



Human Brain Project

How model standardization enables new tools and applications in neuroscientific research

Insights from the HBP

Yann Zerlaut

Neuroinformatics team / group of A. Davison

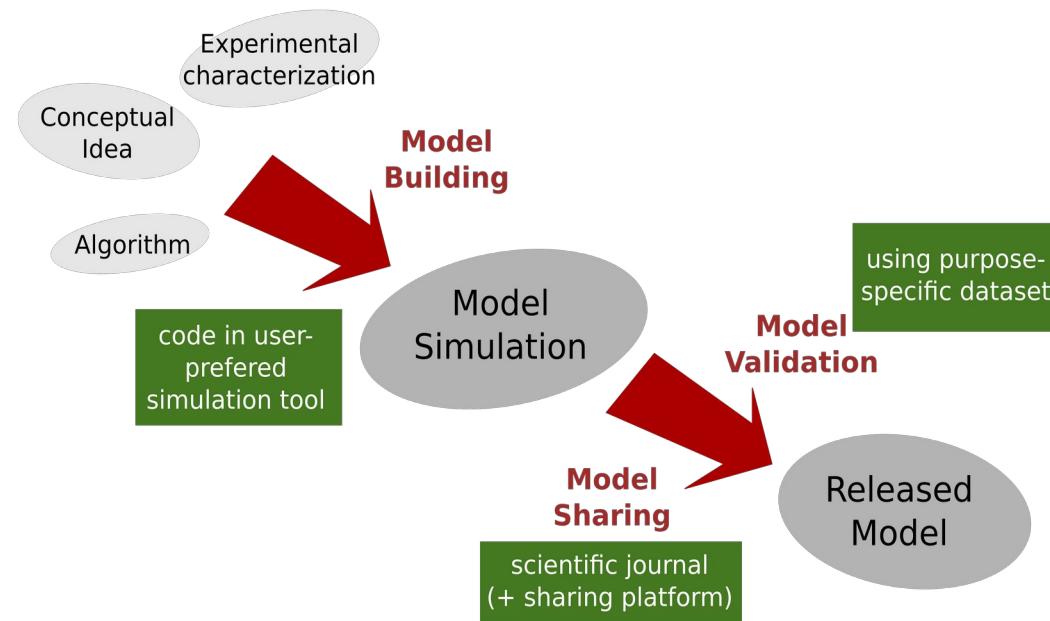
Centre National de la Recherche Scientifique, France



Open Source Brain Meeting 2019, Alghero

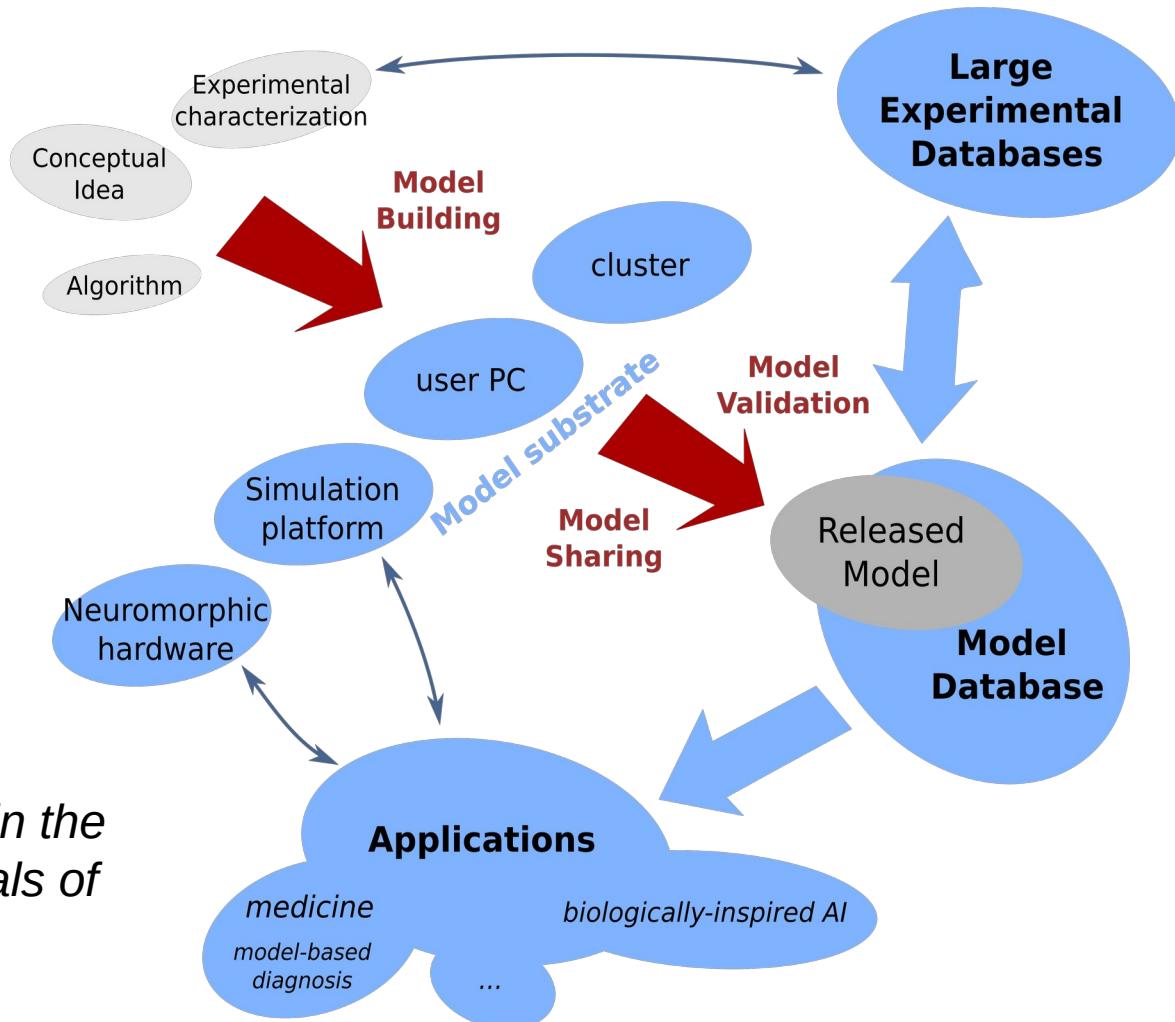


Motivation



A typical model production pipeline in neuroscientific research

Motivation

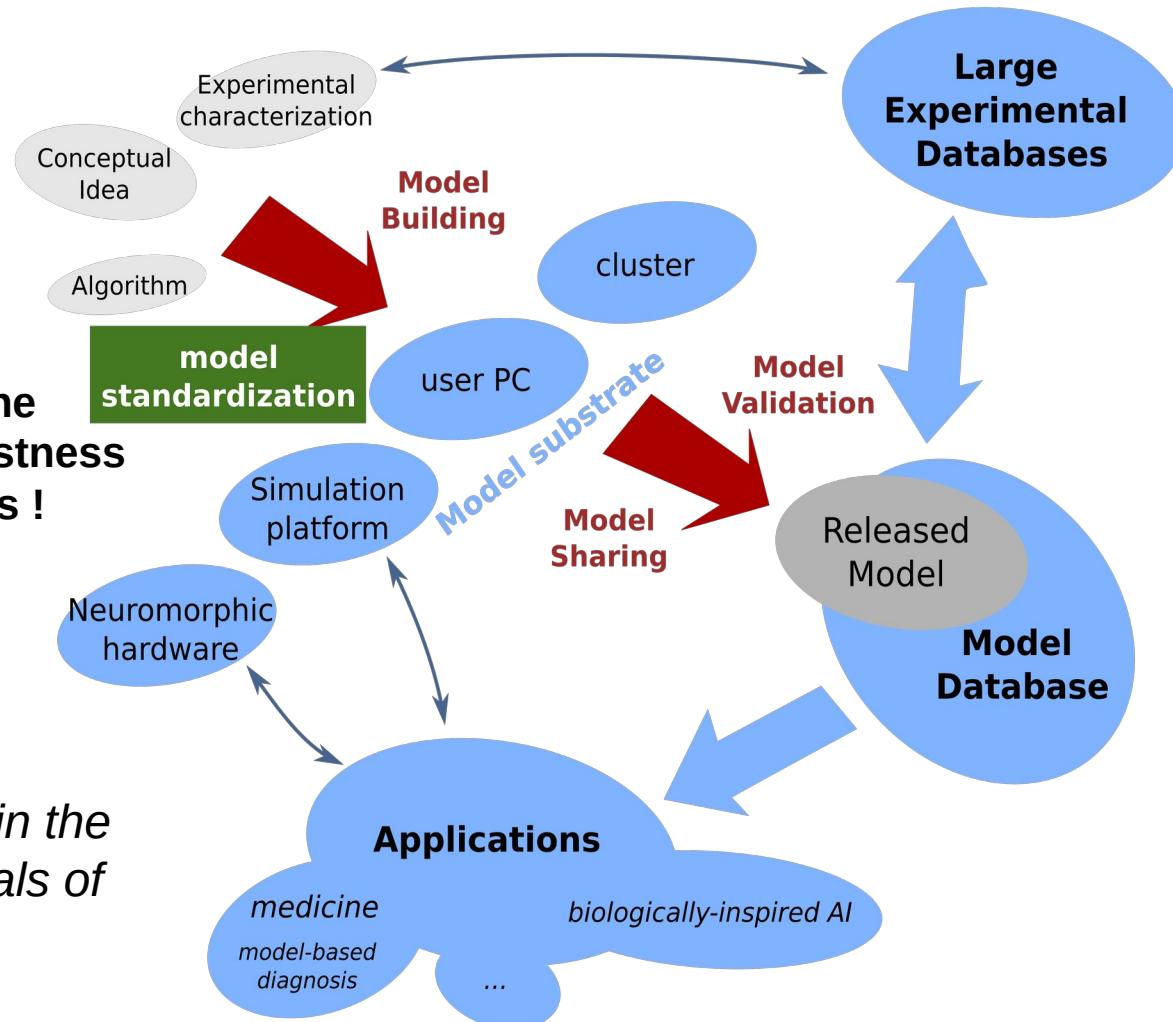


Model production pipeline within the infrastructure and research goals of the Human Brain Project

Motivation

decisive to insure the feasibility and robustness of the entire process !

Model production pipeline within the infrastructure and research goals of the Human Brain Project



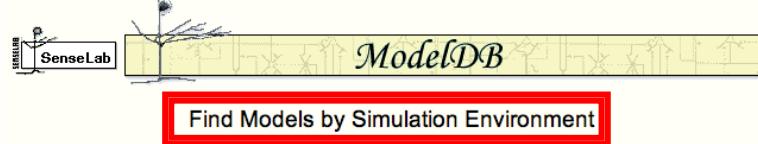
Overview

I) Model standardization:

- **model building**
 - PyNN
 - Sonata (pyNN.Sonata)
 - SciUnit
- **model release/sharing**
 - Model Catalog
 - Knowledge Graph
 - Live Papers

II) New tools and applications:

- Neuromorphic hardware
- Neurorobotics
- Brain Simulation Platform
- **Model Validation framework**



Click on a link to show a list of models implemented in that simulation environment or programming language.

Simulation Environment	Homepage	Number of models
BioPAX (web link to model)		1
Brian		4
C or C++ program		34
C or C++ program (web link to model)		19
CONTENT		1
CSIM		1
CSIM (web link to model)		3
CaLC Calcium Calculator		1
CaLC Calcium Calculator (web link to model)		7
Catacomb (web link to model)		1
CellExcite (web link to model)		1
CellML		0
CellML (web link to model)		1
Chemosis		2
Dynamics Solver		1
Emergent/PDP++		3
FORTRAN		4
FORTRAN (web link to a model)		1
GNUstep NextStep/OpenStep		1
Genesis		13
Genesis (web link to model)		7
iChMAScot		0
IGOR Pro		3
IonChannelLab		0
Java		5
Java (web link to model)		2

KiNeSS (web link to model)		1
L-Neuron		0
MATLAB		67
MATLAB (web link to model)		34
MCcell		1
MOOSE/PyMOOSE (web link to method)		1
MVA Spike		1
MedSim		1
NCS		1
NEST (formerly BLISS/SYNOD)		2
NEURONPM (web link to tool)		2
NSL		0
Neosim		0
Network		1
NeuGen		0
Neuron		261
Neuron (web link to model)		14
NeuronC		0
NeuroneExperimenter (web link to model)		1
Octave		1
PCSIM		1
PSice		2
Pascal (web link to model)		1
Pascal/Delphi		2
PyNN		2
Python		5
Python (web link to model)		1
QBASIC/QuickBasic/Turbo Basic		2
QuB		1
R (web link to model)		1
SABER		1
SBML (web link to model)		1
SNNAP		21
SciLab		1
Scilab (web link to model)		2
Simulink		6
Spice Symbolic SPICE		1
Surf-Hippo		0
Synthesis		0
Topographic		0
Topographic (web link to model)		1
Virtual Cell (web link to model)		3
XML (web link to model)		3
XNBC		0
XPP		50
XPP (web link to model)		7
neuroConstruct (web link to model)		1
parplex		2

Simulator diversity: problems and opportunities

Cons

- Considerable difficulty in translating models from one simulator to another...
- ...or even in understanding someone else's code.
- This:
 - impedes communication between investigators,
 - makes it harder to reproduce other people's work,
 - makes it harder to build on other people's work.

Pros

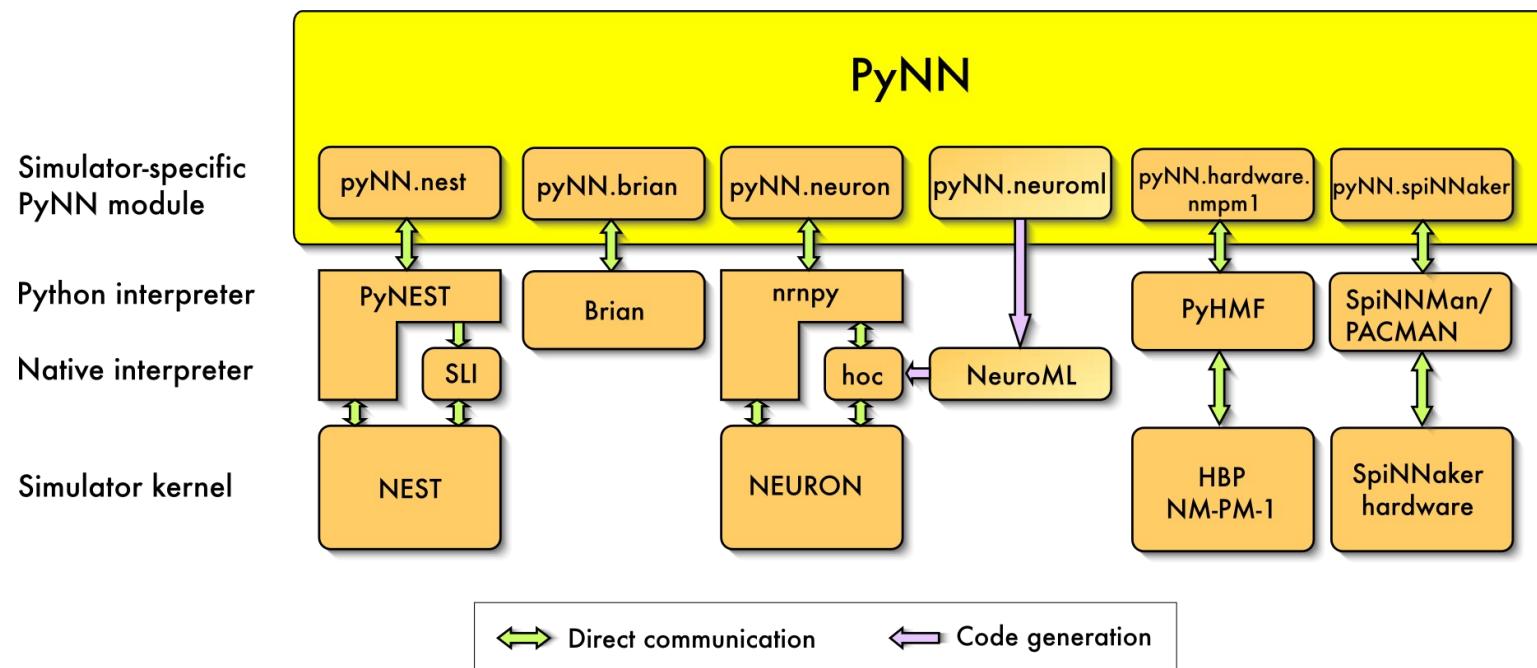
- Each simulator has a different balance between efficiency, flexibility, scalability and user-friendliness → can choose the most appropriate for a given problem.
- Any given simulator is likely to have bugs and hidden assumptions, which will be revealed by cross-checking results between different simulators → greater confidence in correctness of results.

**Simulator-independent environments
for developing neuroscience models:**

- keep the advantages of having multiple simulators or hardware devices
- but remove the translation barrier.

Three (complementary) approaches:

- GUI (e.g. neuroConstruct)
- XML-based language (e.g. NeuroML, NineML)
- interpreted language (e.g. Python)



Sonata (pyNN support)

Large-scale simulation of biophysically-detailed neuronal circuits
→ sets specific constraints

the SONATA Data Format emerges as the standard optimized for performance for simulation, analysis and visualization of large-scale circuits

(joint initiative of Blue Brain Project and the Allen Institute for Brain Science)

Export to Sonata format

```
from pyNN.network import Network
from pyNN.serialization import export_to_sonata

sim.setup()
...
# create populations, projections, etc.
...
# add populations and projections to a Network
net = Network(pop1, pop2, ..., prj1, prj2, ...)

export_to_sonata(net, "sonata_output_dir")
```

Import from Sonata format

```
from pyNN.serialization import import_from_sonata, load_sonata_simulation_plan
import pyNN.neuron as sim

simulation_plan = load_sonata_simulation_plan("simulation_config.json")
simulation_plan.setup(sim)
net = import_from_sonata("circuit_config.json", sim)
simulation_plan.execute(net)
```

Include a validation framework in model development

✓ **What is SciUnit?**

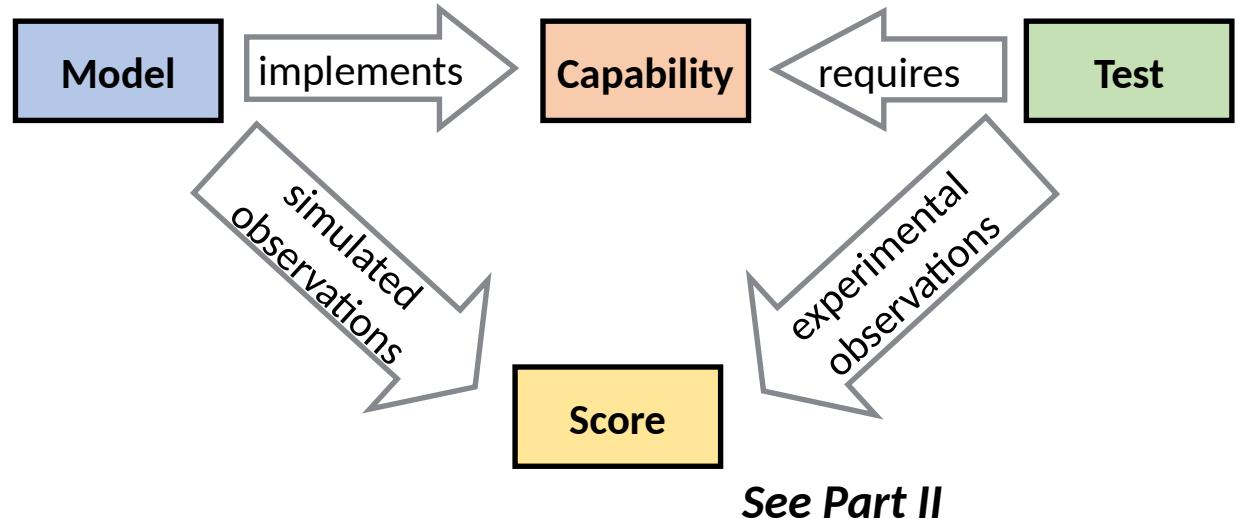
A **Test**-driven framework for formally validating scientific models against data.
It employs the concept of **Capabilities**.

✓ **What are Tests?**

A procedure intended to establish the quality, performance, or reliability of a model

✓ **What are Capabilities?**

- *interfaces through which the model and the validation framework communicate*
- *implemented as methods (functions) within the model*



See Part II

Requires the participation of modellers:

- ✓ support to wrap your models for SciUnit
- ✓ add/request new tests to the library
- ✓ critique existing tests
- ✓ suggest new features

Model Catalog App

Hosts the models developed and/or used within the ecosystem of tools provided by the HBP Platforms

The screenshot shows the 'Model Catalog' application interface. At the top, there are several dropdown menus labeled 'Select:' followed by 'species', 'brain region', 'cell type', 'model scope', 'abstraction level', 'Select organization', 'Select privacy', and 'Select collab'. Below these is a 'Search:' input field and a 'Sort:' dropdown set to 'Newest first'. A 'Help' link is located in the top right corner. The main area is titled 'Model Catalog' and contains a table with the following columns: Name, Alias, Species, Brain region, Cell type, Model scope, Abstraction level, Author(s), Organization, and Collab ID. The table lists five entries:

Name	Alias	Species	Brain region	Cell type	Model scope	Abstraction level	Author(s)	Organization	Collab ID
Rall Morphology Model for Layer 5 Pyramidal Cells in Mouse V1	Rall-Morpho-L5PyrMouseV1	Mus musculus	cerebral cortex	L5 tufted pyramidal cell	single cell	spiking neurons	Zerlaut Yann	HBP-SP5	60843
msn_d2_morphologies		Mus musculus	striatum	medium spiny neuron (D2 type)	single cell	spiking neurons: biophysical	Alexander Kozlov	HBP-SP6	6351
msn_d1_morphologies		Mus musculus	striatum	medium spiny neuron (D1 type)	single cell	spiking neurons: biophysical	Alexander Kozlov	HBP-SP6	6351
fs_morphologies		Mus musculus	striatum	fast spiking interneuron	single cell	spiking neurons: biophysical	Alexander Kozlov	HBP-SP6	6351
str-fs-161205_FS1-BE37A-20180212		Mus	striatum	fast spiking	single cell	spiking	Alex	Collaboration	

Enables 3 levels of “sharing”:

- private: with user-defined collaborators
- public: visible to all users
- published: DOI + entry in the HBP Knowledge Graph

Two step process for publication:

- 1) Model submission by the users
- 2) Curation that the required “standards” are met

Model Catalog App

Model Versions

Name	ID	Created on
1.0	e1ee5736-7a29-42a6-aa1e-1ea56127c7d5	29/03/2018, 02:23

Description:

Parameters:

Morphology: https://object.csccs.ch/v1/AUTH_c0a333ecf7c045809321ce9d9ecdfdea/Migliore_2018_CA1/i View morphology

Code format: asc, py, hoc, mod, json

Download location: https://object.csccs.ch/v1/AUTH_c0a333ecf7c045809321ce9d9ecdfdea/hippocampus_optimization/optimizations/CA1_pyr_cACpyr_optimized.hoc

workspace Model Catalog 

CA1_pyr_cACpyr_oh140807_A0_idG_20170915113354

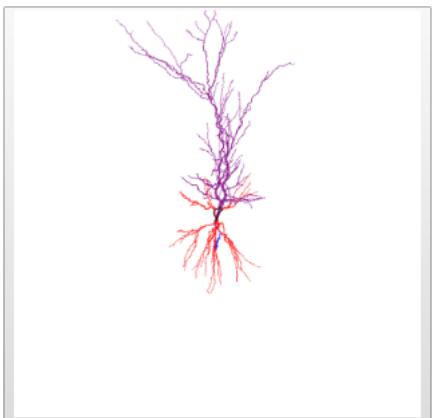
Author(s): Rosanna Migliore

[Home](#) [Edit](#) [New version](#)

Permissions
Read and Write

Model Description

Single cell model optimized using BluePyOpt



Morphology

Model information

Public
ID: d4272705-bc99-4c4a-9e4d-3ce114382b90
Collab ID: 9821
Organization: HBP-SP6

Species: Rat (*Rattus rattus*)
Brain region: Hippocampus
Model scope: Single cell model
Cell type: Pyramidal Cell

Model Catalog App - Morphology Viewer

[Readme](#) | [Terms of use](#) | [What's new](#) | [Feedback](#)

Select neuron from my computer NeuroMorpho.org Allen Cell Types HBP Model Catalog

Model instance: `e1ee5736-7a29-42a6-aa1e-1ea56127c7d5` ▾

Load neuron: `CA1_pyr_cACpyr_oh140807_A0_idG_20170915113354, item 0: oh140807_A0_idG.asc` ▾

- Meta data at the [HBP Model Catalog](#).

[Export PNG](#) [Export SVG](#) [Export SWC+ ...](#)

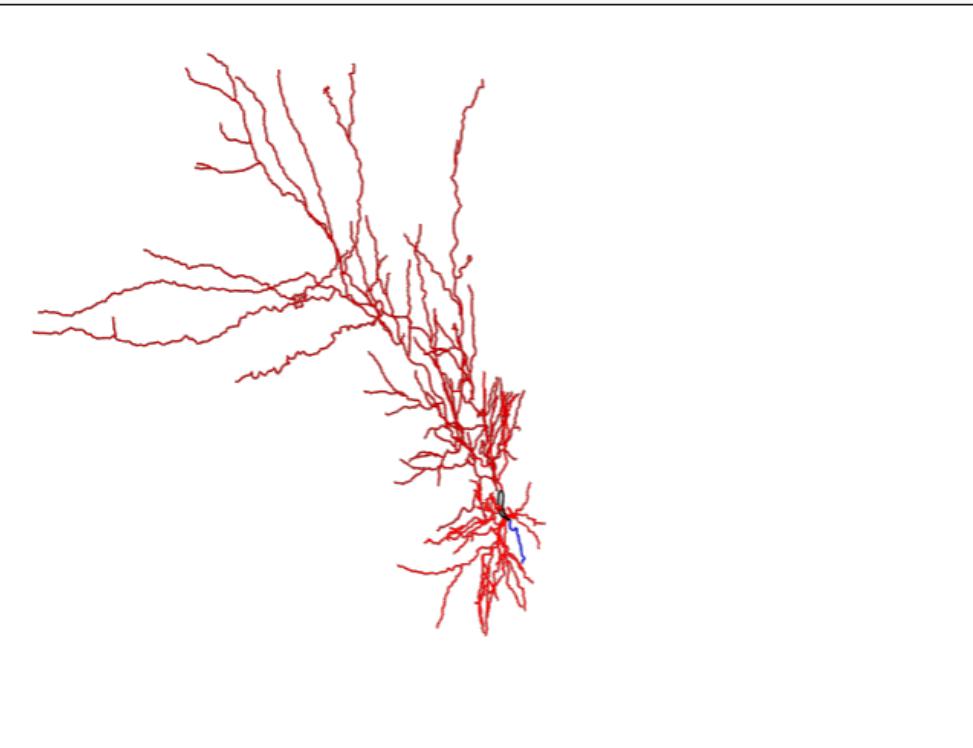
Soma: Axon: Dendrite: Apical dendrite: Render: [thin lines \(fast\)](#) ▾

oh140807_A0_idG.asc

- *contours* ...
 - [+] NewContour #1
 - [+] NewContour #2
- *borders* ...
 - [+] SR/SP
 - [+] SLM/SR
 - [+] SP/SO
 - [+] SO/ALV
 - [+] HF/SLM
- Soma (contour)
 - Attributes (8) ▶
 - Points (49) ▶
- Axon
 - Attributes (8) ▶
 - Points (47) ▶
- *dendrites* ...
 - [+] (basal) Dendrite #1
 - [+] (basal) Dendrite #2
 - [+] (basal) Dendrite #3
 - [+] (basal) Dendrite #4
 - [+] Apical dendrite

Spatial registration

The neuron currently has its coordinates in the *local* spatial reference system.



Thanks to
Rembrandt Bakker
(Jülich) for his
support on this task.

HBP Knowledge Graph

<https://www.humanbrainproject.eu/en/explore-the-brain/search>

Human Brain Project

Science · Platforms · Collaborate · Follow HBP · About · Education & Training ·

Explore the Brain · Brain Simulation · Silicon Brains · Understanding Cognition · Medicine · Robots · Massive Computing · Social, Ethical, Reflective

Knowledge Graph Search

HBP Atlases · Share Data · Find Data · Use Data

Search (e.g. brain or neuroscience)

SEARCH · i

Project 63 Results · Dataset 536 Results · Subject 460 Results · Sample 821 Results · Model 32 Results · Contributor 405 Results

FILTERS · Viewing 1-20 of 32 results · View as Grid · List · Sort by Relevance

No filters available for your current search.

Model of excitable dendrites
In order to investigate the role of signal integration in dendritic trees for large networks of neurons it is crucial to construct simplified models of dendrites.
Detailed multi-compartmental Hodgkin-Huxley (HH) type...

Granule cell - Multi compartmental
Cerebellar Granule cell multi compartmental model.
To correctly simulate it:
1) Temperature = 30°
2) Vinit (V_m) = -.70
3) Current injections physiological range = 0nA to 0.03nA (30pA)

Effect of active conductances on LFP from cortical population
Investigation of the effect of active subthreshold conductances on the Local Field Potential.
This repository contains the code to reproduce all result figures in the manuscript:
Ness, Remme, Einevoll, h-type membrane...

Potjans and Diesmann 2014
Microcircuit model of early sensory cortex from [Potjans and Diesmann (2014)](<https://doi.org/10.1093/cercor/bhs358>), displaying asynchronous irregular activity with layer-specific firing rates similar to the activity...

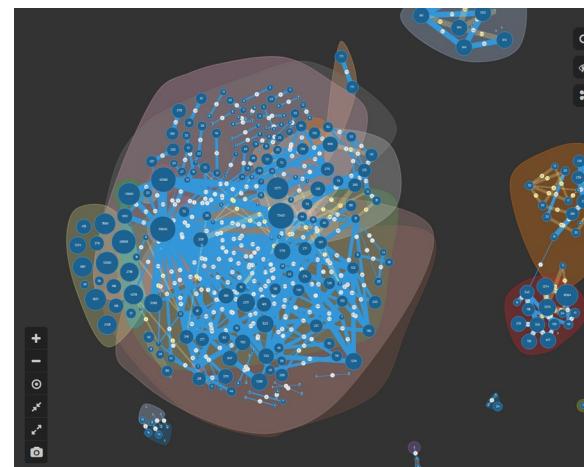
Active model HL2/3 1303Cell03
A model of HL2/3 PC

Technical support that provides the required information to make research data:

- Findable
- Accessible
- Interoperable
- Reusable

(FAIR)

Linked data, Relational database



Live papers

<https://www.humanbrainproject.eu/en/brain-simulation/live-papers/>

The Brain Simulation Platform "Live Papers"

The physiological variability of channel density in hippocampal CA1 pyramidal cells and interneurons explored using a unified data-driven modeling workflow

Authors: Rosanna Migliore ¹, Carmen A. Lupascu ¹, Luca L. Bologna ¹, Armando Romani ², Jean-Denis Courcol ², Stefano Antonel ², Werner A.H. Van Geit ², Alex M. Thomson ³, Audrey Mercer ³, Sigrun Lange ^{3,4}, Joanne Falck ³, Christian A. Rossert ², Ying Shi ², Olivier Hagens ⁵, Maurizio Pezzoli ⁵, Tamas F. Freund ^{6,7}, Szabolcs Kali ^{6,7}, Elif B. Müller ², Felix Schürmann ², Henry Markram ², and Michele Migliore ¹

Author information: ¹ Institute of Biophysics, National Research Council, Palermo, Italy, ² Blue Brain Project, École Polytechnique Fédérale de Lausanne, Campus Biotech, Geneva, Switzerland, ³ University College London, United Kingdom, ⁴ University of Westminster, London, United Kingdom, ⁵ Laboratory of Neural Microcircuitry (LNMC), Brain Mind Institute, EPFL, Lausanne, Switzerland, ⁶ Institute of Experimental Medicine, Hungarian Academy of Sciences, Budapest, Hungary, ⁷ Faculty of Information Technology and Bionics, Pázmány Péter Catholic University, Budapest, Hungary.

Corresponding author: Rosanna Migliore (rosanna.migliore@cnr.it)

Journal: Plos Computational Biology

Download Url: <https://doi.org/10.1371/journal.pcbi.1006423>

Citation: Migliore R, Lupascu CA, Bologna LL, Romani A, Courcol J-D, Antonel S, et al. (2018) The physiological variability of channel density in hippocampal CA1 pyramidal cells and interneurons explored using a unified data-driven modeling workflow. PLoS Comput Biol 14(9): e1006423.

DOI: <https://doi.org/10.1371/journal.pcbi.1006423>

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Abstract:

The peak conductance of many ion channel types measured in any given animal is highly variable across neurons, both within and between neuronal populations. The current view is that this occurs because a neuron needs to adapt its intrinsic electrophysiological properties either to maintain the same operative range in the presence of abnormal inputs or to compensate for the effects of pathological conditions. Limited experimental and modeling evidence suggests this might be implemented via the correlation and/or degeneracy in the function of multiple types of conductances. To study this mechanism in hippocampal CA1 neurons and interneurons, we systematically generated a set of morphologically and biophysically accurate models. We then analyzed the ensembles of peak conductance obtained for each model neuron. The results suggest that the set of conductances expressed in the various neuron types may be divided into two groups: one group is responsible for the major characteristics of the firing behavior in each population and the other more involved with degeneracy. These models provide experimentally testable predictions on the combination and relative proportion of the different conductance types that should be present in hippocampal CA1 pyramidal cells and interneurons.

Resources

Data and models: all data and models used in the paper are available at the links reported below, grouped into the following categories:

- Morphologies
- Electrophysiological Traces
- ModelDB link and test simulations
- Optimizations

The Brain Simulation Platform "Live Papers"

https://www.humanbrainproject.eu/en/brain-simulation/live-papers/

Live Catalog app — HBP Validation Team — Live Papers — HBP DSR — Live Paper — Migliore et al. 2018 — sop.eprx

https://bbp.epfl.ch/public/morphview/CA1_int_cAC_010710HP2_20180118155959.html

KG Search KG Editor HBP support HBP Curation neuroInfo Miscell My Collabs GitHub Gmail My Drive Scholar

HBP2_20180118155959

Resources

Data and models: all data and models used in the paper are available at the links reported below, grouped into the following categories:

Morphologies

Electrophysiological Traces

Int-bAC Int-cAC Int-oNAC pyr-oAC

abf-int-cAC/OLM_980205FHP/98205021

98205021.abf

Show signals from all segments on the same axes:
Segment #3 Signal #0 (Chan0mV)

Channel #0

abf-int-cAC/OLM_980205FHP/98205022

abf-int-cAC/OLM_980205FHP/98205023

abf-int-cAC/OLM_980205FHP/98205025

Tools and applications

Neuromorphic hardware

Neuromorphic computing implements aspects of biological neural networks as analogue or digital copies on electronic circuits.

- offers a tool to understand the dynamic processes of learning and development
- applying brain inspiration to generic cognitive computing

Key advantages:

- *energy efficiency*
- *execution speed*
- *robustness against local failures*
- *ability to learn*

A common pyNN interface :

```
import pyNN.BrainScaleS as sim  
//  
import pyNN.SpiNNaker as sim
```

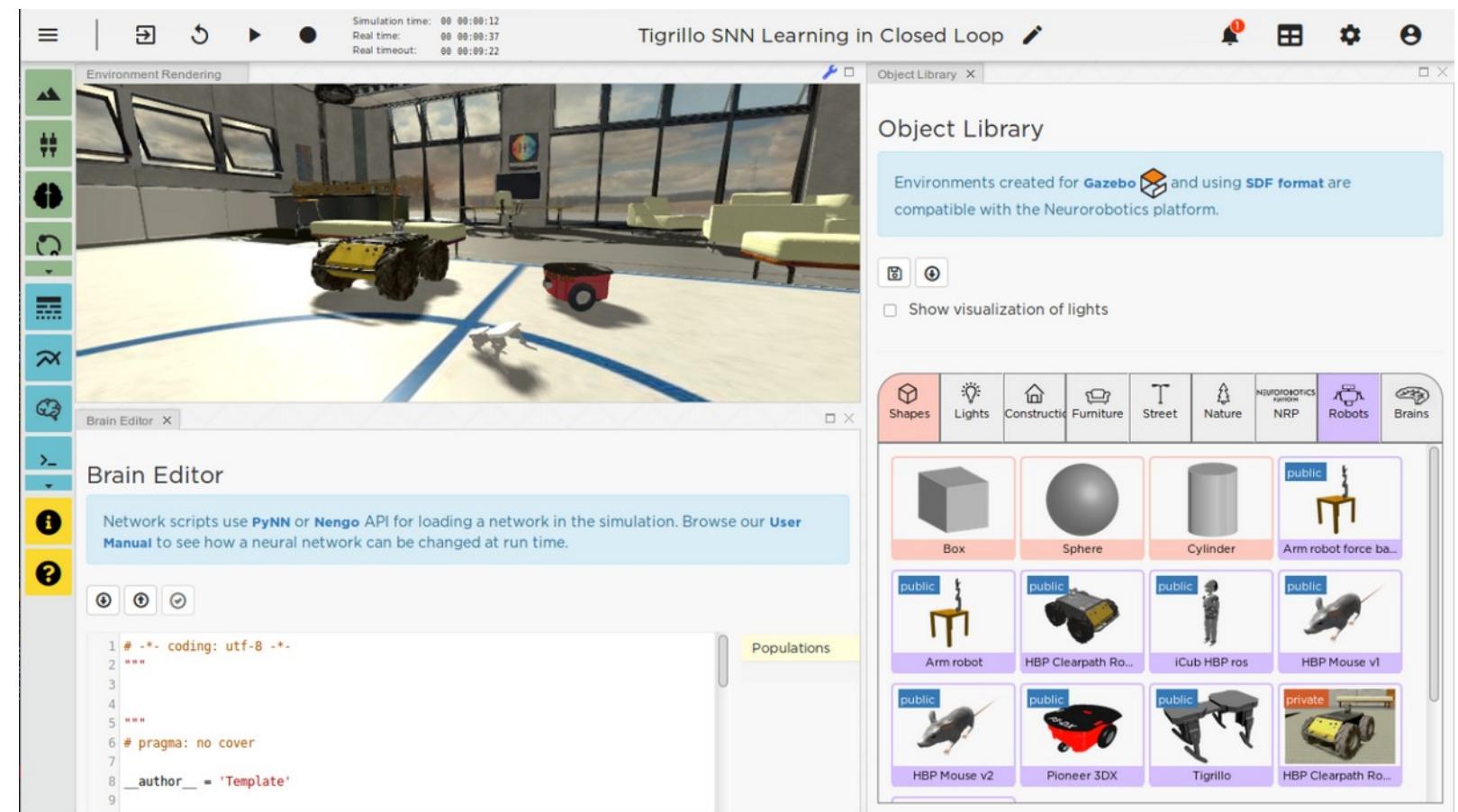
Two complementary technologies:



NeuroRobotics

<https://www.humanbrainproject.eu/en/robots/>

allows researchers to give any simulated brain model its own “body” — virtual or even real — and explore how it controls movement, reacts to stimulus and learns in a virtual environment



The Platform is public, online, and available for all researchers who want to test their brain models or to build the brain-inspired robots of the future.

The Brain Simulation Platform

<https://www.humanbrainproject.eu/en/brain-simulation/brain-simulation-platform/>

The Platform

The Brain Simulation Platform is part of the Human Brain Project (HBP) platform ecosystem. It aims at providing scientists with powerful tools to reconstruct and simulate scaffold models of brain and brain tissue in a state-driven fashion. Its development is embedded in Subproject 6 of the HBP, where a tight co-design loop between science and engineering ensures the required substantial technical and scientific innovations.

The Brain Simulation Platform is divided into three main sections: **Online Use Cases**, **Models** and **Open Source Tools**. Please refer to the following sections for a brief introduction and to learn about other tools that help the user in their experience with the Platform.



Online Use Cases

The Online Use Cases enable you to work through a number of pipelines; these are categorised by level of expertise and by their service maturity level. This section also highlights the use cases under development.

[EXPLORE THE SIMPLEST USE CASE](#)

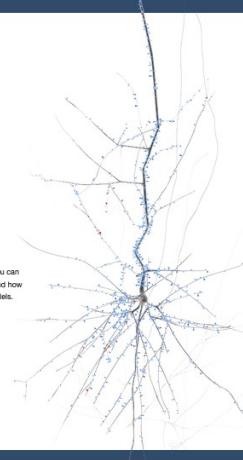
Models

The Models section presents a catalog of scaffold models of rodent, non-human primate and human brain regions; these include:

- o basal ganglia
- o cerebellum
- o hippocampus
- o somatosensory cortex

Description pages are provided for different model families. You can also find a useful description of "What is a Scaffold Model?" and how we will transition from scaffold to more community-driven models.

[OPEN THE MODEL CATALOG](#)



Open Source Tools

Key software developed and integral to the Platform can be found in this section. Many of the applications, such as the simulators NEST, STEPS, NEURON, or tools for analysing morphologies and optimising parameters, can be accessed directly or through the Software Catalog.

[LINK TO THE BLUE-NaaS TOOL](#)

The Brain Simulation Platform is an internet-accessible collaborative Platform designed for reconstruction and simulation of brain models.

Neuron as a Service (Blue NaaS)

Neuron as a Service

Upload a model bundled in a zip file

Expected zip file format(one of the following)

File No file selected.

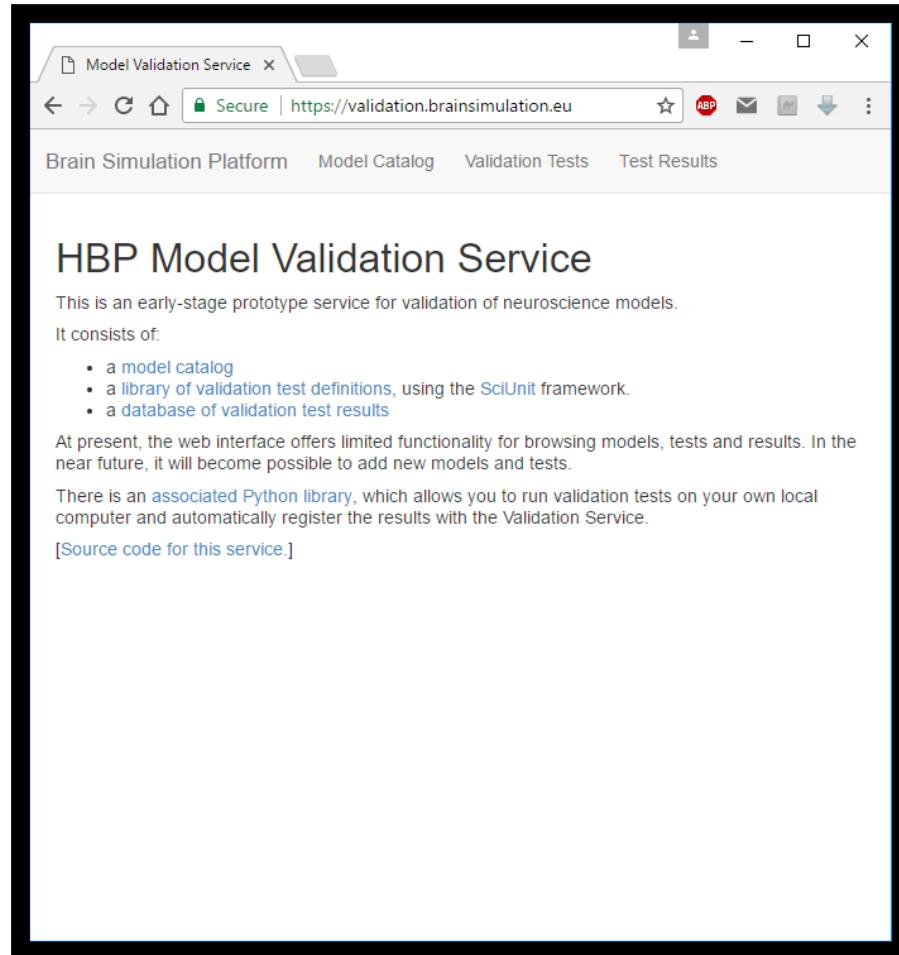
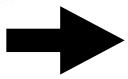
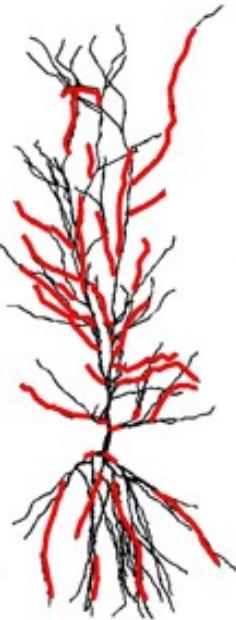
model_name.zip
 model_name
 mechanisms
 *.mod files
 morphology
 morphology file loaded by cell.hoc
 checkpoints
 cell.hoc template arg = morphology folder

model_name.zip
 model_name
 mechanisms
 *.mod files
 morphology
 morphology file loaded by template.hoc
 template.hoc template arg = 0

<https://blue-naas.humanbrainproject.eu/>

The Model Validation Framework

My_model_v2

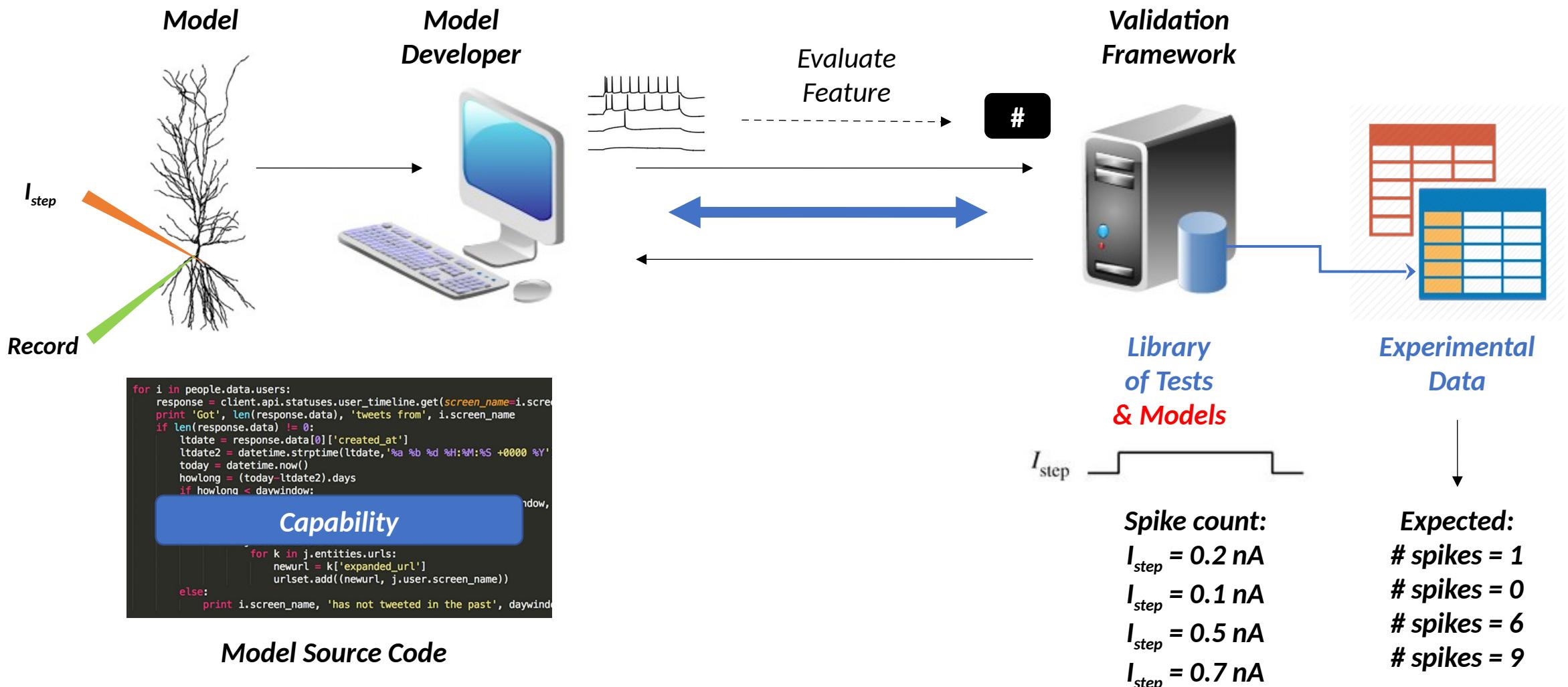


Adds a new type
of ionic channels
with respect to:
My_model_v1

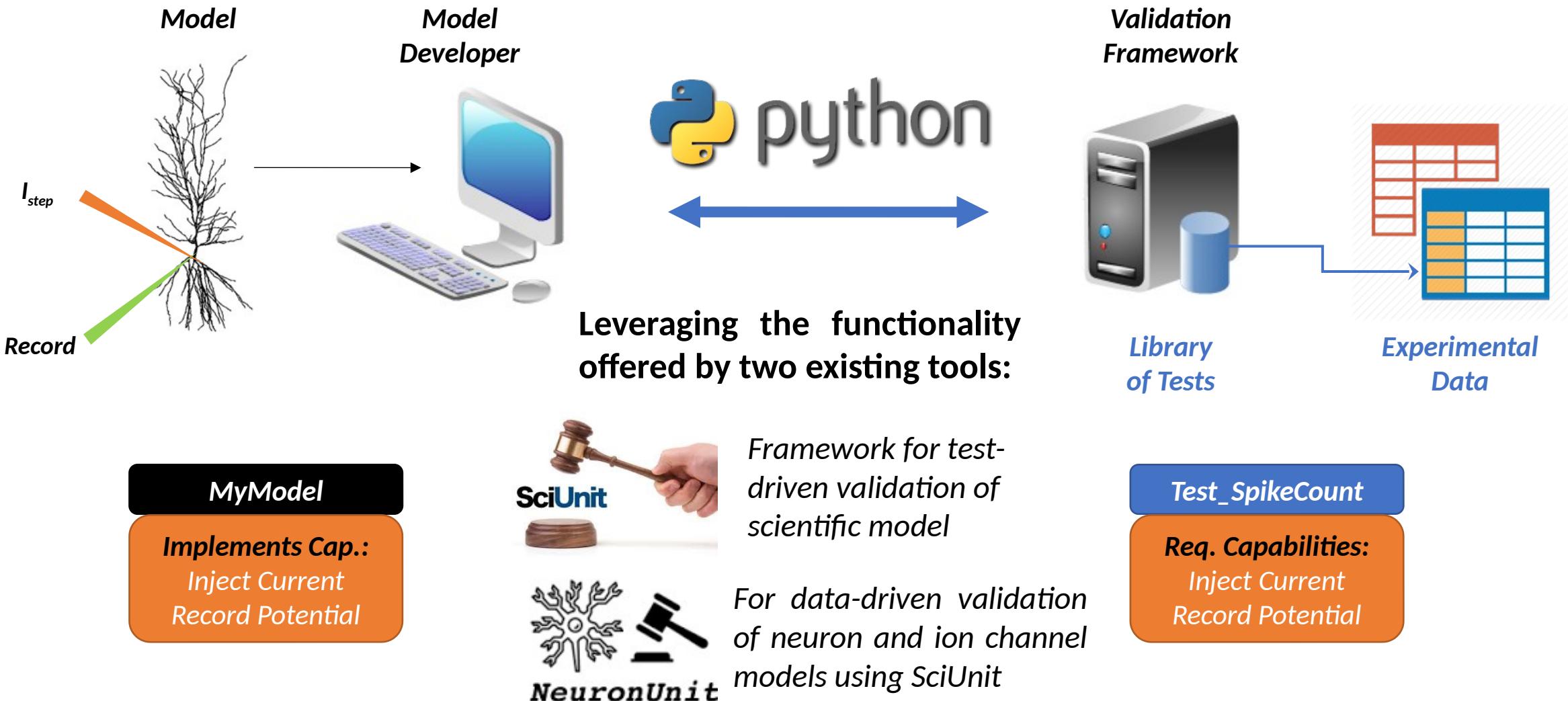
Test (against data) Score Result

Test (against data)	Score	Result
Resting Membrane Potential	0.01	Pass
Model Name	Net Score	Tests Passed
Input Resistance	0.20	Pass
Action Potential Height	0.05	Pass
Oblique Integration	4.73	Fail
CodeJam et al., 2018	2.73	18
Xyz et al., 2010	3.25	15
My_model_v2	3.51	15
Random et al., 2014	4.73	12
My_model_v1	5.02	10
Abcde et al., 2017	5.09	10
•		
•		
•		

Validation Framework - Quick Overview



Validation Framework – Python Client



The screenshot shows a web browser displaying the documentation for the HBP Validation Framework - Python Client. The URL in the address bar is <http://www.hbp-validation-client.readthedocs.io/en/master/#testlibrary>. The page title is "HBP Validation Framework - Python Client: Documentation". The left sidebar contains a navigation menu with sections like "Table Of Contents", "Quick Overview", "General Info", "Regarding HBP", "Authentication", "TestLibrary", "ModelCatalog", and "Utilities". Other menu items include "This Page", "Show Source", and a "Quick search" bar. The main content area starts with a "Quick Overview" section, followed by definitions for "Model", "Model Instance", "Test", "Test Instance", "sciunit", and "Result". At the bottom, there is a "General Info" section with contact information for Andrew Davison and Shailesh Appukuttan.

Table Of Contents

- Quick Overview
- General Info
- Regarding HBP
- Authentication
- TestLibrary
- ModelCatalog
- Utilities

This Page

Show Source

Quick search

Go

HBP Validation Framework - Python Client: Documentation

A Python package for working with the Human Brain Project Model Validation Framework.

Andrew Davison and Shailesh Appukuttan, CNRS, 2017

License: BSD 3-clause, see LICENSE.txt

Quick Overview

We discuss here some of the terms used in this documentation.

Model

A Model or Model description consists of all the information pertaining to a model excluding details of the source code (i.e. implementation). The model would specify metadata describing the model type and its domain of utility. The source code is specified via the model instance (see below).

Model Instance

This defines a particular version of a model by specifying the location of the source code for the model. A model may have multiple versions (model instances) which could vary, for example, in values of their biophysical parameters. Improvements and updates to a model would be considered as different versions (instances) of that particular model.

Test

A Test or Test definition consists of all the information pertaining to a test excluding details of the source code (i.e. implementation). The test would specify metadata defining its domain of utility along with other info such as the type of data it handles and the type of score it generates. The source code is specified via the test instance (see below).

Test Instance

This defines a particular version of a test by specifying the location of the source code for executing the test. A test may have multiple versions (test instances) which could vary, for example, in the way the simulation is setup or how the score is evaluated. Improvements in the test code would be considered as different versions (instances) of that particular test.

sciunit

A Python package that handles testing of models. For more, see: <https://github.com/scidash/sciunit>

Result

The outcome of testing a specific model instance with a specific test instance. The result would consist of a score, and possibly additionally output files generated by the test.

More detailed tutorials will be published soon.

For any queries, you can contact:

- Andrew Davison: andrew.davison@unic.cnrs-gif.fr
- Shailesh Appukuttan: shailesh.appukuttan@unic.cnrs-gif.fr

General Info

v: master

Test Packages

The overall test suite has been divided into a number of components, some containing validation tests specific to particular brain regions, others more generic. All validation tests are written in Python, using the SciUnit framework. Some of these are listed below:

Test suites for specific brain regions

- ❑ **HippoUnit:** <https://github.com/KaliLab/hippounit>
- ❑ **HippoNetworkUnit:** <https://github.com/pedroernesto/HippoNetworkUnit>
- ❑ **CerebUnit:** <https://github.com/lungsi/cerebellum-unit>
- ❑ **BasalUnit:** <https://github.com/appukuttan-shailesh/basalunit>

Test suites for model features, independent of cell type or brain region

- ❑ **MorphoUnit:** <https://github.com/appukuttan-shailesh/morphounit>
- ❑ **NetworkUnit:** https://github.com/mvonpapen/simrest_validation
- ❑ **eFELUnit:** <https://github.com/appukuttan-shailesh/eFELunit>

HippoUnit

Targeted at electrophysiological validations on detailed hippocampal CA1 pyramidal cell model. Simulation outcomes are tested closely against experimental findings. It currently comprises the following tests:

- **Somatic Features Test**

Experimental data: Migliore et al. 2018

- **Depolarization Block Test**

Experimental data: Bianchi et al. 2012

- **Backpropagating Action Potential (AP) Test**

Experimental data: Golding et al. 2001

- **Post-Synaptic Potential (PSP) Attenuation Test**

Experimental data: Magee & Cook 2000

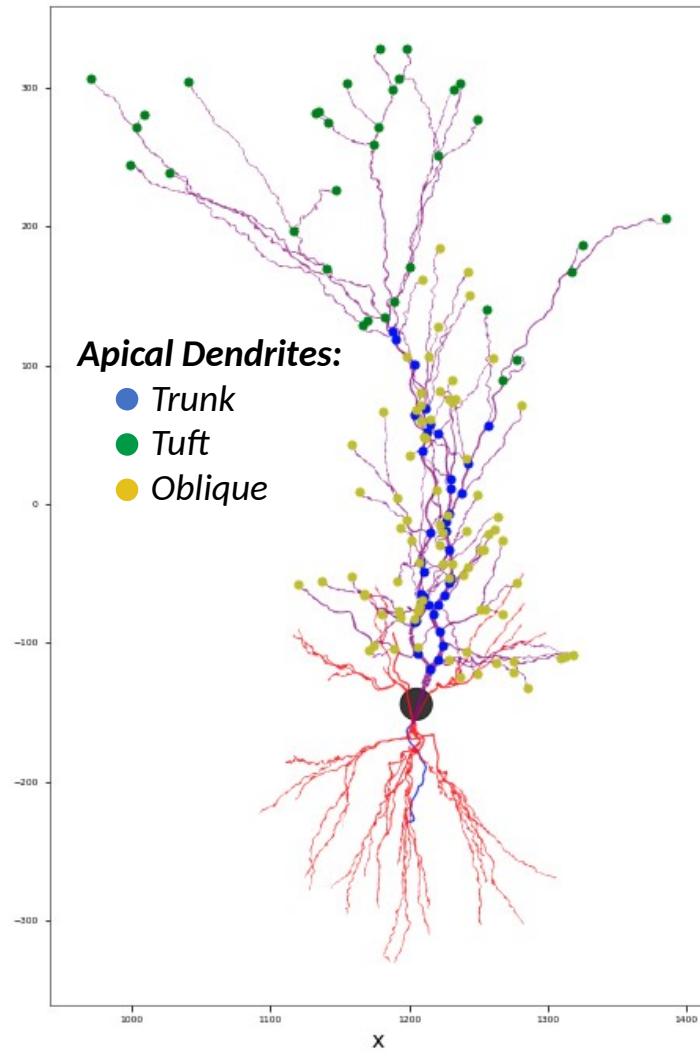
- **Oblique Integration Test**

Experimental data: Losonczy & Magee 2006

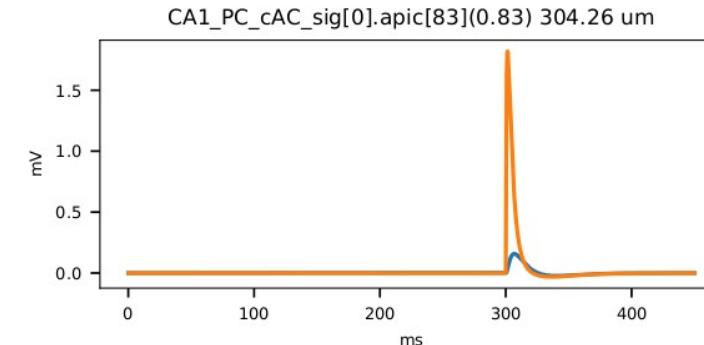
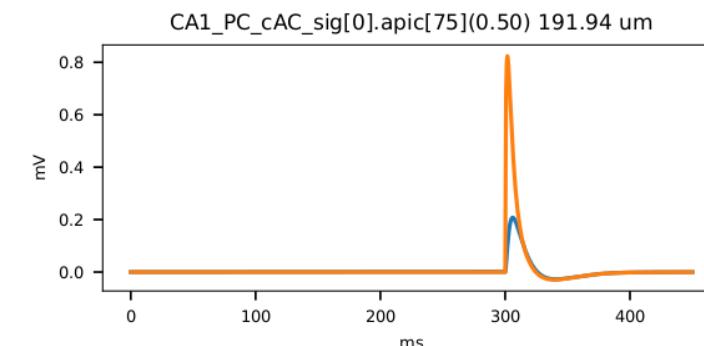
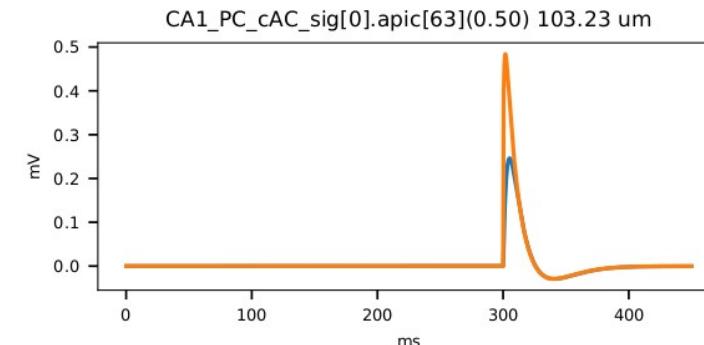
*Developed by
Sára Saray and Szabolcs Káli (IEM, HAS)*

Post-Synaptic Potential (PSP) Attenuation Test

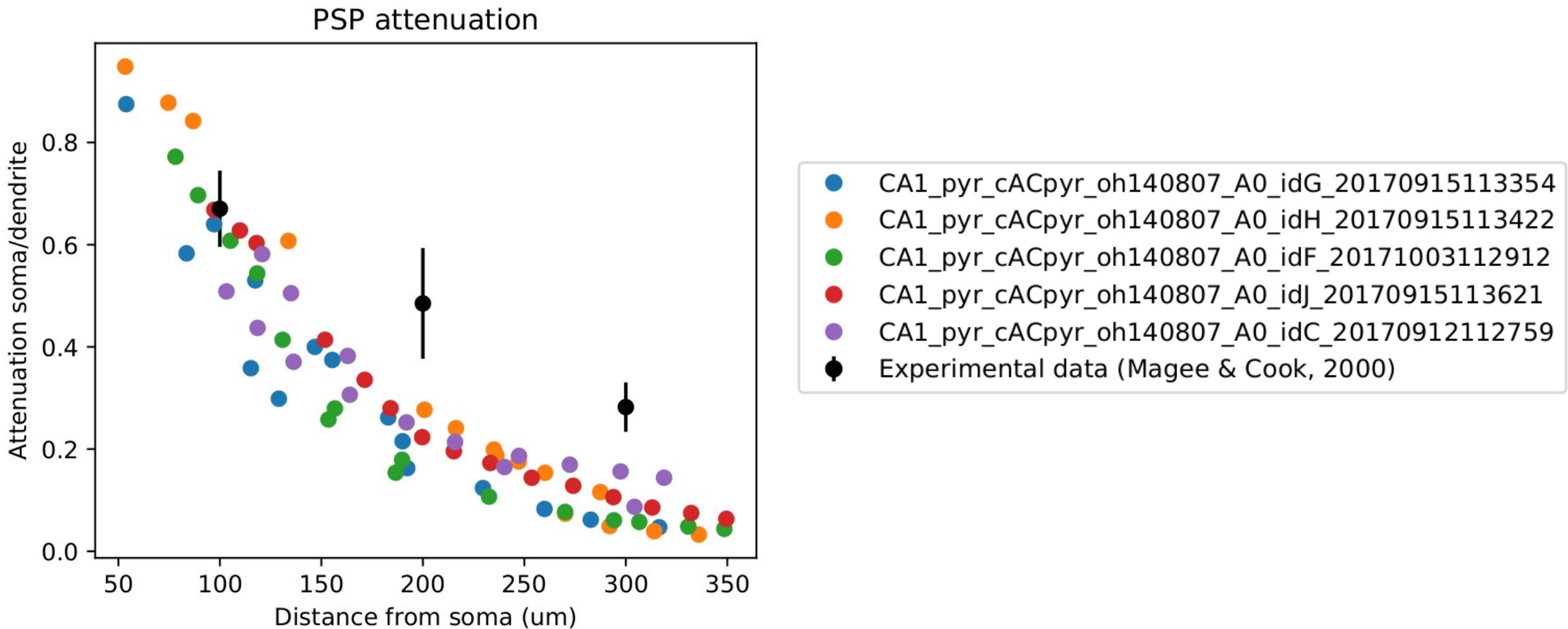
Neuronal Morphology



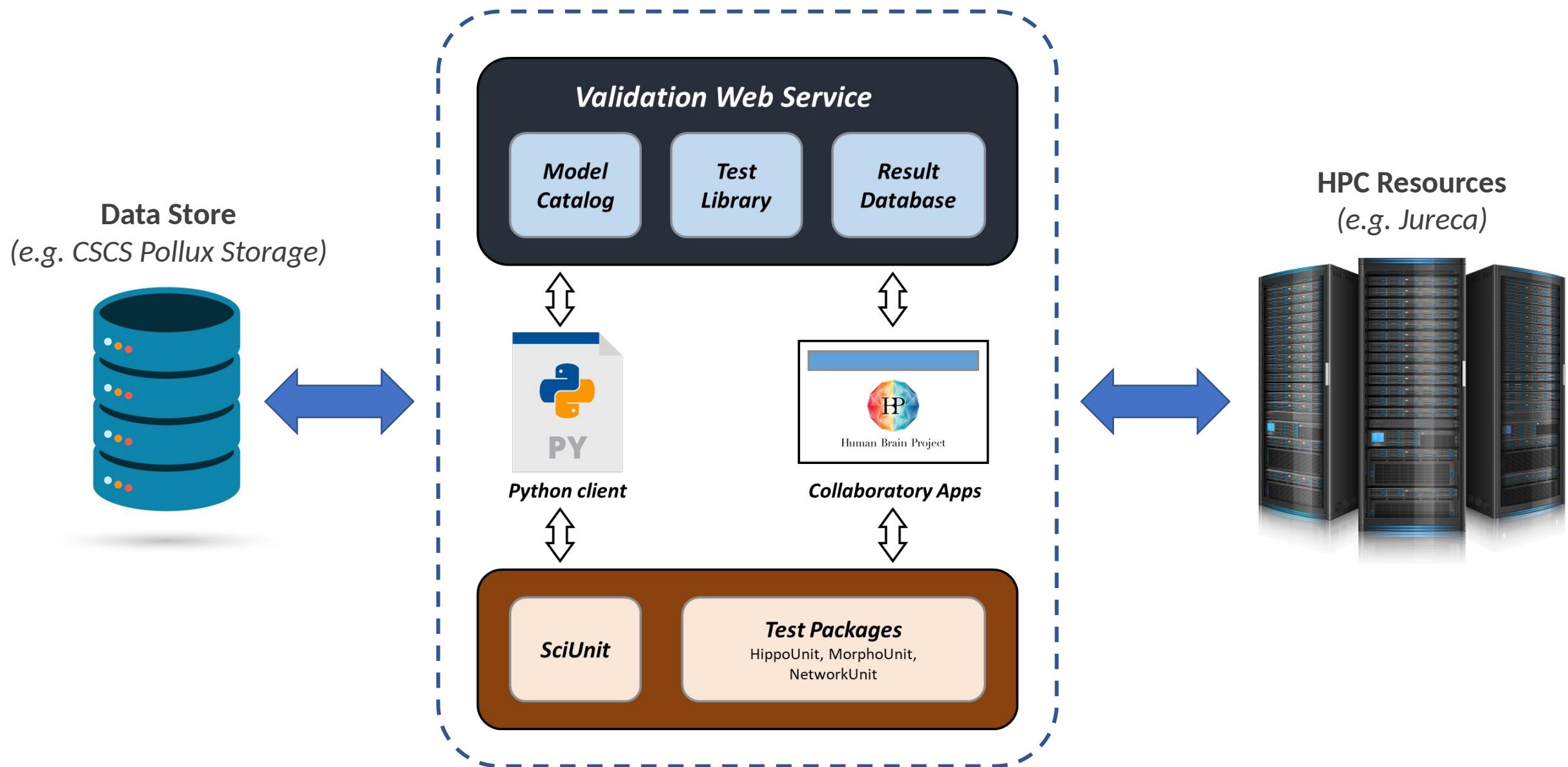
Model Responses



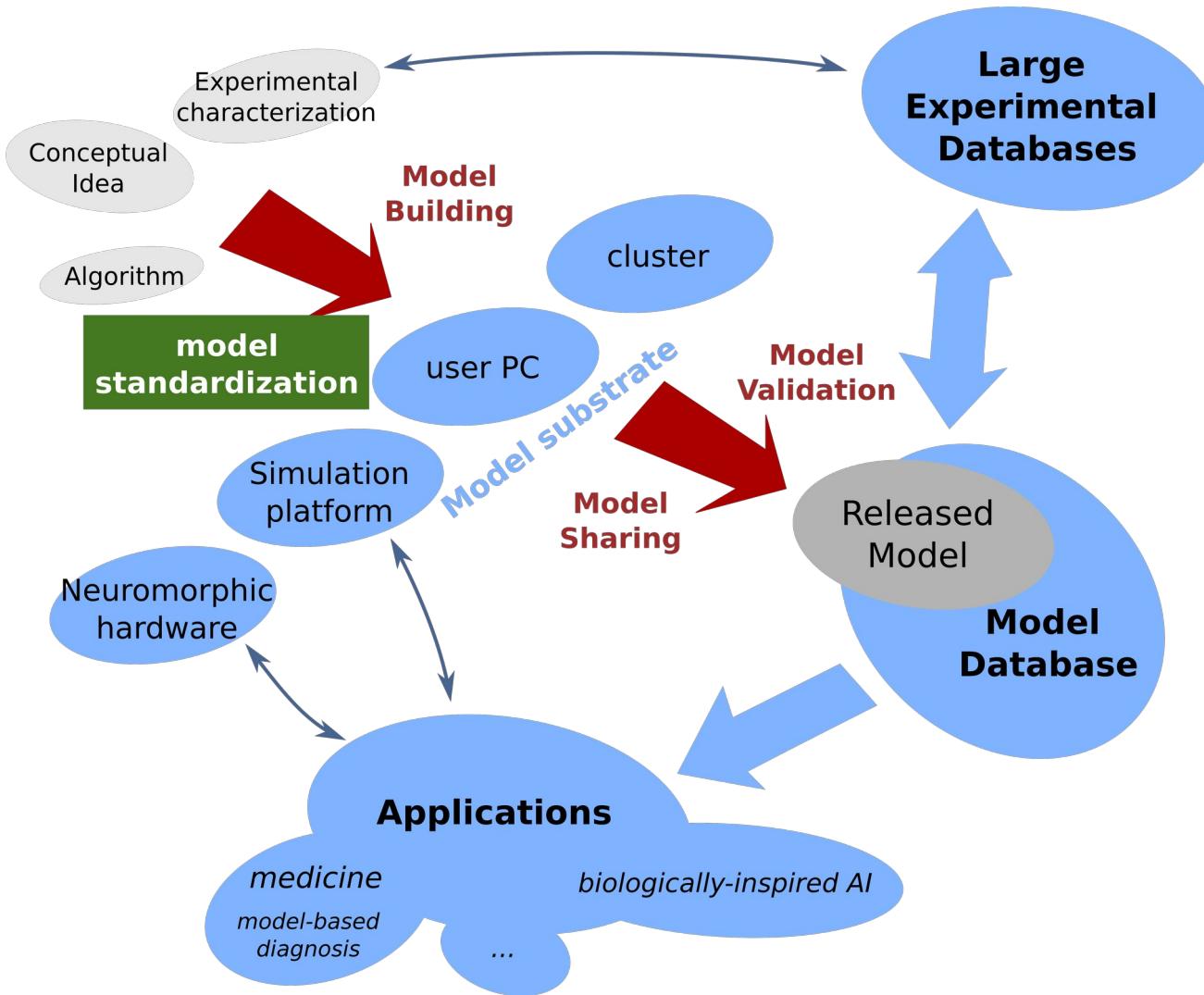
Post-Synaptic Potential (PSP) Attenuation Test



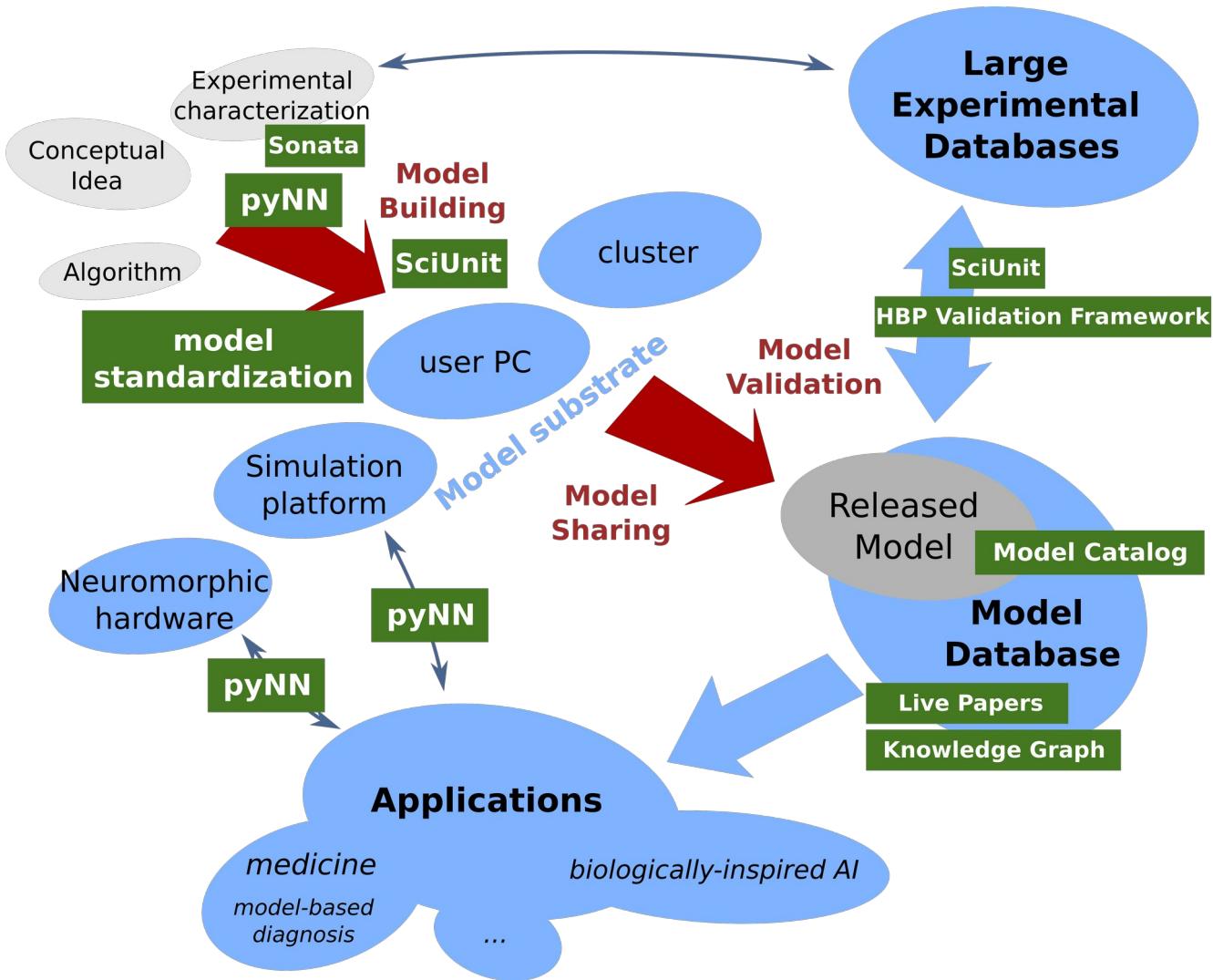
Validation Framework – Various Components



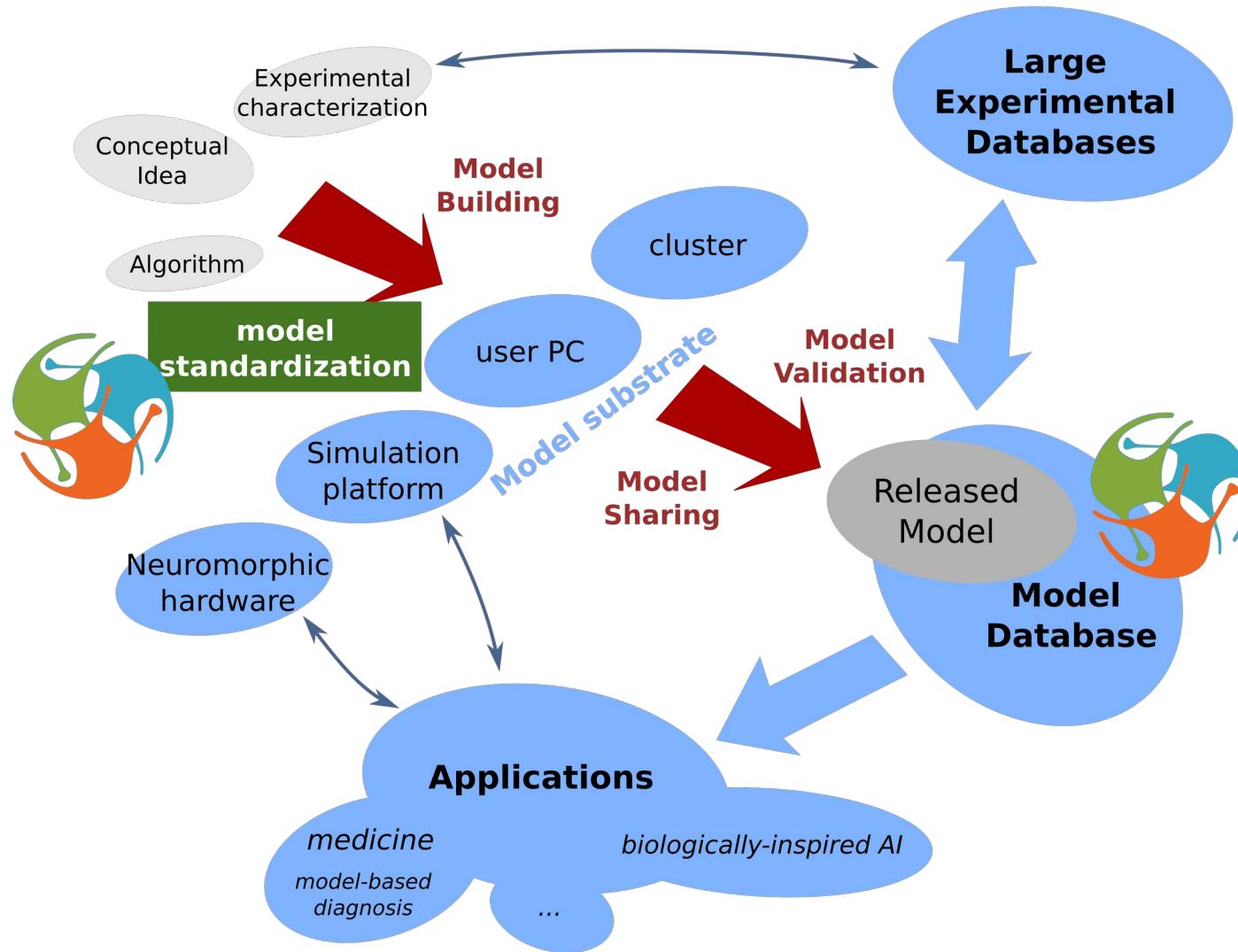
Summary



Summary



Summary





Human Brain Project



Thank you



Andrew
Davison



Shailesh
Appukuttan



Jonathan
Duperrier



Helissande
Fragnaud



Pedro
Garcia



Joffrey
Gonin



Domenico
Guarino



Elodie
Legouée



Lungsi
Sharma



Matthieu
Senoville



Onur
Ates