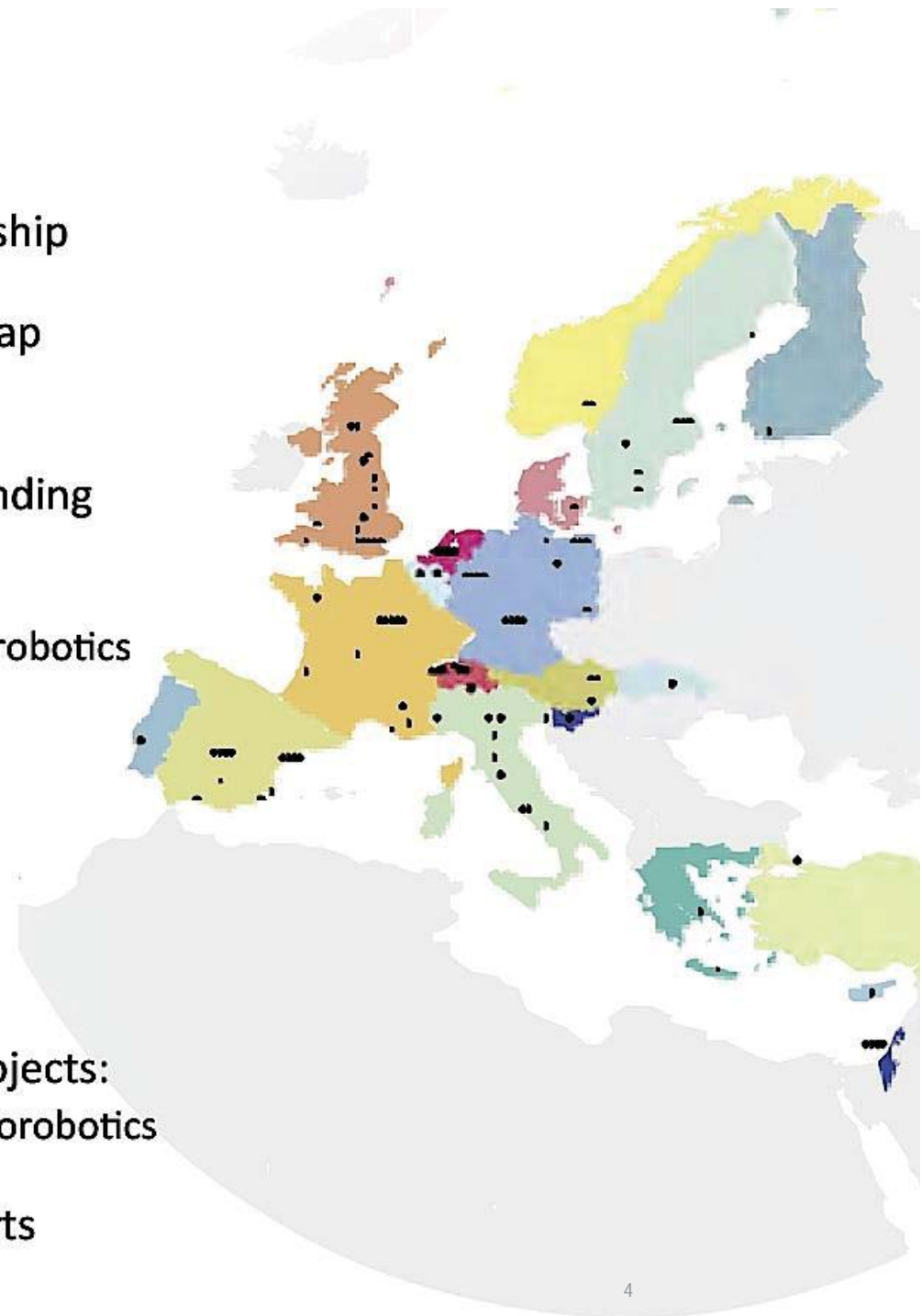
24 countries, mainly Europe & Americas/Asia

Builds on pre-existing EU & national projects:

Blue Brain, BrainScaleS, JSC, SpiNNaker, Myorobotics

Interfaces with EU & international efforts

PRACE, US BRAIN initiative, ...



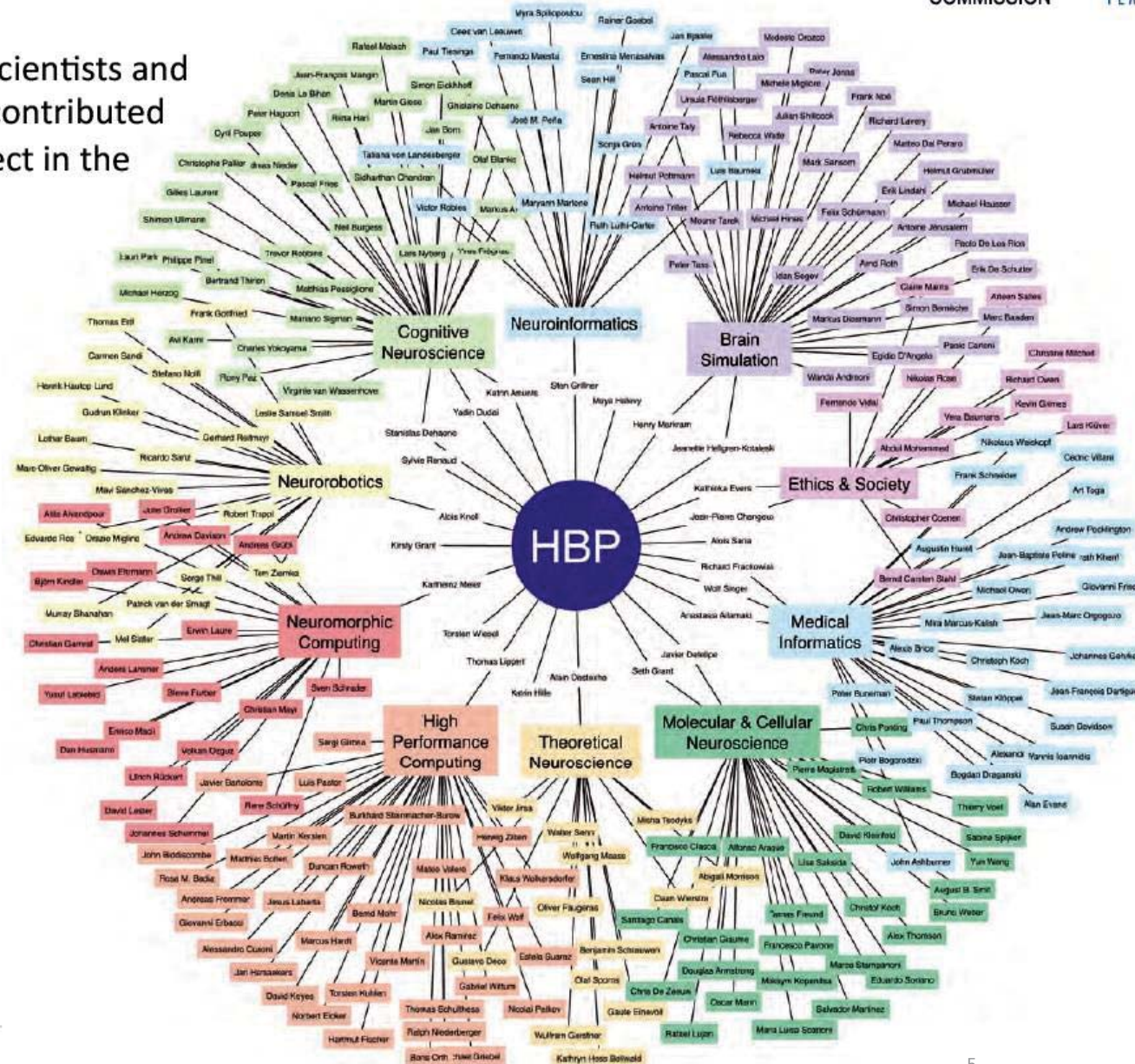
The HBP Consortium



- More than 750 scientists and engineers have contributed to the Core Project in the Ramp-up phase

- 60-70% Core
- 30-40% Grants

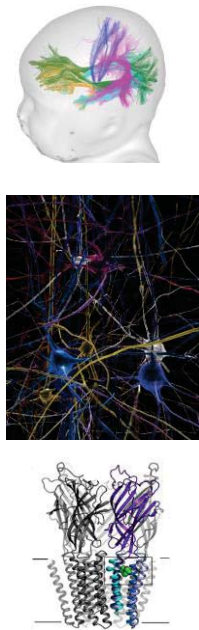
- USA
- Israel
- Japan
- China
- Canada



HBP A Major Epistemological Challenge

multiple spatial- & time-scales levels in brain organisation & function

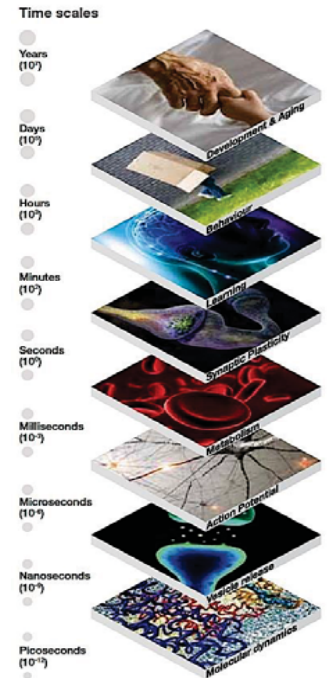
structure



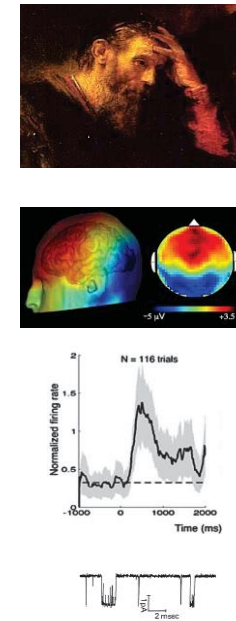
space



time



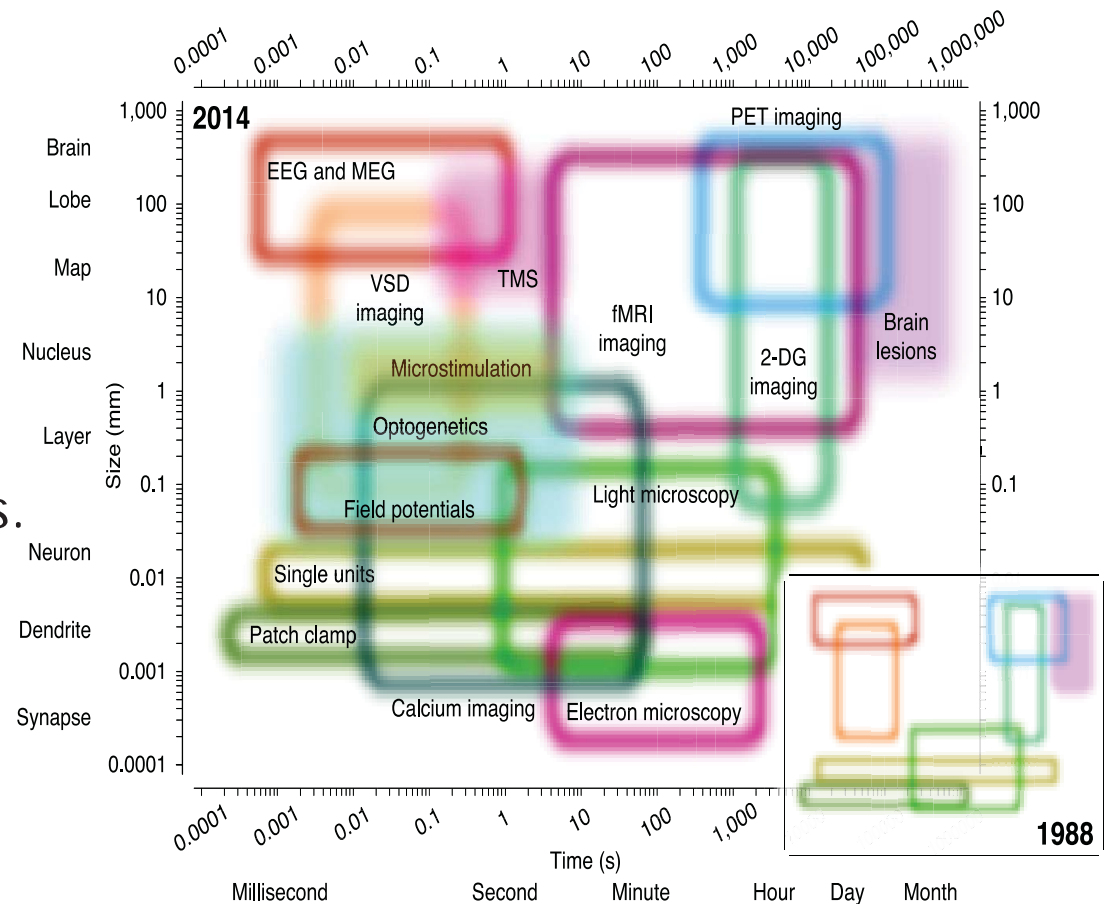
function







nested evolutionary processes:
integrated simulation of brain structure, functions & behavior
 from molecular up to cognitive level & conversely

HBP Flagship Objectives (from SGA1)

1. Create & operate a European scientific Research Infrastructure for Brain Research
2. Build multi-scale scaffold theory and models for the brain.
3. Simulate the available brain models.
4. Gather, organise/disseminate data describing the brain & its diseases.
5. Develop brain-inspired computing, data analytics & robotics.
6. Ensure HBP work is undertaken responsibly & benefits society.





4 mainly Neuroscience Subprojects

Subproject	Role within HBP
 SP1 Mouse Brain Organisation	Understand better the structure of the mouse brain, from molecular to whole brain level, including its electrical and chemical signalling mechanisms
 SP2 Human Brain Organisation	Understand better the structure of the human brain, from molecular to whole brain level, including its electrical and chemical signalling mechanisms
 SP3 Systems & Cognitive Neuroscience	Understand better how the brain performs its systems level and cognitive functional activities
 SP4 Theoretical Neuroscience	Derive high-level mathematical models to synthesise conclusions from research data

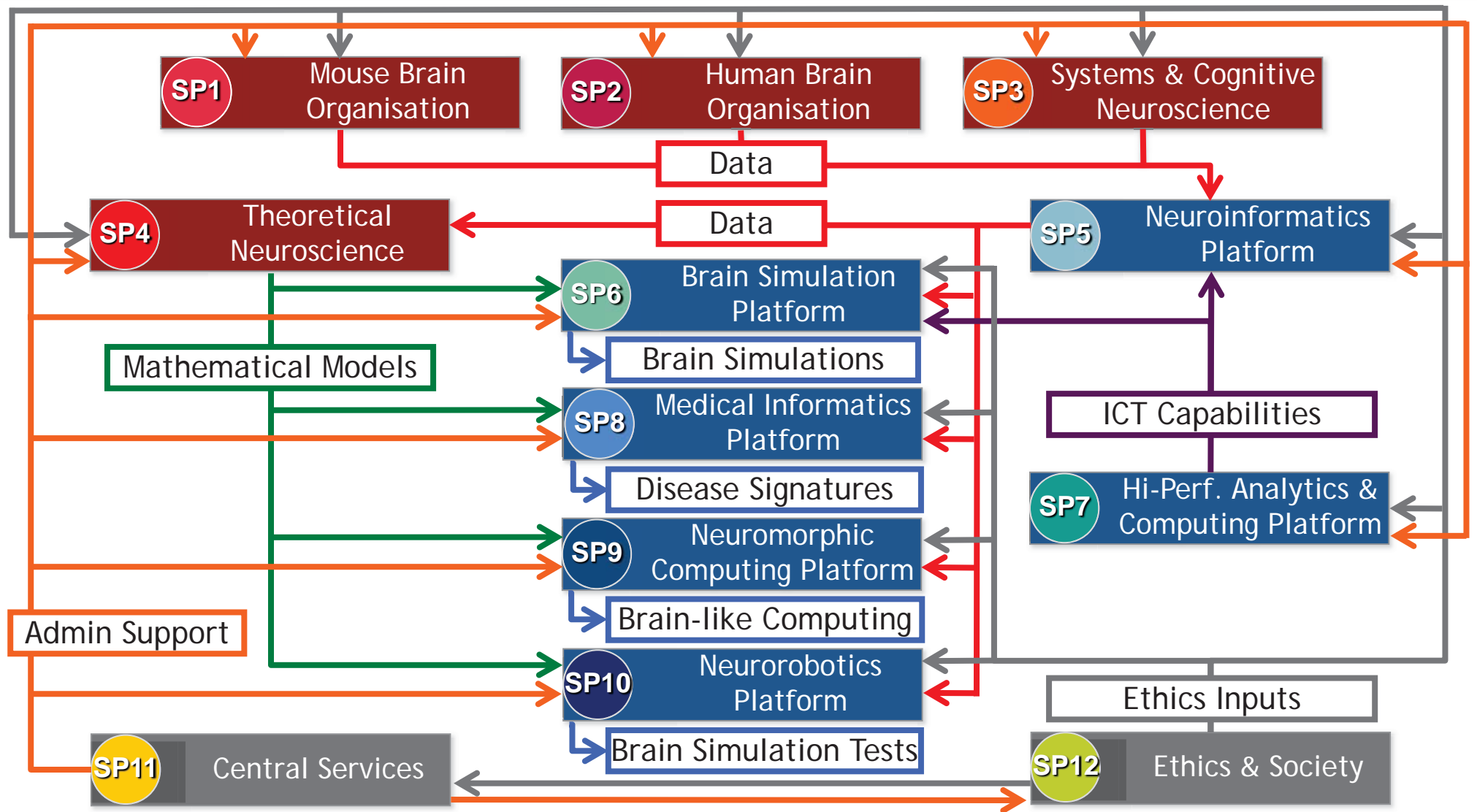
6 mainly Infrastructure Subprojects

Subproject	Role within HBP
SP5 Neuroinformatics Platform	Gather , organise and make available brain data
SP6 Brain Simulation Platform	Develop data-driven reconstructions of brain networks and simulation capabilities to explore them
SP7 Hi-Perf. Analytics & Computing Platform	Provide ICT capability to map the brain, construct complex models, run large simulations and analyse large volumes of data
SP8 Medical Informatics Platform	Develop infrastructure to share hospital and medical research data, to help understand disease clusters and their signatures
SP9 Neuromorphic Computing Platform	Develop and apply brain-inspired computing technology
SP10 Neurorobotics Platform	Develop virtual and real robots and environments for testing brain simulations

2 mainly Supporting Subprojects

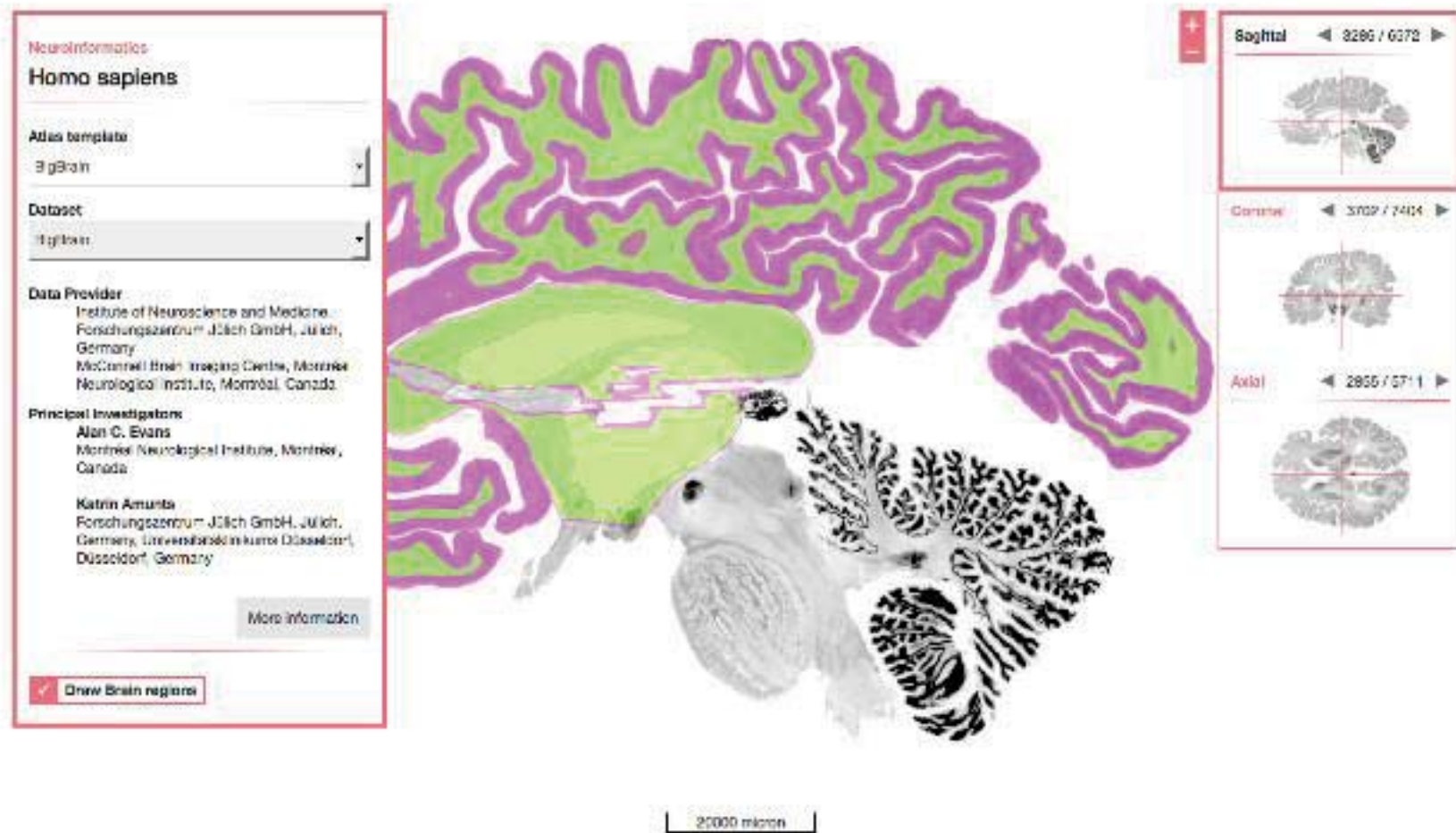
Subproject	Role within HBP
 SP11 Central Services	Budgets, funding proposals, contracts, liaison with EC, internal standards, project management, dissemination, education programme, etc.
 SP12 Ethics & Society	Explore the ethical and societal impact of the HBP's work; provide ethics management and compliance

How the HBP Subprojects fit together

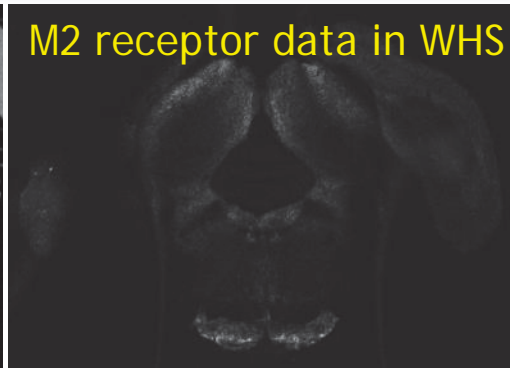
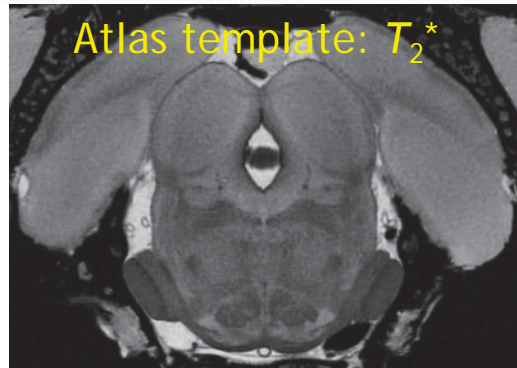


SP5 Neuroinformatics Platform (Deputy Leader S Grillner)

- Objective: to organize and standardize a vast array of *neuroscience data* types to ensure *access* and *use* through brain atlases and other specialized databases.

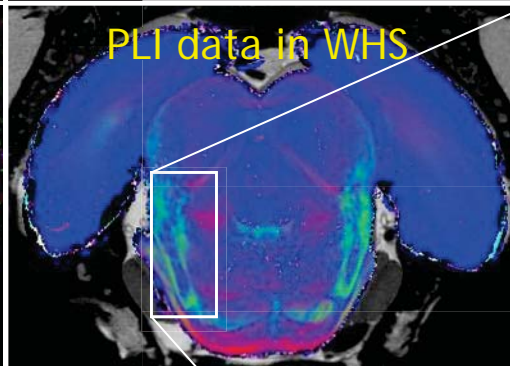
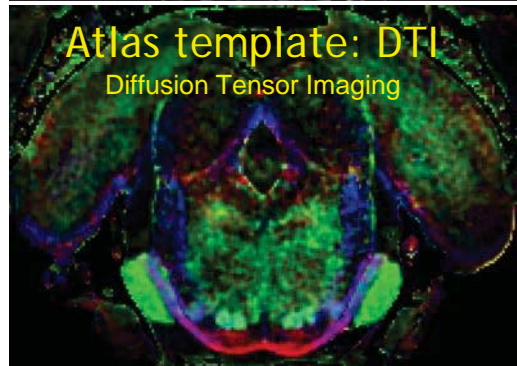


SP5 Neuroinformatics Platform



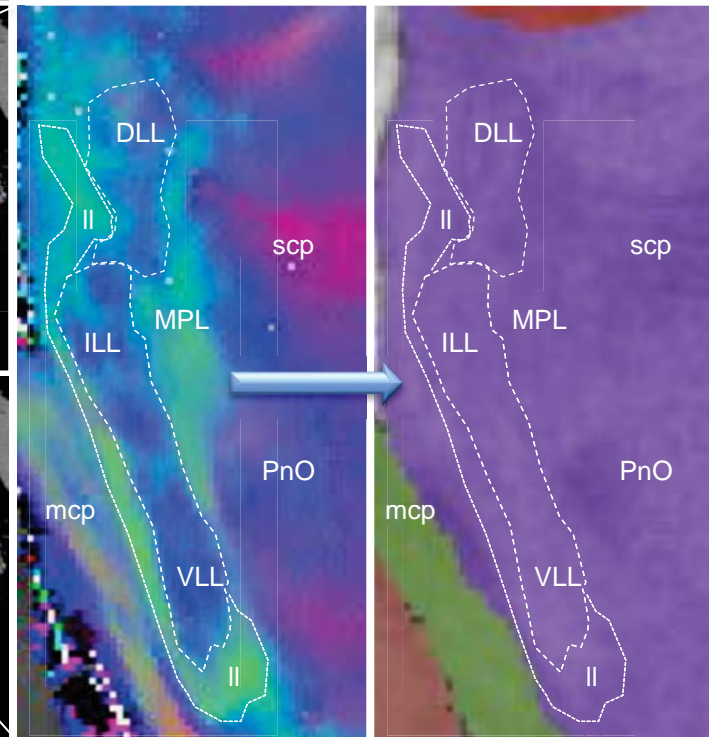
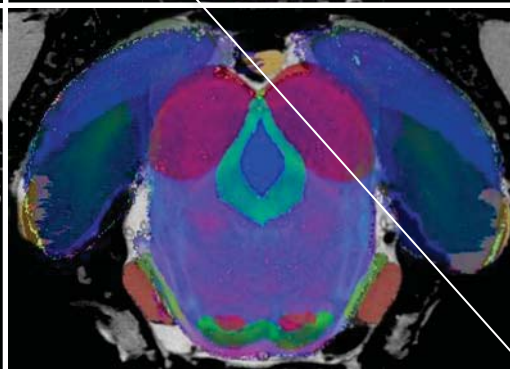
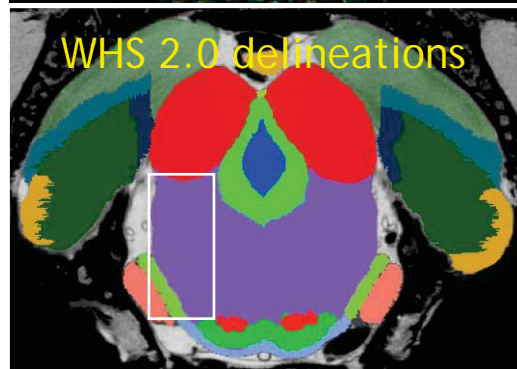
Data enriched atlas with use of M2 receptor and PLI data in standardized atlas space

SP1



Example: use of PLI data in delineation of auditory pathways

SP2



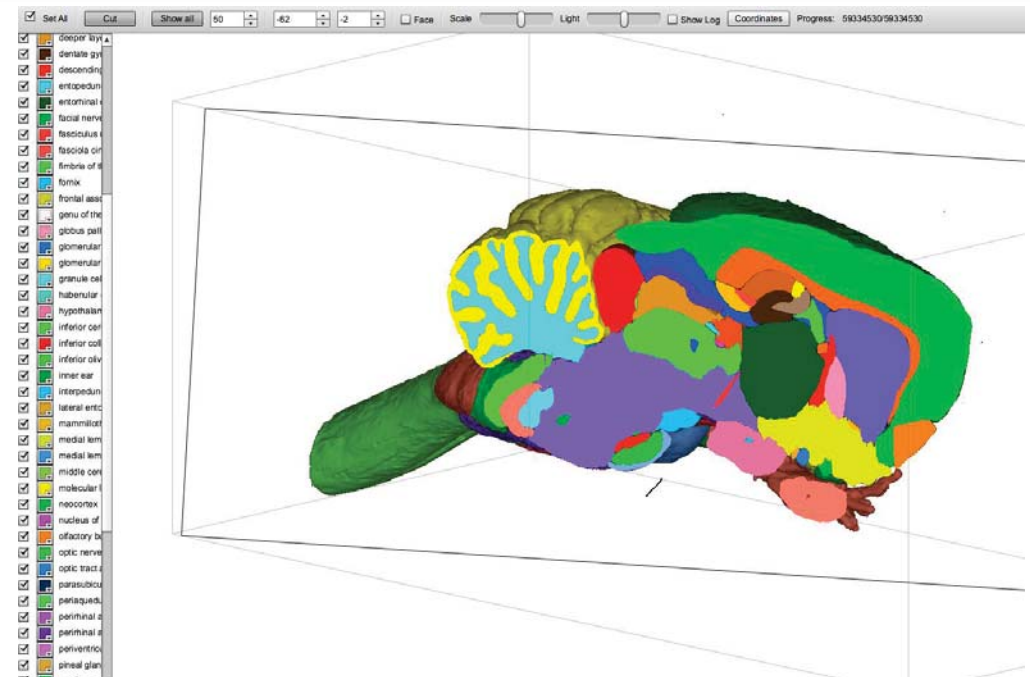
Getting Access

Web Accessible

- Access the Neuroinformatics Platform through the HBPMore information the application process is available in the HBP Collaboratory:

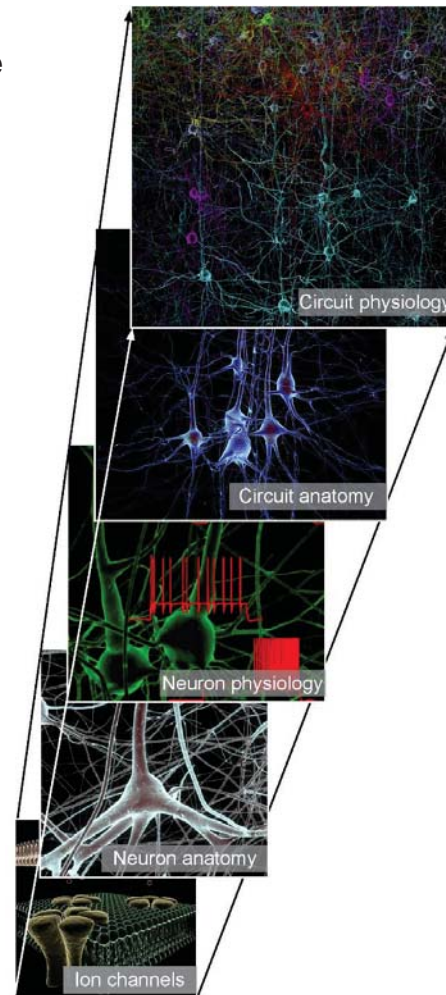
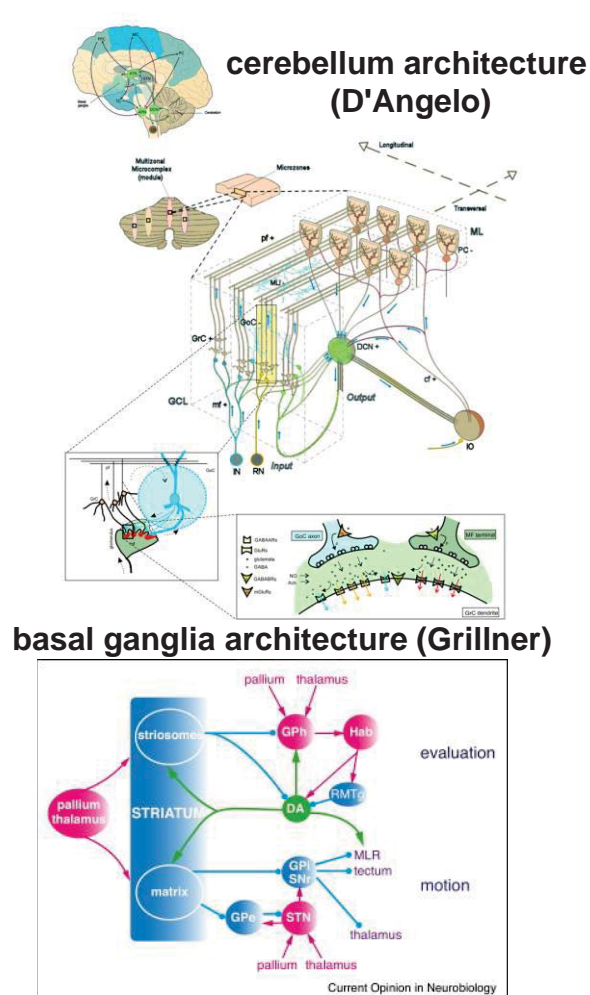
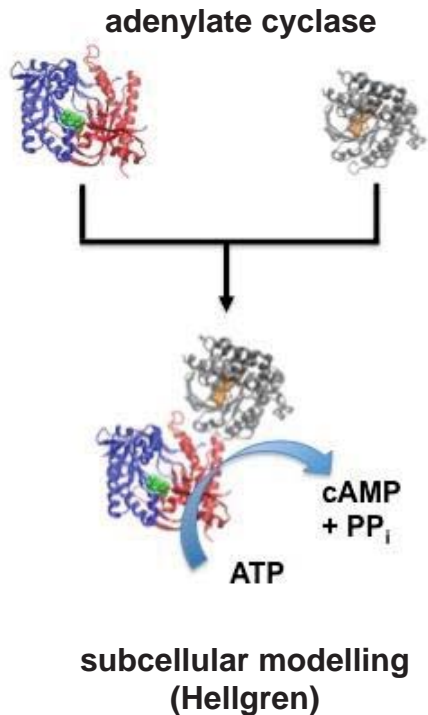
<https://collab.humanbrainproject.eu/#/collab/264/nav/330>

- Numerous other tools are available as **OpenSource** via the Collaboratory Software Catalogue.

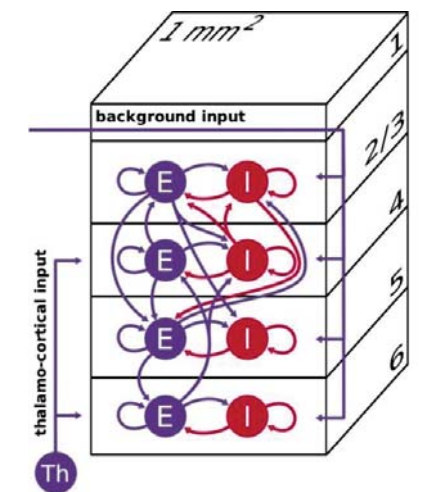


SP 6 Brain Simulation Platform (Leader H Markram)

- Objective: to develop **Applications, Application Programming Interfaces, and Foundation Software** to support productive collaborations to *build, simulate, analyze, validate* and disseminate *data-driven brain models* at many scales



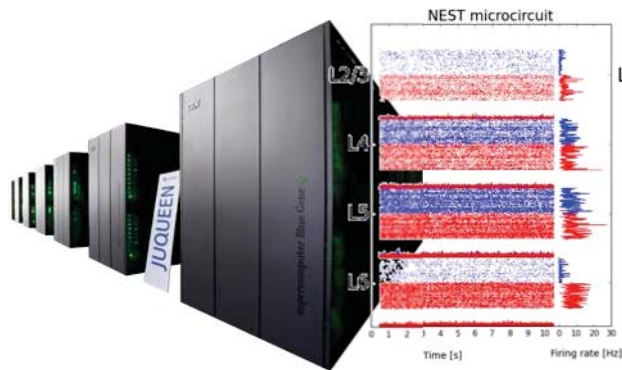
cortical reconstruction workflow (Markram)



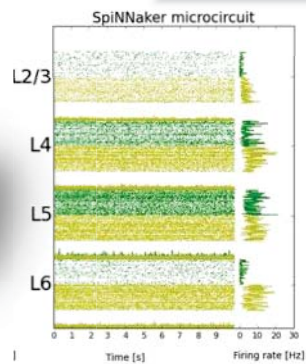
point neuron multi-layer cortical model (Diesmann)

SP7 Hi-Perf. Analytics & Computing Platform

(Leader T Lippert)



Single Sign-on to Collaboratory and HPAC Platform
exascale supercomputer simulations



Data transfer: from supercomputer & external sites into Collab storage

From desktop to high-fidelity systems

Simulation

Analysis

Visualisation



HBP Collaboratory <https://collab.humanbrainproject.eu/#/collab/264/nav/3304>

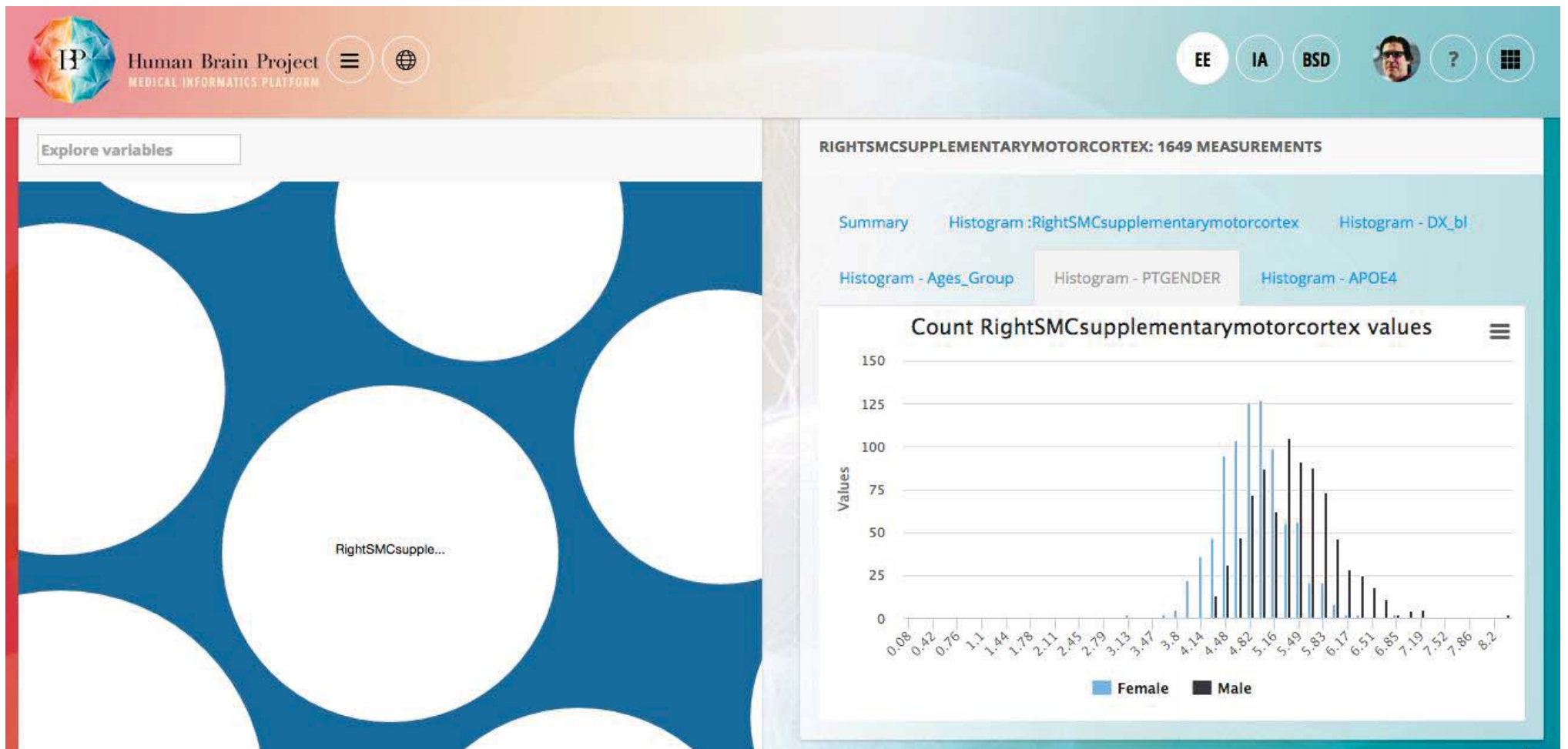


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SP8 Medical Informatics Platform (leader Ferath Kherif)

- Objective: to *federate* human *research* and *clinical data* and provide the *tools* to the experts to effectively analyse it and advance more rapidly in *understanding* neurological and psychiatric *diseases*.



SP9 Neuromorphic Computing Platform

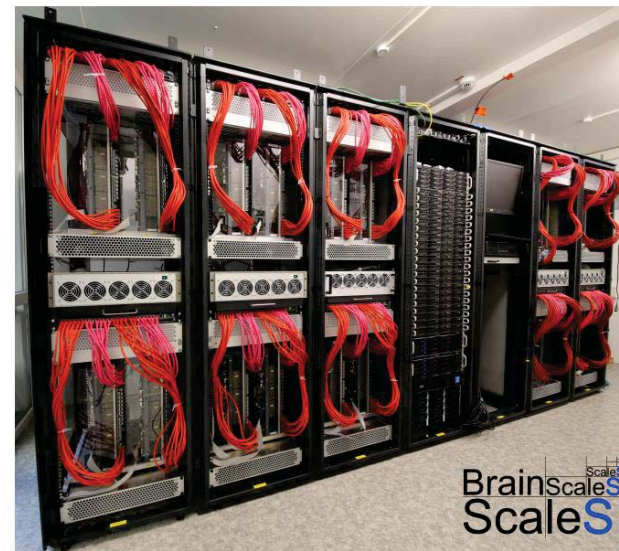
(Leader Karlheinz Meier)

- Objective: Develop, operate and maintain *two* custom *complementary neuromorphic machines* for modelling neural microcircuits and applying *brain-like principles in machine learning and cognitive computing*



- SpiNNaker - Manchester (UK)
- 0.5 Million digital ARM processors with novel address-event-based, small packet, asynchronous communication
- Real-time neuromorphic simulation

- BrainScaleS - Heidelberg (Germany)
- Local *analogue* computing with binary, asynchronous communication
- 4 Million neurons and 1 Billion plastic running synapses
- 10000 real-time neuromorphic simulation



Next Generation Neuromorphic Chip Prototypes

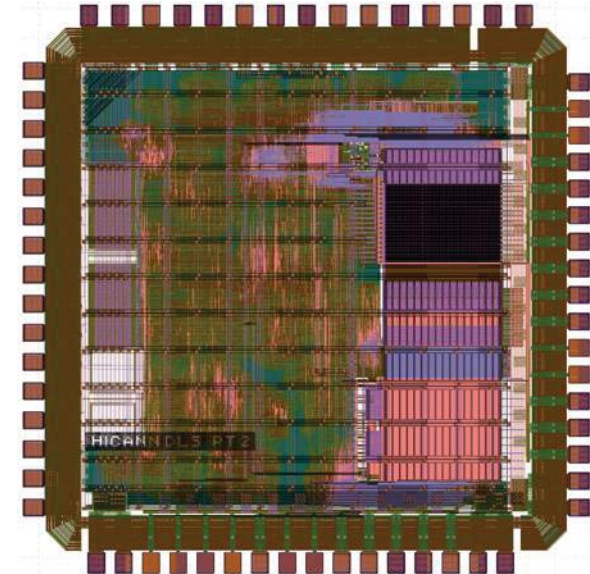
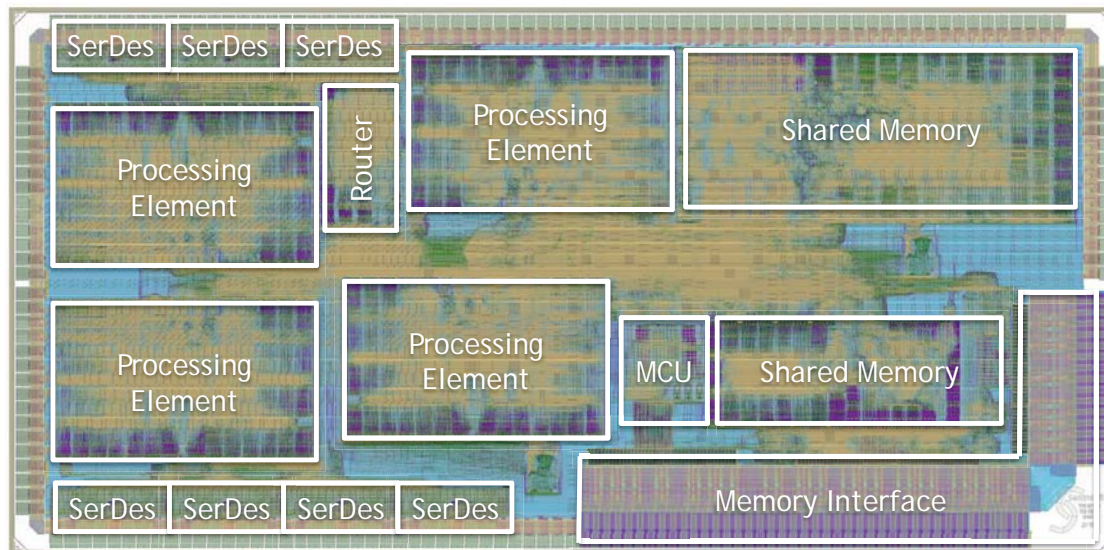
SpiNNaker 2

Power Management
Floating point precision
True random numbers



BrainScales 2

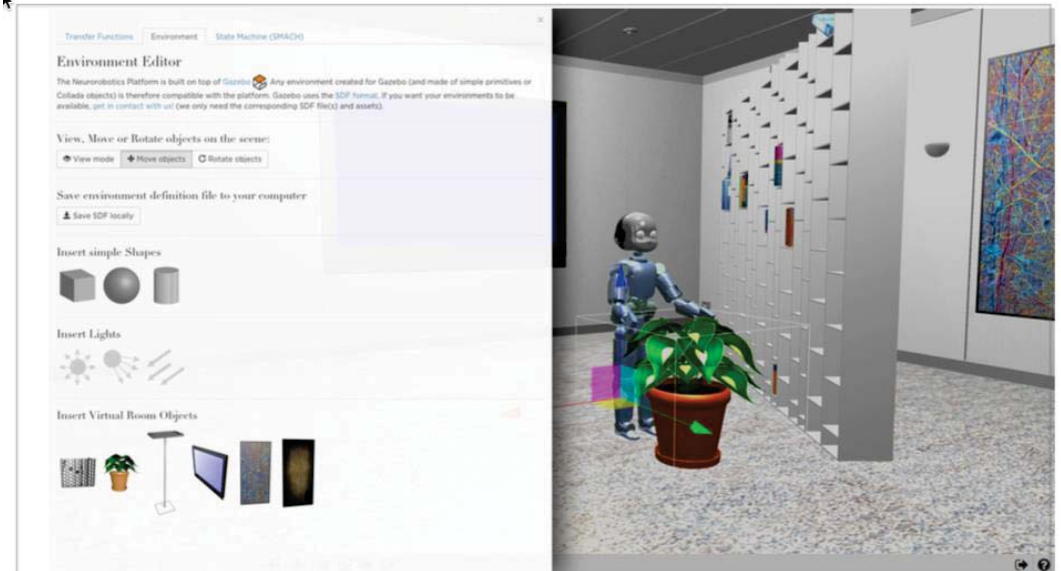
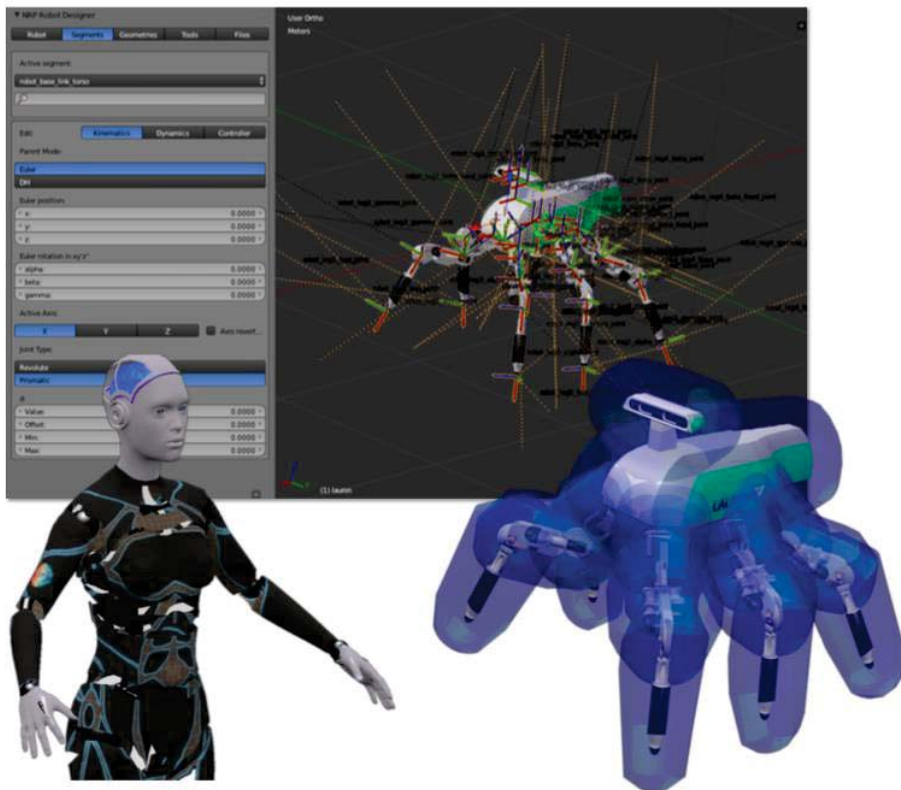
PowerPC plasticity processors
Flexible local learning rules
Improved parameter storage



- Chip prototypes designed, produced and tested during the ramp-up phase
- Close collaboration with **SP4** and **WP11.3** for requirements (EITN and Fürberg Workshops)
- **Major common emphasis : Strongly improved plasticity, learning capabilities**
- **Getting ready for CDP5 and applications in cognitive computing**

SP10 Neurorobotics Platform (Leader Alois Knoll)

Objective: To develop and operate a suite of powerful *web-based applications* for performing *complex neuro-robotics experiments*. It provides a *Robot Designer*, an *Environment Designer*, and *Designers for Experiments and Brain Interfaces and Body integrators (BIBI)*.



Robotic simulation cluster availability: **22/34**



Empty Template iCub experiment

This experiment loads the iCub robot in an empty world, with an idle brain and basic transfer functions. You are free to edit it...



Husky Braitenberg experiment

SP10 Neurorobotics Platform

With the Neurorobotics Platform, researchers can collaboratively design and run virtual experiments in cognitive neuroscience using brain models developed within and outside the Human Brain Project.

The Neurorobotics platform provides software and hardware tools for researchers to demonstrate how brain models can control robots in complex environments.

SP6

SP7

SP9

SP11



SP12 HBP Ethics and society

The Society and Ethics Pillar

Jean-Pierre Changeux, Paris Yadin Dudai, Rehovot

**First meeting in preparation for the FET Flagship Program
Lausanne, July 28 2010**

Original mission of the HBP "Society and Ethics pillar" among the other 14 SPs of HBP
to ensure upstream engagement of the project with its ethical and social aspects

**...to support the implementation of Responsible Research and
Innovation in HBP.**

SP12 Ethics & Society budget 2017 4 million euros

SP12 Organization and Specific Aims

SP 12 Leader Kathinka Evers (SE) & Deputy Leader Jean-Pierre Changeux

ANTICIPATION: Foresight analyses of social and ethical concerns

Nikolas Rose, S Warr, C Aicardi, M Reinsborough Imperial College London

Identifies potential ethical and social concerns at an early stage by **producing scenarios of potential developments and implications**, and feeds these back to the HBP researchers to build capacity to adapt to differing uncertain futures

REFLECTION: Conceptual analyses and researcher awareness

Kathinka Evers, A Salles, M Farisco, K Sallin Uppsala University - Jean-Pierre Changeux Pasteur Paris

Performs **philosophical, ethical and social analyses of HBP key activities and issues**, thereby contributing to the conceptual and epistemological development of neuro- and computational sciences; and the reflective capacity of HBP researchers and others in addressing societal implications.

ENGAGEMENT: Public and stakeholder dialogue and feed-back

Lars Kluver, L Egsdal, L Bitsch, K Riisgaard, K Dollerup Copenhagen Tekno Institute

Engaging and debating with a range of public communities and stakeholders, in an open and transparent manner, the implications of the work of the HBP in order to feedback the priorities and concerns by citizens into the project

ACTION: Strategic pathways to social benefit

Kevin Grimes, S Patel, Abdul Mohammed Karolinska Institute Stockholm

To integrate anticipatory ethical and social foresight, conceptual reflection, and public concerns into the management and strategy of the HBP itself by feeding the priorities and concerns of citizens and researchers into the project

SP12 Organization and Specific Aims

WP12.1 The Foresight lab Leader Nikolas Rose

Data federation, data protection & privacy

Future Challenges

Informed consent in patients with brain disorders?

Disease signatures & personalised medicine

Future Challenges

Legal implications for specific disease signatures
Working with stakeholders to decide if/how
to implement in clinical settings

Building a Modelling Community for Future Neuroscience

Challenges

Multiple modelling communities with different
methods, design approaches, scales, species
(how to bridge scales, coherence..)

Future ICT and Robotics

Challenges

Don't design the human out of the technology

Recognise that the living brain is in constant interaction
with its interpersonal and social environment

Recognise both benefits and limits of displacement of
human labour by robots etc

SP12 Organization and Specific Aims

WP 12.2 Neuroethics & Philosophy Task leader K Evers with JP Changeux

Simulation (with Yadin Dudai)

taxonomy of simulation and the goals of computer brain simulation within it

Challenge

scarcity of neurobiological data; epistemic opacity
representational parsimony; contextual factors

Dudai Y. & Evers K, To Simulate or Not to Simulate: What Are the Questions?,
Neuron (2014) 84: 254-61.

Synaptic epigenesis & brain cultural imprinting (with JPC)

the concept of “epigenetic rules”, the selection of cultural circuits in the brain
during development & the transmission of cultural imprints.

Challenge

Genesis of novel ethical rules: is there a universal

Evers, K. & Changeux, J-P. ^{ethics?} Proactive epigenesis and ethical innovation
EMBO reports (2016) *in press*

Drug design & innovation (JPC with Paolo Carloni creation of CDP6)

social & ethical issues about current scientific & political strategies of drug innovation

Challenge

Ethical urgency to discover new drugs against brain diseases

SP12 Organization and Specific Aims

Dual use: a new interface between brain and technologies

no Ethics committee no International declaration or regulation about new technologies...engineering, robotics, informatics ... and their military applications

«**NEURON**» **COMBAT DRONE** which let France be competitive with the US...

(La Tribune 2015)



Five partners: Italy, Sweden, Spain, Greece, Switzerland.
cost 406 millions euros

dual use becomes a real concern for research at interface brain science and informatics e.g. autonomous weapons systems, mind reading, cyber war...

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